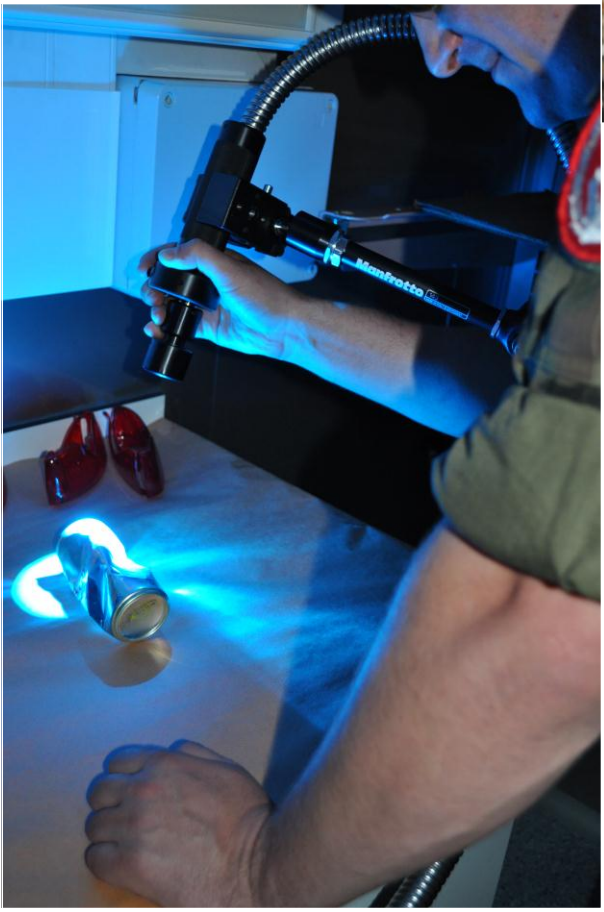
Resilient Threat Management Conference

4 – 6 March 2013



Proceedings

Uachtaránacht na hÉireann ar Chomhairle an Aontais Eorpaigh
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Special Thanks To

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James RYAN

Raymond LANE

Brian DOWLING

The Royal Military Academy in Brussels

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	13:30 – 14:45	Session B: Calling on a Black Box to Help Solve the Forensic Jigsaw *Speakers:* Mr Javier FUENTES, E&Q Engineering GOVERNMENT-ONLY
	14:45 – 15:45	Session C: Delivering a Multi-National Level 2 Capability *Speakers:* Mr Jim BLACKBURN, Project Officer C-IED, EDA Lt Col Jean-Francois SOUPRAYEN, French Armed Forces GOVERNMENT-ONLY
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		Explosives Trace Detection Using Imaging Raman Spectroscopy Ms Anneli EHLERDING, Senior Scientist, FOI **Advanced Situational Awareness Training** Mr Martin WOOLLEY, Senior Manager; Human Behaviour Pattern Recognition & Analysis / Irregular Warfare, Orbis **Self-Learning Radio System for C-IED** Dr Markku JENU, Key Account Manager – Electronics (Space) and Defence, and Senior Scientist, VTT OPEN	FOI **Structure, Methodologies and Capabilities of German Exploitation Level 3 in the Military Environment** Mr Frank DOSQUET, TRDir, WTD 91 – 450 OPEN
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			Mr Stephen W DIRITO, Chief National Explosives Task Force, FBI Asst Comm John O'MAHONEY, An Garda Síochána Mr Peter KOSTERS, Head of Counter Terrorism Department, EUROPOL Mr Manuel MARION, Senior Programme Officer, Action Against Terrorism Unit, OSCE
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Counter IED at EDA –Summary

Dinesh H C REMPLING (EDA), Jim BLACBURN (EDA), James RYAN (IE Perm Rep)

Recent operations have shown that Improvised Explosive Devices (IEDs) have become the weapon of choice for the adversary. This has driven the creation of a Countering IEDs (C-IEDs) approach. In the future it will remain important to retain a general war fighting capability as a deterrent; however it is more likely that the actual operations conducted will be about countering adversary networks hidden in civilian populations. As such, many of the traditional skills sets of policing are increasingly being used in a defence environment, using evidence and a judicial type of approach to drive operational activity.

As the threat from terrorism has crossed from deployed operations into the Homeland there are more opportunities for interagency capability development, focusing on defeating the adversaries' networks. In this challenging environment the aim is to ensure the maximum security for European and foreign citizens whilst conserving democracy, to maintain the rule of law and to provide the best value for money for European taxpayers. Working together between different countries and different agencies is the only viable way to achieve this goal.

During the resilient Threat Management Conference 2013; the European Defence Agency and the Irish Presidency of the Council of the European Union, together with experts from the Member States and a wide range of Defence and Security Organisations will present the EDA's efforts so far whilst looking forward at future requirements. The aim is to ensure a high level of preparedness for countering threats – IEDs and beyond – in the future, at home and on deployed operations.

The EDA Project Team on C-IED was founded in 2008. Based on its strategy "Guidelines for Developing a National C-IED Capability", collaborative efforts have been launched. Key achievements include:

- A novel train-the trainer approach enabling Member States to nationally develop key skills resulting in programmes on Search, Ground Sign Awareness, Combat Tracking and Manual Neutralisation Techniques;
- The definition, acquisition, design and deployment of an in-theatre forensic exploitation capability manned by a multinational team in record time. Operational since autumn 2011, EDA's Counter-IED laboratory shows the effectiveness of forensics as an integral part to the ISAF operation;
- A wide range of efforts and projects addressing new protective systems for vehicles and personnel; a scenario-driven approach to optimising the use of detection techniques and technologies; a "Black Box" concept for vehicles.

IEDs Won't Go Away

Dinesh H C REMPLING (EDA), Jim BLACBURN (EDA)

Three days of the Resilient Threat Management 2013 conference and the conclusion is undisputed – IEDs are here to stay and the only way to defeat them is through a comprehensive approach at a global level drawing on the strengths of both military and civil security resources.

Resilient Threat Management 2013 – a partnership between the Irish Presidency of the Council of the European Union and the EDA –aimed at taking stock of all the efforts to date dedicated to Countering Improvised Explosive Devices (C-IED) while pointing the direction to the future. IEDs are beasts that have existed for hundreds of years and there is a consensus that they will continue to exist for many more years to come. What complicates things is that they are employed by networks adversaries that range from terrorists to organised criminals affecting both the European homeland as well as crisis zones around the world. Each of these adversary networks have an agenda and employ IEDs along with other types of asymmetric methods to achieve their goals, with no consideration to civilian bi-standards. Consequences are heartbreaking tragedies.

Resilient Threat Management 2013 saw experts come together for two days to share information, experiences and ideas on how to take C-IED to the next phase. Come the end of current operations, the fight against IEDs will continue but in a different way. Experts delved into the overarching strategic aspects as well as discussing the future of specifics such as forensic exploitation – its dual-use nature and its role as the hub for intelligence building, evidence gathering and for technology development. Scientists provided further insights into novel approaches to defeating the network, detection technologies, neutralization techniques and deployable forensic laboratories.

The third and final day brought decision-makers to the table. With Professor Sven Biscop (Egmont Institute) addressing the EU's role in future crisis management, Dr Jamie SHEA (NATO) spoke about the complexities of asymmetric warfare. A panel with representatives from the IHS, EU Military Staff, Irish Defence Forces, Guardia Civil and RUSI then addressed what threat management needs to be like beyond 2020. A second panel with representatives FRIDE, EDA, FBI, An Garda Siochana, EUROPOL and OSCE explored how we can solidify inter-institutional cooperation platforms, within Europe and also outside.

Ciaran Murphy (Irish Department of Defence) addressed the need for the EU to mirror President Barak Obama's recent C-IED policy. Peter Round and Graham Muir (EDA) spoke about EDA's role in developing a comprehensive strategy for Member States in partnerships with other institutions in order to establish a vehicle for ensuring that we are prepared to tackle the evolving threats in a resilient manner.

Many lives have been lost in combating the IEDs. Many more lives have been lost in relearning how to combat IEDs. We cannot afford to lose more lives. Resilient Threat Management 2013 has shown that that there is a will among experts, decision makers, Member States and institutions to work together and to build on the current momentum. The fight against the IED needs to continue. It must, however, do so as part of a comprehensive approach to managing the evolution of asymmetric threats and their networks. Preparedness and resilience are key to success.

European Defence Agency Capability Development in Countering Improvised Explosive Devices

Jim BLACKBURN (EDA), Dinesh REMPLING (EDA)

IEDs have become the weapon of choice of our adversaries, with modern militaries becoming so powerful, adversaries no longer get value from direct attacks and look to exploit weaknesses by attacking softer targets. The EDA set out to analyse the requirements of how to counter the effects of IEDs, building on NATO work and in conjunction with the Member States the EDA, firstly analysed exactly what an holistic C-IED approach meant and how to define a limited scope for the purposes of capability development. Once the capabilities were agreed there was analysis done on exactly how to help Member States to develop capabilities in these areas. Sometimes this was with training courses, other times by doctrinal development, yet others with forming expert groups and sometimes with developing a demonstrator. Over a 5 year period the EDA has developed a robust international team of participating Member States (pMS) who have together with EDA initiated strong programmes to catalyse capability development andmany of the initiatives started in an EDA context have continued to flourish beyond the EDA environment.

Introduction

Improvised Explosive Devices (IEDs) are the greatest cause of casualties on current operations, responsible for around 70% of all coalition deaths in Afghanistan , they account for more deaths and injuries than all other reasons combined. It is difficult to get precise figures, but the number of soldiers wounded is significantly higher than those killed . Not only does this menace affect our own forces, but also those whom it is our duty to protect. Again, according to figure published by Human Rights Watch, over the last 3 years the civilian population suffers somewhere between 2.8 and 4.2 times the number of casualties as the coalition forces . Whilst the International Security Assistance Force in Afghanistan (ISAF) is a NATO led mission, the interest for the European Defence Agency (EDA) is clear; of the 26 participating Member States (pMS) of the EDA, 24 are ISAF Troop Contributing Nations (TCN). It is therefore clear Countering IEDs (CIED) represents a high priority for EDA pMS.

However, Afghanistan is not the only motivation. The Western Powers now having strong military forces with capabilities such as Aircraft Carries, Main Battle Tanks and Fast Fighter Jets that play an essential role in deterring future State on State aggression. Therefore, adversaries do not try to meet strength with strength, but rather will try and bypass strength to attack weaknesses in an asymmetric fashion. Asymmetric attacks look to defeat the will of their opponent, rather than seeking military victory on a battlefield. These attacks are targeted at: (a) the soldiers fighting the battle in order to demoralise them; (b) the soldiers' homeland populations to sap at the will to continue; and (c) the local population to convince them that the attacker is stronger and more capable than the defender. It is felt by many that these tactics spell out the next generation of warfare . Asymmetric threats manifest in a number of ways including Chemical, Biological attacks, Cyber warfare and IEDs.

The IED displays a far lower level of technology when compared to more conventional forms of warfare, such as attack helicopters or armoured vehicles, but is nevertheless effective as a tool. Whilst sophisticated weapons platforms are excellent when pitched against each other, when looking to defeat a much lower technology level, speaking to people, understanding atmospherics and persuasion are much more powerful tools. Significant scientific effort continues to search for automated techniques for detecting IEDs, however it is clear that currently the majority of those found are done so in much more human ways, such as being "turned in" by locals, or simply being seen.

Scoping C-IED

To try and address the challenges presented by IEDs, it was necessary to define exactly what was meant by CIED. The process was started in 2007 when accepted doctrine was coming out of NATO that stated that Countering IEDs consisted of 6 key operational areas :

- Detect
- Mitigate
- Neutralise
- Exploit
- Predict
- Prevent.

In an EDA context, a group of willing participants set out to analyse exactly what each of these disciplines meant and break them down into military capabilities arriving at those that were specifically considered to be in the CIED envelope. For example, predicting an IED attack involves, intelligence gathering, all sources intelligence fusion and intelligence preparation of the battlefield (IPB). A number of distinct capabilities necessary for CIED were deduced. Then those felt to be general military skills were deleted. For example, whilst all sources intelligence fusion is key to a CIED fight, it is similarly crucial in almost any military campaign and was therefore not in the scope of CIED. As a result, the capabilities below were published as forming a CIED capability:

- Military Search
- IED Exploitation
- Route Clearance
- Tactics Techniques and Procedures (TTPs)
- Improvised Explosive Device Disposal (IEDD)
- Mitigation
- Detection
- Counter Radio-controlled IED Electronic Warfare (CREW)

Defining the Work Programme

Each capability was then addressed across all of the Defence Lines of Development (DLODs) using the Multi-nationally accepted DOTMLPFI to see how EDA participating Member States (pMS) could have their capabilities enhanced. Whilst none wanted to go forward with CREW, due to security concerns, all other capabilities were addressed. In the most part it was felt that the provision of catalytic training to spread understanding was the most appropriate method of assisting pMS. The intention was not to train a number of individuals, but to train key personnel who then return home and develop capabilities. The EDA is not a training organisation and whilst enduring training is not carried out, one-off catalytic courses can be.

Capability Development

Military Search

In Military Search it was essential to get common agreement on what exactly search meant so a draft EU Search concept was produced and agreed, once this was done it was decided to run a number of catalytic training courses in Search. Under and Italian lead a four-year programme under Italian leadership was run. with Train The Trainer and Advisors 'courses respectively in Basic, Intermediate, Advanced and Specialist Search. Under an Irish lead, a course in Ground Sign Awareness has run and a Combat Tracking course is planned. Each of these courses have been picked up by the Member States and are now being implemented in those countries

Exploitation

The EDA together with the pMS developed a Level 2 exploitation capability which deployed under the lead nation France into ISAF in Mid 2011. 9 Member States signed a Technical Arrangement and took a full part in the project AT, ES, FR, IT, LU, NL, PL, RO, SE. Ireland provided training support and expertise. The project involved EDA buying the basic capability through a contract with Indra of Spain and a number of enhancements in terms of contributions to equipment from France, Austria and Sweden with Luxembourg contributing by paying for the deployment. The Process followed was:

- Approval for the Project at ministerial level
- Development of the Common Staff Target
- Parallel development of the General Conditions under which the laboratory could be used by Member States.
- Development of a Common Staff Requirement.
- Development of the Technical Specifications
- Contracting for the purchase
- Selection of Tender
- Development of a training package
- Design Reviews
- Reaching agreements on the deployment
- Acceptance of the tender
- Training of the teams

- Transport of the Equipment to Theatre
- Set up in Theatre
- Initial Operating Capability
- Full Operating Capability

The Processes all took place in paralle and between ministerial approval and full operating capability was only an 18 month period.

A follow on Project will be initiated under a Netherlands lead, the Joint Deployable Exploitation and Analysis Laboratory or JDEAL with a kick off meeting on 23 May 2013.

Route Clearance

For Route Clearance, again under an Italian lead, a process of Concept Development and Evaluation (CD&E) is in progress, examining the next generation of Route Clearance capability. This will develop as far as Member States wish it to, by first using the finalized concept to have a clear multi-national understanding of what Route Clearance means, then going on to develop a Common Staff Target. Finally, if sufficient Member States wish to, then a Category B programme can be developed to produce a common European Programme.

Tactics Techniques and Procedures

In TTPs a Lessons Identified, several Member States mentioned that they felt a Lessons Identified multi-national conference forum was needed. EDa together with Sweden developed and ran an initial workshop in Sweden in 2010. This workshop has been continued by the NATO accredited CIED Centre of Excellence in Spain and become an annual event.

Mitigation

Projects on Mitigation technologies revolve mainly around new materials for personal protection as well as improved vehicle armour. Several of these projects can be found both within the Joint Investment Programme on Force Protection and the research forum for Materials and Structures (GEM 1).

Detection and Reseach

In the area of detection, a five-stage process in identifying a potential research and technology programmes was initiated:

- Two scientific studies into state of the art detection techniques and a terahertz detection technology survey;
- A workshop was held where a number of IED scenarios were defined;
- Engineering analysis was done to match the scenarios to possible detection technologies;
- The results of this analysis were then briefed to industry, who then contributed;

- The final results will be used to suggest research programmes to pMS in a possible joint programme.
- Other Research and Technology programmes in the EDA have addressed armours and a new helmet to mitigation the effects of IEDs.

Improvised Explosive Device Disposal

Whilst much of this topic was felt by Member States to already be addressed one specific area of Manual Neutralisation was not. This is where it is not possible to use standard IEDD techniques such as in a circumstance where a device is attached to a hostage. The EDA sponsored 2 pilot courses in this area, one in C-IED Manual Neutralisation and one in CBRN Manual Neutralisation. Having attended the 2 EDA courses, Austria in conjunction with Luxembourg decided run a Manual Neutralisation Exercise hosted in Austria in 2012, Exercise European Guardian. Now, under the pooling and Sharing of C-IED training initiative, Austria is offering courses and an exercise in 2013, hopefully this will become an annual event.

Countering Radio Controlled IED Warfare (CREW)

Whilst agreeing that CREW was an essential part of C-IED, the EDA pMS did not want to develop this in an EDA context and as such no Capability work was done. However bottom up research efforts have been made within the Joint Investment Programme on Force Protection.

Pooling and Sharing of C-IED Training

Spain has lead an initiative into using the EDA to Pool and Share C-IED training opportunities across the European Union. The initiative is initially developing a C-IED Education and Training Framework and may then go on to develop a Database for sharing information on common C-IED training opportunities. Under This initiative the Netherlands are running Exercise International Bison Counter, a C-IED Exercise which will be open to all EDA pMS to send participants or observers to.

Conclusions

The EDA Programmes are designed to systematically analyse the requirements, define what is needed and then proceed with those aspects of capability development that can be done in a multi-national context. The projects do not produce an on-going EDA capability, but to catalyse a development and then movem it on to Member States for their further development and institutionalisation.

Structure, Methodologies and Capabilities of German Exploitation Level 3 in the Military Environment

Frank DOSQUET (Wehrtechnische Dienstsstelle fuer Waffen und Munition – WTD 91, Meppen, Germany)

Abstract – The exploitation process can be separated into three phases: The reconstruction of the incident, the comparison of capabilities of friendly and opposing forces, and the derivation of effective counter measures. The level of detail of each process has an impact on the duration and the quality as well as the precision of the related investigations. However, exploitation capabilities in the military environment have to be characterized by specific needs in relation to civil forensic treatment. Especially the strong demand on deriving a broad spectrum of counter measures to improve the situation for the soldiers in theatre is evident. Due to the requirement considering different types of counter measures as fast as possible NATO specified a three level approach for ISAF C-IED exploitation. The related standard operating procedure (SOP) reflects this by specifying specific responsibilities for field, technical and scientific exploitation. This consecutive approach does not consider different levels of capabilities as well as different levels of assertiveness. Hence, this paper is displays the needs of an exploitation system for military applications focusing on the exploitation level three. The German expert team on the analysis of incidents (ETAV) is described as an example for an exploitation level three capability to reflect these needs.

Introduction

The exploitation of hostile attacks was always a very important contributor to improvements of military equipment and TTP. By understanding enemy TTP and their technical capabilities efficient counter measures have been derived. However, the exploitation process was very often only a tentative approach by addressing singular phenomena without considering generic effects. For such a holistic and effective approach scientific procedures have to be applied.

The general goal of an exploitation process is always the derivation and implementation of effective counter measures. Exploitation processes which do not follow this approach end in themselves and are obsolete. For the derivation of effective counter measures incidents have to be analysed in several steps. The baseline is always a reconstruction of the incident. This step is very important to understand the general phenomena of threat design and operation, TTP etc. Based on the results of the reconstruction processes friendly TTP and technologies but also enemy TTP and technologies have to be assessed to compare capabilities. Furthermore elements of the enemy chain have to be identified.

Weak points must be identified and corrected by deriving recommendations for effective counter measures. The implementation of these counter measures by means of technologies, TTP and law enforcement is the last but not least step of the exploitation process. The exploitation process is a typical lessons learned process [1].

Military exploitation application is characterized by specific needs in relation to civil forensic treatment. Especially the strong demand on deriving counter measures to improve the situation for the soldiers in theatre is evident.

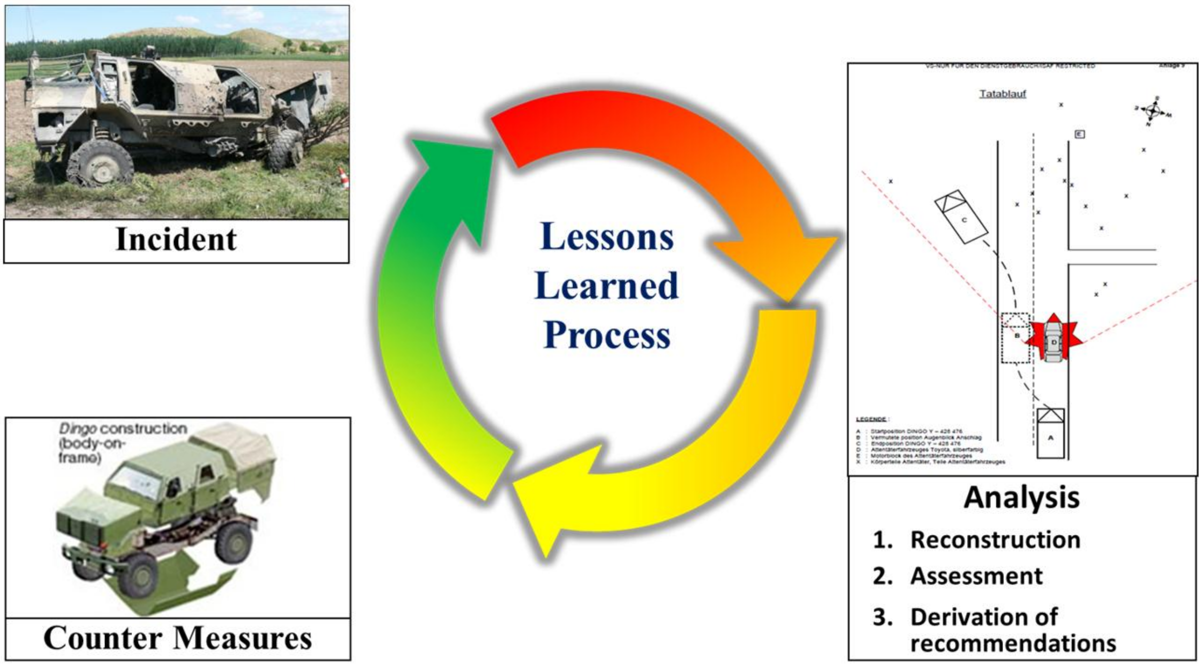

Figure 1: Generic military exploitation process

NATO Exploitation Approach

NATO addressed the exploitation by introducing three levels of exploitation for the IED threat in AJP-3.15 (B) [2]. The first level, the so-called field exploitation, is covered by weapon intelligence teams (WIT) or their national equivalents which capture incident context (scene and events) and preserve, recover and identify physical evidence. Level 1 exploitation goal is to produce immediate intelligence on friendly and enemy TTPs and local trends and prepare IED materials for follow-on Level 2 and/or 3 exploitation. The second level, the theatre exploitation, involves the technical and forensic examination of IED related materials. Level 2 exploitation's goal is to provide technical assessments on device capabilities, identify design and TTP similarities between IEDs, and detect emerging enemy TTPs. Level 3 exploitation , the so-called out of theatre exploitation, involves further technical and forensic examination of IED related material by specialist facilities. Level 1 – 3 are characterized by different locations (level 1 and 2 in theatre, level 3 homeland), different level of details, reporting and time frames.

For some operations it will not be possible to implement e.g. level 2 facilities and capabilities in theatre, while level 3 facilities and capabilities usually still will be available. Furthermore the exploitation approach of NATO is only focusing on the IED threat. In consequence the exploitation capabilities are not responsible for the exploitation of other attacks (e.g. ballistic, mine, SAF, RPG). However, forces should make use of the available exploitation experts to improve their situation independently of the type of threat which was utilized against them.

German Level 3 Exploitation Approach

In Germany the level 3 exploitation capability is covered by the expert team on the analysis of incidents (ETAV). The backbone of the ETAV is built by the technical center for weapons and munition (WTD 91) in Meppen. Furthermore several military and civil experts in the scope of the

German MOD are involved. Additional members of the ETAV are the federal intelligence service and the federal police office. ETAV is based on a mixed organizational and operational structure to provide all relevant elements for data recovery, analysis and implementation of counter measures.

ETAV is not limited to IED attacks. They are analysing all attacks on German forces independently of the type of threat which was utilized against them. Furthermore, selected attacks against friendly forces were analysed by ETAV to support partner nations.

This holistic approach assures that all relevant elements of the level 1 exploitation, all reconstruction processes and the analysis topics are covered by the ETAV. The ETAV directly derives counter measures e.g. to improve protection systems. The allocation of team members which are responsible for the general analysis topics results in the implementation of the recommended counter measures.

Incident Reconstruction

The reconstruction of incidents can be separated in several main processes (effects on personnel, effects on platform, effects on environment, threat residuals, tactical and operational principles, intelligence, biometrics, and procedures). These main processes comprise numerous sub-processes.

For the reconstruction of an incident with the focus on the protection performance of a specific platform the load transfer model (LTM) has to be applied [3]. The LTM differentiates between threat, injury and environmental mechanisms which result in effects on the soldiers, the platform and the environment. The effects can be measured to reconstruct the threat and the related transfer mechanisms.

In addition ETAV applies e.g. specific unique software tools to analyse craters, fragmentation effects, accelerated components and plastic deformation. Furthermore virtual and numerical simulation tools are used to reconstruct the incident in 3D dynamically and immersive for variable point of views.

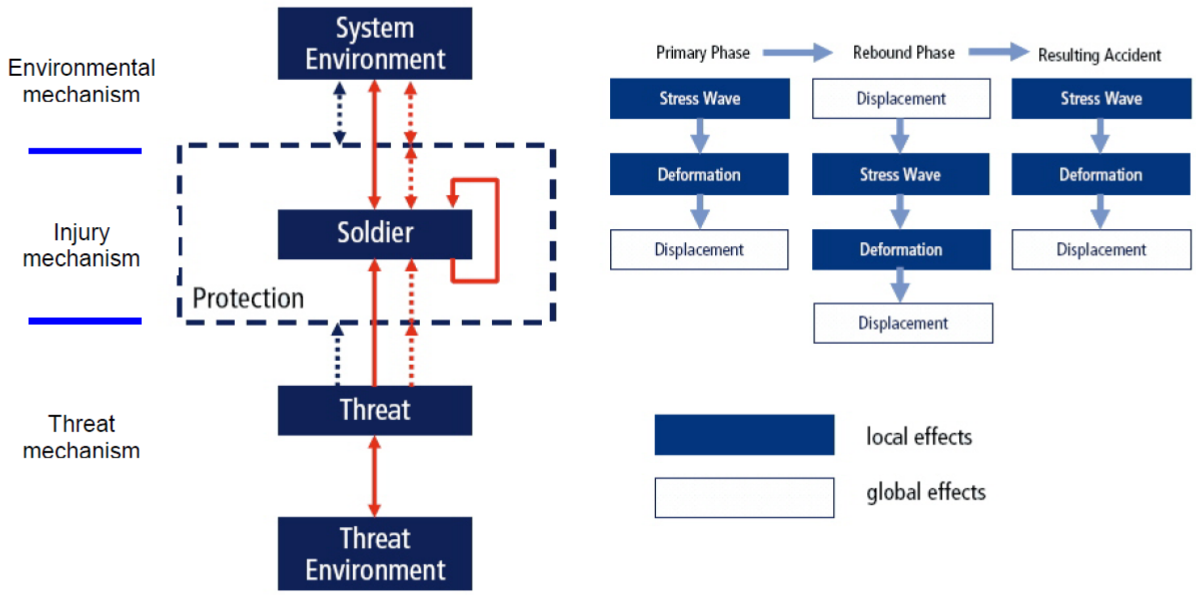

Figure 3: Load transfer model (LTM) and it's under body blast application

Conclusions

- Exploitation processes have to be focused and assessed by their value for deriving counter measures.
- The C-IED approach is a good starting point but has to be expanded to a holistic incident analysis approach.
- A level 3 exploitation capability should cover all relevant elements of the exploitation process.
- There is a need for a possibility for flexible deployment of capabilities.
- Police capabilities and facilities are only covering a subset of topics of the military exploitation process. Hence, they should contribute to and should not be responsible for the military exploitation process.
- Exchange of procedures and basic research results being applied for the exploitation process is essential.
- Caveat problems can be solved by report tailoring.

References

[1] Dosquet, Frank: "Specific Needs for C-IED Exploitation Level 3 in the Military Environment", Proceedings of CNAD DAT 1st NATO Workshop on C-IED Exploitation, Madrid, Spain, 2009

[2] NATO (Ed.): "Allied Joint Doctrine for Countering – Improvised Explosive Devices", AJP-3.15 (B), 2012

[3] Dosquet, Frank: "Load Transfer Model for Human Vulnerability Applications", Proceedings of 4th European Survivability Workshop (ESW), Malvern, UK, 2008

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Level 3 Exploitation at FOI

Camilla Andersson (FOI)

FOI has during the last decade conducted ad hoc exploitations, especially concerning the ISAF operation in Afghanistan, where equipment and vehicles have been scrutinized in order to recreate attacks, investigate possible protective measures etc. Since 2012, the Swedish Armed Forces commission FOI to establish an organisation and routines to support the on-going operations with Level 3 exploitation analysis within the field of weapons and munitions.

The weapons and protection research currently conducted is the foundation of such a Level 3 capability, where we make use of earlier research and our existing facilities. The exploitation work offers a vehicle to evolve and enhance our methods to better suit the demands from on-going operations. The weapons intelligence and forensic analysis to be conducted includes incident analysis, weapons effect characterisation, threat assessment, lethality calculations, recreations of events etc. The work is conducted on both conventional threats as well as improvised. The aim is that the results from the analyses help the Armed Forces gain a better understanding about the current threat, support changes in TTP's or protective equipment. The project is also responsible for developing training kits for the Swedish weapon intelligence teams (WIT) as well as the EOD/IEDD officers.

The close collaboration with the WIT and the Swedish task force for C-IED ensures that the results are based on the latest available knowledge about the threat, while at the same time helping us conduct research and investigations that are relevant to the troops.

Exploitation poses several challenges for us as researchers. The timeframe available for investigations is very limited, so new methods are being developed and tested. E.g. fewer experiments can be conducted compared to normal research methodology, incomplete information about the incident or threat is to be expected. Also, improvised threats are just that, improvised. Here estimates must be made, which we build on the vast knowledge from earlier research to ensure a relevant answer. When conducting an exploitation analysis many different competencies must come together to help solve the problem at hand, in the Swedish case these competences may also come from different organisations and ministries posing an additional challenge.

The profits of having a functioning exploitation process out-weight all these challenges. Being able to conduct more informed decisions, where accurate level of protective measures, validated TTP's, the most adequate pre-mission training can be selected and will all contribute to the overall force protection of our troops. The close collaboration between the level 1, 2 and 3 is essential to ensure the transfer of knowledge.

Case of Success (MN TEL) & An Innovative Concept – Fast Response Mobile Laboratory

Jesús MADRID (Indra Sistemas), David RENDO (Indra Sistemas}

This paper will describe the process carried out to develop the laboratory in the time and technical requirements demanded by the European Defense Agency. Along with the technical requirements offered by Indra, the main issue to address during the project was the management of the times for design, production and testing, which had to be done in no more than 5 months. Finally this schedule was extended in 1 month for providing the training to the first crew who was going to make the deployment and operation of the laboratory for the first 6 months.

The main restriction was related to the time stages for the design of the project. It was needed to define those specific items which could need long time deliveries. Indra identified these critical items, which needed to be agreed with the EU experts in order to prepare the Purchase Orders. The contract entered into force on January, 17th, only 3 weeks later, on February, 4th there was an EU experts, Indra and EDA meeting to agree on the main aspects of the design and fix those critical items to be purchased. One month after the beginning of the contract, on February, 17th the design was fixed in its main lines; that day it started the production stage, which leaded until May when the first containers were delivered to the C-IED Centre of Excellence for the final integration and deploying. The collaboration with the Center of Excellence was very valuable, providing their facilities and support during the training and testing stages, and being the location for the final deployment before its delivery to Afghanistan.

Indra will show the main parts of the laboratory, including their functionality.

This project has showed Indra the real value of coordination and commitment from all the stakeholders, including the EDA project officers, the EU experts, the final users (being France the lead nation) and other collaborators, as the C-IED CoE.

Indra has continued researching the best ways to deliver this kind of solutions to the Theatre. Recently, Indra has delivered to the Turkish Land Force a CBRN Mobile Laboratory, proving that it is possible to include the main functionalities into a ISO 20' platform that could be transported easily by plane, boat or truck, and deploying the functionality on the theatre in less than one hour once the laboratory is on the field. The paper will finally show our understanding of which are this functionalities and how can they be integrated in a mobile solution.

This paper describes on the first part the case of success when Indra developed the MN TEL Forensic C-IED Laboratory for EDA from the technical prospective (capabilities and functionalities) and from the project management view.

On the second part of this paper we will present the new concept of C-IED Laboratory which is being developed by Indra based on a Fast Response Innovative concept.

Case of Success (MN TEL)

Concept of Use

An improvised explosive device (IED) post-blast scenario is a vast area where massive and diverse evidences must be searched, collected and transferred for analysis to a distant reference laboratory.

IED exploitation is the investigation of IED incidents to establish the technical and tactical information from the attack and identify the IED supply chain (TTP - Techniques, Tactics & Procedures). IED exploitation is achieved through a number of activities which try to technically characterize the IED involved and recover trace material from those who have contacted with the IED (Level 1). IED exploitation at Level 2 is a key part of the intelligence process designed to provide a technical and tactical picture of the IED incident as well as to provide evidence and intelligence of those involved in the IED network.

The exploitation process is intrusive but non-destructive and supports follow-on level 3 exploitation.

An initial triage is executed to ensure safety of personnel and facilities (Small CBR & Explosive samples are handled)

After investigation an IED Level 2 report is released to higher operational level determining used enemy TTPs and relations to other incidents

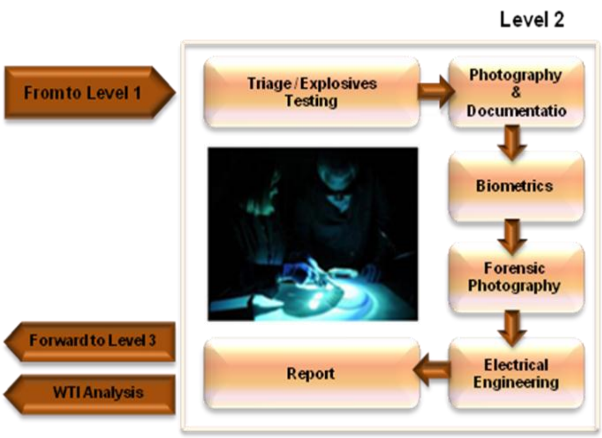


Figure 1: NATO Level 2 workflow

Source: European Defence Agency (EDA)

Capabilities

The laboratory was designed to fulfil the NATO Level 2 Laboratory Capability Requirements, as shown below:

- Analysis is intrusive but non-destructive and supports follow-on level 3 exploitation. After investigation an IED level 2 report is released to higher operational level determining used enemy TTPs and relations to other incidents.
- Initial triage of Devices, Materials, Artefacts and Traces (DMAT) on receipt where they can be initially inspected (CBRNe, X-ray) and prioritized. It is executed to ensure safety of personnel and facilities.
- Biometric traces like DNA and fingerprints are captured. Latent fingerprints can be compared in a local database for matching purposes. Recovered material (including DNA) is prepared for appropriate storage and shipment to a level 3 facility.
- Technical analysis of electronic devices and computing data including the capture of exterior characteristics by HD Photo & video recording.
- Lab C-IED Level 2 capable to handle small explosive samples or swabs for identification of type of explosives used.
- Characterization of weapon systems and explosives, including tool-mark identification.
- Integral Information Management (LIMS): Inter-comparison across incidents, Custodian chain guaranteed, holistic DMAT tracking, automated reporting, etc.
- Capable to host up to 12 people working inside simultaneously, reaching a high production rate of 5 cases per day.

Figure 2: General view of the laboratory

General Funcationalities

Related to the infrastructure of the laboratory it provides the following functionalities:

- Designed for working in a protected Camp. Power, water supply and waste management to be provided by the host camp. Multi Power Supply (UK/USA/EU) and Back-up power supply (UPS).
- HVAC System and Air Filtration System (overpressure), makes it able to operate in all habited climatic regions of the world. Guarantee environmental cleanless according Labs International Standards.
- Short time for complete set-up and dismantling, less than one week.
- Fitted with NATO IT secure networks & Non secure IT Network (internal), also including an Integral Secure System (Control access, Firing System)
- Specific area for preserving & storage samples (tempered, vented, etc.), also includes an Administrative office space as well as sanitation area.

Managerial Issues and Lessons Learned

From a managerial point of view, the project time limitations required to provide the Level 2 functionality on time to the theatre was the main difficulty of the project. Before starting, Indra figured out the main tasks to be performed, included their times and dependencies, and the longest time delivery items, which were identified as the critical items. According to the project team's previous experiences in developing laboratories on mobile platforms, these 5 months time limit was not possible to fulfil unless some of the most important tasks could be done at the same time. Furthermore, the critical items should be fixed before the critical design review meeting.

This limitations and new approach to the project (overlapping tasks and defining critical items) lead the project to be exposed to some specific risks. Related to the critical items, how could we ensure those critical items were exactly the products and configurations needed to fulfil the functionality? And related to the overlapped tasks, how could we avoid later problems when integrating the result of those tasks? The only way to minimize those risks was by involving the EDA project officers and EU experts into the design process and definition of the final configuration of the laboratory. This collaboration needed a flexible and experienced engineering team to be able to adapt and implement on time all the decisions made in the design meetings, also taking into account there was only 1 month to fix the design. Only by ensuring a robust design of the main parts of the laboratory we could be able to start the production stage guaranteeing there won't be any important incompatibility.

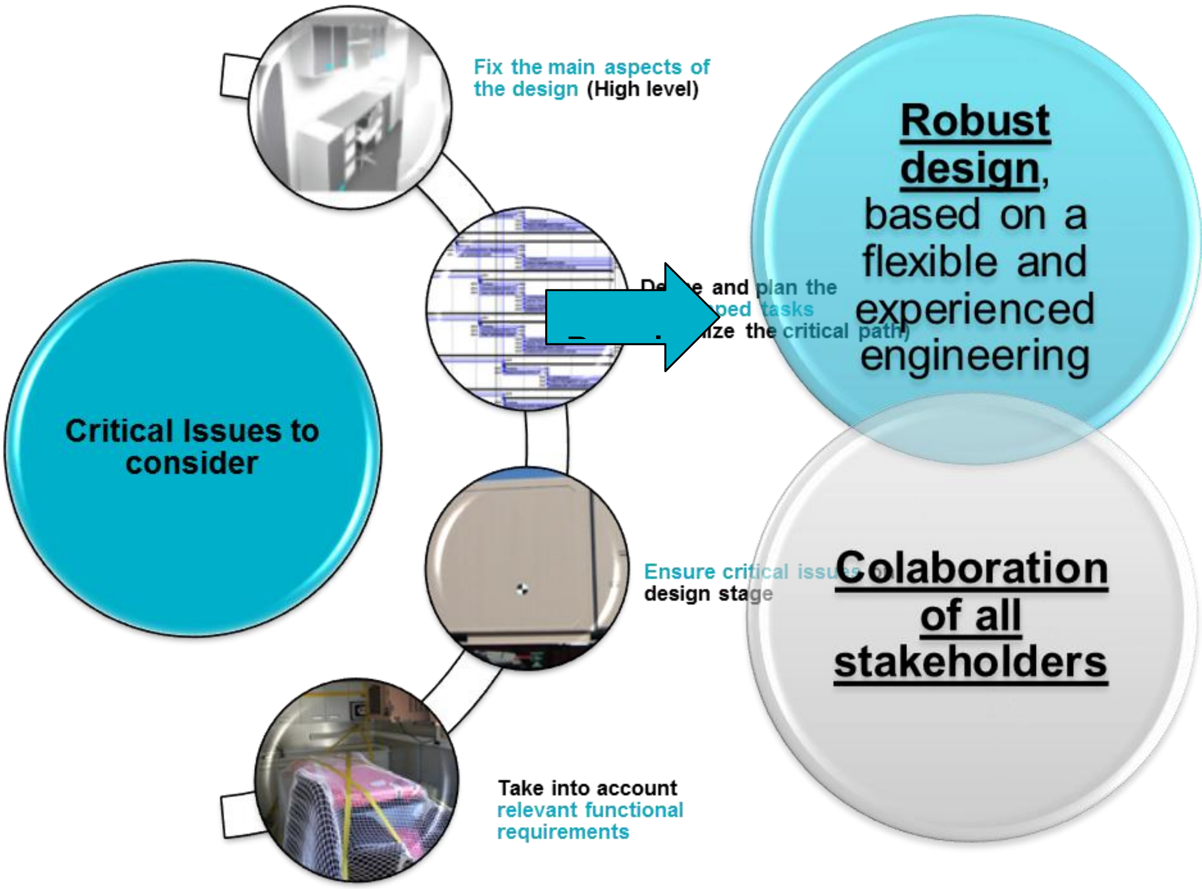


Figure 3: Managerial critical issues

The schedule was very tight, with most of the tasks planned to be done in the final stage of the project (integration), so it was critical to avoid any delay in the production stage that could affect to the time deliveries. During most of this part of the project there were up to 9 tasks running at the same time that had to be coordinated by the project team of the project.

Due to the time limitations, the project office at Indra had to manage up to 10 subcontractors producing all the parts that had to be integrated later: containers, tunnel tents and other container mechanical interfaces, power equipment and cables, IT (including communications and the laboratory information management system LIMS), access control system, water distribution and furniture.

During the integration stage the number of people working on the laboratory were more than 30, which had to be coordinated in order to finish all the works on time for the training of the first crew. It was done in the facilities of the C-IED Centre of Excellence in Madrid.

Also it was important to update all the subcontractors with the requirements of the analytical and laboratory devices. One of the most important issues were related to the way we needed to fix the equipment, specially the heavy equipment, in order to bear the acceleration of the takeoff and landing of the laboratory in its flight to Kabul. We had to take into account the positioning of the heaviest equipment, as there were very accurate limitations in the gravity centre of the containers, in the design stage in order to design the reinforcements of the containers in those parts where the equipment were going to be located. The air cargo company asked us to mark the CoG of every container before its load on the cargo plane.

One of the most critical moments of the project were the air transport of the containers from Luxembourg to Kabul, so it was very important to package and fix all the equipment to avoid the goods to move during the flight. For that purpose, in the design stage, they were designed some specific points in the containers to fix the straps that held the equipment from moving.

Figure 4: Fixing of the equipment for transport

The collaboration with the Center of Excellence was very valuable, providing their facilities and support during the training and testing stages, and being the location for the final deployment before its delivery to Afghanistan.

This project has showed Indra the real value of coordination and commitment from all the stakeholders, including the EDA project officers, the EU experts, the final users (being France the lead nation) and other collaborators, as the C-IED CoE.

Indra has continued researching the best ways to deliver this kind of solutions to the Theatre. Recently, Indra has delivered to the Turkish Land Force a CBRN Mobile Laboratory, proving that it is possible to include the main functionalities into a ISO 20' platform that could be transported easily by plane, boat or truck, and deploying the functionality on the theatre in less than one hour once the laboratory is on the field. The paper will finally show our understanding of which are this functionalities and how can they be integrated in a mobile solution.

Following we have listed the main facts and findings of the project:

- Well proven solution in real conditions (Camp Warehouse - Afghanistan)
- IOC (Initial Operational Capability) achieved within 1 month after delivery, FOC (Full Operational Capability) after 3 months
    - Flash delivery time (7 months) for the whole project execution (design, development, training and delivery)

    - 2010 December 20th - Contract signature
    - 2011 July 26th - Final Delivery

- Full System Safety approval. Design and development fulfilling System Safety standards:
    - MIL STD 822D Standard practice for System Safety
    - M7740-784861 System Safety Manual, H SystSäkE

Some relevant Lessons Learned have been extracted throughout the execution of the project from the draft design until the delivery and FOC stage. Below are listed the most relevant ones:

- Methodical management of approved design versions is needed along the whole design process in order to avoid misunderstanding among the stakeholders.
- System Design must take into consideration from the origin all the logistic issues (deployment, transportation, storage, re-deployment).
- The original rotation has not been responsible of all mountings which generated some assembly issues. For the future the system manufacturer should be involved in the deployment and re-deployment of the Laboratory in Theatre.
- The design should have defined as many as possible existing NATO solutions rather than incorporating new tools for the same applications. The above would facilitate the communality of tools within NATO framework.
- For further designs a new distribution of operational space should be considered, expanding the operational room for some sensitive tasks such as Bio processes.

Innovative Concept: Fast Response C-IED Laboratory

Concept of Use

Fast Response C-IED Laboratory is fully implemented on a unique rapid deployment mobile platform capable to reach the scenario of work. This new concept is also fitted with a lightweight unmanned ground vehicle (UGV) for remote-operated sampling.

Fast Response C-IED Laboratory is capable to encompass both of two lowest exploitation levels: 1 & 2. This new concept provided the users with the following advantages:

- A faster production of results (reporting). The analytical capabilities are deployed just in the scenario decreasing dramatically the time for transfer of samples and reports from Level 1 to Level 2.
- Optimization of recording and sampling (WIT process) in the scenario. It is possible to perform a continuous sampling process based on the first analytical results. The investigation process of the scenario may be guided accordingly the obtained results. So far the evidence collection is undertaken without any feedback from the distant data repository (Lab at level 2)

- Increase of security for specialist. In some critical situations the recording and sampling process can be performed through a UGV minimizing the risk exposure for specialist.

Figure 5: Mobile C-IED Level 2 Laboratory design

System Description : Differential Capabilities

The number of technologies managed by the Mobile configuration is essentially the same but with a notorious decrease of capacity in terms of people hosted (10 vs. 2 specialists) and production rate (5 vs. 2 cases per day)

Following are described the most significant sub-systems composing the Fast Response Mobile Laboratory:

- Housing based on an ISO 20 feet shelter
- Built-in CBRN air filtration and
- Integrated HVAC cooling / heating
- Power generator and Back-up power supply (UPS)
- Water handling systems: Clean and waste water
- Analytical instruments and sampling tools
- Rear side room enhancement Triage & X-Ray

- Incorporates an Integral Security System (Control access, Firing System)
- Specific area for preserving & storage samples (tempered, vented, etc.)
- Holistic data handling throughout the lab by Lab Information Management System (LIMS)
- Full IT network connectivity (Int. LAN/ Ext. Radio-Liks or SATCOM)

The most relevant differential capabilities of the Mobile configuration in comparison with the exiting semi-stationary (modular) configuration are:

- Hosting up to 2 people working inside autonomously for up to 72 h.
- Production rate up to 2 cases per day.
- Fully deployable in 3 hours (built-in lifting legs).

In terms of analytical capabilities, below are described the list of technologies managed by the Fast Response Mobile Lab:

- Platform management & Control (cleanless conditions, security, data processing and sharing)
- SEA Secure Storage Area
- UGV Reporting & Sampling
- Triage (X-Ray technology should be fitted outside the container)
- Chemical Analysis & Biometric Analysis
- Computer Data Recovery & Electronic Analysis
- DVE Detailed Visual Examination

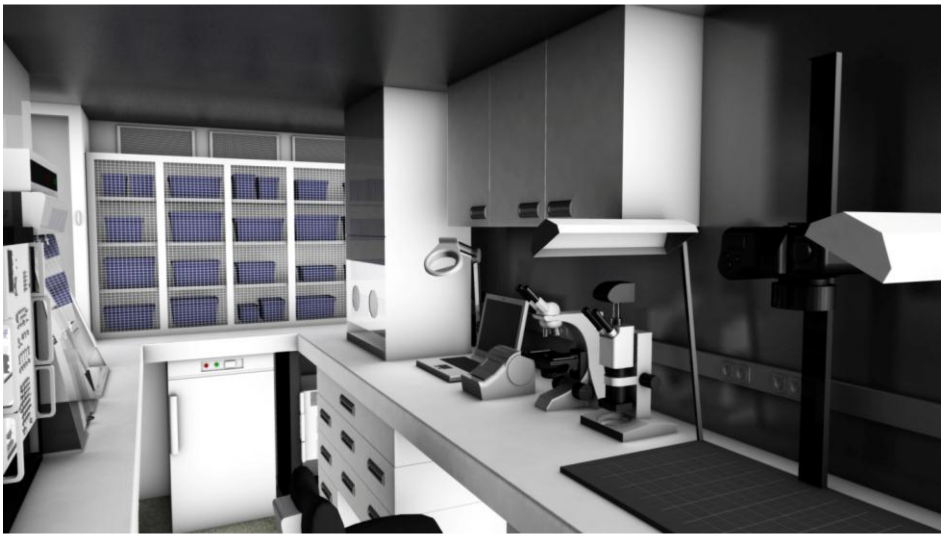


Figure 6: Mobile C-IED Level 2 Laboratory detail

Finally the presentation will be closed showing the most relevant Indra references related to C-IED Laboratories highlighting the our strengths within this field.

Among the most relevant projects or solutions developed are the following:

- Mobile filed CBRN Laboratory (Client: Turkish Army)
- Stationary Biological laboratory (Client: Univ. of Granada)
- Innovative CBRN Reconnaissance Vehicle-AREVE (Client: CDTI)
- Mobile Unit for CRN Reconnaissance (Client: Spanish Civil Protection)

ForLab Project: Forensic Laboratory for in-situ evidence analysis in a post blast scenario

F.Javier HERNÁNDEZ CRESPO (Indra) as coordinator of the ForLab Consortium formed by Indra Sistemas S.A (ES), Italian National Agency for new technologies, energy and sustainable economic development - ENEA (IT), Astrium SAS (FR), University of Thessaly (GR), Space Applications Services NV (BE), Astri Polska SP Zoo (PL), National Bureau of Investigation - NBI (FI), Arma dei Carabinieri - Raggruppamento CCI.S - RACIS (IT), Industrial Research Institute for Automation and measurement - PIAP (PL), Nucletudes (FR). Dirección general de la Policía-Comisiaría General de Policía Científica (ES) and Laboratoire Central de la Prefecture de Police LCPP (FR)

The ForLab project (FORensic LABoratory for in-situ evidence analysis in a post blast scenario) has been approved by the European Commission and funded under the 7th FWP (Seventh Framework Programme - topic SEC 2010.1.3-2 "Forensic Analysis of an explosion or an unexploded IED).

ForLab aims to provide the investigators with a new tool for the investigation of explosive-related incidents, improving their efficiency on evidence collection and the corresponding documentation.

The project, in order to achieve its ambitious goals, will apply novel searching technologies that detect difficult to see evidences and analytical technologies for in-situ selection of the most relevant ones. The overall process of investigation will be optimized to provide a real-time overview of the investigation to a commander, who will in turn provide guidelines to the investigators.

Introduction

An improvised explosive device (IED) post blast scenario usually is a vast area where massive and diverse evidences must be located, collected and transferred for analysis to a distant reference laboratory. Every single detail may be crucial for the identification of the terrorist group responsible of the attack, the person who emplaced the explosive or even the person that assembled the IED.

Any knowledge about the terrorists or their procedures can be of vital importance to prevent new attacks. However, it is hard to differentiate general debris from "clue evidences" and usually the investigators collect a huge number of samples that must be analyzed in one of the few existing specialized laboratories. The time gap between collection and analysis makes necessary to collect many evidences that, after the analysis in the laboratory, are identified as non-relevant and this generates a considerable amount of work and data of no use for the investigation.

ForLab [1] is a novel systematic methodology for optimizing the evidence collection that provides:

- Fast analytical technologies to perform preliminary field analysis of evidences, reducing the number of non-relevant evidences sent to the laboratory.
- Search technologies helping to locate difficult to discover debris of the IED.
- A real time 3D recreation of the scene where all the evidences are depicted as soon as they are collected in the field.

- A command and control centre where the commander has real time overview of the investigation with 'one click' access to the details of any existing evidence. Such information is crucial for the commander so as to guide, from a remote or nearby location, the investigators in the field.

One of the main objectives of the project is to provide a tool that can support and increase the efficiency of the existing forensic procedures making special consideration on giving full support to the necessary chain of custody of evidences.

The ForLab project started on March 2012 and has a duration of three years involving partners of 12 organizations from seven European countries. Four out of those are scientific police agencies directly engaged on investigation of IED related events.

ForLab operational mode

The proposed system (see figure 1) will consist of:

- A dedicated secure network for data communication
- A positioning system to provide accurate location of evidences in outdoor and indoor scenarios
- Analytical and searching technologies for in situ sample screening
- A 3D modelling system capable to recreate the scene in real time using different resolutions for different areas of the scene
- A command and control centre where the 3D model of the scene will be presented to the officer driving the investigation. Through the 3D model, all the information about the investigation will be readily available in real time within a few clicks.

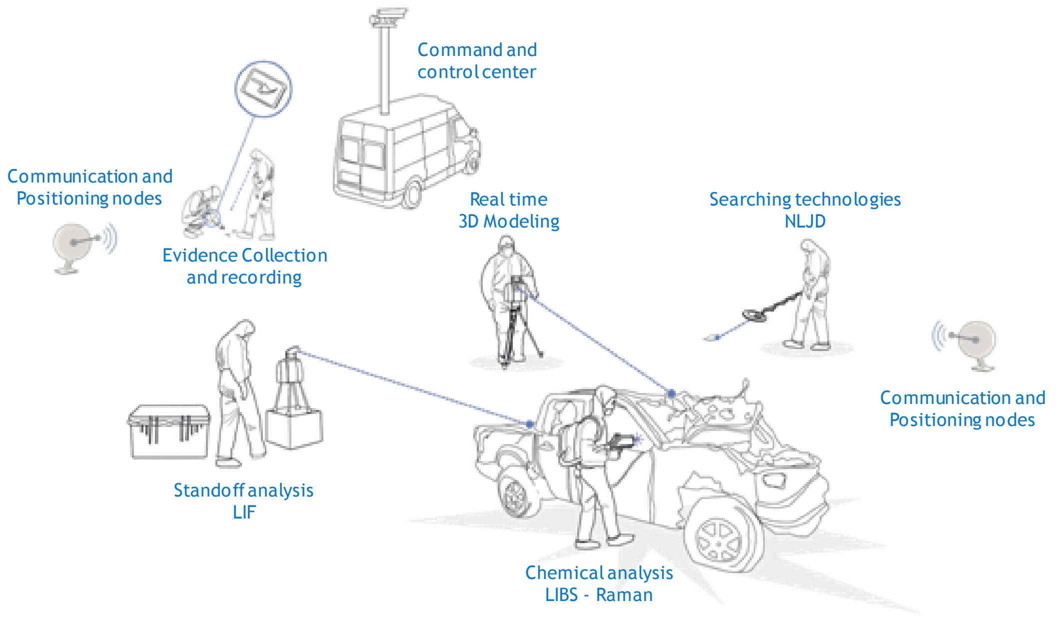


Figure 1 Operational schematic the ForLab

The operational procedure can be summarized in a few steps; the main steps are applicable to any investigation supported or not by ForLab:

- Acquiring an overview of the situation.
    - A quick low resolution model of the scene and pictures are transmitted to the command centre.
- Outline the investigation strategy: The investigators, guided by the commander, define the search strategy.
    - The 3D modelling tool and the communication and positioning system are deployed.
- The investigators enter the scene to perform a visual inspection.
    - The investigator may be equipped with one or more of the technologies provided by ForLab.
- Identification of evidences: Every time an evidence is identified, pictures, position and any other relevant information of the sample are recorded.
    - Operator, place of collection, time of collection, pictures, description, chemical analysis, etc are sent to the Command and control centre in real time.
    - The evidence are presented to the commander at their exact location on the 3D model of the scene.
    - The commander analyzes the situation and provides guidance to the investigators. He can request higher resolution 3D models of specific areas of the scene, to perfom additional analysis on samples or a deeper search in a given area.
    - The evidence can be prioritised for the analysis in the laboratory based on the real time available information.
- The evidences are collected and sent to the laboratory for further analysis.

Technologies developed in ForLab

The first element to be deployed in the scene will be the **3D modelling tool** that will be based on a combination of existing 3D imaging system and standard pictures. It will be a man portable system to ensure that it can be deployed without compromising the integrity of the scene

The system will be able to generate a quick (low resolution) model of the scene a few minutes after deployment. The resolution of the model will be progressively increased over time, while the investigation takes place.

Once the first overview of the scene is recorded, the **positioning and communication system** will be deployed at convenient locations, providing secure data communication for the elements of ForLab and accurate location of the equipment and operators within the scene.

Portable sensors for fast screening of the evidences will be developed in the ForLab project, but the overall concept of ForLab is to be an open architecture where the information provided by any other existing technology can be easily integrated into the ForLab system.

The screening technologies developed in ForLab are:

- **LIF (Laser Induced Fluorescence) [2]:** A standoff technique to acquire fluorescence maps to detect different types of evidences (plastics, textile fibres, polymers…) in the scanned area
- **LIBS (Laser Induce Breakdown Spectroscopy) [3] and Raman spectroscopy [4]:** A man portable device that will provide information on the composition of the samples based on their atomic composition (LIBS) and molecular structure (Raman). These technologies are non-destructive and do not require any preparation of the sample allowing to preserve the evidence for a deeper analysis in the laboratory. The aims of this equipment are to help the investigator to identify the origin of fragments, detection of traces of explosive left by the explosion and identification of other chemical components in the samples that will be sent to the laboratory or over surfaces that due to its size or weight cannot be easily transported to the laboratory.
- **NLJD (Non-Linear Junction Detection) [5]:** A technology suited to find electronic debris produced by the explosion even if they are hidden by other debris and cannot be seen with bare eyes.

To complement the screening technologies, a **tool to record the information of the evidences** and transmit the information to the command and control centre will be developed in the project.

This tool will be implemented in a laptop or tablet that will be connected to the ForLab network and will provide automatically the exact position of the sample, the time of collection, the operator and all necessary information to support the chain of custody of evidences. The information will be digitally signed and transmitted to the command and control centre in a tamper-proof way.

At the **Command and control centre,** a navigable 3D representation of the scene will be presented. Inside the representation, every evidence collected at the scene will be shown and all the information about the evidence will be made available to the commander in a few clicks.

The command and control centre may be located nearby the scene or in a remote place (connected via internet) allowing technicians with high qualification on investigation to provide the necessary guidance for less qualified investigators operating in the scene.

Conclusions

ForLab will develop a new concept for the investigation of a post blast scene of an IED based attack, complementing the existing procedures used by security forces in Europe.

ForLab will introduce several aspects of novelty. A new approach for evidence collection that will reduce the number of samples sent to the laboratory for further analysis and will help in the prioritization of the evidences for its analysis in the laboratory based on preliminary analysis of samples.

In many occasions, the pressure to conclude the field investigation of the scene in the shortest time is very high e.g. due to the need to restore the area affected by the explosion to its normal function. Once the initial investigation is concluded and the security perimeter surrounding the area is removed, any evidence left behind is lost and therefore it is quite important to be able to have an overall assessment of the quality of the evidences collected before leaving the scene.

The availability of the 3D model of the scene reflecting the exact location of the evidences will help on the documentation of the investigation but will also be a powerful tool to complete the investigation once the scene has been cleared. The 3D model can provide valuable information for simulations.

Sometimes the personnel available to perform on-field investigation of an IED attack doesn't have the necessary training or experience, and the time needed to deploy trained personnel on the scene will have a high cost in economic terms but also in the quality of the evidences that can be collected. Let us consider the costs of delaying the investigation for some hours in cases of investigation of outdoor explosions in rainy days or attacks using very volatile homemade explosives in hot days. Some hours of delay in the investigation and collection of samples may be the difference between finding residues of the explosives and finding nothing.

ForLab will enable non-skilled personnel to conduct a good quality investigation guided by experienced investigators that will be able to determine (based on readily available information) if a sufficient number and kind of evidence have been collected and secured before leaving the scene.

Acknowledgements

The ForLab Project is funded by the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement no 285052.

References

[1] http://www.fp7-forlab.eu/

[2] W. Demtröder, Laser spectroscopy Volume 2. Experimental Techniques (2008) 57

[3] A.W Miziolek, V. Palleschi, I Schechter, Lasers Induced Breakdown Spectroscopy (LIBS): Fundamentals and applications, Cambridge University Press (2006)

[4] LEWIS, Ian R.; EDWARDS, Howell GM. Handbook of Raman spectroscopy: from the research laboratory to the process line. CRC, 2001

[5] http://www.tsmc.com/tmdenljd.html

Advanced Situational Awareness Training (ASAT) ® – Predictive and Proactive Sense Making offering a non material solution to combat threats across the contemporary operating environment

Martin WOOLLEY (Senior Manager, Advanced Situational Awareness Training, Orbis Operations).

Orbis Operations, LLC (Orbis) is focused on serving Government Agencies and Defence Sector clients, offering them access to seasoned professionals with years of experience in conflict and post-conflict zones. Orbis' team is involved in projects at the tactical, operational and strategic levels, leveraging an unparalleled network of commercial and government contacts. In our areas of operation we are able to deliver unique insight critical to national security interests. The Company's core competencies include Counterinsurgency (COIN), Counterterrorism (CT), Counterintelligence (CI), Stability Operations (SO); assistance and training in the collection, analysis and dissemination of cultural and, or atmospheric information in austere environments; training related to intelligence and information collection; and the integration of intelligence and planning functions in COIN/CT/CI.

Human Behaviour Pattern Recognition and Analysis

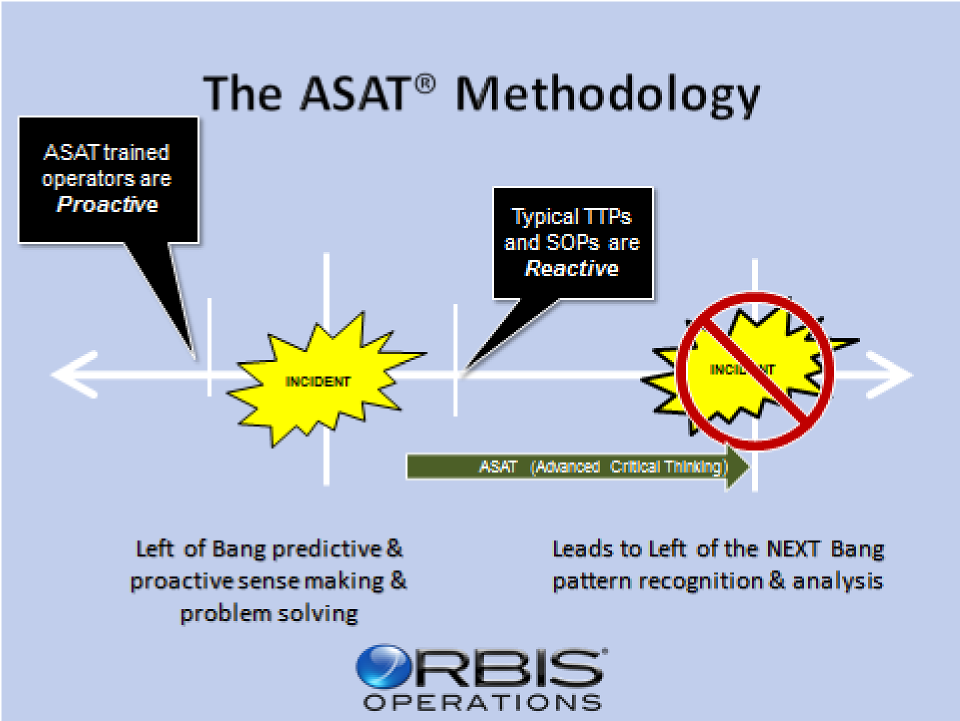
Orbis has developed training programmes in the area of Human Behaviour Pattern Recognition & Analysis (HBPR&A), and has titled this, "Advanced Situational Awareness Training (ASAT) ® . The programme was originally developed to offer a non materiel solution to the Improvised Explosive Device (IED) challenge, aimed at reducing military casualties and breaking up the IED Networks across the Contemporary Operating Environment. This methodology provides individuals with enhanced cognitive tools for the detection of threats in any situation or context, allowing for the adaptability critical for remaining ahead of ever-changing security threats and challenges. Despite its' original intent, ASAT® is not just a C-IED tool. Rather, ASAT ® imparts individuals with skills that transcend the C-IED fight and that are relevant across the spectrum of military conflict, law enforcement operations, and a wide variety of security challenged environments. Orbis' instructional regime offers a scalable mechanism to provide ASAT® training by leveraging a deep cadre of highly experienced Subject Matter Experts (SMEs) to train end-users in bespoke ASAT® Courses and deliver advanced courses where necessary to proliferate these skills across organisations and sustain them.

Battle Tested and Scientifically Proven

This unique training has been successfully implemented in both Iraq and Afghanistan. It is a scientifically validated[1] and a battle tested training programme that allows individuals to cognitively make sense of highly complex environments. All people, events, and vehicles give off certain signals when they are measured against context, relevance, and the societal baseline. These 'signals' are read as 'anomalies.' Establishing a baseline, detecting and then acting on anomalies is the essence of ASAT®. Such training imparts individuals with enhanced cognitive tools for the detection of potential threats in any situation or context, thereby providing the skills and ability to detect, observe, and engage criminals, terrorists, insurgents, fugitives, their networks, and prevent evolving threats. These essential skills enable individuals to "**see first and**

[1] . Scientific reports are listed at Reference section.

act first." In essence ASAT® provides humans with the tools to act in a logical and structured manner; thereby allowing trained personnel to become **proactive and predictive**, **vice reactive** and enabling action to be taken **prior** to incidents occurring.



ASAT® is an enduring skill set that is applicable across culture or geography and can be applied to any type of operation (For example Irregular Warfare, Law Enforcement, Maritime Board and Search, Military Base Security, Customs and Border Operations, and Village Stability Operations). This training combines classroom instruction and practical training scenarios, it is a non materiel capability that complements and enhances current equipment and existing Standing Operating Procedures/Tactics, Techniques and Procedures.

Courses and Accolades

Orbis' HBPR&A courses are being taught to a wide audience, including:

- Ongoing courses at the US Army Maneuver Centre of Excellence (MCOE) at Fort Benning.
- A wide variety of US Army Mobile Training Team events to include training every Security Force Assistance Team headed to Afghanistan.
- US Navy Naval Special Warfare Group and Naval Special Warfare Command.
- US and NATO Teams deployed in Afghanistan (Insider Threat ASAT).
- US Special Operations Command.
- NATO (A Countering IED Course and a developing Maritime Course).

Numerous compelling accolades exist regarding the effectiveness of ASAT®. Three examples are as follows.

- Sergeant from Task Force Paladin (Afghanistan): "This was the most valuable training we have received in the seven months we have been deployed to Afghanistan, a real eye opener".
- ASAT® Course student (Officer): ASAT® trained personnel are also able to be proactive instead of reactive, giving them relative superiority in any situation."
- Commanding Officer of US Navy Seal Squadron: "ASAT® enables operators to short-circuit threats before they harm friendly forces or public perception. The training enables individual shooters to reduce civilian casualties and collateral damage from preventable firefights. ASAT® trained operators are also able to be proactive instead of reactive, giving them relative superiority in any situation."

Insider Threat Situational Awareness Training (IT SAT ℠)

ASAT® is utilised when conducting operations outside of the security of a protected base. IT SAT℠ is applicable when personnel are inside the base; this training is currently being provided to coalition troops in Afghanistan. IT SAT ℠ is based on the fundamentals of ASAT® and therefore the description of ASAT® applies equally to IT SAT ℠. However, In order to clarify the difference, IT SAT ℠ can be summarised as follows:

- Purpose:
  - Close the capability gap permitting "green on blue attacks" by arming individual members with the skills of HBPR&A to identify an insider threat and provide the tools for action within a decision making framework.
  - Provide coalition members with the gift of time and space to identify a developing threat and replace hyper vigilance with "informed" hyper awareness.
- Method:
  - Deliver practical, skills oriented, SME delivered training and education in HBPR&A.
  - Training is scalable and customised to each type of unit to fit unique challenges and situations.
  - Instruction is interactive and scenario driven.
- End State:
  - The most exposed elements of the force are trained in HBPR&A to identify the insider threat and linked to a decision making framework.
  - Foster a climate of "informed awareness" to mitigate the risk to force at the tactical level for units operating in a partnered environment and reduce risk to mission at the operational level by closing the capability gap.

Maritime Advanced Situational Awareness Training (M-ASAT)

Following interest from NATO, Orbis Operations is developing a M-ASAT course that will be hosted at the Greek Training Centre, The NATO Maritime Interdiction Operational Training Centre (NMIOTC) in July this year.

The NATO Allied Command Transformation (ACT) HQ in Norfolk has recognised that Naval boarding teams are critical enablers in supporting Attack the Network (AtN) operations. In addition to collecting traditional boarding data, boarding teams have the potential to collect vital forensic, biometric, material and technical data that can be exploited to support countering threat networks. Influenced by the success of ASAT®, the aim of this M-ASAT course is to produce students who are motivated, agile, and adaptive, and who can use advanced critical thinking skills to apply M-ASAT principles to maritime situations in order to enhance boarding operations, non-combatant evacuation operations, and mission planning.

Conclusion

ASAT® is an enduring skill set that is applicable across culture or geography and can be applied to any type of operation. This experiential based learning combines classroom instruction and practical training scenarios; it is a **non materiel capability** that **complements and enhances** current equipment and existing Standing Operating Procedures/Tactics, Techniques and Procedures.

Further information regarding ASAT® can be obtained from Orbis Operations LLC; point of contact is Martin Woolley whose e-mail address is: m.woolley@orbisops.com

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Close Sensing Radar Systems enhanced by Microwave Tomography for IED detection and localization

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Abstract – This paper deals with the use of radar systems for IED detection and characterization. In particular, the focus is on advanced data processing able to make the radar images fully usable for the purposes at hand. Moreover, open scientific and technical challenges for a real use of these technologies in the operative conditions are briefly sketched out.

Radar Systems for IED Detection

In IED threat management and mitigation, one of the most relevant capability areas is the detection [1, 2], that means not only to localize person-borne, vehicle-borne and buried IEDs but also to identify suspicious activities associated with IED emplacement [1, 2]. In this frame, there are several scientific and technical challenges to be faced, among which: to capture, catalogue and identify IED and component signatures; to detect IEDs from a safe stand-off distance; to detect IEDs while dismounted or mounted; to detect IEDs from airborne platform. In addition, high reliability and low false alarm have to be ensured.

One of the most relevant technologies regards radar systems for close and medium distance sensing, which allow important advantages in terms of timely and high resolution localization of hidden and buried targets. Moreover, compared to the usually deployed metal detectors, they allow the detection of low- or non-metallic devices at safe distances by exploiting stand-off platforms.

The radar systems relevant to IED detection can be grouped into two classes: Ground Penetrating Radar (GPR) [3] and stand-off systems for through–wall–imaging (TWI) [4] and for concealed objects detection. Both these kinds of systems work by emitting a Ultra Wide Band electromagnetic signal that propagates through the soil (or beyond an obstacle) until it impinges on a target (representative of IED); this arises a scattered field that is collected by a receiving antenna. Such a received signal is gathered at different measurement points and, after, visualized in a space-time image, so to achieve the raw-radargram [3, 4].

Despite the simple electromagnetic sensing mechanism, the use of radar system in operative conditions is not with immediate impact, since the provided raw radar images suffer of “blurring” effects, which can make the interpretation very difficult by not expert users. As a consequence, a widely tackled research topic is the development of data processing approaches capable of dealing with realistic scenarios and providing real-time and easily understandable images.

Microwave Tomography as radar data processing: state of art and perspectives

A class of approaches particularly suitable to process data gathered by means of radar systems designed to image hidden and buried targets, as IED, is based on microwave tomography [5, 6], For these approaches, the targets (IED) are searched for as electromagnetic anomalies with respect to the background medium and the scattering phenomenon, which is at the basis of the sensing, is properly modelled.

From many years, research activities have been concerned with the design, implementation, validation and use of microwave tomographic approaches able to face realistic scenarios, with the aim of detecting and estimating the geometrical features of targets buried in large spatial domain, while keeping the processing time feasible for realistic applications. In this frame, the main outcomes of the research activities carried out at the Institute for Electromagnetic Sensing of the Environment – National Research Council of Italy regard the development of efficient microwave tomographic approaches able: to deal with different scenarios and situations, to carry out near real time imaging; to deal with large investigation domain; to achieve solution robust with respect noise and clutter and, last but not the least, to provide images easily and quickly interpretable also by non-expert users.

The advantages in terms of reconstruction capabilities offered by the combined use of standard or advanced radar data filtering procedures, devoted to noise and clutter reduction, and microwave tomographic approaches has been demonstrated in many scenarios ranging from demining [7], to through wall imaging [8, 9] and tunnel detection [10]. An example of the effectiveness of the achievable imaging capabilities is provided by Figure 1, which shows results concerning landmine detection experiments carried out in controlled conditions [7]. In particular, the data have been collected by means of a radar system, which is not in contact with the air/soil interface, and are referred to simulant of landmines buried in a tank filled with sand. The targets features and locations are given in Table 1.

Figure 1.a depicts the raw radargram as provided by the GPR system with the location of the radar signature of the targets evidenced by black contour boxes. As can be seen, but for the anti-tank landmine, the other landmines are difficult to be detected. Conversely, the combined use of

Type	Metal content	Diameter (cm)	Height (cm)	Case Material
Antitank (AT)	High	25	8	Plastic
PMN2 (AP)	Low	12.5	5.2	Plastic
M14 (AP)	Low	5.6	4.2	Plastic

Table1. The features of the landmines used in the experiment

advanced techniques, devoted to erase and mitigate clutter [11], and a microwave tomographic

approach, makes possible not to detect the three landmines but also to localize them and to obtain a reliable information about their extent (geometry) . This is assessed by the tomographic reconstructions depicted in fig. 1.b, 1.c and 1.d for the AT, PMN2 and M14 targets, respectively.

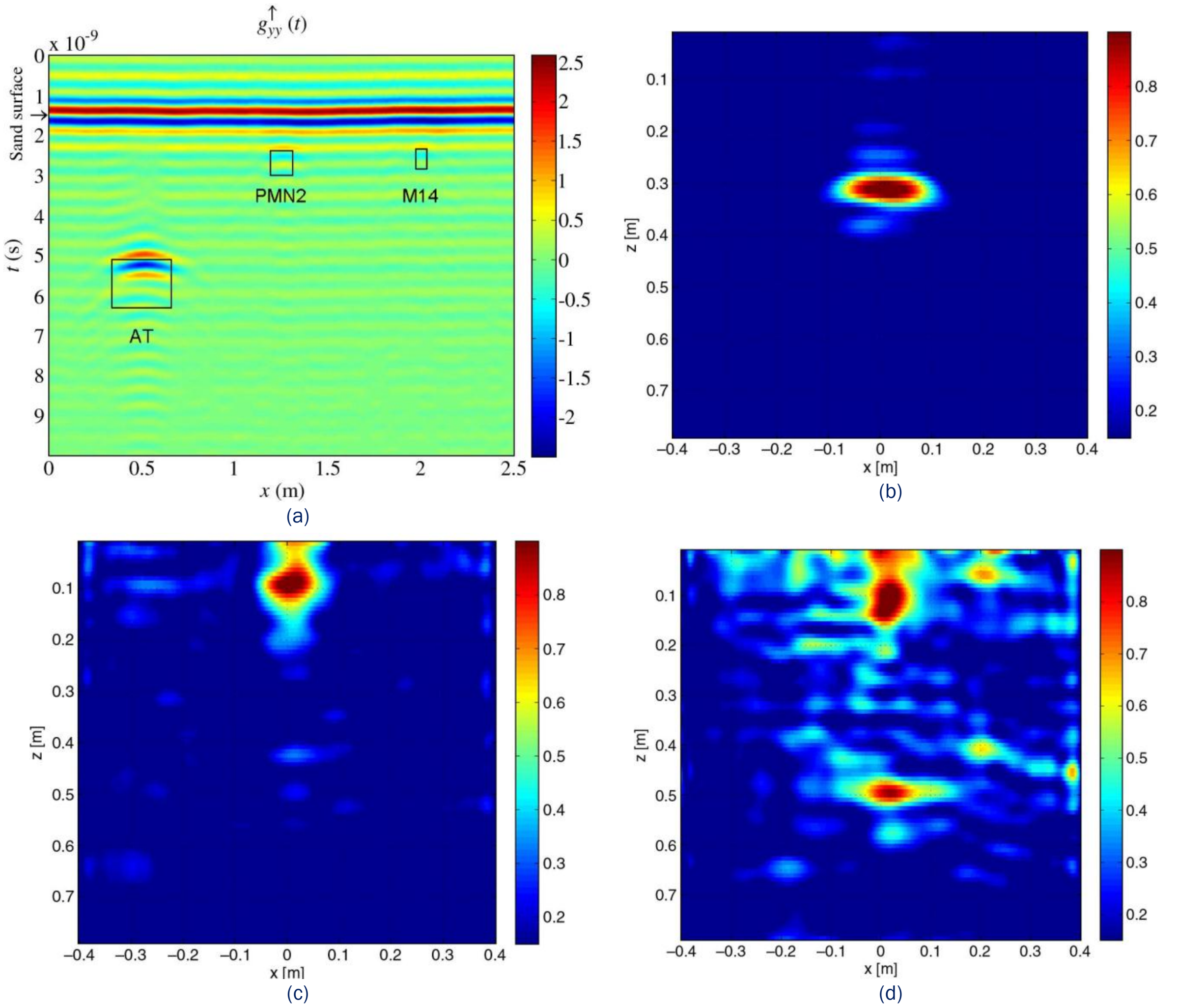

Figure 1. Landmine detection: a) raw-radargram - the black boxes indicate the location of the three targets; b) tomographic reconstruction of the AT landmine; c) tomographic reconstruction of the PMN2 landmine; d) tomographic reconstruction of the M14 landmine.

Open challenges

Beyond the use of radar systems enhanced by advanced data processing approaches, as the microwave tomography, many scientific and technological issues have to be still tackled to achieve fully effective radar imaging tools for IED threat. In particular, the most relevant necessities, few of them counteracting each other, are:

- Clutter mitigation in radar systems for hidden and buried targets;
- Coupling data processing procedures with target classification [12] and visualization strategies;
- Combining radar observations with the outcomes of other sensors (radiometric systems, infrared thermography, and so on) [13];
- Development of portable systems with low hardware complexity;
- Use of non-conventional observation platforms as airborne one [14] and systems mounted on vehicle for a forward looking observation [15, 16].

These challenges fall in the general frame concerning the integration of different technologies in order to engage the precision, close-in and persistent sensing, and to provide situational awareness of the scene, in full compliance with the Layered Sensing framework, where the use of radar is one of the "observable quantities to be exploited through overt or covert observations" [17].

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Explosives detection at FOI – Imaging Raman spectroscopy

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At the Swedish Defence Research Agency, FOI, effort is currently put into developing techniques for detection of explosives traces at stand-off distances. One such technique, based on multispectral imaging Raman spectroscopy, has been developed to detect and identify explosives particles. When handling explosives, residues are often spread for example via fingerprints. By imaging a surface using the multispectral imaging Raman technique, the explosive particles can be identified and displayed as a colour-coded image. The HLIN system has now reached the point where the detection limits have shown potential for detection of trace amounts of explosives at stand-off distances. Hence, detection of fingerprints of explosive material on 10 m distance has been demonstrated. The system is also under development to be more robust and to work with UV wavelength, thereby being invisible and eye-safe.

Introduction

In the past decade terrorist attacks using homemade explosives or improvised explosive devices have increased. Early detection of explosives or production of explosives would be an aid to authorities in trying to prevent new attacks. At FOI, the Swedish Defence Research Agency, work has been put into several national and EU-projects aiming at detecting explosives or precursors of explosives during production, handling and transport. One of the techniques in focus is Raman spectroscopy, which is a technique widely used by analytical chemists for decades but for which the application areas have expanded the last few years thanks to the technical developments. The interest in Raman spectroscopy for standoff explosives detection is shared by other research groups working on bulk detection [1-4]. One issue that has to be handled is the problem of fluorescence – both from the background but also from the explosive itself. To overcome this problem, it has been suggested to use shorter wavelengths, preferably below 250 nm [4, 5], or to use picosecond laser systems and temporal filtering [6, 7]. There is also an interest in using resonance enhanced Raman spectroscopy (RRS) for explosives detection [8-10]. At FOI, conventional Raman spectroscopy has been used to detect explosives in bulk phase at stand-off distances. Pettersson et al.[11] showed that bulk amounts of homemade explosives (HME's) and precursors were possible to detect and identify at a 55 m distance in realistic environmental conditions e.g. rain, snowfall, and sunshine. Detection limits for the setup used by Pettersson et al.[11] were later on established by Nordberg et al.[12] to a few hundred micrograms for 2,4-dinitrotoluene (DNT), 2,4,6-trinitrotoluene (TNT), and ammonium nitrate with the same technique.

A challenging problem when detecting Raman signals is how to discriminate it from the background light or fluorescence coming from the sample itself and other compounds. The fluorescence can be suppressed e.g. by using picosecond lasers and very fast gating [13]. At FOI, a technique based on multi-spectral imaging Raman spectroscopy has been developed for detection of explosive particles at stand-off distances in order to distinguish the Raman scattered light from the background [14, 15]. With this technique it was demonstrated that the signal to noise ratio can be improved approximately 1000 times for TNT compared to conventional Raman spectroscopy, which means sub microgram levels of detection [16, 17]. The measurements done to verify the limits of detection and the results from those studies [16, 17] are presented in this paper. Here we also share the latest developments and current status of the system, named the HLIN-system.

Multispectral imaging Raman spectroscopy

Principle of detection

The multispectral imaging system used in the measurements have been described in detail elsewhere [14, 15]. The detection principle can be explained by considering two small areas on a surface illuminated by a laser as in Figure 1. In the blue area there is no particle while in the red a particle is present. Both areas are imaged on the ICCD-chip by an optical system e.g. a telescope. A tuneable filter with a very narrow bandwidth will only transmit one wavelength at a time, and the recorded image will only hold information for this particular wavelength. If the tuneable filter is scanned through a number of wavelengths and at each wavelength a 2D-image is recorded of the surface; a set of images called a multi-spectral cube will be formed. The multispectral cube will contain both the spatial and spectral information of a surface (in a conventional Raman system, a sum of the total spectral information of the whole surface is obtained). In the case of the two areas considered above, for the red area, which contained an explosive particle, a specific spectrum containing the spectral information of the particle is found. For the blue area, where we had no particle, only the spectral information of the background is found. Because there is little or no interference between different sub-areas the signal-to-background can significantly be increased, making it possible to find much smaller targets than with conventional Raman spectroscopy.

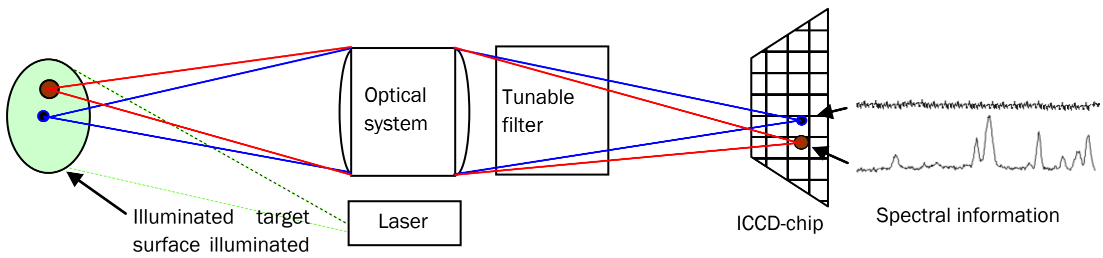

Figure 1: The principle of the multispectral imaging Raman system

Current status of the HLIN system

In our set-up, the laser used to illuminate the target is a 532 nm Nd:YVO4 laser and the back-scattered light is collected by a 200 mm Smith-Cassegrain telescope. The field of view of the ICCD measures 28 mm × 28 mm at 10 m distance with an image resolution of approximately 70 μm. Each point, down to the resolution of the ICCD camera, will be recorded in a unique pixel on the ICCD-chip, at each wavelength selected by the tuneable filter. The spectral region of interest, i.e. the wavelengths selected for our measurements, is chosen depending on the substances and the specific Raman peaks.

Figure 2: The current HLIN system mounted on a pan-and-tilt head and used during outside stand-off measurements.

The current prototype of the HLIN system is mounted on a pan-and-tilt head and computer operated and controlled. A photograph of the system is shown in Figure 2. A wide angle camera mounted on the sensor platform and integrated in the data analysis is used to steer the system onto the surface of interest as seen in Figure 3, upper right. The Raman sensor samples the area displayed by the square in the centre of the image. The backscattered light from the sample is split after the telescope, and another CCD-camera displays the image "seen" by the sensor, see Figure 3, bottom left.

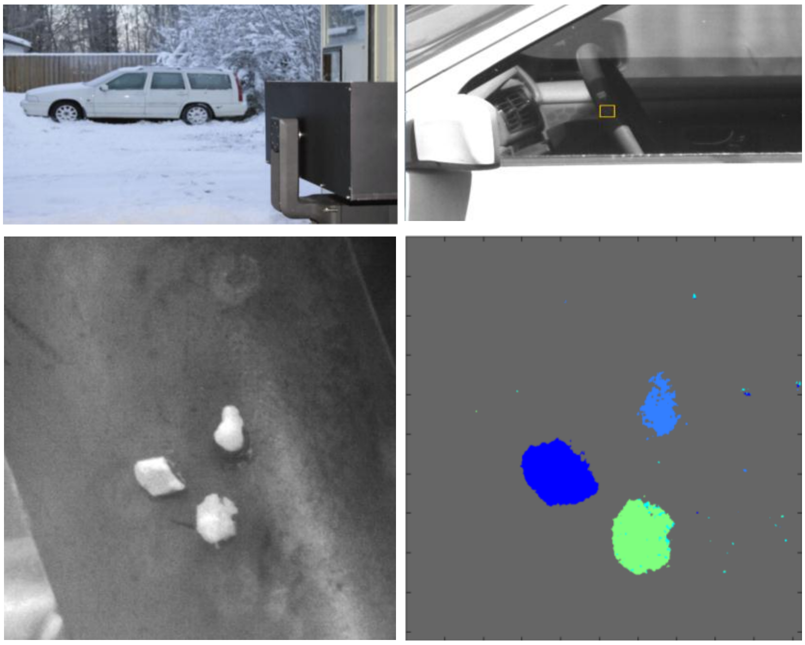

Figure 3 : Stand-off detection and classification of substances placed on the steering wheel of a car. The classified substances are sulphur (blue), ammonium nitrate (light blue), and DNT (green).

The spectral signal from the sensor is analysed as described in [14, 18] and the result is presented as a chemical-specific colour-coded image which displays the chemicals found on the surface, where the particles are positioned and how they look. The current time for measurements and data analysis is around 50-60 seconds, however a lot of effort is put into refining the software for data analysis to reduce time and, more importantly, increase the sensitivity [18].

The particles in Figure 3 are several millimetres large, but studies have also been made with smaller particles. Detection of trace amount from fingerprints of different chemicals were presented in a study by Nordberg et al.[15]. Three fingerprints, each containing small particles of sulphur, DNT and ammonium nitrate were placed on the same spot on an aluminium plate, see Figure 4, left. The plate was placed in front of the setup at a distance of 10 m and 28 images were recorded with Raman wavelength shifts ranging from 400 to 2020 cm^{-1}, and each image was recorded during 5 s (50.000 laser shots). Figure 4, right, shows the evaluated data from these measurements, where each pixel has been colour -coded according to which substance is found.

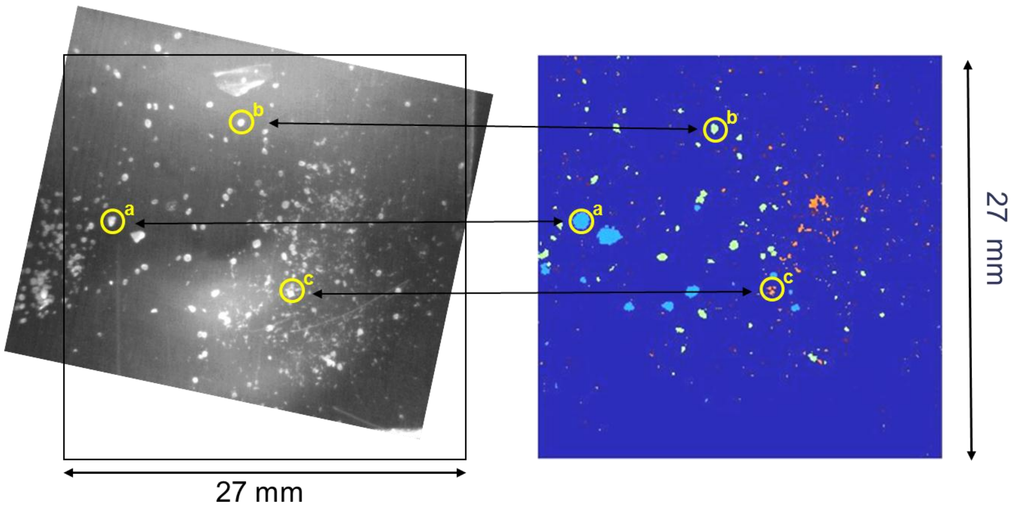

Figure 4: Photographic image recorded with a d CCD-camera mounted on the telescope (left) and colour-coded Raman image (right) of particles in a mixed fingerprint containing sulphur (a), ammonium nitrate (b) and DNT (c).

Another study was made by Ceco et al. [17] in order to determine the detection limits of the current imaging Raman system and evaluate the possibility to find realistic trace amounts of different chemicals. Systematic measurements were made on known amount of chemicals placed on aluminium plates were holes with different sizes and depth had been drilled, see Figure 5, left. The holes get gradually shallower throughout a column and thus the volumes of the holes are reduced. The plates were each filled with one of four different substances; RDX, DNT, TNT and sulphur, sulphur was included as a reference substance due to its high Raman cross section. The volumes were estimated from the conical angle of the drill, the depth of each hole. By knowing the densities of each substance the mass in every filled hole could be estimated. The sample plates were then analysed at a stand-off distance of 10,6 m, detection times were not optimised since the focus was directed towards optimal detection and a low amount of false alarms.

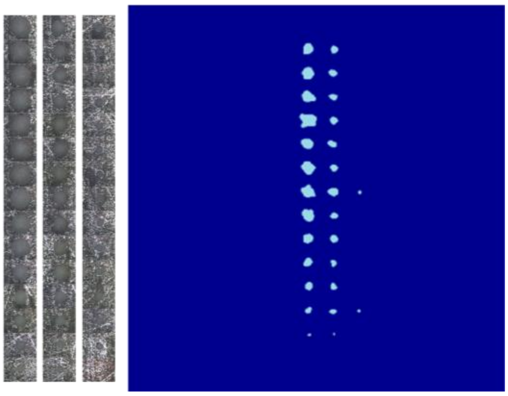

Figure 5: Photographic image (left) and colour-coded Raman image (right) of the sample holes for determining the detection limits. In this example the holes were filled with DNT.

Figure 5, right, shows the results for DNT from the HLIN system as a colour-coded image [17]. By comparing the colour-coded images with the known amount of sample in the holes (Figure 5 left), the current detection limits of the HLIN were determined to be 25,9 µg for RDX, 460 ng for DNT, 470 ng for TNT, and 200 ng for sulphur [17]. The limit of detectability found for RDX was higher than for the other substances in the study, and it did show somewhat lower peak intensities in the reference spectra, we do however believe that it can be further reduced by some alternations of both the laser and the algorithms for data evaluation. DNT and TNT, which have analogous molecular structures, showed a similar level of detectability (460 ng and 470 ng respectively). Sulphur, having the highest signal to noise ratio in the reference spectra of the four investigated substances, was detected with the lowest mass (200 ng).

Conclusions and future improvements

Multispectral imaging Raman spectroscopy has been demonstrated to be a powerful tool for detection of explosives traces. The HLIN system is currently at a point where the resolution is good enough to enable detection of trace levels comparable to traces from fingerprints.

The total detection time is currently around 60 seconds, which depend on the signal strength and the number of substances chosen to be included. The number of wavelengths included in the analysis and the algorithms for evaluating the signal are still need to be optimised. Apart from these improvements, work is currently put into upgrading the HLIN system with respect to some main parameters. Changing to UV-wavelengths will make the system eye- and skin-safe, which would be preferable in many civil and military applications. The upgraded system will also be remote-controlled and stand-off, which means that the system could be stand-off (>10m) from the target and the operator even further away (>100m). Work is also put into improving the user-friendliness of the system in collaboration with end-users.

Acknowledgements

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Detection of IEDs Through Explosive Vapours Detection by Mass Spectronscopy

Vicente MARCAN (SEDET)

It is globally accepted the useful help of canines to search and find explosives. Now imagine an explosives detector with sensitivity 10.000 times better, capable to detect and identify plastic and non-plastic explosives with an availability of 24 hours per day, 7 days a week. Actually you do not need to imagine it, we talk of a new generation of Explosive Vapors Detectors (EVD) which does already exist, and is starting certification to ensure the security of the cargo transported in civil aviation airplanes.

Of course the EVD would not be able to jump over packages being draw by a conveyor belt, and it could not walk in a crowded market either; however it would do at once and in few minutes the inspection of a 110 m^3 cargo in the bay of a truck or container. One immediate application of this new generation of EVD, conveniently ruggedized, could become an efficient tool to detect explosives concealed in vehicles at scenarios for protection of compounded areas (control at the entrance of a MOB) or for mobile check points to disrupt the transport chain.

Looking to DETECTION OF THE THREAT the applications of this kind of equipment is very promising for scenarios such as clearance of roads as a short distance or a remote precise detection system due to its very low false alarm rate. The existing equipment can be tailored to detect emissions of explosive vapors from buried IEDs, and with an additional sampler carried by a small robot would provide a good inspection tool to search for IEDs inside narrow culverts. As a plus, the ability of the EVD to identify the explosive substances detected would provide the EOD/IEDD specialists with valuable information on the nature of the IED detected.

More elaborate applications of the EVD could be used to provide a first and second line forensic tool, and detection of explosives vapors in the vicinity of explosives manufacturing facilities, manipulation or storage centers. These inherent capabilities of the EVD though nor formally demonstrated, have being experienced in real tests.

The paper proposed for consideration of the conference of Experts on the 5th March will present the performances demonstrated by the EVD developed by SEDET, and the roadmap to develop solutions to help the Forces to detect the IEDs threat.

Basics

The search of solutions to detect IEDs has produced a series of technologies and equipments aimed to detect IEDs components like metals, electronic components and explosives. Being explosives the only component always present in the IEDs most of the solutions produced are focused to explosives detection

The explosives detection technologies can be sorted out in two groups: the Explosives Trace Detectors and Bulk or Images based detectors.

This article presents advantages associated to Detection of Explosives Trace Detection by Mass Spectrometry.

Detection of Explosives Vapors

Present technology used for vapor analysis is based on Ion Mobility Spectrometry (IMS) a technique whose performances are many orders of magnitude away from requirements for buried IEDs detection.

US National Academy of Sciences concluded in 2004[2] that "Mass Spectrometry based trace detection systems have the capability to address many of the limitations of present IMS based systems",

SEDET have conducted since 2008, with the support of the Spanish MOD and the NATO DAT PoW a research project aimed to develop an Explosives Vapor Detector (EVD) capable to detect any type of explosive (including plastic explosives) in the gas phase.

The SEDET detection system named ACES is built from the integration of the following components (see Figure 1):

- A Sampling Unit: This filters the air and concentrates the vapors in a filter. (100/1),
- The Analyzer unit where the filter is inserted desorbs the vapors retained in it. Vapors are ionized in a Secondary Electro-Spray Ionizer (SESI). Then ions are filtered through a mobility separation device (DMA), and finally analyzed by a tandem of mass spectrometer (API MS/MS).

Summarizing: The Analyzer performs a triple filtering process: by ion mobility, by mass of the explosive molecule ion, mass of its characteristics fragments and the stoichiometric relationship among them.

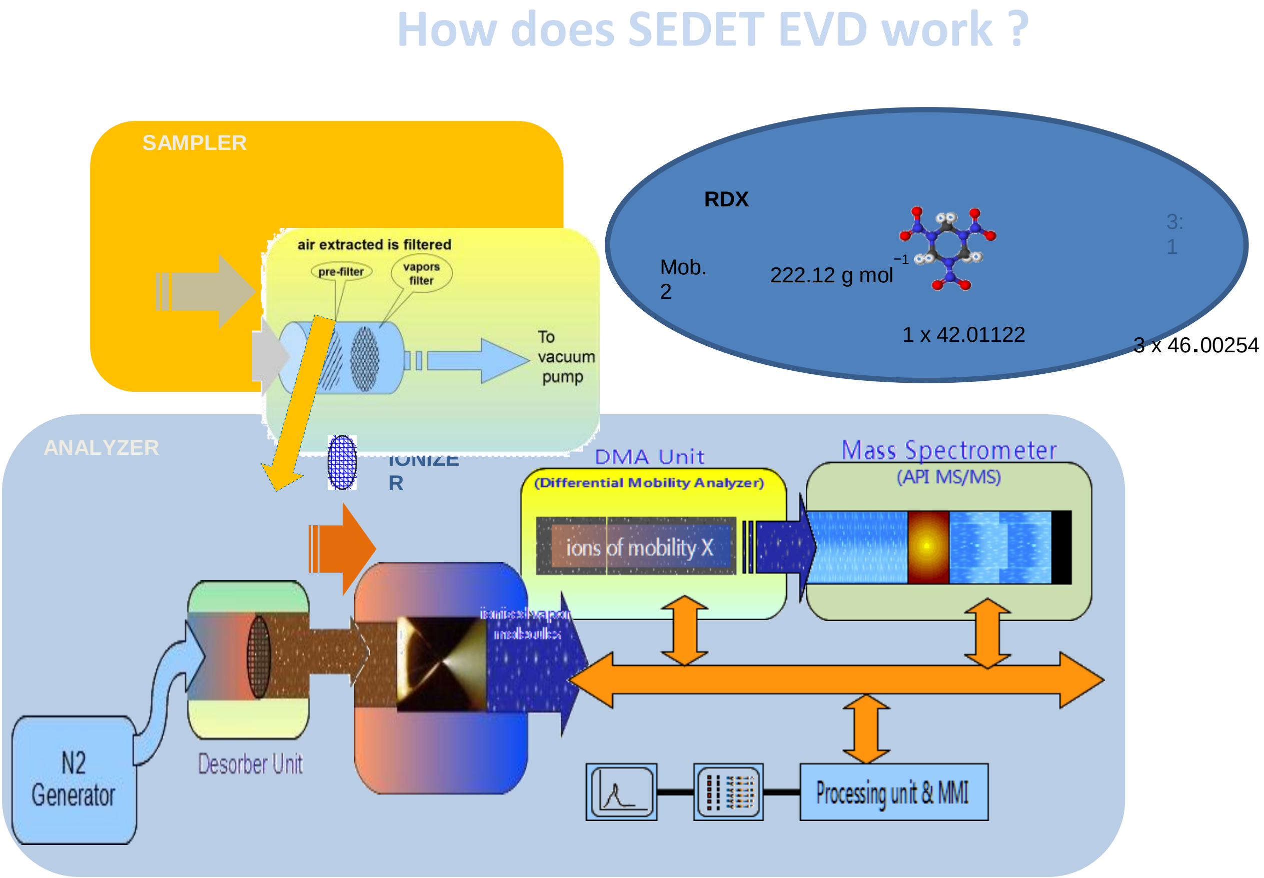
The detection capability resulting from the ACES analyzer allows the detection, identification and measure the presence of explosive vapors down to the level of 10^{-16} atm. In other terms ACES allows the characterization of gases and particles present in the atmosphere in concentrations below 1 pg/m^3.

IEDs Detection Based on Detection of Traces of Explosives

It is evident that explosives are the only component always present in an IED. In addition explosives detection gives to forces the maximum of opportunities during transportation, store and manipulation of the explosive before it becomes part of an IED. Once the IED is put in place hidden in a vehicle, in the body of an insurgent, buried under a road or inserted in a narrow culvert we can detect explosives. Even after deactivation or destruction of the IED the analysis of the samples can provide pieces of intelligence information.

[2] US Research Council of the National Academies: "Opportunities to improve Airport Passenger Screening with Mass Spectrometry", 2004. See http://www.nap.edu/catalog/10996.html

Architecture of ACES detection System



Potential Solutions Based on the Explosives Vapour Detection

From scenarios discussed by EOD specialists SEDET has selected three as more suited to implement an explosive vapor detection solution (primary or secondary) to detect IEDs.
The Scenarios where a solution based on explosives vapor detection can help are:

- Route Protection: EVD as primary or secondary inspection
- Protection of compounded areas: Inspection of vehicles and people
- Factory, store and dispatch of explosives/ IEDs: (ISR)

The solutions proposed by SEDET for the generic scenarios selected can be implemented as Short, Medium and Long term solutions.

Short and Medium Term Solutions

These solutions are mainly based on the existing equipments developed by SEDET

- Detection of explosives hidden in the cargo of trucks or containers,at a fixed inspection post to protect a compound (MOB) or as a mobile unit for road controls.

  The solution would consist in a militarized version of the existing ACES detection system (Air Cargo Explosives Screener)

- Detection of explosives hidden in vehicles

  To perform inspection of vehicles an ad-hoc sampling unit shall be developed. The analysis unit would be the same proposed above for inspection of cargo trucks and containers.

Medium and Long Term Solutions (4 TO 8 YEARS)

SEDET has collected enough evidences on the ability of its equipment to detect vapors of explosives emanated from buried explosives and detection of vapors in the open close to contaminated areas.

Detection of Buried IEDs

Initial tests performed with the existing ACES equipment (sampler not adequate for real operation) shows that vapors of explosives are detected from buried explosives and ammunitions. To develop a vehicle with capability to detect IEDs buried under a road surface the following generic tasks have been identified:

- Development of a new sampler optimized to collect vapors from the soil covering buried IED, and deposit them into a filter,

- Adapt the new sampler to a vehicle through an arm or other sweeping device (tbd by operators)

- Modify the analysis unit to fulfil the operational requirement (surface to inspect and speed)

Detection of explosives in the vicinity of an explosives factory, store or dispatch centre. Detection of mined areas could become a target for this solution.

Detection of explosive vapors in the air in the vicinity of areas with explosives has repeatedly happened during tests with the existing equipment.

After evaluation of the real capability to detect targets defined by operators a sampler mounted in a vehicle carrying the same analyzer used for short term solutions will have to be designed

Self-Learning Radio System for C-IED

Markku JENU, Tauno VÄHÄ-HEIKKILÄ and Manu LAHDES (VTT Technical Research Centre of Finland)
Juho MARKKULA and Harri SAARNISAARI (Centre for Wireless Communications, University of Oulu, Finland)

A concept for the self-learning counter IED (C-IED) system was developed. The system can be implemented on a platform based on software-defined radio. The concept covers the detection and analysis of the firing radio signal and the generation of the jamming signal and the update of the threat library. Methods of opportunistic spectrum use for communications, detection and IED jamming based on cognitive radio networks are discussed. A key idea is to employ all the (capable) radios in the convoy for these tasks in a cooperative manner. The developed simulator system can be used for the research and development of a networked C-IED system and for the verification of the methods and operational models in different scenarios.

Introduction

IEDs are probably the most significant threat in the peace keeping and crisis management operations. They are often initiated from the distant posts using wireless devices, whose signals are difficult to detect in a dense and dynamic frequency environment. Today's radio controlled IED (RCIED) detection and jamming systems are not optimized for the specific wireless firing signals. They require the use of dedicated equipment, whose preparation with the algorithms and operative data for the mission is expensive and time-consuming. Therefore, there is a definite need for a more advanced radio based C-IED system.

EDA's C-IED scenario definition

EDA Counter IED Detection Expert Group has developed a definition for the C-IED scenarios that is based on a three dimensional approach [1]. The scenario can be applied also to the case, where the adversaries are using radio controlled IED trigger devices. The scenario is defined with the equation

Scenario = Device x Context x Operation

where *Device* is a threat technology such as roadside bomb or person borne IED; *Context* consists of the environmental factors such as physical conditions, visibility, markers, local event history, changes/anomalies, infrastructure etc.; and *Operation* is a patrol, a check-point, a convoy etc. in question.

The three dimensional model proposes that a scenario can be described as a Device in a particular Context into a type of Operation (see below). There are potentially thousands of different scenarios, i.e. combinations of device, context and operation. However, they may be reduced to a small number of the most representative scenarios.

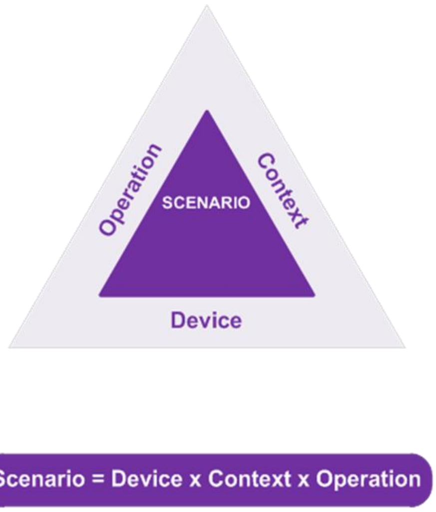


Figure 1: C-IED scenario definition [1].

Research scenario: dirt road patrol and convoy

The paper's research scenario is defined as follows applying EDA C-IED scenarios. The operation is a convoy and the threat is a buried IED. The context is the following. The vehicles advance in the daylight in a queue in the rural area on a non-paved road. An IED with radio controlled switch or pressure plate has been buried in the road. There are suitable look-out points for adversaries. The trigger man releases either the RC arming switch well before or the RC trigger switch (instead of using pressure plate) just before the convoy arrives to the IED spot. The convoy speed is quite low so that pulling trigger switch is easy. The bomb explodes just, when the first vehicle is on the top of the IED.

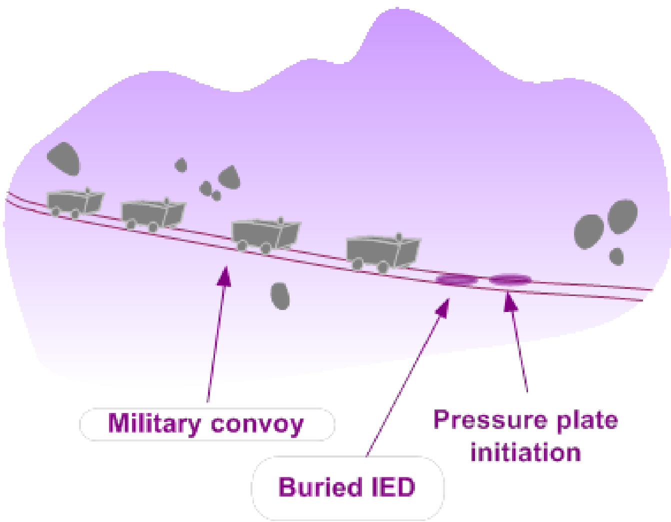


Figure 2: Operation is convoy and threat is Buried IED [1].

System model for the signals around convoy

The system model used in the development of the concept includes the following elements:

- Firing signal: detection of firing signal; direction finding for RC-trigger

- Communication signals: inside vehicle and convoy; command centre; threat library updates; other convoys
- Navigation signals
- IED jamming signal
- Environmental signals: electronic warfare; radar; mobile phones; broadcasting, TV; background radio frequency noise from electrical devices; and other

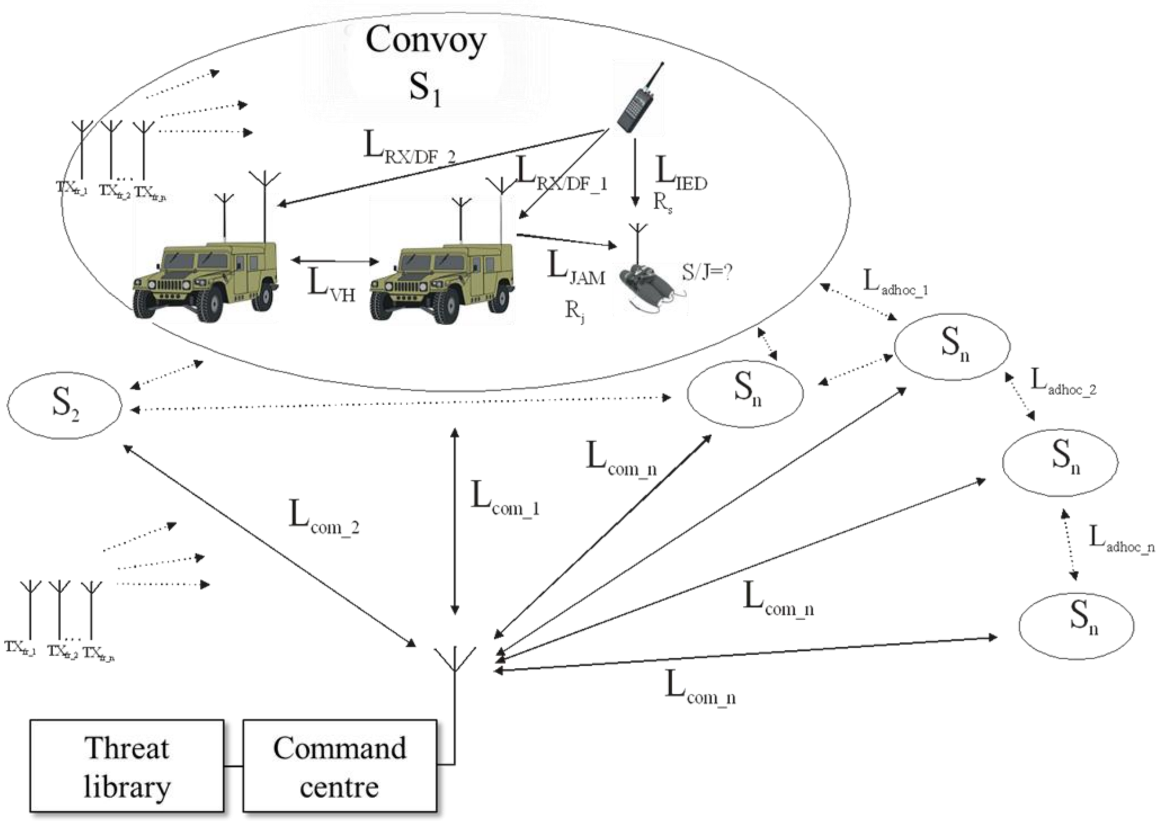


Figure 3: System model for the signals.

The parameters effecting the jamming of radio controlled IED

The physical jamming phenomenon can be described using the radio link budget parameters, see Figure 4. The jamming effect is dependent on:

- Transmit powers Ps (firing signal) and Pj (jamming signal)
- Antenna radiation patterns Gs (firing antenna), Gj (jamming antenna) and Gied, s and Gied, j (IED receiver)
- Distances Rs and Rj
- Coding and modulation
- Length for data symbol

The triggering of the IED can be inhibited, when a sufficient RF jamming signal is injected into the input of the IED-receiver. The effect of the jamming is not immediately known by the jamming operator, but only by the trigger man.

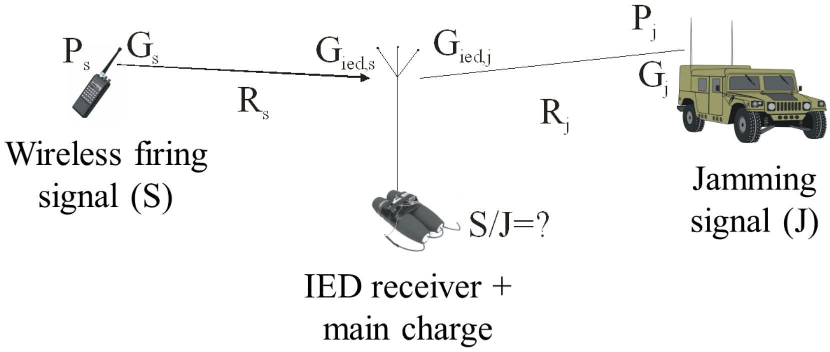


Figure 4: The radio link parameters for the RCIED and C-IED system.

Self-learning counter IED system concept

The system must be able to

- Provide alarm information for the operator in the vehicle at safe distant to the threat after the (distributed) C-IED system has detected and identified the existing IED trigger signal
- Start tailored jamming waveform against the trigger signal immediately after detection and identification
- Record and save data of the radio frequency spectrum for the time period before and after the explosion
- Enable the transmission of the spectrum data, updated code for the jamming waveform and patrol location information in a networked structure in real time
- Enable the normal functionality of the non-military and other military radio frequency signals (such as navigation) under dedicated IED jamming operation

Methods of opportunistic spectrum use and cognitive radio networks for counter IED

The self-learning system consists of the operations of cooperative sensing, detection and, after identification of the threat signal, jamming. The method assumes that several vehicles have a sensor and jammer equipment on-board.

Spectrum sensing methods used in this study are two spectrum analysis methods called *localization algorithm based on double-thresholding (LAD)* and *LAD with adjacent cluster combining (LAD ACC)* [2], [3]. They measure energies of signals on the frequency band and use two detection thresholds to detect and separate existing signals. The latter has improved signal separation capability in multisignal scenarios. Both the methods are blind in the sense that information about signals and noise level are not required and they adapt themselves into signal and noise level variations. Further signal recognition and classification (based on library, modulation etc.) were not considered, since target was to investigate detectability.

Cooperative spectrum sensing with diversity reception

Utilizing sensor cooperation in conjunction with the self-learning radio system will increase the probability of interception and detection. In the diversity reception all the receivers (in different vehicles) are using the same frequency band, which increases the probability of detection of an IED signal in a fading channel. In other words, the probability of the missed IED signal detection due to fading is minimized. Another mode of operation for diversity reception is that the sensors in the vehicles search for signals on different frequency bands that fastens the search over the frequency band.

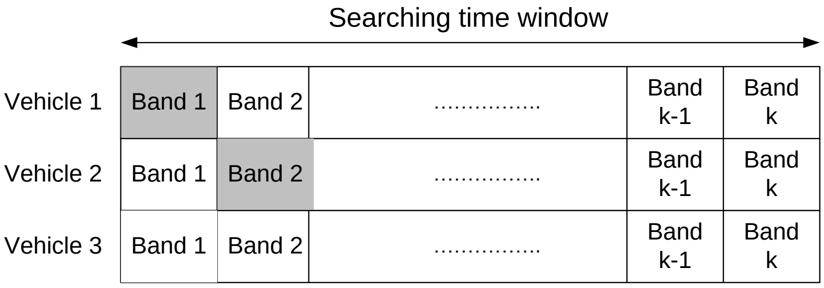


Figure 5: Diversity reception with all the sensors in different vehicles receiving the same frequency at the same time by selecting the band concurrently during searching time window.

Searching frequency band prioritization

In the frequency band prioritization technique the whole searching frequency band is sensed, but a certain band or bands are searched more often. Prioritization is needed, when the IED signal is assumed being transmitted in a specific frequency band. It also helps, if the duration of the IED signal is shorter than the duration of the searching time window.

To utilize the prioritization method, the specific frequency band is sensed several times during searching time window (see band 1 in the Figure 6). The method Implies faster and more reliable IED signal detection, but there is a requirement for a priori knowledge of the potential threat frequency.

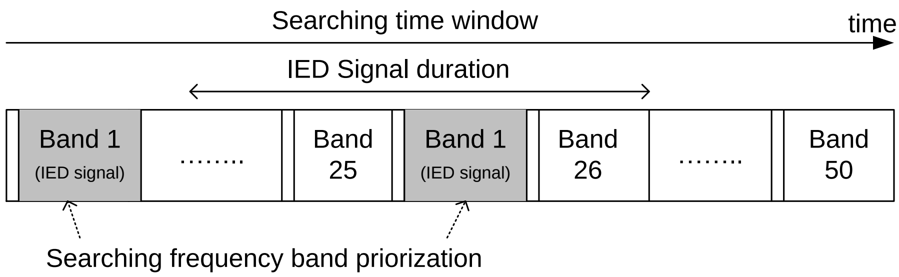


Figure 6: Utilizing frequency band prioritization on band 1 over the searching time window.

Direction of arrival of the signal

The direction of arrival (DOA) estimation improves significantly the situation awareness, because the the direction (or position) for the source of a potential threat signal can be found out. The direction of arrival estimation can be performed with the antenna group applying suitable algorithm.

To utilize DOA method with a self-learning C-IED system, where there are several separate receivers, each with their own antenna, a so called *virtual antenna system* could be established. In such a system separate sensor antennas operate as elements of the virtual antenna. The system requires the use of a dedicated broadband link with low latency between C-IED sensors to enable the accurate DOA estimation. Applying virtual antenna enables not only the detection of the position of the IED signal transmitter, but also gives direction for the pointing of the jamming signal.

There are some limitations for the virtual antenna method due to physical reasons. Because of the wide frequency band, it is very difficult to fabricate antenna array based on single sensor antennas that operates well on the entire frequency band. On the low frequencies, the antenna array elements would necessarily be impractically large.

Over-the-air programming

Need for over-the-air programming (OTA) updates rises from several facts. Current C-IED sensors are quite slow and difficult to update after new IED signals have been detected and identified. Manual reprogramming of the sensor system is necessary, carried out by a professional operator. This slows down the preparation for operation and thus lowers the level for force protection in a situation, when the opponent puts abruptly a new doctrine into operation and changes IED firing signal parameters such as frequency or modulation.

With OTA update, the self-learning C-IED devices can be updated instantly, after a new IED signal is detected and analyzed. The amount of the transmitted data is low. Only IED signal and jamming signal parameters must be delivered. Transmission waveform implemented on a software-defined radio (SDR) or other suitable transmission method can be applied.

Simulator for self-learning counter IED system

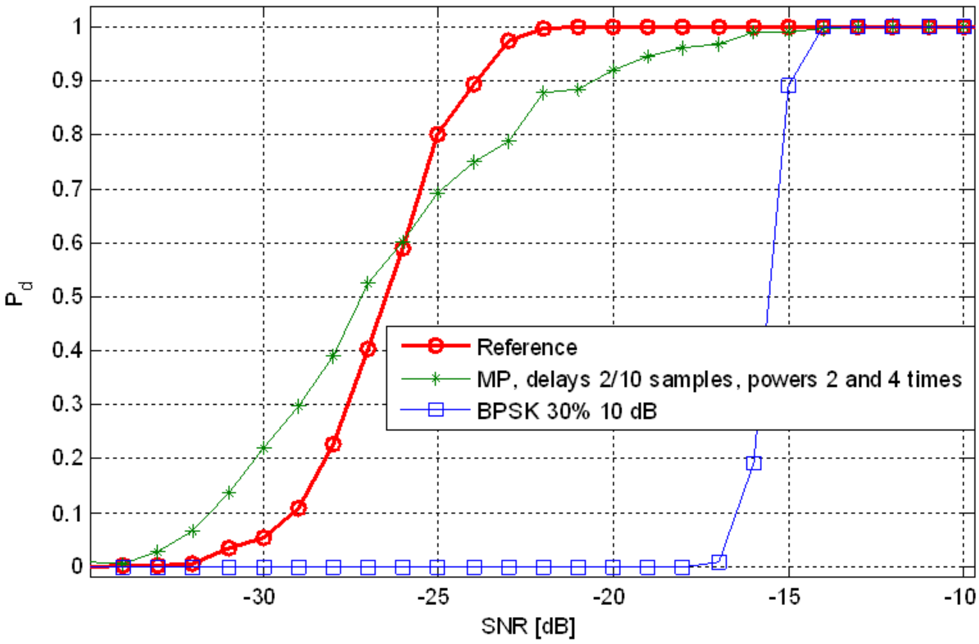


Figure 7: Simulated probability of detection for trigger signal in three different cases. SNR (signal to noise ratio) is per channel symbol.

Simulation for the spectrum sensing was done based on LAD ACC method. The results are given in the Figure 7, where the IED trigger signal detection probability P_d is shown as a function of signal to noise ratio (SNR). There are three cases shown in the figure. In the reference case only the IED signal and background noise are present (red curve). In the multipath (MP) case there is the IED trigger signal with multipath propagation (green curve). And finally, in the BPSK case, there is a strong interfering signal using BPSK modulation on the search frequency (blue curve). From the simulation results one can see that the BPSK interference significantly affects the sensing performance. But on the other hand, even the low power IED signals could be detected assuming sufficient integration time.

These obtained probabilities of detection and times for detection are used in the network (convoy) simulation in the next chapter.

Network simulation scenario

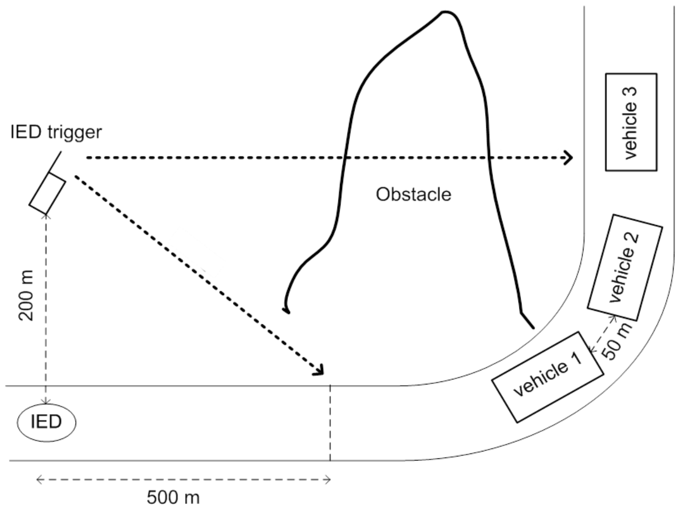


Figure 7: The network simulation scenario.

In the network simulation, an OPNET modeler simulator with LAD ACC ”interfering signal case” was used. In the theoretical scenario, the convoy approaches the IED at 30 km/h. As illustrated in Figure 7, there is an obstacle on the route between the IED trigger and convoy. The aim is to study, when, ie. at what distance, the trigger signal is detected.

Simulation for cooperative spectrum sensing with diversity reception

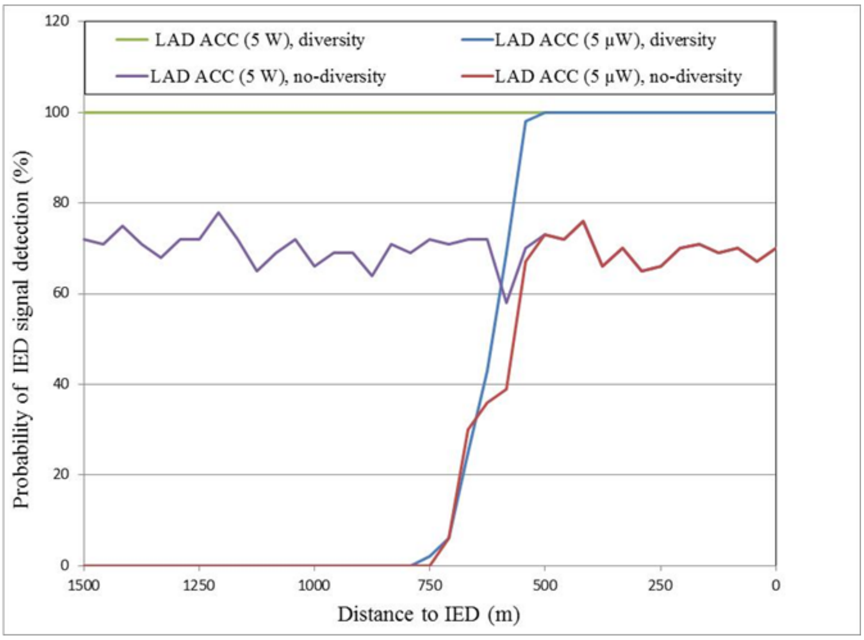


Figure 8: Signal detection probability [%] as a function of distance [m] to the IED. Different signal power levels of 5 W and 5 μW were used, with or without diversity.

The cooperative spectrum sensing was done for the low power trigger IED signal using diversity reception. The results in the Figure 8 show that with cooperative spectrum sensing a 100 % detection probability can be achieved at a distance more than 500 m before IED spot. Without co-operative spectrum sensing (ie., without diversity) the IED signal can be detected only with approximately 70 % probability. Thus, the detection probability increases considerably with co-operative spectrum sensing.

Simulation results with searching frequency band prioritization

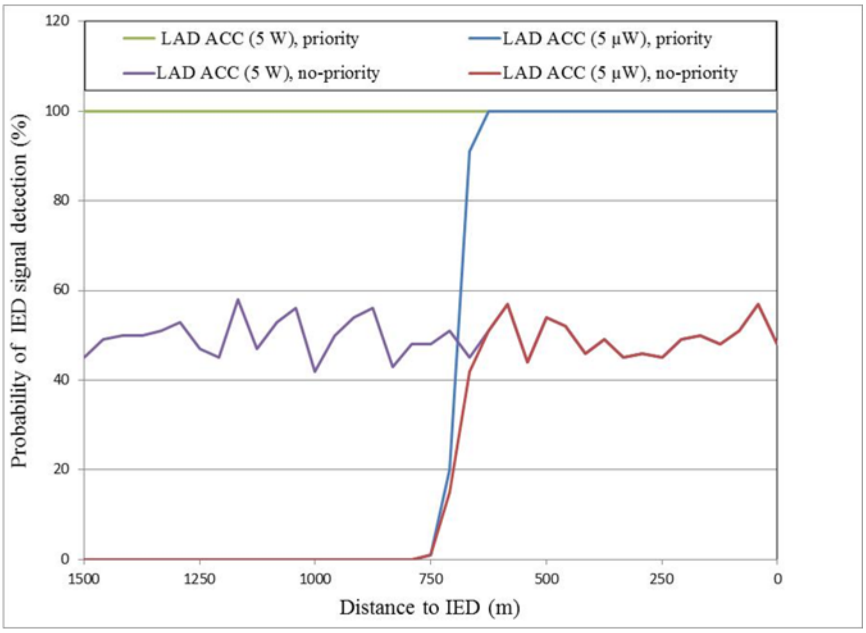


Figure 9: Signal detection probability [%] as a function of distance [m] to the IED. Signal duration is half of the searching time window.

The cooperative spectrum sensing was done for the low power trigger IED signal using searching frequency band prioritization. The results show that with searching frequency band prioritization a 100 % detection probability can be achieved at a distance more than 500 m before the IED spot. Without searching frequency band prioritization the IED signal can be detected only with approximately 50 % probability. Thus, the detection probability increases considerably with searching frequency band prioritization.

Conclusions

The self-learning counter IED system concept includes the capabilities to detect the wireless IED trigger signal in dynamic and dense spectrum environment using single or multiple sensing receivers, to analyze and identify the trigger signal, to update the threat library and to generate the jamming signal.

Signal detection simulation results show that the used LAD method is effective in IED signal detection and that it can be applied for multiple types of radio signals.

In the network simulation, the networked operation of the convoy was considered. Even the extremely low power IED signal was detected efficiently. It was shown that the cooperative spectrum sensing provides remarkable benefit, when frequency channel quality is time varying, ie. fading. Also searching frequency band prioritization provides remarkable benefit especially, when the IED signal duration is shorter than the searching time window.

Acknowledgements

The research project was funded by the Scientific Advisory Board for Defence (MATINE), Finland, and the participating organizations.

References

[1] EDA C-IED Detection Expert Group, C-IED Definitions of Scenarios (D1), 2011.

[2] Vartiainen, J., Lehtomäki, J., Saarnisaari, H., Juntti, M., Umebayashi, K., Two-dimensional Signal Localization Algorithm for Spectrum Sensing, IEICE Transactions on Communica tions, vol. E93-B, no. 11, November 2010, pp. 3129-3136.

[3] Lehtomäki, J., Vartiainen, J., Juntti, M., Saarnisaari, H., Analysis of LAD methods, IEEE Signal Processing Letters, vol. 15, 2008.

Counter IEDs and Camp Protection Ammunition Solutions

Jan Gunnar Hasslid(Nammo) and Michael J. Murphy (Hydrosoft International)

Abstract – This paper addresses recent research and development on the neutralization of IEDs and novel rockets, artillery and mortar designs utilized by non-symmetric units. The paper focuses on the interaction between the friendly fire and the hostile threat. The work was originally initiated by feed-back from the Norwegian Armed Forces and learning's from operations in AF. The use of anti-material ammunition is common by the Joint International Forces, but the interaction between the projectile and novel ordnance is not fully understood. It is an advantage to be able to use existing weapons and qualified/fielded ammunition when trying to defeat some of the novel threats at a safe stand-off with little time to spend in the theatre. Nammo Raufoss specializes in precision ammunition, and the study of projectile and target interactions was easy to access by means of existing permits and experience to fire ammunition and to analyze terminal ballistics. The work was sectioned into two separate blocks, with the first block focusing on use of 12,7mm Armour Piercing and Multipurpose ammunition currently fielded with the Armed Forces. The target scenario focused on 155mm High Explosive artillery shells, as this is recognized as a dominant IED base. The study revealed that the 12,7mm ammunition was capable of defeating the artillery steel casing with substantial energy delivered inside the target. This was measured as a post impact linear impulse energy. The usage of live ammunition was restricted at the time of the study due to environmental considerations. The conclusion was that the in line of sight target will be defeated by impact energy of the 12,7mm ammunition fired from an in-service weapon. The second block focused on finding a solution on a critical threat: the 120mm Mortar bomb. This was a true engineering analysis, including interior, exterior and terminal ballistics. The result of the study is that a new ammunition design is required to support the successful Counter Rockets, Artillery and Mortar, CRAM systems. The design solution is called the 20mmx102 AP-T/SD, featuring armour defeat capabilities, tracer(visible) and a Self-Destruct feature to minimize the risk of collateral damage. The new design has raised an International interest, and live demonstrations have been requested in support of a growing concern over safety at Camp sites.

Overview

The need for new technologies and solutions for eliminating the IED and Camp Protection threat is understood by representatives of all coalition forces. A big concern about the IED's is that they are not so improvised anymore. Although the number of IED incidents has declined, the IED quality and sophistication has improved. Nammo's goal is to use ammunition to eliminate the IED threat followed by forensics to identify, capture, and prosecute the IED designers and builders.

FBI Approach for eliminating the IED threat

Past FBI Director Robert Mueller states that "Identifying and reconstructing timing devices and explosives in IED's may well enable us to prevent the use of those devices in the future. Experts have reconstructed entire explosive devices including their unique timing mechanism and linked them to individual bombers". Identification parameters include biometric residue, fingerprints, circuit boards, batteries, receivers, …

JIEDDO Approach for eliminating the IED threat

1) Attack the network, 2) Defeat the device, 3) Train the force. Defeating the device includes all initiatives designed to thwart the impact of IEDs after they are emplaced. This includes technologies that assist in detecting IEDs from greater distances, mitigating blast effects and protecting against blast injuries, and tools to enable troops to safely disarm or detonate IEDs before they can be activated by the enemy

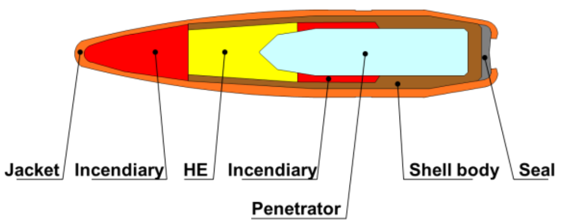
NAMMO Approach for eliminating the IED and Camp Protection threat

The Nammo Special Anti Warhead (SAW) Ammunition addresses all aspects of IED defeat. It can be used at very long range to disassemble suspected IED's. No need to worry about possible blast effects and injuries – you are out of range. It disarms the IED through the disassembly caused by SAW impact. Disassembly is accomplished before the IED is activated by the enemy. Disassembly allows for near total forensic evaluation of all components. The SAW ammunition approach for eliminating the IED threat is a low cost innovative solution that will help eliminate future IEDs.

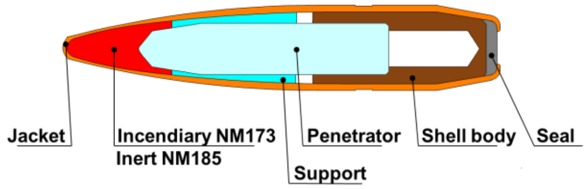
Nammo Special Anti Warhead (SAW) Ammunition

The Nammo SAW ammunition can disassemble an IED at very long range (up to 2000m). The SAW does not detonate or deflagrate the IED. The SAW separates the explosives from the firing circuit allowing for safe and rapid collection of components and forensic evidence. The 12,7 x 99 multipurpose ammunition and the 12,7 x 99 armor piercing super ammunition (shown below) have been fired against dry sand filled 155mm HE to demonstration penetration capability.

12,7mm MULTIPURPOSE MP NM140

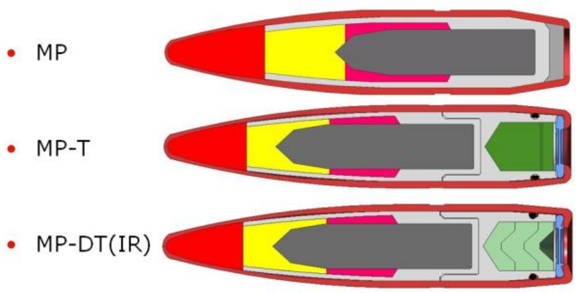


12,7 mm ARMOUR PIERCING SUPER AP-S NM173 AND AP-S NM185



Test Results - 12,7 x 99 MultiPurpose Ammunition

The 12,7 x 99 multipurpose ammunition family consists of 3 rounds as shown on the right. The top configuration was fired into a dry sand filled 155mm HE. The projectile weight is 45g, with a 900 m/s V0 and 850 m/s Ve 100.

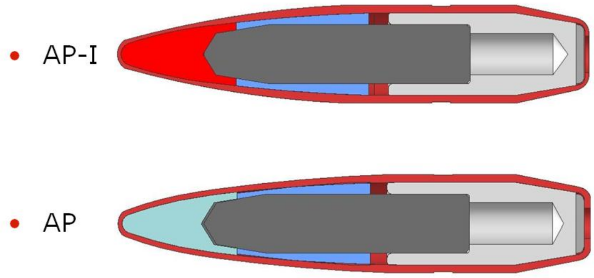


Test results showing full penetration of the shell body are at the top of the following page.

Test Results with the 12,7 x 99 MultiPurpose Ammunition

Test Results - 12,7 x 99 Armor Piercing Super Ammunition

The 12,7 x 99 armor piercing super ammunition family consists of 2 rounds as shown on the right. The top configuration was fired into a dry sand filled 155mm HE. The projectile weight is 48g, with a 890 m/s V0 and 845 m/s Ve 100.

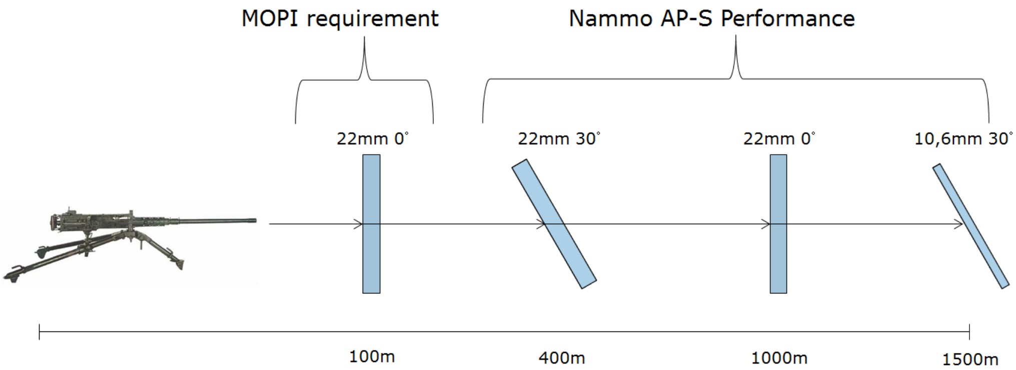


Test results showing full penetration of the shell body are presented below.

Test Results with the 12,7 x 99 Armor Piercing Super Ammunition

Penetration Performance - 12,7 x 99 Armor Piercing Super Ammunition

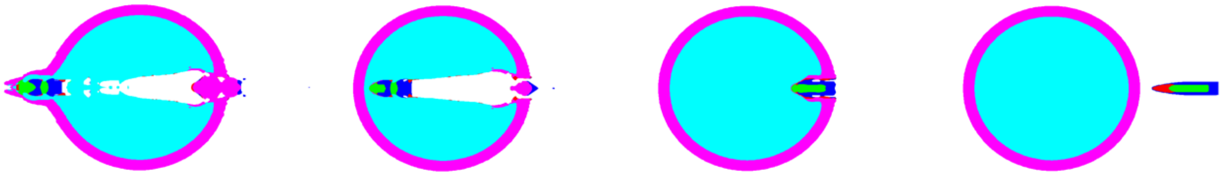
The 12,7 x 99 armor piercing super ammunition is sufficiently robust that it should also penetrate into the 155 mm HE shell after penetrating barriers as shown below.



Barrier penetration results for the 12,7 x 99 armor piercing super ammunition

Penetration Simulations of the 12,7 mm ammunition

Computer simulations of the Nammo SAW ammunition show below, indicate full penetration thru the case and CompB HE of a 155 HE round. The CompB fill is modeled with a reactive flow explosive model which indicates munition disassembly without an HE reaction.



Computer simulation of 155m HE round penetration by the Nammo SAW ammunition

20mm x 102 AP-T/SD for Counter Rockets Artilley & Mortars

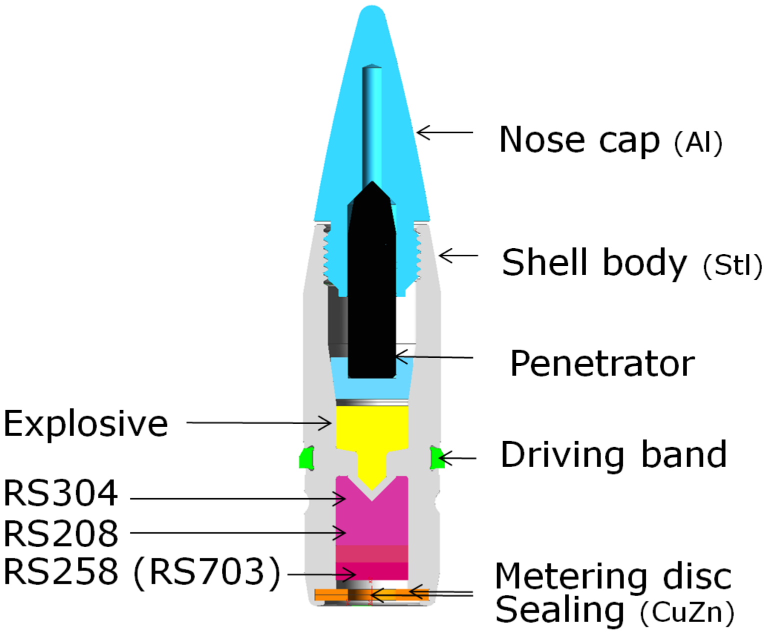
The new 20mm x 102 AP-T/SD ammunition is designed to defeat CRAM targets (specifically the 120mm HE Mortar). The new ammunition incorporates a reduced risk approach based on proven technologies in simulation, design analysis, projectile assembly, propulsion system, launching and self destruct as well as range limiting technology. Key features include a V100 of 1100 m/s, low drag design for maximum terminal ballistic energy, a visible tracer (IR to be verified), self destruct function (SD), armour piercing hard core penetrator (tungsten carbide), and sintered driving band.

The outer body profile from driving band to nose cap is similar to 20mm x 102 MP LD M70A1.

The outer body profile behind the driving band is similar to the 20mm x 102 MPHC-T.

The armour piercing hard core is similar to 12,7mm MP NM140.

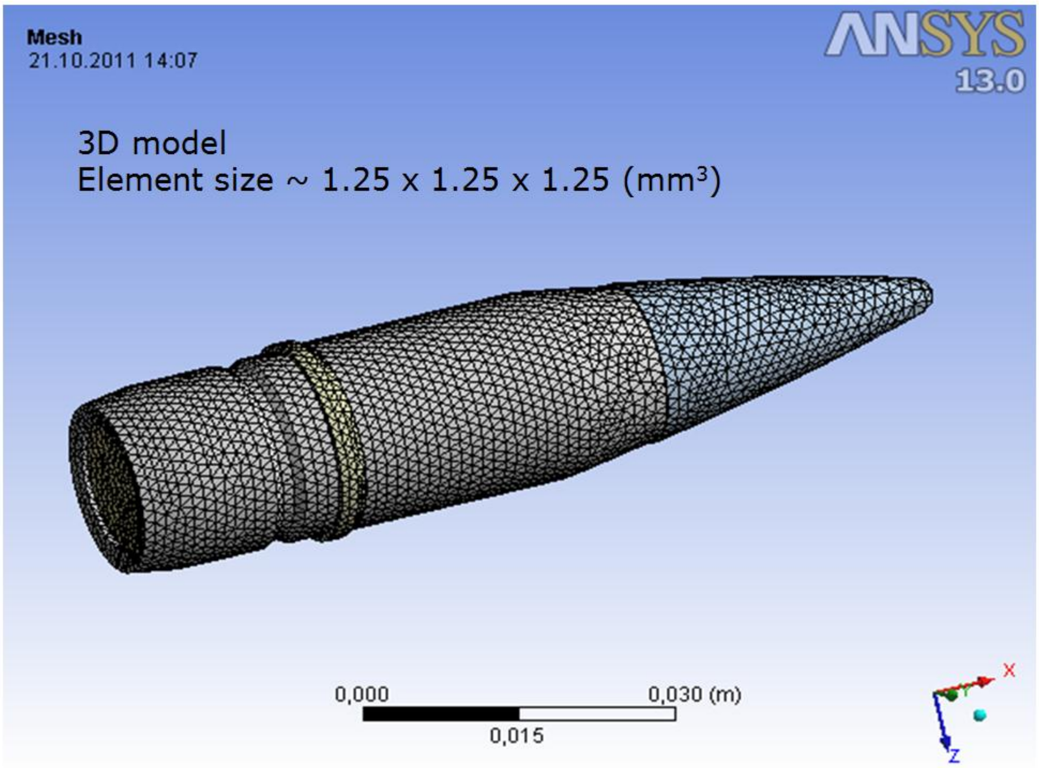
Tracer burns through base bottom and ignites an explosive charge to split the projectile body, introducing a self destruct (SD) function.



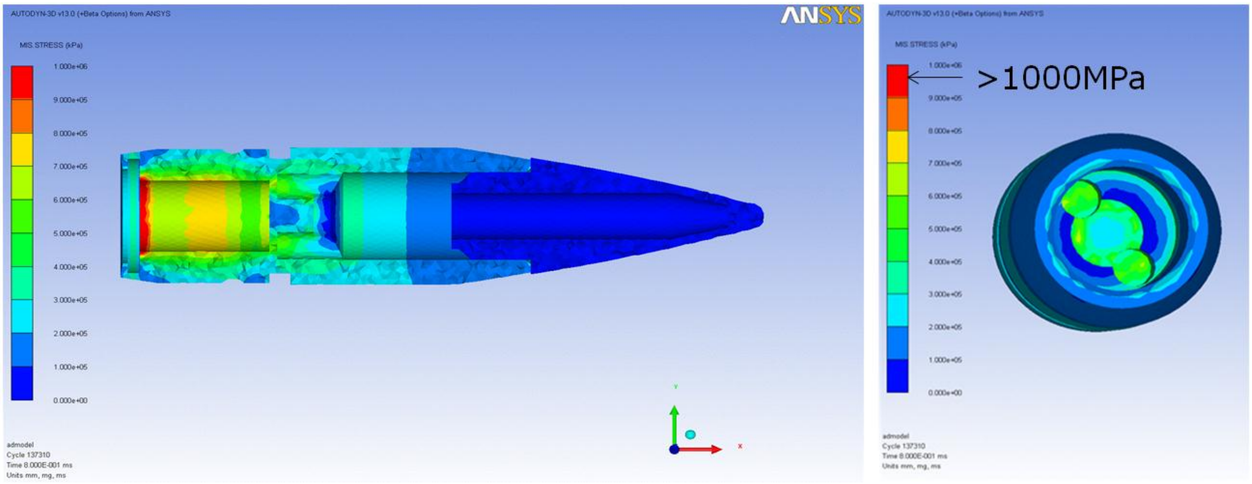
References 1, 2, and 3 provide an overview of the new ammunition, development and qualification, and pricing.

Interior Ballistics Simulations of the 20mm x 102 AP-T/SD

The mesh created with ANSYS 13.0 and used in the interior ballistics simulations is shown below. An AUTODYN 3D elastic-plastic simulation of the gun launch loads at peak setback (0.8 msec) is shown at the bottom of the page.



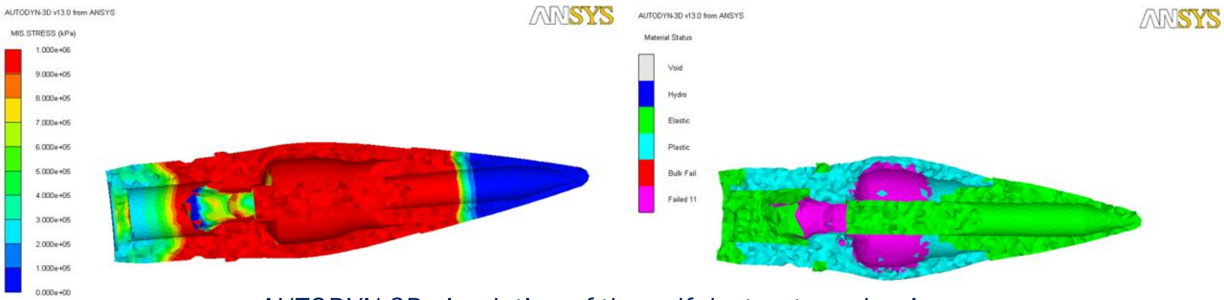
Mesh used in the interior and exterior ballistics simulations



AUTODYN 3D elastic-plastic simulation of the gun launch loads

Exterior Ballistics Simulations - SD Function

The results of an AUTODYN 3D simulation of the self destruct mechanism is shown in the figure below. The left hand fram is at 6.586 msec and the right hand frame is at 9.815 msec.



AUTODYN 3D simulation of the self destruct mechanism

Summary

The 12,7mm MP and AP ammunition provide enough punching power to accurately defeat 155mm HE targets. Weapons and ammunition exists and represents in-service readiness. The studies of a new 20mm ammunition indicates successful defeat of all CRAM threats at minimum risk of collatteral damage to civilians. The new ammunition types does give existing weapon systems increased usage and performance at low risk and at low cost.

The estimated development phase is 12 months at a cost of 5,6 MNOK, The qualification phase is 6-9 months at a cost of 1,9 MNOK. Preliminary for the new ammunition is the M61A1 extended cannon provided by OTO Melara/Italy and shown below.

PORCUPINE WEAPON SYSTEM- GUN & AMMUNITION

WEAPON PERFORMANCE

Weapon	M61A1 20mm Gatling 6 barrel
Rate of fire	3000 ÷ 6000 rds/min
Ammunition	20mmx102 Multi Purpose with self destruction- M940
Useful engagement range	Up to 1500m
Sensor	High resolution IR / EO stabilized sensors IFF System

References

(1) A Study of 20mmx102 AP-T/SD ,TR-763805-920

(2) Development & Qualification of a 20mmx102 AP-T/SD, TR-763805-1601

(3) Budget Pricing for 20mmx102 AP-T/SD, TR-763805-1602

Acquisition – Getting the Balance Right

Dinesh H C REMPLING (EDA)

In times of budget cuts the defence and crisis management communities are facing the challenge of having to deliver a plethora of capabilities to tackle ever evolving asymmetric threats as well as the conventional ones. This paper attempts to shed light on what this actually means and the role of international collaboration as part of the solution.

Battlefields, Iron Curtain and Insurgency

The threat of armed conflicts was for centuries associated with battlefields and casualties by the number, initially by sharp blades and later on by gunpowder enhanced projectiles. This morphed into trenches and the subsequent inclusion of the chemical element. Shortly after mechanisation enabled increased mobility. Combined with the nuclear component an arms race took place on either side of the curtain. Come the nineties, the curtain fell and the military strategy was in for a change. Twenty years on, change is still on-going. Looking back, the end to cold war started the change but it was the use of improvised devices in New York, London and Madrid that really opened the eyes of the western world.

A new type of warfare had emerged and we were still in cold war mode. Since then the European defence and crisis management community has always been a step behind. The reason is simple. The threat evolution is rapid and unpredictable. While the operational weapons faced are often simple, in the form of improvised devices, they are employed by sophisticated and intelligent networks, which operate across borders and will stop at nothing to reach their goals. In addition the role of armed intervention is far from what it used to be. In fact it is more of a last resort.

The Capability Spectrum

Often defence and crisis management capabilities are associated with equipment but the reality is that systems and technology are merely there to enhance capabilities. The core of capabilities lies in doctrine and concepts and implemented through education and training into an organisation that ensures readiness and deployability. Systems and technology act merely as an enabler and a tool to increase operational effectiveness and to ensure the safety and survivability of personnel.

Once implemented they can be used to support the following:

- **Prevention:** Being able to prevent crises is by far the most important capability as it saves lives and cuts costs. However it is also the most complex. It includes being able to predict future crises and involves early warning mechanisms, mediation and sustainable post-conflict reconstruction.
- **Reaction:** The most visible type of mission, which in the past has often been associated with military intervention, involves peacekeeping and humanitarian operations, increasingly with policing type duties supporting law enforcement operations.

- **Enabling:** Support capabilities constitute the vital infrastructure that is needed to enable operations to be undertaken in the first place.

The Acquisition Process – Requirements is the Glue

The process of acquisition can be described using the ”V” model and transforming it into a ”Y”. The essence is that the capability development process in theory uses a systems engineering approach that starts with defining capability targets and breaking them down into capability requirements in order to translate them into functional and technical requirements. The functional and technical requirements is the glue holds the acquisition process together. They steer science and technology, the classic bottom-up approach. They support product development and act as the base for acquisition.

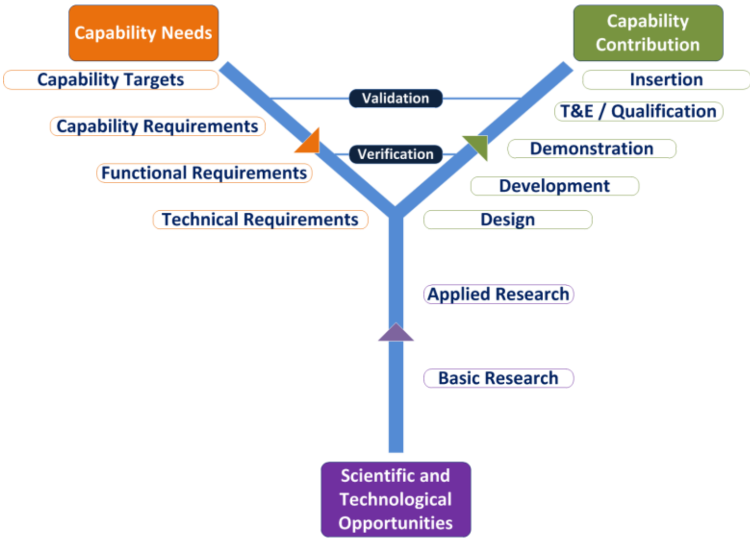


Figure 2: *The Bottom-Up and the top-down approaches held together by requirements in the "Y" model*

Theses capability needs were refined over a number years following the World Wars and they are still Cold War tinted. The static nature of the capability targets and requirements often results in that they automatically associate themselves with equipment platforms. This worked in the past but in view of recent operations and the likely evolution of threats the overall process must see a shift from "copy-paste" of the last edition to a purer and practical capability development process. This needs to overall be more effective and therefore there is a need to separate strategic long term process and there is from the fast track process that can handle urgent needs free of bureaucracy.

Sustainable Capability Development – Well what is It?

Sustainable Design is an approach and philosophy that advocates designs that do not affect the environment negatively while taking into account social and economic aspects. It has emerged in later years as a contributor to Sustainable Development. It tackles topics such as recyclability, waste, water, energy efficiency and emissions.

So how does sustainable design translate into a defence and crisis management context with all its particularities? The approach needs to be comprehensive and needs to take into account:

- Environmental considerations

- Livelihood of the domain
- The domain's purpose and credibility

Below is an attempt to develop these aspects into parameters that affect the requirements and choices in the design and acquisition process.

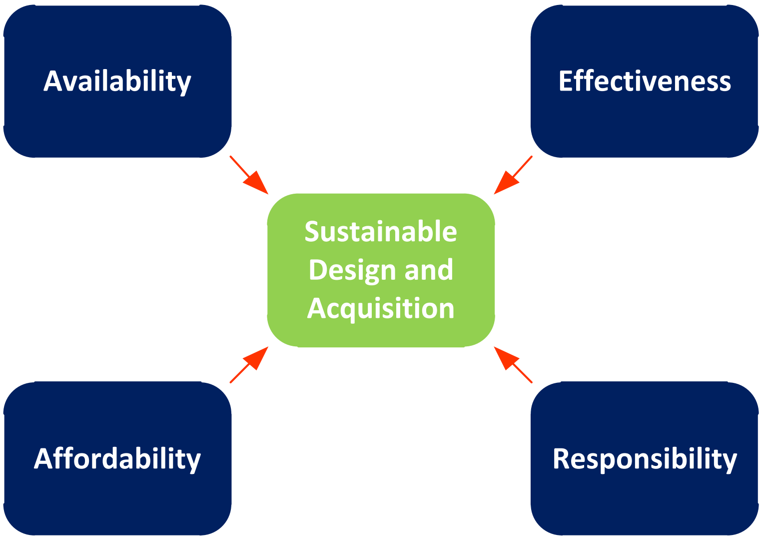


Figure 2: Parameters associated with Sustainable Design and Acquisition

- **Availability:** Readiness levels, supply-chain aspects, knowledgebase etc
- **Effectiveness:** Capability impact in terms of endurance, autonomy, mobility, effect etc
- **Affordability:** Costs associated with research, acquisition, through-life management etc
- **Responsibility:** Aspects associated with safety, socio-economics, ethics etc

While this approach focuses on heavily on equipment the subsequent discussions in the paper will also address capabilities as a whole

The Balancing Act

The future process of capability development, acquisition included, will need to be even more carefully than ever balance a number of parameters and it is likely that the weighting will be different than that of the past and present.

Effectiveness

Resilience is the word that today is best used to describe what is expected of future capabilities. More emphasis will be put on getting it right the first time. This applies to preventive, operational and enabling capabilities. The preventive will receive more attention and information processing will need to tackle large amounts diseparate types of information and effectively discriminate in order to provide timely actionable decision making support within both national and multinational institutional structures.

Reactive capabilities will be viewed upon more as last resort. Getting it right will be even more important, with as little collateral damage as possible. This will set tough requirements on aspects such as effectiveness, autonomy, endurance, readiness and mobility.

For all types of EU capabilities the challenge will be to deliver what is expected from policy while dealing with a wide range of different types of adversaries that will draw on both conventional and asymmetric means. Furthermore defence and crisis management capabilities, according to the current policy, cover a wider scope than peace-keeping and peace-making taking into account disaster relief, humanitarian aid and advisory tasks. In addition ensuring sovereignty for many Member States is still the main task for armed forces, the plot thickens.

To be able to address all of the above for one country is far from realistic, especially for smaller ones. The need to collaborate is inherent. The challenge will continue to be to allocate niche areas for each stakeholder, while building up sufficient mutual trust and recognition. It should not be about rationalisation. It should be about drawing on each other’s strengths so that the total is greater than the sum of each individual contribution

Availability

Ensuring a good level of availability of capabilities is essential. A certain amount of redundancies is therefore needed.

In terms of equipment the balancing act needs take into account two things. The first is that sophisticated equipment might not always be the solution, especially when dealing with low-tech adversaries on their home turf, as has been witnessed in recent operations.

The second addresses equipment from a bottom-up science and technology point of view. There needs to be a balance between investments into low maturity with high risk and high maturity with low risk. Both come with their pros and cons from an investor perspective. A broad high risk portfolio may actually deliver something disruptive but with high uncertainty. A low risk portfolio will deliver hardware but while doing that there is a danger of ending-up obsolete.

Furthermore the science up-stream and technology downstream need to be connected in order to unmask effective exploitation routes. Today this suffers from the infamous “valley of death”, the void between phase-out of research funds and development resources. But bridging this is not enough. There is a need to ensure that promising demonstrators have a good shot at becoming actual competitive products. In this context the supply chain needs to be de-risked as well. Furthermore the overall knowledgebase needs to be sustained.

Speed is also of essence. Enabling fast track research and development will enable keeping up with the evolution of adversary threats.

Affordability

Affordability is of high relevance in times of budget cuts. Often focus is on the acquisition cost as it is immediate and visible. But it is only the tip of the iceberg, separated by different budget lines that conceal potential other big costs associated with development, through-life management and end-of-life.

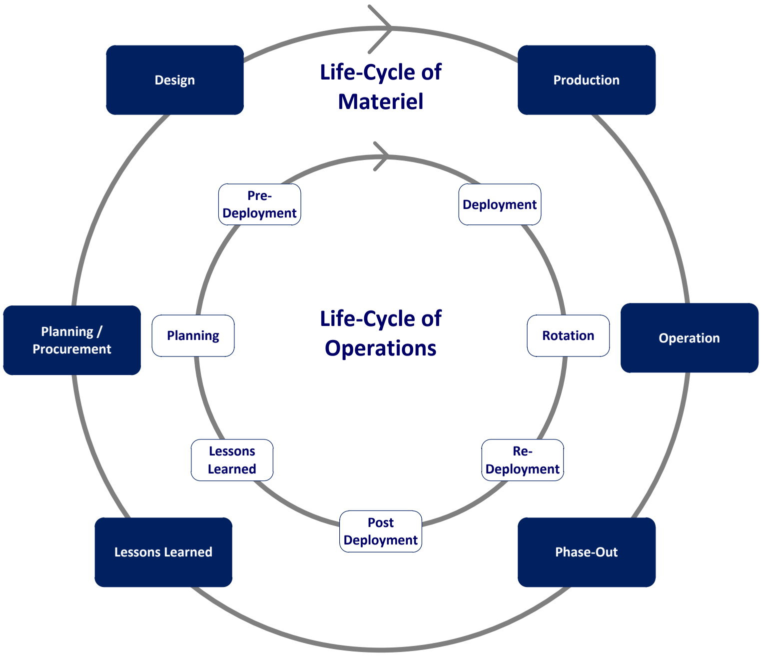


Figure 3: *The lifecycles of operations and materiel*

Defence equipment has traditionally been acquired with a view on long lifecycles. Their inherent expensive nature and long lead times has steered the lifecycle horizon towards the thirty-year mark with the potential of life-extensions. The large, cold-war armed forces have thus had their assets tied to huge fleets of equipment waiting to be used. Times have changed though and today the equipment is not only waiting to be used – with routine exercises to break the monotony – but is actually used in theatre as part of deployed operations. Thus they get subjected to the wear and tear in asymmetric contexts. This in itself reduces the expected life of equipment immensely, increasing the burden on the constrained budgets over time.

In parallel the consumer driven markets are seeing shortened lifecycles. While the for the most part have been shorter than those of defence equipment, there is a change in mind-set as to how acquired assets are viewed. While they were viewed as long term investments in the past, today the aim of the acquisition is utilisation rather than saving for later. This is clearly visible in the approach to acquiring clothing, electronics and software.

So perhaps it is time to be less rigid in terms of requirements on defence equipment life-expectancy. With modular design approaches emerging this offers new opportunities to cut costs and still maintain a high technological sophistication. Based on open architectures, platforms and payload can be renewed independently of each other while ensuring enduring interoperability. This enables payloads to have shorter lifecycles in order to stay in tune with the latest developments and the platforms can have longer lifecycles in the traditional sense.

This harmonises well with the distinction between the lifecycle of operations and the lifecycle of materiel. The payload can thus be adapted to the operation, perhaps through more effective means of acquisition a la the just-in-time delivery model in order to be mounted onto flexible platforms that are on standby.

Furthermore there is the aspect of asset management to take into account. Today armed forces own most of their equipment. Perhaps in the future new ownership models will evolve increasingly involving third parties.

Responsibility

Responsibility will play an increasingly important role. The scope will not only need to cover safety and survivability aspects but also ethical aspects with regard to the use of equipment as well as in the manufacturing supply chain. There is also the aspect of socio-economics, sustaining jobs in regions all around Europe. This sets requirements on the customer side to shop more transparently and intelligently. It also sets requirements on the market to strive towards less fragmentation. Responsibility also needs to take into account reducing the environmental footprint, since it comes with significant cost benefits.

Conclusions

This paper has attempted to examine how acquisition needs to adapt to be able to cater to resilient threat management. It is a balancing act that is complex and there are many parameters to consider. Revolving around increasing around getting requirements right, sustainable acquisition will need to be responsive to urgent needs as while not compromising the long term. It will require new business models as well as new design architectures, both of which need to be flexible and interoperable. Lifecycles need to be viewed in a more pragmatic way. The path will need to be cleared early for various different kinds of exploitation routes of science and technological opportunities – once again requirements need to be made clear at an early stage to enable this. There is an opportunity to harmonise Europe's approach to this and thus strengthen its global position as a competitive and effective player in support of defence and crisis management.

References

[1] REMPLING D H C, Sustainable Design and Acquisition, Military Green 2012 Conference Proceedings