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# Mechanized neutralization technology demonstration project

*Completion Report*

Geoff Coley
DRDC Suffield



**Defence R&D Canada**
Technical Memorandum
DRDC Suffield TM 2012-126
October 2012

Canada

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**Defence R&D Canada – Suffield**

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DRDC Suffield TM 2012-126

December 2012

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# Abstract

The Mechanized Neutralization Technology Demonstration Project (12RN) was completed in March 2012. This project examined mechanized neutralization assets in-service with the Canadian Forces, or available to the Canadian Forces, and evaluated their potential for enhancing the survivability of Canadian Forces personnel in dealing with the explosive hazard threats of landmines, improvised explosive devices, unexploded ordnance, and the like.

Through the Mechanized Neutralization Technology Demonstration Project, the Canadian Forces has been able to replace aging equipment with proven "best-in-class" alternatives. In-service equipment has been upgraded to enhance its performance. Survivability of equipment and personnel has been improved through more effective countermine / counter-IED effectiveness. The project improved the CF ability to make such decisions based on scientific evidence, objective data and quantified improvements in performance.

# Résumé

Le projet de démonstration de la technologie de neutralisation mécanisée (12RN) a pris fin en mars 2012. Ce projet consistait à examiner les éléments de neutralisation mécanisée qui sont en service au sein des Forces canadiennes ou auxquels celles-ci ont accès, et à évaluer leur capacité d'améliorer la sécurité des membres des Forces canadiennes exposés aux risques d'explosion des champs de mines, des dispositifs explosifs de circonstance, des engins non explosés et autres.

Grâce au projet de démonstration de la technologie de neutralisation mécanisée, les Forces canadiennes ont été en mesure de remplacer l'équipement vieillissant par des mécanismes éprouvés. L'équipement en service a fait l'objet d'une mise à niveau afin d'en améliorer le rendement. La capacité de survie de l'équipement et du personnel a été améliorée grâce à une plus grande efficacité des opérations de contreminage et de lutte contre les dispositifs explosifs de circonstance. Le projet a amélioré la capacité des FC à prendre des décisions fondées sur des preuves scientifiques, des données objectives et des améliorations quantifiées du rendement.

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# Executive summary

## Mechanized Neutralization Technology Demonstration Project: Completion Report

**Geoff Coley; DRDC Suffield TM 2012-126; Defence R&D Canada – Suffield; December 2012.**

**Summary of Achievements**: The Mechanized Neutralization TD Project has achieved its aim, goal and objectives, and has fulfilled technical expectations by ensuring exploitation of the outputs beginning early in the project. Capital acquisition projects have been guided by the TD Project, in-service equipment has been optimized due to the TD Project, and the TD Project ensured that equipment being fielded under UOR conditions was enhanced even before the equipment was delivered. These gains were achieved either due to work directly under the TD Project or due to the technical and scientific underpinnings developed and refined through the TD Project. As a result of the technical excellence of this TD Project, cooperation and assistance from the TD Project team at DRDC Suffield has been sought by DND project offices and by allied nations, most notably the United Kingdom and Australia.

**Schedule Summary**: The project was originally scheduled to end by March 2011, but funding issues caused a one year hiatus during fiscal year 2009/2010. The original plans for demonstrations of particular pieces of equipment were overtaken by a very early start to the exploitation activities, and by the informing effects of parallel projects such as (i) the Medium Weight Mine Roller, (ii) Project 1112 – Enhanced Counter IED, (iii) FME00001494 – Leopard 2 Tank Tactical Mobility Implements, and (iv) work on the tires of the Husky and its Mine Detonating Trailers (EROC) – Project 1199.

**Resource Summary**: The project concluded approximately 4.5% under budget.

**Follow-On Activities**: DRDC Suffield has been informed that the need for an ongoing 'mechanical R&D program' has been fulfilled, in part by the success of this project. The resident expertise now at DRDC Suffield and within the Canadian Forces ensures that operational implementation of the project output can continue in a rational manner. This will effectively mean that DRDC Suffield is well placed to provide advice and test & evaluation support to the acquisition and application of current and future neutralization assets. This capability is essential to Canadian Forces Counter-IED efforts.

**Lessons Learned**: A close relationship between the TD Project team and the eventual end user community is essential. At its highest level this was achieved by working closely with DLR 9 for this TD Project, but frequent conversations with CF personnel with recent, relevant, in-theatre experience operating equipment is often as valuable. This interaction helps keep the civilian S&T team connected with the reality of on-the-ground 'soldier work.' There is another disconnect between the scientific community and the user community in that the user community often does not see value in the laboratory-type benchmarking tests conducted by the science workers. This disconnect is best mitigated through close communication with the client(s). Finally, it can be very difficult for the science workers to gain access to the soldiers' real world (in-theatre operations) to do real world tests of equipment.

# Sommaire


## Projet de démonstration de la technologie de neutralisation mécanisée: rapport de clôture

## Geoff Coley; RDDC Suffield TM 2012-126; R & D pour la défense Canada – Suffield; décembre 2012.

**Sommaire des réalisations** : Le projet de démonstration de la technologie de neutralisation mécanisée a réalisé les buts et objectifs établis et respecté les attentes techniques en faisant en sorte que l'exploitation des résultats commence dès le début. Les projets d'acquisition d'immobilisations ont été guidés par le projet de démonstration de la technologie, l'équipement en service a été optimisé grâce au projet de démonstration de la technologie et le projet de démonstration de la technologie a fait en sorte que l'équipement mis en service dans des conditions de besoin opérationnel non prévu a été amélioré même avant la livraison de l'équipement. Ces gains ont été obtenus, soit en raison du travail réalisé directement dans le cadre du projet de démonstration de la technologie, soit en raison des fondements techniques et scientifiques élaborés et mis au point dans le cadre du projet de démonstration de la technologie. Étant donné l'excellence technique du projet de démonstration de la technologie, les bureaux de projet du MDN et les pays alliés, notamment le Royaume-Uni et l'Australie, ont cherché à obtenir la collaboration et l'aide de l'équipe de projet de démonstration de la technologie de RDDC Suffield.

**Sommaire de l'échéancier** : Le projet devait prendre fin à la fin de mars 2011, mais des problèmes de financement ont causé une interruption d'un an au cours de l'année financière 2009-2010. Les plans originaux relativement à la démonstration de pièces d'équipement particulières ont été modifiés compte tenu du début des plus précoces des activités d'exploitation et des informations tirées de projets parallèles comme (i) le rouleau de déminage moyen (ii) le projet 1112 – Projet amélioré de lutte contre les dispositifs explosifs de circonstance (iii) FME00001494 – Outils de mobilité tactique sur le char Leopard 2 et (iv) travaux sur les pneus du Husky et la remorque de détonation de mine (COIC) – Projet 1199.

**Sommaire des ressources** : Le projet s'est terminé à environ 4,5 p. 100 sous le budget.

**Activités de suivi** : RDDC Suffield a été informé que le besoin d'un « programme de R et D mécanique » permanent a été comblé en partie grâce à la réussite de ce projet. L'expertise interne que possèdent désormais RDDC Suffield et les Forces canadiennes fait en sorte que la mise en œuvre opérationnelle des résultats du projet peut continuer de façon rationnelle. Ceci signifie que RDDC Suffield est bien placé pour fournir des conseils ainsi que du soutien aux essais et à l'évaluation relativement à l'acquisition et à l'utilisation d'outils de neutralisation courants et futurs. Cette capacité est essentielle aux efforts des Forces canadiennes en matière de lutte contre les engins explosifs de circonstance.

**Leçons apprises** : Un rapport étroit entre l'équipe de projet de démonstration de la technologie et l'éventuel groupe d'utilisateurs finaux est essentiel. Cette relation a été établie, au plus haut niveau, en travaillant étroitement avec le DBRT 9 pour ce projet de démonstration de la technologie, mais des conversations fréquentes avec des membres des FC ayant une expérience récente et pertinente de l'utilisation d'équipement opérationnel dans le théâtre ont souvent autant de valeur. Cette interaction aide à garder l'équipe civile de S et T en lien avec la réalité du travail des soldats sur le terrain. Il y a un autre fossé entre la collectivité scientifique et la collectivité des utilisateurs, c'est-à-dire qu'il arrive souvent que celle-ci ne voie pas la valeur des essais en laboratoire réalisés par les travailleurs scientifiques. Ce fossé est atténué grâce à des communications étroites avec la clientèle. Enfin, il peut s'avérer extrêmement difficile pour les travailleurs scientifiques d'avoir accès au monde réel des soldats (opérations dans le théâtre) afin d'effectuer des essais d'équipement dans un monde réel.

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# Acknowledgements

The Mechanized Neutralization Technology Demonstration Project was conceived in early 2004 and was guided to its conclusion in March 2012 by a number of people, some of whom are no longer in their original positions.

DLR 9, LCol Geoff McCarthy, and his predecessors, have been essential champions of the need for an engineering / technical / science based support to the acquisition and use of mechanized neutralization assets by the Canadian Forces.

Maj (ret) Kent Hocevar, was the original Project Manager and shepherded it through the approvals process. This was at a difficult time when mechanized equipment was recovering from a negative image through misuse of inappropriate machines in the field of humanitarian demining. That support and skill continued until the final year of the project when Maj Hocevar retired from the position at DRDC Suffield.

John Fowler took over the reins as DRDC Suffield Project Manager on the retirement of Maj Hocevar, and successfully juggled the competing demands for resources between Project 1112 (Enhanced Counter IED), FME00001494 (Leopard 2 Tank Tactical Mobility Implements), and the completion of the Mechanized Neutralization TD Project.

Dr Chris Weickert, occupying different positions at DRDC Suffield from Head of the Military Engineering Section to Deputy Director General, provided ongoing managerial support and leadership to the project team from project conception onward.

Maj Robert Walker provided documentation, advice, and a fervent voice of support dating back to the time of the Board of Inquiry into the Jowz Valley landmine strike.

Members of the Neutralization and Protection Group at DRDC Suffield provided essential direct and indirect support to the project. This included consultations, advice, trial planning, execution, and reporting, work on parallel projects such as the Husky and Mine Detonating Trailer tires. Thanks are due especially to William Roberts, Tyson Josey, Brian VanderGaast, Matt Ceh, Sgt Bill McDougall, Russ Fall, Les Eagles, Dan Roseveare and Andy McFaul, and Jennifer Mah.

Without the ongoing participation of dozens of DRDC Suffield personnel in Corporate Services and the Field Operations Section, much of the project would simply not have occurred; purchasing equipment, executing the hundreds of field trials, and obtaining the trial data – including photographic, video records, and instrumentation data – would have been impossible.

Finally, the active interest and engagement by our international partners in the Netherlands (Mr. Ton Verhoeven), Sweden (LCol Anders Tengbom), and especially the UK (Mr Alun Mansfield), were essential, and greatly appreciated.

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# 1 Project performance summary

## 1.1 Technical performance summary

Ultimately, the technical performance of the Mechanized Neutralization Technology Demonstration Project needs to be evaluated on how well the results or outputs can be exploited by the Canadian Forces. At the September 2010 SRB the Exploitation Manager concluded with the statement that the Mechanized Neutralization TDP was "...doing its job, [and] doing it well."

From the start, the TD Project has had a defined set of aims, goals and objectives. Going back to the original project approval documents, and allowing for the scope migration from just mines to explosive hazards including mines and IEDs, the project aim, goals and objectives are summarized below; they reflect the form shown at the 2007 Senior Review Board presentation, and have remained unchanged since that time.

### 1.1.1 Project aim

*"To enhance the survivability of Canadian Forces personnel by demonstrating a coherent suite of mechanical assets, validating procedures and doctrine to deal with the continuing threat of landmines."*

The Mechanized Neutralization TD Project has gone beyond simply demonstrating the capabilities of mechanical assets, and has ensured early exploitation of the TDP by

a. improving in-service equipment (MCRS);

b. improving the capabilities of equipment being procured for UOR theatre operations even before it was delivered (Husky); and

c. ensuring that the capital acquisition of new and replacement equipment results in the CF obtaining the most effective, most flexible assets available (ROMECS, lightweight rollers).

Each of these examples is described in some detail below in the discussion of objectives.

### 1.1.2 Project goal

*"To provide a scientific basis to guide the new countermine strategy, and to provide theoretical and empirical data along with a validation of capabilities and demonstration equipment to support the informed, rational selection of mechanical neutralization equipment for CF Capital Acquisition Programs."*

With the facilities, test equipment and expertise developed by the project, the Mechanized Neutralization TD Project has measured, evaluated, and quantified the capabilities and limitations of in-service equipment, and equipment soon to be acquired by the CF. It has also ensured that the CF is guided away from equipment which will not fit requirements. This has all been accomplished through rigorous, technically sound, scientifically defensible trials and analyses, creating a demand for the DRDC Suffield-based TD Project team not only by the CF but also by allied nations.

### 1.1.3 Project objectives

It is beyond the scope of this project completion report to go into great detail about each of the technologies described below. This report provides only a summary for each area, while other reports generated by the TD Project, especially DRDC Suffield TR 2012-146 (Mechanized Neutralization TDP Summary), contain far more in-depth information and analyses.

#### 1.1.3.1 Objective 1

*Evaluate existing mechanized neutralization (MN) equipment to address an immediate need for clearance, route confirmation, and breaching equipment for both AP and AT mines and for certain PIED threats.*

One of the first steps in addressing this objective was to examine the literature of what is and was available for MN equipment. The findings could be divided into a few categories:

- Equipment currently available (COTS or MOTS)
- Equipment previously available as COTS or MOTS but not currently available
- Equipment built in-house by a military lab and used previously or currently but not easily available to outside customers.
- Equipment previously or currently available only as experimental systems

COTS and MOTS equipment currently available was the highest priority because it should represent the fastest, lowest risk improvement to the CF's MN capabilities.

Equipment no longer commercially available was generally found to be in this category because it had been overtaken by improved equipment. Most early chain flails, of which there were several, were in this group. In some cases, the threat changed, and in some cases there were technical shortcomings which were only accepted under extreme circumstances (high intensity combat).

The third group represents equipment that cannot easily be obtained but whose performance might be observed and those observations turned to improving other machines. A lightweight mine roller designed by a US government military lab, built on contract for the US military, but not available on a commercial basis would be an example of this group.

Finally, there are many machines which exist as orphans. For some reason they have never been turned into a successful product and picked up by a customer. This may be due to contractual issues, cost issues, intellectual property issues, performance/effectiveness issues or any other complication. A machine in development may simply not have matured to the point where it is effective, affordable, reliable, and/or survivable. In other cases, effective machines can fall victim to negative campaigns by rival manufacturers. The world of machines for humanitarian demining is littered with examples of these two situations. Many machines have been designed, and some built, by people who have no concept of the destructive power of a mine blast. The results are almost always unsatisfactory.

In total, several hundred machines were identified which fit into one or more of the above four categories. Excluding those which were no longer available brought the list down to less than one hundred. Some machines were available but were ill suited to most military operations. Excluding these brought the number down to a few dozen machines.

Excluding certain experimental equipment fielded in any number of places, existing military equipment for mechanized neutralization is limited to only a few examples. For the most part, the examples are variations on a few basic designs.

**Heavy Construction Equipment**: This group of equipment is generally not used for neutralization except in very unusual situations. An armoured dozer could be used to strip soil from an area to make way for a base camp, for instance. Generally, the purpose assigned to the equipment is simply to shift the potential problem to another location; this is similar to the classic neutralization/breaching operation. An armoured road grader might be useful as a host vehicle to carry neutralization attachments or tools; even in ordinary grading operations, armoured graders have found use in select humanitarian demining operations, most notably by the company MgM.

**Rollers**: Only a few basic heavy roller designs are available to western militaries. The Urdan rollers used as the Mine Clearance Roller System (MCRS) by the CF is one example. The American military uses a similar heavy roller, dubbed Panther. Most of these are configured as track-width rollers, having roller wheels only in front of the vehicle tracks. The area between the tracks is usually protected only by a chain-and-dogbone assembly for dealing with tiltrod fuzes on antitank mines. These roller designs all rely on the deadweight of the roller wheels and supporting linkages for the downward force applied to the pressure plate.

Given that the heavy rollers are too heavy to be moved by anything except a main battle tank chassis or something similar, only a few lightweight roller designs were available at the start of the TDP. This is an area that experienced significant development during the period of the TDP. While the TD Project might claim some credit for testing equipment and watching the evolution of refinements by that manufacturer, the TD Project cannot claim to have actually generated the improved equipment.

One of the key pieces of mechanized neutralization equipment has been, and remains, the roller. Many explosive hazards use a pressure activation system which may be vulnerable to a roller or similar device. The project team frequently heard opinions expressed which implied either that (i) rollers don't work, (ii) rollers do work and there is no real need to thoroughly test them, or that (iii) testing them is a simple matter.

The subtleties of successfully designing and executing a test and evaluation exercise for a roller were not well understood at the start of the project. While it would be inaccurate to claim that all is now known about evaluating rollers, the ability of DND to efficiently and effectively measure the performance of different roller systems, and to produce scientifically defensible results, has improved significantly due to this project.

**Ploughs**: The term "plough" is usually reserved for a deep-penetrating plough used in classical breaching operations. Ploughs usually need a tank chassis or similar vehicle due to the traction and power loads. They may be found in full width or track width configurations. Aside from some relatively minor enhancements made under the Force Mobility Enhancement Project, the TD Project team is unaware of any significant changes to ploughs currently available to the CF.

**Surface Ploughs**: Originally intended for clearance of scatterable mines from surfaces such as airstrips, a number of segmented blades or flexible frames are available to skim over a smooth, hard surface. The Pearson Engineering Surface Clearance Device (also known as the Surface Mine Clearance Device or Surface Mine Plough) is probably the best known example of the type.

**Flails**: Chain flails have existed for decades and are easily recognized. In the past decade, largely due to activity in humanitarian demining, flails have changed significantly. The improvements gained by the newer models are often subtle – faster flail head rotation, slower and more controlled forward speed, improved hammer shape and durability, tight control of depth of cut – and can easily be missed in simply looking at photographs or brochures.

Considerable work by DRDC Suffield, the former Canadian Centre for Mine Action Technologies (CCMAT) and International Test and Evaluation Program (ITEP) partners helped establish that a few critical parameters govern most of a flail's effectiveness. A flail is effective at neutralizing (triggering or breaking apart) a mine or mine-like IED only if the flail hammers actually physically make contact with the target, as the load from flail hammers does not transfer through the soil and depress the pressure plate.

All else being equal, forward speed is the single most critical flail performance parameter. A flail travelling too fast will not dig to the same depth as a slower moving machine, and therefore will not be effective against mines to the same depth. For typical conditions used by ITEP test teams running evaluations under CWA15044 (an international test and evaluation standard for demining machines), a typical flail must be travelling at less than one kilometre per hour if targets are to be expected down to 15 cm. For ROMECS, a relatively powerful mid-sized flail, a speed of only 0.3 km/h is recommended.

Further, a consistent forward speed must be maintained. A machine with an uneven speed will create a flailed area with an uneven depth, and therefore uneven effectiveness. If the soil is very hard, or if heavy clay is encountered, slower speeds are needed.

Tight control of the height of the flail shaft is essential to achieving a reliable depth of soil penetration. While this seems self evident, several remotely controlled flails still rely on the operator standing hundreds of metres away, driving the machine by remote control through a cloud of dust, to manually adjust the height. Operators sitting in a manned flail often have very poor visibility of the area directly in front of them for the same reason. Most flails now use wheels or skis of some kind to maintain the proper height, accepting the risk that eventually the ski could trigger a mine.

Along with speed and depth of cut, flail effectiveness is governed by the amount of energy being imparted to the soil by the flail hammers. This is a complex combination of rotation speed, chain length, and hammer mass. With a limited amount of power at the flail head, optimum performance may be achieved by one manufacturer with longer chains, and by another with faster rotation, and by yet another with heavier hammers. Other factors which play a role include the angle with which the hammers strike the ground, and the shape and sharpness of the hammers.

A characteristic often overlooked in the use of flails is that of skip zones. An uneven control of the flail head height will create lateral skip zones - areas of shallow digging or even no digging at all – across the width of the machine. Even with good depth control, however, longitudinal skip zones can develop. The chain/hammer assemblies will naturally take the path of least resistance when digging through the soil. If the flail head rotation is too slow, the assemblies are easily deflected away from hard spots and into trenches created by neighbouring assemblies. Driving the machine too fast can result in the hammers bouncing off the ground instead of digging. Blunt hammers may bounce or hammer the ground instead of cutting through the soil to reach the targets. Unfortunately, in actual use, skip zones are rarely visually discernible as they tend to be covered by loose soil left by the flailing operation.

#### 1.1.3.2 Objective 2

*Develop longer term solutions for clearance, route confirmation and breaching that are, compared to existing methods, more effective at neutralization, more rapid, more survivable, more versatile, more cost-effective, more mobile and that are compatible with a primarily-wheeled vehicle fleet.*

Concepts and prototypes for new tools, machine attachments, and non-traditional uses of existing equipment have been identified. The concepts, prototypes and attachments can be seen most readily in the tools and attachments considered for the Remotely Operated Mechanical Explosive Clearance System (ROMECS) and road graders.

From the viewpoint of the start of the TD Project, the enhancements to the Expedient Route-Opening Capability (EROC) system Husky and its Mine Detonating Trailers (MDT) represent a "longer term solution." Changes to the host vehicle have resulted in increased vehicle and operator survivability. Changes to the Mine Detonating Trailers have resulted in a system which is more effective at neutralization. Compared with the only other roller in service with the CF at the time – the tank-mounted MCRS – the newly configured Husky is certainly more cost effective and more compatible with the primarily-wheeled fleet. It is also a better tool for use in route operations, as the MCRS is intended primarily as a breaching tool.

As a direct result of the TD Project, the MCRS for the Leopard tank has been optimized and tested, and the proposed new design is expected to be used with the Leopard 2 fleet. If implemented, the proposed new design should provide a capability that is, in comparison to the currently in-service MCRS, "... more effective at neutralization, ... more survivable, more versatile, more cost-effective, [and] more mobile."

Project 1112 has also benefitted from the TDP in terms of the replacement of the Aardvark flail with the more effective, more versatile, more mobile ROMECS, which will serve into the longer term. Customized tools which were prototyped for ROMECS may eventually yield additional future benefit through Project 1112.

#### 1.1.3.3 Objective 3

*Assess existing remote-control vehicle technology for ability to reduce the risk to equipment operators.*

Remote control technology has been accepted in new areas by the CF, including the adoption of ROMECS through Project 1112. Evaluation of the ROMECS by the DRDC Suffield TD Project team (under Project 1112) resulted in several observations and recommendations about the ROMECS remote control system being provided back to the Project 1112 team.

#### 1.1.3.4 Objective 4

*Assess existing GPS and GIS technologies for tracking equipment passes and providing a digital record of the cleared route/area.*

*Assess terrain marking technologies for the identification of safe lanes for vehicles.*

The use of GPS to accurately map the route processed by mechanized neutralization assets was seen as a way to get away from physical markers which are open to removal or relocation by opposing forces. It was always intended to be a small part of the project.

As early as the 2008 SRB meeting, activity in this area demonstrated that it was technically feasible; highway construction (guiding dozer blades) and agricultural (monitoring, guiding, and even driving mobile equipment) applications make frequent use of these capabilities. The difficulty for the TD Project was not one of technical complexity, but one of compatibility with existing and projected CF GPS technology. In addition, the world of GPS navigation was changing so quickly that it made no sense for the small TD Project team to try to keep up with the entire world of GPS manufacturers. In the time between the start and end of this TD Project, GPS has moved from a relatively expensive and exotic product to an inexpensive consumer device which is built in to almost every new mobile phone.

The requirement to assess terrain marking technologies was considered to have been addressed by the capability of GPS and GIS to electronically identify and map safe lanes for vehicles.

Having demonstrated that the concept was technically feasible, the TD Project ceased further work in this area.

#### 1.1.3.5 Objective 5

*Provide advice on new CF doctrine, procedures and training for counter explosive operations.*

Direct interaction between the TD Project team and those charged with CF doctrine and training has been minimal. There is little to be gained by consuming the valuable time of doctrine and training personnel in discussions about a new piece of equipment that will never be bought, or a procedure which will never be adopted. Rather, the advice has been provided indirectly, routed through the particular project staff. Examples which illustrate this include:

a. In development of the documentation for the eventual purchase of ROMECS, the experience of the TD Project team was communicated to the relevant Project 1112 staff. This resulted in the procurement of a flail which could double as a forklift, a dozer, and a loader, with the attendant effects on doctrine, procedures and training.

b. Use of, and evaluation of ROMECS by the TD Project personnel at DRDC Suffield has resulted in several observations about the remote control system, the remote vision (camera) system, the electrical system, the attachment locking mechanism, recommended operational speeds and safety standoff distances.

c. In re-engineering the MCRS rollers, the procedures for use and maintenance had to be revised. This was integral to the product delivered by DRDC Suffield to the Force Mobility Enhancement project.

d. Evaluation of the lightweight SPARK II roller system revealed a clear link between vehicle speed and roller effectiveness. Ultimately this should be reflected in doctrine, training, and Tactics, Techniques & Procedures (TTPs).

#### 1.1.3.6 Objective 6

*Develop the necessary framework to ensure these activities and capabilities have a proper scientific foundation.*

From well before the start of the TD Project, DRDC Suffield has been involved in the development of methods and simulators for testing mechanized neutralization equipment. The test facilities created and refined by the TD Project provide the baseline for virtually all evaluation of mechanized neutralization effectiveness available to the CF. This complements other critical aspects of equipment evaluation performed by LFTEU and other organizations within DND.

In addition to the facilities, the latest simulators developed for testing mechanized neutralization equipment are the direct result of the TD Project. While it may seem a simple matter to drop a few pressure plates into the ground and drive over them, the TD Project revealed that the exact method used to bury the targets, and the manner in which they are encountered by the vehicle are critical to the reliability and repeatability of the data. The way the soil is prepared and maintained before and during the tests must also be controlled carefully if the results are to be valid and comparable from one test to another. Whether an evaluation exercise was conducted under the TD Project itself, or under a separate project, the success or failure of that exercise, and the quality of the data generated, have all hinged on the work of the TD Project. The various simulators, test facilities, and test methodologies are described in detail in companion reports.

### 1.1.4 Areas not fully pursued or achieved

Two areas originally identified by the TD Project documents were eventually abandoned for different reasons: (i) cataloguing the footprint, and therefore, the susceptibility of CF vehicles to triggering pressure plate threats, and (ii) an expert system for optimum application of mechanized neutralization tools. Both of these were listed as subtasks of the scientific framework of the TD Project.

#### 1.1.4.1 Fleet footprint characterization

The problem of measuring the footprint of all vehicles in the CF fleet was overly ambitious and ultimately impractical:

- There are so many different vehicle types and so many variations of each type that the list became impractically long given the limited resources available.
- Any given vehicle might be loaded in myriad different ways, creating different footprint loads each time.

- Vehicles with pneumatic tires, especially those with central tire inflation, might have different tire pressures at any given time, thereby creating different footprint characteristics.
- It quickly became apparent that attempting to coordinate with the holders of all vehicles, and obtaining the necessary operator and facility support would be unachievable.
- Beyond the simple, and insufficient, weighing of each road wheel of a vehicle, it would be necessary to make more accurate measurement of the load distribution of the wheels. The main tool identified for this job – a pressure sensitive mat – turned out to be very difficult to use effectively, and even toward the end of the project, it could only be used to obtain relative loads and not actual load magnitudes.
- The footprint characteristics of any vehicle are partially governed by the type of soil in which it is operating. The footprint of a Leopard 2 main battle tank on concrete is very different from its footprint on loose, sandy clay. It would have been impossible to measure all realistic combinations of vehicle, loading, and soil type.

#### 1.1.4.2 Expert system

An early goal of the TD Project was to develop a tool which would allow a user to accurately measure the load transferring capacity (not the load bearing capacity) of soil, and to relate that to the capability of particular mechanized neutralization tools. Three main factors conspired against this subtask being brought to completion.

- **Measuring tool**: No off-the-shelf devices were available for measuring this soil characteristic. It was necessary to insert a gauge from the side so that a load could be applied from above through undisturbed soil. Many different gauges and techniques were evaluated, some with greater success than others, but it was almost impossible to ensure proper contact with the surrounding soil. As a result the investigators were never able to get repeatable data sets associated with the measurement of soil load transfer capacity.
- **Too many conditions**: Even with a workable pressure gauge and a technique to ensure good soil contact, and therefore reliable data, the number of combinations of soil type and soil condition was impractically large. Further, even if all relevant soil types and conditions could be accurately measured, the performance of each type of machine could not possibly be evaluated under every relevant soil condition for every possible type of threat.
- **Limited mechanized assets**: It was realized that no commander would be in a position on any given day to have available flails, heavy rollers, light rollers, and every other possible type of equipment. Far more likely is the situation where a commander will have just a few tools, and will simply have to understand the limitations of how each should be used to achieve the best results. A typical case might be that a flail and a lightweight roller are available. The advice to the commander, which would not need to be communicated through an expert system, might be:
    - If the flail is used on a road it will destroy the road.
    - The roller has been found to be effective against threat "X" under condition "Y" and the vehicle speed should be kept under "Z" to ensure maximum ground contact.

#### 1.1.4.3 Effect of not pursuing footprint characterization and expert system

Like any activity, the Mechanized Neutralization TD Project was limited by time and resources. As information became available, it was clear that some activities would provide bigger payoff to the CF than others. The TD Project team attempted to maximize the payoff by concentrating on those areas and by minimizing areas that would consume vast resources without a corresponding payoff. As noted, the fleet footprint measurement and the expert system became impractically large with only marginal payoff to the CF.

The October 2010 SRB presentation by the exploitation manager confirmed that, although these two areas were desirable, the net effect of minimizing them and focussing the effort on other areas would result in higher-impact, more concrete, measureable, and exploitable benefits to the CF.

### 1.1.5 Technical performance summary

The Mechanized Neutralization TD Project provided to the CF and its allies a unique capability for evaluating and quantifying the effectiveness of various mechanized neutralization assets. Facilities, test equipment, and expertise were useful not only to the CF itself but were utilized to aid evaluation efforts and leverage information from our allies including the United Kingdom, Australia, the Netherlands, and the United States.

- Several concepts, complete with prototypes, were created for mechanized neutralization tools that could be applied to various vehicles. Any of them could be advanced if they provide the CF a useful capability.
- The TD Project is credited with ensuring that, in replacing the dated and limited Aardvark flail and the ineffective mini-flail, the CF was provided with one of the most effective flails in the world, and one which provided multi-tool, and therefore multi-task, capability.
- Before fielding Husky, the CF was able to identify and implement performance improvements, through the TD Project team expertise, ensuring the best possible effectiveness and level of protection for the operator.
- The TD Project provided the essential background and capability to ensure that the lightweight rollers being procured for the Enhanced Counter-IED project (1112) are the best available. It also ensured that the effectiveness and limitations of those rollers were measured, quantified, and understood by the CF.
- Project 1112 also directly benefitted from the TD Project in the acquisition and evaluation of ROMECS.
- The TD Project was directly responsible for designing, testing and quantifying the performance upgrade to the heavy MCRS rollers for the CF.

The Mechanized Neutralization TD Project has achieved its aim, goal and objectives, and has fulfilled technical expectations by ensuring exploitation of the outputs beginning early in the project. Capital acquisition projects have been guided by the TD Project, in-service equipment has been optimized due to the TD Project, and the TD Project ensured that equipment being fielded under UOR conditions was enhanced even before the equipment was delivered. These gains were achieved either due to work directly under the TD Project or due to the technical and scientific underpinnings developed and refined through the TD Project. As a result of the technical excellence of this TD Project, cooperation and assistance from the TD Project team at

DRDC Suffield has been sought by DND project offices and by allied nations, most notably the UK and Australia.

## 1.2 Schedule performance summary

Within the project period, exploitation activities began earlier than expected, and effectively eliminated the need for demonstrations of various mechanized equipment.

- Project 1112 (Enhanced Counter IED) called upon the expertise in the TD project to help write the specifications, requirements and statement of work for what became ROMECS (Remotely Operated Mechanical Explosive Clearing System), the replacement for the aging Aardvark flail.
- TD project expertise was again requested by Project 1112 for advice and evaluation of various lightweight rollers, and for assistance with the various documents to support equipment purchase.
- In addition, as a result of the TD project expertise, DRDC Suffield was engaged by FME00001494 (Leopard 2 Tank Tactical Mobility Implements) to design, build, and test performance enhancements to the heavy rollers used on the main battle tank.
- Evaluation of the existing tires on the Husky vehicle and its Mine Detonating Trailers also used TD project staff expertise to ensure maximum survivability of the host vehicle and maximum pressure-plate-detonating trailers.

Each of these examples occurred at a point in the TD project schedule before an equipment demonstration had occurred. The clear inference is that the project and the project staff had demonstrated the necessary knowledge and expertise to obviate the need for demonstrations of particular hardware, and that the exploitation of project output could begin earlier than anticipated. From this viewpoint, the project met and exceeded the expectations of the schedule.

The original schedule called for the project to be completed by March 2011, but with the turbulent funding of FY2009/2010, the completion date was extended to March 2012 as noted in the various Senior Review Board presentations.

With the exception of some documentation, the work of the TD Project concluded on time (March 2012) Allowing for the final Senior Review Board meeting being scheduled for September 2012, the overall project has met the schedule expectations.

## 1.3 Cost performance summary

The overall budget for the project was $5000K. According to the final accounting for the project in Collaborative Planning and Management Environment (CPME), the final cost was $4773K. Being under budget, but within less than 5% of the original budget suggests that the project performance was highly successful from a cost point of view.

# 2 Recommendations for follow-on activity

## 2.1 Transition of project products into operations

The transition of project products into operations is effectively the question of exploitation of the project outputs. As noted above, exploitation activities began early in the TD Project, and continued until approximately the end of FY 2011/2012. As future CF missions evolve, the CF will have a resident expertise for ongoing exploitation.

## 2.2 Follow-on R&D project(s)

The ongoing need for a 'mechanical R&D program' may be a matter of debate, especially with different definitions of what falls under the umbrella of R&D compared with what falls under the development of Test and Evaluation (T&E). The evaluation of the in-service MCRS, which lead to the development and evaluation of an enhanced performance model of MCRS is an example of a crossover between the categories. Whatever definitions are used, priorities of time, resources or funding may simply preclude the possibility of ongoing 'mechanical R&D.' The resident expertise now at DRDC Suffield and within the Canadian Forces ensures that operational implementation of the project output can continue in a rational manner. This will effectively mean that DRDC Suffield is well placed to provide advice, and test & evaluation support to the acquisition and application of current and future neutralization assets.

While the need for long-horizon R&D in the area of mechanized neutralization may be debated, the Mechanized Neutralization TD Project provides clear evidence of the ongoing need for in-house expertise and capabilities for test and evaluation, and equipment optimization. Without some means to maintain that capability, it will inevitably fade. There is no specific project in this area at DRDC Suffield, although there are minor aspects of other activities that still call on this expertise – CLS99, and the Advanced Heavy Equipment Replacement project, for example.

## 2.3 Intellectual property management

All Intellectual Property (IP) generated by the Mechanized Neutralization TD Project resides with the Crown. There are no outstanding IP issues to resolve.

## 2.4 Disposition of project products

A number of prototype tools and attachments remain in DRDC Suffield custody. None are of a type that can be fielded. These devices will remain at DRDC Suffield for approximately one year from the date of the final SRB to give the exploitation manager time to evaluate whether there are any likely current or near-future requirements that can be addressed by further development of any of them. After that time, any remaining materials will be stripped of useful parts (encoders, electrical or hydraulic components, etc), and the remainder disposed of as either scrap or surplus, as appropriate, by DRDC Suffield.

# 3 Lessons learned summary

The TD Project team at DRDC Suffield benefited from a close and ongoing relationship with DLR 9 throughout the project. Links to other directorates, including DLR 7 (for the MCRS/FME work), were essential to ensuring successful, albeit unexpected, exploitation.

In both its work in humanitarian demining and its support activities for the Canadian Forces, DRDC Suffield has frequently heard that laboratory-type tests are not indicative of real world performance since they employ prepared test beds and not the ugly conditions faced by the soldier in the field. In one way, this is a valid concern, but in another it is not.

- Efforts were made during FY 2008/2009 to send TD Project team personnel to Afghanistan to conduct trials on lightweight rollers under operational conditions. For what were probably very good reasons, this trial did not proceed and the promise of real-world testing went unfulfilled. It is difficult to generate buy-in from operators when S&T personnel do not have sufficient support to execute trials of this type.
- In defence of the use of laboratory-type tests, everyone who buys a new car reviews the fuel consumption ratings. Almost everyone knows that those tests were done under artificial conditions and that there is no possible way they will ever achieve the mileage listed on the brochures. Still, the numbers are considered valid as benchmarks against which different cars can be compared. More education is needed to ensure that the same understanding is there regarding benchmark tests of mechanized neutralization equipment as a relative performance metric.

# 4 Additional details

Annex A provides a list of the reports and other documents generated by through TDP, along with additional information which was not obtained directly through the TDP, but which was identified by the TDP as providing useful additional information.

Annex B lists the Memoranda of Understanding which were created specifically in support of the TDP.

Annex C lists the major contractors for the TDP.

# Annex A Related documentation

This annex provides a listing of TDP-related documents which are broken into three categories as described in the sections below. The documents are referenced to specific work in TR2012-146, the Mechanized Neutralization Summary report.

## A.1 TDP publications

The following publications were created directly by the TDP or were obtained specifically through the TDP.

- Carruthers, A., Burke, H., Swiddle. (2008) Development Report: Phase 3: COTS Grader Attachment Assessment for Military Countermine Operations, Project 81307P (DRDC Suffield CR2012-132), Prairie Agricultural Machinery Institute.
- Coley, G. (08 March 2012) BAE [sic] Roller Trial (SECRET), (DRDC Suffield 300001112 (MES)) Defence R&D Canada – Suffield
  - (note: this document refers to the SPARK II roller not the BAE roller)
- Coley, G. (2012), Mechanized Neutralization TDP Summary (U), (DRDC Suffield TR 2012-146), Defence R&D Canada – Suffield.
- Coley, G. (in press) Grader & Grader Attachments for Mechanized Neutralization (U), (DRDC Suffield TR 2012-129) Defence R&D Canada – Suffield
- Coley, G. (in press) Vibrating Rollers for Mine Neutralization; Preliminary Study (U), Defence R&D Canada – Suffield.
- Coley, G., (August 2012) BAE Mine Roller Evaluation (SECRET), (3700-IED (MES)) Defence R&D Canada – Suffield.
- Coley, G., Roberts, W., VanderGaast, B. Mah, J., Doyle, S. (in press) Mounted Countermine Capability Concept Demonstrator Trials; DRDC Suffield Trials 2007 (U), Defence R&D Canada – Suffield
- Dzwilewski, P. (in press) ARA Project 18521 GEOTECHNICAL TRIAL SUPPORT W7702-07R171/001/EDM FINAL REPORT, ARA Project 18521, Applied Research Associates
- Dzwilewski, P. (in press) ARA Project 18552 Numerical Modeling of Roller/Soil/Mine Interaction W7702-07R170/001/EDM Final Report, Applied Research Associates
- Goulton N, Holland S, Hammond P. (2007) MC3D UK Trial Report (U), QinetiQ, United Kingdom.
- Hindle, S. (2009) Light Weight Mine Roller Trial (UK RESTRICTED) (DSTL/TR39934 V2) Dstl, United Kingdom
- Josey, T. (in press) Review of COTS GPS Technology in Support of Mine Clearance; Mine Clearance and Route Marking (U), Defence R&D Canada – Suffield
- Lee, J (in press), Testing and Evaluation of Flail Capabilities with CCFEP (U), DRDC Suffield, Defence R&D Canada – Suffield

- Roberts, W.C. (19 June 2007) Preliminary Results of MC3D Effectiveness Trials (U), (3700-TDP-MMN (MES)) Defence R&D Canada – Suffield.
- Royal Engineers Trials and Development Unit (2010) L3 Communications Medium Roller Vehicle Integration Kit Evaluation and Integration Trials Report (UK RESTRICTED) Ministry of Defence, United Kingdom
- Sharpe, M (2012) The Effects of Velocity on the Performance of Mine Roller Systems (U) (DRDC Suffield TN2012-140) Defence R&D Canada – Suffield
- Swiddle, S., Chorney, H. (in press) Development Report: Grader Attachment Assessment for Military Countermine Operations, Phase 2 Report: Physical Testing, Results and Recommendations, Project 81307P, Prairie Agricultural Machinery Institute.
- Swiddle, S., Chorney, H. (in press) Development Report: Grader Attachment Assessment for Military Countermine Operations, Final Report: Physical Testing, Results and Recommendations, Project 81408P, Prairie Agricultural Machinery Institute.
- Swiddle, S., Chorney, H. (in press), Grader Attachment Assessment for Military Countermine Operations, Phase 1 Report: Industry Liaison, Literature Search and Detailed Test Plan, Project 81307P, Prairie Agricultural Machinery Institute.
- Van de Kasteele R.M., Verhoeven T.A. (2008) Safety analysis for driver of MC3D system for AT-mine detonations (U), (TNO-DV 2008 A227) TNO, The Netherlands.
- VanderGaast, B. (in press) Mechanized Neutralization Test & Evaluation Specialized Equipment and Processes (U), Defence R&D Canada – Suffield.
- VanderGaast, B. (in press) Mechanized Neutralization Test & Evaluation Device Calibration (U), Defence R&D Canada – Suffield.
- VanderGaast, B. (in press) Roller Mine Clearing Systems; Vehicle Coverage and Simulation (U), Defence R&D Canada – Suffield.


## A.2 TDP-influenced publications

The publications listed below were created through spin-off work directly informed by, supported by, or influenced by the TDP. While the work described by these publications was not directly funded by the TDP, that work would not have occurred without the TDP.


- Coley, G. (08 November 2011) Task 3 FME Project 00001494 (SECRET), (DRDC Suffield 3772 (MES), 7035-P35, 1000-14-4) Defence R&D Canada – Suffield.
- Coley, G. (13 October 2011) Letter Report – FME Project 00001494; Supplementary Report (U), (DRDC Suffield 3372 (MES) & 7035-P55) Defence R&D Canada – Suffield
- Coley, G. (16 November 2011) Letter Report – FME Project 00001494; MCRS Mk2C Interim Maintenance Instruction; Project FME 1494.3 (U), (DRDC Suffield 3372 (MES) 7035-P55 1000-14-4) Defence R&D Canada – Suffield
- Coley, G. (16 November 2011) Letter Report – Project FME00001494; MCRS Mk 0 → Mk2C Change-over Procedure; Project FME1494.3 (U) (DRDC Suffield 3372 (MES) 7035-P55 1000-14-4) Defence R&D Canada – Suffield

- Coley, G. (28 September 2010) Letter Report; Final Report Task 1494-1.2, Tasks 1494-2.2 (SECRET), (DRDC Suffield 3372 (MES) & 7035-P55) Defence R&D Canada – Suffield
- Roberts, W. (29 May 2008) Trip Report – UK Warrior LWMR Trials (SECRET), (DRDC Suffield 3700-TDP-MMN) Defence R&D Canada – Suffield.
- Roberts, W. and Josey, T. (10 January 2010) Quick Look Results Husky and Mine Detonation Trailer Tire Testing in South Africa (CONFIDENTIAL), (DRDC Suffield 1776-1 (MES)) Defence R&D Canada – Suffield.


## A.3 Other informative publications

The following publications were not created by the TDP or by sprin-off work. They are included here as they provide useful additional references in the field of mechanized neutralization.


- Chen, Y. (in press) Final Report, Survey of sensors suitable for in-soil measurement of pressures/loads imparted by the movement of machines or people, University of Manitoba.
- Chen. Y., Kumar, A., Wylde, J. (in press). Parametric Study of Factors Affecting the Forces and Displacements Exerted on Landmines by Mine Rollers for Humanitarian Demining Applications – Final Report, University of Manitoba.
- Coley, G.G., Roseveare, D.J., Danielsson, P.G., Karlsson, T.T., Bowne, S.M., Wye, L.M., Borry, F.C.A., (2007), Demonstration Trial of Bozena-4 and MV-4 Flail, ITEP Trial at International Mine Action Training Centre, Nairobi, Kenya (U), (DRDC Suffield TR 2007-045), Canadian Centre for Mine Action Technologies, Defence R&D Canada – Suffield.
- Comité Européen de Normalisation (2009), CEN Workshop Agreement CWA15044:2009, Test and evaluation of demining machines (online), Comité Européen de Normalisation, http://www.gichd.org/fileadmin/pdf/publications/CWA-15044-2009%20-T&E-Demining.pdf (accessed 19 June 2012).
- Geneva International Centre for Humanitarian Demining (2011 and earlier), Mechanical Demining Equipment E-Catalogue (online), Geneva International Centre for Humanitarian Demining, Switzerland, http://www.gichd.org/publications/subject/technology-machines-and-demining-equipment/mechanical-demining-equipment-catalogue-en (accessed 19 June 2012).
- International Test & Evaluation Program (2010), Reports Database (online), International test & Evaluation Program, http://www.itep.ws/reports/search1.php (accessed 19 June 1012).
- Kittel, Lars-Erik, (2002), Slutrapport avseende fordonsförsök med Lätt minvält till strf 90, 13 322:90478 (U), (informal correspondence) FÖRSVARSMAKTEN, MARKSTRIDSSKOLAN, Sweden.

- Kushwaha, R.L. (2006) Smooth Surface Roller – Speed Relationship at Various Vertical Loads (U), University of Saskatchewan.
- Kushwaha, R.L. (July 2009) Final Report: Task 1-8 – Assessment of DRDC Plough and Design of New Full/Medium Width Mine Plough (U), University of Saskatchewan.
- Kushwaha, R.L. (November 2008) Final Report: Soil Bin Optimization of Prototype Medium Weight Mine Roller (MWMR) Parameters – Tasks 1-5 (U), University of Saskatchewan.
- Kushwaha, R.L. (September 2008) Final Report: Soil Bin Optimization of Prototype Medium Weight Mine Roller (MWMR) Parameters – Tasks 2-5 (U), University of Saskatchewan.
- Kushwaha, R.L., (2008) Soil Characterization, Soil Parameters for the Test Soil in the TMR (U), University of Saskatchewan.
- Leach, C., Blatchford, P., Coley, G., Mah, J. (2005) TEMPEST V System with Ground Engaging Flail; Cambodia Trials Report (U), (QINETIQ/FST/ILDS/TRD052379) QinetiQ, United Kingdom
- Lodhammer, P. (2009), Mechanical Demining: From 1942 to the Present, The Journal of ERW and Mine Action (electronic journal), Issue 12.2, Winter 2008/09, http://maic.jmu.edu/journal/12.2/notes/lodhammar/lodhammar.htm (accessed 19 June 2012).
- Roberts, W. (2006), Medium Weight Mine Roller Project Technical Summary to January 2006 (U), (DRDC Suffield TM2006-209) Defence R&D Canada – Suffield..
- Roberts, W. (11 March 2008) Trip Report – EROC Meetings US Army TACOM and RSD South Africa (CONFIDENTIAL), DRDC Suffield 1776-1 (MES)) Defence R&D Canada – Suffield.
- Roberts, W. (17 October 2006) Results of Upgraded ILDS PV Trials at Former LETE Site (CONFIDENTIAL), (DRDC Suffield) Defence R&D Canada – Suffield.
- Roberts, W. (19 May 2004) Results of Pearson FWMR Trials on ILDS PV (CONFIDENTIAL), (DRDC Suffield 3772-2mh (MES)) Defence R&D Canada – Suffield.
- Roberts, W. (2003) Results of Panther Light Countermine Roller Testing (CONFIDENTIAL), (DRDC Suffield TM 2003-152). Defence R&D Canada – Suffield.
- Roberts, W. (2004). Results of Pearson Full Width Mine Roller Testing (CONFIDENTIAL), (DRDC Suffield TM2004-003) Defence R&D Canada – Suffield.
- Roberts, W. (2006) Results of ILDS PV FWMR Testing at Former LETE Site (CONFIDENTIAL), (DRDC Suffield TM2006-206) Defence R&D Canada – Suffield.
- Roberts, W. (2007) Preliminary Results of EROC Trials (CONFIDENTIAL(, (DRDC Suffield 3700-TDP-MMN (MES)), Defence R&D Canada – Suffield.

- Roberts, W. (2008) Leopard C2 Mine Clearing Roller System: Effectiveness Evaluation (SECRET), (DRDC Suffield TM-2008-282) Defence R&D Canada – Suffield.
- Roberts, W. (29 May 2007) Limitations of Leopard Mine Clearing Roller System (SECRET), (DRDC Suffield 3700-TDP-MMN (MES)), Defence R&D Canada – Suffield.
- Roberts, W., Monckton, S., Coley, G., Russell, K. (12 February 2008) Technical Limitations for Husky Upgrades (U), (DRDC Suffield 1776-1 (MES)), Defence R&D Canada – Suffield.
- Roberts, W.C., Fall, R.W. and Eagles, J.L. (2007), Way Industry Bozena-5 Flail Test and Evaluation (U), (DRDC Suffield TR2007-279) Defence R&D Canada – Suffield.

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# Annex B Memoranda of understanding

## B.1 TDP-specific MOUs

Two MOUs were accessed by the TDP to share resources and information relating to mechanized neutralization. In both cases specific annexes to existing MOUs were created.

### B.1.1 United kingdom

- ANNEX NUMBER 1-07 (Mechanized Mine Neutralization) to the MEMORANDUM OF UNDERSTANDING Between THE DEPARTMENT OF NATIONAL DEFENCE OF CANADA And THE SECRETARY OF STATE FOR DEFENCE OF THE UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND Concerning DEFENCE SCIENCE AND TECHNOLOGY DATED 16 JANUARY 1999.
- Canadian point of contact for the Annex: Mr. Geoff Coley
- UK point of contact for the Annex: Mr. Alun Mansfield
- In addition to the sharing of reports and advice, this MOU facilitated cooperative work on sub-projects including the "Mounted Countermine Capability Concept Demonstrator Trials" and the "UK Warrior LWMR Trials" described above.

### B.1.2 Sweden and the Netherlands

- PROJECT ARRANGEMENT NUMBER 2006-01 TO THE CA/NL/SW COOPERATIVE SCIENCE AND TECHNOLOGY MEMORANDUM OF UNDERSTANDING DATED 28 MAY 2003 CONCERNING Mechanized Mine Neutralization.
- Canadian point of contact for the Annex: Mr. Geoff Coley
- Netherlands point of contact for the Annex: Mr. Rens Righarts
- Sweden point of contact: LCol Anders Tengbom
- This MOU facilitated information sharing and the cooperative work on the "Mounted Countermine Capability Concept Demonstrator Trials."

## B.2 Other MOUs

In addition to the two MOUs described above, mechanized neutralization information and efforts were shared with two additional allies through existing MOUs without the need for TDP-specific annexes.

### B.2.1 Australia

- Subsidiary Arrangement 31 (A-AU-SA31) of the ADVANCED COUNTER-IMPROVISED EXPLOSIVE DEVICE TECHNOLOGIES FOR SURVIVABILITY ENHANCEMENT Memorandum of Understanding.
- Canadian point of contact: Mr. Mark Espenant
- Australia point of contact: Dr. Norbert Burman
- This MOU facilitated information sharing and the cooperative work on the SPARK II roller trial, incorrectly titled above as "BAE [sic] Roller Trial."

### B.2.2 Denmark

- E102053 - CTS 1968 No. 17 (also referred to U-DK-1968-17), entitled "Canada-Denmark Defence Science Information Exchange Programme."
- There is no technical or project authority listed in either country. The information was obtained through Mr. Mark Espenant.
- This MOU facilitated information sharing, especially on the SPARK II rollers and the MCRS rollers.

# Annex C Major contractors

## C.1 Major contractors

Several major contracts were let as part of the TDP. This included contracts to Canadian industry, foreign industry, academia, and other government departments. The major contractors are listed below, and the reports delivered under those contracts are included in Annex A.

- Amtech Aeronautical
- Advanced Research Associates
- BAE (British Aerospace Engineering) System
- University of Saskatchewan
- Prairie Agricultural Machinery Institute
- National Research Council Canada

In addition to the above, numerous small contracts were issued to a variety of sources to support the day-to-day operations of the trial site, maintenance and improvements to the simulators and other essential instrumentation, and other TDP-related activities.

# List of symbols/abbreviations/acronyms/initialisms

| | |
|---|---|
| CCMAT | Canadian Centre for Mine Action Technologies |
| CF | Canadian Forces |
| COTS | Commercial Off The Shelf |
| CPME | Collaborative Planning and Management Environment |
| CWA15044 | CEN (Comité Européen de Normalisation) Workshop Agreement #15044 |
| DLR | Directorate Land Requirements |
| DND | Department of National Defence |
| DRDC | Defence Research & Development Canada |
| DRDKIM | Director Research and Development Knowledge and Information Management |
| DSTL | Directorate Science & Technology Land |
| EROC | Expedient Route Opening Capability |
| FME | Force Mobility Enhancement |
| FY | Fiscal year |
| GIS | Geographic(al) Information System |
| GPS | Global Positioning System |
| IED | Improvised Explosive Device |
| IP | Intellectual Property |
| MCRS | Mine Clearance Roller System |
| MN | Mechanized Neutralization |
| MOTS | Military Off The Shelf |
| R&D | Research & Development |
| ROMECS | Remotely Operated Mechanical Explosive Clearance System |
| S&T | Science & Technology |
| SRB | Senior Review Board |
| TD(P) | Technology Demonstration (Project) |
| UK | United Kingdom |
| US | United States |

**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.)<br><br>Defence R&D Canada – Suffield<br>P.O. Box 4000, Station Main<br>Medicine Hat, Alberta T1A 8K6 | 2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.)<br><br>UNCLASSIFIED<br>**(NON-CONTROLLED GOODS)**<br>**DMC A**<br>**REVIEWED: GCEC JUNE 2010** |

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

Mechanized neutralization technology demonstration project: Completion report

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

Coley, G.

| | | |
|---|---|---|
| 5. DATE OF PUBLICATION (Month and year of publication of document.)<br><br>October 2012 | 6a. NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.)<br><br>37 | 6b. NO. OF REFS (Total cited in document.)<br><br>1 |

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 Memorandum

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

Defence R&D Canada – Suffield
P.O. Box 4000, Station Main
Medicine Hat, Alberta T1A 8K6

| | |
|---|---|
| 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.)<br><br>12RN | 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.)<br><br>DRDC Suffield TM 2012-126 | 10b. OTHER DOCUMENT NO(s). (Any other numbers which may be assigned this document either by the originator or by the sponsor.) |

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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.)

The Mechanized Neutralization Technology Demonstration Project (12RN) was completed in March 2012. This project examined mechanized neutralization assets in-service with the Canadian Forces, or available to the Canadian Forces and evaluated their potential for enhancing the survivability of Canadian Forces personnel in dealing with the explosive hazard threats of landmines, improvised explosive devices, unexploded ordnance, and the like. In addition, the project addressed scientific/technical issues to enhance the ability of the Canadian Forces in making rational, science-based decisions in the acquisition and use of mechanized neutralization assets.

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.)

mechanized; mechanised; neutralization; landmine; ied

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