Defence Research and Development Canada
Recherche et développement pour la défense Canada

DEFENCE DÉFENSE

Defensive aids suite for light armoured vehicles

Closure report (12rd)

J. Fortin
J. Bédard
DRDC Valcartier

Terms of release: The information contained herein is proprietary to Her Majesty and is provided to the recipient on the understanding that it will be used for information and evaluation purposes only. Any commercial use including use for manufacture is prohibited. Release to third parties of this publication or information contained herein is prohibited without the prior written consent of Defence R&D Canada.

Defence R&D Canada – Valcartier
Technical Report
DRDC Valcartier TR 2006-710
March 2007

Canada

Defensive aids suite for light armoured vehicles

Closure report (12rd)

J. Fortin
J. Bédard
DRDC Valcartier

Terms of release: The information contained herein is proprietary to Her Majesty and is provided to the recipient on the understanding that it will be used for information and evaluation purposes only. Any commercial use including use for manufacture is prohibited. Release to third parties of this publication or information contained herein is prohibited without the prior written consent of Defence R&D Canada.

Defence R&D Canada – Valcartier

Technical Report
DRDC Valcartier TR 2006-710
March 2007

Principal Author

Jean Fortin

Concepts and Integration

Approved by

Phil Twardawa

SL / EOW

Approved for release by

C. Carrier

Chief Scientist

© Her Majesty the Queen as represented by the Minister of National Defence, 2007

© Sa Majesté la Reine, représentée par le ministre de la Défense nationale, 2007

Abstract

This report summarizes the work done at Defence R&D Canada - Valcartier under project 12rd nicknamed *Defensive Aids Suite for Light Armoured Vehicles*. The aim of this project was to identify, investigate and evaluate modular "plug-and-play" defensive aids technologies to improve the protection of future Canadian Forces land platforms.

The project succeeded in demonstrating a second-generation defensive aids suite prototype to improve vehicle survivability against threats such as laser beam rider, target designators, range finders and missile plume simulators. Such a wide variety of sensors and countermeasures integrated on a single platform had never been demonstrated elsewhere.

This project enabled Defence R&D Canada - Valcartier and the Canadian Forces to gain tremendous knowledge on means to protect land assets against current and future threats. It has been an ideal tool of exchange with allied nations and to augment our understanding of survivability mechanisms. The results will have a direct impact on future acquisition projects such as the Mobile Gun System and the Multi-Mission Effect Vehicle.

Résumé

Ce rapport résume le travail effectué à R&D pour la défense Canada – Valcartier dans le cadre du projet 12rd intitulé *Suite d'aide à la défense pour véhicules blindés légers*. Le but de ce projet était d'identifier, d'étudier et d'évaluer des technologies modulaires d'aide à la défense « plug-and-play » pour augmenter la protection des plates-formes terrestres des Forces canadiennes.

Le projet a permis de démontrer un prototype de suite d'aide à la défense de seconde génération augmentant sa survie contre des menaces telles que les armes guidées par corridor laser, les désignateurs de cibles, les télémètres et les simulateurs de plumes de missiles. Une telle variété de capteurs et de contre-mesures intégrés sur une même plate-forme n'avait jamais été réalisée ailleurs.

Ce projet a permis à R&D pour la défense Canada – Valcartier ainsi qu'aux Forces canadiennes d'acquérir une quantité de connaissances extraordinaires sur les moyens de protection contre les menaces actuelles et futures. Il a constitué un outil d'échange idéal avec les nations alliées pour augmenter nos connaissances des mécanismes de survie. Les résultats auront un impact direct sur les projets d'acquisition futurs tels que le Système de canon mobile et le Véhicule à effets multi-mission.

This page intentionally left blank.

Executive summary

The decision of the Canadian Forces to move toward lighter vehicles with increased mobility and thinner armour has stressed the need for the development of better detection and countermeasure systems to improve their survivability. This report summarizes the work done at Defence R&D Canada - Valcartier under the project 12rd entitled *Defensive Aids Suite for Light Armoured Vehicles*. This project started in April 2000 and ended in September 2004, in synchronism with the Future Armoured Vehicle System Technology Demonstrator technical and tactical trials.

The aim of the project was to identify, investigate and evaluate modular “plug-and-play” defensive aids technologies to improve the protection of future Canadian Forces land platforms. The project succeeded in demonstrating a second-generation defensive aids suite prototype to improve vehicle survivability against threats like laser beam rider, target designators, range finders and missile plume simulators. Such a wide variety of sensors and countermeasures integrated a single platform had never been demonstrated elsewhere.

The project enabled Defence R&D Canada - Valcartier and the Canadian Forces to gain tremendous knowledge on means to protect land assets against current and future threats. It has been an ideal tool of exchange with allied nations to augment our understanding of survivability mechanisms. The results will have a direct impact on future acquisition projects such as the Mobile Gun System and the Multi-Mission Effect Vehicle.

Defensive Aids Suite technologies are still in development at Defence R&D Canada - Valcartier. A follow-on project entitled *Integrated Protection for Light Armoured Vehicles* (12rf) was proposed and accepted. This project intends to build on the second generation defensive aids suite demonstrator in order to optimize the sensor and countermeasure suite in simulated operational scenarios. The outcome will propose a modular protection architecture including hard kill and soft kill countermeasures.

Fortin J. and Bédard J. 2007. Defensive aids suite for light armoured vehicles. DRDC Valcartier TR 2006-710. Defence R&D Canada – Valcartier.

This page intentionally left blank.

Sommaire

La décision des Forces canadiennes d'opter pour des véhicules plus légers ayant une mobilité accrue mais un blindage plus mince a accentué le besoin de développer de meilleurs systèmes de détection et de contre-mesures pour améliorer leur protection. Ce rapport résume le travail effectué à R&D pour la défense Canada – Valcartier dans le cadre du projet 12rd intitulé *Suite d'aide à la défense pour véhicules blindés légers*. Le projet a débuté en avril 2000 et s'est terminé en septembre 2004, en synchronisme avec les essais techniques et tactiques du démonstrateur de technologie Système de Véhicule Blindé du Futur.

Le but était d'identifier, d'étudier et d'évaluer des technologies modulaires d'aide à la défense "plug-and-play" pour améliorer la protection des plates-formes futures des Forces canadiennes. Le projet a permis de démontrer un prototype de suite d'aide à la défense de deuxième génération augmentant la survie d'un véhicule contre des menaces telles que les armes guidées par corridor laser, les désignateurs de cibles, les télémètres et les simulateurs de plumes de missiles. Une telle variété de capteurs et de contremesures intégrés sur une même plate-forme n'avait jamais été démontrée ailleurs.

Ce projet a permis à R&D pour la défense Canada – Valcartier ainsi qu'aux Forces canadiennes d'acquérir une quantité de connaissances importante sur les moyens de protection des véhicules terrestres contre les menaces actuelles et futures. Il a constitué un outil d'échange idéal avec les nations alliées pour augmenter nos connaissances des mécanismes de survie. Les résultats auront un impact direct sur les projets d'acquisition futurs tels que le Système de canon mobile et le véhicule à effets multi-mission.

Les technologies d'aide à la défense sont encore en développement à R&D pour la défense Canada – Valcartier. Un projet subséquent intitulé « Protection intégrée pour véhicules blindés légers » (12rf) a été proposée et acceptée. Ce projet propose de bâtir sur le démonstrateur de suite d'aide à la défense de deuxième génération afin d'optimiser les capteurs et les contre-mesures dans des scénarios opérationnels simulés. Le résultat de ce projet proposera une architecture modulaire de protection incluant des contremesures de type "hard kill" et "soft kill".

Fortin J. et Bédard J. 2007. Defensive aids suite for light armoured vehicles. DRDC Valcartier TR 2006-710. R & D pour la défense Canada – Valcartier.

This page intentionally left blank.

Table of contents

Abstract i
Résumé i
Executive summary iii
Sommaire v
Table of contents vii
List of figures viii
List of tables ix
1. Introduction 1
2. Approach 2
2.1 Work plan 2
2.1.1 12rd14: DAS demonstrator for trial PRONGHORN 2
2.1.2 12rd15: Definition study of future DAS activities 2
2.1.3 12rd16: Modeling and simulation relevant to DAS systems 2
2.1.4 12rd17: Defence against non-laser based threats 2
2.1.5 12rd18: Detection of small arms' fire from a moving LAV 3
2.1.6 12rd19: Enhanced DAS demonstrator (phase II) on LAV III 3
2.2 Project work plan 3
2.3 Resource plan 3
2.4 Output/deliverables 4
2.4.1 National collaboration 4
2.4.2 International collaboration 4
3. Results and discussion 6
3.1 12rd15: Definition study of future DAS activities 6
3.2 12rd16: Modeling and simulation relevant to DAS systems 8
3.3 12rd17: Defence against non-laser based threats 8
3.4 12rd18: Detection of small arms' fire from a moving vehicle 10
3.5 12rd19: DAS demonstration phase II 11
4. Lessons learnt 14
5. Conclusions 15
6. Future work/exploitation 16
References 17
List of symbols/abbreviations/acronyms/initialisms 21

List of figures

Figure 1. Vehicle interface module 9

Figure 2 a. Enhanced DAS architecture, b. Vehicle integration.. 13

List of tables

Table 1. Major milestones of the DAS project 3

Table 2. Resource allocation of the DAS project 4

This page intentionally left blank.

1. Introduction

The aim of this project was to identify, investigate and evaluate modular “plug-and-play” defensive aids technologies to improve the protection of future Canadian Forces (CF) land platforms. Essentially, the goal was to develop and model passive and active defensive aids suite (DAS) technologies and to demonstrate these technologies on a Light Armoured Vehicle (LAV) III platform.

The project started in April 2000 and was supposed to end in March 2004. It was extended until September 2004 to end in synchronism with the Future Armoured Vehicle System (FAVS) Technology Demonstrator (TD) technical and tactical trials.

As a major outcome, a second generation DAS system featuring a plurality of sensor and countermeasures (CM) was developed. Such a wide variety of sensors and CM integrated on a single platform and featuring interfaces with the vehicle vetronics had never been demonstrated elsewhere in the world.

The uniqueness of this project essentially originates form the high level of sensor data fusion achieved and the diversity of CMs implemented. The DAS was also network enabled through the FAVS capabilities. It also featured two human machine interfaces; one based on a high-resolution display and control interface designed for conventional use and a second one based on a the enhanced capabilities provided by the immersive visualization display of FAVS.

This project was done in order to gain better knowledge of the effectiveness of DAS technologies when used in the field. New sensor architectures and countermeasures were developed in order to improve the protection of CF vehicles in realistic scenarios. These developments enabled us to develop a database for modeling and simulation of sensors and CMs performance.

This project was a consequence of the decision taken by the CF to go toward a lighter and more mobile force. It will have a direct impact on the future acquisition programs such as the Mobile Gun System (MGS) and the Multi-Mission Effect Vehicle (MMEV).

2. Approach

2.1 Work plan

The DAS project was structured as a series of six Work Breakdown Elements (WBE). These are described hereafter including a brief description of their main objectives.

2.1.1 12rd14: DAS demonstrator for trial PRONGHORN

This WBE was introduced to help finalize the documentation on the Pronghorn trial. The outcome of this WBE is given at reference [1]. It will not be further described as no specific R&D work was done.

2.1.2 12rd15: Definition study of future DAS activities

The objective of this WBE was to prepare a way-ahead scoping study and work plan to develop a modular mission-configurable DAS which could be integrated in a future LAV. The conclusions and recommendations of Pronghorn were used as a basis to plan future DAS activities.

2.1.3 12rd16: Modeling and simulation relevant to DAS systems

This WBE had three specific objectives, namely:

- to acquire, develop and use modeling and simulation (M&S) tools to assess the effectiveness of basic DAS technologies,
- to develop and use the M&S tools to assess and develop more elaborate DAS technologies, and
- to extend the capabilities described above through more direct collaboration with other organizations.

This work involved a number of national and international collaborations. As examples, the M&S tools developed were used to feed the IRON GORGET simulation (Ref. [2]) on soft kill and hard kill DAS effectiveness. This work unit also supported task #10 of the EWS-TP5 TTCP group. More details on this collaborative work will be given in the next chapter.

2.1.4 12rd17: Defence against non-laser based threats

The objective of this WBE was to investigate on technologies to enhance the capability of a basic DAS to detect and defend against non-laser-based threats. The Missile Approach Warning System (MAWS) technology was studied and integrated in the DAS prototype to protect against non-laser threats.

2.1.5 12rd18: Detection of small arms' fire from a moving LAV

The objective of this WBE was to demonstrate that sniper direction-of-fire could be detected from a single LAV moving at 30 km/h. The goal was to build upon the S&T expertise developed during a previous R&D project, namely: GUARDIAN I. New algorithms and improved hardware were implemented to achieve the objective.

2.1.6 12rd19: Enhanced DAS demonstrator (phase II) on LAV III

This WBE had three main objectives. Firstly, to develop an enhanced DAS demonstrator effective against laser and non-laser Anti-Tank Guided Missile (ATGM) threats. The second objective was to demonstrate the DAS on a LAV III and the third objective was to integrate it in the FAVS demonstrator prototype. These objectives were successfully reached and demonstrated during the FAVS technical and tactical trials.

2.2 Project work plan

The work plan of the overall project is shown in Table 1.

Table 1. Major milestones of the DAS project

Ser	Milestone	Date	Remarks
1	Demonstrate and evaluate a basic modular DAS against laser guided weapons on a LAV during the multi-national "Pronghorn" trial.	2-Oct-99	Completed
2	Prepare a way-ahead scoping study and workplan to develop a modular mission-configurable DAS which could be integrated on a future LAV.	1-Jun-03	Completed
3	Evaluate, acquire and develop modeling and simulation tools to assess the effectiveness of a basic suite of DAS technologies.	1-Mar-04	Completed
4	Demonstrate the feasibility of a basic DAS to detect bearing-of-fire of a non-lasing ATGM or anti-tank rocket and respond with a basic countermeasure by March 2004.	1-Mar-04	Completed
5	Demonstrate that sniper direction-of-fire can be detected from a single LAV moving at 30 km/h	1-Jun-03	Completed
6	Demonstrate an improved DAS effective against advanced laser guided weapons and, integrate and demonstrate on a LAV.	31-May-04	Completed

2.3 Resource plan

The monetary and human resources were allocated as shown in Table 2.

Table 2. Resource allocation of the DAS project

Funding Source	Previous	04/05	Total
FTEs (PY)	13.3	1.3	14.6
FTEs Full Cost (k$)	1477.6	142.3	1619.9
Contract/Local (k$)	2411.0	100	2511.0
Other DND	-	-	-
External	-	-	-
External In-Kind (k$)	300	-	300
Grand Total (k$)	4188.6	242.3	4430.9

The achievement of this project required the contribution of many organizations. In particular for the Pronghorn trial, the contribution of personal of the Combat Trainning Center in Gagetown as well as the crews of the Armour School and personal of the Land Forces Test and Evaluation Unit need to be underlined. Similarly, the FAVS technical and tactical required coordination with various organizations of the CF. Their contribution was clearly underlined in the FAVS reports.

2.4 Output/deliverables

The most significant outcome of this project has been the second generation DAS demonstrator that was tested during the FAVS technical and tactical trial. Improvements to the Ferret system can also be accounted as a significant outcome of this project. However, the DAS project was not the only source of revenue for Ferret. As secondary outcomes, one must take into account a missile and rocket signature database as well as the M&S tools developed.

2.4.1 National collaboration

The M&S tools developed as part of this project as well as the Pronghorn trial data were extensively used for the IRON GORGET simulation. This simulation was the first attempt to characterize hard kill and soft kill DAS systems in a wargame scenario [2].

2.4.2 International collaboration

The DAS project also supported numerous international collaborations. In particular, the PRONGHORN trial which was run under the aegis of the TTCP EWS-TP5 group. This collaboration involved three countries, namely US, UK and CA. As a follow-on to the Pronghorn trial, a new task on the modeling and simulation of DAS systems (task #10) was proposed and supported by most of the TTCP nations.

This project also supported a bi-lateral collaboration between CA and UK. As part of this agreement, a trial nicknamed SHALD took place in UK to evaluate the effectiveness of laser dazzling to counter a threat involving a human in the loop.

An international collaboration between Canada and the Netherlands (IA-21) [3] was also initiated during this project. This collaboration on DAS sensor development has been an occasion to collect signature data of flying Rocket Propelled Grenades (RPGs). Two trials were organized, one in the Czech Republic under the auspices of the Netherlands and one in Canada where RPGs tandem warhead were fired.

A data exchange agreement on DAS technologies was signed between US Army TARDEC and DRDC Valcartier [4]. This agreement had been a platform for numerous fruitful exchanges and visits among the two laboratories.

The DAS project also supported the activities of NAAG LG.2 and more specifically the DAS team of expert. This activity is still on-going and the team of expert was mandated by the LG.2 to draft a STANAG on DAS.

The meetings of LG.2 have been the ideal platform to develop contacts with other countries involved in DAS developments and in particular with France. These contact essentially led to Specific Arrangement 26 (SA-26) that was recently signed [5]. Contacts with Sweden and Germany are also of significant importance and could not have been made without this project.

The development of Ferret was also at the center of a multi-national evaluation made at the McKenna MOUT site in Fort Benning, Georgia. This trial was performed under the auspices of NATO SET Panel ET-08 TG-25. During this trial, acoustic signature data was gathered and work was done to explain how the sound propagates in an urban environment, especially the reverberation of the shock wave and muzzle blast. The data collected was included into the DRDC Valcartier acoustic database.

3. Results and discussion

3.1 12rd15: Definition study of future DAS activities

The study made as part of this WBE essentially included the main conclusions and recommendations of the PRONGHORN trial [1]. PRONGHORN was an international trial held under the aegis of TTCP EWS TP5. It took place in October 1999 on a range at the Canadian Forces Base, Gagetown, which is near Fredericton, New Brunswick. The active participants in PRONGHORN were Canada, the USA and the UK.

PRONGHORN had the objective of gathering quantitative data on the performance of laser warning receivers (LWRs) and the associated CMs when they were mounted on Armoured Fighting Vehicles (AFVs) operating under realistic conditions in the field.

The vehicles used in PRONGHORN were a troop of four Canadian reconnaissance LAV (Coyotes) operating hatch-down. Within the troop of four vehicles, there were two capable of launching smoke grenades automatically, two capable of providing high resolution angle-of-arrival information for counter-fire, two capable of detecting beam-riders and two carrying versions of a laser decoy CM. One of the vehicles was fitted with a fully integrated prototype DAS system, which included provision for semi-automatic control of the turret. The vehicles and the various threat devices were provided with Global Positioning Systems (GPS). A digitized map of the terrain had been produced and a real-time map display of the progress of trial was available to the test conductor.

The trials procedure comprised a technical trial and a tactical trial. The technical trial was designed to evaluate the performance envelopes of the LWRs when fitted to their vehicles in static tests on one vehicle at a time. It comprised a set of standardized measurements, or “serials”. The tactical trial was designed to measure the effectiveness of CMs initiated by these LWRs when the vehicles were operating together under simulated combat conditions. It was organized as a matrix of engagements, each playing a given threat against a given CM on a given vehicle. The engagements were called up by the test conductor in the course of attacks by the troop of four "Coyotes" over broadly-defined lines of advance. The traces were broken up into bounds approximately 1 km in length. Typically, each vehicle would be engaged once when static and once when moving in each bound.

The following conclusions were drawn regarding the LWRs. The importance of providing an audio cue via the intercom to all members of the crew was confirmed. The importance of mounting LWR sensors in positions giving a completely clear field of view (e.g. on the periphery of the turret) was also confirmed. A high-resolution angle-of-arrival capability coupled with a semi-automatic turret drive was useful. This was particularly evident when counter-fire or smoke CMs were used. The clock-face type display used in one prototype was very good and is to be recommended whether the threat bearing is referenced to the hull or the turret. The HARLID/Type 480 LWR combination worked well in the tactical trial, providing accurate bearings without confusion by ground-scatter, but the display (in the gunner’s sight) appears not to have been used to the best advantage in counter-fire engagements. This may have been due partly to the prevailing doctrine, which gives the commander control of counter-fire up to the point of authorizing firing. The potential value of the off-axis detection (with correct threat bearing) of attacks on nearby vehicles, while not a direct goal of the experiment, was demonstrated to a certain extent on two prototypes. The importance of rejecting ground scatter was confirmed. The Gold Block LWR demonstrated a very good capability against both types of beam-rider used in PRONGHORN and would probably give warnings with useful "time-to-go" at normal operational ranges for these devices. False alarms were a problem with the more experimental devices in the trial. The BERD beam-rider detector was plagued with false alarms resulting, apparently, from modulated bright sunlight. The Gold block appeared to suffer from the same problem but to a far smaller extent. Type 480 LWR, although relatively immune from problems caused by sunlight or surface scatter, suffered from false alarms of electro-mechanical origin, i.e., from mechanical pressure on the fibre-optic/photo-diode array interface at the Central Processing Unit (CPU).

The following conclusions were drawn regarding the CMs. The technique for implementing the laser decoy CM from a moving vehicle has not yet been perfected. Likewise, a methodology for evaluating the laser decoy CM from a moving vehicle has also not yet been perfected. Only a partial record of seeker data was recovered from the trial and it proved difficult to extract quantitative data on the performances of the three variants of the laser decoy that were used. On the basis of these partial records, it appears that the CM was successful in several engagements.

Two practicable, effective methods for launching automatic smoke were demonstrated and tactical doctrine for employing this CM is emerging. There was a significant time advantage in launching smoke automatically. The dominant factor determining the effectiveness of the smoke CMs, whether manually or automatically initiated, was the true wind vector. Correct placement of the grenades in relation to the threat bearing and the true wind vector is vital if line-of-sight (LOS) is to be broken in the minimum time.

The combination of high-resolution threat bearing and high-speed electric turret was shown to provide effective counter-fire.

Although much of the equipment used was experimental, it was evident, both from the steep learning curves shown by the crews during the trial and from the immediate changes of doctrine following the trial, that PRONGHORN provided a unique and valuable experience for the CF. Similarly, it provided valuable technical guidance to the development of DAS equipment within the TTCP nations. The quality and quantity of the data obtained in PRONGHORN would justify further effort on analysis and modelling.

The following specific technical recommendations are made:

It is recommended that there be further development effort on the specific problem of employing laser decoy on a moving armoured vehicle. Although equipment failures and recording failures greatly restricted the amount of quantitative data obtained from the laser decoys, each of the three variants was clearly successful on at least one occasion, indicating that the problems were not fundamental and that it is a valuable approach.

It is recommended that further analysis be carried out to determine the optimum technique for implementing automatic smoke in a future DAS. The two methods tested (launch on detection or align turret then launch) were both found to give good results, one being significantly faster, the other better-directed.

The effectiveness of smoke CM, whether manual or automatic, was largely determined by the true wind vector. It is recommended that means be developed for projecting smoke grenades in the optimum direction with respect to the combination of vehicle motion vector, true wind vector and threat bearing.

These conclusions and recommendations were largely used as a guide to determine the way ahead of the DAS project.

3.2 12rd16: Modeling and simulation relevant to DAS systems

The PRONGHORN trial had been an ideal occasion to collect data on DAS sensor and CM performance. To fully exploit this data and better plan future work, a task on advanced DAS for surface assets (task #10) was proposed and supported by a majority of the EWS-TP5 participating nations.

The goal of this task was to perform a combined assessment of threat, sensors and countermeasures in a system of systems approach in order to establish the optimal technical solution and operational protocol for the protection of military platforms. To achieve that goal, an assessment of the state of the art DAS technology was made using prototype development, field trials and numerical analysis. Different approaches were taken by the nations and allowed to compare and reinforce the results. Digital processing of current and previous trial data provided the information required to improve and validate DAS models. Various configurations were defined and studied in a system of systems context to determine survivability (e.g. integrated situational awareness, signature management, etc).

In summary, the DAS configurations studied under this task significantly improved vehicle survivability by allowing a light armoured force to operate longer against a more heavily armed force. The DAS did not allow a light force to win against a heavy force; however, the results gave valuable insights into the technical direction/requirements needed to develop efficient DAS systems. The soft kill DAS systems studied significantly reduced the long range capability of the enemy weapons and hard kill DAS systems significantly improved survivability in asymmetric war scenarios. The work also revealed that depleatable countermeasures must be supported by sufficient firepower to defeat the enemy before the countermeasures are exhausted and that depleatable countermeasures must be matched with sensor sensitivity to prevent premature expenditure. Similarly, it was shown that DAS and passive armour must complement each other in order to ensure that protection is provided over the full expected threat spectrum.

This work gave valuable insights into the direction the TTCP nations envisage for the protection of their light armoured fleets. Publications prepared under this WBE include [6]-[13].

3.3 12rd17: Defence against non-laser based threats

This WBE had essentially two objectives. The first was to enhance DRDC Valcartier’s missile signature recording capability and improve the database. To achieve that, a Missile Approach

Warning Sensor (MAWS) was procured and configured for signature measurement and recording. The unit selected was the German Missile Launch Detection System (MILDS) manufactured by EADS. This unit was selected because of its eventual capability to detect and track land missiles with high resolution accuracy (±2º). No other comparable device was available on the market.

While the initial intent was to acquire the P-MILDS (panzer-MILDS) version optimized for land applications, time and budget constraints prevented this approach. At the time of the acquisition, the P-MILDS was only available as a prototype. While both the MILDS and the P-MILDS use similar ultraviolet (UV) imaging arrays, larger optics, longer integration times and different declaration algorithms are implemented in the P-MILDS to achieve the sensitivity level required to detect land threats. This, however, had limited impact on the signature measurement capability and the DAS project demonstration.

The WBE supported three missile signature acquisition campaigns. UV and infrared (IR) signature of the Javelin and Spike missiles were recorded during summer and winter trials in 2001. Canada was then invited by the Netherlands to participate in a RPG live fire trial in 2002. This trial had been the first occasion to familiarize with this threat and record its UV and IR signature.

The second sub-objective was to integrate the MAWS in the DAS prototype to provide protection against non-laser threats. The interface to the MAWS was provided by a Vehicle Interface Module (VIM) custom designed at DRDC Valcartier. Figure 1 shows a representation of the VIM.

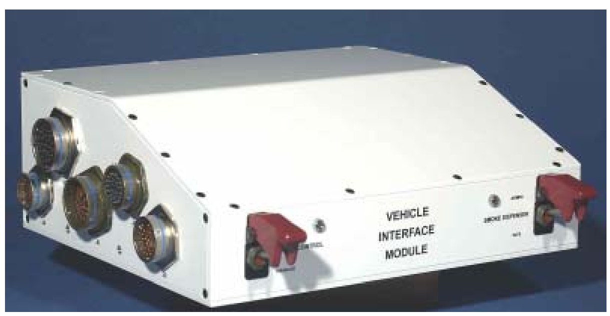

Figure 1. Vehicle interface module

The VIM included an interface to MILDS sensor as well as the hardware required to control the rotation of a LAV III turret, the elevation of the main weapon and the release of smoke grenades. Interfaces with the commander and gunner joysticks were also provided to prevent accidental release of smoke as well as unwanted movements of the turret.

The information from the MILDS transited through the VIM toward the DAS processor which in turn was programmed to respond with the most appropriate CM to the detected threat. More information on the DAS demonstrator will be given in Section 3.5.

3.4 12rd18: Detection of small arms' fire from a moving vehicle

The need for the localization of a small arms' fire emerged during the past peace-keeping operations in the former Republic of Yugoslavia. The CF Director Land Requirements (DLR) identified a general requirement for the detection and localization of the origin and direction of small arms' fire. The aim was to detect that a shot had been fired at the peace-keepers in a UN Observation Post (OP) or between parties in the OP area. As a result of this identified need, Defence R&D Canada – Valcartier engaged in research and development of an in-air acoustic-based system for the localization of small arms' fire. The system is nicknamed Ferret.

In the recent years, acoustic systems have appeared in various military forces around the world. Acoustics has proven useful for the detection and localization of armoured vehicles and helicopters. In the recent past, the US tested an acoustic sensor system in the wide area mines. Similarly, France and Israel designed and tested first-generation systems for the localization of small arms' fire. The emergence of this new technology brings with it the need for system test and evaluation criteria.

The acoustic localization of small arms' fire relies entirely on the sounds produced by shock wave of the supersonic bullet and the muzzle blast of the weapon. The Ferret system uses the detection and recognition of the shock wave to determine if a shot has been fired. The system then waits for the arrival of the muzzle blast to estimate the location of the shooter. In good propagation conditions, a bullet passing within 200 meters of the sensor array will give rise to a signal that can be classified as a shock wave. Muzzle blast recognition is also possible for a shooter located within similar ranges. In rare cases only, muzzle blasts can be recognized at the full effective range of all small arms. For that reason, Ferret does not rely on the full recognition of the muzzle blast signal, but only on the classification of some of its features.

Atmospheric conditions and the environment alone dictate the performance of an acoustic detection system. Technology is at a point where the noise and bandwidth of the sensors and acquisition systems are sufficient to obtain an adequate representation of the sound pressure at the microphones. Atmospheric turbulence and refraction affect significantly the shape of the acoustic pulse. Turbulence destroys the coherence of the shock wave and muzzle blast sounds. It affects both the time-domain signal and the spatial coherence of the two sounds. Atmospheric refraction curves the acoustic rays upward or downward. In upward propagation the sound energy is refracted into the upper atmosphere and that decreases significantly the detection range of distant muzzle blast. On the contrary, downward refraction keeps the sound energy near the ground, which enhances detection range.

Surrounding encompasses everything that affects or restrains the propagation of the shock wave and muzzle blast. That includes the type of ground or ground cover (concrete, grass, ice, snow, etc.), the terrain features (buildings, hills, etc.) and the fact that the shooter may be firing from within a building. The line of sight between the source of sound and the sensors affects the fidelity of sound and its direction of propagation. For example, for sensors located behind a building, the sound always propagates from the corner of the buildings to the sensors because of the diffraction. Unless one models the diffraction around the building, the angles measured will be more a reflection of the geometry than the actual bearing to the shooter. On the other hand, if a building hides the shooter and the sensors are located at some distance from that building, the direction of arrival of the muzzle blast will not be affected greatly and localization is still meaningful.

The work done under this WBE clearly established the performance parameters of the Ferret system. One must keep in mind though that most of the acoustic data was obtained from field experiments held in Eastern Canada under a variety of weather conditions. The performances can significantly change if the environmental conditions are altered.

Publications prepared under this WBE include [14]-[23].

3.5 12rd19: DAS demonstration phase II

The Pronghorn trial clearly showed the importance of better sensors, countermeasures and man/machine interfaces to improve the survivability of land platforms. Various studies were conducted to develop new CMs and characterize their effectiveness in operational scenarios. Among the cases studied, laser dazzling, laser decoy and laser jamming were found to be most promising considering the cost, the size, and the possibility to implement them on future vehicles.

Laser based CMs are interesting for a number of reasons. Firstly, they can be deployed rapidly and do not need to be replenished. Secondly, they can be used under cover as they are directed against a specific threat and almost invisible to other opponents. Thirdly, they can be used to defeat a threat while other resources can be directed to others tasks.

Laser dazzling consists in irradiating an enemy with light of sufficient power to disrupt its ability to aim at a given target. Previous work done at DRDC Valcartier [18] has shown the effectiveness of this technique on LBR weapons even with laser light power significantly lower than the eye safety level. This countermeasure can be used to defeat any threat requiring clear line of sight however to be effective, it requires precise localization of the firing post and system's operator.

Laser decoy is a technique used to defeat weapons involving target designators. It essentially consists in creating a false target away from the vehicle. By following the rules of the art, it is possible to confuse the missile seeker and deviate it from its intended trajectory.

Laser jamming essentially deals with wire-guided threats where a flare located in the back of a missile is used for guidance. The jammer mimics the operation of the flare and feeds false guidance information to prevent the threat from hitting its target.

With the availability of small-size low-cost lasers on the market, it is possible to envisage the development of a multi-function laser to augment the CM suite of a LAV.

As already mentioned, the objectives of this project element were:

- to develop an enhanced DAS demonstrator effective against laser and non-laser ATGM threats.
- to demonstrate the DAS on a LAV III and
- to integrate in the FAVS demonstrator.

It is important to understand that the core of the CM suite consisted of a multi-function laser. This unit was developed as part of the FAVS-TD project while the remaining of the DAS system was developed under the 12rd project. Because of their inter-dependence, they are considered as a whole hereafter.

FAVS was designed to develop and demonstrate advanced technologies for future armoured fighting vehicles, in three very different environments: real technologies were developed in industry and military labs, and integrated into a LAV III vehicle; a simulated vehicle was created in a virtual environment to include models of these and other advanced technologies; and a computer simulation of the resulting vehicle was created. Evaluations were carried out in the three environments on the performance of the individual technologies, on their individual effects on the battlefield effectiveness of the vehicle, on the human-machine interface usability and usefulness, and on the overall performance of the vehicle and its crew in realistic battlefield scenarios. The DAS technology was one of the technologies integrated in the LAV III and evaluated in the FAVS tactical and technical field trials.

The enhanced DAS demonstrator was based on a classical architecture. Sensors were interfaced to a processor, which in turn was interfaced to the vehicle vetronics and man/machine interface to allow the vehicle commander/gunner to have manual/automatic control over the turret and CM suite. A high-level communication network was also implemented to control the DAS system through the immersive visualization interface provided by the FAVS project. Figure 2a shows the enhanced DAS system architecture, while Figure 2b shows the integration on the FAVS vehicle.

As shown in Figure 2b, two laser sensor modules are installed to cover the front arc of the vehicle. These low-resolution sensors are designed to pick-up the radiation from target designator, range finder, laser weapon and laser beam rider and to provide a first indication of the threat angular localization. Once cued in the appropriate direction, a second module of laser sensors installed on top of the turret demodulates the laser signal and provides the information required for better threat localization and CM control.

The MAWS sensor used in this integration was thoroughly studied in WBE 12rd17. It is used in a similar way as the laser sensors. It gives a first indication (within ±2º) of the threat angular localization and the resolution is improved by active imaging, assuming that the firing post can be imaged by retro-reflection.

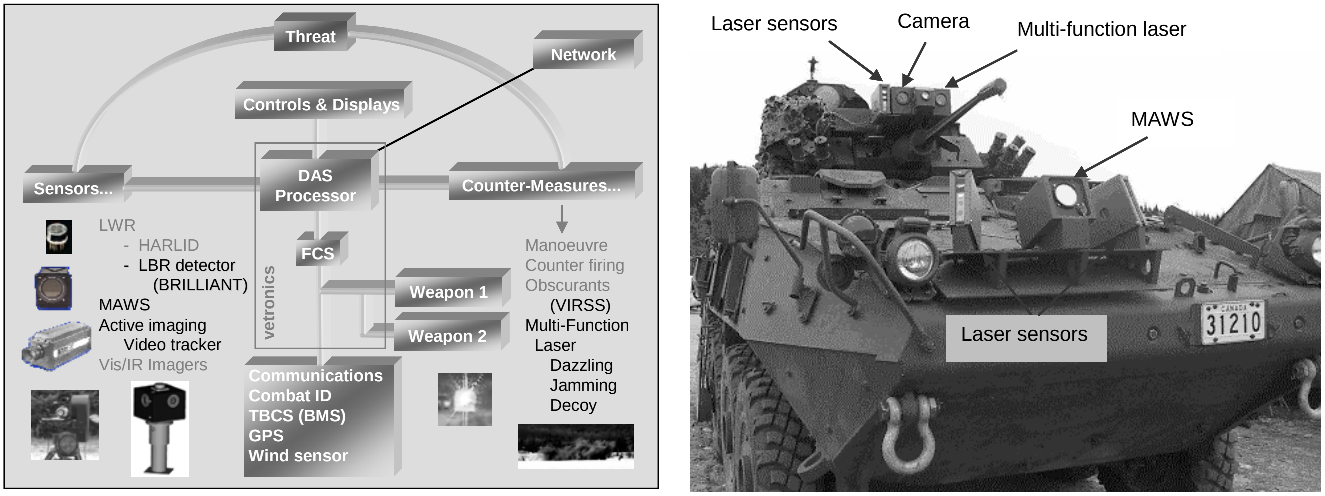

Figure 2 a. Enhanced DAS architecture, b. Vehicle integration

Two user interfaces were provided. The first consisted of a small VGA video display and four reprogrammable switches placed on the left hand part of the enclosure. The functions assigned to each switch were indicated by labels shown on the screen. They were menu dependent and could be reprogrammed using software. The DAS could also be operated through the FAVS network and the immersive visualization system. In that manner, software menus could be accessed using the FAVS operator hand controls.

The multi-function laser was based on a commercial off the shelf Nd:YAG source with appropriate optics to control the beam divergence and output port direction. The variety of wavelengths required for the DAS application was obtained by doubling the frequency of the Nd:YAG source and by merging the beam with the signal obtained from a series of laser diodes operating at selected wavelengths.

The operation of the enhanced DAS demonstrator was evaluated during the FAVS technical and tactical trials using threats stimulators such as laser beam rider, laser range finder, laser target designator and ultraviolet missile plume emulator. The DAS succeeded in defeating the threats and to improve the survivability of the LAV III platform in realistic simulated scenarios.

Publications prepared under this WBE include [24]-[33].

4. Lessons learnt

Within the last decade, the DAS technology has evolved quite significantly. While basic stand-alone detection devices were available a few years ago, integrated defence systems are now available on the market. The effectiveness of a second-generation DAS system including a wide variety of sensors and CMs coupled with a sophisticated human machine interface was demonstrated. The technology is believed to be ready for implementation on military vehicles and should be considered as a high-priority for future acquisition.

5. Conclusions

This project was achieved on time and within the budget initially allocated. The technical objectives were met and allowed DRDC Valcartier as well as the CF to gain tremendous knowledge in the field of sensor and CM and their integration on military vehicles.

The success of this project has enabled Canada to keep its reputation of world leader in the field of DAS systems. It has been an ideal occasion to develop collaborative agreements with other nations and to get insights in other countries programs for the protection of their surface assets.

6. Future work/exploitation

The DAS technologies are still in development at DRDC Valcartier. A new project entitled *Integrated protection for LAV* (12rf) was proposed and accepted where the second generation DAS system will be tested against various threats in simulated operational scenarios to determine the best characteristics for countermeasure. In the short term it is planned to develop a “Laser-based Countermeasure Test-bed” (LaCOMET) to characterize the effectiveness of laser-based countermeasures against real threats. Modelling and simulation tools will be developed to understand the interaction of threats on hard kill and soft kill countermeasures as well as their residual effect on vehicles. The project will also characterize sensor and countermeasure performances in order to be ready to advise the CF on their limitations, feasibility and collateral effects.

References

[1] Brown, C.R., Burrett, K., Cantin, A., Manatt, B. and Fortin, J. (2002). Final report on Pronghorn (U), TTCP report SL 2002-052, Valcartier, Quebec, DRDC Valcartier.

[2] Leclerc K., Ormrod, M. and Scale, C. (2004). An initial investigation of the potential benefits of defensive aid suites (DAS) to Canadian armoured fighting vehicles. ORD Project report PR2004/16, Ottawa, Ontario: Operational research division.

[3] Implementing arrangement number 21 on defensive aid suite sensor evaluation under the memorandum of understanding between the minister of national defence of Canada and the minister of defence of the kingdom of the Netherlands concerning co-operation in defence science and technology (2003).

[4] Data exchange agreement number DEA-CN-2002-1639 on defensive aids suites technologies for ground combat vehicle systems. (2002).

[5] Specific agreement number 26 on "Etudes de protection active pour plate-forme blindée". (2004).

[6] Fournier, P. (December 2002). Analysis of vehicle survivability to simulated attacks by laser threats at the PRONGHORN 99 field trial (U). DRDC Valcartier TM 2002-055 CONFIDENTIAL. Valcartier, Quebec: DRDC Valcartier.

[7] Rapanotti, J.L., Cantin, A. and Dickinson, R.G. (December 2006). Preliminary study of defensive aids suite technology for the armour combat vehicle programme. DRDC Valcartier TM 2003-274. Valcartier, Quebec: DRDC Valcartier.

[8] Rapanotti, J.L., Gilbert, B. and Richer, G. (December 2006). Prediction of spectral intensities from 70mm rocket plumes. DRDC Valcartier TM 2003-275 CONFIDENTIAL, Valcartier, Quebec: DRDC Valcartier.

[9] Rapanotti, J.L. (2004). Developing soft-kill capability for light armoured vehicles through battlefield simulations. DRDC Valcartier, TM 2003-276, Valcartier, Quebec: DRDC Valcartier.

[10] Palmarini, M. and Rapanotti, J. (2004). Integrated development of light armoured vehicle survivability based on war-gaming simulators, , Orlando, FL: Proceedings of SPIE 5423-30.

[11] Rapanotti, J.L. and Palmarini, M. (2003). Common DAS development for LAV variants. 14th US Army conference on Ground Target Modeling and Validation.

[12] Rapanotti, J.L. and Palmarini, M. (2003). Detectability of future non-line-of-sight missiles. 14th US Army conference on Ground Target Modeling and Validation.

[13] Rapanotti, J.L. and Palmarini, M. (2003). ModSAF-based development of operational requirements for light armoured vehicles. Orlando, FL: Proceedings of SPIE 5091-61.

[14] Johnson, T., Bédard J., (2004). *Ferret Training*, Presentation published by MacDonald Dettwiler and Associates.

[15] Johnson, T., Bédard J., (2004). *Ferret Testing*, Document published by MacDonald Dettwiler and Associates, November 2004.

[16] Bédard, J., Paré, S., (2003), Ferret, A small arms' fire detection systems: localization concepts, sensors, and command, control, communications, and intelligence (C3I) technologies for homeland defense and law enforcement II, Proceedings of SPIE Vol. 5071, 497-509.

[17] Bédard, J., (2003). Ferret acoustic small arms fire localization system, REPORT OF AN INVENTION – DRDC Valcartier, Val-Bélair.

[18] Dubois J. (July 1999). Beam rider laser localization imaging and neutralization tracker (BRILLIANT) system (U). DREV R-9831, Quebec, SECRET.

[19] Bédard, J., (September 2003), Acoustic small arms detection system for moving vehicles: system requirements (U), DRDC Valcartier TR 2002-202, Quebec, Canada, PROTECTED B.

[20] Bédard, J., (September 2003), Ferret localization concepts (U), DRDC Valcartier TR 2002-201, Quebec, Canada, PROTECTED B.

[21] Bédard, J., (2001). Canadian measurements at the NATO SET panel ET-08 TG-25 trial at Fort Benning, Georgia (U), NATO Publication, RELEASABLE TO NATO SET PANEL.

[22] Bédard, J., (May 2000). Real-time sniper detection and the Guardian system, DREV TM 1999-206, Quebec, Canada: DRDC Valcartier

[23] Bédard, J.R.J., (March 1998). On the use of acoustic sensors for the Coyote, DREV-9803, Quebec, Canada.

[24] Fortin, J., Dubois, J. and Fournier, P., (April 2002). Investigation of laser dazzling countermeasure – System development and trial results (U), DRDC Valcartier TR 2002-267, Quebec, Canada, SECRET.

[25] Fortin, J., Dubois, J. and Fournier, P., (April 2003) Study of eye-safe laser dazzle of an optical aiming system (U), DRDC Valcartier TR 2003-007, Quebec, Canada, CONFIDENTIAL.

[26] Jeffrey, A., Fortin, J., Dubois, J. and Fournier, P., (January 2004). Laser beam-rider missile performance model – Effect of operator tracking noise (U), DRDC Valcartier TM 2003-252, Quebec, Canada: DRDC Valcartier.

[27] Fortin, J. and Dubois, J., (December 1999). Early detection of laser beam riders using digital signal processing: An introduction, DREV TM-1999-200, Quebec, Canada.

[28] Pelletier, G., Maheux, J., Fortin, J., Cruickshank, J., De Villers, Y. and Dubois, J., (2002). Integration of a sensor suite on a light armoured vehicle, Military Sensing Symposium, Gaitherburg, MD.

[29] Fortin, J., Development of protection systems for new generation LAVS, SMI Armour & Anti Armour Conference, London, March 2002.

[30] Cantin, A., Fortin, J., Venter, J., Philip, B., Hagen, R., Krieger, D. and Greenley, M., (2001). Defensive aids suite prototype for light armoured vehicles, Unattended Ground Sensor Technologies and Applications III, Vol 4393, p. 183. Orlando, FL: Proceedings of SPIE.

[31] Webb P., Soltesz S., Cantin A., Fortin J. and Pomerleau D., (2001). Improved Miniaturized HARLID™ for Laser Warning Systems Having High Angular Resolution, Infrared Technology and Applications XXVII, Vol 4369, p. 194. Orlando, FL: Proceedings of SPIE.

[32] Fortin, J., Cantin, A., Dubois, J. and Trudel, C. (2000). Mission Configurable Threat Detection Sensor Suite, Proceedings of the ICAPT.

[33] Fortin, J., Cantin, A., Chouinard, L. and Webb, P., (1999). Development of a Modular Suite Demonstrator for 2-Band HARLID Based On Highly Independent Detection Units and Ethernet Communication. Digitization of the Battlespace IV, Vol 3709, p. 221-229. Orlando, FL: Proceedings of SPIE.

This page intentionally left blank.

List of symbols/abbreviations/acronyms/initialisms

AFV	Armoured Fighting Vehicle
ATGM	Anti-Tank Guided Missile
CF	Canadian Forces
CM	Countermeasure
CPU	Central Processing Unit
DAS	Defensive Aids Suite
DLR	Directorate Land Requirement
DND	Department of National Defence
EWS-TP5	Electronic-Warfare Systems – Technical Panel 5
FAVS	Future Armoured Vehicle System
GPS	Global Positioning System
HARLID	High Angular Resolution Laser Irradiance Detector
IA	Implementing Arrangement
IR	Infrared
LAV	Light Armoured Vehicle
LWR	Laser Warning Receiver
M&S	Modelling and Simulation
MAWS	Missile Approach Warning System
MILDS/P-MILDS	Panzer-Missile Launch Detection System
MOUT	Military Operations on Urban Terrain
OPI	Office of Primary Interest
R&D	Research & Development
RPG	Rocket Propelled Grenade
RPG	Rocket Propelled Grenade
SA	Specific Arrangement
STANAG	NATO Standardization Agreement
TARDEC	Tank Automotive Research, Development and Engineering Center
TTCP	The Technical Cooperation Panel
UV	Ultraviolet
VIM	Vehicle Interface Module
WBE	Work Breakdown Element

This page intentionally left blank.

Distribution list

Document No.: DRDC Valcartier TR 2006-710

LIST PART 1: Internal Distribution by Centre:

1	Director General
3	Document library
1	J. Fortin
1	J. Bédard
1	P. Twardawa
1	G. Pelletier
1	E. Thibeault
1	J. Dubois
1	J. Maheux
11	TOTAL LIST PART 1

LIST PART 2: External Distribution by DRDKIM

1	DRDKIM (pdf)
1	DLR 3
1	DLR 3-3
1	DLR 7-3
1	DOMSSP
1	DOMSSP 2
1	DOMSSP 3
1	DAVPM
1	DAVPM 8-4
1	DAVPM 8-4-2a
1	DLR 3-2
1	DLR 2-5
1	DLR 10
1	DLR 10-3-2
1	DLR 11
15	TOTAL LIST PART 2

TOTAL COPIES REQUIRED

This page intentionally left blank.

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (The name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's report, or tasking agency, are entered in section 8.) DRDC Valcartier	2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.) UNCLASSIFIED

3. TITLE (The complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S, C, R or U) in parentheses after the title.)

Defensive Aids Suite for Light Armoured Vehicles (12rd) (U)

4. AUTHORS (last name, followed by initials – ranks, titles, etc. not to be used)

Fortin, J. and Bédard, J.

5. DATE OF PUBLICATION (Month and year of publication of document.) March 2007	6a. NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.) 23	6b. NO. OF REFS (Total cited in document.) 33

7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

Technical Report

8. SPONSORING ACTIVITY (The name of the department project office or laboratory sponsoring the research and development – include address.)

DLR-3

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant.)	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)
10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document.) DRDC Valcartier TR 2006-710	10b. OTHER DOCUMENT NO(s). (Any other numbers which may be assigned this document either by the originator or by the sponsor.)

11. DOCUMENT AVAILABILITY (Any limitations on further dissemination of the document, other than those imposed by security classification.)

(x) Unlimited distribution
(   ) Defence departments and defence contractors; further distribution only as approved
(   ) Defence departments and Canadian defence contractors; further distribution only as approved
(   ) Government departments and agencies; further distribution only as approved
(   ) Defence departments; further distribution only as approved
(   ) Other (please specify):

12. DOCUMENT ANNOUNCEMENT (Any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11). However, where further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected.))

13. ABSTRACT (A brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual.)

This report summarizes the work done at Defence R&D Canada - Valcartier under project 12rd nicknamed *Defensive Aids Suite for Light Armoured Vehicles*. The aim of this project was to identify, investigate and evaluate modular “plug-and-play” defensive aids technologies to improve the protection of future Canadian Forces land platforms.

The project succeeded in demonstrating a second-generation defensive aids suite prototype to improve vehicle survivability against threats such as laser beam rider, target designators, range finders and missile plume simulators. Such a wide variety of sensors and countermeasures integrated on a single platform had never been demonstrated elsewhere.

This project enabled Defence R&D Canada - Valcartier and the Canadian Forces to gain tremendous knowledge on means to protect land assets against current and future threats. It has been an ideal tool of exchange with allied nations and to augment our understanding of survivability mechanisms. The results will have a direct impact on future acquisition projects such as the Mobile Gun System and the Multi-Mission Effect Vehicle.

Ce rapport résume le travail effectué à R&D pour la défense Canada – Valcartier dans le cadre du projet 12rd intitulé *Suite d’aide à la défense pour véhicules blindés légers*. Le but de ce projet était d’identifier, d’étudier et d’évaluer des technologies modulaires d’aide à la défense « plug-and-play » pour augmenter la protection des plates-formes terrestres des Forces canadiennes.

Le projet a permis de démontrer un prototype de suite d’aide à la défense de seconde génération augmentant sa survie contre des menaces telles que les armes guidées par corridor laser, les désignateurs de cibles, les télémètres et les simulateurs de plumes de missiles. Une telle variété de capteurs et de contre-mesures intégrés sur une même plate-forme n’avait jamais été réalisée ailleurs.

Ce projet a permis à R&D pour la défense Canada – Valcartier ainsi qu’aux Forces canadiennes d’acquérir une quantité de connaissances extraordinaires sur les moyens de protection contre les menaces actuelles et futures. Il a constitué un outil d’échange idéal avec les nations alliées pour augmenter nos connaissances des mécanismes de survie. Les résultats auront un impact direct sur les projets d’acquisition futurs tels que le Système de canon mobile et le Véhicule à effets multi-mission.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

DAS, Defensive Aid Suite, Countermeasures, Laser, Acoustic

Defence R&D Canada

Canada's Leader in Defence
and National Security
Science and Technology

R & D pour la défense Canada

Chef de file au Canada en matière
de science et de technologie pour
la défense et la sécurité nationale

DEFENCE DÉFENSE

WWW.drdc-rddc.gc.ca