Advances in Multisensor Mine Detectors
A presentation for the UN Workshop, GICHD Geneva, February 2006
Ian Dibsdall

Overview

- Background to multisensor detectors
  - ITEP
  - History
  - Development
- Advantages / Potential performance
- Performance during ITEP trials
  - HSTAMIDS Thailand
  - MINEHOUND Bosnia/Cambodia
- Implications for demining
- Summary
Aims of ITEP

• Develop and use universally accepted and respected T&E protocols and evaluation methodologies.
• Collect, generate and distribute scientifically objective data and information products on technology, materiel and systems for humanitarian demining.
• Establish a cost effective and responsive international test and evaluation programme.
• Conduct test and evaluation of existing demining equipment and systems; equipment and systems under development and promising technologies, processes and algorithms.

Aims of ITEP MSWG

• Share information on Multisensor mine detector trials:
  – Plans
  – Execution
  – Results
  – Lessons learned
• Produce “Best Practice” document for testing of multisensor mine detectors
• Leading ultimately to produce CEN working agreement, similar to CWA14747 (metal detectors)
• Contact:
  – Coordinator, Ian Dibsdall [imdibsdall@qinetiq.com]
  – Secretariat, Franciska Borry [franciska.borry@itep.ws]
  – or Yann Yvinec [yvinec@elec.rma.ac.be]
Multisensor detectors - Background

• Metal detection has been a useful tool for mine detection since WW2

• Ongoing improvements reduced bulky equipment, improved battery life etc.

• Threat from low metal mines drove development of high sensitivity detectors

Multisensor detectors - Background

• The problem with metal detectors –

simply increasing sensitivity does not always bring about the desired results
Overview

• Background to multisensor detectors
  – History
  – Development
• Advantages / Potential performance
• Performance during ITEP trials
  – Training
  – Trials
• Implications for demining
• Summary

Multisensor detectors - Background

• The goal of the latest detectors is to introduce a degree of discrimination to the detection task.

• The promise:
  – Two or more sensors (working sequentially or in parallel)
  – Detect mine-like features of targets in the ground
  – Maintain metal detector levels of detection
  – Reduce false alarms
Multisensor detectors - Background

• A lot of research has been carried out into sensors that could possibly provide the discrimination required.
  – Acoustic/Seismic detection
  – Explosive Vapour sensing (electronic & animal)
  – Ground Penetrating Radar
  – Infra Red Imaging (passive and active)
  – Magnetometry
  – Mechanical force (active prodders)
  – Metal Detection (frequency discriminating)
  – Millimetric Imaging (passive and active)
  – Nuclear Quadrupole Resonance
  – Thermal Neutron Activation
  – X Ray backscatter....

Multisensor detectors - Background

• A selection of some of the many research projects undertaken to prove sensor capabilities...

EU Project HOPE: Metal detector + GPR + radiometer
Photo Credit: RST

Portable Humanitarian Mine Detector - PHMD

Pacific Northwest National Laboratory - Timed Neutron Detector
Photo Credit: Pacific Northwest National Laboratory

EPFL - DETEC2
Photo Credit: EPFL

Early Minendet
Photo Credit: QinetiQ

and many more...
Multisensor detectors - Advantages

• Potentially, the multisensor detector is a productivity tool to:
  – Maintain (or improve) metal detector performance
  – Discriminate mines from clutter
  – Reduce false alarms

• NOTE
  – No (serious) claims have been made to eliminate false alarms, only reduce them
  – They will also not detect all mines at any depth in all conditions – gradual improvement in capability.

Multisensor detectors - Advantages

• Potentially, the multisensor detector is a productivity tool to:
  – Maintain (or improve) metal detector performance
  – Discriminate mines from clutter
  – Reduce false alarms

• Can this be achieved in a realistic device for demining use?
  – Draw on research
  – Draw on military programmes
  – Draw on commercial developments
Multisensor detectors - Advantages

- One combination of sensors has proven to be a useful combination for mine detection:
  - Traditional Metal Detector
  - Ground Penetrating Radar
- The Metal detector is used as now to locate (perhaps small amount of) metal in mine
  - signal from mines, but also scrap, fragments, etc
- The Radar looks into the ground to give an indication of an anomaly (dielectric contrast)
  - signal from mines, but also stones, tree roots etc
- Combining MD & Radar will tend to give a signal only from mines

Overview

- Background to multisensor detectors
  - History
  - Development
- Advantages / Potential performance
- Performance during ITEP trials
  - HSTAMIDS Thailand
  - MINEHOUND Bosnia/Cambodia
- Implications for demining
- Summary
ITEP Trials – HSTAMIDS Thailand

Trials Aims

- Demonstrate performance of in-service HSTAMIDS in a demining scenario
- Train demining organisations in proper use and care of HSTAMIDS
- Assess performance of trained deminers after limited experience and training in use of HSTAMIDS.
- Trial location: Thailand Mine Action Center’s (TMAC) Humanitarian Demining Action Unit (HMAU) #1 in Nongyakaeo, Thailand.

Site Overview

- 10 lanes, 1m wide 25m long
- Mines & Clutter
- Indigenous clutter left in lane
  - or removed if close to mine
  - positions surveyed
- Fixed corner markers
- Designation & direction labels
- Vegetation cut short
- AP mines 5cm, AT 10cm
- Prepared 5 weeks before start of trial for weathering
ITEP Trials – HSTAMIDS Thailand

- Classroom sessions
- Familiarisation
- Practice areas
- Training grids
- Performance monitoring

Summary

- 4 week trial, The HALO Trust & TMAC operators trained (2 weeks)

From the published results -

- Pa (probability of alert) 99.7% for experienced HSTAMIDS operators
- Pd (probability of detection) with correct classification 94% overall, whilst significantly reducing the false alarm rate.
- Correctly classified 81% of the emplaced clutter as clutter. 77% overall clutter rejection.
- Pa 98% for the HSTAMIDS trainees. They also detected most of the characterized clutter.
- Pd with correct classification was 86% for the trainees,
- Reduced the total FAR by about 68%. Their clutter rejection results were nearly as good as the experienced operators at 77%.

- For full information on the trial please see the published SPIE paper - www.itep.ws/pdf/HSTAMIDSSPIE_5794_146.pdf
ITEP Trials – HSTAMIDS Thailand

Summary

• 4 week trial, The HALO Trust & TMAC operators trained (2 weeks)

• Trainees performance after 2 weeks training was almost as good as the experienced operators (detection)

• High probability of detection and able to reject a lot of clutter

– For full information on the trial please see the published SPIE paper - www.itep.ws/pdf/HSTAMIDSSPIE_5794_146.pdf

ITEP Trials - ERA “Minehound”

Trial

• Working with
  – MAG, Cambodia (Kamrieng) – “Lvea Te” minefield (in K5)
  – NPA, Bosnia (near Sarajevo)
  – MAG, Angola (Luena)

• Deminers trained to use detector (2 weeks)

• Detector used in minefield to “follow-up” detections from deminers in-service detector [ATMID/Ceia] & record data (6 weeks)
  – NOTE: prototype detector not used for demining, only recording data. Deminers re-survey detection with their “normal” detector before carrying out clearance SOP’s – see next slides

• Trial observed by ITEP representatives & assistants.
ITEP Trials - ERA “Minehound”
Test methodology in live clearance operations (SUMMARY)

• **Safety first** – prototype detector NOT used for clearance
• Operator calibrates both detectors for soil conditions
• Normal detector used to locate & mark metal in ground
• Operator retreats and places normal detector 5m down lane
• New detector brought forward and operator investigates alarm (with both MD & GPR sensors)
• Results recorded
• Operator retreats and places new detector 5m down lane – normal detector brought forward to confirm alarm & then follows clearance SOP

ITEP Trials - ERA “Minehound”
Test methodology in live clearance operations (SUMMARY)

• **Advantages**
  – Detector tested against actual threat
  – User can directly compare existing and new detectors
  – Confidence in results
  – No modification to clearance SOP

• **Disadvantages**
  – How to handle additional alarms?
  – New detector must follow existing detector, so cannot highlight its own new or false alarms
  – Slows clearance operation during testing
ITEP Trials - ERA “Minehound”
Training

• Deminers trained by manufacturer to use detector

ITEP Trials - ERA “Minehound”
Training

• Practicing search technique using current detector
  (Schiebel ATMID in Cambodia)
ITEP Trials - ERA “Minehound”
Training

• Practicing search technique using Minehound detector in test lanes (Bosnia)

ITEP Trials - ERA “Minehound”
Training

• Training continues whatever the weather!
ITEP Trials - ERA “Minehound”
Assessment

• Deminers performance assessed

ITEP Trials - ERA “Minehound”
Trial

• Minefield conditions in Bosnia were poor for radar use – large rocks, clay, mineral soil, saturated ground. Area used was wet & rough but without so much standing water.
ITEP Trials - ERA “Minehound”

Results

• Cambodia - 8 week trial period (4 deminers)
  – Live tests: 1143 detections, 13 mines (100% Pd).
  – Strong signal FAR reduction >5:1. All signal FAR reduction 1.75:1
  – Blind tests: Whole trial Pd 92.5%, FAR reduction 2.15:1

• Bosnia – 8 week trial period (2 deminers)
  – Live tests: 1069 detections, 7 mines (100% Pd).
  – Strong signal FAR reduction 7.4:1. All signal FAR reduction 2.2:1
  – Blind tests: Whole trial Pd 92.5%, FAR reduction 1.89:1

• Angola – 8 week trial period (4 deminers)
  – Live tests: 1153 detections, 0 mines (no Pd to report yet)
  – Blind tests: Whole trial Pd 96.5%, FAR reduction 3:1

In all countries deminers tended to improve their performance towards the end of the trial (last week Pd’s of Cam:98%, Bos:100% and Ang:100% on blind tests)

ITEP Trials - ERA “Minehound”

Results

• Performance improved as deminers gained experience with the system.

• All mines detected in live minefield with new detector (PMN, PMD-6)

• Trials methodology allowed deminers to safely relate signals they hear with objects excavated.
Overview

• Background to multisensor detectors
  – ITEP
  – History
  – Development
• Advantages / Potential performance
• Performance during ITEP trials
  – HSTAMIDS Thailand
  – MINEHOUND Bosnia/Cambodia
• Implications for demining

Implications for demining

• The new detectors would allow operators to discriminate clutter from mine-like objects
  – Fewer false alarms
  – increased productivity
• Purchase of new detectors
  – high initial cost (compared to MD)
• Introduction of new QA procedures
• Re-training of metal detector operators required
  – ongoing performance monitoring / refresher training
• Logistics
  – new detectors more power hungry than existing MDs
Implications for Demining

- New advanced detectors becoming available
  - AMD-14 (“HD-HSTAMIDS”)

Photo Credit: NVESD

Implications for Demining

- New advanced detectors becoming available
  - Vallon VMR-1 (“Minehound”)

Photo Credit: QinetiQ
Overview

• Background to multisensor detectors
  – ITEP
  – History
  – Development
• Advantages / Potential performance
• Performance during ITEP trials
  – HSTAMIDS Thailand
  – MINEHOUND Bosnia/Cambodia
• Implications for demining
• Summary

Multisensor Detector - Summary

• Multisensor detectors developed to counter problem of increased false alarms with increasing MD sensitivity
• Potentially, the new detectors can detect mines, not just metal
  – not in all situations – verify your threat can be countered
• Performance of early units demonstrated during ITEP trials
  – HSTAMIDS Thailand/Namibia
  – MINEHOUND Bosnia/Cambodia
• Implications for demining
  – Changes to QA procedures for metal detectors
  – Potentially Fewer false alarms
  – Increased productivity