Technical Evaluation Report

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1. Introduction

Active and passive sensors and their associated information coupling capability are absolutely important elements for conducting successful military engagements. The present military involvement and assignment of small groups of warfighters in the urban structures of Iraq and mountainous environment of Afghanistan are certainly new in comparison to the "classical" actions in World War I and II and subsequent engagements.

This new fighting environment requires appropriate modifications and technical sensor improvements as well as introduction of new ideas based on new military organizational structures and operational concepts/requirements.

The theme of this meeting addressed the need for improved sensor technology to support the warfighters who are increasingly faced with conflicts in densely populated urban environments. The recent series of urban operations worldwide has motivated the North Atlantic Treaty Organization nations to put considerable effort into identifying and correcting shortcomings within NATO's ability to successfully conduct urban military operations. In the original thought process for developing the agenda for this specialist meeting, it appeared desirable to study the present state of the military art in the areas of sensors, and specifically focusing the effort on the military warfighter based upon the experiences and needs encountered in recent years.

The timing and location of this specialists' meeting also provided a great opportunity to couple this agenda simultaneously with ongoing sensor performance evaluation/testing activities conducted by the NATO Landgroup 6. These combined activities set the stage to evaluate extended and new sensor/sensing devices, and at the same time discuss important modified and new requirements along with their possible technical background and military applications.

2. NATO Participation

The NATO participants of the specialist meeting included 16 nations with 70 military and civilians. There was sufficient opportunity for questions, personal interaction and follow-up activities. One invited paper and nine specialist subject papers were presented.

Participating NATO Nations

- Austria
- Belgium
- Canada
- Denmark
- France
- Germany
- Greece
- Hungary
- Italy
- Netherlands
- Norway
- Poland
- Spain
- Turkey
- United Kingdom
- United States

3. Discussion of Papers and Presentations

Efforts are underway by NATO Nations to improve and increase the maneuverability of dismounted troops in urban areas through the development of technologically advanced sensor systems. Several NATO Nations are considering the development of technology needed for the next generation requirements of ground based warfighters. An interesting systems approach (Felin) is presently being pursued in France. Minimized weight, energy consumption and reduced volume provide the basic concept with an evolutionary interoperable and modular building block approach. The proposed integrated systems suite, employed with select weapon systems, includes a helmet mounted visual system, M.S.I., multifunction imager system, computer, radio and GPS location device, and onboard power source. The first system demonstration with full capability will be conducted in early 2006; Army field testing will begin in early 2007 with two-thirds of the infantry equipped (15,000 systems delivered) in 2008.

This Technical Evaluation Report addresses the ongoing research presented during the Specialists Meeting concentrating on the overall challenges and improvement needs with a focus on Situational Awareness and Combat Identification; Improved Targeting and Tracking; and current Technology Underpinnings.

<u>Overview</u>

Key area for discussion are the modifications toward changing from conventional fire and maneuver operations to asymmetric warfare and associated asymmetric warfare and urban operations. The following presents a listing of important elements required for improvements and changes:

- Improved situational awareness
- Limiting collateral damage

- Combatant vs. non-combatant CID
- Operation of armored vehicles without infantry support replaced with internal sensing techniques
- None-line-of-sight communications
- Improved ability to communicate with unmanned platforms
- Provide timely and tailored firepower
- Provide customized weapons to fit target geometry
- Use of large numbers of reconnaissance platforms with long dwelling and large number of weapons
- Provide embedded fire support and coordination with small units
- Provide improved intelligence available at the platoon level
- Develop better and smaller FLIRS/thermal weapon sight
- Provide better laser pointing, range finding and ultra-lightweight laser designators
- Introduce helmet mounted information displays
- Provide addition of GPS to UAVs to project target locations

The urban environment consists basically of many manmade structures (buildings, roads, high brick structured fences) all constructed in various formats and layouts. As a consequence they complicate, confuse and degrade the established command and control process. These structures also provide cover and concealment and limit the clear observation and selection for optimum action. It is easy to overlook features which can provide maneuver capabilities, communication options and escape routes. Battles in build-up areas also introduce stress, involve target engagement in complex terrain, require squad and platoon sized actions, require base equipment and special sensors (mobility and targeting sensors), and effective communications with clearly established rules of engagement. Fratricide avoidance and clearly established situational awareness is extremely important.

From a critical sensor point of view, in many cases they are too heavy and bulky, lack sufficient range and long range ID, and are not working in interior spaces in true darkness.

Improved Situational Awareness and Combat Identification

Situational Awareness becomes more important as soldiers operate in urban terrain due to its complexity. A high percentage of human error results from system capabilities deficiencies or degradation in the information provided to the operator. Accurate situational awareness forms the basis for all subsequent decision making and performance. The following paragraphs provide information regarding existing technology being pursued to address improved situational awareness for individuals operating in an urban environment.

Researchers have recently conducted comprehensive modeling experiments relevant to the use of advanced sensors (passive, visible and infrared) and active scanners for creating 3D models directly/immediately from reconnaissance existing and new data sets with high resolution and highly useful informational content. With use of different spectral bands robustness against environmental conditions is achieved and operational changes are clearly recognized. These experiments have been conducted with several different sensors and platforms designed for selected military applications with promising results supporting the situational awareness issue. Since timely and quality situational awareness is fundamental for the ground warrior, the provided experimental data (with different sensors and platforms) is very convincing and sets the stage for rapid field implementation.

Cooperative combat identification in complex urban environments in most cases is complicated and difficult to reliably handle because of the ever changing mix of friend, foe and variable distribution of neutrals. Also, the complexity of the typical urban structure frequently limits the operation of the applied sensor system. NATO has developed a STANAG for a cooperative CID system, and some systems are field tested, but these are not applicable in the dense and confusing city structure. Consequently, non-cooperative approaches need to be explored and evaluated.

2D and 3D LADAR imaging vibrational resonance approaches recently have been extensively tested within a NATO sponsored field trial. It involved a large number of military and civilian vehicles, as well as personnel equipped with shoulder launched weapons and rifles.

The results establish that LADARs offer several NCID approaches: 2D LADAR imagery can provide significant imagery improvement over conventional FLIR performance; 3D LADAR imagery supports automatic Target ID; laser vibration sensing can provide none-line-of- sight identification; LADAR approaches permit looking into vehicles and buildings to determine presence of hostile forces; all LADAR systems can be used by the dismounted soldier directly or mounted on platoon level UAV's.

It is important to point out that the current MMW cooperative CID is inadequate in the urban environment, because it lacks sufficient directionality and range resolution.

Engineers and subject matter experts continue to explore ultra low cost approaches for thermal imaging technology/devices, which are particularly applicable for short range situations and provide functional applications specifically for the need of dismounted soldiers with direct view and remote set-up use. For this proposed design (uncooled thermal imaging bolometer) the researchers provide detailed modeling and performance estimates. The key design components (low cost optical design elements and appropriate detector array packaging approaches) include all relevant technical information. The concept, with select paramilitary and civilian applications, has the potential of providing the warfighter around the clock imaging capability employing low-cost disposable sensors in support of improved situational awareness. These strategically placed unattended ground sensors has the potential to provide detailed scene information and have increased effectiveness when fused with complimenting sensor data.

Improved Targeting and Tracking

For the detection of small targets under highly cluttered see-state conditions, the traditional CFAR applies a threshold to the incoming image data to make a binary decision for target or noise/clutter which impacts on both probability of detection and probability of false alarm.

Lowering the threshold leads to increased probability of detection and increased probability of false alarm. The discrimination against false alarms is performed in the tracking system; therefore, the capabilities of the tracker determine the tolerable probability of false alarms and the minimum value for the decision threshold. The system uses multiple intelligent software agents to detect features in the environment and modifies the areas over which the statistic gathering processes are performed. The system can be coupled to an agent-based pre-tracker which allows a depressed threshold to be used and, therefore, low-observable targets to be detected.

The discussed material may be beneficial to other environments which may be valuable for other related applications. While this technology was initially germane to radar system applications, it was determined that it could as well be applied to electro-optical systems.

Technology Underpinnings

As the science of nanotechnology advances, research continues to explore the use of developing nano-scale materials for future sensor applications relevant to existing and new military requirements. These materials show unusual sensitivity to external signals. Established tests have identified their potential usefulness for reacting to light, heat and electrical signals, as well as to specific chemical and possibly biological species identification. In addition, their submicron structure leads to the ultimate miniaturization of sensing devices and their associated electronic components. At the same time, power requirements and consumption is greatly reduced in comparison to conventional sensing devices.

A simplistic approach for non-cooperative target identification was proposed for further discussion and consideration for further investigative research. Various groups have investigated the EM response of military targets to radar illumination and have focused this idea on aircraft, ground targets and ships. As the basic principle, it may also be considered for use for dismounted ground troops. One approach is to connect an antenna with the solder's rifle such that the main signal lobe is aligned with the aiming direction. The antenna could also be acting as the receiver. The implementation of ID could be established with embedding metallic fibers in the uniform. The EM return to interrogation will identify the returning soldier as not hostile.

It must be noted here that other related approaches have been previously investigated; for example, the use of the laser pointer (lined up with the rifle and selectively modulated for ID interrogation). The interrogated soldier has body mounted laser receivers which identify the laser signal and returns an RF signal for identification.

PVC tissue coated with aluminum was industrially developed for covering bio-gas-installations. It was assumed that the same material could be explored as an IR camouflaging material for the dismounted soldier. Experimental results using a QWIP SC3000 thermal imager clearly supported this concept. The possibility to use the same material for radar signature reduction was also investigated. As expected, the contradicting requirements between IR and radar camouflage applications provided only a small signal reduction.

This activity is one part of the continuous area of activity for camouflage improvement and combinations for military field applications and applies also for the individual soldier. While this technology has implications for force protection, it warrants further investigation to determine the feasibility for the dismounted soldier.

4. Conclusion

Since the end of the Cold War, military forces have been engaged in a far different and complex battlespace. The urban environment poses significant technological challenges due to its restrictive and constrictive space of operation. This scenario is likely to continue; therefore, military forces must be well prepared to gain a substantial advantage and mitigate risk through the development of state-of-the-art sensor systems to support the level of operation encountered whether it is policing, raids, or sustained urban combat. The casualty rate on the urban battlefield is very high, and as we continue to shift more and more towards asymmetrical warfare technology must continue to focus on the military mission of saving lives, improving quality of life, and equally improve combat effectiveness.

The Specialists' Meeting provided an opportunity for NATO Nations and SET Panel members to collectively address future sensor enhancements for the next generation combat warrior and advances in technology for manportable sensor systems. The comprehensive technical presentations, from various nations, provided an outstanding overview of present areas of concern and suggestions for additions and improvements. The overall event provided an excellent insight into the existing state of the art from a sensor point of view and clearly sets the stage for improved/new sensor development providing significantly increased fighting capability in the urban environment coupled with greatly reduced vulnerability and survivability for ground based warfighter.

This meeting has been the first specialist meeting focusing exclusively on the needs of sensor capability and associated new requirement for the ground war fighter in the urban environment. Ongoing and new work aspects and activities have been discussed, and it is expected that follow-up programs within the SET Panel are being initiated in the future.

The SET Panel will benefit to conduct further exploration and may propose to conduct a follow-on meeting in a classified setting with continued dialogue that focuses on state of the art sensor systems supporting the dismounted soldier.

As mentioned earlier, the SET -103 Sensor Technology for the Future Dismounted Warrior was held in conjunction with the Landgroup 6 Structured Technology Demonstration. Participants of the SET -103 were afforded an opportunity to view the equipment on hand. The LG-6 STD Technical Evaluation Report should provide insight into the type of equipment participating in this demonstration along with system specifications and data collection results. Combat sensor devices, fielded or under development, provided during this data collection and demonstration effort could bring to bear some important factors applicable to the current mission and research efforts to develop advanced sensor technology for use by the dismounted warrior in an urban environment. Appendix A provides an overview of the LG-6 Structured Technology Demonstration.

The Author:

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1978 - Director of Laser Division, Night Vision Laboratory, Fort Belvoir, VA.

1989 - Director, US Army Communication-Electronics Command's Research and Engineering Center/ Night Vision and Electronic Sensor Directorate.

1993 - NVL technical activities extended including mine detection, neutralization, countersurveillance, deception and physical security elements.

1996 - IPA, Center for Research and Education in Optics at the University of Central Florida.

1998 - Founded RGB and Associates (Consulting in the areas of sensors and associated electro-optics technologies)

Participates as US Member at Large at the NATO SET Panel focusing on electro-optical activities.

2002 - Re-elected as Member at Large (Term expires 2007).

APPENDIX A

NATO LG-6 Structured Technology Demonstration Summary

NATO LG-6 Structured Technology Demonstration

VIP Demo Overview

April 04, 2006

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LG-6 STD Objectives

- Demonstrate the application of mature sensor systems in urban scenarios and assess their performance.
- Identify critical technical issues employing sensors in an urban operational concept.
- Identify opportunities to leverage & transfer technologies across NATO Organizations.
- Document lessons learned in a final report

Test Scenarios

- Gunfire Detection Systems (Fixed Site)
- Gunfire Detection Systems (Soldier Wearable)
- Gunfire Detection Systems (Vehicle Mounted)
- Mortar Detection
- Vehicle and Personnel Detection (Radar)
- Vehicle and Personnel Detection (Electro-Optics)
- Vehicle and Personnel Detection (Multi-Sensor)

Summary

Conclusions:

- Demonstration successfully conducted with realistic scenarios encountered in typical urban environment.
- Progress report will be published as part of the NVESD symposium
- Final LG-6 STD report will be published to document performance of systems that participated in the STD

Recommendations for future STDs:

- Increase sensor & CCD systems participation from NATO nations
- Implement interoperability of sensor systems into a common ground station display
- Collaborate on networking of sensors for improved situational awareness