INTERNATIONAL AND INTERAGENCY TECHNOLOGY TRANSITION PROGRAM

TECHNICAL SUPPORT WORKING GROUP

2006 NATO COUNTER-IED ADVANCED RESEARCH DEMONSTRATION/CONFERENCE REPORT

PREPARED BY:

THE INTERNATIONAL INSTITUTE FOR HOMELAND SECURITY, DEFENCE AND RESTORATION

IN COOPERATION WITH NATO AND SPANISH MINISTRY OF DEFENCE (MOD)

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Executive Summary

In an effort to collect, analyze and disseminate the information presented at the NATO C-IED Demonstration and Conference held in Madrid, Spain on 7-9 November 2006, focusing on emerging counter-terrorism methods of standoff IED detection, TSWG contracted with the International Institute for Homeland Security Defence and Restoration. Immediately after the September Kick-Off Meeting, efforts were underway to provide support to NATO and the NATO lead nation for the Defence Against Terrorism Counter-Improvised Explosive Devices (CIED) Program of Work -- Spain. The International Institute is tasked to provide global avenues to increase the ability of the Combating Terrorism Technology Support Office (CTTSO) and to identify potential contributors to its mission of rapid prototyping solutions to combating terrorism requirements. A main element of this work for the International Institute requires support to NATO's Defence Against Terrorism (DAT) efforts and NATO's Counter Terrorism Development Programme.

To ensure that the Demonstration/Conference forum produced meaningful results, the International Institute, under TSWG task order and working agreements with NATO and Lines of Cooperation with the Spanish Ministry of Defence, provided program management, technical and tactical support to NATO Armaments Directorate and the lead nation Spain, specifically the Spanish Ministry of Defence, in the execution of this project. NATO (DAT) - 4 Program of Work for CIED includes sponsoring demonstrations, conferences, working groups and launching the IPT to engage NATO nations in the pursuit of identification of global capabilities to address threats posed by IEDs. The NATO CIED Demonstration Conference conducted in Madrid 2006 titled ***Journeys on Standoff Detection***, provided an international forum by which NATO nations, Partner for Peace nations and Mediterranean Dialogue nations presented advanced research and innovative stand-off detection technologies. The International Institute together with an International Capability Advisory Panel (CAP) assessed technology capabilities against operational requirements. The analysis in this report is provided by personnel who are active in the standoff IED detection field, including operational experts, scientific engineers and industry representatives with relevant scientific and academic expertise.

The success of this event may be contributed to the following factors:

- Excellent communication, oversight and guidance from NATO Armaments Directorate and TSWG,
- Strong cooperation between NATO Lead Nation - Spain and the International Institute, and
- Expeditious input from operational elements within NATO and within Nations (i.e. RTO, ACO/SHAPE, ACT, RTO, ISAF, Spain MOD/Universidad de Malaga, US-JIEDDO, US-Counter Explosives Hazards Center, nations and industry)

The details of this report include three main sections highlighting: technology descriptions and assessments of technology related to standoff IED detection, the results and procedures of the event and a final section documenting the lessons learned and recommendations for future endeavors. The initial section of the report includes the list of participants from both military and civilian IED incident response teams including investigators from military, local, regional and national law enforcement agencies and policy makers from key governments, particularly those recently confronting the IED threat. Participants hailed from NATO, NATO – member countries, Partner for Peace and Mediterranean Dialogue countries.

Given security classification issues and the fast pace with which the International Institute responded to TSWG and NATO requirements to plan the conference, execute the demonstration, capture participants, identify technology, assess capability and report on findings based upon

international feedback, extensive technical analysis on specific products is not included in this report. If further information is requested on specific technology, please feel free to request this information from NATO.CIED.Conference@theinternationalinstitute.org.

Stand-off detection technologies were presented by international scientists and operators participating on five panels over the two(2) day conference and exhibition. Day three(3) included live demonstrations presented by industry or nations, technology categories include the following:

- Laser Induced Breakdown Spectroscopy,
- Infra-Red Spectroscopy,
- Differential Ion Mobility Spectrometry/Differential Mobility,
- Terahertz Spectroscopy,
- Millimeter Wave Imaging,
- Electromagnetic,
- Polarized Light Camera,
- Non-Linear Junction Detector,
- Enhanced CCTV and Intelligent Video, and
- Persistent Surveillance Technology.

The report includes details concerning the following tasks of cooperation: registration, participation information management, conference execution and reporting. The final conference agenda highlights the various speakers and subjects identified by the International Institute with a particular emphasis on assessments of current IED design and tactical employment. In order to improve knowledge and awareness at the political level and better understand specific technology requirements and briefing information, results from the conference survey and feedback from conference participants is provided. The final section of this report provides a summary of the task order, lessons learned (e.g. close cooperation with host nation, participant approval process and logistics) and recommendations (e.g. future collaboration, advanced planning, lines of cooperation and conference management system).

Successful international and interagency coordination between TSWG, the International Institute, NATO, Nations, Industry, and Academia is crucial to establishing functional partnerships in the execution of counter-terrorism projects. Close cooperation between the International Institute and the host nation was the critical factor in the success of this program of work. The International Institute recognizes the importance of establishing global partnerships, understanding geopolitical issues, transitioning operational requirements to technical capabilities and fostering cooperation between TSWG, NATO and other actors enhancing knowledge and awareness of operability and technical conditions which are fundamentally important in the design of successful security responses to current and emerging threats. The International Institute will continue to provide an international forum for collaboration on strategic counter-terrorism best practices, counter terrorism technology, intelligence and consequence management. .

1 Introduction

1.1 Background

The Technical Support Working Group (TSWG) initiated outreach program to provide technical assistance to NATO to provide Counter-Terrorism support. One avenue for this support involves the International and Interagency Program Contract support provided by The International Institute for Homeland Security, Defence & Restoration (*The International Institute*). TSWG, under NATO's requirements, tasked the International Institute to provide technical, tactical and program management assistance to NATO's Defense Against Terrorism (DAT– 4) Counter Improvised Explosive Device (CIED) Program of Work (POW), particularly focusing on execution of the November 2006 Spanish lead NATO CIED Demonstration Conference on Standoff Counter-IED Detection Technologies. TSWG objectives remain focused on technology identification and assessment. Spain is the lead nation in NATO for counter IEDs. Therefore the International Institute worked directly with the Spanish Ministry of Defence (MoD) in planning and executing the Counter-IED conference program and Demonstration held in Madrid, Spain from 7-9 November, 2006.

The International Institute provided program management, technical and logistic support in order to effect conference coordination, planning and execution for NATO efforts relating to the Counter-Terrorism Programme on behalf of TSWG. While challenged with a limited timeframe, the International Institute worked to identify global C-IED capability for standoff detection.

The International Institute for Homeland Security, Defence & Restoration with the mission of "*Partnering with the World for Security Peace and Economic Development*" enables critical infrastructure stakeholders throughout the international public and private sectors to improve their ability to prepare for and respond to terrorist attacks and other events which threaten public safety and security. The International Institute is a not-for-profit institution with congressional recognition and support. It provides the organizational framework and mechanisms by which the secure exchange of anti-terrorism and counter-terrorism information and technologies can occur among global partners. The International Institute further enhances the ability of the public and private sectors to work together across international boundaries to deter, prevent, and mitigate global terrorism. The International Institute provides a multi-national operational forum of public and private partners so that a more comprehensive capability for the international community exists to respond to acts of terrorism. The International Institute supports the Department of Defense, Combating Terrorism Technology Support Office (CTTSO) and its Technical Support Working Group (TSWG). It provides program management support, analytical and research capabilities, data resources and repository. It also supports the technical conference and demonstration coordination. In addition, the International Institute offers administrative and logistical support to effectively implement the technology transfer and other components of their International and Interagency Technology Transition program.

The NATO Armaments Directorate initiated their Counter Terrorism Programme that features ten Defence Against Terrorism (DAT) areas of work. Established in 2004, NATO DATP is a multinational effort to develop cutting-edge technologies that address today's most pressing terrorism- related security needs. Over the past year, the International Institute coordinated with several NATO directorates, including the Research Technology Organization (RTO), the Allied Command Transformation (ACT) and the Armaments Directorate.

NATO Defence Against Terrorism (DAT) Programme of Work is focused on ten areas where technology can help to protect troops and civilians against terrorist attacks. Individual NATO countries or Conference of National Armaments Directors (CNAD) groups are leading these 10 areas with support from other member countries:

The ten areas in the program are:

1. Large Aircraft Survivability led by the UK.
2. Protecting Harbours and Vessels from Surface and Subsurface Threats led by Italy.
3. Protection of Helicopters from Rocket Propelled Grenades led by Bulgaria with the support of Greece.
4. Countering Improvised Explosive Devices led by Spain with significant US involvement.
5. Precision Air-Drop Technology for Special Operation Forces led by the US.
6. Detection, Protection and Defeat of CBRN Weapons led by the France with the support of the Czech Republic.
7. Technology for Intelligence, Reconnaissance and Target Acquisition led by Germany.
8. Defence Against Mortar Attacks led by the Netherlands with the support of Germany.
9. Explosive Ordnance Disposal (EOD) and Consequence Management led by Slovakia with the support of Norway.
10. Protection of Critical Infrastructure led by Belgium.

Under this task, past performance and coordination enabled the International Institute to respond quickly to the immediate need to provide C-IED program management support to Spanish Ministry of Defence and NATO. Under reference to the TSWG engagement letter to NATO, the Spanish Ministry of Defence developed Lines of Cooperation with the International Institute to clarify roles, responsibility and project scope. To ensure that conference and demonstration presentations, technology and demonstrations were relevant, close coordination on the CIED DAT POW was critical. Close coordination between the parties enabled current and future vision to be executed. Initial scope for conference was reduced from the full CIED “kill chain” to narrowly focus on stand-off detection techniques. Given that the Spanish lead 2004 NATO CIED Conference focused on a broad arena of CIED technologies, senior executives from Spain choose to focus on particular discipline to provide the forum for a more in depth discussion. However, during the exhibition the International Institute together with Spain provided a summary of the future vision of the NATO CIED DAT POW. The International Institute hosted a booth for NATO Armaments, Spanish Ministry of Defence and TSWG.

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Cutting edge technologies to protect NATO forces against improvised explosive devices were the focus of the conference held in Madrid, 8-9 November. This effort received input from industry in several member countries and through the NATO Industrial Advisory Group (NIAG). New technologies were explored and promising results achieved, in particular in the area of stand-off detection. Future cooperation between the International Institute and Spain will continue the development and exploration of C-IED technologies.

NATO Armaments Directorate launched the Defence Against Terrorism initiatives in 2004. As the lead nation for CIED DAT 4, Spain provides the direction and leadership for this effort. NATO Armaments facilitate efforts on this critical progam of work and are serving as program leads on the NATO CIED IPT. As evidenced at the RIGA summit, close attention from all nations to this vital threat is necessary. The U.S. JIEDDO, TSWG and other nations interagency organizations are working in cooperation with NATO on this effort. The International Institute for Homeland Security, Defence & Restoration contracted with TSWG to support NATO’s Defence Against Terrorism Initiatives specifically with the Spanish Ministry of Defence, continues to provide technical, tactical and programmatic support to this effort as they impact the launch of NATO Counter Terrorism Development Programme launch.

The event was an important opportunity for national experts and involved industries to work together to find solutions to the force protection needs of deployed forces. Participants comprised a mix of government officials from NATO, Partnership for Peace and Mediterranean Dialogue countries, as well as representatives from industry and research institutions. The event was aimed at enhancing the interoperability and deployment capacities of NATO's military forces through the incorporation of new technological developments. Particular emphasis was placed on standoff detection of improvised explosive devices and their components. Several of the technologies have already been tested or even fielded. However, issues such as portability, reliability, strength and ease of use continue to pose challenges to the research scientists and developmental engineers.

In partnership with the Spanish Ministry of Defence, the International Institute supported the efforts to develop an overarching international strategy for the 2006 CIED conference. In facilitating the conference, the International Institute recognizes the importance of establishing global partnerships and fostering cooperation between NATO and other actors to reduce misunderstanding and miscommunication and enhance knowledge and awareness of operability and technical conditions which are fundamentally important in the design of successful security responses to current and emerging threats. The conference, therefore, served as a functional partnership forum in which specific areas of cooperation were established as a means toward on-going dialogue and collaboration.

1.2 Demonstration/Conference Scope

As part of the Task Order requirements of the TSWG/NATO C-IED Advanced Technology Demonstration/Conference the International Institute for Homeland Security, Defence and Restoration (*The International Institute)* prepared this Conference Report documenting a summary of the presentations, (detailed presentations may be obtained from NATO or the Spanish Ministry of Defence). The International Institute obtained TSWG approval to combine CLINs/deliverables to combine Conference Report, Technology Assessment and Final Report into one document. This report serves as a synopsis of the event, including list of participants, exhibitors, demonstrators, and provides technical analysis.

One of the primary objectives of the effort is to obtain attendee feedback and reaction to the technologies and products discussed, displayed or demonstrated at the conference. The report pays special attention to this requirement and contains a section highlighting new focus areas suggested by participants. The information gathered provides knowledge and awareness at the multiple levels and results in a more effective mission-specific technology requirements baseline. The conference focused primarily on presenting, exhibiting, and demonstrating technologies or advanced research geared for use in stand-off detection of IED threats. TSWG required capabilities commensurate with NATO Technology Readiness Levels (TRL) 5 through 8. NATO TRL requirements for this effort remained open ended from Basic to Advanced Research; however, emphasis is on TRL 4-9. Additional Task Order requirements included a thorough analytical review of technology presented, specifically focusing on providing a description of the technology, state of technology readiness for operational use, commercialization/sustainment availability and other relevant factors. The corresponding analytical assessments of the deemed technologies are addressed in this report.

The following tables and figures provide a short synopsis of the three day event and a reference framework for the technology reviews found in Section 2. For detailed presentations or contact lists, please contact NATO or Spanish MOD. For detailed conference report, please see Section 3 of this Report.

1.2.1 Synopsis

EVENT: ***"Journeys on Standoff IED Detection" Conference and Demonstration***
NATO Defense Against Terrorism (DAT) 4 CIED, Madrid, Spain 7, 8 and 9 November 2006

HOST AND SUPPORT: NATO and Ministry of Defense for Spain sponsored the event with cooperation of the International Institute for Homeland Security, Defence and Restoration on behalf of the TSWG. Attendance was very well attended with over 150 interested participants from over 22 countries, including Israel, Australia, Turkey, and Jordan. After Spanish MOD review of waiting list participants final authorization was provided to 132 participants.

> **The International Institute** is a public not-for-profit 501(c)(3) organization established to provide the forum needed for the secure exchange of strategic counter-terrorism capabilities that address operational needs of defense interagency users, responder communities and infrastructure managers. They are tasked by TSWG to support NATO and assist Spain in setting up the forum for this NATO CIED DAT Conference.

OVERVIEW:
Spain hosted the three day conference dedicated exclusively to stand-off IED detection. The initial two days consisted of presentations and panel discussions with a static display of various counter IED equipment with a heavy emphasis on detection. Presentation and panel members were an international mix of government, academic and industry representatives organized five panel themes of IED Detection using,
1) Laser Spectroscopy,
2) Molecular Detection,
3) Detection of Concealed IEDs,
4) Detection of Non-Explosive Components of IEDs and
5) Intelligent Scene Analysis and Detection of IED Delivery.

Several presentations presented were of notable interest, either from scientific capability or real world applicability. Afghanistan and Chechnya threat analysis and real world scenarios presented by the Russian Federation provided a realistic backdrop of past, current and future IED challenges and lessons learned. CBRN detectors from Finland, demonstrated innovative technology poised for deployment. Given the strong government participation, attendees provided feedback on the utility of this event in establishing meaningful international contacts. Demonstrations took place on Day 3 at the Spanish Army Engineer Academy outside Madrid and focused on Malaga University's Laser induced breakdown spectroscopy (LIBS) system, a display of various types of IEDs along with Spanish Army EOD equipment and Thru Vision Ltd's Terahertz Imaging equipment currently in use in the UK.

DAY ONE

The Spanish MOD Under-Director for International Relations, Major General Jose L. Ceballos opened the conference along with the Executive Director of the International Institute for Homeland Security, Defence and Restoration, Ms. Mary S. Ungar.

Panel One focused on **IED detection using various forms of Laser Spectroscopy** i.e. (LIBS) Laser Induced Breakdown Spectroscopy. The Chair was Dr. Javier Laserna from the University of Malaga. Dr. Laserna also demonstrated his LIBS technology on Day 3. Highlights of the discussion included combining high-resolution mid-infrared absorption spectroscopy with Pulsed Laser Fragmentation (PLF). Although he was unable to attend in person, Dr. Andrzej Miziolek from the U.S. Army Research Lab presented a paper and detailed briefing of the ARL LIBS capability. Spanish and U.S. collaboration over the past several years have resulted in significant advances in this capability. In December 2004, U.S. sponsored Dr. Laserna to perform multiple successful tests during challenging conditions at Yuma Proving Ground, which resulted in continued LIBS research. Significant advances have been made and Dr. Miziolek has substantial test data supporting ARL LIBS advances. U.S. LIBS technology, currently deployed in IRAQ for in a man-portable prototype capacity, provides accurate explosive detection over 200 meters. Ongoing research to combine LIBS and Terahertz or other technology to strengthen capabilities is now underway. Panel member and presenter Dr. Wolfgang Schade from Technische Universitat Clausthal, Germany proposed that combining different laser techniques is the only way to fulfill full detection criteria. Part of his solution outlined fiber coupled LIBS sensors for explosive detection linked to assess the different explosive signatures through the use of neuronal networks combining different laser techniques.

Dr. Carlos de Miguel from INDRS Systems Spain explained the fundamentals of his work on LIBS inspection of distant objects on manned platforms using Light=Dispersion=Analysis fundamentals of a four step process, including:

STEP 1: laser-sample interaction
STEP 2: separation of material
STEP 3: plasma formation
STEP 4: plasma spectral analysis.

Based upon results of a December 2004 Yuma Proving Ground test, Dr. Miguel presented on the Yuma test success (6 out of 6) success detection rate. Participants were interested in receiving recent test data. Two Spanish universities have combined efforts in this area and have established a goal of a target range of 120 meters. This dual pulse laser system characterizes the interaction and possible delay of the pulse systems. The new platform will have a 120 m range, 400mmm Tweaked Commercial Telescope.

IED Detection Based on Molecular Detection using Infra-Red Spectroscopy was presented by Dr. George Coyle from Northup Grumman. He was followed by a lecture on an Aroma Serial DMA/AF Detector by Fernandez de la Mora (SEADM) Spain. Mr. Migual Sanchez from (RAMEM) Spain presented a paper on detection of explosives as a system and briefed capabilities of their IONER Checkpoint system. The SEADM Aroma DMA Sniffer system appears to use Differential Mobility Analysis (DMA) Steady ion separation in space.

Several NATO nations currently focused on CBRN detector capabilities, expressed interest in the chemical detector capabilities of the Finish Environics technology. With the focus of their presentation on the detection of peroxide based explosives by handheld chemical detectors, operational applicability for rapid deployment was discussed by several NATO nations.

Day 2 of the conference started with a brief by A.A. Reznev and N. Perederiy of Russia on a device called **Shpinat M-1 which uses a gas chromatography** method as a backup for conventional X Ray machines at Russian airports. The device looks like a computer with two sensors using Ion Mobility Spectrometry. Mr. Perederiy briefed a system used to screen luggage with the nomenclature EDS-5101. The EDS-5101 appears to use a combination of X Rays and neutron radiation with a detection period of 20-35 sec. The device is currently in use at airports in Moscow and St Petersburg. Again this appeared to be a backup or confirmation device used after a suspicious package is detected on a normal X Ray luggage screening system. The suspect luggage is removed and then placed into the EDS 5101 for verification. The required manual handing is the drawback to the system. The last device briefed used **Nuclear Quadropole Resonance** called the NQR-160 and again is used in conjunction with conventional X Ray machines.

The rest of the morning focused on detection of concealed IEDs on persons and within vehicles using various forms of **millimeter wave and terahertz technology.** A panel discussion chaired by Mr. Ian Raitt from DSTL Fort Halstead, UK along with Roger Appleby from QinetiQ, Dr. Kemp from Iconal Technology Ltd UK and Thruvision UK Ltd's Dr. Jonathan James along with Holland's Lucas van Ewijk from TNO Defense, Security and Safety and Dr Arnold Schoolderman discussed the limitations and value in using high frequency millimeter terahertz in various formats and resolution to detect IEDs hidden on persons. The limitations imposed by aperture size to resolution and contrast were covered as well as modesty issues and overall cost of systems and the future possible user of higher frequencies. The panel believed future needs will eventually drive cost down and higher freq up to 540 GHz could be used in the future. Dr. Jonathan James from Thru Vision Ltd presented. The Dutch engineer system using a **Duncan Technical Camera with a polarized beam splitter on a R&D Camera** was demonstrating the ability to enhance and discriminate manmade objects from the background could possibly be of some use in the detection of pressure plate activated IEDs, but the system shown had to be on top of the area to work (well within the blast radius of an IED).

Mr. Patrick Arounie presented Lockheed Martin's Integrated IED Detection Architecture which was very basic and with a long term planning basis. Mr. Jorg Mathieu presented on the detection of flammable explosive liquids concealed in commercial liquid containers using an electromagnetic device called a CEIA EMA-2 (Electromagnetic Bottle Analyzer) produced by Mr. Jorg Mathieu. This technology, while helpful is not unique.

Established in 1994 by ex-KGB officers, a Russian company called the STT Group proposed the use of a Non-Linear Junction Detector NLJD. Based upon 1970s de-bugging technology and 1980 IED removal technology, the Russians briefed that they have developed the NR900 series NLJ-detector, produced over a 1000 detectors and demonstrated with car alarms, cordless telephones etc. They have produced in 2003 Eagle and this was adopted in 2005 latest NLJD called NR-900EK. It looks like a mine detector but detects electronic devices 5-6 meters and using a handheld device held out in front showing detection ranges of 4 meters against a detected IED under heap of garbage. The obvious problem is the 4 meter range. They also claimed to detect PIRs at 10 meters.

Intelligence Scene Analysis and Detection of IED Delivery Panel by Dr. Andrea Cavallaro. Despite a large number of CCTVs most operators cannot watch more than 10 min etc. So the panel looks at possible ways to use CCTVs to extract meaningful information from surveillance imaging prior to an incident using:

- Statistical signal processing
- Pattern recognition
- Foreground/background etc
- Detection and tracking of faces
- 3D facial scan analysis
- People tracking
- Detection of dangerous events
- Automated performance evaluation of CCTV surveillance systems

Carnegie Mellon gave a very interesting brief on face and gait recognition software for CCTV. Geospatial and ITT concluded the conference presentations with their imaged enabled surveillance system,

Spain MOD adjourned the conference after providing summary comments and conference survey forms.

Table 1 - List of Panel Presentations

Panel	Organization	Country	Technology
LIBS	Clausthal University	Germany	LIBS with Mine Prodder

	INDRA Systems	Spain	Standoff Trace Detection with LIBS
	Army Research Labs	United States	ST-LIBS
2 - Molecular Detection	Northrop Grumman	United States	Mobile Chemical Agent Detector (MCAD)
	Ramen	Spain	NEDS- New Explosive Detection System
	SEADM	Spain	DMA-MS Explosive Detection System
	Environics	Finland	ChemPro 100
3 - Concealed IEDs	QinetiQ	United Kingdom	Millimeter Wave Passive Imaging
	Thruvision	United Kingdom	T4000
	TNO	The Netherlands	Terahertz Person Screening
	CEIA	Italy	EMA-2
	TNO	The Netherlands	Mine Detection with Polarized Light Cameras
4 - Non-Explosive Components of IEDs	EMC-1	Russia	Non-Linear Junction Detector
Other Presentations	US Army Armaments Research & Development Center's (ARDEC)	United States	Perspective on Standoff Detection of Concealed IEDs
	Lockheed Martin	United States	Integrated IED Detection Architecture
5 - Intelligent Scene Analysis	University of London	United Kingdom	Surveillance Imaging for Intelligent Scene Analysis
	Virage Security & Surveillance	United Kingdom	Enhancing Effectiveness of CCTV in Detection of IEDs
	Carnegie Mellon University	United States	Computer Vision & Scene Analysis
	Geospatial Systems, Inc.	United States	Persistent Surveillance for IED Detection & Defeat
	GE Research	United States	Intelligent Video Scene Analysis

Table 2 - List of Exhibits

Organization	Country	Exhibit
RAMEM	Spain	DMA: Checkpoint and detection system. Ionization and related products
Clausthal University of Technololgy	German	Laser technology, Laser spectroscopy and fibre technology: LIBS in combination with a conventional mine.
Environics OY	Finland	Chemical warfare agent/toxic industrial chemicals detection: ChemPro100 TATP + CBRN handheld detector for peroxide based explosives.
CEIA	Italy	Electromagnetic detection of flammable and explosive liquids concealed in commercial bottles; Electromagnetic Bottle Analyzer CEIA-2.
Allen-Vanguard	United Kingdom	ROV-2 Bomb Disposal Robot
Geospatial Systems, Inc	United States	Intelligent scene analysis: video software for the detection and identification of anomalies
Thruvision, Ltd	United Kingdom	T4000 TeraHertz IED detection: images of concealed objects in real-time on moving people, at a distance, in real-time
Virage Security & Surveillance	United Kingdom	Intelligent Video Survaillence Systems
ImageBase Technology	United Kingdom	Bombic & Photophone - IED Incident Reporting
Northrop Grumman	United States	Mobile Chemical Agent Detector (MCAD)

Table 3 - List of Demonstrations

Organization	Country	Demonstration
RAMEM	Spain	DMA: Demonstration of Ion sniffer applied to a checkpoint situation
INDRA	Spain	LIBS: Demonstration of the ability to detect traces of explosive material over surfaces at distances above 30 meters by means of a standoff LIBS setup.
Thruvision, Ltd.	United Kingdom	T4000 Demonstration of images of concealed objects in real-time
Northrop Grumman Corp.	United States	Video demonstration of MCAD System

1.3 Capability Advisory Panel

The International Institute, with guidance from NATO, established a Capability Advisory Panel (CAP) of scientific experts to provide additional input to post conference technology assessments. This multi-national C-IED technology assessment team worked to evaluate technologies presented at the conference and to make recommendations on how to best further develop the most promising technologies. The International Institute identified the appropriate scientific experts to comprise the Panel. CAP members were contacted and provided with usernames and passwords to access the Combating Terrorism Technology Information Platform. Once login information was completed, CAP members were provided access to the technology specific assessment forms and corresponding power point presentations. CAP members were allowed to evaluate as many technologies as they wished and were able to save changes and return to complete forms at a later time. CAP members were also provided the NATO Technology Readiness Levels to use when completing the forms. The assessor was asked the following 11 questions about each technology or product:

Table 4 - Technical Survey Questions

1.	What is your assessment of the viability of the underlying science or technology with respect to its use in IED stand-off detection applications?
2.	What is your general assessment of the technical performance capabilities or limitations of the technology?
3.	What is your assessment of the integration or interoperability capabilities of the technology with other systems or technologies?
4.	What potential deployment/implementation considerations, limitations and constraints of the technology do you foresee (e.g. training, manpower, organizational impacts, operational impacts, maintenance, physical size of the technology, mobility of the technology)?
5.	What is your rough estimate of time and cost for further development of the technology in order to make it suitable for deployment/implementation (if the technology is not already available for purchase and installation in an operational environment)?
6.	Using the attached table of NATO Technology Readiness Levels (TRL), please indicate the TRL where you believe the technology currently belongs.
7.	Please provide “pros” and “cons” of the technology versus other Counter- IED technologies and products presented at the conference.
8.	Would you or your agency/organization consider further financial investment and development of the technology worthwhile for Counter-IED or other uses? Please identify the other possible uses of the technology in defense of homeland security environments, if any.
9.	Please identify any import or export restrictions which may apply to the technology, as pertaining to your own country.
10.	Please identify any issues that could possibly affect the commercialization (e.g. intellectual property rights, environmental impact, safety) and sustainment availability of the technology (e.g. lack of critical materials, production capacity.)
11.	Please provide any other comments or observations that you have concerning the technology.

The creation of the Capability Advisory Panel and the contributions of its members increased the breadth, depth and quality of the post-conference technology assessments as well as establishing a working group that will continue these efforts of cooperation and support.

1.4 Feedback on Conference Technologies

1.4.1 Conference Survey

A post conference survey was created by the Spanish Ministry of Defence and distributed on the last day of the conference. The International Institute made this survey available via the conference website as an online survey form.

Following the conference, the Conference Survey distributed by the Spanish Ministry of Defense at the end of conference proceedings, was re-formatted and sent via email to conference attendees. This follow-up allowed for the completion of more surveys in turn producing a more complete understanding of attendee's experience at the conference. This follow-up also provided a forum for attendees' comments regarding future standoff detection exploration (see Table 11) as well as how to improve the relationship between the IED operational experts and industry scientist. One of the main components of the Conference Survey was the evaluation of how interesting, useful and appropriate each panel was. These results can be seen below in Attendant's Response to Panel 1-5.

NATO Defence Against Terrorism
Journeys on Standoff IED Detection

Questionnaire

1. Which is your area of work Military/Scientific/Industry?

2. How would you evaluate the conferences?

Panel 1: IED Detection Based on Laser Spectroscopy
Panel 2: IED Discussion Based on Molecular Detection
Panel 3: Detection of Concealed IEDs
Panel 4: Detection of Non-Explosive Components of IEDs
Panel 5: Intelligent Scene Analysis and Detection of IED Delivery

High	Low
5 4 3	2 1

	Interesting	Useful	Appropriate Level	Comments
Panel 1				
Panel 2				
Panel 3				
Panel 4				
Panel 5				

3. What areas of standoff detection would you recommend to explore in 2007?
4. In general, please suggest new areas of work for 2007.
5. For 2007, we have planned to expand activities focusing on the areas in the table below. Please mark your interest for each of these.
   a) Development of a tool (MATRIX SHEET) with the capability to relate operational requirements with technological advancements
   b) C-IED Detection systems definition, through:
      - combining detection techniques
      - combining standards for platforms
   c) NATO Staff requirements for C-IED equipment based on:
      - the combination of feasible techniques
      - integration standards for platforms
   d) Technological capability to improve and expedite training
   e) Technologies and techniques of C-IEDs focusing on other kill chain phases besides the detection of explosives
6. How would you improve the relationship between the IED operational experts and industry/scientists?
7. What other aspects of IEDs standoff detection would you have included in the conference?

Form will be posted at http://theinternationalinstitute.org/conference for further comments.

Figure 1 – Conference Survey

Table 5 - Recommendations for Areas of Standoff Detection to Explore in 2007

• *High Power Microwave (HPM) aerial surveillance*
• *Focus on battlefield areas like Iraq/Afghanistan and areas like metal detection, ground penetration radar, high power microwave; unmanned and manned vehicles capable of detection speeds of 720 km/hr.*
• *More technologies that deal with detection of network components versus detection of IEDs.*
• *Molecular detection.*
• *Detection of concealed IEDs in the field.*
• *Focus more on combination of different technologies.*
• *Spectroscopy working dogs in conjunction with other trace detection and laser persistent surveillance/cameras.*
• *LADAR and LIDAR systems*
• *DMA: Differential Mobility Analyzers and Sniffers*
• *Detection of IEDs buried underground, stand-off detonation and jamming of radio controlled IEDs would be useful. Detection of IEDs in the field.*
• *Standoff detection; Intelligence; Post-blast assessment*
• *More work related to LINB showing to what extent it can actually be sensitive and selective enough for real environment detection. More experimental work related to these issues and a discussion about capabilities and limitations.*
• *Advanced training and cognitive skills for military/police/security. Web based training.*
• *Test bench among the different technique. Integration of different detector to form a system with complementary explosive detectors in order to reduce false alarms.*
• *A more rigorous session on stand-off detection using MMW and THz techniques multi- spectral techniques; Thermal imaging.*
• *Nuclear resonance florescence, Terahertz imaging and spectroscopy, Raman spectroscopy.*
• *Establishing signature standards for spectroscopy techniques.*
• *Standoff detection in urban environment*
• *Terahertz-technology with the option of chemical analysis at higher frequencies.*
• *Analysis of vapors with IMS*
• *Countering of IEDs by means of microwaves and jamming.*
• *Non-vis imaging; remote material identification, Raman, THz, vapour detection.*
• *Operational aspects of the problem, the vision of the potential user of a standoff detection system to guide the industry to provide a possible solution to real problems.*
• *Millimeter wave, x-ray.*
• *Combination of video and millimeter wave and terahertz imaging for integration of concealed weapon/explosive detection and intelligent CCTV video analysis.*
• *Talks by operational experts defining the operational requirements. Important for scientists to get input regarding operational requirements in order to design appropriate systems.*

Attendee recommendations following Question 6 of the Conference Survey heavily emphasized the importance of continued cooperation between operational experts, scientists and industry. Some of these recommendations included carrying out joint pilots with science/technological projects in cooperation with military operations from NATO nations. Close collaboration between both sectors on pilot projects is vital. Likewise, many attendees commented on the importance of funding studies to evaluate technologies from both scientific/technical and operational points of view. Other recommendations highlighted the importance of facilitating face to face meetings, providing videos showing the terrain and operational problems, quarterly conferences focusing on operational aspects, training events and web based forums. Participation in joint R&D programs was also continuously noted. Finally, a conference led by operational users with industry as attendees was noted as major area to improve the relationship between the IED operational experts and Industry/Scientists. The Conference Survey results highlight the success of this event centered around the interactive role of participants in both the formal and informal meetings. Positive feedback from participants recognized the large attendance of NATO government participation. This creates forum for future collaboration. Positive feedback continues to be received regarding a continued role with participants on the Capability Advisory Panel.

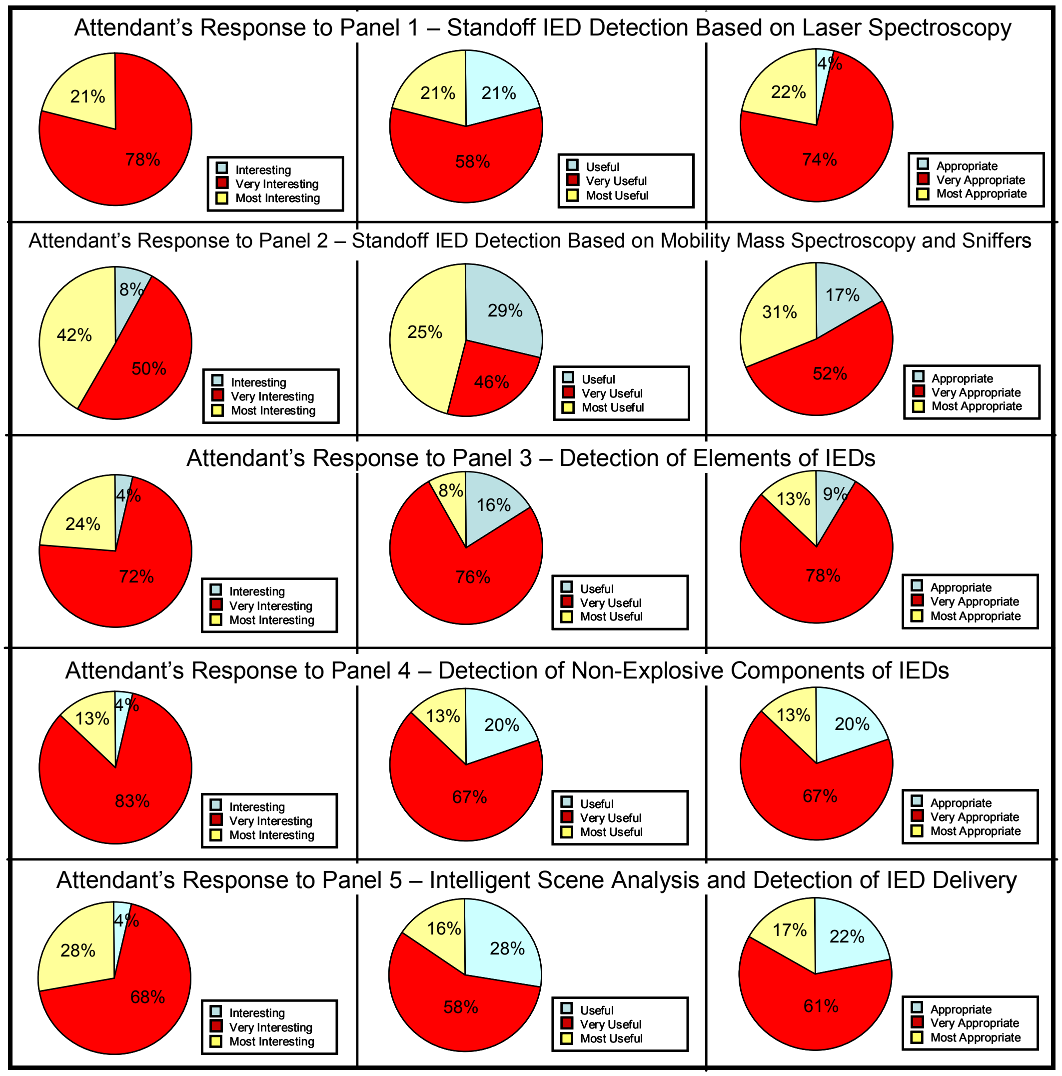


Figure 2 - Attendant's Response to Panel 1-5

The following two sections provide a high-level overview of Detection Principles and Desirable Properties. To achieve an interoperable assessment framework, consensus on these basic principles and requirements is necessary to ensure that capabilities meet both TSWG and NATO operational mission needs. A detailed set of criteria and metrics is needed to provide the requirements baseline, especially in a NATO environment.

1.5 Detection Principles

Detection methods can be divided into two groups, bulk detection methods and trace detection methods. Bulk detection methods look for the explosive itself in the explosive device and require presence of large amounts of explosives to find it. Trace detection methods work from trace amounts of explosives in gas phase or in the form of explosives particles. These traces are present around an object, on the packing material or on the person or persons handling the object. Methods for both bulk- and trace-detection with their respective advantages and disadvantages will be treated in this report. However, there is more focus on trace detection methods. The existence of spot tests for identification of unknown substances by color change are mentioned in the trace detection chapter, but they are not extensively treated and no direct survey of available spot tests has been made. The methods available today and presented at the conference, are generally able to detect a types of explosives and markers* (substances with high vapor pressures that are easier to detect and which are mixed into explosives at manufacture to facilitate detection) and are too slow to allow for screening of all passengers at an airport for example. It is focused on existing and emerging technologies for trace detection (including stand-off detection). Boundaries that exist between existing and emerging technology need to be clarified to fully assess specific technology applications. The most commonly used techniques are however based on X-ray for bulk detection and IMS for trace detection. Exact information about how a commercial instrument works is not always easily accessible, neither is an independent and reliable evaluation of performance.

1.6 Desirable Properties

One of the methods available for trace detection and most commonly used today is Ion Mobility Spectrometry (IMS). In a recent report, “Opportunities to improve airport passenger screening with mass spectrometry” one of the findings was that “The relatively low chemical specificity of IMS means that the instrument alarm threshold must be set high to avoid excessive false alarms; yet, lower alarm levels are desirable to account for inefficient manual and portal sampling techniques and, possibly “cleaner” perpetrators”. It was also found that “currently deployed IMS systems are designed to detect only a specific list of explosives and cannot easily be reconfigured to detect an expanded list of explosive, chemical and biological threat substances”. This describes the needs for improvement very well. It can be concluded that it is desirable to find a better detection method with lower false alarm rate, higher selectivity and sensitivity and with an increased range of detectable threat substances. A complete list of desired specifications may not be easily realizable, since different applications specify different needs. However, certain criteria can be specified as universally desirable; however, specific TSWG/NATO criteria may need to be defined clearly to enable effective technical analysis, in general:

High selectivity: The selectivity of the method is of great importance since poor selectivity is detrimental to the failure-to-detect frequency as well as the false-alarm frequency.

The Limit of Detection (LOD)/High Sensitivity: A trace detection method per definition needs to be able to find very small amounts of explosives. Therefore, it is desirable to have a very low limit of detection, i.e. very high sensitivity. The exact amount detected is of less importance, but a measure of “much”, “little” or “more” may provide useful information when attempting to determine the origin of a positive response.

High detection probability / Low false alarm rate: For a detection method to be reliable, it must prove to have a very high probability for detecting explosives if they are present, and a very low risk of false alarms. Too many false alarms will make personnel handling the instrument less apt to take alarms seriously.

Throughput: The speed by which the sample is being analyzed is of importance since it determines whether the technology can be used in real-time or not.
Harmless to humans when people are involved: Some bulk detection methods based on various types of radiation are not suitable for inspection of human subjects.
Other important factors are cost, size and mobility. The importance of these factors, as well as some of the above mentioned, varies with application. Specific TSWG/NATO factor metrics are needed to more accurately assess specific technology capabilities.

Below, a few other factors are listed. These relate to some of the factors considered for each detection method mentioned:

Table 6 – Detection Methods

• The applicability defined in this study as the principal applicability of a certain method not only to detect one specific explosive, but rather the lot.
• The cost involved in utilizing the method. Within the concept of costs, also maintenance costs should be considered.
• The sample type is also of importance. If two detection methods can be considered as equally good with respect to the other criteria, the method applicable to samples of all aggregation states (solid, liquid and vapor) will stand out as superior. The sample type applicable for a detection method will also be of guidance as to the complexity of the sample work-up procedures required prior to detection.
• The skill level required of the operator handling the instrument will also influence the applicability. Most analytical systems require a quite large degree of knowledge on the principles of the methodology in order to work optimally. Also the interpretation of the signal response of the method should preferably be straightforward.
• The field ability is merely a factor discriminating certain methods from field use due to size, lack of robustness etc.
• The size of the instrument could also be an important consideration. The rapid development of Micro-Electro-Mechanical System (MEMS) technology may render it possible to miniaturize some techniques without severely compromising their performance.

Depending on the operational scenario, not all properties of a detection system may be required at the same time. Each detection system must be appropriate for the use it is intended for. Therefore, the intended scenario must be taken into account when judging performance of a particular detection method or system. An information list (LoD, speed, selectivity, applicability, cost, sample type, skill, field ability and size) can be found in the end of the description of most trace detection methods. Information to complete this list is not always available. Sometimes the source is the manufacturer of a commercial instrument and sometimes it is a scientific paper. The available information, especially concerning selectivity, applicability, skill, field ability and size has sometimes been subjectively estimated from crude knowledge about the technology needed and the information that can be extracted. This is especially true for emerging technologies where much of this information is lacking. Future technical advances may change these estimations. When no information is available or it is not even possible to estimate n/a is given.

1.7 Acknowledgements

1.7.1 Spanish Ministry of Defense

The International Institute would like to acknowledge the Spanish Ministry of Defense for all of their support and collaboration. Spanish MOD and International Institute cooperation was critical to the successful performance of the Standoff CIED Detection Conference in Madrid. Close coordination with Spain and the NATO Armaments Directorate enabled the International Institute to capture requirements for the event and execute the program of work. On-site International Institute staff assistance and daily conference calls between both organizations enabled a co-development of the CIED database and registration process. .The Basic Lines of Cooperation, under reference to TSWG letter provide the groundwork for Spain – USA cooperation on the NATO/CNAD CIED projects. Close cooperation with Spain served the NATO DAT objectives in their efforts to develop an overarching international strategy for the Defence Against Terrorism and bring the necessary industry counterparts to the conference. This interagency and international cooperation produced a real exchange of technical information between experts that can foster future efforts of collaboration and meets TSWG goals for interagency and international cooperation.

Table 7- Spanish Ministry of Defence

Name	Organization	Country
CF Emilio Fajardo Jimena	Commander Assistant Defense Counselor NADREP NATO	Spain
LTC Vicente Martinez Candela	Spanish Ministry of Defense Defense Cooperation Armaments	Spain
Gen. Jose Luis Ceballos Porras	Spanish Ministry of Defense Subdirector of International Rel. Gen. Director of Armaments	Spain
Gen. Antonio Cieza Gonzalez	Spanish Ministry of Defense Subdirector of Technology	Spain
Capt. Angel Mora Dominguez	Polytechnic Military School	Spain
Capt. Pedro Carlos Ruiz Ruiz	Spanish Ministry of Defense	Spain
Guillermo Gonzalez Munoz de Morales	Spanish Ministry of Defense SDG Technician	Spain
Roberto Arribas	Spanish Ministry of Defense Information Technician	Spain
LT Cmdr. Francisco Martinez Vazquez	Spanish Ministry of Defense Logistics Division & Resources	Spain
Diego Villanueva Cuenca	Spanish Ministry of Defense International De-mining Center	Spain
Jorge Lega de Benito	Spanish Ministry of Defense SDG Technician	Spain

1.7.2 International Capability Advisory Panel

The International Institute acknowledges members of the Capability Advisory Panel (3.2) as well as industry representatives and scientists for their contributions in the technology review and assessment process. Table 7b below provides a summary by Name, Organization and Country of these participants. Ongoing dialogue on this topic continues to provide insight and multi-national feedback on defeating CIEDs.

Table 8 - Capability Advisory Panel

Name	Organization	Country
Cedric Berthome	French Ministry of Defense	France
Christoph Thelen	Federal Office of Defense	Germany
Col. Oleksandr Burdiian	Ministry of Defense	Ukraine
Col. Reyes Arevalo Tobajas	Jefatura de Investigación y Analisis de Ingenieros	Spain
Dr. Arnold Schoolderman	TNO Defense, Security & Safety	The Netherlands
Dr. Helmut Oppenheim	Austrian Ministry of Defense	Austria
Dr. Ian Raitt	DSTL	UK
Dr. Matthew Brooks	DSTL	UK
Dr. Tim McKay	Land Operations Division	Australia
Dr. William Miceli	U.S. Office of Naval Research	USA
Francesco Colao	ENEA	Italy
LTC (Ret.) Zvi Eyal	Head of IMOD Mission to Brussels	Israel
LTC Jeremy Mansfield	National Defense Headquarters	Canada
LTC Viliam Belej	Ministry of Defense	Slovak Republic
Maj. Gen. Ret. Arik Yakuel	Trace Guard	Israel
Michael Haygarth	United Kingdom MOD, Joint EOD & Research Staff	UK
Michael Troffer	Naval EOD Technology Division	USA
Necati Subasi	MND Undersecretary for Defense Industry	Turkey
Nicholas Langhorne	U.S. Office of Naval Research	USA
Rami Katav	Israel MOD, R&D Directorate, Land System Division	Israel
Ronald Molway Jr.	Department of Homeland Security	USA
S. Thomas Tate	U.S. Army International Technology Center	USA
Sara Wallin	Swedish Defense Research Agency	Sweden
Stefano Francesconi	Italian Ministry of Defense	Italy
Anthony Carbonari	Marine Corps System Comm	USA
Michael Cline	Counter Explosives Hazard Center Division Chief	USA

1.7.3 NATO Armaments Directorate

Guidance received from the NATO Armaments Directorate proved to be instrumental in International Institute ability to coordinate within NATO elements. The International Institute worked closely with the NATO Armament's Directorate in order to better achieve US, NATO and Spanish objectives for the event. This coordination allowed for the International Institute to quickly respond to the immediate need to provide C-IED program management support to Spain. This also enabled the International Institute to capture NATO requirements including technology identification, analysis, demonstration and transition support for NATO Counter IED Capabilities.

Table 9 – Other Acknowledgements

Name	Organization	Country
Rick Froh Krassi Kouzmanov Jim Kren	Defence Investment Division Head of Joint Armaments Section Joint Armaments Section/NATO NATO Special Advisor to Assistant Sec. General Defense Investment	Canada Bulgaria United States
Francoise Perret	NATO Counter-Terrorism Unit Defence Investment Division	France
Carlos de Miguel	Programme Manager - Indra Sistememas	Spain
Gonzalo Fernandez de la Mora	SEADM – General Manager	Spain
Krister Liljegren	Environics OY – Area Manager	FInland
Lucas van Ewijk	TNO Defence Security & Safety	The Netherlands
Simon van Aartsen	TNO Defence Security & Safety	The Netherlands

2 Technologies and Products

The following table provides a list of technologies presented at the conference/demonstration as well as technologies not presented but are considered, or in use, for the detection of IEDs and other explosive materials. Those technologies listed that **were not** discussed, exhibited or presented at the conference, but recommended as disciplines of interest by participants and the International Institute staff. The primary reasons for these technologies not being presented was due to time constraints which affected vendor notification and response, as well as scheduling conflicts concerning the availability and shipment of specific products or technologies to the conference. The table below also provides a summary of the key considerations and areas of interest concerning the various Counter-IED technologies.

The manner in which the various technologies and products were presented at the conference are indicated as “Panel” (oral presentation with associated PowerPoint presentation), “Exhibit” (product or technology was displayed in the conference Exhibit Hall), or “Demonstration” (product or technology was actively demonstrated at the Spanish Military Engineers School facility).

Technology CONOPS, doctrine, Export Control issues and other acquisition issues, i.e. Intellectual Property, liability and commercialization issues are key areas to investigate. Given the timeframe associated with the conference, additional research in to these areas is necessary to provide comprehensive assessment and future planning.

Table 10 - Table of Technologies and Products

C-IED TECHNOLOGIES PRODUCT & ORGANIZATION	Technology Presented at Conference/Demo	Technology/ Presented by (Country)	Technology/ Product Availability	Estimated Technology Readiness Level
1. Laser Induced Breakdown Spectroscopy (LIBS)	YES		Prototype	-Trace Detection -Standoff Detection

C-IED TECHNOLOGIES PRODUCT & ORGANIZATION	**Technology Presented at Conference/Demo**	**Technology/ Presented by (Country)**	**Technology/ Product Availability**	**Estimated Technology Readiness Level**
INDRA	Panel, Exhibit, Demo	Spain	2nd Generation Prototype	NATO TRL 6
Clausthaler University	Panel, Exhibit, Demo	Germany	Research Prototype	NATO TRL 6
Army Research Laboratory	Panel	USA	3rd Generation Prototype	NATO TRL 6
2. Infra-Red Spectroscopy	YES			
Northrop Grumman	Panel, Exhibit, Demo	USA	Working Prototype	NATO TRL 8
3. Ion Spectrometry (IMS)/Differential Mobility Analyzer (DMA)	YES			
Ramen	Panel, Exhibit, Demo	Spain	Commercial Product	NATO TRL 9
4. Terahertz Spectroscopy	YES			
Thruvision	Panel & Demo	United Kingdom	Commercial Product	NATO TRL 9
TNO	Panel	Netherlands	Prototype	NATO TRL 6
5. Millimeter Wave Imaging	YES			
QinetiQ	Panel	United Kingdom	Prototype	NATO TRL 7
6. Polarized Light Camera	YES			
TNO	Panel	Netherlands	Prototype	NATO TRL 6
7. Electromagnetic (bottle) Analyzer	YES			

C-IED TECHNOLOGIES PRODUCT & ORGANIZATION	Technology Presented at Conference/Demo	Technology/ Presented by (Country)	Technology/ Product Availability	Estimated Technology Readiness Level
CEIA	Panel	Switzerland	Commercial Product	NATO TRL 9
8. Non-Linear Junction Detector	YES			
EMC-2	Panel	Russia	Commercial	NATO TRL 9
9. Enhanced CCTV, Intelligent Video, Persistent Surveillance Technology	YES			
London University	Panel	United Kingdom	Prototype	NATO TRL 7
Autonomy/Virage Inc.	Panel	United Kingdom	Commercial Product	NATO TRL 9
Carnegie Mellon	Panel	United States	Commercial	NATO TRL 7
ITT/Geospatial Systems Inc.	Panel, Exhibit	United States	Prototype	NATO TRL 8
General Electric	Panel	USA	Commercial	NATO TRL 7

Technologies not presented at the Demonstration/Conference.
The following technologies were not presented or generally discussed at the Counter-IED Standoff Detection Conference.

Table 11 - Counter-IED Technologies not present at the conference

Foundation	Technique
X-Ray Scatter	1. Compton Scattering 2. Coherent Scattering 3. X-Ray Fluorescence (XRF)

Neutron and γ-Based Techniques	4. Thermal Neutron Analysis 5. Associated Particle Technique 6. Pulsed Fast/ Thermal Neutron Analysis (PFTNA) 7. Neutron Backscattering
Magnetic Techniques	8. Nuclear Magnetic Resonance 9. Nuclear Quadrupole Resonance
Trace Detection Methods	10. Desorption Electrospray ionization (DESI) 11. Matrix Assisted Laser Desorption/ Ionization Mass Spectroscopy 12. Electronic “Noses”???? 13. Immunoassays or Immunosensors 14. Photoluminescence and Semi-Conducting Organic Polymers (SOP) 15. Surface Plasmon Resonance (SPR) 16. Cavity Ringdown Spectroscopy (CRDS) 17. Ion Mobility Spectrometry (IMS) 18. High Field Asymmetric Waveform Ion Mobility (FAIMS) 19.. Laser Induced-Mass Spectroscopy (LI-MS) 20. SERS 21. Electrochemistry 22. Spot Tests 23 Chemiluminescence

The following subsections (Sections 6.1 – 6.10) provide summary technical analysis and assessments of the technologies and products within specific technology groups that were discussed in detail during conference panel (Journeys) sessions, exhibited at the conference or demonstrated at the conference.

2.1 Laser Induced Breakdown Spectroscopy (LIBS)

2.1.1 Technology Description

LIBS is a type of atomic emission spectroscopy which utilizes a highly energetic laser pulse as the excitation source. LIBS can analyze any matter regardless of its physical state, be it solid, liquid or gas. Even slurries, aerosols, gels, and more can be readily investigated. Because all elements emit light when excited to sufficiently high temperatures, LIBS can detect all elements, limited only by the power of the laser as well as the sensitivity and wavelength range of the spectrograph & detector. Operationally, LIBS is very similar to arc/spark emission spectroscopy.

A typical LIBS system consists of a neodymium doped yttrium aluminum garnet (Nd:YAG) solid-state laser and a spectrometer with a wide spectral range and a high sensitivity, fast response rate, time gated detector. This is coupled to a computer which can rapidly process and interpret the acquired data. As such LIBS is one of the most experimentally simple spectroscopic analytical techniques, making it one of the cheapest to purchase and to operate.

The Nd:YAG laser generates energy in the near infrared region of the electromagnetic spectrum, with a wavelength of 1064 nm. The pulse duration is in the region of 10 ns generating a power density which can exceed 1 $GW \cdot cm^{-2}$ at the focal point. Other lasers have been used for LIBS mainly Excimer (**Exc**ited d**imer**) type generating energy in the visible and ultraviolet regions.

The spectrometer consists of either a monochromator (scanning) or a polychromator (non-scanning) and a photomultiplier or CCD detector respectively. The most common monochromator is the Czerny-Turner type whilst the most common polychromator is the Echelle type, even so the Czerny-Turner type can be (and is often) used to disperse the radiation onto CCD effectively making it a polychromator. The polychromator spectrometer is the type most commonly used in LIBS as it allows simultaneous acquisition of the entire wavelength range of interest.

The spectrometer collects electromagnetic radiation over the widest wavelength range possible, maximizing the number of emission lines detected for each particular element. Spectrometer response is typically from 1100 nm (near infrared) to 170 nm (deep ultraviolet), the approximate response range of a CCD detector. All elements have emission lines within this wavelength range. The energy resolution of the spectrometer can also affect the quality of the LIBS measurement, since high resolution systems can separate spectral emission lines in close juxtaposition, reducing interference and increasing selectivity. This feature is particularly important in specimens which have a complex matrix, containing a large number of different elements. Accompanying the spectrometer and detector is a delay generator which accurately gates the detectors response time, allowing temporal resolution of the spectrum.

LIBS operates by focusing the laser onto a small area at the surface of the specimen, when the laser is discharged it ablates a very small amount of material, in the range of nanogram to picogram which instantaneously superheats generating a plasma plume with temperatures of about 10,000-20,000 °C. At these temperatures the ablated material dissociates (breaks down) into excited ionic and atomic species. During this time the plasma emits a continuum of radiation which does not contain any useful information about the species present, but within a very small timeframe the plasma expands at supersonic velocities and cools. At this point the characteristic atomic emission lines of the elements can be observed. The delay between the emission of continuum radiation and characteristic radiation is in the order of 10 μs, this is why it is necessary to temporally gate the detector.

Because such a small amount of material is consumed during the LIBS process the technique is considered essentially non-destructive or minimally-destructive, and with an average power density of less than one watt radiated onto the specimen there is almost no specimen heating surrounding the ablation site. Due to the nature of this technique sample preparation is typically minimized to homogenization or is often unnecessary where heterogeneity is to be investigated or where a specimen is known to be sufficiently homogeneous. This reduces the possibility of contamination during chemical preparation steps. One of the major advantages of the LIBS technique is its ability to depth profile a specimen by repeatedly discharging the laser in the same position, effectively going deeper into the specimen with each shot. This can also be applied to the removal of surface contamination, where the laser is discharged a number of times prior to the analyzing shot. LIBS is also a very rapid technique giving results within seconds, making it particularly useful for high volume analyses or on-line industrial monitoring.

LIBS is an entirely optical technique, therefore it requires only optical access to the specimen. This is of major significance as fiber optics can be employed for remote analyses. And being an optical technique it is non-invasive, non-contact and can even be used as a stand-off analytical technique when coupled to appropriate telescopic apparatus. These attributes have significance for use in areas from hazardous environments to space exploration. Additionally LIBS systems can easily be coupled to an optical microscope for micro-sampling adding a new dimension of analytical flexibility.

The use of specialized optics or a mechanically positioned specimen stage can be used over the surface of the specimen allowing spatially resolved chemical analysis and the creation of 'elemental maps'. This is very significant as chemical imaging is becoming more important in all branches of science and technology.

Recent interest in LIBS has focused on the miniaturization of the components and the development of compact, low power, portable systems. This direction has been pushed along by interest from groups such as National Aeronautics and Space Adminstration (NASA), European Space Agency (ESA) as well as the military. Portable LIBS systems are more sensitive, faster and can detect a wider range of elements (particularly the light elements) than competing techniques such as portable x-ray fluorescence. LIBS does not use ionizing radiation to excite the sample, because it could be carcinogenic.

LIBS, like all other analytical techniques is not without limitations. LIBS is subject to the matrix effect which can be minimized by good specimen preparation and the use of accurate calibration standards. It is also subject to variation in the laser spark and resultant plasma which often limits reproducibility. The accuracy of LIBS measurements is typically better than 10% and precision is often better than 5%. The detection limits for LIBS vary from one element to the next depending on the specimen type and the experimental apparatus used. Even so detection limits of 1 to 30 parts per million (ppm) by mass are not uncommon, but can range from >100 ppm to <1 ppm.

Recent developments in LIBS have seen the introduction of double-pulsed laser systems. This operates by discharging the laser twice in the same position on the specimen. The pulse separation is typically in the order of a couple of hundred microseconds, and the spectral analysis is conducted after the second pulse. This process increases the sensitivity of LIBS and reduces errors caused by the differential volatility of elements (such as that of Zinc compared to Copper in brasses), it also significantly reduces the matrix effects. Double-pulsed systems are also proving useful in conducting analysis underwater, as the initial laser pulse forms a cavity bubble in which the second pulse acts on the evaporated material.

LIBS is technically very similar to a number of other laser-based analytical techniques, sharing much of the same hardware. These techniques are the vibrational spectroscopic technique of Raman spectroscopy, and the Fluorescence spectroscopic technique of Laser-Induced Fluorescence (LIF). In fact devices are now being manufactured which combine these techniques in a single instrument, allowing the atomic, molecular and structural characterization of a specimen as well as giving a deeper insight into physical properties.
LIBS can often be referred to as its alternative name—laser induced plasma spectroscopy (LIPS). Unfortunately the term LIPS has alternative meanings that are outside the field of analytical spectroscopy, therefore the term LIBS is preferred.

2.1.2 Technology Readiness

The products presented and demonstrated (only one product was demonstrated in a controlled environment) utilizing LIBS technology are rated as NATO Technology Readiness Level 5 (See **Appendix A** for NATO Technical Readiness Levels and description). Prototypes have been developed and heavily tested. So far, development and testing have been focused on basic physics and proof of concepts. It seems little analysis has been done on determining operational requirements. This technology as it currently exists would be better suited for non-hostile environments and fairly controlled situations. More research needs to be undertaken on the IED side of the equation. This technology as it stands relies on assumed stability of molecular emissions, clearly identifiable compounds.

As an IED detection tool, this technology requires much more research and under more realistic and dynamic conditions. A great deal of effort needs to go into characterizing influences that affect measured spectra, such as chemical species migration after laser plasma coalescence. Chemical/explosive signature standards need to be established taking into consideration variations due to difference in lasers (manufacturer quality control/spec differences) and other associated equipment used in the system. Since LIBS can only detect surface contaminants, it cannot resolve whether it is residue from a previous explosion. A clean IED may not be able to be detected without penetrating many layers of the outer casing. More thorough testing needs to be performed against more compounds and against a greater number of backgrounds and mediums.

The technology is sound but fielding an operational unit has many obstacles. Current performance distances are not tactically viable unless integrated into an unmanned mobile delivery vehicle. Power requirements may relegate this technology to stationary positions. Fielded units will need to be hardened, possibly restricting deployment options. Field maintainability and logistics, user training, and false alarm rates, need to be considered in future development efforts.

Tactically, an IED must be exposed in order to employ this technology. LIBS also creates a loud popping noise resulting from the breakdown and will alert anyone nearby to the presence of the interrogation. Operation of the system may be hindered by obscurants and environmental conditions.

Lastly, LIBS technology utilizes lasers that may or may not be “eye safe” and it also requires destruction of the item being analyzed, however small, and may result in health, safety, and liability issues.

2.1.3 INDRA

Figure 3 - Indra's 2nd Generation LIBS Prototype

Indra’s first generation LIBS prototype used a proprietary in house telescope to focus the laser for both abating and reading. In the second generation, LIBS has moved to a Commercial Off the Shelf system (COTS) telescope. The second generation prototype is currently capable of accurate spectroscopy with a single pulse shot at distance of up to 100 meters.

LIBS has demonstrated capabilities for multi-elemental analysis, analysis of solids, liquids, gases, aerosols and single particles. It also has capability in the analysis of conductive and non-conductive materials as well as bulk analysis, microanalysis, analysis of thin films, depth profiling, chemical imaging, tomography and teledetection. However, the exclusive competence of LIBS is the remote or standoff chemical analysis of the elemental composition of solids.

INDRA – LIBS Prototype	
Technology/Product Description, Applications (Use), and Capabilities	• Physical size and power requirements are essential hurdles for new equipment manufacturers to overcome • Minimal or no sample protection • Works in open air, at atmosphere pressure. • Simple spectra • Non destructive (or microdestructive)

	• Fast, time real analysis • Standoff detections of 100m and beyond are possible • Real time field detection of unknown, possibly hazardous materials. • Detection of landmines and discrimination of buried solid objects. • Detection and characterization of radioactive material (e.g. spent nuclear Fuel) • Detection of unexploded ordnance (UXO) on former battlefields and military ranges. • Underwater analysis (e.g. identification of mines). • Soil, water analysis of heavy metals • Standoff detection of aerosol clouds • Check point surveillance for explosive traces • Has demonstrated its capability to detect certain trace levels of high explosives at standoff distances over the bodywork of a car. • Current experimentation will increase the working range up to 50-100 m and expectations are that longer working distances may be increased. • Short/contact range applications of LIBS are also being addressed with much less constraints and requirements. This can be applied to: checkpoints as a trace detection technology (after sample collection), remote detection, e.g. robots or optical probes (remote meaning a separation, distance, from operator to sensor, but sensor close to sample), forensics. • Applicability to detection of chemical and biological agents is currently being addressed.
Technology/Product Strengths and Weaknesses	• Limits remain such as relying on the chemical contamination of the case or carrier of an IED. • LIBS cannot determine if soil contains an IED or just residue from a previous explosion. • A LIBS based system will work only when line of sight with the target sample is possible. • Pros: LIBS is the only technology that is capable of detecting and identifying explosives at standoff distances (analytical capability). Other technologies deal with shapes, electronic components or other IED characteristics. • Cons: Line of sight is a must. Presence of traces of the explosive in the external surface of the package is assumed. • Safety restrictions may reduce the operational capability of systems. • Surface ablation may not be acceptable.
Technology/Product Acquisition Issues	• No restrictions are known are foreseen.
Technology/Product Implementation Issues	• Integrating LIBS with unmanned vehicles seems plausible and would greatly increase stand-off detection. • The use of high energy focused laser represents an operational limitation that needs to be addressed. However it would still apply for certain applications or scenarios of interest. • Performance is somehow dependent on the physical context as far as the sample, e.g. better when targeting traces over compact of metallic surfaces like a car's bodywork. • Heavy rain, fog, smoke or high concentration will affect system performance. • For standoff operations the use of high energy laser systems is mandatory and therefore, the size, weight, and power requirements will be imposing. The systems will have to be vehicle borne or fixed. • Operation and training at initial stages, while LIBS systems are not

	fully developed, will become an issue of concern. • LIBS analysis requires the ablation of a microscopic but noticeable quantity of the substance under study or the substrate. This may represent an operational limitation in certain environments.
Assessment of Technology/Product Investment Potential	• No special restrictions are foreseen with integration with other systems. • There is a high potential for other standoff spectroscopies and technologies (fluorescence, absorption, Ramam,etc) to be integrated in an orthogonal-approach platform, because of commonality of equipment and data analysis. • Specially important could be an integration with video surveillance systems. • For standoff detection LIBS system, an estimation of time and costs to have field deployable units would be around 4 to 5.000.000 € (4 to 5 million euros) and around two to three years. • Fieldable prototypes could be available in one and a half years. • High power laser radiation is not eye safe and potentially dangerous, therefore imposing limitations on usage, even for an operator. • No other commercialization or availability constraints are foreseen.

2.1.4 Clausthal University of Technololgy

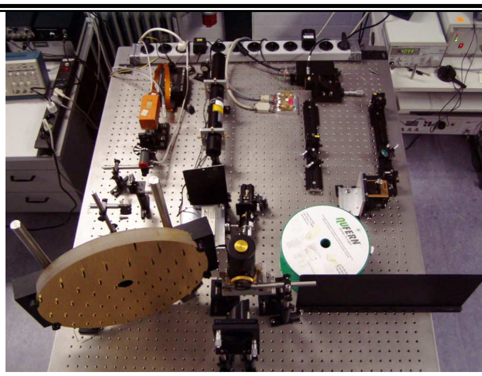


Figure 4 - Clausthal's Laser Demonstration Setup

Clausthal University of Technology's LIBS prototype features a handheld "mine prodder" attached to the LIBS unit via a fiber optic cable. The detection tip can be touched to a sample by the operator to perform spectroscopy upon a solid surface. The handheld detection probe means that this unit can be used to inspect solids which are obscured by soil or foliage. The primary application of this system would be the classification of mines and unexploded ordinances which are buried beneath the soil.

Pulsed laser fragmentation (PLF) in combination with high-resolution mid-infrared laser absorption spectroscopy offers new possibilities for sensitive and selective stand-off analysis of surface contaminations under real-time operation conditions. The detection of NO_x production rates emitted from contaminated surfaces after interaction with an infrared PLF laser beam allows analysis of different surface contaminations, e.g. distinguishing between energetic and non-energetic materials but also between molecules with similar atomic composition. For efficient laser fragmentation of surface contaminations excitation wavelengths at 1.5 μm are preferred compared to the conventional Nd:YAG laser line at 1.06 μm.

Clausthal University – LIBS with Mine Prodder	
Technology/Product Description, Applications (Use), and Capabilities	Classifying mines beneath the soil. A great deal of effort needs to go into characterizing influences that affect measured spectra. The measured spectra arise from the coalescence of the laser induced plasma. This leaves gaps in the resulting spectra. The gaps are not always the same. The influences that cause the variation are not fully characterized. In summary, the science is real, but not as well understood as proponents wish to believe. Signature standards must be established. Influences of equipment variation on measured spectra need to be characterized. Requires more research. • Standoff IED detection using LIBS technology in combination with a nonmagnetic mine prodder. • Operational modes are kneeling or upright position of the operator while carefully digging in the soil. • Prodder is lightweight and robust and the probe must directly contact objects to analyze them. • With the use of the laser drilling the IED can be analyzed internally without detonating the device. • Applicable uses include detecting: TNT, HNS, H5, PVC and PA reflecting its competencies with plastic housed explosives.
Technology/Product Strengths and Weaknesses	• Man Portable • Handheld probe allows sample beneath the soil, etc. • Weaknesses include a small sample area. Probe must be in contact with a potentially explosive object. Other weaknesses are property damage, health risk, low technical maturity. Furthermore, this technology is not capable of penetrating the casing of a possible IED. The casing must be contaminated by the maker in order for LIBS and LIPS to work. The ARL approach is better suited to standoff IED detection.

Clausthal University – LIBS with Mine Prodder	
Technology/Product Acquisition Issues	• None of note. This is just a repackaging/missionization of the underlying LIBS technology.
Technology/Product Implementation Issues	• The significant potential for property damage prohibits use anywhere but a war zone. Power requirements also limit mobility. • Challenges include remote/automatic operation, communicating results and/or alarms, power supplies and safety. • Can be used in airport or voting establishment security, also possibly humanitarian de-mining. • Deployment would require that it would need to be hardened; size may also be an issue. Possible power drainage issues could ensue when integrated with other technologies currently being used.
Assessment of Technology/Product Investment Potential	Has little value in the Counter-IED explosive arena. More useful in de-mining situations. Rough estimate for time and cost for further development would be 25 to 50 million $ and 10 years. At this time it appears as there has been no operational analysis of performance to determine operational requirements. • Prototype of product is operable and the timeline on project completion is less than one year.

2.1.5 US Army Research Laboratory

 **Figure 5 - ARL's 3rd Generation LIBS Prototype**	ARL's 3rd Generation LIBS prototype is a new paradigm that uses broadband, high resolution, single-shot spectral capture with analysis using advanced chemometrics. This has transformed LIBS from the traditional "elemental detector" to a powerful new tool that determines the relative stoichiometry of the target material. Key to success has been the use of the double- pulse technique as well as significant advances in chemometric data analysis. Current work includes construct ruggedized and automated 100 meter ST-LIBS system for testing in theater. To be operated by warfighters. Also working to explore enhancement techniques such as different wavelengths, microwave enhancement and combining LIBS with orthogonal technologies.

Army Research Labs – ST-LIBS	
Technology/Product Description, Applications (Use), and Capabilities	• ST-LIBS sensors with appropriate enhancement techniques are projected to be capable of detection of hazardous reside materials up to 400 meter standoff distances. • Can be used for material analysis at a distance.
Technology/Product Strengths and Weaknesses	• Weakness: Relies on contamination to the case or carrier. Cannot determine the results from previous explosion.
Technology/Product Acquisition Issues	• The main issue is to find the right application for this capability. Theatre operational trials are required.
Technology/Product Implementation Issues	• Integration with unmanned vehicles is plausible. Physical size and power requirements are serious hurdles. Issues that it may face in deployment include: how will it cope with a lack of line or sight with obscurants. There is a need for TTP changes, i.e., search method and speed. False alarms will also be a problem due to contamination. Soldiers may find it difficult to trust this system. Maintenance will be problematic. • ARL is currently working to expand the standoff distance beyond 100 meters and study a larger number of car panels/substrates and interferents.
Assessment of Technology/Product Investment Potential	• The current state of this technology is very mature. This product takes the existing technology and "missionizes" it for the purpose of detection of land mines and shallow-buried explosive devices. Other technologies such as Non-Linear Junction Detection (NLJD) provide some stand-off detection protection since it doesn't require direct contact with a device. This product is better suited for identifying IEDs that do not utilize microprocessors, semiconductors, diodes, etc. It may be more safe and cost effective to assume that any possible IED that has been detected by other means (metal detectors, NLJD) is an explosive and to destroy it versus taking the risk, time and expense for positive identification.

2.2 Infra-Red Spectroscopy

2.2.1 Technology Description

Infrared spectroscopy (IR Spectroscopy) is the subset of spectroscopy that deals with the Infrared part of the electromagnetic spectrum. This covers a range of techniques, with the most common type by far being a form of absorption spectroscopy. As with all spectroscopic techniques, it can be used to identify a compound and to investigate the composition of a sample. The interpretation of infrared spectra involves the correlation of absorption bands in the spectrum of an unknown compound with the known absorption frequencies for types of bonds.

The infrared portion of the electromagnetic spectrum is divided into three regions; the near-, mid- and far- infrared, named for their relation to the visible spectrum. The far-infrared, (approx. 400-10 cm-1) lying adjacent to the microwave region, has low energy and may be used for rotational spectroscopy. The mid- infrared (approx. 4000-400 cm-1) may be used to study the fundamental vibrations and associated rotational-vibrational structure, whilst the higher energy near-IR (14000-4000 cm-1) can excite overtone or harmonic vibrations.

Infrared spectroscopy works because chemical bonds have specific frequencies at which they vibrate corresponding to energy levels. The resonant frequencies or vibrational frequencies are determined by the shape of the molecular potential energy surfaces, the masses of the atoms and, eventually by the associated vibronic coupling. In order for a vibrational mode in a molecule to be IR active, it must be associated with changes in the permanent dipole. In particular, in the Born-Oppenheimer and harmonic approximations, i.e. when the molecular Hamiltonian corresponding to the electronic ground state can be approximated by a harmonic oscillator in the neighborhood of the equilibrium molecular geometry, the resonant frequencies are determined by the normal modes corresponding to the molecular electronic ground state potential energy surface. Nevertheless, the resonant frequencies can be in a first approach related to the strength of the bond, and the mass of the atoms at either end of it. Thus, the frequency of the vibrations can be associated with a particular bond type.

In order to measure a sample, a beam of infrared light is passed through the sample, and the amount of energy absorbed at each wavelength is recorded. This may be done by scanning through the spectrum with a monochromatic beam, which changes in wavelength over time, or by using a Fourier transform instrument to measure all wavelengths at once. From this, a transmittance or absorbance spectrum may be plotted, which shows at which wavelengths the sample absorbs the IR, and allows an interpretation of which bonds are present.This technique works almost exclusively on covalent bonds, and as such is of most use in organic chemistry. Clear spectra are obtained from samples with few IR active bonds and high levels of purity. More complex molecular structures lead to more absorption bands and more complex spectra. The technique has been used for the characterization of very complex mixtures.

Gaseous samples require little preparation beyond purification, but a sample cell with a long pathlength (typically 5-10 cm) is used as gases show relatively weak absorbances.

Liquid samples can be sandwiched between two plates of a high purity salt (commonly sodium chloride, or common salt, although a number of other salts such as potassium bromide or calcium fluoride are also used). The plates are transparent to the infrared light and will not introduce any lines onto the spectra. Some salt plates are highly soluble in water, and so the sample, washing reagents and the like must be anhydrous (without water).

Solid samples can be prepared in two major ways. The first is to crush the sample with a mulling agent (usually nujol) in a marble or agate mortar, with a pestle. A thin film of the mull is applied onto salt plates and measured.

The second method is to grind a quantity of the sample with a specially purified salt (usually potassium bromide) finely (to remove scattering effects from large crystals). This powder mixture is then crushed in a mechanical die press to form a translucent pellet through which the beam of the spectrometer can pass.

It is important to note that spectra obtained from different sample preparation methods will look slightly different from each other due to the different physical states the sample is in.

Typical apparatus
A beam of infra-red light is produced and split into two separate beams. One is passed through the sample, the other passed through a reference which is often the substance the sample is dissolved in. The beams are both reflected back towards a detector, however first they pass through a splitter which quickly alternates which of the two beams enters the detector. The two signals are then compared and a printout is obtained. A reference is used for two reasons: It prevents fluctuations in the output of the source affecting the data, and allows the effects of the solvent to be cancelled out (the reference is usually a pure form of the solvent the sample is in).

With increasing technology in computer filtering and manipulation of the results, samples in solution can now be measured accurately (water produces a broad absorbance across the range of interest, and thus renders the spectra unreadable without this computer treatment). Some machines will also automatically tell you what substance is being measured from a store of thousands of reference spectra held in storage.

By measuring at a specific frequency over time, changes in the character or quantity of a particular bond can be measured. This is especially useful in measuring the degree of polymerization in polymer manufacture. Modern research machines can take infrared measurements across the whole range of interest as frequently as 32 times a second. This can be done whilst simultaneous measurements are made using other techniques. This makes the observations of chemical reactions and processes quicker and more accurate.

Fourier transform Infrared spectroscopy
Fourier transform infrared (FTIR) spectroscopy is a measurement technique for collecting infrared spectra. Instead of recording the amount of energy absorbed when the frequency of the infra-red light is varied (monochromator), the IR light is guided through an interferometer. After passing the sample the measured signal is the interferogram. Performing a mathematical Fourier Transform on this signal results in a spectrum identical to that from conventional (dispersive) infrared spectroscopy.

FTIR spectrometers are cheaper than conventional spectrometers because building of interferometers is easier than the fabrication of a monochromator. In addition, measurement of a single spectrum is faster for the FTIR technique because the information at all frequencies is collected simultaneously. This allows multiple samples to be collected and averaged together resulting in an improvement in sensitivity. Because of its various advantages, virtually all modern infrared spectrometers are FTIR instruments.

Two-dimensional infrared spectroscopy
Two-dimensional infrared (2DIR) spectroscopy is the infrared version of correlation spectroscopy. It utilizes ultra short infrared laser pulses with typical pulse lengths of 100 fs. It allows the observation of coupling between different vibrational modes. Because of its extremely high time resolution it can be used to follow changes in molecular configurations taking place on a picosecond timescale. It was used employed in 1998 in the lab of Robin Hochstrasser at the University of Pennsylvania on protein structures. It is still a largely unexplored technique for fundamental research. [i]

2.2.2 Technology Readiness

The products presented and demonstrated (only one product was demonstrated in a controlled environment) utilizing Infra-Red Spectroscopy technology are rated as NATO Technology Readiness Level 9 . Improvements in trace detection technology are appropriate and inevitable. Sample collections will always be a weakness of this approach.

2.2.3 Northrop Grumman

Figure 6 - Northrop Grumman's MCAD Detection Head

Northrop Grumman's MCAD system can be used to detect the presence of airborne chemicals and particles from a distance. By combining several MCAD systems, forces can monitor an entire city area for explosions and deadly gasses. Can be used in explosive ordnance disposal, anti-terrorism efforts, law enforcement and with improvised explosive devices.

Northrop Grumman – MCAD	
Technology/Product Description, Applications (Use), and Capabilities	Low vapor/explosives detection is a needed tool in the current fight against chemical threats. • Uses naturally occurring IR light to detect chemicals. • CW Agents and TICs have unique spectral "fingerprints" in the 7-14μm region of the IR. • MCAD monitors the air for those unique spectral features. • Provides standoff identification and location of CW "clouds" out to 5 km.
Technology/Product Strengths and Weaknesses	• **Weakness**: Explosives present a much smaller vapor signature than chemical agents, this may limit future success. Available vapor plume off of explosives is miniscule compared to the threat for which the device was designed. • **Strengths**: Standoff detection, no ionizing radiation, no damaging emission.
Technology/Product Acquisition Issues	• No specific acquisition issues to be considered at this time.
Technology/Product Implementation Issues	• Integration concerns should be minimal and many current systems/platforms exist and are fielded such as unmanned ground vehicles. Current platforms should be utilized vs a new mobile platform due to associated costs and limited man-power to operate a "stand alone" additional platform. Broad applicability if it works in a real environment
Assessment of Technology/Product Investment Potential	• Further development costs should be minimal, Integration should be fairly quick if utilizing existing platforms. Sustainment, initial train-up, maintenance team and repair turn-around time are all cost areas that will need to be looked at. Costs for investment should be minimal. If near term testing indicates that the approach is not suitable for explosive detection, there is little that could be done to make it better. If it works, development will follow.

2.3 Differential Ion Mobility Spectrometry (IMS)/Differential Mobility Analyzer (DMA)

2.3.1 Technology Description

Ion mobility spectrometry (IMS) is an analytical science field that is used widely for detecting dangerous substances and is currently the primary technology being used by the Transportation Safety Administration (TSA) for passenger and luggage/cargo explosives screening.

An ion mobility spectrometer is a device capable of detecting and identifying very low concentrations of chemicals based upon the differential migration of gas phase ions (electrically charged particles) through a homogeneous electric field. Different chemical substances, when converted to ions, display different velocities in an electrical field, so IMS devices can be designed to detect and identify specific toxic chemicals, traces of explosives or other targets. In its simplest form an IMS system measures how fast a given ion moves in a uniform electric field gradient through a given atmosphere. The IMS analyzer separates and detects ions that have been sorted according to how fast they travel through an electrical field in a tube. Small ions travel very fast, and they reach the detector first, with successively larger ions following along behind. More advanced ion mobility instruments are coupled with mass spectrometers where both size and mass information may be obtained simultaneously.[ii]

A typical ion mobility spectrometer comprises an ion molecule reaction chamber, an ionization source associated with the ion reaction chamber, an ion drift chamber, an ion/molecule injection shutter (Bradbury-Nielsen-Shutter) placed between the ion reaction chamber and the ion drift chamber, and an ion collector (Faraday plate). A carrier gas, normally air or nitrogen, transports the subject gases or vapors into the ion mobility spectrometer. [iii]

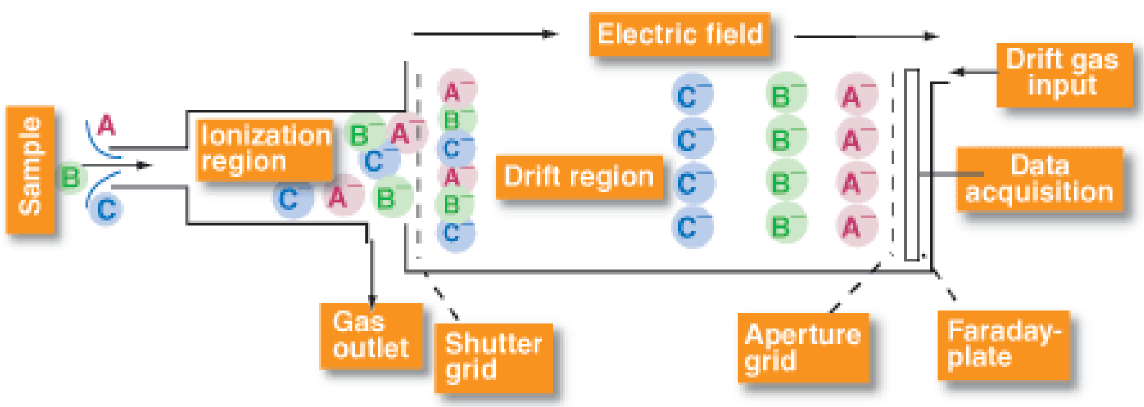


Figure 7 - Basic ion mobility spectrometer diagram

The molecules of a sample need to be ionized, usually by corona discharge, atmospheric pressure photo ionization (APPI), electro spray ionization (ESI), or a radioactive source (e.g., a small piece of ^{63}Ni or ^{241}Am), similar to those used in ionization smoke detectors. Inside the instrument, a radioactive substance is housed in a small chamber that is shielded from the outside, but accessible to the inside of the instrument. This radioactive source constantly gives off high-energy electrons, which collide with the sample molecules and the carrier gas to form ions.

The ionized gas moves through an electrical field inside a drift tube. Smaller ions collide less frequently than large ions because they present a smaller target and are harder to hit. Thus, they move through the tube relatively unimpeded and reach the detector first. The largest ions take several seconds longer to travel to the detector because they collide more frequently with other ions along the way.

The traditional instrument for sizing aerosol particles is the Differential Mobility Analyzer (DMA). A simplistic description of the DMA is that the instrument is just two charged concentric cylinders with an inlet slit and a sampling slit. The DMA separates particles based on their electrical mobility. Aerosol particles for sizing are inserted into the annular region between the two cylinders at the inlet slit. They are carried by clean air flowing through the annular region. Particles with mobility in a certain narrow range are sampled at the sampling slit. Then, an inversion calculation is done to infer the size distribution. [iv]

IMS devices come in a wide range of sizes (often tailored for a specific application) and are capable of operating under a broad range of conditions. Systems operated at higher pressure (i.e. atmospheric conditions, 1 atm or 760 Torr) are also accompanied by elevated temperature (above 100° C), while lower pressure systems (1-20 Torr) do not require heating. Elevated temperature assists in removing ion clusters that may distort experimental measurements. Unlike the mass spectrometry technique, which relies on very low pressures to keep the ions from colliding with each other, IMS operates at normal atmospheric pressure, and the ions collide with each other over and over again.

Perhaps ion mobility spectrometry's greatest strength is the speed at which separations occur--typically on the order of 10s of milliseconds (and that it can be performed in ambient pressure.) This feature combined with its ease of use, relatively high sensitivity, and highly compact design have allowed IMS as a commercial product to be used as a routine tool for the field detection of explosives, drugs, and chemical weapons.

Although, because IMS only sorts molecules by size, and not by chemical properties or other identifying features, it is not a particularly good technique for making positive identification of unknown compounds. However, IMS can make a measurement in only a few seconds, as compared with several minutes to over an hour for more conventional techniques such as chromatography and mass spectrometry.

2.3.2 Technology Readiness

The products presented and demonstrated (only one product was demonstrated in a controlled environment) utilizing Infra-Red Spectroscopy technology are rated as NATO Technology Readiness Level 8.

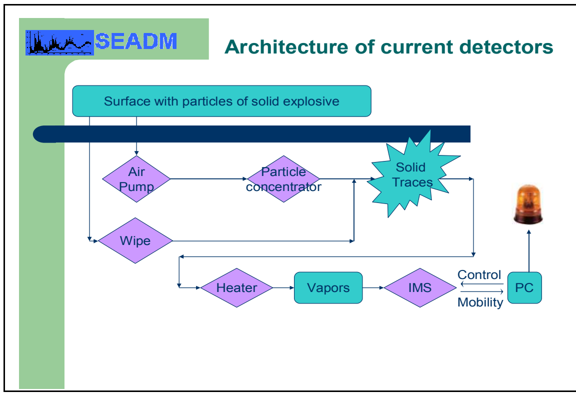
There are many products currently in operational use that are derived from IMS technology. The TSA currently has around 700 ion mobility spectroscopy (IMS) systems operating in U.S. airports as part of a spectrum of trace detection technologies the government is studying. Others include Raman spectroscopy, unwieldy mass spectrometry (MS), and MS on a chip. IMS leads the homeland security charge.

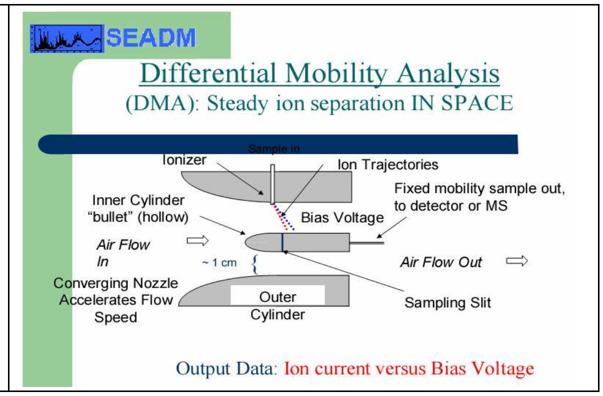
The TSA deployed IONSCAN, an IMS-based trace explosives detector from Barringer Instruments (www.barringer.com), at Salt Lake City Airport for the 2002 Winter Olympics. It installed 80 systems at the ticket check-in counters to screen checked baggage. The technology demonstrated its effectiveness in screening baggage for explosive devices while maintaining high passenger throughput rates. Analysis time is 6-8 seconds. The device detects RDX, PETN (the active ingredients in the plastic explosive Semtex), TNT, and other explosives at picogram levels.

It also detects cocaine, heroin, cannabis, LSD, and other illegal chemicals at the subnanogram level.

Some companies have combined or integrated technologies/capabilities, such as IMS and a mass spectrometer, that provide near-simultaneous additional data for making classification or flexibility. Others have designs that offer flexible options such as the method of ionization.

2.3.3 SEADM





SEADM's research and development proposal seeks to incorporate the combination of Differential Mobility Analyzer with a resolution of between 50-100 with a time-of-flight Mass Spectrometer with a resolution of between 3,000 and 10,000 resulting in a combined resolving power of between 10^5 and 10^6 in a relatively light and affordable tandem system. The goal is to create a light weight, low cost, robust DMA-MS instrument that detects explosives with a high sensitivity without false positives.

The technology is partly owned by Yale University which has licensed it to SEADM (Spain). SEADM's R&D staff consists of 5 engineers who are based out of testing facility of $250m^2$ located in Boecillo, Spain.

SEADM – AROMA DMA w/ Mass Spectrometer	
Technology/Product Description, Applications (Use), and Capabilities	• Explosives detection and identification, contraband particle detection • Tandem use of mobility separation at atmospheric pressure (DMA) with API mass spectrometry (MS) • Mobility alone can distinguish less than 40 species within mobility range of most volatile species. Many more present at ppt, hence false alarms unavoidable. • MOBILITY – MS can resolve 10-50 times more species than MS alone • and strengthen vapor recognition algorithms (two-dimensional separation). • Program will develop a new prototype with a target factor of sensitivity increase better than 100. • In defense of homeland security environments. Can also be used for civil purposes, such as explosive detection in airports, ports, buildings, metro stations, etc.
Technology/Product Strengths and Weaknesses	• Close contact required • Detects particles, not vapors • Liquids are difficult to detect • Too many possible candidate peaks at each resolvable motility (High False Alarm Rates) • Cannot detect complete explosives list, much less the ever growing list of IEDs • Of no use to route clearance teams. Limited to suicide bombers and "suit case" type bombs. Possible use at election/voting facilities for

	base security. • Limitations: Detects solid particles not vapors, close contact required, liquids are difficult to detect. • Other limitations include: limited resolution, too many possible • candidate peaks at each resolvable mobility (high false alarm rate). • Cannot detect the complex explosive list, much less an ever growing number of IEDs. • Need to increase drastically both sensitivity and resolution. • The proposed technology is based on detection of ambient explosive vapours. Therefore, a completely isolated container will prevent detection. However, this “complete isolation” is difficult to achieve, and the technology offers detection capabilities unmatched by other technology, at least in the level of canine olfaction.
Technology/Product Acquisition Issues	• No export restrictions to NATO countries are applicable.
Technology/Product Implementation Issues	• Unit feasibility is a main issue in implementation considerations. • The interoperation will be very easy, since new technology already incorporates interface standards. • Constraints of new technology will be related to the fact that initially it will be based in laboratory equipment, with limitations in transportability, ruggedness and maintainability.
Assessment of Technology/Product Investment Potential	• Technology is well understood and many companies and research institutes are actively working to improve the technology and to develop products and tools. • Appears to provide a low-cost and quality performance capability to increase IED detection while reducing the potential cost of installing a much more expensive and heavyweight Ion Cyclotron Resonance system. • In R&D phase, commercial equipment scheduled for 2009. • ROM: $5 million and 2 years. • The only limitation is the financial capability of the company, which needs further resources for technology development. • The DMA-MS technology would appear to contribute to improved explosive detection capabilities both in the commercial and military arena when fully developed.

2.3.4 RAMEM

Figure 8 - Ramem's IONER Product Line

Formed 1958 in Madrid, Spain. Current product is a nanoparticle detector for aerosols. The device consists of an operation module (a cylinder with a sharp tie electrode coaxial with an earthed outlet metallic cone), and a control module (HV adjustment and display of relevant operation information).

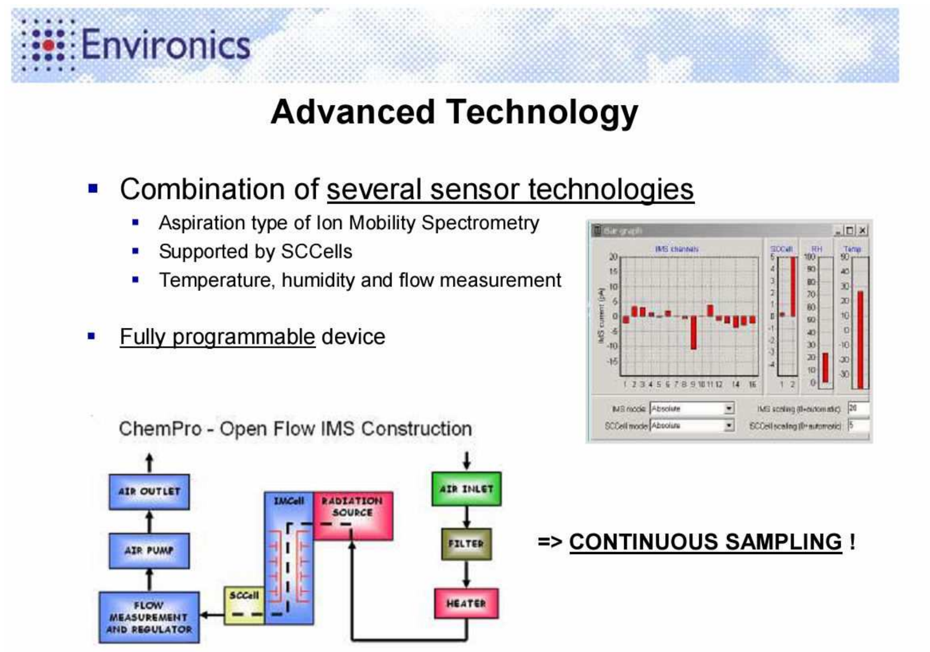
RAMEN – SNIFFER 10^{X}	
Technology/Product Description, Applications (Use), and Capabilities	• Explosives detection • Possible integration with unmanned vehicles and technology. • All vapor type detectors need to be close to the target in order to negate wind issues and other natural interference. Unless it is integrated with an unmanned system, seriously reduces stand-off. • DMA is a type of IMS system with slightly higher performance. • Sensitivity of the instrument is a concern. However, if particles can be evaporated into a small enough volume, this concentration may be achievable. • High use of computer simulation and intensive use of automation for minimal man interaction. • Carefully aerodynamically designed.
Technology/Product Strengths and Weaknesses	• Multiple (selectable) ionization methods • High throughput (air volume processed) • Close contact required • Cannot detect complete explosives list, much less the ever growing list of IEDs • Selectivity is a major strength • Flexibility in the ionization method selection • Possibility of: electrospray (primary & secondary method), corona charger, chemical ionization and mixing chamber for ionization • Software is easy to update when new explosive appears, also has pattern recognition
Technology/Product Acquisition Issues	• No specific export control issues identified.
Technology/Product Implementation Issues	• Potential lack of stand-off capability.
Assessment of Technology/Product Investment Potential	• Technology is well understood and many companies and research institutes are actively working to improve the technology and to develop products and tools • Working to increase the resolving power (more than 500) • Patent application has been filed

2.3.5 Environics OY

 **Figure 9 - The ChemPro 100 handheld chemical detector**	Environics OY's ChemPro 100 handheld chemical detector detects peroxide-based explosives. One of the most popular groups of explosives used in Improvised explosive devices IEDs is peroxide-based explosives, like Triacetone Triperoxide (TATP). Peroxide-based explosives and their precursors have typically reasonable vapor pressures for detection. Their ingredients are typically sufficient volatile and thus provide promising base for application specific library to ChemPro100. Many present explosive detection systems and sniffer dogs lack of the performance to detect and identify peroxide-based explosives. Handheld chemical detector initially developed for detecting CWA and TIC vapors and gases. Combination of several sensor technologies: aspiration type of Ion Mobility Spectrometry, supported by SCCells, temperature, humidity and flow measurement.

Environics OY – ChemPro 100	
Technology/Product Description, Applications (Use), and Capabilities	• Peroxide-based explosives detection • Not feasible for route clearance teams and roadside IEDs • Used primarily for suicide bombers using explosives such as triacetone triperoxide (TATP) • Works for peroxide based explosives • Useful for chemical, biological and radiation detection • Cempro 100 is an improved version of a system already in use by NATO. • Multi-sensor technology with advanced fuzzy logic algorithm for pattern recognition • Sample large amounts of air • Very sensitive detector • Fast responses to detected substances • Fully programmable device • Full scale operation temperature: -30 • Can be used for: military forces, UN forces, civil defence forces, security organizations, police force & customs/airports, fire brigades, industry, etc. • Designed for operation in heavy protective suit • Multi-function CBRN device • Applications: Chemical, biological and radiation detection • Upgradeable to allow for the attachment of a radiation detector module for Gamma and X-ray radiation detection.
Technology/Product Strengths and Weaknesses	• Handheld. Easily transported/deployed • Little training required to successfully employ • Limited explosives list (peroxide-based only) • Detects explosive but no identification of particular substance • Close contact required • Cannot detect complete explosives list, much less the ever growing list of IEDs • Sample large amounts of air. • Very sensitive detector. • Fast responses to detected substances. • Fully programmable device. • Provides accurate gas cloud/contaminated area screening. • Rugged design meets military standards for electromagnetic and environmental conditions • Provides accurate gas cloud/contaminated area screening.
Environics OY – ChemPro 100 (Cont.)	
Technology/Product Acquisition Issues	• None
Technology/Product Implementation Issues	• The technology is small and fills many warfighter requirements • Excellent potential uses.
Assessment of Technology/Product Investment Potential	• Technology is well understood and many companies and research institutes are actively working to improve the technology and to develop products and tools. • Further development costs should be minimal. • Integration should be fairly quick if utilizing existing platforms. • Sustainment, initial train-up, maintenance team and repair turn-around time are all cost areas that will need to be looked at. • Need to decrease false alarms.

	• Cost effective and rugged, Capable of detecting a number of hazardous materials including the precursors to IEDs as well as other • CWAs and TICs/TIMs.



2.4 TeraHertz Spectroscopy

2.4.1 Technology Description

Electromagnetic waves sent at terahertz frequencies, known as terahertz radiation, terahertz waves, T-rays, T-light, T-lux and THz, are in the region of the electromagnetic spectrum between 300 gigahertz and 3 terahertz, corresponding to the wavelength range starting at sub-millimeter (<1 millimeter) and 100 micrometres (ending edge of far-infrared light).

Like infrared radiation or microwaves, terahertz waves usually travel in line of sight. Terahertz radiation is non-ionizing and shares with microwaves the capability to penetrate a wide variety of non-conducting materials. They can pass through clothing, paper, cardboard, wood, masonry, plastic and ceramics. They can also penetrate fog and clouds but cannot penetrate metal or water.

The Earth's atmosphere is a strong absorber of terahertz radiation, so the range of terahertz radiation is quite short, limiting its usefulness. In addition, producing and detecting coherent terahertz radiation was technically challenging until the 1990s.

Sources
While terahertz radiation is emitted as part of the black body radiation from anything with temperatures greater than about 10 kelvin, this thermal emission is very weak. As of 2004 the

only effective stronger sources of terahertz radiation are the gyrotron, the backward wave oscillator ("BWO"), the far infrared laser ("FIR laser"), quantum cascade laser, the free electron laser (FEL), synchrotron light sources, and single-cycle sources used in Terahertz time domain spectroscopy.

There have also been solid-state sources of millimeter and sub-millimeter waves for many years. AB Millimeter in Paris, for instance, produces a system that covers the entire range from 8 GHz to 1000 GHz with solid state sources and detectors. Nowadays, most time-domain work is done via ultrafast lasers. .

Theoretical and technological uses under development
Medical imaging:
Terahertz radiation is non-ionizing, and thus is not expected to damage DNA, unlike X-rays. Some frequencies of terahertz radiation can penetrate several centimeters of tissue and reflect back. Terahertz radiation can also detect differences in water content and density of a tissue. Terahertz imaging could allow effective detection of epithelial cancer and replace the mammogram with a safer and less invasive or painful imaging system.

Some frequencies of terahertz radiation can be used for 3D imaging of teeth and could be more accurate and safer than conventional X-ray imaging in dentistry.

Because of terahertz radiation's ability to penetrate fabrics and plastics it can be used in surveillance, such as security screening, to uncover concealed weapons on a person, remotely. This is of particular interest because many materials of interest, such as plastic explosives, exhibit unique spectral fingerprints in the terahertz range. This offers the possibility of combining spectral identification with imaging. Some controversy surrounds the use of terahertz scanners for routine security checks due to the potential capability to produce detailed images of a subject's body through clothing.

Spectroscopy in terahertz radiation could provide novel information in chemistry and biochemistry. The recently developed techniques of THz time-domain spectroscopy (THz TDS) and THz tomography have been shown to be capable of performing measurements on, and obtaining images of, samples which are opaque in the visible and near-infrared regions of the spectrum. The utility of THz-TDS is limited when the sample is very thin, or has a low absorbance, since it is very difficult to distinguish changes in the THz pulse caused by the sample from those caused by long term fluctuations in the driving laser source or experiment. On the other hand, the fact that THz-TDS produces radiation that is both coherent and broadband means that such images can contain far more information than a conventional image formed with a single-frequency source.

There are potential applications to satellite telecommunications, and high-altitude communications (aircraft to satellite or satellite to satellite). Many possible applications of terahertz imaging have been proposed in manufacturing, quality control, and process monitoring. These generally exploit the fact that plastics and cardboard are transparent to terahertz radiation, so that it is possible to inspect packaged objects.

One of the main applications of sub-millimeter waves in physics is the study of condensed matter in high magnetic fields since at high fields (say above 15 T), the Larmor frequencies are in the sub-millimeter band. This work is carried out at many high-magnetic field laboratories around the world. Another important application is in millimeter/submillimeter wave astronomy

Terahertz versus millimeter and submillimeter waves
One terahertz is 1012 Hz. Conventionally the microwave band extends to 30 GHz or so. While the far-IR is nominally reckoned to start at around 1 THz. So the terahertz band lies between micowaves and the far-IR. On the other hand, in this frequency range the wavelengths of

electromagnetic waves (in vacuum) are millimeter or sub-millimeter. So, logically, terahertz waves are the same thing as millimeter or subm-illimeter waves. However, in practice people who use the term terahertz are generally speaking of signals generated by ultrafast optical techniques or far-IR lasers. Focusing a sub-picosecond pulse on a photoconductive antenna of suitable dimensions will produce EM waves in the THz band. On the other hand, people who use the term millimeter or sub-millimeter waves are invariably speaking of sources and detectors based on harmonic multiplication of microwave signals.

2.4.2 Technology Readiness

The products presented and demonstrated (only one product was demonstrated in a controlled environment) utilizing Infra-Red Spectroscopy technology are rated as NATO Technology Readiness Level 7.

The first images generated using terahertz radiation date from the 1960's; however, in 1995, images generated using terahertz time-domain spectroscopy generated a great deal of interest, and sparked a rapid growth in the field of terahertz science and technology.

The Terahertz Photonics and Electronics research group at the Institute of Microwaves and Photonics at the University of Leeds in the United Kingdom is one of the main centers of research into uses of Terahertz radiation.

2.4.3 TNO Defense, Security & Safety

 Figure 10 - TNO's Terahertz Scanning Prototype	TNO has developed an imager capable of detecting objects hidden under clothing. Millimeter wave passive imaging is utilized in this process.

TNO	
Technology/Product Description, Applications (Use), and Capabilities	• Civil applications of mm-wave cameras include controlled access of mass gatherings, public safety and security, airport security, luggage search, left behind bags and suitcases. • Military applications of mm-wave cameras include compound security, mass control during patrols, non escalating search for guns and explosives, security own personnel, adverse weather observation. • Non contact measurement, currently with cooperation of the searched people. Prediction of carried weapons and possibly explosives. The latter by anomaly detection; there is no explosive substance detection possible. • Operating range: 2m

	• Current system is a single channel receiver. The new system will be a 4-channel receiver. • Faster acquisition times can be obtained by more channels (focal plane arrays) or more sensitive receivers. • More channels can be accommodated without excessive cost by changing to another frequency.
Technology/Product Strengths and Weaknesses	• Environmental constraints currently indoor application, temperature between -5°C and 40°C. • Less need for images, thanks to automated detection. • Acceptable stand off distances.
Technology/Product Acquisition Issues	• Not ready for acquisition.
Technology/Product Implementation Issues	• None of note.
Assessment of Technology/Product Investment Potential	• CWD by mm-wave imaging is viable and supplementary to other systems.

2.4.4 Thruvision, Ltd.

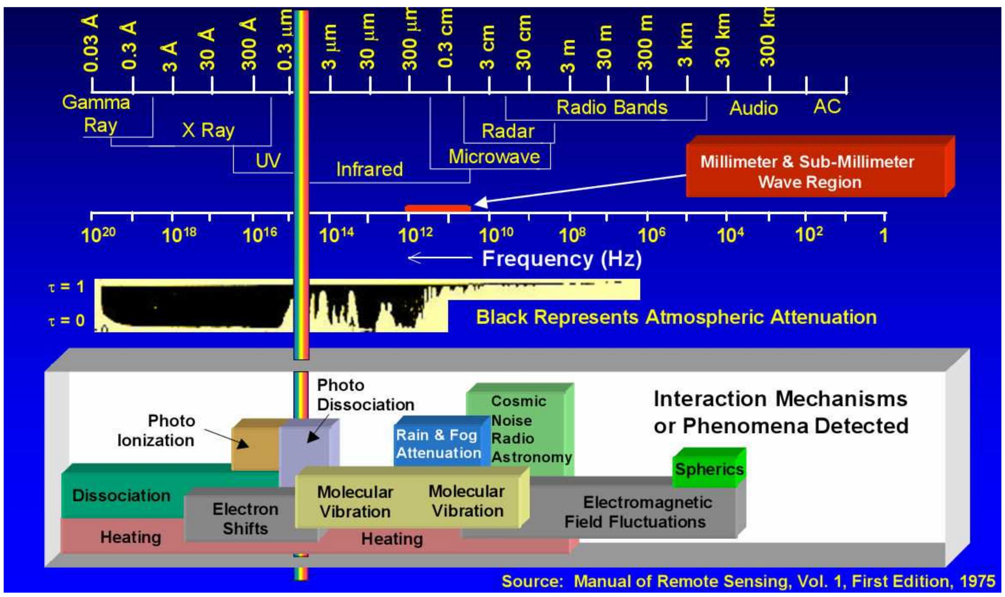
 **Figure 11 - ThruVision's T400 Terahertz Security Scanner**	ThruVision’s new passive imaging products reveal concealed objects on personnel. Users and applications include custom agencies (imaging concealed contraband, narcotics, etc.), building and asset protection (entry screening of personnel for concealed threat objects), police (imaging of concealed threat objects, both metal and non-metal concealed threat and contraband objects including ceramics, plastics, liquids, etc.). ThruVision technology is entirely passive. The subject is not illuminated with any form of radiation such as X-ray. Images are formed using terahertz waves naturally produced by all objects and people. Benefits include screening without introducing ‘bottlenecks, passivity (the subject is not illuminated with any form of radiation), its non invasive elements (anatomical details of the subject are not revealed), all concealed objects are imaged and its installation flexibility.

Thruvision, Ltd. – T400 TeraHertz Security Scanner	
Technology/Product Description, Applications (Use), and Capabilities	• Possible use at checkpoints and FOB Security Gates if this technology could be used outdoors in a harsh environment. • Currently there is no other technology available for integration as far as a use for checkpoints and outdoor security gates. • Standoff weapon and IED detection as well as secure entry screening.
Technology/Product Strengths and Weaknesses	• Anatomical data not shown would eliminate any cultural difficulties. • Concealed objects are imaged passively with no ionizing radiation.

	• Compact and portable: made for both indoor and outdoor environments. • Non-invasive: displays concealed objects without revealing anatomical detail. • High contrast: imaging done with high contrast through clothing combinations • Rapid screening: sub-second imaging times. Rugged technology: core technology has been tested in various environments to prove its application in rugged and demanding operations scenarios.
Technology/Product Acquisition Issues	• No acquisition issues with UK.
Technology/Product Implementation Issues	• None of note.
Assessment of Technology/Product Investment Potential	• Has demonstrated a non-invasive analytical imaging capability to detect IED components and materials. • Product appears to have a rapid processing/identification capability. • Terahertz image data would appear to be conducive to the development of a more comprehensive C-IED solutions when integrated with other C-IED technologies. • The products appears to be readily portable and ruggedized for use in difficult operating environments. • Also provides non-IED detection capabilities, potentially reducing costs. • Government organizations responsible for Homeland Security programs have an on-going interest in non-intrusive and non-destructive detection of IEDs. • Provides a competing solution to other terahertz based imaging products.

2.5 Millimeter Wave Imaging

Innovations from the 1975 millimeter framework provide modern day warfighter capability.



2.5.1 Technology Description

All natural objects whose temperatures are above absolute zero emit passive millimeter-wave radiation. The amount of radiation emitted in the millimeter-wave range is 10^8 times smaller than the amount emitted in the infrared range. However, current millimeter-wave receivers have at least 10^5 times better noise performance than infrared detectors and the temperature contrast recovers the remaining 10^3. This makes millimeter-wave imaging comparable in performance with current infrared systems.

The wavelength of millimeter-waves are long enough to pass through materials with minimal attenuation and to avoid scattering in many obscurants, such as smoke and fog, but are short enough to obtain images of usable resolution with apertures of a practical size. Due to this lower attenuation, millimeter-waves are also much more effective than infrared in poor weather conditions such as fog, clouds, snow, dust-storms and rain.

MMW spectrometry utilizes the unique absorption and emission spectral lines of chemical structures in order to identify materials. The lines are specific to particular molecular configurations because they are associated with the existence of associated electric dipole structures. Electromagnetic radiation windows occur at 35 GHz, 94 GHz, 140 GHz, and 220 GHz. The Choice of frequency depends on specific application.

The key component in many concealed weapons detectors identification of substances is a radiometer, which images the millimeter wave "signature" of objects. The millimeter wave signature is also known as blackbody radiation and is made up of two properties: emissivity and reflectivity. Everything in the universe has a millimeter wave signature, whether living, inorganic, naturally occurring or manmade material. The system images these millimeter wave signatures and processes them via the system's sophisticated software algorithms. The system next compares these images to its database of known guns, knives and assault rifles; these can be made of such materials as metals, plastics, composites or ceramics.

2.5.2 Technology Readiness

The products presented and demonstrated (only one product was demonstrated in a controlled environment) utilizing Infra-Red Spectroscopy technology are rated as NATO Technology Readiness Level 8.

Work on passive millimeter-wave sensing was strong during the 1960s and 1970s but attention was diverted by the advent of FLIR (forward-looking infrared) systems. At the time, equipment for this region of the spectrum was bulky, but developments in microwave and millimeter wave integrated circuit (MMIC) technology allow sensing in this region from small integrated chips.

Active radar at longer wavelengths and infrared (and optical) systems at shorter wavelengths are more mature technologies, but passive millimeter wave sensing could add some imaging capability, either in use alone or as one part of an imaging system that allows sensor fusion. The area of passive millimeter wave imaging is relatively mature and both commercial and military applications and research abound for the technology.

Notable developments have occurred in room-temperature microbolometer arrays for this part of the spectrum. Other developments include superheterodyne techniques, direct detection, and monolithic microwave integrated circuit (MMCI) component technology advances.

2.5.3 QinetiQ

The passive millimeter wave imaging technology allows for a chromatographic image of an object revealing an image based upon natural thermal background radiation given off. Detection of concealed objects through clothing at or around 100GHz of radiation transmitted is imaged by coupling the millimeter wave transmission technology with two types of detectors used in the focal plane. The first type of receiver is a discrete component receiver and the second is a MMIC receiver.

Figure 12 - 94 GHz Security Scanner

Figure 13 - SPO 20 Standoff Scanner

QinetiQ	
Technology/Product Description, Applications (Use), and Capabilities	• No use for Route Clearance Teams, but may be useful at FOB Gates and Checkpoints • Could be used for entry control point screening • Exploiting higher frequency (sub-millimeter or terahertz) may ultimately prove to provide greater utility. • Future products seem to be operable at higher distances and in smaller sizes. • The 94GHz security imager is a little over 1m x .75m x 1m in size, the SPO-20 IED defeat senor is similar but more robust and suitable for military applications. • Mounted on military vehicles fixed site locations such as airports, base entry points, arenas, commercial centers.
Technology/Product Strengths and Weaknesses	• Limited outdoor capabilities would be a factor in utilizing this capability at gates and checkpoints • Using this technology in theater or any Muslim area may cause cultural problems if and when used on female gender • Outdoor performance is lacking. • Weakness: Marginal effectiveness • Anatomical details are not revealed with the usage of this technology. Real time full body analysis is possible; whereas, THz technologies have similar sample areas with limited attenuation constraints.
Technology/Product Acquisition Issues	
Technology/Product Implementation Issues	• Initial training, sustainment training and maintenance requirements are all factors that will need to be considered. • Needs significant further development.

Assessment of Technology/Product Investment Potential	• Cost and further development could 2 million $US, 3 years • A dual frequency system may prove more robust • Production of receiver technology has proven unexpectedly problematic. • Technology lacks spectral feedback in mm wave region yet is relatively mature in its development. • Technology is comparably more mature than the majority of THz technology on the market today. Some of the key setbacks are its lack of ability to give chromatographic readouts with spectral information which the THz technology provides. • The cost and size of this technology are also potential disadvantages to its attractiveness in both the civilian and military sectors. • The potential upside of this technology's final stage could provide a boost for C-IED efforts in combat scenarios if a mountable robust unit such as the SPO-20 can be deployed before the end of 2007.

2.6 Polarized Light Camera

2.6.1 Technology Description

Sunlight and almost every other form of natural and artificial illumination produces light waves whose electric field vectors vibrate in all planes that are perpendicular with respect to the direction of propagation. When a light wave hits an object, what happens to it depends on the energy of the light wave, the natural frequency at which electrons vibrate in the material and the strength with which the atoms in the material hold on to their electrons. Based on these three factors, four different things can happen when light hits an object: it can be reflected or scattered, absorbed, refracted, or can pass through with no effect.

Reflection of light (and other forms of electromagnetic radiation) occurs when the waves encounter a surface or other boundary that does not absorb the energy of the radiation and bounces the waves away from the surface. The incoming light wave is referred to as an incident wave and the wave that is bounced away from the surface is called the reflected wave. If the electric field vectors are restricted to a single plane by filtration of the beam with specialized materials, then the light is referred to as plane or linearly polarized with respect to the direction of propagation, and all waves vibrating in a single plane are termed plane parallel or plane-polarized.

Unpolarized light can also undergo polarization by reflection off of nonmetallic surfaces. The extent to which polarization occurs is dependent upon the angle at which the light approaches the surface and upon the material which the surface is made of. Nonmetallic surfaces such as asphalt roadways, snow fields and water reflect light such that there is a large concentration of vibrations in a plane parallel to the reflecting surface. A person viewing objects by means of light reflected off of nonmetallic surfaces will often perceive a glare if the extent of polarization is large. Polarized Light Camera technology makes use of the polarization of ambient light reflected by smooth (man-made) surfaces.

2.6.2 Technology Readiness

The products presented and demonstrated (only one product was demonstrated in a controlled environment) Polarized Light Camera technology are rated as NATO Technology Readiness Level 9.

2.6.3 TNO Defense, Security & Safety

The polarization camera has demonstrated to be a valuable sensor for the discrimination of man-made objects from their surroundings.

Figure 14 - TNO's Polarized Light Camera mounted on top of a vehicle

Figure 15 - TNO's Polarized Light Camera mounted on a remote controlled robot

TNO	
Technology/Product Description, Applications (Use), and Capabilities	• Possible use with BCT Sappers as well as Fixed Site Security use • Fairly simple technology; appears to be "user friendly" • No known detection distance; no known night capabilities. • Claimed detection performance: low metal content mines. • Advanced system that uses the polarization properties of visible light. • Part of the IED should be above the surface. • Operation concept: support of surveillance of the road side by military from an armored vehicle. • Camera for enhanced discrimination of "man-made objects" from its surrounding. • Makes use of polarization of ambient light by smooth "man-made surfaces. • Modification of existing Duncan Tech camera. • Can be mounted on a moving platform. • Detection software has been developed. With this software, landmines can be detected automatically in images that are recorded with the polarization camera. • Applicable in landmine detection scenarios; also applicable for road proving, road-side inspection and detection of improvised explosive devices.
Technology/Product Strengths and Weaknesses	• Weakness: No IR capabilities for night usage • Not gyro-stabilized • Detection distance unknown

Technology/Product Acquisition Issues	• None.
Technology/Product Implementation Issues	• Feasible integration onto current platforms. • Need further testing of speed and detection claims.
Assessment of Technology/Product Investment Potential	• Possible improvements in software and discrimination.

2.7 Electromagnetic (bottle) Analyzer

2.7.1 Technology Description

Uses weak non-ionizing electromagnetic fields to analyze chemical make-up of liquids.

2.7.2 Technology Readiness

The products presented and demonstrated (only one product was demonstrated in a controlled environment) utilizing the products presented and demonstrated (only one product was demonstrated in a controlled environment) utilizing Infra-Red Spectroscopy technology are rated as NATO Technology Readiness Level 9. Electromagnetic analysis technology are rated as NATO Technology Readiness Level 9.

2.7.3 CEIA

 **Figure 16 - CEIA's EMA-2 Electromagnetic Bottle Analyzer**	The bottles can be detected by X-ray machines. However, this cannot determine if the original content has been replaced by dangerous liquids of similar density. In 2003, CEIA launched a research project to develop an electromagnetic device for the non-invasive inspection of bottles and similar containers with the goal of preventing flammable and explosive liquids (e.g. alcohols and hydrocarbons) from being brought into sensitive areas. The CEIA- EMA- 2 (Electromagnetic Bottle Analyzer) is the result of this research.

CEIA – EMA Electromagnetic Bottle Analyzer	
Technology/Product Description, Applications (Use), and Capabilities	• No feasible use for C-IED purposes. • Real Time Analyzer for the inspection of containers made of plastic, glass or ceramics, transparent or opaque with capacity up to 2 liters. • Uses weak non-ionizing electromagnetic fields, completely safe for operators and inspected bottles. • Meets all applicable Electrical Safety & Electromagnetic Standards.

	• Meets Hazard & Electronic Radiation to Ordnance Safety Standards. • IP20 indoor application; Portable stand alone unit. • No field calibration. Calibrates automatically upon start-up. • No performance degradation over life cycle. • Has a high degree of applicability to many environments, i.e. airports, bus terminals, hotel security, arena, stadium visitor cleaning, building security, transportation screening etc.
Technology/Product Strengths and Weaknesses	• Limited to liquid identification for IED applications, but useful • Self contained, needs to be battery powered, ease of operation..
Technology/Product Acquisition Issues	• Switzerland still needs paperwork to clear imports.
Technology/Product Implementation Issues	• Looks like it can be used alone of data, can be sent through wireless LAN connectivity. • Main limitation is the fact that it requires 110vac “wall power” to operate. Would like to see a battery operatedm smaller form factor device for more applications. • Devive antenna could be integrated into baggage screening equipment to do same identification instead of taking bottle into the unit’s chamber.
Assessment of Technology/Product Investment Potential	• Looks like a “cots” device with no future funding and schedule for development. • From data shown, it had a 100% identification arte under tests. • Limited to an area where 1210vac is accessible. • Need to remotely update the library of fluids for identification of new battery powered materials. • Seems like the product is COTS and may not require further development.

2.8 Non-Linear Junction Detector

2.8.1 Technology Description

Semiconductors contain multiple layers of silicon, a P-Type and an N-Type, the point where they meet is called a Non Linear Junction. This junction also appears in nature when dissimilar metals come in contact with one another (such as that used in the old crystal radio set). Also, the rust on a screw, the springs in a car, or the support structure in any piece of furniture may also contain non linear junctions (resulting from corrosion).

A Non Linear Junction Detector finds potential eavesdropping devices by flooding a suspect area or target with a spectrally pure microwave RF signal (usually around 888 or 915 MHz). Various frequencies are then monitored for a reflected harmonic signal.

The instrument typically has an antenna and a control unit. The antenna is mounted on an extendable pole, and really nothing more than a microwave waveguide which both emit and collects the signals (with a duplexer). The control unit is usually a multiple channel, highly sensitive radio receiver tuned to specific second and third harmonic frequencies. While it is possible to measure the 4th, 5th, 6th, and other harmonics those above the third are only of limited Technical Surveillance Countermeasures (TSCM) value.

Remember, a Non Linear Junction Detector is nothing more than an instrument which detects harmonic anomalies, nothing more. Any positive indication must be verified with a metal detector, X-Ray examination, thermal viewer, and a physical inspection to confirm the actual presence or absence of an eavesdropping device.

Illuminating Signals and Harmonics

Transistors, diodes, integrated circuits, and other dissimilar or metallic junctions will usually cause a signal to be emitted at the second or third harmonic of the fundamental flooding frequency.

Fundamental or Illuminating Signal - Conductive or Metallic Surface

This is the flooding frequency, typically 888 MHz or 915 MHz. Power levels range from 15 mW to 7.5 Watts, 3 W typical for government, below 1 W ERP for commercial. A reflection of this frequency may be monitored to allow the calibration of the instrument or to control output power levels.

Linear Response

A linear response will be caused when a NLJD is passed over a non metallic, non-ferrous or organic item. This material includes potted plants, wood, paper, rubber, plastic, wool, fabric, or other item. Instead of reflecting the fundamental frequency or generating a harmonic the signal is instead absorbed by the material. Most objects will respond in a linear fashion.

Fundamental Signal, 3rd, 5th, and other Odd Harmonic Reflections
(Conductive or Metallic Surfaces)

This harmonic will be reflected by any conductive or metallic surface within the area being inspected. Normally this harmonic is only useful for locating nails, screws, studs, conduit, and other normal structural components. This will include any metal to metal junctions of the same type of material such as electrical conduit, HVAC duct work, and metallic studs. This is considered a negative response and may be considered a non-linear symmetrical response.

2nd, 4th, 6th, and other Even Harmonic Reflections
(Dissimilar Metallic Junction and Non Linear Junctions)

Any type of metallic junction between multiple items of metal will cause a second harmonic to be generated. This signal may be created by solid state devices, diodes, transistors, or integrated circuits. However, this signal may also be caused by the presence of paper clips, rusty nails, sheetrock screws, steel studs, re-bar, upholstery springs, or any loosely touching metallic parts. This is considered a positive response, and will require further inspection involving a portable X-ray instrument, thermal imaging, borescopes, and other physical equipment. This may also be considered a non-linear asymmetrical response. A noisy asymmetrical response indicates the possibility of a corrosive target as opposed to a bugging device.

2.8.2 Technology Readiness

The products presented and demonstrated (only one product was demonstrated in a controlled environment) utilizing Non Linear Junction Detection technology are rated as NATO Technology Readiness Level 9 (See Appendix XX for NATO Technical Readiness Levels and description).

A Non Linear Junction Detector may be used to identify:

- Active or Live Bugs, Inactive Bugs, Turned On Bugs, Turned Off Bugs, Burned Out Bugs, Dead Bugs, Remote Control or Remote Powered Bugs,
- Covert or Concealed Video Cameras
- Microwave Transmitters
- Resonant Cavity Devices, Covert Eavesdropping Devices
- Concealed Cellular, PCS, and GSM Telephones
- Electronic Timers for Hidden Bombs
- Wireless Microphones
- Hidden Tape Recorders (even broken ones)

2.8.3 EMC-1

STT Group was founded in 1994 by former KGB officers. It consists of 2 affiliated companies: ECMC-1 Ltd. &Security Group – UTTA Inc. STT Group focuses it activity on security technologies and equipment for law enforcement agencies and private security.

Russian NLJ-based products originally field proven as detectors of electronic surveillance “bugs” in government buildings.

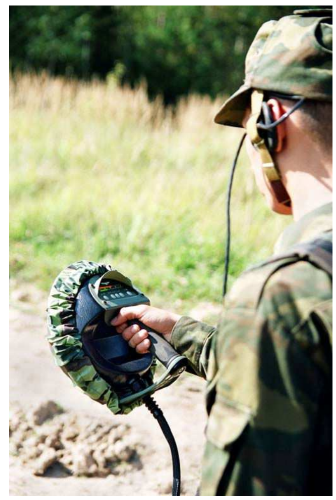
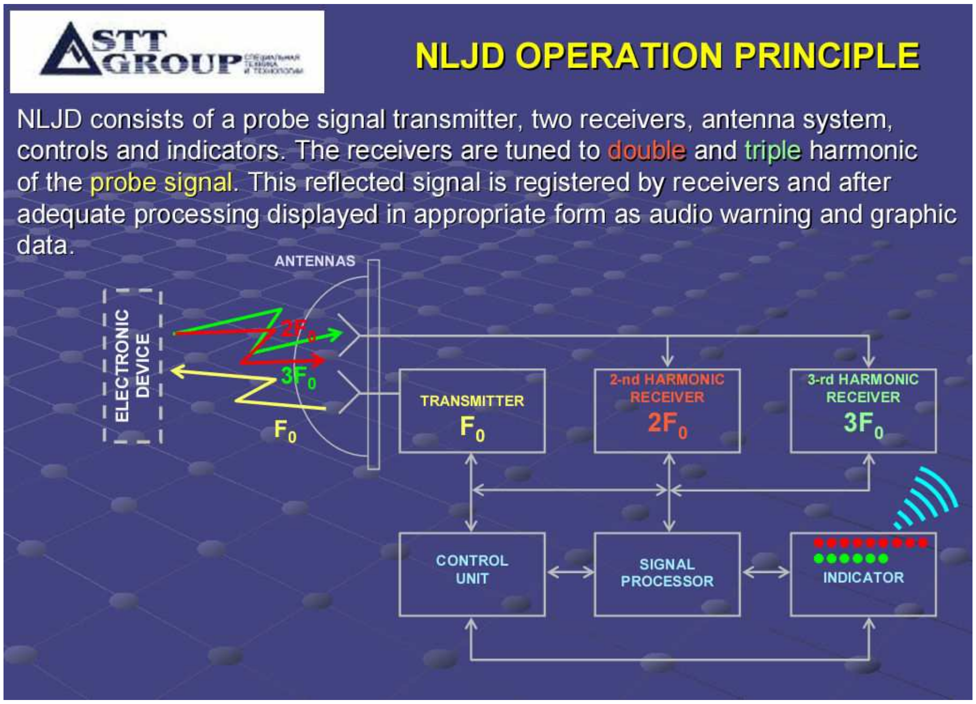


Figure 17 - A soldier using EMC-1's Non-Linear Junction Detector product

EMC-1 – Non-Linear Junction Detector “Eagle”	
Technology/Product Description, Applications (Use), and Capabilities	• Mine reconnaissance & clearance (Primary) • Detection of electronic triggering devices of IEDs • 7-10 meter detection range advertised • Science and technology experts support it’s viability for use against IEDs • Applicable for law enforcement agencies and private security. • Consists of probe single transmitter, two receivers, antenna system, controls and indicators. The receivers are tuned to double and triple harmonic of the probe signal. This reflected signal is registered by receivers and after adequate processing displayed in appropriate form as audio warning and graphic data.

Technology/Product Strengths and Weaknesses	• Portable • Long operation time on batteries • Use in extreme environmental conditions • Ease of use, low training requirement • Need to get within close proximity of target. Potentially within blast radius of IED • Unsure of usefulness in "open" environment
Technology/Product Acquisition Issues	• None stated by Russian company representative.
Technology/Product Implementation Issues	• Constant improvements in the product to meet changing threat environment. • Original application in close proximity to target standoff distance unknown. • Should be easily integrated with other systems. • Appears to be better suited for counter surveillance or possible discovery of more conventional type explosives.
Assessment of Technology/Product Investment Potential	• No investment potential. Fully developed.



2.9 Enhanced CCTV and Intelligent Video

2.9.1 Technology Description

As a scientific discipline, computer vision is concerned with the theory and technology for building artificial systems that obtain information from images or multi-dimensional data. Since perception can be seen as the extraction of information from sensory signals, computer vision can be seen as the scientific investigation of artificial systems for perception from images or multi-dimensional data.

As a technological discipline, computer vision seeks to apply the theories and models of computer vision to the construction of computer vision systems. Examples of applications of computer vision systems include systems for controlling processes (e.g. an industrial robot or an autonomous vehicle), detecting events (e.g. for visual surveillance), organizing information (e.g. for indexing databases of images and image sequences), modeling objects or environments (e.g. industrial inspection, medical image analysis or topographical modeling) and interaction (e.g. as the input to a device for computer-human interaction).

Computer vision can also be described as a complement (but not necessarily the opposite) of biological vision. In biological vision, the visual perception of humans and various animals are studied, resulting in models of how these systems operate in terms of physiological processes. Computer vision, on the other hand, studies and describes artificial vision systems that are implemented in software and/or hardware. Interdisciplinary exchange between biological and computer vision has proven increasingly fruitful for both fields.

Sub-domains of computer vision include scene reconstruction, event detection, tracking, object recognition, learning, indexing, ego-motion and image restoration.

Related fields

Computer vision, Image processing, Image analysis, Robot vision and Machine vision are closely related fields. If you look inside text books which have either of these names in the title there is a significant overlap in terms of what techniques and applications they cover. This implies that the basic techniques that are used and developed in these fields are more or less identical, something which can be interpreted as there is only one field with different names.

On the other hand, it appears to be necessary for research groups, scientific journals, conferences and companies to present or market themselves as belonging specifically to one of these fields and, hence, various characterizations which distinguish each of the fields from the others have been presented. The following characterizations appear relevant but should not be taken as universally accepted.

Image processing and Image analysis tend to focus on 2D images, how to transform one image to another, e.g., by pixel-wise operations such as contrast enhancement, local operations such as edge extraction or noise removal, or geometrical transformations such as rotating the image. This characterization implies that image processing/analysis neither require assumptions nor produce interpretations about the image content.

Computer vision tends to focus on the 3D scene projected onto one or several images, e.g., how to reconstruct structure or other information about the 3D scene from one or several images. Computer vision often relies on more or less complex assumptions about the scene depicted in an image.

Machine vision tends to focus on applications, mainly in industry, e.g., vision based autonomous robots and systems for vision based inspection or measurement. This implies that image sensor technologies and control theory often are integrated with the processing of image data to control a robot and that real-time processing is emphasized by means of efficient implementations in hardware and software.

There is also a field called Imaging which primarily focus on the process of producing images, but sometimes also deals with processing and analysis of images. For example, Medical imaging contains lots of work on the analysis of image data in medical applications.

Finally, pattern recognition is a field which uses various methods to extract information from signals in general, mainly based on statistical approaches. A significant part of this field is devoted to applying these methods to image data.

A consequence of this state of affairs is that you can be working in a lab related to one of these fields, apply methods from a second field to solve a problem in a third field and present the result at a conference related to a fourth field! [v]

Recognition

The classical problem in computer vision, image processing and machine vision is that of determining whether or not the image data contains some specific object, feature, or activity. This task can normally be solved robustly and without effort by a human, but is still not satisfactory solved in computer vision for the general case: arbitrary objects in arbitrary situations. The existing methods for dealing with this problem can at best solve it only for specific objects, such as simple geometric objects (e.g., polyhedrons), human faces, printed or hand-written characters, or vehicles, and in specific situations, typically described in terms of well-defined illumination, background, and pose of the object relative to the camera.

Different varieties of the recognition problem are described in the literature:

Recognition: One or several pre-specified or learned objects or object classes can be recognized, usually together with their 2D positions in the image or 3D poses in the scene.

Identification: An individual instance of an object is recognized. Examples: identification of a specific person face or fingerprint, or identification of a specific vehicle.

Detection: The image data is scanned for a specific condition. Examples: detection of possible abnormal cells or tissues in medical images or detection of a vehicle in an automatic road toll system. Detection based on relatively simple and fast computations is sometimes used for finding smaller regions of interesting image data which can be further analyzed by more computationally demanding techniques to produce a correct interpretation.

Several specialized tasks based on recognition exist, such as:

Content-based image retrieval: Finding all images in a larger set of images which have a specific content. The content can be specified in different ways, for example in terms of similarity relative a target image (give me all images similar to image X), or in terms of high-level search criteria given as text input (give me all images which contains many houses, are taken during winter, and have no cars in them).

Pose estimation: Estimating the position or orientation of a specific object relative to the camera. An example application for this technique would be assisting a robot arm in retrieving objects from a conveyor belt in an assembly line situation.

Optical character recognition (or OCR): Identifying characters in images of printed or handwritten text, usually with a view to encoding the text in a format more amenable to editing or indexing (e.g. ASCII).

Motion

Several tasks relate to motion estimation, in which an image sequence is processed to produce an estimate of the local image velocity at each point. Examples of such tasks are:

Egomotion: determining the 3D rigid motion of the camera.

Tracking: following the movements of objects (e.g. vehicles or humans).

Scene reconstruction

Given two or more images of a scene, or a video, scene reconstruction aims at computing a 3D model of the scene. In the simplest case the model can be a set of 3D points. More sophisticated methods produce a complete 3D surface model.

Image restoration

The aim of image restoration is the removal of noise (sensor noise, motion blur, etc.) from images.

Computer vision systems

The organization of a computer vision system is highly application dependent. Some systems are stand-alone applications which solve a specific measurement or detection problem, while other constitute a sub-system of a larger design which, for example, also contains sub-systems for control of mechanical actuators, planning, information databases, man-machine interfaces, etc. The specific implementation of a computer vision system also depends on if its functionality is pre-specified or if some part of it can be learned or modified during operation. There are, however, typical functions which are found in many computer vision systems.

Image acquisition: A digital image is produced by one or several image sensor which, besides various types of light-sensitive cameras, includes range sensors, tomography devices, radar, ultra-sonic cameras, etc. Depending on the type of sensor, the resulting image data is an ordinary 2D image, a 3D volume, or an image sequence. The pixel values typically correspond to light intensity in one or several spectral bands (gray images or colour images), but can also be related to various physical measures, such as depth, absorption or reflectance of sonic or electromagnetic waves, or nuclear magnetic resonance.

Pre-processing: Before a computer vision method can be applied to image data in order to extract some specific piece of information, it is usually necessary to process the data in order to assure that it satisfy certain assumptions implied by the method. Examples are:

- Re-sampling in order to assure that the image coordinate system is correct
- Noise reduction in order to assure that sensor noise does not introduce false information
- Contrast enhancement to assure that relevant information can be detected

Feature extraction: Image features at various levels of complexity are extracted from the image data. Typical examples of such features are:

2.9.2 Technology Readiness

The products presented and demonstrated (only one product was demonstrated in a controlled environment) utilizing Enhanced CCTV and Intelligent Video technology are rated as NATO Technology Readiness Level 9.

2.9.3 University of London

Figure 18 - University of London's Object Recognition Software

The work has been widely applied to vehicle and people detection, face recognition, object tracking, counting and recognition in public space CCTV, human gesture recognition for visually-mediated interaction, abnormal behaviour recognition in visual surveillance, visually-mediated human-computer interaction and virtual studios. A current significant focus is in crime prevention, with work on real-time surveillance and biometrics.

Core expertise includes dynamic scene analysis, mathematical modelling, multi-view geometry, pattern recognition and learning, biologically inspired vision and image compression. An additional new research line concerns the extraction of 3D information from image sequences using geometric information. In particular, research is being carried out into self-calibration of cameras and 3D metric reconstruction of scenes viewed by uncalibrated cameras. Work is also being undertaken to develop novel computer vision algorithms and hardware based on neurobiological principles.

University Of London Object Recognition Software	
Technology/Product Description, Applications (Use), and Capabilities	• Very limited viability with respect to its use in IED stand-off detection. • 3D facial scan analysis for person recognition in airport security applications. • Detecting and tracking faces in CCTV video, detection of dangerous events, automated performance evaluation of CCTV surveillance systems.
Technology/Product Strengths and Weaknesses	• Immature software and algorithms. • Small area coverage for surveillance. • Best application is still post-event forensics.
Technology/Product Acquisition Issues	• Not ready for acquisition/deployment.
Technology/Product Implementation Issues	• Can be easily integrated. • May be an issue that cameras are not mobile and in a fixed position.
Assessment of Technology/Product Investment Potential	• At this time, it is not feasible.

2.9.4 Virage Security & Surveillance

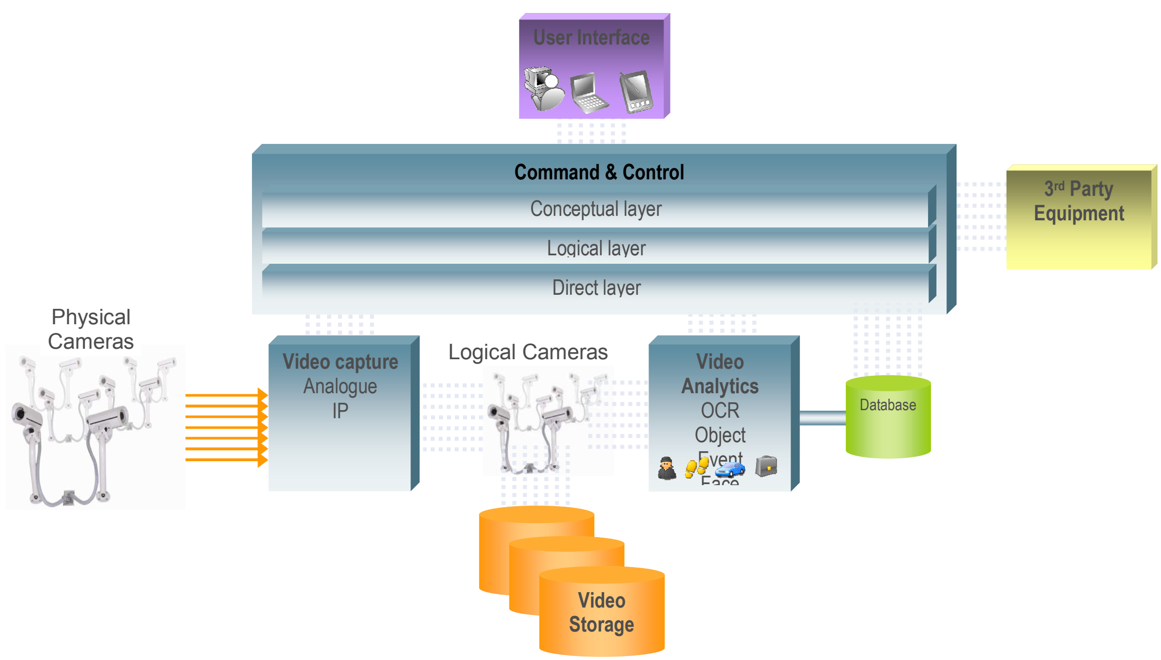


Figure 19 - Virage's System Diagram

Virage	
Technology/Product Description, Applications (Use), and Capabilities	• Detection of suspicious objects/events. • Video motion detect, non-motion detect, tracking, behavioural, object identification (face recognition, vehicle type, car manufacturer and packaging). • Limited – fixed or limited mobility camera surveillance. • Will provide detailed view of a pre-selected area. Monitors onlythat area for any activity. • Better application in monitoring high value target or suspect suchas IED tracking of person of interest. • Can be applied in airports, roads and motorways, railways and by police. • Real-time plate matching; retrospective search assistance. • Speaker recognition, sound recognition, speech recognition.
Technology/Product Strengths and Weaknesses	• Weaknesses: Not mobile. • Limited change detection applications, not a military stand-off IED defeat system. • Low cost, simple deployment, low false alert rate.
Technology/Product Acquisition Issues	
Technology/Product Implementation Issues	• Can be easily integrated.
Assessment of Technology/Product Investment Potential	• Not a high value stand-off IED defeat product.

2.9.5 Carnegie Mellon University

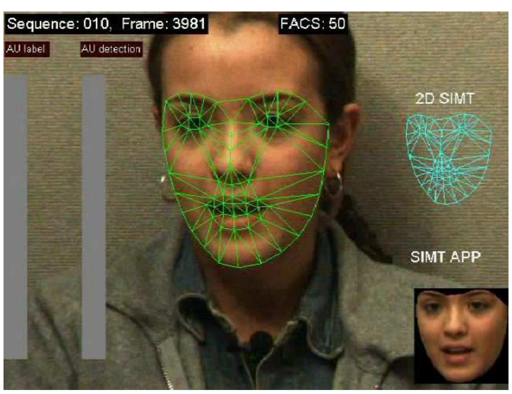


Figure 20 - CMU's face mapping algorithm

Figure 21 - Stationary and mobile cameras afford a higher level of object tracking

Carnegie Mellon	
Technology/Product Description, Applications (Use), and Capabilities	• Limited – camera based on visual surveillance. • Visual identification and tracking security system. • Security system for surveillance, ID and tracking of threat, suspect or person of interest. • Has security and surveillance applications, not C-IED applications. • New techniques for motion detection under challenging situations (partial occlusion) include illumination compensation. • Acquisition systems at a distance. • High level video understanding – behavorial scene analysis. • Multimodal biometrics – gait analysis and face recognition. • Stationary master camera: detect/track all people in wide field view. • Disambiguates between multiple people. • Slave camera with active pan/tilt/zoom control. • Control to take views of each person and zoom control to take views of body and face. • Classification accuracy – 95% • Route learning from observations. • Automatic detection of unusual events.
Technology/Product Strengths and Weaknesses	• Not mobile. • Not a true stand-off IED defeat or detect candidate. • Stationary and mobile cameras afford a higher level of object tracking • Strengths: non-cooperative subjects, natural outdoors environments, distance of 120 m and multiple people. • Weakness: Need for better tracking algorithms for articulated motion. • Face recognition is non-intrusive biometric and can be done at a distance.
Technology/Product Acquisition Issues	• None
Technology/Product Implementation Issues	• Could be integrated with current operators viewing monitors.
Assessment of Technology/Product Investment Potential	• Need for more research in computer vision and machine learning algorithms for efficient indexing and biometrics in large amounts of video. • Vision by itself will not solve the IED detection problem but it is an important component. • Cost and time for further development: 1-2 mil, 2-3 yrs.

2.9.6 GE Research

Figure 22 - GE's "One World View" Camera Aggregation

GE Research	
Technology/Product Description, Applications (Use), and Capabilities	• Auto calibration, combined application, constellation detection, articulated tracking, monolithic detection, crowd segmentation, tracking in crowds, person reacquisition. • Articulated motion, gaze estimation, multi-view enhancement • Limited applications for IED stand-off detection. • Camera based surveillance identification and tracking system. • Has surveillance, security, ID and tracking applications. • Could be applicable in IED since it can identify multiple objects/people in a crowded area with a high degree of accuracy. • Performance level is high, limitations may be in illumination levels vs. sensitivity. • Could be used for visitor control, package identification, identification of individuals.
Technology/Product Strengths and Weaknesses	• Not mobile.
Technology/Product Acquisition Issues	• None
Technology/Product Implementation Issues	• Could be integrated fairly easily. • Limitations may include cost. • Some training issues as well as human factors, i.e., weight, size, power requirements are areas that need to be addressed.
Assessment of Technology/Product Investment Potential	• 6- 8 months for development; funding $2-500k

2.10 Persistent Surveillance Technology

2.10.1 Technology Description

The use of photographic “real-time” surveillance camera technology and microprocessors for change detection and post event forensics.

2.10.2 Technology Readiness

The products presented and demonstrated utilizing Persistent Surveillance Technology are rated as NATO Technology Readiness Level 9.

2.10.3 Geospatial Systems, Inc. and ITT

Geospatial Systems, Inc. product is a real-time surveillance analytical platform technology comprised of a suite of plug-and-play metric cameras that interface to a geo-spatial processor which can support custom applications (e.g. Intelligent Scene Analysis). The products seeks to employ exception analysis where in the algorithms will eliminate normal data and focus on objects and activities of interest. This technology provides an understanding of how computer vision and intelligent scene analysis technologies can enable more effective C-IED and border control solutions. Persistent surveillance provides transformational intelligence gathering for IED detection and defeat.

Figure 23 - "Six Pack" camera rack

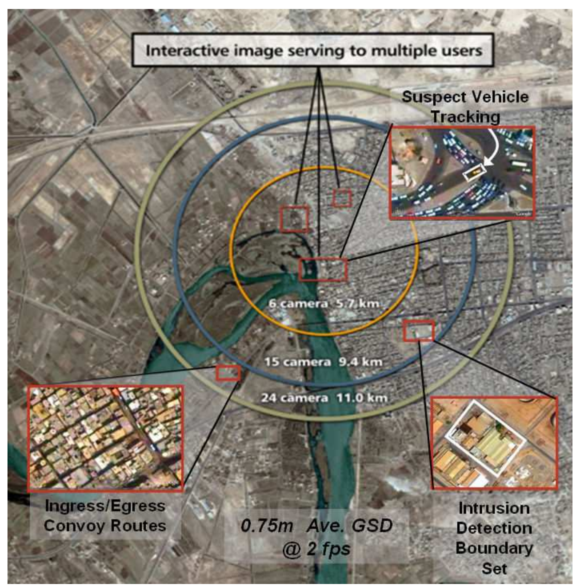


Figure 24 - Example of wide area surveillance capabilities

GeoSpatial Systems	
Technology/Product Description, Applications (Use), and Capabilities	• Airborne persistent surveillance or input for change detection analysis is a current development program – ASTAMIDS – airborne stand-off mine detection.

	• Potential for quality performance. • Reference /claims real time down links into RF SINGARS tactical radios. • 3-stage real time instantaneous surveillance. • The artificial intelligence for this product is in development. • Geo-referenced image data is distributed by a Gigabit Ethernet switch fabric, making system configuration simple, extensive and flexible. • Supports standoff IED detection through customized application and integration. • Provides wide area image coverage. • Installs on fixed or mobile platforms (to include airframes). • Interoperates with other systems, other technologies (e.g. other sensors) and communications. • Airborne persistent surveillance provides the high ground view of operations for command and control as well as interactive image serving to multiple tactical users. • Enables forensic analysis of movers. • Time stamped column of imagery provides unparalled, real-time and historical view of enemy and patterns. • JPEG200 provides more efficient compression (reduces storage and transmission requirements). • JPEG 2000 is scalable in resolution, quality and region of interest. • Parameters can be traded to meet the limitations of the downlink data rate or storage limits. • Stores lossless or high quality compression for forensic mission. • Compression provides much needed bandwidth extension required for efficient downlink and dissemination • Applications: port security, event security, planes, aerostats, border security, disaster relief and ground based. • Cross cueing between sensor systems maximizes intelligence collection
Technology/Product Strengths and Weaknesses	• A flexible mounting scheme allows for multiple KCM camera modules to be configured on a single Sensor Frame Assembly for wide angle oblique or nadir imaging. • Environmental/Operational contraints: Image capture capabilities can be impaired by adverse weather, darkness, dust and other factors.
Assessment of Technology/Product Investment Potential	• Comparable ASTAMIDS program already funded with a firm development timeline. • Can be compared to ASTAMIDS features for possible merge to improve current technology. • Can be effectively customized to support various Intelligent Scene Analysis applications which allow for the early identification of IEDs. • The core system can be integrated with other IED sensor systems and can further enable more comprehensive and interoperable IED countermeasures. • Core technology can be installed on aircraft, vehicles or fixed sites and locations. • Can provide and support a more complete visualization/analysis of IED geographic threat environments.

2.11 Methodology and Framework

The International Institute's Technology Transfer and Risk Assessment Framework, displayed below in Figure 25, provides a comprehensive technology assessment template that is used to support the identification of the following:

- **I. Identify Operational Risks and Preliminary Needs**
- **II. Identify Countermeasures and Best Practices**
- **III. Measure Effectiveness of Countermeasures**
- **IV. Conduct Business Risk Analysis**
- **V. Perform Cost / Benefit Analysis**

The functional workflow of the technology transfer and risk assessment process can be below in Table 4. While our methodology will be fully employed for TSWG Task 2 counter-terrorism technology assessments, components of this framework provided baseline foundation for ongoing technology analysis. currently being performed by the International Institute team.

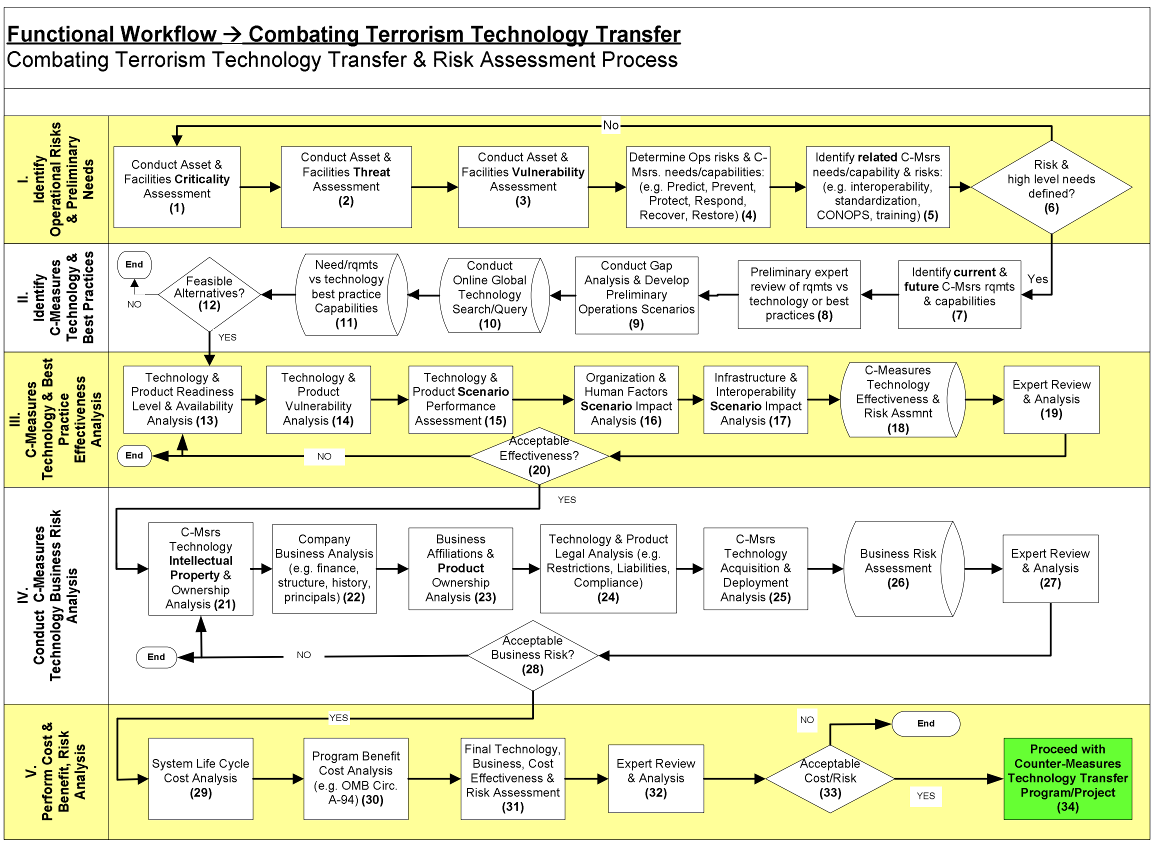


Figure 25 – Functional Workflow: Combating Terrorism Technology Transfer

PHASE I - IDENTIFY OPERATIONAL RISKS & PRELIMINARY NEEDS:

The steps identified in Phase I are essential to identifying and defining NATO/TSWG operational requirements and capabilities and combating terrorism technology needs. This Phase is typically led by the operations personnel and organizations that are responsible for identifying and effectively articulating their organizational or mission needs and capabilities. Personnel from various technical disciplines should be included as appropriate in Steps 1, 2, and 3, depending on the likelihood of technical threats and potential vulnerability of the assets, facilities, and personnel.

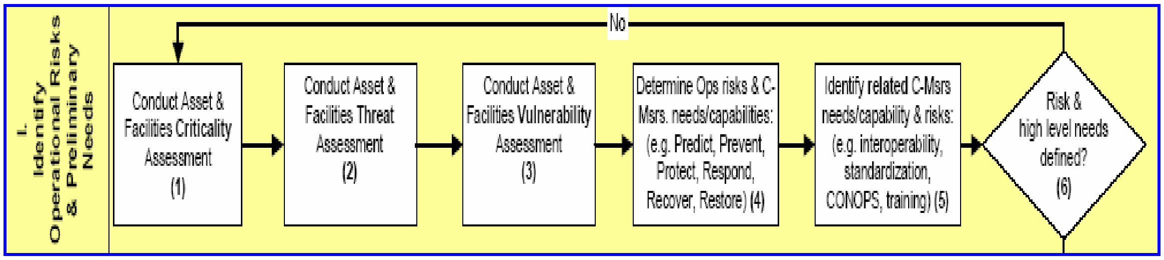


Figure 26 – Phase I – Steps and Process Flow

Steps 1, 2, and 3 – Criticality, Threat and Vulnerability Assessments.
These three steps are conducted in sequence, though concurrent activities can occur between the steps. Each step can be performed by the responsible organization using their approved or preferred risk and vulnerability analytical approaches and tools.

Work product/deliverables may include:
Asset Criticality Assessment Report, Asset Threat Assessment Report, Asset Vulnerability Report, Decision Support Tool Applications and/or spreadsheet reports, tables, and graphics.

Step 4 – Determine Operational Risks and Counter-Measure Needs/Capabilities.
Based on outcomes of Steps 1-3, and other risk factors considered as part of Step 4, the responsible organization (or appropriate third party) identifies and rank orders the operational risks and Counter-Measure needs and capabilities. Specific Counter-Measure needs and capabilities should be identified and categorized as “Prediction”, “Prevention”, “Protection”, “Response”, “Recovery”, and “Restoration” needs or capabilities. There can be multiple specific needs/capabilities listed under each category. Step 4 outcomes can be depicted in table or spreadsheet format along with the use of “weighting” values to quantify risks and prioritize needs/capabilities.

Work products/deliverables may include:
Risk Assessment & Combating Terrorism Counter-Measures Needs/Capabilities Report, Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics.

Step 5 – Identify Related Counter-Measure Needs/Capabilities and Risks.
Other related Counter-Measure needs and capabilities are identified and prioritized which effectively enable and/or enhance the performance and effectiveness of the Counter-Measure technology or product and associated processes. Related needs/capabilities may include systems interoperability or integration capabilities, development of appropriate doctrine, training considerations, and technology CONOPS development. Risks specifically associated with the Counter-Measure technologies will also be identified.

Work product/deliverables may include:
Updated/revised Operational Risk Assessment & Counter-Measures Needs/Capabilities Report, CONOPS (technology/product non-specific), Mission Needs Statement, Updated/revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics, Risk Mitigation Analysis Report.

Step 6 – Determine if Risks and Needs/Capabilities are Accurately Defined. The reports, data, and information prepared in Steps 1-5 are considered at this step to determine if risks, needs, capabilities and other factors are sufficiently identified and defined before proceeding to the requirements definition step (Step 7). If not sufficiently identified and defined, the material/information is referred back to one of the preceding steps for appropriate revision. Alternatively, the decision can be made at this step not to proceed due to lack of mission or operational needs or risk, or due to other factors.

Work product/deliverables may include:
Decision Memorandum or equivalent document which provides further program/project guidance and direction.

PHASE II - IDENTIFY COUNTER-MEASURE TECHNOLOGY & BEST PRACTICES:

Upon approval and receipt of Phase I documentation and other work products, the process of identifying feasible Counter-Measure technologies and best practices begins. The objective of Phase II to is to identify the universe of technology and process alternatives that are available to satisfy the previously identified operational needs and capabilities and reduce it to a limited number of feasible alternatives. These alternatives will be further evaluated as to their technical and operational effectiveness in Phase III.

If the universe of feasible solutions is already known to the responsible organization, and if there is already sufficient needs and capabilities information/data available and equivalent to that identified in Phase I, Phases I and II of this model can be effectively skipped or by-passed and Phase III activities can be initiated.

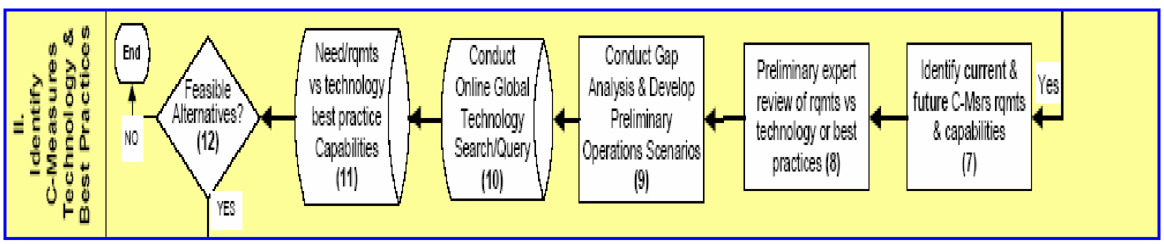


Figure 27 – Phase II – Steps and Process Flow

Step 7 - Identify Current and Future Counter-Measure Requirements and Capabilities. Identify and develop current and future functional and technical requirements through use and analysis of decision guidance created at Step 6 and the other documents and work products created in Phase I. The analysis at this step should result in the identification of preliminary technical and functional goals and objectives which will allow for further identification and definition of requirements and capabilities which can be satisfied or achieved in a time-phased incremental manner, if necessary.

Work product/deliverables may include:
Requirements Definition Document, Functional Requirements Document, Updated/revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics.

Step 8 – Conduct Expert Review of Requirements versus Technology and Best Practices. An expert review or Red Team process is conducted to specifically determine if there are existing and proven technologies and best practices that exist and can be implemented to provide the required capabilities and satisfy the operational needs. If there are known effective solutions available, and an overriding or immediate need exists, a decision can be made at this step to proceed with their implementation. Regardless of any decision to provide an immediate implementable solution, the technology transfer and risk managed selection process may still proceed, depending on guidance from the expert group or Red Team.

Work product/deliverables may include:
Decision Memorandum or other guidance document, Revised Requirements Definition Document, Revised Functional Requirements Document, Updated/revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics.

Step 9 – Conduct Gap Analysis and Develop Operations Scenarios.
A "Gap" analysis is conducted to accurately define the current operational environment in order to establish a baseline to assess the "gap" between current capabilities versus the needs and capabilities of the future operational environment. The gap analysis should effectively identify those capabilities which presently exist that can/will satisfy future operational needs and identify those future needs which cannot be satisfied and capabilities that will have to be developed. Preliminary operational scenarios are developed and entered into the Decision Support Tool. The decision support scenarios establish the baseline for assessing the effectiveness of competing technologies and/or best practice solutions and allow for the controlled introduction of multiple variables, constraints, and other factors into the scenarios.

Work product/deliverables may include: Gap Analysis Report (inclusive of identified current and future needs/capabilities), Updated/revised Decision Support Tool Applications with Operational Scenarios, Technology Evaluation Criteria, Best Practices Evaluation Criteria.

Step 10 – Conduct On-line Global Technology Query/Search.
An on-line global search of technologies, products, best practices, lessons learned, and other solutions is conducted in order to identify possible alternatives to satisfy the needs, capabilities and requirements identified in Steps 8 and 9. The global search is intended to be comprehensive in that it is intended to identify technologies and other solutions which may not be intuitively considered as viable alternatives. This is intended to be an on-line, near-real time response to structured and unstructured search/query parameters enabled through a scalable super-computing environment which accesses massive amounts of data, globally.

Work product/deliverables may include:
Database and Inventory of Technology and Best Practices Alternatives, Analysis of Initial Tech/Best Practices Report, Updated/revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics.

Step 11 – Conduct Operational Needs/Requirements versus Technology/Best Practices Capabilities Analysis. The Decision Support Tool, and the baseline operational scenarios created in Step 9, will be used to assess the effectiveness of the various technologies and solutions identified in Step 10. This decision support analytical process will enable the identification of technology, best practices and other solutions which satisfy the identified operational needs, capabilities and requirements. Other decision criteria (e.g. cost, risk, schedules, legal requirements) may be used in the decision support process to further improve the identification of implementable feasible alternatives.

Work product/deliverables may include:
Feasibility and Alternatives Analysis Report, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics.

Step 12 – Determine if there are Feasible Alternatives.
The identification and selection of a feasible alternative or alternatives, if any, will be made using the outputs from Step 11 and other documentation and factors considered in Phases I and II of the process. If no feasible alternatives are identified the process can end or go back to Step 8 to attempt to again identify feasible alternatives.

Work product/deliverables may include:
Decision Memorandum and/or other project guidance documents, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics.

PHASE III – COUNTER-MEASURE TECHNOLOGY AND BEST PRACTICES EFFECTIVENESS ANALYSIS:

Phase III is a comprehensive assessment of the feasible technical and/or best practices alternatives identified in Phase II. The assessment of the technical and operational effectiveness of the alternatives is conducted through the use of operational scenarios developed and analyzed by means of automated decision support and risk management tools and applications. As previously noted, Phase III can be initiated without formally going through Phases I and II if equivalent information/data is available to support the Phase III process and steps. The performance of Steps 13 and 14 are heavily dependent on comprehensive data mining and query techniques. Analysis performed in Steps 15 through 18 is enabled by a scenario driven effectiveness and risk assessment decision support tool. Review and decisions made in Steps 19 and 20 will be supported by the decision support tool and data query and mining capabilities.

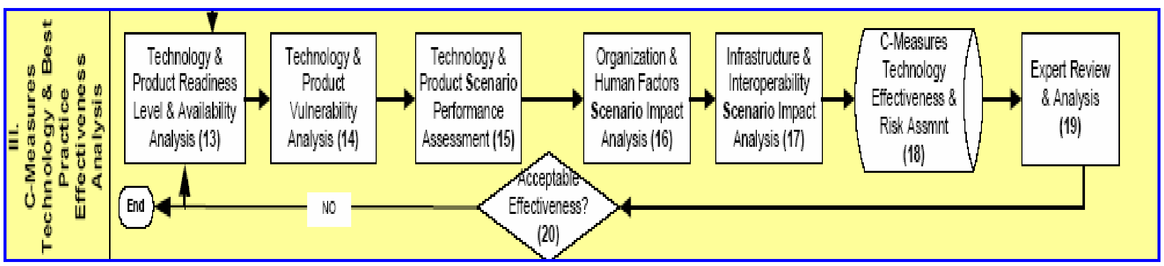


Figure 28 – Phase III – Steps and Process Flow

Step 13 – Conduct Technology and Product Readiness Assessment and Availability Analysis. The availability of technologies and products, as well as broader solutions and best practices, in the global marketplace will be determined and assessed as will the general readiness of the technology or product to perform effectively. The analysis will, where possible, provide an estimated or known timeline for the commercial availability and/or implementation of the technology/product.

Work product deliverables may include:
Market Surveys, Technology Analysis and Readiness Assessment Report, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives.

Step 14 – Technology and Product Vulnerability Analysis.
The general vulnerability of the specific technology and products will be identified and assessed without regard to specific scenarios in which they may be subsequently for deployment/implementation. The purpose of the analysis at this step is to determine if there are clearly identified vulnerabilities, known counter-measures, and other factors that would preclude further consideration of the technology or product as a viable alternative.

Work product deliverables may include:
Technology and Product Vulnerability Analysis Report, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics, Decision Memorandum or other guidance document.

Steps 15, 16, 17, and 18 - Scenario Driven Technology/Best Practice Performance, Impact, Effectiveness, and Risk Analysis. Utilizing a comprehensive decision support analytical capability, an assessment of the performance of the technology/product in a given operational scenario will be conducted. Multiple scenarios or iterative variations of the baseline scenario may be used at this step to assess the performance and impact of the product or technology. Variable threat, risk, operational and environmental factors (Step 15); human and organizational factors (Step 16); and factors affecting infrastructure, interoperability and integration (Step 17) may be introduced into the scenarios to provide more realistic and thorough analysis of the technology/product capabilities, impacts and vulnerabilities. The overall assessment of a technology/product versus other competing technologies/products (if applicable) that have gone through Steps 15 -17 will be accomplished at Step 18.

Work product deliverables may include:
Technology and Product Performance/Impact Analysis Report, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics, System Simulations and Modeling/Visualization of Technology and Product Alternatives.

Steps 19 and 20 – Conduct Expert Counter-Measure Review and Effectiveness Analysis. The decision support outputs and information created in Steps 15 – 18 will be reviewed and considered by appropriate qualified personnel at Step 19. A final decision concerning the effectiveness of the technology/product and/or additional technical or project guidance may be made at Step 20.

Work product deliverables may include:
Decision Memorandum or other guidance documents, Updated Technology CONOPs Document, Decision Support Test and Evaluation Scenarios, Technology/Product Assessment Report(s), Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics, Simulation/Modeling Demonstrations.

PHASE IV – CONDUCT COUNTER-MEASURES TECHNOLOGY BUSINESS RISK ANALYSIS:

If an acceptable level of technical performance and effectiveness is determined for one or more of the feasible alternatives identified in Phase II, based on the analysis conducted in Phase III, a comprehensive business risk assessment will be performed to determine all aspects of risk related to technology/product/intellectual property ownership, business organization/personnel relationships, legal restrictions, liabilities, finances/investments, acquisition, deployment and other business factors which could impact the implementation of the Counter-Measure technology and/or process. Steps 21 through 24 are heavily dependent on the use of comprehensive real-time data access and data mining techniques and tools. Steps 25 and 26 utilize the same data mining technical support capabilities but also require the use of the scenario driven decision support tool as do Steps 27 and 28.

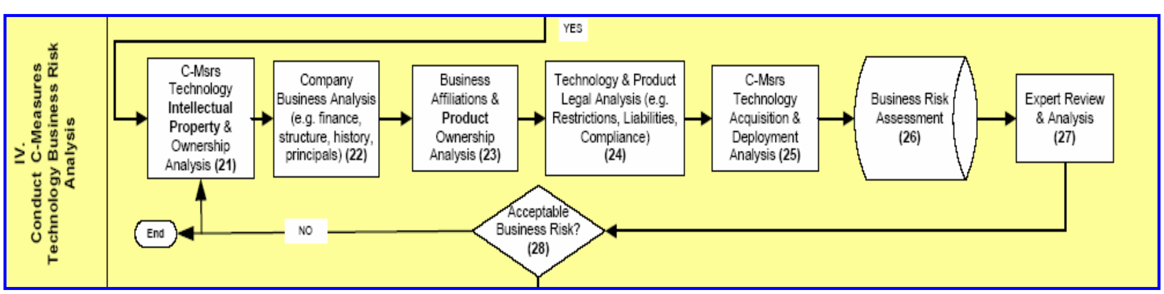


Figure 29 – Phase IV – Steps and Process Flow

Step 21 – Conduct Counter-Measures Intellectual Property and Ownership Analysis.
The technologies, products, and processes are assessed and analyzed from the perspective of the ownership, control, restrictions, conflicts, and liabilities associated with any intellectual property that may be knowingly or inadvertently embodied in the technology or process alternative(s) under consideration.

Work product deliverables may include:
Intellectual Property and Ownership Analysis Report, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics.

Step 22 – Conduct Company Business Analysis.
A comprehensive analysis of the company or companies involved in the development, marketing, manufacturing and ownership of the technology or process solution under consideration will be performed to assess their viability and risks with respect to finances, investments, organizational structure, other resources, management, ownership, legal business issues, market analysis, competitiveness, longevity, sustainability, vulnerabilities and other factors pertinent to the business entity.

Work product deliverables may include:
Company Business Analysis and Risk Assessment Report, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics.

Step 23 – Conduct Business Affiliation and Product Ownership Analysis.
The various business relationships and affiliations of the company providing the technology and/or process solutions will be analyzed with the intent of determining if there are issues or potential risks associated with doing business with the company under consideration due to its business relationships. Specifically, this analysis will also be used to determine if there are any possible conflicts or issues associated with the ownership of the technology or process under consideration.

Work product deliverables may include:
Business Affiliation Analysis Report, Technology/Product/Process Ownership Assessment Report, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics.

Step 24 – Conduct Technology/Product and Process Legal Analysis.
The technology/product or process under consideration will be analyzed with respect to any legal, environmental, contractual, or pending legislative or other restrictions and constraints which would preclude or impede the deployment or operational effectiveness of the technology or process. Cultural and social constraints affecting the use or operation of the technology or process within specific operational scenarios may be considered in this step of the business risk analysis. If there clearly identified legal restrictions or prohibitions that preclude the use of the technology or process within the operational scenario then a decision can me made at this step to terminate further analysis of the technology or process.

Work product deliverables may include:
Technology/Product and Process Legal Analysis Report, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics, Decision Memorandum or other guidance concerning restrictions or prohibitions on the use of a technology/product/process.

Step 25 – Conduct Counter-Measures Acquisition and Deployment Analysis.
A high-level acquisition and deployment analysis will be conducted in order to determine if there are potential issues associated with funding, manufacturing, exporting, importing, or otherwise deploying and sustaining the technology in specified operational scenarios. Preliminary acquisition and deployment approaches may be developed in order to provide alternatives which can be implemented in operational scenarios that must mitigate risks identified in Phase I (or through similar processes), but are constrained by time, funding, technology availability, and other industry and organization business factors.

Work product deliverables may include:
Technology Acquisition and Deployment Analysis Report, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics.

Step 26 – Conduct Business Risk Assessment.
The information and data created in Steps 21 through 25 will be used as the basis for performing the overall risk assessment associated with industry, corporate, legal and other non-technology/product performance factors which determine the level of business risk to further develop, acquire, deploy, operate and maintain a specific technology/product or process solution.

Work product deliverables may include:
Business Risk Analysis Report (with recommendations), Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics.

Steps 27 and 28 – Conduct Expert Review and Analysis and Determine if there is Acceptable Business Risk. After expert review or a Red Team type review of the business risk analysis completed at Step 26, and in consideration of other data and information created in Steps 21 through 25, the decision concerning the acceptable level of business risk must be made. The purpose of this decision is to assure that independent consideration is given to the numerous non-technical performance factors which may ultimately determine the viability of a proposed technology/product solution.

Work product deliverables may include:
Decision Memorandum or other guidance document, Updated/Revised Business Risk Analysis Report, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics.

PHASE V – PERFORM COST BENEFIT & OVERALL RISK ANALYSIS:

The associated Steps 29 thru 33 within Phase V can be performed concurrently with Phases I thru IV or be performed subsequent to Phase IV. In any event, Steps 29 thru 33 should be completed before proceeding with the technology transfer project initiated in Step 34.

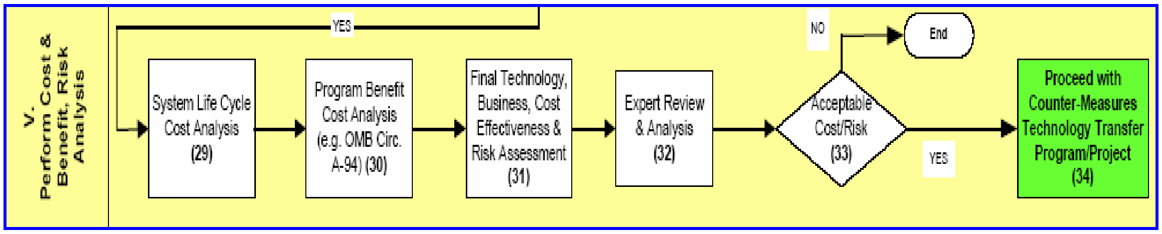


Figure 30 – Phase V – Steps and Process Flow

Step 29 – System Life-Cycle Cost Analysis.
The technology and all associated system costs are identified. The cost analysis and data produced at this step will be provided as an input to the cost-benefit analysis which occurs at the next step. A primary reason for doing the cost analysis at this point is to determine the rough order of magnitude of the required investment absent any other financial or budgetary considerations. Depending on the outcome of the cost analysis and in consideration of other factors at this step, a decision may be made to delay, cancel or modify/adjust the project in some manner.

Work product deliverables may include:
Technology/System Life-Cycle Cost Analysis Report, Alternatives Analysis, Cost Benefit Analysis, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics, Decision Memorandum or other guidance document.

Step 30 – Program Cost Benefit Analysis.
A full cost benefit analysis (CBA) is conducted in accordance with the responsible organizations prescribed or selected methodology. A decision support tool will be used to facilitate the quantification, control, processing and accuracy of the data used in the analysis as well as being used to assure the integrity and reliability of the analysis of the alternatives addressed in the CBA. The global query and data mining capability will be used to provide a comprehensive identification of all quantifiable and non-quantifiable cost factors and benefits that need to be considered in the Analysis.

Work product deliverables may include:
Cost Benefit Analysis Report, Alternatives Analysis Report, Technology and Process Assessment and Selection Criteria Report, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics.

Step 31 – Final Technology Effectiveness, Business Risk, and Cost Benefit Assessment.
Utilizing the data, information and other outputs created during Phases I, II, III and IV, as appropriate, perform a final consolidated effectiveness and risk assessment of the technology/product, processes, business environment, cost, benefits, funding, and other factors that must be considered when making a decision whether or not to proceed with a technology transfer or development and acquisition program. The automated decision support tool may be used to provide comprehensive assessment of the possible alternatives, again, through scenario driven evaluations with additional analytic capabilities provided by the data mining, inference, and risk management applications.

Work product deliverables may include:
Final Effectiveness and Risk Assessment Report, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics, Simulation and Modeling Applications.

Steps 32 and 33 – Expert Review and Determination of Acceptable Cost/Risk and Decision to Proceed. The data, information and other outputs from Step 31, including recommendations, are reviewed and analyzed in order to make a "go" or "no go" decision concerning the technology transfer, development, acquisition, or deployment project. Both the decision support tool applications and global data mining and query/search capabilities may be used support the analysis and decision making process. The decision at Step 33 effectively ends the technical analysis and risk assessment of the technologies and/or processes. Step 34 essentially begins a separate related project or other initiative.

Work product deliverables may include:
Decision Memorandum or other guidance document, Updated/Revised Database and Inventory of Technology and Best Practices Alternatives, Updated/Revised Decision Support Tool Applications and/or spreadsheet risk reports/tables/graphics, Update/Revise other documents from previous Phases and Steps, as required.

Step 34 - Proceed with Technology Transfer Project.
Initiate technology transfer/development/acquisition process or program or other applicable programmatic initiative.

Work product deliverables may include:
Project Plan, Project Management Plan,etc.

CDRL A005
Conference Report

1 Introduction

2 International & Interagency Coordination

Working with the appropriate Spanish and NATO officials assured successful coordination and collaboration of the conference. It also ensured that the technology presented at the conference was within NATO operational and technical requirements. This collaboration and incorporation of the DAT requirements, facilitated the maximum technical output from NATO members, Mediterranean Dialogue and Partner for Peace countries..

2.1 NATO

2.1.1 Armaments Directorate/ACT/RTO

Armaments Directorate

Under authorization from TSWG, The International Institute worked closely with the NATO Armament's Directorate in order to better achieve US, NATO and Spanish objectives for the event. This coordination allowed for the International Institute to quickly respond to the immediate need to provide C-IED program management support to Spain. This also enabled the International Institute to capture NATO requirements including technology identification, analysis, demonstration and transition support for NATO Counter IED Capabilities. The 14 September 2006 Kick-off Meeting in Brussels (Figure 21) further solidified these relationships providing for clear communication throughout the conference process.

Figure 31 – NATO Kick-Off Meeting

NATO Allied Command Transformation

The International Institute conducted multiple meetings with the NATO Allied Command Transformation (ACT) to identify existing initiatives and build upon synergetic efforts for the future. Based upon these meeting and input from ACT staff, the International Institute was able to incorporate integration and interoperability capabilities in the selection and final assessments of the technology.

NATO Research Technology Organization

Interagency collaboration with NATO Research Technology Organization (RTO) was essential in the analysis of the data and technology presented at the conference. Given that the conference was on stand-off detection, existing NATO studies and analysis were utilized to identify topics of interest and panel members. RTO also provided the International Institute with relevant POC's pertaining to the conference's specific subject matter. This RTO POC database was applied in the conference distribution list. The RTO information ensured that the appropriate industry, academia, scientific and operational experts were invited to participate in the conference. RTO also assisted in providing releasable DAT POW data, specifically CIED studies and analyses performed. Upon review of RTO materials, International Institute CIED engineers mapped those NATO RTO guidelines for the conference demonstrations addressing the IED "kill chain" elements (Figure 22) which were utilized in conference demonstrations and International Institute technology assessments.

TECHNOLOGY ASSESSMENT

C-IED TECHNOLOGY AREAS	PREDICTION	DETECTION	PREVENTION	NEUTRALIZATION	MITIGATION
1. Test Methods– Personnel Protection					✓
2. Test Methods– Protect Vehicle Occupants			✓		✓
3. Criteria/Test Methods – Injury Assessment (Veh)			✓		✓
4. Multi-Robot Sys in Military Domain		✓	✓	✓	
5. Military Application Multi Robot Systems		✓		✓	
6. HPM Threat to Infrastructure Military Equipment		✓	✓		✓
7. Military Sensing	✓	✓			
8. Complementarity of LADAR & Radar	✓	✓			
9. Ground Target– Auto Radar Recogn.	✓	✓			
10. Robust Acq. Of Relocatable Targets Using MMM Sensors	✓	✓			

NATO UNCLASSIFIED BRIEF

Figure 32 – IED "Kill Chain" Elements

TECHNOLOGY ASSESSMENT

C-IED TECHNOLOGY AREAS	PREDICTION	DETECTION	PREVENTION	NEUTRALIZATION	MITIGATION
11. Short-term Realisible Multi-Robot Systems in Mil Domain	✓	✓	✓	✓	✓
12. Eng. Corps Tech/Countermining		✓	✓	✓	
13. Tactical Implications of HPM	✓	✓	✓	✓	
14. HPM Threats to Infrastructure Mil Equip		✓	✓	✓	
15. Countermining Tech		✓	✓	✓	
16. Enabling EW Sys Technologies – 2010 +		✓	✓	✓	
17. N-Dimension Eye Safe LADAR Imaging		✓	✓	✓	
18. HP Passive MM Wave Imaging		✓	✓	✓	
19. Solutions for Radar Multi-Parameter Prob		✓			
20. Recog Dynmic/Static Targets Using MMW&RF	✓	✓	✓	✓	

NATO UNCLASSIFIED BRIEF

Figure 32 – IED "Kill Chain" Elements (Cont.)

2.2 Spanish Ministry of Defense

The cooperation between the Spanish Ministry of Defense and the International Institute is a crucial element in the coordination and preparatory proceedings of the conference. The limited time constraints called for rapid action to enhance the level of scientific and military expertise of the conference. Beginning in July of 2006, the International Institute began to communicate and coordinate with the Spanish Ministry of Defense through the office of DGAM/NATO/CNAD. Upon finalization of the TSWG Contract in September 2006, cooperation began to further develop. The International Institute attended meetings from September 11 – 20 in both Madrid and Brussels.

The preparatory meetings in Madrid led to the formation of Basic Lines of Agreement between the Spanish Ministry of Defense and the International Institute (**Appendix B**). Cooperation was aimed to enhance the level of the global scientific, industrial and governmental institutions/specialists/technologies participating in the event. Specific emphasis was placed on incorporating Russian and Israeli technologies. Both parties also worked together to prepare a plan to continue the promotion of C-IED technologies during 2007. This cooperation also included working together to achieve the CNAD goals under the guidance of their respective NAD offices.

The identified detail tasks of cooperation included registration, participant information management, technology assessment, conference execution and reporting. These tasks will be further discussed throughout the report.

The limited time constraints and different geographical locations of the International Institute and Spanish Ministry of Defense required strategic forms of cooperation. International Institute staff was placed on site at the Spanish Ministry of Defense to assist in logistical and preparatory support. The Spanish language skills of the International Institute team also facilitated communication between the two parties. The International Institute staff also assisted in Spanish to English translations and was instrumental in official communication with conference participants. Future efforts are planned for upcoming NATO Counter-Terrorism Development Programme Demonstration, currently planned for Ankara Turkey.

Along with having International Institute staff on-site, daily conference calls between the International Institute and the Spanish Ministry of Defense contributed to effective and rapid communication. Email correspondence was also a critical element in making sure that both parties were up to date with the conference preparations.

3 Conference Management

3.1 Conference Agenda

Prior to the conference, the agenda was continuously updated to reflect the ongoing modifications including names of speakers, panelists and exhibitors. The International Institute worked to ensure that the most relevant panelists, exhibitors and demonstrators would attend and present at conference. Communication between the Spanish MOD and the International Institute was a critical element in the successful ongoing updates to the agenda as well as its final publication.

Close coordination with TSWG management and NATO Armaments Directorate enabled the International Institute to fully support the Spanish Mission. The International Institute guided Spain to the conference attendees, panel members, exhibitors and demonstrators. Coordination with panel members regarding the Conference Program required close coordination with the Spanish team. Given that the conference was specifically focused on the areas of standoff detection the International Institute engaged in identifying, selecting and contacting the experts from industries and institutions to present their programmes and discuss with other experts the benefits of the solutions proposed. The International Institute rapidly responded to a short timeframe to conduct this project. Upon governmental approval of the subjects, speakers and demonstration activities the International Institute and the Spanish MOD finalized the Conference Agenda. Specific timelines and activities of the Agenda can be found in 5.1.1.

3.2 Call for Presentations/Papers

Prior to the Call for Papers, the Spanish MOD and International Institute established 5 panel sessions to organize the conference. The Spanish MOD and International Institute worked together to identify presenters, exhibitors and demonstrators within each topic. The International Institute contacted potential presenters, exhibitors and demonstrators to solicit their participation. Once participation was ensured, the International Institute and Spanish Ministry of Defense requested papers and presentations from the specific panelists selected to present at the conference. Upon review and final approval of their presentation topics, the panelists information and abstracts were added to the Conference Agenda.

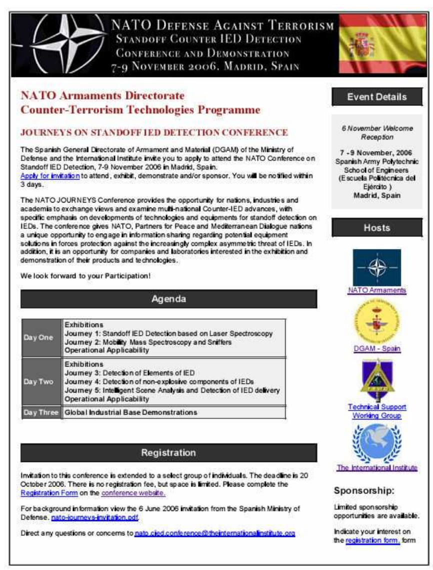
3.3 Registration and Database Management

The registration process was a joint effort between the Spanish MOD and The International Institute. The International Institute developed an on-line registration form and website, see snapshot below, that provided the NATO approved and Spanish MoD conference invitation letters. The Spanish MOD was ultimately authority for attendance. Jointly, the team managed an interactive database of conference attendees and participation level.

Spanish officials distributed the conference invitation to the following International Distribution List: NAAG Chairman, NIAG Chairman, IS/DI Head of Armaments Section, IS/DI CTTU Head and Attendees to the 12th May 2006 IEDs Coordination meeting. The Invitation was also distributed internally to the SDG Technology Centers, EMACON DIVLOG, AFARMADE, National Group of Coordination. As of September 2006, registration was minimal with less than 30 conference attendees. These issues were addressed at the Spain MOD/International Institute meetings the week of September 11 -15, 2006. Spanish MOD Officials requested International Institute assistance regarding this matter. The International Institute acted rapidly employing its team to establish a Conference Management System and identify the appropriate conference attendees. Within a short period, registration increased from 30 to 140 participants and was limited solely because of the size constraints of the selected conference site.

The International Institute was responsible for promoting the conference, and managing correspondence with attendants. To this end, The International Institute created a conference website and bulk email promotion that are detailed in the next section (Section 3.6 – Conference Website). The International Institute maintained contact with panelists, exhibitors and demonstrators via telephone and email. Give the limited time constraints, communication was a crucial element in bringing the key law enforcement personnel, policy makers from key governments and scientific expertise to the conference.

3.3.1 Conference Website



As part of the outreach strategy and to ensure expeditious processing of information, the Institute created a conference website and corresponding mass email campaign. The mass email promoted the conference and pointed recipients to the conference website where they could complete an online registration form to indicate their interest in attending. Correspondence with potential attendants was managed via emails and phone calls. The International Institute worked with the Spanish Ministry of Defense to correspond with and select attendants.

The conference website was used to disseminate logistical information to guests including:

- Event Location
- Hotels & Reservation Information
- Bus transportation logistics
- Frequently Asked Questions
- Information for Exhibitors about equipment and setup procedure

For security reasons, the mass email campaign was designed so that no recipient could see any other recipient's email addresses. This was an important considering the email was sent to over 1,000 recipients.

3.3.2 Conference Management System

The International Institute developed an online Conference System to expedite correspondence and registration with exhibitors, presenters and attendants. The Conference Management System was instrumental in dealing with logistical issues and participant status. It also was helpful in recording issues, action items and correspondence. The International Institute was able to document these various issue and provide the information to the Spanish MOD. The International Institute provided the Spanish MOD with login information so that they could also utilize the system.

Through the Conference Management System, the International Institute was able to manage the contact information and volumes of presentation data for participants.

4 Logistics Support

4.1 Transportation

The International Institute was responsible for selecting and organizing the bus transportation services during the conference. The shuttle company Autocares M. del Moral was contracted on November 7 and 8, 2006 to provide this service. Arrangements were made for two shuttle buses, each with space for 50, to pick up conference attendees from Hotel Orense and Hotel Gran Atlanta and transport them to the La Escuela Politecnica Superior del Ejercito. Transportation was also available to attendees from La Escuela Politecnica Superior del Ejercito to Hotel Orense and Hotel Gran Atlanta after conference proceedings. On November 9, the day of Demonstrations, transportation was provided by the Spanish Ministry of Defense. Conference attendees were transported by three shuttle buses from Hotel Gran Atlanta, Hotel Orense and the La Escuela Politecnica Superior del Ejercito to Academia de Ingenieros in Hoyo de Manzanares.

4.2 Accommodations

The Hotel Orense and Hotel Gran Atlanta were presented to guests as the two official options for Hotel accommodations during the conference. Through an agreement with these two hotels, attendants were able to take advantage of a reduced rate. Additionally, attendants were able to use the bus transportation provided, which serviced these two hotels directly.

4.3 Video

The Spanish Ministry of Defense was responsible for making arrangements for a video of the conference. Abalos Sistemas Audiovisuales was contracted to record and produce the video. Abalos was also contracted to rent microphones and run the sound system during conference proceedings.

5 Conference Execution

5.1 Program

5.1.1 Agenda

The conference program was designed around the 5 panel discussions featuring Stand-off Detection capabilities. The agenda included bio and background information regarding the panel chairs, presenters and short abstracts of the presented material. Each panel was followed by a discussion session addressing the specific issues and concerns of the specific subject matter.

NATO Defence Against Terrorism
Journeys on Standoff IED Detection

Day One 7th November	
8:30 to 9:00	Arrival and accreditation of Participants.
9:00 to 9:20	Welcome and opening of the Conference Sessions – **Gen. Jose L. Ceballos** - Underdirector for International Relations – Spain MoD Opening remarks by **Ms Mary Ungar** (The International Institute)
9:20	Administrative remarks
Panel 1: IED Detection based on Laser Spectroscopy	
9:30	Introduction by the Panel Chair : **Dr. Javier Laserna** (Málaga University) *Spain*
9:40-10:00	**Dr. Gerhard Holl** (WIWEB) *Germany* "Trace Detection of Explosives with LIBS"
10:00-10:20	**Mr. Carlos de Miguel** (INDRA Systems) *Spain* "Standoff Trace Detection with LIBS"
10:20-10:50	Coffee Break in the Exhibition Room
10:50-11:10	**Dr. Wolfgang Schade** (Technische Universitat Clausthal) *Germany* "Fibre coupled LIBS Sensor"
11:10-11:30	**Mr. George Coyle** (Northop Grumman Corporation) *United States* "Infra –Red Spectroscopy"
11:30-11:50	Discussion
12:00	Lunch
13:15	Opening of Exhibition
Panel 2: IED Detection Based On Molecular Detection	
14:00	Introduction by the Chair: **Dr. José Pedro Santos Blanco** (RAMEM) *Spain*
14:10-14:30	**Mr. Tim Corcoran** (presenting for Andrei Miziolek/ARL) *United States* "ST-LIBS: A Promising New Tool for Trace Explosives & Other Hazards Detections at a Distance"
14:30-14:50	**Mark Carl Meyer** (CEIA) *Italy* "Detection of Flammable Explosive Liquids Concealed in Commercial Liquid Containers"

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NATO Defence Against Terrorism
Journeys on Standoff IED Detection

14:50-15:20	Coffee Break in the Exhibition Room
Panel 2: IED Detection Based On Molecular Detection (continued)	
15:20-15:40	**Mr. Gonzalo Fernandez de la Mora** (SEADM) *Spain* "Aroma: Serial DMA/AF Detector"
15:40-16:00	**Mr. Miguel Sanchez** (RAMEM) *Spain* "NEDS New Explosive Detection System"
16:00-16:20	**Mr. Krister Liljegren** (Environics OY) *Finland* "Detection of Peroxide Based Explosives and Their Precursors by Chemical Handheld Detector"
16:20-16:50	Discussion
16:50 -17:10	**Lt. Col Alexander Zolotukhin** (Ministry of Defense) *Russia* "Russian Experience of IEDs"
End of first day	
Day Two 8th November	
Panel 3: Detection of Concealed IEDs	
9:00 – 9:10	Introduction by the Panel Chair: **Mr. Ian Raitt** (Delt Fort Halstead) *United States*
9:10-9:30	**Mr. Roger Appleby** (QinetiQ) *United Kingdom* "Detecting IEDs Under Clothing"
9:30-9:50	**Mr. Michael Kemp** (Iconal Technology, Ltd) *United Kingdom* "High Frequency Inspection"
9:50-10:10	**Mr. Lucas van Ewijk** (TNO Defense, Security & Safety) *The Netherlands* "Concealed Weapon Detection"
10:10-10:30	**Dr. Jonathan James** (Thruvision, Ltd.) *United Kingdom* "Deployable Standoff Screening"
10:30-10:50	**Dr. Arnold Schoolderman** (TNO Defense, Security & Safety) *The Netherlands* "Polarised Light Cameras : A tool to detect IEDs"
10:50-11:10	Discussion
11:10-11:30	Coffee Break in the Exhibition Room
11:30-11:50	**Mr. V Patrick Adrounie** (Lockheed Martin Corporation) *United States* "Integrated IED Detection Architecture"

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Figure 33 - Conference Agenda

5.2 Participants

5.2.1 Attendees

The International Institute endorsed TSWG and Spain's concept that the conference would be a working-level gathering for industry, scientific and operational communities. The International Institute ensured that most conference attendees contributed in some way to conference whether as a presenter, exhibitor or demonstrator.

It was also agreed that non-participating observers were only able to attend subject to space availability. Overall, the attendees of the conference were comprised of a multi-national crowd including experts from governments and industry of NATO, PfP and MD countries. In addition to the Armaments Directorate participation, specialists from several NATO bodies such as ACT, NC3A and RTA attended complementing the synergetic efforts in the fight against terrorism.

Table 12 - List of Participants

Name	Organisation	Country
V. Patrick Adrounie	Lockheed Martin Corporation	USA
Orkun Agiroglu	As an observer for Turkish MND	Turkey
Hasan Akkoc	Turkish Contigency	Turkey
Roger Appleby	QinteiQ	UK
Reyes Arevalo Tobajas	Jefatura de Investigación y Análisis de Ingenieros (Dirección de Investigación y Analisis-MADOC)	Spain
Jose Ramón Armada Mz De Campos	Spanish MoD	Spain
Yossef Bar	SNRC	Israel
Alexey Baronin	Ministry of Defence	Russia
David Beckett	TRL/L3	UK
Peter Benwell	Allen Vanguard	UK
Slawomir Berdak	Engineering Department, General Staff of Polish Armed Forces	Poland
Cedric Berthome	MOD - DGA	France
Taoufic Bouayoun	Gendarmería Real	Morocco
Todd Brethauer	TSWG	USA
Vance Briggs	Autonomy LLC	UK
Fernando Briones Fernandez-Pola	RAMEN	Spain
Matthew Daniels Brooks	Explosives Detection Group	UK
Bernard Brower		USA
Ulrich Brozowski	NATO, ACT	Germany
Oleksandr Burdiian	Agregados de Defensa de Ucrania	Ukrania
David Burke	National Defence Headquarters	Canada
Vladimir Byvaltsev	Federal State Unitary Enterprise " ROSOBORONEXPORT"	Russia
Antonio Carbonari	United States Marine Corps	USA
Andrea Cavallero	University of London	UK
Francesco Colao	ENEA	Italy
Tim Corcoran	The International Institute	USA
George Coyle	Northrup Grumman	USA
Fernando De La Torre	Carnegie Mellon University	Spain
Carlos De Miguel Gi	INDRA Systems	Spain
Olcay Denizer	Turkish General Staff	Turkey
Giedrius Dvilaitis	Lithuania Army Land Forces Engineer Battalion	Lithuania
Arunas Dzidzevicius	Lithuania Army Land Forces Engineer Battalion	Lithuania
Paul Henry Eisenbaun	Excellims	USA
Zvi Eyal		Israel
Gonzalo Fernandez De La Mora	Sociedad Europea de Analisis Diferencial de Movilidad (SEADM, SL)	Spain
José A. Ferrer Garcia	Centro EOD del Ejercito del Aire	Spain

Stefano Francesconi	Stato Maggiore dell´Esercito - Reparto Logistico	Italy
Rafael Gallego Lorenzo	Jefatura de Investigación y Análisis de Ingenieros (Dirección de Investigación y Analisis-MADOC)	Spain
Gerardo Gallegos Garcia	Spanish MoD	Spain
Francesco Giannatiempo	Stato Maggiore Dell´esercito Reparto Logistico	Italy
Guillermo Gonzalez Muñoz De Morales	Spanish MoD	Spain
Alexander A. Gurvich	Federal State Unitary Enterprise " ROSOBORONEXPORT"	Russia
Markus Hanke	General Electric Global Research Europe	Germany
Matt Harden	TSWG	USA
Erin Hardmayer	US Army Armament Research and Development Center	USA
Michael Haygarth	United Kingdom MOD, Joint EOD & Research Staff Baranch	UK
Francisco Javier Hernandez Crespo	INDRA Systems	Spain
Gerhard Holl	WIWEB	Germany
Jennifer Hubbard	JIEDDO	USA
Vincent Hubert	Giat Industries	France
David Humphrey	Virage Security & Surveillance	UK
Robert Ijsselstein	TNO Defence, Security and Safety	The Netherlands
Renald Ilyushchenko	"EMC-1 (" Ltd STT-Group")	Russia
Jonathan James	THRUVISION LTD.	UK
Jose Antonio Jimenez Lorenzo	Servicio de Desactivación de Explosivos G.C	Spain
Rami Katav	Israel MOD, R&D Directorate,Land System Division	Israel
Kevin Kearney	GeoSpatial Systems	USA
Michael Kemp	Iconal Technology Ltd	UK
Krassi Kouzmanov	Counter-terrorism Technology Unit, NATO IS/DI (ARM-JAS)	Bulgaria
Leendert Lagerwerf	Army Taskforce for Countering-IED´s	The Netherlands
Marian Langford	Detection 4 Security	UK
Nicolas Langhorne	US Office of Naval Research	UK
Javier Laserna	Universidad de Malaga	Spain
Philippe Le Carff	NATO HQ SACT	USA
Michel Lefebre	Royal Military Academy	Belgium
Jorge Lega De Benito	Spanish MoD	Spain
Nikolay Likhachev	Federal Security Service of the Russian Federation	Russia
Krister Liljegren	ENVIRONICS OY	Finland
Patricia López Vicente	Spanish MoD	Spain
Tom Luders	EADS Defence and Security Systems	Germany
Murat Mala	Turkish General Staff	Turkey

Luca Manneschi	CEIA SPA	Italy
Alessandro Manneschi	CEIA SPA	Italy
Jeremy Mansfield	National Defence Headquarters	Canada
Capitan Juan Marín	Spanish MoD	Spain
Jorg Mathieu	Armasuisse,Science + Technology, MOD Switzerland	Switzerland
Tim Mckay	Land Operations Division	Australia
Mark Karl Meyer	CEIA USA LTD	USA
William Miceli	U.S. Office of Naval Research Global	USA
A. Fenner Milton	Nigth Vision & Electronic Sensors Directore	USA
Carlos Miró Fernández	Cuerpo Nacional de Policia	Spain
Ronald Molway		USA
Virginia Morlock	Northrup Grumman	USA
Vladimir Nemirovskiy		Russia
Luis Fernando Nuñez Allué	Centro Internacional de Desminado	Spain
Patricia O´reilly	US Army Armament Research and Development Center	USA
Helmut Oppenheim	Ministry of Defence	Austria
Fredy Ornath	TRACE GUARD	Israel
Ercan Oruc	Turkish General Staff	Turkey
Ralph Pasini	The International Institute	USA
Anatoly Perederiy	Federal Security Service of the Russian Federation	Russia
Krasimir Pingelov		Bulgaria
Iñigo Prado		Spain
Ian Raitt	Delt Fort Halstead	UK
Avi Ravid	Soreq NRC	Israel
Angel Romo Carrasco	Cuerpo Nacional de Policia	Spain
Juan Rosillo Parra	Centro Internacional de Desminado	Spain
Pedro Carlos Ruiz Ruiz	DGAM SP MoD	Spain
Miguel Sanchez Martin	RAMEM	Spain
Jorge Sánchez Martínez	Spanish MoD	Spain
José Pedro Santos Blanco	RAMEM S. A	Spain
Wolfgang Schade	Technische Universitat Clausthal, Instit fur Physik	Germany
Itzhak Schnitzer	Armament Development Authority Ltd.	Israel
Tim Schofield	ImageBase Technology Ltd	UK
Arnold Schoolderman	TNO Defence, Security and Safety	the Netherlands
Valery Semin	Federal Security Service of the Russian Federation	Russia
David Sexton	Bomb Removal Squad	Ireland
Noam Shaffir	Soreq NRC	Israel
Paul Ralph Shelly	ITT	USA
Joachim Sigmund	Federal Ministry of Defence-Armaments Directorate	Germany
Sergey Silantiev	Federal Security Service of the Russian Federation	Russia

Evgeny Svobodin	RS Military Mission to NATO	Russia
Adam Vicent Tarsi	TSWG	USA
Thomas Tate	US Army International Technology Center-Atlantic	USA
Charles Taumoepeau	Joint IED Defeat Organization	USA
Alexander Terehov	Federal Service of the Russian Federation on Armaments Coorperation	Russia
Christoph Thelen	Federal Office of Defense Technology and Procurement (BWB)	Germany
Vladimir Tkach	"EMC-1 (" Ltd STT-Group")	Russia
Antonio Torres Díaz-Malaguilla	Spanish MoD	Spain
Michael Troffer	Naval Explosive Division	USA
Peter Tu	General Electric	USA
Mary Ungar	The International Institute	USA
Lucas Van Ewijk	TNO Defence, Security and Safety	The Netherlands
Diego Villanueva Cuenca	Centro Internacional de Desminado.	Spain
Sarah Wallin		Sweden
Graemp Woodhouse	Explosives Detection Group	UK
Arik Yakuel		Israel
Alexander Zolotukhin	Ministry of Defence	Russia

5.2.2 Panelists

Panelists approved to present at the conference underwent a selection and approval process to assure the most appropriate subject matter and technology experts. The International Institute, in full cooperation and approval from Spain MOD, immediately began to contact prospective panelists and solicit their interest in presenting at the conference. The panelists represented 10 different countries including: Spain, Germany, United States, United Kingdom, Finland, Russia, Italy and The Netherlands. The presentations facilitated meaningful discussions while establishing the foundations for important relationships between key individuals in the fight against terrorism. A list of panelists and their respective presentations can be found in Table 1.

5.2.3 Exhibitors

The exhibitors displayed their technologies in the exhibition hall outside of the conference room. The International Institute facilitated the rental of the necessary equipment for the exhibition companies. This logistical support was very helpful as many of the companies faced time and export restraints in bringing their products and supporting materials. The Agenda included daily break-out sessions to enable conference participants to visit the exhibition room. These interactions proved to be valuable allowing the key individuals to visit exhibitions and interact with NATO, nations and respective industry representatives. The coffee breaks facilitated these interactions and provided an environment conducive to interaction for all conference participants. A list of the exhibitors and their products can be found in Table 2.

5.2.4 Demonstration

The Demonstration took place on 9 November 2006 at the International De-mining Training Center (Centro Internacional de Desminado) in Hoyo de Manzaneres outside of Madrid. Transportation to the demonstration site was provided by the Spanish MOD. Time constraints producing logistical complications and export restrictions limited the scope and size of the demonstrations. A list of the demonstrations can be found in Table 3.

5.3 Additional Outreach Efforts

5.3.1 VIP Host Dinner

General A Cieza Gonzalez and General Jose Luis Ceballos Porras were invited with LTC Martinez Candela and his team to join TSWG, JIEDDO and International Institute executives to strengthen relationships for host and sponsors.

5.3.2 Welcome Reception

A pre-conference welcome reception was hosted by The International Institute at the Hotel Orense. The reception featured Spanish cuisine and a traditional flamenco guitar player.
The welcome reception provided a unique opportunity for conference attendants to engage in meaningful dialog prior to the conference opening. It was an excellent idea as it achieved the intended goal of creating familiarity amongst the conference attendants. This event set a positive atmosphere for the Conference week.

5.3.3 Nations Luncheon

Spain MOD requested for the International Institute to host Conference Luncheon on 7 November 2006 with 25 participants, due to space constraints at luncheon facility. Luncheon logistics were executed and invitations were distributed to 25 government officials representing 16 NATO countries. This luncheon created an open atmosphere that fostered a basis for international and interagency cooperation and collaboration. Prior to lunch, the International Institute provided opening remarks and then opened the floor for individual introductions from government individuals engaged in their nation's effort to defeat CIEDs. A list of the luncheon attendees can be found in Appendix C, Form 3.

5.4 Conclusions

5.4.1 Task Order summary

The work was organized to assure maximum technical input from NATO members and partners that receive the most comprehensive and relevant information concerning effective counter measures to Improvised Explosive Devices and the IED "delivery/kill chain." The identification, assessment and review of regional technical expertise in combating terrorism has also increased the breadth and depth of information enhancing CTTSO's ability to develop and transition technologies to the warfighters and first responders its supports.

The International Institute provided conference coordination, planning, demonstration execution, feedback mechanisms and other capabilities to assure the successful performance of the NATO IED Conference. Conference planning and logistics support was provided as well as the tasks of identifying IED technologies, the development of the IED Conference agenda, selection of demonstration technologies/products and selection of the conference briefing topics and speakers.

The International Institute prepared a Final Conference Report, documenting the results of the technology assessment and conference, including a synopsis and timeline of the demonstration, as well as a list of all participants, their home country and organization. Spain MOD produced and delivered the video recording of this event and CD disk of presentations.

This Final Report meets task order requirements, and provides a summary of the task order, lessons learned and recommendations for the future. The successful completion of Task Order 0001 has also established important international and interagency collaboration fostering future relationships while also improving the visibility of TSWG to NATO, NATO- member countries and Mediterranean Dialogue countries; thereby increasing TSWG's base of potential technology developers.

6 Lessons Learned

6.1 Advanced Planning for Premier Technology Participation

The initial invitation was issued by the Spanish MOD on 30 June 2006. The International Distribution List was to: NAAG Chairman, NIAG Chairman, IS/DI Head of Armaments Section, IS/DI CTTU Head and attendees to the 12^{th} May 2006 IEDs Coordination meeting. Spain's Internal Distribution was to: SDG Technology and Centers, EMACON DIVLOG, AFARMADE and the National Coordination Group. After the initial distribution, registration forms were sent to the organizational department head that expressed interest via email in attending the conference. Follow-up therefore did not take place and as of 1 October 2006 only 13 confirmations from a small number of NATO Nations were received and no speakers/panelist had been scheduled.

The International Institute was tasked to bring more participants, presenters, exhibitors and demonstrators to the conference. The International Institute successfully engaged the participation of over 130 individuals, and over 22 countries. Given the limited time frame, technological contributions were limited due to a number of factors, religious holiday, export control issues, pre-booked schedule etc. The development and utilization of an International Institute conference management system was a crucial element in rapidly contacting potential conference participants and recording their current status/security information, etc.

Recommendation 6.1: *Ensure notification process is well thought-out and advanced planning is performed and targeted at specific user communities.*

6.2 Close Cooperation with Host Nation

Spain MOD and International Institute cooperation was critical to the successful performance of the Standoff CIED Detection Conference in Madrid. Close coordination with Spain and the NATO Armaments Directorate enabled the International Institute to capture requirements for the event. The close cooperation, on-site International Institute staff assistance and daily conference calls between the two parties greatly developed the relationship while also establishing significant foundations for future collaboration regarding CNAD IPT Initiatives. The Basic Lines of Spain – USA Cooperation on the NATO/CNAD CIED Initiative highlights this partnership and lays the foundations for future cooperation in the promotion of C-IED technologies during 2007. Close cooperation with Spain served the NATO DAT objectives in their efforts to develop an overarching international strategy for the defence against terrorism and bring the necessary industry counterparts to the conference. The conference, therefore, served as a functional partnership forum in which specific areas of cooperation were established as a means toward on-going dialogue and collaboration in the fight against terrorism.

Recommendation 6.2: *Formalize host nation support with clear roles and responsibility. Formalize NATO relationships to obtain interagency support.*

6.3 Participant Approval Process

Given the limited time, size of the facility and nature of the very specific subject matter the Spanish MOD stated that conference participation was for experts in the specific subjects of discussion. The conditions surrounding the participant approval process were not as clear as needed.

Recommendation 6.3: *Define "rules of engagement" approval process and audience. Set boundaries in writing to ensure all parties are aware of constraints.*

6.4 Logistics

Spain made it clear in initial invitation that hotel reservations were the responsibility of conference participants. Providing more information about other options for hotel accommodations is necessary to ensure all participants have accommodations. IT is recommended that transportation to and from the designated facilities from Participants be factored into pre-planning activities. A clearer definition of logistical responsibilities and costs would have eased this process. Automating registration and approval process and managing information on-line is a lesson learned and recommendation for future efforts. Effective security measures and database security protocols must be in place to manage sensitive data.

Recommendation 6.4: *Ensure notification process is well thought-out and advanced planning is performed and targeted at specific user communities.*

Appendix A – NATO Technology Readiness Level

NATO Technology Readiness Level		Description
0	Basic Research with future Military Capability in mind	Systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and /or observable facts with only a general notion of military applications or military products in mind. Many levels of scientific activity are included here but share the attribute that the technology readiness is not yet achieved.
1	Basic Principles Observed and Reported in context of a Military Capability Shortfall	Lowest level of technology readiness. Scientific research begins to be evaluated for military applications. Examples of R&T outputs might include paper studies of a technologies basic properties and potential for specific utility.
2	Technology Concept and / or Application Formulated	Invention begins. Once basic principles are observed, practical applications can be postulated. The application is speculative and there is no proof or detailed analysis to support the assumptions. Example R&T outputs are still mostly paper studies.
3	Analytical and Experimental Critical Function and/or Characteristic Proof of Concept	Analytical studies and laboratory/field studies to physically validate analytical predictions of separate elements of the technology are undertaken. Example R&T outputs include software or hardware components that are not yet integrated or representative of final capability or system.
4	Component and/or Breadboard Validation in Laboratory / Field (eg ocean) Environment	Basic technology components are integrated. This is relatively low fidelity compared to the eventual system. Examples of R&T results include integration and testing of ad hoc hardware in a laboratory/field setting. Often the last stage for R&T (funded) activity.
5	Component and/or Breadboard Validation in a Relevant (operating) Environment	Fidelity of sub-system representation increases significantly. The basic technological components are integrated with realistic supporting elements so that the technology can be tested in a simulated operational environment. Examples include high fidelity laboratory/field integration of components. Rarely an R&T (funded) activity if it is a hardware system of any magnitude or system complexity.
6	System / Subsystem Model or Prototype Demonstration in a Realistic (operating) Environment or Context	Representative model or prototype system, which is well beyond the representation tested for TRL 5, is tested in a more realistic operational environment. Represents a major step up in a technologies demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory/field environment or in simulated operational environment. Rarely an R&T (funded) activity if it is a hardware system of any magnitude or of significant system complexity.
7	System Prototype Demonstration in an Operational Environment or Context (eg exercise)	Prototype near or at planned operational system level. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in a relevant platform or in a system-of-systems. Information to allow supportability assessments is obtained. Examples include extensive testing of a prototype in a test bed vehicle or use in a military exercise. Not R&T funded although R&T experts may well be involved.
8	Actual System Completed and Qualified through Test and Demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of Demonstration. Examples include test and evaluation of the system in its intended weapon system to determine if it meets design specifications, including those relating to supportability. Not R&T funded although R&T experts may well be involved.
9	System Operationally Proven through Success –ful Mission Operations	Application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation and reliability trials.. Using the final system under operational mission conditions.

Appendix B

Basic Lines of Cooperation

BASIC LINES OF SPAIN-USA COOPERATION ON THE NATO/CNAD CIED INITIATIVE

(TSWG ref. GC-06-00368 and ESP NADREP letter date 06-09-2006)

Memorandum for the Logistics Tasks for the Journey´s on IEDs Standoff Detection.

Madrid 7-9 November 2006

General.- The cooperation of Spain and the USA for the preparation of the event will take place through the office of DGAM/NATO/CNAD (DGAM) and The International Institute of Homeland Security, Defence and Restoration (The International Institute). This NATO event includes participation from NATO, Partners for Peace (PfP) and Mediterranean Dialogue (MD) countries. The cooperation is aimed to enhance the level of the global scientific, industrial and governmental institutions/specialists/technologies participating in the event. To strengthen the C-IED capabilities, specific emphasis will be placed on incorporating Russian and Israeli technologies. In particular, the International Institute is requested to coordinate the participation of the C-IED scientific and industrial base in the USA.

Preparation Tasks.-The identified detail tasks of cooperation relating to registration, participant information management, technology assessment, conference execution and reporting are provided below.

DATA COLLECTION: For collection of the data and in order to avoid confusion, the invitation, registration documentation and database structure will be used. The DGAM will provide the International Institute with the registration database to handle the data. Any party can propose changes to the database which will be implemented simultaneously to ensure full systems interoperability and data exchange. *Before 10 October 2006 the two parties will join to collate the global data and produce the final list of participants.*

PARTICIPANTS: For the promotion of the event and selection of participants, the criteria in the original invitation will apply. Contributions, exhibitions and demonstrations directly dealing with the topic of the Journey's headlines will take precedence. Indirectly related technologies will be considered when the applications are collated. The limit of 100 attendees to the conferences and a maximum of 120 attendees to the demonstrations will be respected. If need be national representations will be limited. The details of the tasks will be directly and dynamically agreed between the two parties. The organization of parallel events will not obligate the Spanish MoD other than for distributing at the meeting information provided by organizers. *The goal will be to produce by 13 October 2006 the fixed list of contributors and participants in every journey.*

ROUND TABLES: The list of individuals that will be invited by the Armaments Directorate of Spain MOD to chair the four round tables will be decided before the 30 September 2006. *The two parties will meet prior to the 15 October 2006 to determine the resources needed for conducting the event.*

AUTHORIZATIONS: It is clear that it is of the full responsibility of the participants to obtain the required authorizations from their country authorities, in order to make available the material/data needed for the conferences, exhibition or demonstrations. The International Institute and DGAM will facilitate to the possible extent the resolution of administrative processes to ensure the availability of items needed for the event.

<u>Outline of the generic tasks covered by the cooperation ESP-USA cooperation through the International Institute and the NATO-CNAD office in the DGAM (the parties)</u>

The NATO CNAD structure will be kept informed through the reports on the preparation of the event, presented by the lead nation to the DAT Workshop on the 5 October 2006 and the CNAD on 25-26 October 2006. The International Institute help to prepare those reports will be very much appreciated.

1. The two working parties will cooperate to perform the following tasks:

- Before the event they will prepare a questionnaire that participants in the Journeys will be requested to fill in.
- After the event and based on the analysis of the responses and the content of the presentations, exhibitions and demonstrations a report will be produced.

This final report will be presented jointly to NATO in both operational and technical fora.

2. The two parties will work together to prepare a plan to continue the promotion of the C-IED technologies during 2007 and a more general one to cover the medium term activities.
3. The two parties will work together for the achievement of the CNAD goals and under their guidance through their NAD offices
4. At any time is up to each part to establish the level of effort they consider appropriate.
5. This memorandum imposes no obligation on either of the two organizations. It has been prepared as a living guide for the working cooperation on the CNAD DAT C-IED initiative and will be amended as need by consensus of the two parties.

Appendix C – List of Government Offsite Meeting

Name	Organization	Country
LTC Alexander Zolotukhin	Ministry of Defense	Russia
Michael Haygarth	MOD, Joint EOD & Research Staff	United Kingdom
Francesco Colao	ENEA	Italy
Nikolay Likhachev	Federal Security Service of the Russian Federation	Russia
Maj. Rami Katav	Israel MOD, R&D Directorate	Israel
LTC Viliam Belej	MOD Slovak Republic	Slovak Republic
Necati Subas	MND Undersecretary for Defense Industry	Turkey
Capt. Cedric Berthome	MOD- DGA	France
LTC Jeremy Mansfield	National Defence Hdq	Canada
Major Philippe Le Carff	NATO HQ SACT	United States
Michel Lefebre	Royal Military Academy	Belgium
Col. Evgeny Svobodin	Russian Military Mission to NATO	Russia
Maj. Gen. Ret. Arik Yakuel		Israel
Dr. Helmut Oppenheim	Ministry of Defence	Austria
Krasimir Pingelov	NATO	Bulgaria
David Burke	National Defence Hdq.	Canada
LTC Juan Rosillo Parra	International Center of De-mining	Spain
Joachim Sigmund	Federal Ministry of Defence – Armaments Directorate	Germany
Maj. Francesconi Stefano	Ministry of Defence	Italy
Cap. Giedrius Dvilaitis	Lithuania Army Land Forces Command	Lithuania
Maj. Leendert Lagerwerf	Netherlands Army/Taskforce Countering-IEDs	The Netherlands
Dr. Matthew Brooks	Explosives Detection Group	United Kingdom
Col. Oleksandr Burdiian	Ministry of Defence	Ukraine
Thomas Tate	U.S Army International Technology Center – Atlantic	United States

Appendix D – Final Agenda

Ministerio de Defensa

Secretaria de Estado de Defensa
Dirección General de Armamento y Material

Journeys on Standoff IED Detection

Madrid 7, 8 & 9 November 2006

Escuela Politécnica Superior del Ejército
Academia de Ingenieros / Centro Internacional de Desminado

With the cooperation of the International Institute for Homeland Security, Defence and Restoration on behalf of the TSWG of the USA

Programme of Activities

7 November 2006

Venue : Escuela Politécnica Superior del Ejército
Calle Joaquín Costa num. 6
28200 Madrid

Activity Conferences and Exhibition

Panel 1: IED Detection based on Laser Spectroscopy

Panel 2: IED Detection Based On Molecular Detection

8 November 2006

Venue : Escuela Politécnica Superior del Ejército
Calle Joaquín Costa num. 6
28200 Madrid

Activity Conferences and Exhibition

Panel 3: Detection of Concealed IEDs

Panel 4: Detection of Non-Explosive Components of IEDS

Panel 5: Intelligent Scene Analysis and Detection of IED Delivery

9 November 2006

Venue : Academia de Ingenieros del Ejército
Centro Internacional de Desminado
Carretera de
Hoyo de MAnzanares (MADRID)

Activity Demonstrations

6.4.1.1.1.1 Day One 7th November

8:30 to 9:00	Arrival and accreditation of Participants.
9:00 to 9:20	▪ Official Welcome and Opening – **Gral. Jose L. Ceballos** - Under-Director for International Relations – Spain MoD ▪ Opening remarks by **Ms Mary Ungar** (The International Institute)
9:20	Administrative remarks

6.4.1.1.1.1.1.1.1 Panel 1: IED Detection based on Laser Spectroscopy

9:30	Introduction by the Panel Chair : **Prof. Dr. Javier Laserna** (Málaga University) *Spain*
9:40-10:10	**Dr. Wolfgang Schade** (Technische Universitat Clausthal) *Germany* **Fibre Coupled LIBS Sensor** Pulsed laser fragmentation (PLF) in combination with high-resolution mid-infrared laser absorption spectroscopy offers new possibilities for sensitive and selective stand-off analysis of surface contaminations under real-time operation conditions. The detection of NO_x production rates emitted from contaminated surfaces after interaction with an infrared PLF laser beam allows analysis of different surface contaminations, e.g. distinguishing between energetic and non-energetic materials but also between molecules with similar atomic composition. For efficient laser fragmentation of surface contaminations excitation wavelengths at 1.5 µm are preferred compared to the conventional Nd:YAG laser line at 1.06 µm. The concept of this method and first results are shown and discussed. Curriculum Vitae Address: Prof. Dr. Wolfgang Schade, Clausthal University of Technology, Institute of Physics and Physics Technology, Leibnizstrasse 4, 38678 Clausthal-Zellerfeld Private address: Zum Bohrfeld 6, 38644 Goslar Phone (+49) 5323 72 2061 — Phone: (+49) 5321 389700

E-mail: wolfgang.schade@tu-clausthal.de	E-mail: wolfgang.schade@tu-clausthal.de

Research Interests

Photonics, fiber optic sensor devices for gas detection, laser spectroscopy, injection seeded fiber amplifiers, chip lasers, near-field scanning optical microscopy, nanowires for photonics

Academic vitae

2005-	Head of LaserApplicationCenter	Clausthal University of Technology
2003-	Dean of Faculty	Clausthal University of Technology
1998-	Professor of Physics	Clausthal University of Technology
1996-1998	Visiting Professor	JILA, University of Colorado at Boulder (USA)
1994-1996	Assistant Professor	University of Kiel
1992-1994	Visiting Fellow	JILA, University of Colorado at Boulder (USA)
1987-1992	Scientific Assistant	University of Kiel/Lund Institute of Technology (Sweden)
1993	Habilitation (Dr. rer. nat. habil.)	University of Kiel
1987	Ph.D. (Dr. rer. nat.)	University of Kiel
1984	Diploma in Physics	University of Kiel

Scientific profile:

Wolfgang Schade studied physics at the University of Kiel from 1978 to 1984 and received his diploma in physics with the thesis “3-wavelength laser interferometry for measuring electron densities in plasmas”. He received his Ph.D. after three years with the thesis “Lifetime measurements of singly ionized atoms with sub-nanosecond laser pulses” and the Habilitation in 1993 with the thesis “Time-resolved laser spectroscopy with short laser pulses –basics and applications” for experimental physics at the physics department of the University of Kiel.

In 1984 he joined the Lund Institute of Technology (Sweden) to work in the field of generation of short laser pulses. After his Ph.D. in 1987 he concentrated his research more to applications of laser spectroscopy in environmental monitoring and medical physics. During this time there was a strong collaboration with the Medical Laser Center in Lübeck and the Medical Faculty of the University of Kiel. During his stays at JILA he changed his field of research more to high resolution laser spectroscopy in drift tubes and femtosecond laser spectroscopy with near-field scanning optical microscopy. In 1998 he became professor of physics at Clausthal University of Technology where he is now heading the research group “Applied Photonics”.

Recent research activities concentrate on the development of miniaturized solid state laser sources and their applications in gas sensing for industrial process control and very recently also for applications in security research. In this context novel concepts for mid-infrared evanescent field fiber sensors for high temperature combustion diagnostics and a laser sensor for anti-personnel mine detection are developed. Most of the work is done in joint projects with industry and partner universities, e.g. DLR, HVG, NLR, ONERA, University of California at Berkeley, Rice University or Indian Institute of Technology. He also serves as regular reviewer for several highly ranked journals and as referee for funding in the Deutsche Forschungsgemeinschaft (DFG). Since 2006 Wolfgang Schade is member of the BMVg Consultative Committee on “Applications of Laser Technology for the detection of improvised explosive devices (IEDs)” and member of the editorial board of the journal “Lasers in Engineering”.

Academic awards and distinctions:

2004	MAZ Award for Optical Technologies and Nanotechnology, HansePhotonik
2001	Technology Transfer Award, IHK Braunschweig
2000	Position offered: Professor for Physics (C4) at the University of Hohenheim, offer declined
1998	Position offered: Associate Professor of Physics at the Michigan Technological University (USA), offer declined

Total number of refereed publications: >90
Total number of supervised PhDs: 11 in Kiel, Boulder and Clausthal
Total Number of Patents: 6
Professional Memberships:
Deutsche Physikalische Gesellschaft (DPG), Optical Society of America (OSA)

10:10-10:40 **Opening of the Exhibition** and Coffee Break

10:40-11:00	**Mr. Carlos de Miguel** (INDRA Systems) *Spain* **Laser induced breakdown spectroscopy. Inspection of distant objects using manned platforms** Laser-induced breakdown spectroscopy (LIBS) is today considered one of the most promising tools in materials analysis. Probably the most distinguishing characteristic of LIBS is flexibility. LIBS is used in a broad front of applications, including laboratory bulk analysis, microanalysis and nanocharacterization, analysis of solids, liquids, gases, aerosols and single particles, field analysis of environmentally significant compounds, inspection of metal and ceramic materials under water, etc. However, the exclusive competence of LIBS is the remote or standoff chemical analysis of the elemental composition of solids. This presentation discusses the capabilities of LIBS to detect, identify and measure the concentration of energetic materials (i.e. explosives) at operationally significant ranges. It also presents the work being carried out in Spain by the University of Málaga and Indra to assess those capabilities by means of the design and construction of several LIBS platforms for standoff applications.
11:00-11:20	**Mr. Tim Corcoran** (presenting for Andrzej Miziolek/ARL) *United States* "ST-LIBS: A Promising New Tool for Trace Explosives & Other Hazards Detections at a Distance" *abstract*
11:30-11:50	Discussion
12:00 – 14:00	***Lunch***

Panel 2: IED Detection Based On Molecular Detection

14:00

Introduction by the Chair:

Dr. José Pedro Santos Blanco (RAMEM) *Spain*

14:10-14:30

Mr. George Coyle (Northop Grumman Corporation) *United States*

"Infra –Red Spectroscopy"

14:30-14:50

Mr. Gonzalo Fernández de la Mora (SEADM) *Spain*

"Aroma: Serial DMA/AF Detector"

To fulfill the need for a practical instrument that achieves both high sensitivity *and* high resolution in order to discriminate explosives, a new technology which couples a Differential Mobility Analyzer (DMA) with a Mass Spectrometer (MS) will be presented and discussed. The DMA can be viewed as a very fast chromatograph. The goal for this new technology is to develop a rugged, economical DMA-MS instrument that responds in seconds, detects explosive vapour concentrations as low as 10^{-12}, and that resolves molecular mass to 1 part in 10^{5}-10^{6}. Results achieved with this new technology will be presented.

CURRICULUM VITAE

PERSONAL DATA

Name	:	FERNANDEZ DE LA MORA y VARELA, Gonzalo
Born	:	June, 1951
Nationality	:	Spanish
Studies	:	Master in Electrical Engineering , Columbus, Ohio (USA), 1974 Physics Graduate, Madrid, 1973
Languages	:	Spanish, French, English

PROFESIONAL DEFINITION

Twenty years of experience in Management of R&D national and international Programs for Defense, Space and Communications, in the area of Information Technologies.

PROFESIONAL EXPERIENCE

From 2004 ILIA SISTEMAS SL and SEADM SL, as Founder and General Manager

Founded in 2004, ILIA is devoted to commercial and technical consultancy for R&D Programs in the area of Defense and Security.

Founded in 2005, SEADM is an R&D company in the field of explosive detection.

1982-2004 SENER INGENIERÍA Y SISTEMAS, S.A. Aerospace Division

Responsibility :
2002-2004: Proposal Manager
1998-2002: Program Manager
1988-1998: Software Head
1982-1988: Systems Engineer

14:50-15:20	Coffee Break in the Exhibition Room
15:20-15:40	**Mr. Miguel Sanchez** (RAMEM) S*pain* **“NEDS New Explosive Detection System”** In this presentation the author will expose the new device to detect explosive as a whole system. The physical fundamentals and the break down of the system will be discussed. Te device is able to ‘sniff’ the components of the explosive following recognition of the molecular compounds. The design process and performances, especially resolution and sensibility, will be addressed, as well. To finalise, the application scenarios where the company developer, RAMEM, has already set real products will be presented IONER CHECKPOINT, for parcel bombs, concealed IED in briefcase or similar and CHECKPOINT for screening people at the entry gate. A mobile IED finder, as next development, will be also presented.
15:40-16:00	Discussion
16:00-16:20	**Mr. Krister Liljegren** (Environics OY) *Finland* **“Detection of Peroxide Based Explosives and Their Precursors by Chemical Handheld Detector”** *Presentation of Environics biological, chemical and radiological handheld detectors.*
16:20-16:40	**LtCol Alexander Zolotukhin & Col Alexey Baroni** *Russia* “Russian Experience of IEDs” *abstract*
16:40 - 17:00	**A.A. Reznev & a. N. Perederiy** *Russ* “New Russian Devices for Explosive Detection” *abstract*

End of first day

Day Two 8th November

6.4.1.1.1.1.1.1.2 Panel 3: Detection of Concealed IEDs

9:00 – 9:10	Introduction by the Panel Chair: **Mr. Ian Raitt** (Delt Fort Halstead) *United States* of America
9:10-9:30	**Mr. Roger Appleby** (QinetiQ) *United Kingdom* **Detection of IEDs hidden under clothing at 100GHz** At 100GHz clothing is transparent and imaging and sensor system can be constructed to detect weapons and contraband. This paper will review the properties of clothing and the materials used in IEDs and describe prototype equipments developed at 100GHz. **Biography R Appleby 2006** Roger Appleby was awarded his PhD in 1977 from Leicester University from where he also graduated. In 1980 he joined the Royal Signals and Radar Establishment at Malvern. He has worked on imaging sensors for 25 years. His work began on image intensifiers where he developed computer models to aid design and predict performance. He was also technical authority for the general purpose night vision goggle which went into service with the British Army. He studied novel scan patterns for a prototype lightweight thermal imager and eventually started to address imaging in poor weather and began to work on passive millimetre wave imaging in 1986. He currently leads the team researching passive millimetre wave imaging at QinetiQ and it was this team that built the first real time imager in the UK. More recently this concept has been used to develop poor weather surveillance aids and security scanning imagers to detect weapons and contraband hidden under clothing. His achievements in passive millimetre wave imaging were recognised by QinetiQ in May 2000 when he was appointed as a QinetiQ Fellow.
9:30-9:50	**Dr. Michael Kemp** (Iconal Technology, Ltd) *United Kingdom* **6.4.1.1.1.2 High Frequency Inspection** There has been intense interest in the use of millimetre wave and terahertz technology for the detection of concealed weapons, explosives and other threats. Electromagnetic waves at these frequencies are safe, propagate at least short distances through the atmosphere, penetrate barriers and have short enough wavelengths to allow discrimination between objects. At frequencies above 600GHz, corresponding to wavelengths of 0.5 mm or less, many solids, including common explosives, exhibit characteristic spectroscopic signatures. This opens up the prospect of identification of

explosives, even when concealed under clothing or similar barriers. Whilst there are significant engineering challenges still to be overcome, the combination of properties – propagation, penetration through barriers, safety and materials specificity – offered by terahertz technology is unique. This paper reviews the progress which has been made in recent years and identifies the achievements, challenges and prospects for these technologies in checkpoint people screening, stand off detection of improvised explosive devices (IEDs) and suicide bombers as well as more specialized screening tasks.

Biography

Dr Mike Kemp heads Iconal Technology, which he founded in 2006. Iconal Technology Ltd is a consultancy company focusing on imaging, detection and identification technology which works for government and industrial clients in security and other areas. From 2002-2006, he was Senior Vice President at terahertz specialist TeraView Ltd, responsible for the company's activities in security, medical imaging and NDT, where he led an extensive R&D programme into explosives detection using terahertz technology.

A former Managing Consultant at IT and systems integration house Logica plc, Mike has a wide range of business, commercial and technical experience from R&D, through product development, marketing and sales to the implementation of major systems. He has worked in signal, image and data processing, speech technology, medical imaging, customer relationship management & database systems as well as in security screening and CBRNE.

Mike read Natural Sciences at Downing College Cambridge and was awarded a PhD in Radio Astronomy from the University of Cambridge, Cavendish Laboratory in 1978. He is a Chartered Engineer, a member of IEE and SPIE, a Fellow of the Royal Society of Arts and a member of the NATO expert working group on Explosives Detection.

9:50-10:10

Mr. Lucas van Ewijk (TNO Defense, Security & Safety) *The Netherlands*

Concealed weapon detection

Abstract

Detecting weapons and possibly explosive material, which is hidden underneath clothing or in bags is an important aspect in current day society. Not only at airports people are searched and luggage is inspected for concealed weapons, but police would like to have this possibility at the streets as well. Also at the entrance of musea, soccer stadiums and public transport stations security checks are carried out. More than one technique or technology is available for this purpose. During the presentation the

	usage of millimeter wave passive imaging will be elaborated. At TNO in the Netherlands we have developed an imager that is capable of detecting objects hidden underneath clothing. The technique and future perspective will be explained and many results will be shown.
10:10-10:30	**Dr. Jonathan James** (Thruvision, Ltd.) *United Kingdom* **Imaging concealed threat and contraband objects under clothing.** ThruVision's new passive imaging products reveal concealed objects on personnel. Users and applications include:**1) Customs agencies** - imaging concealed contraband, narcotics etc..**2) Building and asset protection**– entry screening of personnel for concealed threat objects.**3) Police** – imaging of concealed threat objects. Both, metal and non-metal concealed threat and contraband objects are imaged, including:**ceramics, plastics,liquids, etc** ThruVision technology is entirely passive; the subject is not illuminated with any form of radiation such as X-ray. Images are formed using terahertz waves naturally produced by all objects and people. Benefits include:**1) Screening without introducing 'bottlenecks'** - people are screened at a distance as they move; **2) Passive** - The subject is not illuminated with any form of radiation; **3) Non invasive** - Anatomical details of the subject are not revealed; **4) All concealed objects are imaged** - metal and non-metal; **5) Installation flexibility** - small size
10:30-10:50	**Dr. Arnold Schoolderman** *The Netherlands* **"Polarised Light Cameras : A tool to detect IEDs"** It is well known that smooth surfaces polarise visible light that is reflected by that surface. This phenomenon can be used to discriminate between relatively smooth man made objects like landmines UXO and IEDs and the rough natural background. The presentation shows real time detection results obtained with a polarisation camera mounted on a moving vehicle (speed up to 30 km/hr). Anti vehicle and anti personnel mines were placed on a gravel road and between vegetation. The mines were both surface laid and partly buried. The detection rate is very high, together with a very low false alarm rate.
10:50-11:10	Discussion
11:10-11:30	Coffee Break in the Exhibition Room
11:30-11:50	**Mr. V Patrick Adrounie** (Lockheed Martin Co.) *United States* of America "Integrated IED Detection Architecture"

	presentation available
11:50-12:10	**Mr.Jorg Mathieu** – *Italy/Switzerland* “Detection of Flammable Explosive Liquids Concealed in Commercial Liquid Containers” The bottles themselves can be detected by X-ray machines, which however cannot determine if the original content has been replaced by dangerous liquids of similar density. These substances, once brought inside sensitive areas present dangerous situations, especially on board of aircrafts. Starting from 2003 CEIA launched a research project to develop an electromagnetic device for the non-invasive inspection of bottles and similar containers with the goal of preventing flammable and explosive liquids (e.g. alcohols and hydrocarbons) from being brought into sensitive areas.The result of this research is the CEIA EMA-2 (Electromagnetic Bottle Analyzer). .
12:10-14:20	*LUNCH, & COFFEE IN EXHIBITION AREA*

Panel 4: Detection of Non-Explosive Components of IEDS

14:20 – 14:30	Introduction by the Panel Chair: **Mr. Vladimir Tkach** (EMC -1) *Russia* *abstract*
14:30-14:50	**Mr Renald Ilyushenko** (EMC -1) *Russia* The Use of Non-Linear Junction Detector for Detection of I.E.D. **abstract** A short profile of “STT Group”. Technology of non-linear junction detector (NLJD), physical principles and use for detection of improvised explosive devices. Specialized equipment based on technology of NLJD. The field NLJD “EAGLE” NR900EK. Some results of the use of the detector for IED detection. Technical specification of “EAGLE” NR900EK. Equipment for detection of time-delay IEDs. Highlights on future R&D projects of “STT Group”.
14:50-15:10	**Ms Patricia O¨Reilly – US Army Armaments Research & Development Center “ARDEC´s perspective on standoff Detection of Concealed IEDs (i.e. Terahertz, etc)**

15:10-15:20	Discussion

6.4.1.1.1.2.1.1.1 Panel 5: Intelligent Scene Analysis and Detection of IED Delivery

15:20 – 15:30	Introduction by the Panel Chair:

Dr. Andrea Cavallaro (University of London) *United Kingdom*

Andrea Cavallaro received his M.Sc. (Summa cum Laude) in Electrical Engineering from the University of Trieste, Italy, in 1996, and the Ph.D. in Electrical Engineering from the Swiss Federal Institute of Technology, Lausanne, Switzerland, in 2002. In 1996 and 1998, he served as a research consultant at the Image Processing Laboratory, University of Trieste, Italy, working on compression algorithms for very low bitrate video coding and on digital image sequence de-interlacing. In 1997 he served the Italian Army as lieutenant at the 33rd Electronic Warfare Battalion in Treviso, Italy. From June 1998 to February 2002 he was a research assistant at the Signal Processing Laboratory of the Swiss Federal Institute of Technology (EPFL). From March 2002 to April 2003, he was a senior researcher at EPFL. Since May 2003, he is lecturer at the Department of Electronic Engineering, Queen Mary, University of London (QMUL).

Dr. Cavallaro was awarded a Research Fellowship with British Telecommunications (BT), a Drapers' Prize for the development of Learning and Teaching in 2004; and an e-learning Fellowship in 2006. He is co-author of the paper "Hybrid particle filter and mean shift tracker with adaptive transition model", winner of the student paper contest at the 2005 IEEE ICASSP. Dr. Cavallaro was workpackage leader for the EU projects ACTS Modest and IST art.live and is Principal Investigator in a number of UK Research Council and industry-sponsored projects.

Dr. Cavallaro is the general chair of the 2008 IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS), member of the IEEE Signal Processing Society, Multimedia Signal Processing Technical Committee (MMSP) and has been a member of the organizing/technical committee of several conferences, such as IEEE ICME, IEEE ICIP, SPIE VCIP, ACM Multimedia, IEEE AVSS, ECCV-VS, PETS. He acts as reviewer for several international conferences and journals, and he is author of 50 papers, including 5 book chapters.

Additional information: http://www.elec.qmul.ac.uk/staffinfo/andrea/

Topic: Surveillance imaging for intelligent scene analysis

15:30 – 15:50	**Dr. Andrea Cavallaro** (University of London) *United Kingdom* **Surveillance imaging for intelligent scene analysis** **Can surveillance imaging** be used to automatically **detect** anomalous events and behaviours, and to **predict** an event or behaviour? We will discuss how CCTV footage can be used for intelligent scene analysis, with the goal of shifting it from an '*after the fact'* tool to a '*before the fact'* tool for prevention and monitoring. **Demonstrations will include:** (i) detecting and tracking faces in CCTV video for noncollaborative profiling; (ii) 3D facial scan analysis for automatic person recognition in security applications; (iii) people tracking for object classification and behaviour analysis using CCTV cameras; (iv) detection of dangerous events in underground and train stations using CCTV cameras; (v) automated performance evaluation of CCTV surveillance systems.
15:50-16:10	**Mr. Dave Humphrey** –(Virage Security & Surveillance) *United Kingdom* "Enhancing Effectiveness of CCTV in Detection of IEDs"

16:10-16:30	**Mr. Fernando de La Torre** (Carnegie Mellon U.) *United States* of America **Computer Vision for intelligent scene analysis and IED detection: A review to the past and a look to the future** Improvised explosive devices (IEDs) represent one of the most significant and deadly threats that armed service people and innocent civilians face in current conflicts. Use of IED's has resulted in nearly half of the hostile fire deaths in Iraq and Afghanistan. One very important aspect in fighting IED's is not to focus attention on the bombers as well the bombs.Recent advances in computer vision and machine learning makes it possible to automatically analyze subtle behavior from video. In this talk, I will review previous and state-of- the-art work in surveillance and multimodal biometrics (e.g. face, gait, ...) that put the emphasis on behavioral scene analysis. Biography: Fernando De la Torre received his B.Sc. degree in Telecommunications, M.Sc. and Ph. D. degrees in Electronic Engineering and Ph. D, respectively, in 1994, 1996 and 2002, from La Salle School of Engineering in Ramon Llull University, Barcelona, Spain. In 1997 and 2000 he became Assistant and As Associate Professor in the Department of Communications and Signal Theory in Enginyeria La Salle. Since 2005 he is Research Faculty in the Robotics Institute at Carnegie Mellon University. Dr. De la Torre's research interests include computer vision and machine learning, in particular biometrics, surveillance and pattern recognition. Dr. De la Torre has co-organized a workshop in human sensing from video and he has given several tutorials at international conferences on the topic of subspace methods for computer vision.
16:30-16:50	**Mr. Kevin Kearney** (Geospatial Systems Inc.) *United States of America* "Persistent Surveillance for IED Detection & Defeat"
16:50-17:10	**Mr. Peter Tu** (GE Research) *United States* of America "Intelligent Video for Scene Analysis"
17:00 – 17:20	Discussion
17:20	**End of conferences** **Official Cosure of Sessions by Gral. A. Cieza González** **Under Director for Research and Technology** **Spain MoD**

Exhibitors

7 and 8 November

Escuela Politécnica Superior del Ejército
MADRID

1. Miguel Sanchez Martín **RAMEM**

DMA *:* Check Point and detection system. Ionization and related products

2. Wolfgang Schade **Clausthal University of Technology**

Laser technology, Laser spectroscopy &Fiber technology.*:* Laser-*induced* breakdown spectroscopy (LIBS) in combination with a conventional mine Curriculum Vitae

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E-mail: wolfgang.schade@tu-clausthal.de	E-mail: wolfgang.schade@tu-clausthal.de

Research Interests

Photonics, fiber optic sensor devices for gas detection, laser spectroscopy, injection seeded fiber amplifiers, chip lasers, near-field scanning optical microscopy, nanowires for photonics

Academic vitae

2005-	Head of LaserApplicationCenter	Clausthal University of Technology
2003-	Dean of Faculty	Clausthal University of Technology
1998-	Professor of Physics	Clausthal University of Technology
1996-1998	Visiting Professor	JILA, University of Colorado at Boulder (USA)
1994-1996	Assistant Professor	University of Kiel
1992-1994	Visiting Fellow	JILA, University of Colorado at Boulder (USA)
1987-1992	Scientific Assistant	University of Kiel/Lund Institute of Technology (Sweden)
1993	Habilitation (Dr. rer. nat. habil.)	University of Kiel
1987	Ph.D. (Dr. rer. nat.)	University of Kiel
1984	Diploma in Physics	University of Kiel

Scientific profile:

Wolfgang Schade studied physics at the University of Kiel from 1978 to 1984 and received his diploma in physics with the thesis “3-wavelength laser interferometry for measuring electron densities in plasmas”. He received his Ph.D. after three years with the thesis “Lifetime measurements of singly ionized atoms with sub-nanosecond laser pulses” and the Habilitation in 1993 with the thesis “Time-resolved laser spectroscopy with short laser pulses – basics and applications” for experimental physics at the physics department of the University of Kiel.

In 1984 he joined the Lund Institute of Technology (Sweden) to work in the field of generation of short laser pulses. After his Ph.D. in 1987 he concentrated his research more to applications of laser spectroscopy in environmental monitoring and medical physics. During this time there was a strong collaboration with the Medical Laser Center in Lübeck and the Medical Faculty of the University of Kiel. During his stays at JILA he changed his field of research more to high resolution laser spectroscopy in drift tubes and femtosecond laser spectroscopy with near-field scanning optical microscopy. In 1998 he became professor of physics at Clausthal University of Technology where he is now heading the research group “Applied Photonics”.

Recent research activities concentrate on the development of miniaturized solid state laser sources and their applications in gas sensing for industrial process control and very recently also for applications in security research. In this context novel concepts for mid-infrared evanescent field fiber sensors for high temperature combustion diagnostics and a laser sensor for anti-personnel mine detection are developed. Most of the work is done in joint projects with industry and partner universities, e.g. DLR, HVG, NLR, ONERA, University of California at Berkeley, Rice University or Indian Institute of Technology. He also serves as regular reviewer for several highly ranked journals and as referee for funding in the Deutsche Forschungsgemeinschaft (DFG). Since 2006 Wolfgang Schade is member of the BMVg Consultative Committee on "Applications of Laser Technology for the detection of improvised explosive devices (IEDs)" and member of the editorial board of the journal "Lasers in Engineering".

Academic awards and distinctions:

2004	MAZ Award for Optical Technologies and Nanotechnology, HansePhotonik
2001	Technology Transfer Award, IHK Braunschweig
2000	Position offered: Professor for Physics (C4) at the University of Hohenheim, offer declined
1998	Position offered: Associate Professor of Physics at the Michigan Technological University (USA), offer declined

Total number of refereed publications: >90
Total number of supervised PhDs: 11 in Kiel, Boulder and Clausthal
Total Number of Patents: 6
Professional Memberships:
Deutsche Physikalische Gesellschaft (DPG), Optical Society of America (OSA)

3. Krister Liljegren **Environics OY**

Chemical Warfare Agent / Toxic Industrial Chemicals detection.: ChemPro100 TATP + CBRN Handheld Detector for Peroxide based explosives

4. Mark Karl Meyer **CEIA USA LTD**

***Electromagnetic* detection of flammable and explosive liquids concealed in commercial bottles.:** Electromagnetic Bottle Analyser CEIA EMA-2

Mark Meyer was born in 1956 and raised in Switzerland where he earned a BS in mechanical engineering and a MS in process engineering from the Swiss Federal Institute of Technology in Zuerich (ETHZ).

After graduating, Mark did an internship at a Swiss Banking Institution and then moved on to work for an Italian company providing technical and sales support to customers mainly in the cement industry. In 1983, he moved to the USA for a Swiss company providing vacuum process equipment for the pharmaceutical, food and general chemical industries. In this company, Mark held positions as sales engineer, sales manager, and finally General Manager of the facility with responsibility for sales in all of the USA and Canada.

In 1988, Mark returned to Europe to take on the responsibility of Director of Sales and Technology for a company active in providing turnkey plants for the feed industry. In 1992 Mark again moved to the USA to take on the position of GM and president of the subsidiary of a Swiss company in the field of surface enhancement technology by Chemical and Physical Vapor Deposition. In 2006, mark joined CEIA-USA as Director of Sales for the North American market.

Mark and his family live in Aurora, OH, a suburb of Cleveland.

5. Peter Benwell& Penny While **ALLEN-VANGUARD**

Bomb *Disposal Equipment*

6. James McDonough **Geospatial Systems**

Kevin Kearney

Intelligent *Scene Analysis:* Video software for the detection and identification of anomalies

7. Richard Barfield/Hans Stadler **Thruvision**

Terahertz IED Detection: Passive terahertz imaging of concealed objects including narcotics, contraband, plastics, liquids etc. **ThruVision** technology and products images concealed objects in real-time on walking people at a distance.

8. Vance Briggs **Virage Security and Surveillance**
Dave Humphrey

Video Scene Analysis

10. Tim Schofield **ImageBase Technology**

Surveillance **video systems:** Video analysis software detects the presence of foreign objects in a scene.

Demonstrations
9 November 2006

Academia de Ingenieros
Centro Internacional de Desminado
Hoyo de Manzanares - MADRID

Starting at 10:00 H

1. Carlos de Miguel **INDRA**

LIBS: Demonstration of the Ability to Detect Traces of Explosive Material Over Surfaces at Distances Above 30 Meters by Means of a Standoff LIBS Setup.

2. Timur Bagcaz **Institute of Mechanical and Chemical Industry**

Water Jet Disruptor: A demonstration will be performed based on a predefined scenario.

3. Wolfgang Schade **Clausthal University of Technology**

LIBS: Prototype of fibre coupled LIBS sensor will be demonstrated detecting mine casings and explosives

6. Miguel Sanchez **RAMEM**

DMA: Sniffer detection of volatiles compounds. Vapour detection.

Part 1. Technical Specifications and Considerations

Business Information	
Business Name:	
Address	
Website	
DUNS Number	
Business Point of Contact	
Name	
Title	
Office Phone	
Cell Phone	
Fax	
Email	
Technology	
Name	
Detection Methods Employed	
Technology Readiness	
Intellectual Property and Legal Ownership of this technology: (companies, persons, contries)	
Current Availability of Technology:	
NATO Technology Readiness Level NATO (TRLs 0-9):	
Technical Specifications	
Power Source:	
Operating Environment:	
Interfaces:	
Other Technical Specifications:	
Runtime:	
Operation & Maintenance requirements:	
Resources consumed during operation:	
Human-Machine Interface complexity:	
Other Performance Characteristics	

and Capabilities:	
Standoff IED detection, neutralization, prevention, mitigation, prediction (specify capability(ies):	
Reliability:	
Accuracy:	
Effective Operating Range:	
Interoperability Capabilities	
with other systems (specify):	
with other technologies/products (specify):	
communications systems (specify):	
Constraints	
Environmental constraints (specify):	
Supported by existing doctrine/CONOPS?	
Operational security and safety issues/requirements (specify):	
Acquisition Costs	
Estimated cost of acquisition:	
Estimated maintenance and support complexity:	
Import/Export/IP/Other Legal Issues Associated with technology acquisition, deployment and use:	

Part II: Training and Deployment Considerations

Doctrine	
Is there an existing concept of the operation to leverage or will this require the development of a new concept of the operation?	
What doctrinal development work will have to be done to support the fielding of this end item?	
Can the Doctrine work be done within existing resources? What additional resource is required?	
Organization	

What type of organization will operate this equipment?	
Does this unit require additional logistics support? Will additional persons or groups be required to facilitate the use of this technology?	
What is the total requirement for new organizations to use this technology?	
Training	
What level of training is required to operate this technology?	
What is the target audience of the training courses?	
What are resources are required by the training program? (facilities, equipment, etc)	
How many instructors are required to support the training? What level of expertise is required in instructors?	
Will training be required for support or maintenance personnel? How extensive is this training?	
What is the estimated total cost and timelines for the training?	
Material	
Will the acquisition of this capability result in other materiel impacts or special Package, Handling, and Storage requirements (e.g., additional lines of ammunition, fuel, batteries, power sources, etc.)?	
Are there ecological or hazardous waste issues that will result from this acquisition?	
Can it be deployed within existing transportation assets, or does it require outsized/oversized lift capability?	
Will other systems have to be developed or modified to support this equipment (e.g., radio mounts/ night vision equipment)?	

Does this system operate on a network or frequency that will potentially interfere with other systems?	
What is the cost associated with the material impacts of this system?	
What are the potential legal issues associated with operating this equipment?	
What is the cost of extended usage? What resources are consumed during operation?	
Leadership	
What new leadership training is required (if any)?	
Are there cultural barriers or drivers to overcome?	
What resources are required to enable leadership to use this capability?	
Personnel	
Will there be a requirement for additional personnel to operate this equipment?	
Do operators have the necessary skills to operate the equipment (and support equipment)?	
What are the likely personnel implications for: Primary Users Maintenance Personnel Support Personnel	
Will contract personnel support this equipment? What is the anticipated yearly cost of this support per unit?	

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