Explosive and Object Detection

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The DSTO has conducted research into landmine detection for number of years but recent developments have led to expanded research into the IED detection problem. Detection efforts are concentrated on both stand-off and close-by detection, with separate programs in object detection and explosive detection. One of the key areas being developed is that of standardized protocols for both technology testing and operational evaluation.

I. INTRODUCTION

The detection of IEDs and explosives is an important requirement for the first responder either in the defence or national security environment. A major concern in the detection of both IEDs and explosive compounds is confirming the threat with preferably no, or at worst minimal, physical interference with the IED or explosive. For this to occur, detection approaches may need to include;

- "Stand-off" detection, where the presence of an IED or explosive compound can be confirmed while remaining outside the danger area of the device,
- Identification and recognition of IED components without disturbing the IED,
- Identification of explosive vapors and
- Identification of the explosives residues either on or around the IED (possibly due to contamination).

The following discussion outlines the work that is being carried out in DSTO to enable relatively safe detection of explosive devices.

II. OBJECT AND EXPLOSIVE DETECTION

Over the years DSTO has conducted research into the performance of many explosive/object detection systems (some in stand-off mode) [1, 2].

A. Buried objects

DSTO has developed considerable expertise in a number of technologies for detection of surface laid and buried targets such as IEDs and landmines. These technologies include metal detectors, ground penetrating radar and imaging systems [3]. DSTO has also developed automatic target detection algorithms for detecting targets of interest using a metal detector array and a ground penetrating radar array [4, 5]. Recent trials conducted at DSTO proved that a "Minelab STMR" metal detector array can be used to detect buried metal objects using automatic target detection algorithms supporting vehicle speeds.

B. Imaging systems

Recent studies and field work has demonstrated that both THz and IR imaging may play an important role in explosive device detection systems. A phenomenological trial conducted at DSTO used an imaging system consisting of two infrared cameras and a visual camera, to examine the effectiveness of thermal imaging in the detection of buried simulant targets. Visual analysis of the captured images was performed by human observers and showed that the detection of targets is possible in many circumstances. The temperature distribution of targets and soil were also investigated, and to aid in the analysis of camera images.

C. Explosives detection

The DSTO is currently working on the evaluation of commercial explosive detection equipment for defence and a variety of civilian agencies involved in national security. The explosives that have been involved in the evaluations include both the conventional military explosives as well as home-made (or clandestine) explosives such as the organic peroxides (e.g., triacetone triperoxide [TATP]). The evaluations have investigated detection of explosives in trace and bulk amounts as well as in the vapor phase. The explosive trace detection technologies that have been evaluated include IMS (Ion Mobility Spectrometry), fluorescent polymers as well as wet chemistry detection kits [6, 7, 8]. Generally, the detection of trace and bulk amounts of explosives is reasonably mature with IMS and wet chemistry technologies; however IMS doesn't have the sensitivity to detect explosive vapors. More recent technologies such as fluorescent polymers (which we have evaluated) and possibly others technologies such as chemiluminescence may have the sensitivity to detect military explosive vapors. Also, field detection technologies available, especially IMS, still do not provide definitive results and are prone to false results from interferents.

An important aspect of any evaluation is the response of the detectors to compounds that may be present in the environment, commonly known as interferents. Interferents can produce either false positive or, in the worst case, false negative results. False positive results indicate the presence of an explosive when it is not present and a false negative result indicates the absence of an explosive when it is indeed present (interferents may mask the presence of explosives and produce false negative results). Therefore, testing with known compounds or products that will be present in the operational environment is required to understand the real world performance of detectors. This process has extended to the development of an analytical method where an individual chemical in commercial products may be identified and a library of products containing known chemical interferents may be produced.

D. Explosives Characterization

Other work that is performed within the DSTO is aimed at understanding in detail the responses produced by explosive detectors and thus increasing the overall confidence in detection results. The work is focused on the detection characteristics of explosives as well as the degradation and decomposition of explosive compounds. Currently, the main class of explosives that are being focused upon are the home-made explosives such as the organic explosive peroxides. The detection characteristic studies deal with the behaviour of compounds within the explosive detector. Explosives such as TATP and even MARPLEX taggants, such as dimethyl dinitrobutane (DMNB) readily break down at moderately high temperatures, especially within IMS detectors. Therefore, degradation products are actually observed (detected) rather than the explosive itself. By understanding the mechanism of degradation and breakdown of the compounds, a greater understanding of what is being detected can be developed, which provides the greater confidence in the results obtained.

Work has also been performed on the longer term degradation of explosive compounds, and this program is focusing upon emerging explosive threats to complement the detection research performed on the main explosive compounds. All explosives degrade over time and in the presence of different chemical compounds that may be left over from the synthesis. By determining the identity of the degradation products, further information may be gained from the explosive sample in pre-blast and potentially post-blast scenarios. An example where this work may be beneficial occurs when volatile explosives, such as TATP, are used. The explosive does not persist in the environment but degradation products may persist longer and therefore identify the previous presence of TATP. Thus the aim is to increase the detection of explosives, including clandestine explosives both pre- and post-blast.

III. METHODOLOGY/PROTOCOL WORK

The evaluation of various explosive detectors is required so that the most appropriate detector(s) can be chosen for a specified use. Typically, evaluations of different detectors cannot be performed side-to-side for practical reasons, particularly availability of instrumentation. Therefore, standardized testing is required to enable different instruments to be compared even when they are tested at different times or in different places.

A. Lab Testing

A standard protocol has been developed for the laboratory evaluation of explosive detection equipment within the DSTO. The protocol was developed from other evaluation methodologies used within Australia and overseas and includes practical approach for the determination of the limit of detection which is reliable and statistically valid. The protocol also includes methods that deal with the ability of the instrument to detect a range of explosives; the effects of interferent compounds (which can produce false positive and negative results); temperature and humidity effects; sample throughput rate; overload recovery and usability. The protocol is considered to be a "common sense" protocol and is expected to be further refined through extensive testing to prove its robustness.

B. Operational Testing

DSTO also evaluates detection systems in the operational environment, and have developed a methodology that ensures that the best possible use is made of resources by systematically increasing the interaction between the detector and the environment as testing progresses. The methodology allows for the overall capability of detection systems to be determined through analysis of results obtained in a controlled laboratory environment, combined with the minimum necessary testing in the operational environment. Other considerations, such as human factors issues (especially those relating to the target subjects and operators) are also addressed for each environment. The four levels of analysis are (partially described in Ref. [9].);

1. Review of specifications,
2. Technical (laboratory) testing,
3. Scenario analysis and
4. Full operational analysis.

Operational testing using this basic approach has so far been carried out on;

- THz imaging in airport and field,
- Liquid explosives detection in typical environments,
- Trace explosives detection in airport and
- Metal detector arrays in typical environments.

IV. INTEGRATION

DSTO has conducted research into multiple explosive detection systems (some in stand-off mode). The basic studies into integration have been in the areas of;

– Robotics studies,
– THz and IR results for buried and hidden objects and
– RRAMNS landmine detection test bed (historical),

V. SUMMARY AND CONCLUSIONS

Over the past few years, the Australian DSTO has developed an ambitious and extensive program of research aimed at the detection of explosives and explosive devices. Much remains to be done, but the general approach of testing detection techniques in both the laboratory and in operational conditions, combined with the development of standardized test protocols, will underpin all future activities.

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