Mechanical Assistance Equipment Test and Evaluation Program

Volume 7 – Equipment Evaluation (Omega 5 Aegis Mini-Flail)

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Technical Report

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Abstract

In a program conducted by the Canadian Centre for Mine Action Technologies in the summer of 2000, four machines were evaluated for their potential as Mechanical Assistance Equipment in humanitarian demining operations. This program also developed test and evaluation protocols and highly realistic but inert "reproduction mines" for use in such tests. This report is prepared in 8 separate volumes. While each volume is intended as a stand-alone document, there are important interdependencies between some of the volumes. One of the machines included in the program was the remotely controlled Omega 5 Aegis mini-flail, detailed in this volume.

Résumé

Dans le cadre d'un programme mené par le Centre canadien des technologies de déminage à l'été 2000, on a évalué quatre systèmes de déminage pour en connaître le potentiel en tant qu'équipement d'assistance mécanique pour les opérations de déminage humanitaire. Des protocoles d'essai et d'évaluation, ainsi que des mines de reproduction très réalistes mais inertes ont été conçues pour effectuer les essais. Le présent rapport compte huit volumes distincts. Bien que chaque volume soit conçu comme un document indépendant, certains volumes révèlent d'importantes interdépendances. Le présent volume décrit deux autres machines, une charrue rotative et un tamiseur de sol, qui n'ont été examinés que superficiellement.

Executive summary

The Mechanical Assistance Equipment Test and Evaluation Program sought (i) to develop meaningful, standardized test and evaluation protocols and tools for mechanical assistance technology, and (ii) to identify promising technologies and procedures that could be proposed to the humanitarian demining community. In support of these goals a test facility was designed and constructed, test procedures were drafted, standardized test targets were designed, constructed and installed in the test area, and finally, machines were tested.

The remotely controlled Omega 5 Aegis mini-flail had testing aborted when it suffered structural failure and did not adequately perform against the test pieces in preliminary evaluations.

This report is divided into multiple volumes to adequately deal with the subject matter. This volume describes the Test and Evaluation of the Omega 5 Aegis mini-flail. At a minimum, Volume 1 (which contains the overall program summary) should be read in combination with this volume.

Coley G, Bergeron D M, Fall R W. 2001. Mechanical Assistance Equipment Test and Evaluation Program, Volume 7. DRES TR 2001-078 Defence Research Establishment Suffield.

Sommaire

Le Programme d’essai et d’évaluation d’équipements d’assistance mécanique visait (1) à élaborer des outils et des protocoles d’essai et d’évaluation normalisés et utiles pour la technologie d’assistance mécanique et (ii) à déterminer les technologies et les procédures prometteuses qu’on pourrait proposer pour le déminage humanitaire. Dans la poursuite de ces objectifs, on a construit une installation d’essais, élaboré des procédures d’essais, conçu des cibles d’essai normalisés, construit et installé l’aire d’essais et, enfin, essayé les machines.

Outre les quatre machines choisies pour ce programmes, deux autres ont été examinées brièvement, mais pas essayées autant que les quatre premières. Un tracteur de jardin non modifié muni d’une charrue rotative a été évaluée qualitativement pour déterminer si on pouvait considérer une simple charrue rotative bon marché pourrait servir au déminage. Un tamiseur de sol, qu’on avait obtenu pour d’autres fins, a été analysé qualitativement et essayé plus tard dans un des quatre aires d’essais du site d’essai du CRDS.

On a divisé ce rapport en volumes multiples pour que le sujet en question soit bien traité. Ce volume-ci décrit l’essai et l’évaluation du ProMac BDM48. Le volume 1 (qui contient le sommaire global du programme) devrait être lu au moins en conjonction avec le présent volume.

Coley G, Bergeron D M, Fall R W. 2001. Mechanical Assistance Equipment Test and Evaluation Program, Volume 7. DRES TR 2001-078 Defence Research Establishment Suffield.

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Acknowledgements

The authors wish to acknowledge the contributions of the many parties who ensured the success of this program. Maj. Al Carruthers (retired) and Dr. Bob Suart of the Canadian Centre for Mine Action Technologies (CCMAT) both provided unfailing support at all points in the program. Their co-operation ensured that the changes that occur in a first-of-type program were met with flexibility and encouragement. From his position in Ottawa, Maj. Harry Burke helped co-ordinate the players and activities before, during, and after the official trials took place.

Other key personnel from the Defence Research Establishment Suffield (DRES) provided vital assistance throughout the program. Scott Trebble and Randy Linde provided excellent photographic capability. Maj. Kent Hocevar, Mr. Wayne Sirovyak, and Mr Jack Toews each provided much needed assistance and advice in construction of the test area, surveying the test plots before and after the trials, assisting with the scanning and documentation of the test area, and also in picking up the slack in other activities while the authors were immersed in this program.

Finally, special mention is given to some of the people who assembled, identified, documented, and buried the Mechanical Reproduction Mines and then located and removed the remains of these devices following the trials. Mr. Jim Roseveare, Mr. Dan Roseveare, Mr. Doug Roseveare, Mr. Paul Schile, Mr. Blair Mullen, Mr. Corry Milner, Mr. Gary Milner, and Mr. Erin Milner all performed these tedious and largely invisible duties with good humour and the greatest co-operation.

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1. Document Overview

The documentation of this program has been divided into a number of separate volumes. While each volume listed below is intended as a stand-alone document, there are important interdependencies between some of the documents. For example, the evaluation of the performance of any of the machines is tightly tied to the facilities and types of test pieces used. As each of the machines are intended to perform completely different tasks, no attempt has been made at direct comparisons between the machines. The volumes that make up this document include:

- Volume 1 – Summary
- Volume 2 – Mechanical Reproduction Mines
- Volume 3 – Test and Evaluation Procedures and Facilities
- Volume 4 – Equipment Evaluation (ProMac BDM48)
- Volume 5 – Equipment Evaluation (Loken Mine Disker)
- Volume 6 – Equipment Evaluation (Schulte Extractor Mine Picker)
- Volume 7 – Equipment Evaluation (Omega 5 Aegis Slapper Flail)
- Volume 8 – Equipment Evaluation (Miscellaneous Equipment)

2. Introduction

The Mechanical Assistance Equipment (MAE) test program proposed two main activities for each machine. The first activity, Phase 1, was a set of preliminary tests which would be conducted in Humboldt, Saskatchewan at a site owned by the Prairie Agricultural Machinery Institute (PAMI). This preliminary testing was to examine the machine's operation in a qualitative sense and to help revise the test procedures that would be used in the detailed, quantitative tests to follow. In addition, this was a training period during which the machine operators would become familiar with the use of the machine against something approaching real mines. This is important in that many machinery manufacturers and their respective machine operators have no experience in any kind of demining.

The second activity in the MAE test program, Phase 2, was the testing of each machine in a detailed, quantitative set of trials at DRES. With its procedures suitably modified via the preliminary tests, each machine would be "put through its paces" on the standard test lanes at DRES. The performance of the machine would be quantified in terms of number of mines engaged (extracted, triggered, broken, or otherwise influenced as specific to the machine), area covered per unit time, soil conditions (include soil profile and/or tillage depth) before and after the operations, and any other parameter relevant to the machine.

It was expected that the combination of results of the preliminary tests and the detailed tests would allow the performance of the machines to be evaluated and reported in an objective and consistent manner.

It is critically important that there be some means of evaluating whether a machine or a technology is (i) worth testing, and (ii) mature enough to undergo testing. Regardless who is paying for the MAE testing of a given machine, it is very expensive in terms of time, labour, equipment, and facilities. As constructed for this set of trials at DRES, a test lane for one machine costs well in excess of $30,000. Premature testing of a machine can destroy in minutes what it took many weeks and tens of thousands of dollars to prepare, all without producing any useful data.

It is also critical that everyone be <u>absolutely clear</u> from the start as to what the machine is supposed to accomplish and how the machine is supposed to accomplish it. In this first-of-type program there was considerable slack in establishing the definition of what a machine was to accomplish. It became very clear that any program which seeks to test machines in a fair, consistent, unambiguous manner must <u>first</u> establish the definition of the machine's intended task. In addition, it is necessary to identify the data that define the machine's performance. Is the machine's purpose to eliminate all live mines from an area? Does it succeed in this task if it simply moves them intact to another (controlled) location? Does it succeed if it destroys the mines but leaves large numbers of fuzes, detonators, and other potential Explosive Ordnance Disposal (EOD) hazards behind? Does it make a difference whether those EOD hazards are in the processed area or in the other "controlled" location? Does it succeed in the task only if it leaves "smoking holes" where mines used to be? These and other questions need to be addressed before testing commences, and it should be largely the responsibility of the machine manufacturer to establish exactly what the machine is supposed to do, and how it is supposed to go about doing it. If this has not been done by the manufacturer, the exercise must be undertaken prior to formal Test and Evaluation (T&E) activities in order to interpret the test results in a fair, unbiased manner.

PAMI was contracted to assist with these equipment trials, and to report on their findings. Annex A provides a copy of the PAMI report dealing with the Omega 5 Aegis mini-flail.

2.1 Machine Description

One of the four candidate machines selected for the CCMAT MAE T&E program was the Aegis mini-flail (see Figure 1) from Omega 5 in Ontario. Unlike larger military flails, a small, remotely controlled flail might find use in more confined areas and in situations where the cost, size or support requirements of the larger units cannot be justified. Furthermore, this particular design of flail head presented some innovations relative to existing flails.

Figure 1. *Omega 5 "Aegis" Mini-Flail*

The Omega 5 Aegis mini flail was described as a remotely controlled vehicle with a novel front mounted "slapper" type flail. The intent was that the slapping elements would slap the mine pressure plate or the ground surface. The load would transfer through the soil to buried mines and activate the fuzes. In addition the flail head was equipped with short chains attached to small steel disks which would be used for light bush cutting.

The vehicle portion was a 6 wheeled, hydraulically driven chassis under a wedge shaped cover. The hydraulic drive system was powered by a small portable engine (approximately 10 hp). A second engine of about the same size was used to power the flail hydraulics. The vehicle was fitted with a radio remote control system. Backup manual control was via toggle switches mounted on the rear of the vehicle.

3. Phase 1 Testing – Humboldt Saskatchewan

The rationale behind the phase 1 testing is detailed in Volume 3 of this report, along with the goals, procedures, etc. For convenience, these are briefly summarized below.

Phase 1 testing was conducted in sand, clay soil, black earth, prairie sod, and in poplar and willow groves. This testing was intended to train the operators, revise the test procedures if necessary, evaluate the machine against trees/brush as appropriate, and to act as a filter to eliminate any machines that were clearly not mature or capable enough to warrant the more expensive phase 2 testing at DRES.

Test patches were laid out in each soil/environment for each machine. In each test patch MRMs were buried at depths ranging from 0mm ("flush" buried) to 200mm. The machines were then allowed to operate on each test patch in whatever manner (within certain limitations) seemed most appropriate to the manufacturer. Following each "operation" by the machine, the MRMs were checked to determine the effectiveness of that operation, and a decision was made whether to repeat the operation or to declare that test patch "finished."

Figure 2 and Figure 3 illustrate the placement and marking of the MRMs during this test phase.

Figure 2. *Placement and Marking of MRMs for Phase 1 Testing*

Figure 3. *MRMs Were Located Around Trees And Roots In Poplar Grove*

3.1 Aegis Flail T&E Results (Phase 1)

The results of the PAMI (phase 1) testing of the Aegis mini-flail were not encouraging. There were design deficiencies which prevented the machine from operating as intended; there were issues relating to the safety of the machine; and its effectiveness was questionable. Observations and interpretations include the following:

- The remote control system did not operate properly. While not a necessary part of the system for the purposes of either the preliminary trials or the detailed trials, it did present problems with respect to conducting the trials. As shown in Figure 4, manual operation of the Aegis required the operator to walk behind the machine. This placed the operator directly in the path of any thrown debris (a safety hazard), and also would require the operator to walk inside the test lanes (compromising the MRM data) during the DRES testing. A simple remote control umbilical cable allowing the operator to walk alongside the machine would have been more suitable.

Figure 4. *Omega 5 Aegis Flail Under Manual Control*

- There was no skirt or shroud behind the flail head to catch thrown debris. Ultimately a flail of any description will end up throwing some debris (dirt, stones, sticks, mines or mine fragments, damaged flail components, etc). This lack of containment could mean that mines, or other injurious material could end up being thrown at the vehicle and operator or back into the “cleared” area.

- The “brush cutting” attachments on the flail head did not appear to have any significant effect. Prior to actual testing, the unit was being operated in a part of the willow grove. This area had very small willows averaging approximately 5-10mm in diameter and less than 1m in height. The flail cleared the grass in the area, and stripped the leaves and bark from the willows, but left the stems standing. It seemed unable to do any other brush cutting/clearing. In a conversation between Geoff Coley (DRES) and Chris Hatten (Omega 5), it was mutually agreed that there was no brush cutting being done and that there was therefore no point in conducting any tests of the unit in brush.

- Several slapper attachments came loose or broke free from the flail head during flail operation. Not only did this indicate a design problem, but it also constituted a potential safety hazard for the operator and for those people attending the test. This may have been partially caused by the flail head being operated in reverse (to throw debris away from the operator); the devices used to attach the flail slappers to the shaft may not have been suitable for reverse rotation of the shaft. Nevertheless, the machine was capable of operation in either rotational direction, and the attachments were not designed to allow such operation safely or effectively.

- The flail head appeared to be significantly under-powered. While the flail could be brought up to speed in the air, it stalled out and stopped rotating almost immediately on being brought into contact with the ground. The best that could be achieved in the soil areas tested was to have the slapper attachments "tickling" the ground surface (see Figure 5 and Figure 6). If they were brought into greater contact with the ground the flail head ceased rotating and the slapper elements were prone to breaking off.

- In the soil areas tested the flail was able to set off only 3 mines. Of these, two were flush (0mm deep) buried while the third was buried at 25mm. One of the MRMs, shown in Figure 7, was uncovered by the system but was untriggered.

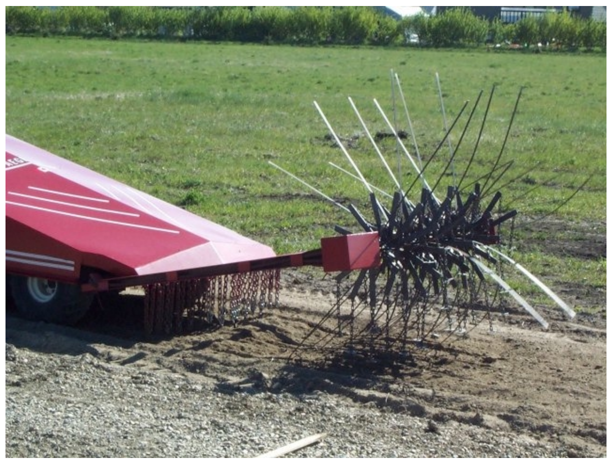

Figure 5. *Aegis Flail Could Not Maintain Rotation While Slapping (Under-Powered)*

Figure 6. *Aegis Flail "Tickling The Ground" Instead Of Slapping*

Figure 7. *PMA-2 Missed By Aegis Mini-Flail Despite Being Exposed*

- Repeated attempts to engage more mines failed even when most of the slapper attachments had been removed to put more power into the ground (i.e.: more horsepower per unit width of flail head.) Ultimately the last of the slapper attachments were removed and the chain/disk brush cutting attachments were tried against the remaining mines with no additional mines being triggered. Figure 8 and Figure 9 show these last two configurations.

Figure 8. *Omega 5 Aegis Mini-Flail With Most Slappers and Cutters Removed*

Figure 9. *Aegis Mini-Flail Operating With Only Cutter Chains*

- Following the failure of the flail to set off any more than 3 mines in the two soil areas, Mr. Hatten stated that there was no point conducting any further tests, and testing of the Aegis ceased. At this point the flail head had no remaining slapper attachments and only a few brush cutting attachments so there would have been no way of continuing testing.

4. Phase 2 Testing – DRES

Following the difficulties with the phase 1 T&E activities, various mail, telephone and email exchanges took place between CCMAT and Omega 5. Initially Mr. Hatten indicated that he had a mock-up of a new flail which he was seeking approval to build and that, on approval of funding, he anticipated being ready by the end of July. This was subsequently revised to August or September.

Omega 5 was advised that the marginal performance and the safety and engineering concerns exposed in phase 1 testing were such that the Aegis would require examination prior to phase 2 testing. This examination would include a review of the engineering/re-engineering of the various systems, some basic operational testing, and effectively, a repeat of the phase 1 testing activities. Only on an acceptable completion of these actions would the Aegis be accepted for the rigourous (and expensive) phase 2 testing. This was the "filtering" mechanism of the CCMAT MAE T&E program in action.

Ultimately, the system was never delivered to DRES for phase 2 testing.

5. Conclusions and Recommendations

The Omega 5 Aegis flail suffered failures of its electronic, hydraulic and mechanical systems during phase 1 activities. While phase 1 activities are not intended to give statistically significant results with respect to the machine performance against MRMs, qualitative statements can be made. The Aegis flail was unable to deal successfully with buried MRMs and was only marginally successful in dealing with surface MRMs. It was also incapable of performing its advertised brush cutting function.

It is recommended that no further MAE T&E work be considered for the system as tested in this program. Any redesign of the system must be carefully evaluated prior to embarking on any renewed MAE T&E activities.

Annex A: PAMI Report "Development Report, Omega 5 Mechanical Demining Trials at PAMI, May 2000"

Mechanical Assistance Equipment Test and Evaluation Program

Volume 7 – Equipment Evaluation (Omega 5 Aegis Mini-Flail)

The PAMI report is attached as a separate document at the end of this report. It is in the contractor's format and is provided "as-is."

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November 2000
Humboldt, Saskatchewan
1400T

Development Report

Omega 5
Mechanical Demining Trials at PAMI
May 2000

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1. Summary

The Omega 5 flail demining implement operated only briefly. It ran in a sand plot and on a clay plot. The machine was unable to deliver enough power to the flail so that the flail straps would "slap" the ground which was an intended function. As a result, only the tips of the flails lightly touched the ground. This provided only a few millimetres of penetration, which was adequate for setting off only surface mounted mines. This operating characteristic caused loose, surface mines to be thrown under the vehicle.

When operated in clay, several flail straps and most of the chains were removed from the axle shaft to increase available torque, so that the flail could be lowered to produce a slapping motion. However, at the same time the flail was run in reverse rotation to prevent throwing mines under the vehicle. This caused extra stress in the straps at the mounting bolts, and nearly all of the remaining straps quickly broke away from the axle shaft. At that time, the Vendor decided that further testing was not warranted. The testing was suspended.

2. Introduction

The Omega 5 was designed and built by Omega 5 Technologies Ltd. of Hamilton, Ontario. It was designed as a small, remotely operated flail device that would detonate anti-personnel mines located on or near the surface of the ground using flat spring steel straps which would "slap" the ground.

This report outlines the results of testing conducted by the Prairie Agricultural Machinery Institute (PAMI) under contract to the Canadian Centre for Mine Action Technologies (CCMAT) in co-operation with the Defence Research Establishment Suffield (DRES), Military Engineering Section.

3. Machine Description

The Omega 5 consists of a six-wheeled propulsion vehicle with a tool frame extending in front of the vehicle as shown in **Figure 1**. The tool frame holds a 1.22 m wide shaft that flail attachments are connected to. There are two spiral rows of attachment anchors. One set of 49 has 280 mm long rigid arms to which "chain and hammer flails" are connected. The other row has 47, 120 mm arms, which flexible steel straps are attached to. The shaft is powered by a hydraulic motor. The vehicle has two gasoline engines (8 hp and 10 hp). One engine powers the vehicle propulsion system; the other powers the flail and lift hydraulics. The vehicle has a remote control operating system.

Figure 1. Omega 5 Flail Demining Implement.

4. Objectives

The objectives outlined in this report represent only the portion of the overall objectives for mechanical demining, which apply specifically to the Omega 5.

PAMI provided a preliminary test site, different from the prepared site at DRES for the purpose of offering flexibility and diversity. A range of conditions was available on PAMI land, adjacent to the PAMI facilities in Humboldt.

The objectives for the Preliminary Test Site at PAMI included:

- Providing a range of conditions similar to where anti-personnel mines might be found.
- Providing an opportunity for the Omega 5 to demonstrate the range of conditions that it could operate in.
- Providing an opportunity for the vendor to try different operating techniques and machine configurations to suit specific conditions.
- Providing an opportunity to install instruments on the demining equipment to measure power requirements.
- Providing an opportunity for Vendor, DRES and PAMI personnel to observe the machine's performance in different conditions.
- Providing an opportunity for "fine-tuning" measuring and evaluating procedures.
- Providing an opportunity to do preliminary evaluation of tool to soil interaction and to determine work rates.
- Providing an opportunity to assess interaction between surrogate mines and the machine tool.

At the DRES, where the conditions represented a "standardised test track", the objectives were similar but focused upon mine neutralization efficiency and work rate. At this site, many more mines were planted in each test plot, and the plots were much larger. The mine locations were not marked, and observers could not coach the operator. The objectives were:

- For the operator to process an entire plot in a manner deemed appropriate for the machine.
- To establish a processing rate.
- To establish a mine neutralization efficiency.

However, the Vendor withdrew the machine before the DRES tests.

5. Test Details

5.1 Scope of Test

The Vendor was required to provide the test machine as well as, any other machinery needed for operating their demining machine. The vendor was also required to supply an operator for their machine as well as spare parts, tools and fuel. All equipment was to be shipped directly to PAMI in Humboldt, Saskatchewan for the preliminary trials and then to Canadian Forces Base (CFB) Suffield, in Alberta.

The Vendor was responsible for equipping the test machine with calibrated transducers that would enable PAMI to record key operating functions that determined the power needed to operate their machine. However, since the machine did not come with transducers, PAMI was prepared to provide suitable transducers to ensure that the test trials would produce information important for defining machine performance. PAMI provided a portable data acquisition system to gather key machine operating requirements. The measurements were to be made while the machine was operating in test plots.

Practice areas of light brush, sod, sand, clay and black soil were made available for the Vendor to operate in and to ensure that the machine was working satisfactorily and to try different operating procedures and techniques.

At PAMI, DRES and PAMI personnel set up test plots in sand, black soil, clay and sod. These plots had six mines buried in each, at depths ranging from flush with the surface to 200mm below the surface. The Vendor was to operate his machine in each plot. The machine's performance was to be evaluated based upon:

Rate of Work

- how fast the plot was processed

Quality of Work

- how deep the tool entered the soil and where the soil was moved to
- what the soil was like after processing
- how the tool interacted with objects in the soil such as stones
- how the tool interacted with the various types of surrogate mines

Ease of Operation

- what special skill was required to operate the machine
- what technique was required for most efficient operation
- what were the consequences of improper operation

Ease of Adjustment

- did the machine require special set up
- were adjustments required and how difficult were they to make

Power Requirements

- the mass of the power unit needed to drive the test implement

Operating Safety

- safety precautions required for the operator
- danger zone around the machine

Durability

- Wear
- Mechanical failures that occurred

At the DRES site, the test plots were much larger and were seeded with a far greater number of mines. The same basic considerations were to be evaluated.

5.2 Test Conditions

The test conditions for the Omega 5 at the PAMI site included:

- Hay land sod, consisting of alfalfa, tame and wild grasses that had been untilled for 20 years. The soil was quite dry. The penetrometer readings increased from about 70 at 25 mm depth to 230 at a 200 mm depth.
- A black soil track, 5 m wide by 33 m long, with a 300 mm depth of black soil. The top, 150 mm layer of the soil had been tilled and then packed using a coil type packer. This provided a firm soil where penetrometer readings increased from 40 at a 25 mm depth to 220 at 200 mm deep. The soil was very dry.
- A packed clay track 3 m wide and 20 m long. The soil had been packed in place using a large wheeled loader. The soil penetrometer readings started at 90 for a 25 mm, decreasing 60 at a 75 mm depth the increasing back up to 80 at 200 mm. This soil was also very dry.
- A sand track 3 m wide by 13 m long filled to a depth of 300 mm. The sand was relatively soft. The soil penetrometer readings increased from about 20 at 25 mm to 100 at 130 mm, and then remained constant at 100 to the 200 mm depth.

Each plot had six surrogate mines buried at random depths of 50, 100, 150 or 200 mm or level with the surface. In the plots, the mine locations were marked with orange paint, to make their location visible to the operator as shown in **Figure 2**.

Figure 2. Mine Location Marked.

The standardized test plots at the DRES site consisted of four Lanes with four Frames in each lane. Frame 1 consisted of mounds and a hole, Frame 2 was packed clay, Frame 3 was packed gravel, and Frame 4 was sod with treated posts imbedded. DRES has complete specifications on the composition and construction of each frame.

5.3 Test Procedures

The Vendor provided an operator for the machine. At PAMI, practice areas were provided where the operator was free to try different operating techniques, then stop and review the performance at any time. These test areas had no surrogate mines planted in them. Test plots were set up in a variety of conditions in order to allow the machine to demonstrate how well it could handle different conditions. In the test plots the mine locations were clearly marked to help the operator direct his machine to the mines. The vendor was also free to coach the operator from a different vantage point.

Prior to processing, the mines were interrogated using the DRES "surrogate mine detector" as shown in **Figure 3**, to ensure that they were functional immediately prior to testing.

Figure 3. DRES Surrogate Mine Detector.

At PAMI, the area where the mines were buried was about 2 m wide and 3 m long.

The operation was recorded on 8 mm video and with digital and film photos. The operating time was recorded and the area calculated in order to provide an estimate for a processing rate. Once the Omega 5 had processed an area, the mines were checked again with the surrogate mine detector and a metal detector. Any signals were investigated and if a mine remained active, it was left in place for a further attempt. The deactivated mines were removed. Pieces of damaged mines were collected, bagged and identified. Movement of undetonated mines was recorded.

The depth of operation was to be determined by scraping away the loose soil and measuring from a straight edge bridged across from undisturbed ground on each side of the processed area.

These tests were not assessed as a pass or fail but rather as an experiment to discover how the machines performed.

At the DRES test site emphasis was on the machine's ability to neutralize mines although the Omega was withdrawn by the Vendor before the DRES testing occurred.

6. Results and Discussion

6.1 Intended Method of Operation

The Omega 5 was to be operated using remote controls manipulated by an operator along side. The machine was to rotate the flail with enough velocity and power that the steel bands would slap the ground detonating mines on or near the surface. It also had hammers on the ends of the chains attached to the flail shaft, these were intended to remove surface vegetation.

6.2 Rate of Work

The Omega 5 was unable to operate for sufficient time to establish a work rate.

6.3 Quality of Work

The Omega 5 was operated in the sand plot. Due to mechanical problems, the machine could not drive the flail with enough force to slap the flails against the ground. The flail had to be raised until only the tips contacted the ground. This caused the flails to appear to "dance" over the ground leaving a pitted appearance as shown in **Figure 4**.

Figure 4. Ground Processed by Omega 5.

After four passes across the sand plot there was little evidence that the Omega 5 would have any chance of neutralizing any mines below the surface. One mine located at the surface was deactivated and another one was rolled onto the surface. It was noticed that with the Omega 5 turning forward, as intended, any surface mines that were uprooted would be thrown under the machine. The Omega 5 was run backwards which solved the problem of throwing the mines under the vehicle.

It was operated in clay soil. On the first pass two shallow buried mines were deactivated. It was recognised that more "slapping" would be required to affect mines below the surface. In an attempt to provide more power, the vendor removed most of the chains and 1/3 or more of the straps. When the Omega 5 was operated with more downward pressure, rotating in reverse, the flails began breaking off at the securing bolt. Within a few seconds the flail had broken off most of the straps. The vendor decided to end the trials.

From the limited results, it appears that a Omega 5 type machine would have little success of detonating mines buried more than a few millimetres underground.

6.4 Ease of Operation

The Omega 5 appeared to be relatively easy to operate, although the remote control was not functioning. Switches at the back of the machine allowed the operator to control the machine direction, forward speed, flail height.

6.5 Ease of Adjustment

The main operating adjustments were relatively easy to make. The flail speed control was located under the protective hood.

6.6 Power Requirements

The Omega 5 was equipped with two engines, one 6 kW and the other a 7.5 kW. These appeared to be suitable for their intended purpose, but the hydraulic system didn't appear to be working properly as it did not provide suitable hydraulic power to the propulsion system and flail simultaneously so it was difficult to make an accurate assessment.

6.7 Operating Safety

The intended design, should have provided reasonable safety for the operator if operating from a remote location. However, the way in which the Omega 5 propelled mines and debris back under and around the vehicle appeared to create a hazard for the machine and for further tasks for recovering the mines. Furthermore, the rotating flail components were totally exposed, so were very dangerous for anyone getting closer than 10 m while it was operating.

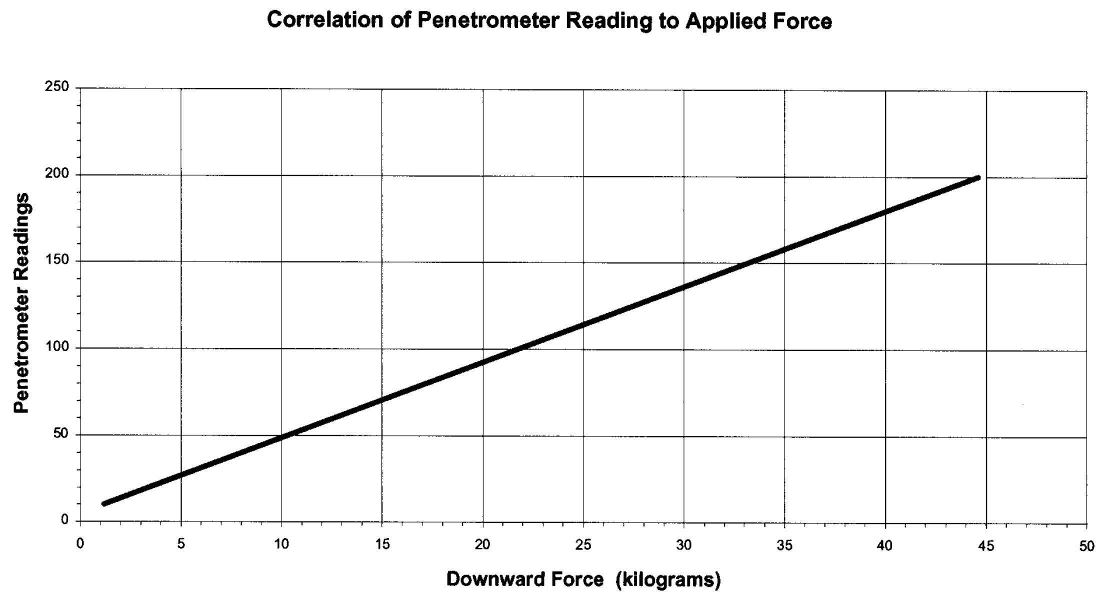
6.8 Durability

From the catastrophic failure of the Omega 5, it was obvious that there were some serious design errors.

Appendix I

Correlation of Penetrometer Reading to Applied Force

Chart 1. Calibration Curve for Penetrometer.



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List of symbols/abbreviations/acronyms/initialisms

DRES	Defence Research Establishment Suffield
CCMAT	Canadian Centre for Mine Action Technologies
MRM	Mechanical Reproduction Mine
MAE	Mechanical Assistance Equipment
T&E	Test and Evaluation
EOD	Explosive Ordnance Disposal (see Glossary)
PAMI	Prairie Agricultural Machinery Institute

Glossary

Technical term	Explanation of term
EOD	“Explosive Ordnance Disposal” is used herein (inaccurately) to refer to pieces or fragments of mines left after a machine’s operation which must then be handled in some manner to render an area “clear.”

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In a program conducted by the Canadian Centre for Mine Action Technologies in the summer of 2000, four machines were evaluated for their potential as Mechanical Assistance Equipment in humanitarian demining operations. This program also developed test and evaluation protocols and highly realistic but inert “reproduction mines” for use in such tests.

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Canadian Centre for Mine Action Technologies
Mechanical Assistance Equipment
Test and Evaluation
Mechanical Reproduction Mine
Anti personnel landmine
Humanitarian demining
Neutralization
Omega 5