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A project to produce, test and evaluate prototype equipment for optimizing the performance of mine detection dogs

Canadian International Demining Corps (CIDC) and PMDesign

Contract Scientific Authority: J.E. McFee
DRDC Suffield

Contract Report
DRDC Suffield CR 2005-168
August 2005

Canada

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Canadian International Demining Corps (CIDC) and PMDesign
PO Box 86
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Contract Number: W7702-04-R012

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Abstract

A limiting factor in the use of mine detection dogs (MDDs) is high ambient temperature on stamina and performance. PMDesign has developed a set of dog cooling devices (DCDs) to be worn by MDDs. With the support of the Canadian Centre for Mine Action Technology and Public Works and Government Services Canada, a test and evaluation program was devised jointly by PMDesign and the Canadian International Demining Corps. The program aimed to collect and analyze empirical data on the efficacy of the DCDs. Field testing was conducted at CIDC's working dog training facilities in Bosnia and Herzegovina. The DCD trial and evaluation involved the collection of subjective and qualitative observations, suggestions and opinions expressed by experienced handlers, through a standardized questionnaire, and quantitative means of evaluating the devices' effectiveness. During the trial period from July to September 2004, maximum daily temperatures varied from 32.5 to 37.4 degrees ºC and average relative humidity varied from 50 to 59 %. Individual temperature differences between the DCDs and the control cassettes varied from 1.2 to 3.9 ºC for the three dogs. Evaluation of the averaged performance of all four MDDs, showed a small to moderate increase in performance for the dogs wearing the DCDs during the early part of the day, followed by a decrease in performance during the middle part, followed by a small increase during the last. Given the subjective nature of the evaluation, it is not clear if the differences are significant. The DCDs proved to be quite durable and the cooling materials exhibited no impact on the environment, as expected.

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Executive summary

In recent years, the use of mine detection dogs (MDDs) has expanded significantly to the point where approximately 750 dogs are currently used in humanitarian demining operations in over 20 countries. A limiting factor in the use of MDDs is climate, especially the effects of high ambient temperatures on stamina and performance. Consequently it is common that working hours for MDDs are restricted to around 5 hours daily (normally early morning). In view of the fact that many of the countries considered "severely" mine-affected are located in tropical or sub-tropical regions, it is evident that elevated ambient day-time temperatures will continue to significantly restrict the potential to optimize MDD global capacity. In an attempt to ameliorate this situation, PMDesign has developed dog cooling devices (DCDs) to be worn by MDDs. With the support of the Canadian Centre for Mine Action Technology (CCMAT) and Public Works and Government Services Canada, a test and evaluation program was devised jointly by PMDesign and the Canadian International Demining Corps (CIDC). The program aimed to collect and analyze empirical data on the efficacy of the DCDs, to support future decisions on the merits of commercializing them for distribution and sale to demining operations utilizing MDDs.

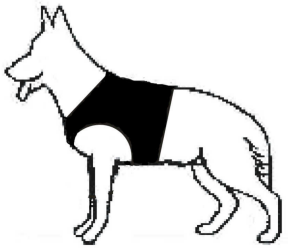
The Dog Cooling Devices are garments designed to be worn by mine detection dogs when working in warm environments. Each DCD consists of two main elements: the actual garment that is worn on the torso of the MDD, and the replaceable/reusable cooling cassettes which attach to the garment. Nine prototype DCDs were manufactured in Canada. Each of the DCDs had unique features and/or sizing such that a wide variety of scenarios could be studied.

Field testing was conducted at CIDC's working dog training facilities in Bosnia and Herzegovina (BiH). The DCD trial and evaluation involved the collection of subjective and qualitative observations, suggestions and opinions expressed by experienced handlers, through a standardized questionnaire, and quantitative means of evaluating the devices' effectiveness. Four main behavioral identifiers of an MDD suffering from heat fatigue were selected: panting (breathing), command recognition (confusion), focus while executing a command (concentration), and pace (thoroughness and efficiency of search patterns). The questionnaire required the handlers to rate each identifier on a scale from 1 to 10, and to note any general comments. Four experienced and accredited MDDs were used. Three MDDs each used a different DCD and cassette material, while one MDD was the control. Relative performances were compared by varying the lengths of time each MDD worked with and without the DCDs. A PMDesign representative controlled the issuance, application and collection of all questionnaires, vests and cooling cassettes, monitored activities throughout each work day, and made detailed notes of his observations of MDD and handler performances. PMDesign recorded and analyzed temperature comparisons of the DCD cooling cassettes and a control cassette. The control cassette was protected from sun and wind, and placed in the locations in which the MDDs wearing the DCDs were working.

During the trial period from July to September 2004, maximum daily temperatures varied from 32.5 to 37.4 degrees ºC, minimum daily temperatures varied from 10.6 to 13.6 ºC, average monthly temperatures varied from 20.0 to 24.9 ºC and average relative humidity varied from 50 to 59 %. Individual temperature differences between the DCDs and the control cassettes varied from 1.2 to 3.9 ºC for the three dogs. Evaluation of the averaged performance of all four MDDs, showed a small to moderate increase in performance for the dogs wearing the DCDs during the early part of the day, followed by a decrease in performance during the middle part, followed by a small increase during the last. Given the subjective nature of the evaluation, it is not clear if the differences are significant.

The DCDs proved to be quite durable and the cooling materials exhibited no impact on the environment, as expected.

Canadian International Demining Corps (CIDC)
and
PMDesign
(Principals: Jason Pearman and Dan McEwen)



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A project to produce, test and evaluate prototype equipment for optimizing the performance of mine detection dogs

FINAL REPORT

Submitted by PMDesign and the Canadian International Demining Corps
August 2005

Contents

1.0 Introduction

One of the most promising developments in humanitarian demining in recent years has been the introduction of techniques that integrate the deployment of mechanical, human and canine assets to speed up the detection and clearance of mines and unexploded ordnance. Consequently the use of mine detection dogs (MDDs) has expanded significantly to the point where approximately 750 dogs are currently used in demining operations in over 20 countries.

MDDs search with their noses close to the ground to detect the scent of landmines or other explosives buried underground. When they do detect a suspicious scent they are trained to sit, thereby indicating to their handlers that they have found something that requires further investigation. The spot indicated by the dog is marked by the handler and explosive ordnance disposal technicians are brought in to uncover and destroy the find. In order to ensure full coverage of the land being searched, CIDC's MDDs work in teams of two, each dog checking the work of its partner. Typically they will work in meter-wide lanes within prepared grids of 100 square meters, with both dogs searching the same ground twice. This ensures that every square meter of ground is searched four times before being declared clear after no indications are made by the dogs.

In order to train and test the MDDs for this type of work CIDC has developed extensive training and testing facilities in Bosnia and Herzegovina (BiH) where it is able to work with actual (defused) landmines buried in the ground. These facilities replicate very closely actual minefield conditions and provide an ideal environment for the program detailed herein.

A limiting factor in the use of MDDs is climate, especially the effects on stamina and performance of high ambient temperatures. Consequently it is common that working hours for MDDs are restricted to around 5 hours daily (normally early morning hours before temperatures increase to the point where consistent performance is jeopardized). In view of the fact that many of the countries considered "severely" mine-affected are located in tropical or sub-tropical regions, it is evident that elevated ambient day-time temperatures will continue to significantly restrict the potential to optimize MDD global capacity.

In an attempt to find a solution to this problem Jason Pearman and Dan McEwen, the principals of *PMDesign*, developed dog cooling devices (DCDs) to be worn by MDDs. Subsequently, with the support of the Canadian Centre for Mine Action Technology (CCMAT) and Public Works and Government Services Canada, a test and evaluation program was devised jointly by *PMDesign* and CIDC (Canada's leading humanitarian demining organization). The program aimed to collect and analyze empirical data on the efficacy of the DCDs, to support future decisions on the merits of commercializing them for distribution and sale to demining operations utilizing MDDs, thereby increasing demining productivity and cost effectiveness.

This report documents the activities and findings of the test and evaluation program.

2.0 Dog Cooling Devices

The Dog Cooling Devices (DCDs) referred to herein are garments designed to be worn by mine detection dogs (MDDs) when working in warm environments. Each DCD consists of two main elements: the actual garment that is worn on the torso of the MDD, and the replaceable/reusable cooling cassettes which attach to the garment. DCDs are not intended to protect the MDD from explosions or other physical harm.

Nine prototype DCDs were manufactured in Canada for field testing in Bosnia and Herzegovina (BiH). (Note: it was originally intended that twenty prototypes would be required, however the nine actually manufactured were made such that they included modular components that could be added and removed to achieve multiple configurations). Each of the DCDs had unique features and/or sizing such that a wide variety of scenarios could be studied. Each DCD was given a unique identification number. All were made entirely with synthetic fabrics which were selected based on wicking ability, stretching capacity, and colour. Brief descriptions of each prototype DCD are given below (full descriptions are contained in *Annex C)*:

- DCD-001 small wick-away vest, black
- DCD-002 large mesh vest, grey
- DCD-003 small lycra vest, white
- DCD-004 large wick-away vest, black
- DCD-005 large wick-away vest, white
- DCD-006 large lycra cape, white (with removable reflective back)
- DCD-007 large wrap with crystals, mesh wick-away, white
- DCD-008 large lycra wrap, white
- DCD-009 lycra back piece (with reflective back)

Note: wicking is the phenomenon of moisture being drawn through or across a material as opposed to being absorbed (in this connection it relates also to heat transfer from the dog into the cassettes).

3.0 Trial Description

Daily routines of the MDDs and their handlers throughout the field trials may be summarized as follows:

- 06.00 am - arrival of handlers at kennels.
- 06.00 am to 0.700 am - kennel cleaning and dog grooming and inspection.
- 07.00 am to 08.00 am - exercise (dog and handler play and walk to their designated work areas (distances vary up to three kilometers).
- 08.00 am to 08.30 am – workplace and equipment preparation, and MDD motivation
- 08.30 am to 12.30 pm - landmine search and detection work divided into 100 square meter grids (typical search period being twenty minutes per 100 square meters followed by forty minutes rest, with water taken as required - typically each MDD worked a total area of 800 square meters - exercise and motivation being provided throughout by the stimulus of playing with a ball).
- 12.30 pm to 1.30 pm - exercise (dog and handler play and walk back to the kennels).
- 1.30 pm to 2.30 pm - feeding the dogs, physical inspections and attendance to any medical or grooming necessities.
- 2.30 pm to 3.00 pm handler debriefing with *PMDesign* and senior instructors.
- 2.30 pm to 6.00 am (following day) kennel rest for the dogs.

DCD trial and evaluation methodologies were developed by *PMDesign* in consultation with CIDC's MDD handlers, veterinarians and other knowledgeable parties. Strategies included the collection of both subjective and qualitative observations, suggestions and opinions expressed by experienced individuals such as the handlers, and quantitative means of evaluating the devices' effectiveness.

In order to comprehensively record the qualitative observations of the MDD handlers a standardized questionnaire was developed for them to address specific variables and note their day to day observations. In this connection four main behavioural identifiers of an MDD suffering from heat fatigue were selected: panting (breathing), command recognition (confusion), focus while executing a command (concentration), and pace (thoroughness and efficiency of search patterns). The questionnaire required the handlers to rate each identifier on a scale from 1 to 10, and to note any general comments. The questionnaire was produced for the handlers in their national language, Serbo-Croat (an english version is included in *Annex D*). The handlers completed their questionaires four times daily.

Four experienced and accredited MDDs were utilized for the trial. Three MDDs, each using a different DCD and cassette material, and one control MDD. By varying the lengths of time each MDD worked with and without the DCDs it was possible to compare relative performances.

A representative of *PMDesign* controlled the issuance, application and collection of all questionnaires, vests and cooling cassettes, monitored activities throughout each work day, and made detailed notes of his observations of MDD and handler performances. By being on-site throughout the field trial process *PMDesign* was able to troubleshoot any

problems, make necessary modifications, and respond to any issues or questions raised by the handlers on a timely basis.

Complementary to the activities noted above, *PMDesign* recorded and analyzed temperature comparisons of the DCD cooling cassettes and a control cassette. The control cassette was protected from sun and wind, and placed in the locations in which the MDDs wearing the DCDs were working. For example, figure 1 shows the control cassette being suspended from a bench in such a working area. The control cassettes were also placed in similar areas to the MDDs at any time when they were resting while wearing the DCDs.

Figure 1. control cassette suspended in an area adjacent to where MDDs were working

The ability to generate direct temperature comparisons was deemed essential for assessing the capacity of the DCDs to draw or remove heat from the canine physiology. The period of application of the DCD for this aspect of testing was focused on the predicted times of highest heat absorption (specifically the period following the second work-break) with work-breaks considered points of evaluation.

Less structured applications of DCDs for observation and modification using the remaining prototypes (eg. abdominal wrap, reflective cape, etc.) were conducted using the control MDD. Program activities therefore encompassed a consistently applied and comprehensive range including detailed field observation of MDD and Handler performance, field application of DCDs and data acquisition of cassette temperatures, and field modifications to the DCDs.

4.0 Trial Conditions

Compared to annual averages temperatures, Trebinje in 2004 was generally cooler. Data provided for Trebinje by state-run meteorological services for July through September 2004 were as follows:

Celsius temperatures	**July 2004**	**August 2004**	**September 2004**
Maximum daily temperatures	37.4	32.5	33.1
Minimum daily temperatures	13.5	13.6	10.6
Average monthly temperatures	24.9	22.9	20.0
Average relative humidities	50	58	59

5.0 Test Team

During orientation at the CIDC training facility it became evident that the best animals to test would be fully trained and accredited MDDs as opposed to those still in training. Thus, all of the data is derived from the 4 accredited MDDs of CIDC's Blue Team:

- Handler Žarko Budinčić with his MDD Alex
- Handler Željko Danilović with his MDD Fanni
- Handler Jozo Jukić with his MDD Rex
- Handler Damir Garibović with his MDD Soves

6.0 Test Sites

All testing was carried out at CIDC's working dog training facilities at Lastva near Trebinje (located in the southernmost region of BiH near its borders with both Montenegro and Croatia). Specific locations used within the training facilities were *Sector 4* (one of the furthest locations from the kennels) and the routes traversed daily by the Handlers and their MDDs between the kennels and Sector 4.

7.0 Test Results

Individual Team Results Vest vs. No Vest

Phase 1

Phase 1 generated data based on the Handlers observations of their dog's performance with and without DCD. Daily, the handlers completed surveys which rated the dogs breathing, concentration, confusion, and speed at 12 different periods in the working day. For each rating category the daily DCD and no DCD data was averaged separately for a given period of the day. Performance enhancement or detriment was considered to be a trend where the DCD data diverged from the no-DCD data for a sustained period of time. Table 1 is a summary of the results that can be found in Annex E.

Table 1: Phase 1 Individual DCD Performance

	Breathing	Confusion	Concentration	Speed
Danilović	No observed change in performance	No observed change in performance except for a decrease in performance at the end and beginning of the third and fourth box	No observed change in performance	Gradual decrease in performance between the third box and return to kennels
Garibović	Moderate loss of performance during the third box, but an increase in performance during the return to the kennels	Increase in performance during the second box, followed by a large decrease in performance that tapers off during the walk to the kennels	Large decrease in performance during the first two boxes, evolving into a small decrease in performance until the walk to the kennels	Moderate decrease in performance, except for large increases during the second box and walk to the kennels
Budinčić	Small improvement in performance, except for a small decrease during the third box	Small improvement in performance, except for a small decrease during the third box	Small improvement in performance, except for a small decrease during the third box	Small improvement in performance, except for a small decrease during the third box
Jukić (control)	Small improvement in performance when DCD applied	Small improvement in performance when DCD applied	Small improvement in performance when DCD applied	Small decrease in performance when DCD applied

Phase 2

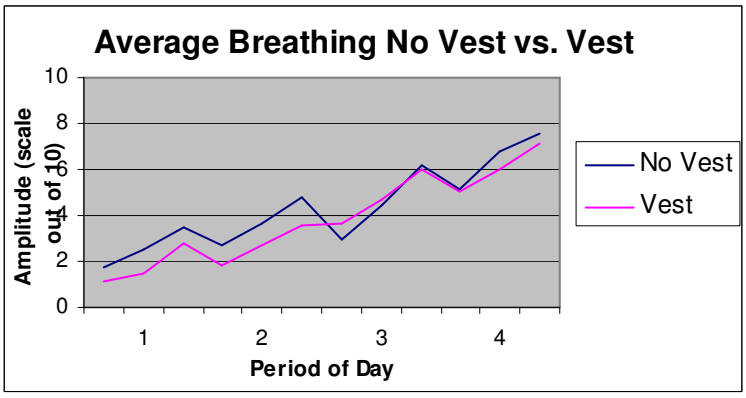
Phase 2 was the temperature comparison of DCD cassettes and a control cassette. The cassettes were applied at various points in the day, and for various lengths of time, followed by the immediate recording of their temperatures. Again, the DCD and control data were averaged separately for a particular period of the day. There was found to be a positive temperature difference between the DCD and control cassette at all periods in the day. Table 2 displays the average temperature difference between DCD and control cassette at any given period in the day.

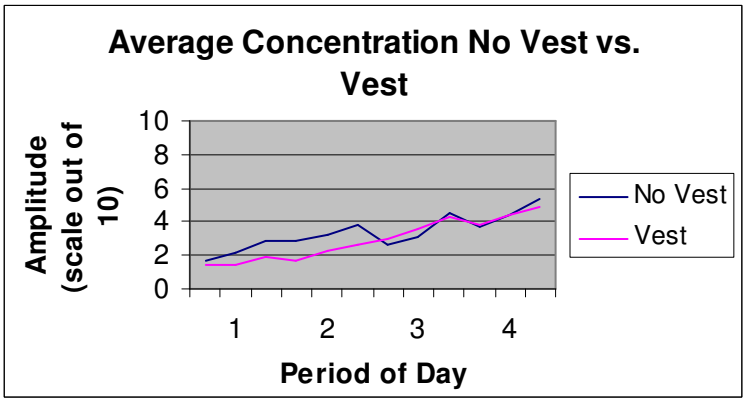
Table 2: Phase 2 Individual Temperature Difference

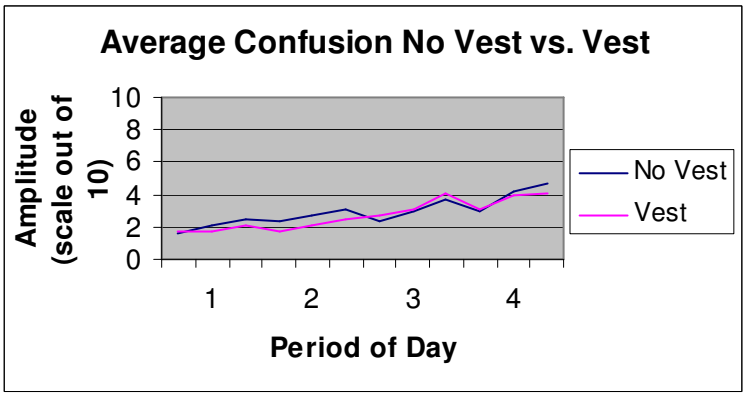
Handler	Average Temperature Difference Between DCD and Control Cassette
Danilović	3.9 ºC
Garibović	1.9 ºC
Budinčić	1.2 ºC

Average Team Results Vest vs. No Vest

Examining the averaged performance evaluation of all four MDDs, there is a small to moderate increase in performance during the first two boxes, followed by a decrease in performance during the third and fourth boxes, followed by a small increase during the walk back to the kennels for all categories. This can be seen below in Figure 2







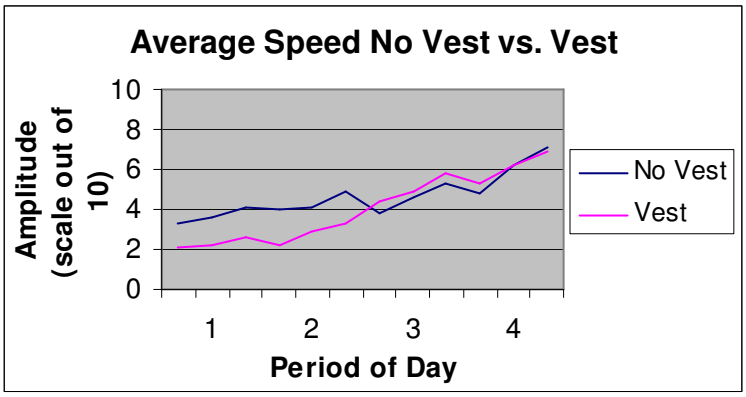


Figure 2. Averaged Vest and No Vest Data for Blue Team

Overall, there is an average increase in performance during approximately 75% of the work day. Also, during each period of the day there was a definite absorption of excess heat with the application of a cassette. From introduction to removal, an average increase of 10.9 ºC for the control and 13.2 ºC for the DCD cassettes. Figure 3 shows the average temperature difference between the control and DCD cassettes of all three MDDs during the daily periods of concern.

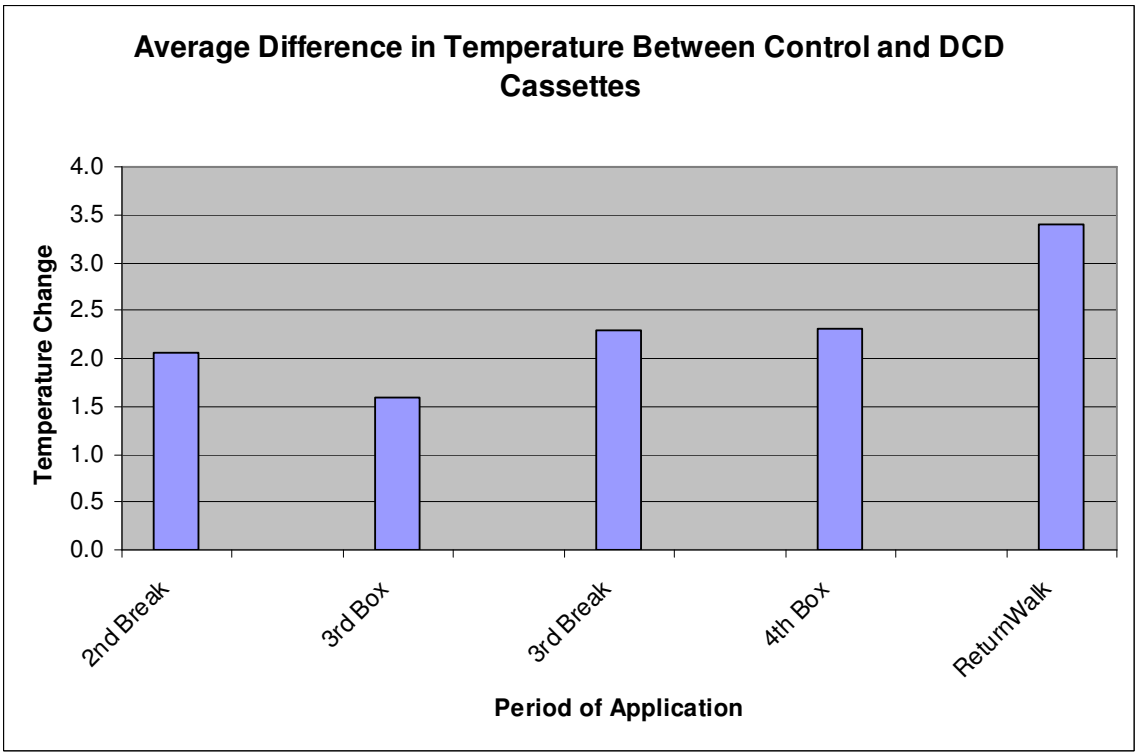


Figure 3. Average Temperature Difference Between Control and DCD Cassettes

DCD Durability Results

The DCDs proved to be durable. Following the field modifications, as detailed in Annex C, the DCDs were more than adequately anchored and endured the wrestling, scratching, and vegetation frequently encountered by MDDs without any major damage. Some

fraying was noticed, exacerbated due to the Velcro on the fastening straps and cassettes. However, this was more a result of inadequate stitching than material failure. It was also found that if any one part of the vest required modifications, it could easily be accomplished, suggesting that if any one part needed to be replaced, that could also be achieved with common sewing equipment.

For the most part, the vests performed well, but there were minor shortcomings for each vest material. DCD-003, the lycra vest, had the best durability and didn't exhibit a single fray over the entire testing period. While it always maintained a tight fit with the MDD's body, the considerable stretching ability of the fabric caused it to sometimes twist in the neck portion or side straps, dislodging cassettes from optimal positioning. Though it managed to avoid any fraying, the fact that it was white allowed for discoloration after continued use.
The two wick-away DCDs (DCD-001 and DCD-010) were much better at remaining anchored to the MDD and minimizing cassette movement. The wick-away vests were thicker and adequately rigid once strapped on. The material did become a bit frayed, and the white version became discolored.

Some of the other DCDs that were tested included the white wick-away wrap, and reflective backpiece. The wrap, wasn't used frequently enough to become either frayed or discoloured, and the back-piece was only tested once. Though, it was predicted that the reflective back portion would have tremendous cooling potential, the DCD would not remain anchored on the MDD, and the reflective material tore in the light wind. While a seeming failure, an adaptation will be discussed later in the report.

Cassette Test Results

There were three types of materials used to encase the polyacrylamide in the cassettes, each having very different short and long term results.

Lycra allowed for closer contact between dog and cooling material since thin, and always returned to original dimensions when dried out. The white lycra cassettes, also contrasted well against the surrounding vegetation, making them easy to find if misplaced or dislodged from the vest. Due to the material's expansion properties, thinness, and tight weave, the required stitching is very small. Small stitching made the seams susceptible to tearing when larger volumes of crystals were used. Precise construction is required. The cassette will deform when hydrated resulting in less than optimal surface contact, if the stitching isn't highly symmetrical, in some cases making the adhesion of the cassette to the vest impossible.

Wick-Away cassettes maintained their charge for almost twice the amount of time as the Lycra cassette. These cassettes have a very large expansion capability, so our assumption was that an above average application of crystals would not cause damage to the cassette. However, we discovered that when stretched too often, the Wick-away cassette deforms permanently. Thicker material also requires more complex construction.

The wrap had a significant advantage, being a large single unit that readily deployed a large amount of cooling chambers. A disadvantage however was that it required a lot of space to submerge crystals, and the whole vest became wet when rehydrated, creating some concern over its ability to guarantee long term wear and sanitation.

In order to definitely evaluate one cassette's superiority over another, a sweating hotplate in addition to incident radiation and air current generator would need to be employed concurrently. However, it is not suspected that the differences in heat transfer properties will be substantial, and that the other observed positive and negatives will determine which cassette is best suited for the DCD.

Effects of DCDs

The use of the DCD proved to be effective in the removal of excess heat from the canine physiology. Examining the average case of the effect of the DCD on an MDD identified points in the working day where its application reduced the amplitude of fatigue indicators. However, considering the individual data, some MDDs were observed to be performing worse at times with the application of a DCD. Though, in the particular case of Handler Željko Danilović with his MDD Fanni, their DCD had the highest level of heat absorption (7.95 ºC) at the same point as their worst speed rating. Also, Handler Žarko Budinčić with his MDD Alex reported consistent positive results during the use of a DCD, but commented repeatedly that he didn't notice a difference in performance on most days.

What can be determined from these test results is that at different periods of the work day DCD applications apparently corresponded to either increases or decreases in perceived performance. Also the period of poorer average performance with the vests, was also the period of largest average heat absorption for the cassettes. The challenge now is to determine if time specific application of the DCD can achieve an overall increase in stamina over a working day period. One such point of application is the return to the kennels from Sector 4. This period is one of the most strenuous throughout the day. Phase 2 data identified this period as one where the cassettes absorbed the most body heat, and Phase 1 data consistently reported it as being a period of enhanced performance.

The selection of vest and cassette material may have more of an effect on the durability and application of the DCD than on heat absorption capacity. However, the use of the white wick-away vest and white lycra cassettes resulted in the highest difference in control and DCD cassette temperature. The white material reflected a considerable amount of the incident radiation from the ground, and wick-away material is probably a good insulator for the coolness of the cassette since so dense, leaving only the MDD body heat to increase the temperature of the cassettes in the system.

In terms of behavioral effects from the use of a DCD none were observed directly, or reported by the handlers. There were also few similarities between MDDs behavioral patterns, making a general case difficult to assume. However, looking at the performance results, the data patterns are altered dramatically for some dogs. It would be generally assumed that the data patterns would be similar, and would just vary in amplitude. For

two of the dogs the vest data was more streamlined, varying less between the boxes. In one case the vest seemed to cause a recurring spike during the second and third boxes' data. But again, as mentioned, there were no directly observed changes in MDD behavior over the entire testing period.

Lastly, there were some initial concerns regarding the application of a cold compress on the dog's abdomen, but there were no reported or observed health effects from the use of the DCD over the entire testing period.

Environmental Effects

There were no adverse environmental effects observed with the use of the DCD. The cassettes contain both dry and hydrated states of polyacrylamide crystals, thus, there is minimal risk of introduction to the environment. However, in the event that a cassette ruptures, polyacrylamide has been identified as being non-toxic, and is often used in the agriculture industry to increase the soil's ability to retain moisture.

It is possible that a loss of a cassette could occur, however on the two occasions it happened the cassettes were recovered easily due to their colour contrast (white) with the surroundings.

Both the vests and the cooling cassettes are designed to be reusable. Cassettes were found to be effective for 2 weeks activity, and the garment portions of the DCDs, lasted throughout the duration of testing with minimal wear and tear, leaving no contamination for the environment.

Other Observations

It proved difficult to assess the effectiveness of the DCDs during the testing period. The occupation of humanitarian demining has a rigidly defined schedule which considers the safety and performance of the Handler as well as the MDD. Although the CIDC training facilities are used for maintenance and enhancement of MDD and Handler standards of performance while not in the field, it was clear that the attendant workload and conditions left little time for the Handlers to undertake additional responsibilities.

Variations in behavioral indicators were observed to fluctuate with the period in the week as well as with the handler' dispositions on any given day. For example Friday's data was generally of higher magnitude than that of Monday's. When a handler was sick or subdued on a given day their MDD often appeared to mimic his energy level.

Deployment of the DCDs was easily accomplished by two persons, and it was found that with increase frequency of use, one person would be able to apply the DCD and attach the spinal strap without any major difficulty. Following the use of a DCD it was necessary for the vest to be rinsed with clean water and then dried to eliminate any odor. To avoid discoloration of the white vests a weekly wash with laundry detergent was sufficient to keep major the stains off the device.

After a day's use the cassettes required immediate rinsing and then rehydration. The best results came from submerging the cassettes in water until their next use, and if possible, storing them in a refrigerated environment. A cooler was used to transport recharged cassettes to the field from the refrigeration unit. It was also observed that cassette absorption abilities decline. Since each cassette requires approximately a teaspoon of crystals, it was easy to remove the existing crystals from the cassettes and add new ones. In terms of the different cassette material, the wickaway mesh cassettes remained charged longer than the lycra, however the wickaway was harder to reuse once stretched several times.
The additional weight on an MDD of the DCDs was an initial concern but this was discounted as an immaterial factor by the Handlers.

A complete list of all (handler and PMDesign) observations can be found in Annex F.

Vest Performance - Future Work

While conducting Phase 2 of the field testing, it was observed consistently that the chest cassettes were at higher temperatures than those of the abdominal cassettes. Also, when comparing the relative temperatures of a MDD's chest and abdomen, the chest area was always warmer to the touch. By assessing temperature results at particular cassette locations in future work, a cassette layout could be determined for optimized heat transfer.

DCD-009 was evaluated, and performed poorly due to inadequate ergonomics. However, an experiment was conducted where the reflective portion of the vest was used to cover a small area of a training box unprotected from the sun from 11am to 1pm. The ground temperature of the area under the vest was 16 ºC compared to 27.4 ºC of the ground directly beside the covered portion. Due to construction limitation, it was possible to only produce one DCD incorporating a reflective cape near the end of the testing period and the prototype was not evaluated. However we believe it is likely that future DCDs will incorporate the reflective portion for incident radiation protection.

Although there was no interference of the CIDC's MDD leash systems by the use of the DCDs, different harnesses and leash systems are used by other MDD operators. Consequently a vest that is attachable to existing rigging will be explored.

Conclusions and Recommendations

Verifiable measurement of variations in stamina of the MDDs was not possible, however performance differences between DCD and no-DCD MDDs were observed. Comparing the Handler based observations with the temperature data also identified some inconsistencies. Particularly, during latter periods of the working day (on the third and fourth boxes). While the Handlers are the field experts concerning MDD performance, PMDesign is in the process of beginning a clinical trial with a team of veterinarians, to evaluate the use of DCDs in a clinical environment. While not the exact same application, it is our hope that this new evaluation will definitively indicate if the DCD has the ability to maintain the core temperature of a dog being thermally stressed.

The main focus for the project was to determine the DCD's ability to positively affect the MDD performance as a commercial product. From the data collected, field observations, and analysis of the results PMDesign believes that there is a strong possibility that the use of DCDs will increase the amount of time that a MDD can effectively and safely work in the field. However, issues involving the conditions and willingness of the Handlers to remain in the field for such additional periods of time will also have to be considered. Although PMDesign believes that further development of the DCD will produce a product suitable for commercialization, the matter of Handler acceptance of increased duration of the work day, or change in scheduling must be addressed by MDD operators.

Costs for the production of one DCD and a year's worth of cassettes (20 cassettes with 26 changes of polyacrylamide (260 work days/a, change every 2 weeks)) excluding labour is approximately CAN$25.00. In small quantities it is estimated to take 2 hours of labour to produce each DCD. In terms of deployment and additional logistics costs, the only expenses will be a result of rinsing the DCDs, rehydrating the cassettes, refrigeration of the cassettes (optional), and transportation of the cassettes (equivalent weight as volume of water). All of which were easily absorbed, in CIDC's case, by existing facilities and resources. Considering these factors, and the positive performance results, with consideration to the negative, it is our belief that the DCD has a real opportunity to be a feasible, low cost strategy of increasing the amount of mine affected land cleared per year.

PMDesign has already taken what was learned in the field to improve on the DCD prototypes that were tested. A second generation prototype is in development for future testing.

Areas Requiring Attention

We believe that humidity is the most important environmental factor that could negatively affect the efficiency of DCDs. Accordingly this is a factor that requires more study, and its effects will definitely be explored in more detail as we proceed with further DCD development.

8.0 Disclosures

We hereby confirm that all activities under this project conformed to applicable national and international standards for the treatment of animals, and in compliance with CCAC guidelines. No harm was caused to any of the MDDs involved in the program.

Mandatory Disclosure Certification (as stipulated in *Annex C* to Contract No. W7702-04R012/001/EDM) is attached.

9.0 Acknowledgements

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Kevin Semenuk MEDENG
EWB-Aeroplan
EWB-Guelph
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SOE – Guelph
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Dan Mercer

Annex A: Handler and MDD daily routine at the CIDC training facility

1. Arrive at kennels approximately 6am. Quick walk and cleaning of kennels.
2. Blue team would walk to Training Section 4, approximately ½ hr walk.
3. Between 8am and 1pm, the Handlers and MDD would completely up to 4 boxes.
    i. A box is a ten meter by ten meter area, surrounded by safe lanes where handlers and manual deminers can safely walk.
    ii. Within a box is where there are suspected mines or UXOs and is where a MDD would be deployed to identify such items.
    iii. Depending on the demining organization, different searching patterns are used to regulate the MDD's searching pattern.
    iv. The CIDC uses stakes and demarcation tape to create ten lanes in a box, which the MDD traverse first up then down.
    v. Once ten lanes had been searched in one direction (width), the Handler would then switch the direction (length) of the lanes and repeat. Having searched both lengthwise and widthwise, 1 box would be completed.
4. Between boxes Handlers and MDDs would rest in the shade, which is referred to as a Break. The Handlers would also use this time to prepare for the next series of Boxes, fill out the PMDesign questionnaire, and complete their own observation and evaluation of their MDD. Break one, would be between the first and second box, and so forth. Breaks could last from 30mins to 1hr depending on weather, Handler, and MDD.
5. At approximately 1pm, the Handlers and MDDs would walk back from Section 4 to the kennels, approximately ½ hr.

Both Sector 4, and the walk to and from the kennels were over varied terrain, both hilly and flat, rock, gravel, grass, and light brush. The temperature varied equally, from being chilly in the early morning till around 9:00~9:30am, increasingly warm till 11am, and then hot from 11am on.

Annex B: CIDC-PMDesign Memorandum of Understanding

Annex C: Descriptions of the DCD's with Field Modifications

Modifications of neck, waist and shoulder strap shortening (All DCDs)

Initial vest fittings identified that all the small DCDs straps were inches too long, thus all were shortened to an appropriate length to maximize area of Velcro adhesion in conjunction with variability of MDD sizes.

Spinal Strap addition (All DCDs):

It was found, once an MDD began to move through boxes, chase after the ball and play with the handler, the DCD would slide down its body. In the most extreme case, since the DCD fabrics are stretchy, the DCD waist strap had the potential to slide right over the dog's rear. However, in most cases it was just a matter of irritating the MDD's genitals. Thus, a stand alone spinal strap was introduced that had three loops spaced along a 14.5 inch piece of nylon webbing at the initial deployment positions of a DCD's straps. Specifically, the first loop was sandwiched between the two Velcro pieces of the neck strap; the second loop, 7 inches from the first loop, and sandwiched between the shoulder strap's Velcro; and the last loop, sandwiched between the waist strap Velcro, 11 inches away from the neck strap.
In addition to maintaining the horizontal position of the DCD, all degrees of motion seemed to be suitably anchored during any level of activity.

Neck piece shortening (DCD 002, white lycra):
The neck piece on DCD002 was too long and had to be shortened by an inch to eliminate bowing of the fabric and cassette, and to maximize surface contact between cassette and dog.

Halter piece addition (DCD 007):
The addition of the halter piece to the large abdominal wrap DCD was of the same necessity which prompted the spinal strap creation. Essentially, a method of anchoring the DCD to its initial deployment position was required. A neck strap was made, and attached to the DCD via three ribbons. Two ribbons at the base of the shoulder straps, perpendicular to the dog's shoulders, come to an apex at the base of the dog's neck and attached to the neck strap. Underneath, a strap is anchored at the centre tip of the wrap, extending to the bottom of the neck strap. The 10 inch strap terminates in loop that is sandwiched between the neck straps Velcro pieces.

Mounting for Reflective Cape addition (DCD 003):

Velcro was placed on the external side of the top pieces of strap ribbon for the adhesion of the reflective cape to the DCD.

Reflective Cape with Cassette mountings Construction:

The large reflective cape was deemed to be too large, and the design did not incorporate any of the underbelly and neck cooling cassettes. Thus, a smaller version was constructed to mount on a DCD, in addition to enabling the deployment cassettes on the underside of the cape.

Due to experiences with the large reflective cape, the reflective material was also stitched to the fabric portion.

Small White Wickaway Fabric DCD (010) Construction:

There were only 2 small standard DCD's prototypes. Since there were only four dogs available, and the small vests fit closer than the large. It was easier to construct a new vest, and white wick away was chosen.

Annex D MDD Handler Questionnaire

i) Before Application, During Use and After Removal of Cooling Vest

****higher the number, the worse the performance for the category******

Panting Scale 1(not hot) ~ 10(very hot)	***Before***	**During**	***After***

Concentration Scale 1(focused) ~ 10 (distracted)	***Before***	**During**	***After***

Confusion Scale 1(understanding orders) ~ 10 (not)	***Before***	**During**	***After***

Speed 1(fast) ~ 10(slow)	***Before***	**During**	***After***

ii) After Removal of Cooling Vest

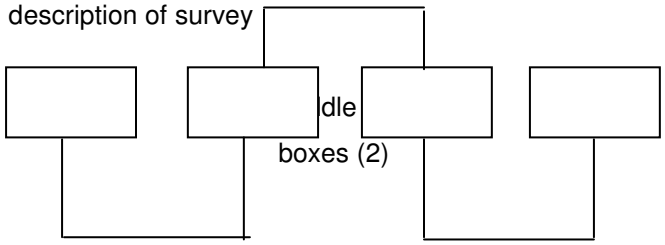
Overall Performance Improvement (check one)

( ) considerably improved
( ) improved
( ) no change
( ) worse
( ) considerably worse

Comments

handlers fill out four of these a day: one for beginning boxes
middle boxes
end boxes
walk from section 4 (training area) to kennels 2km

Graphical description of survey

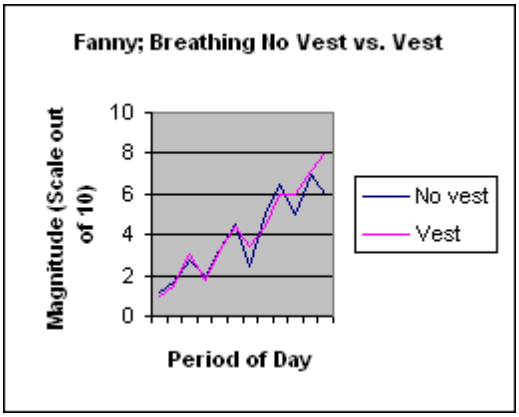


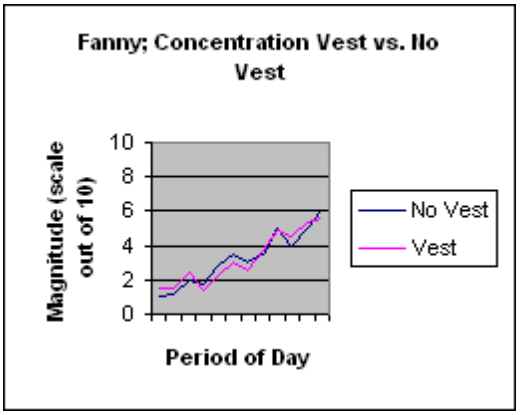
Walk to Kennels (4)

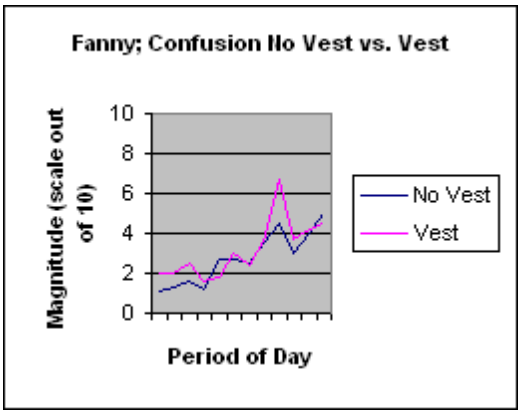
beginning boxes (1)

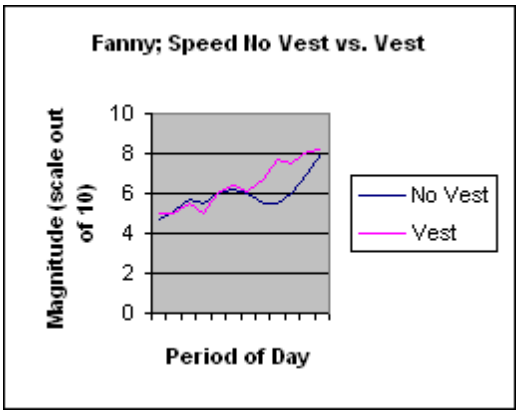
End boxes (3)

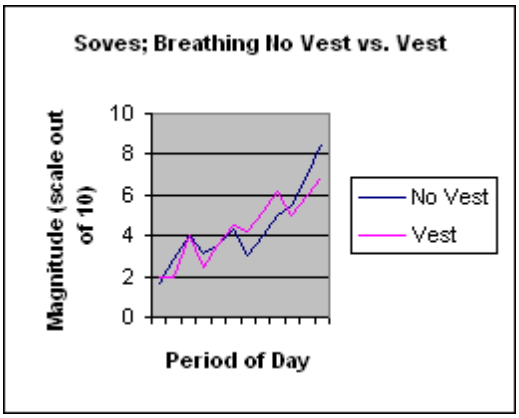
Annex E: Handler and Average No Vest vs. Vest Charts

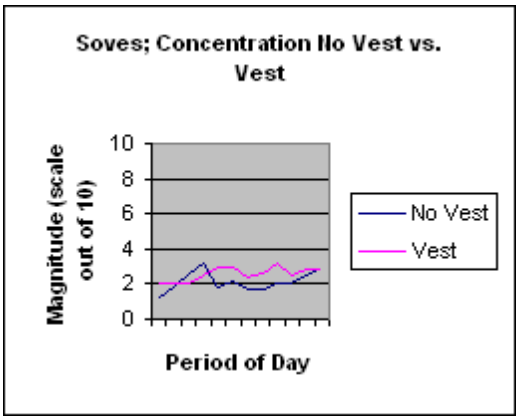


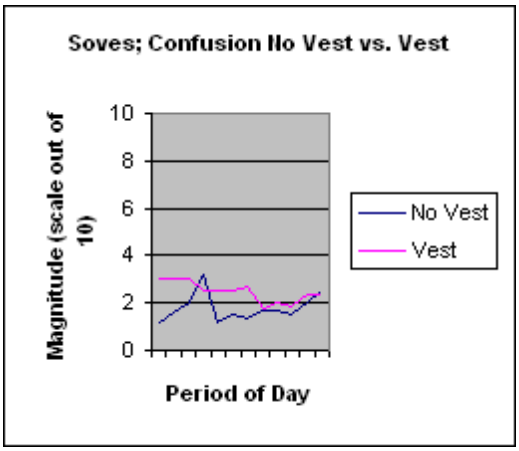


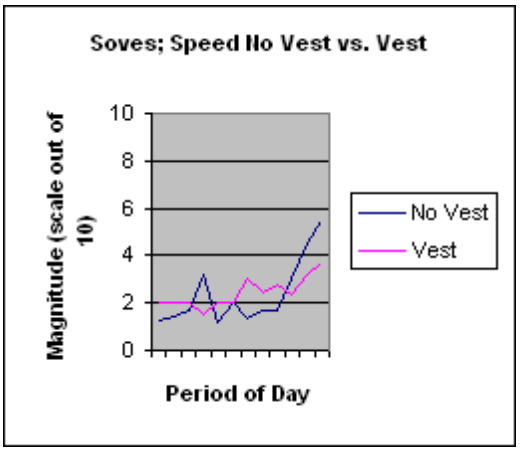


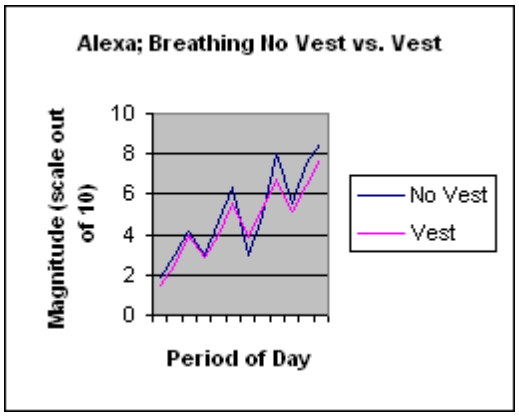


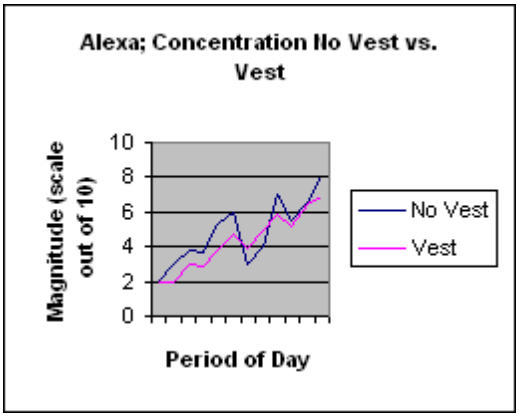


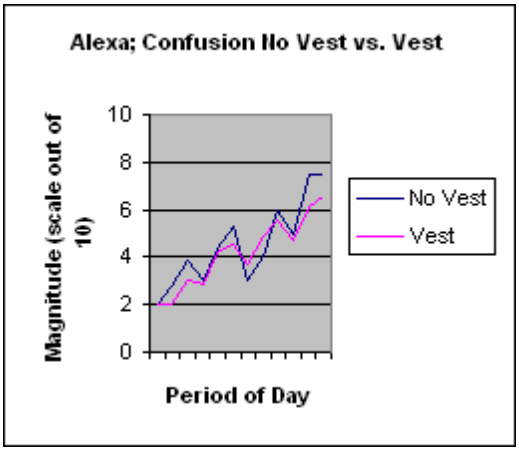


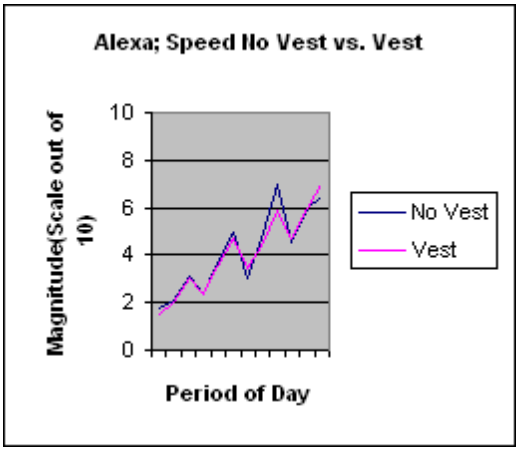

Soves; Confusion No Vest vs. Vest
Magnitude (scale out of 10)
10
8
6
4
2
0
Period of Day
No Vest
Vest

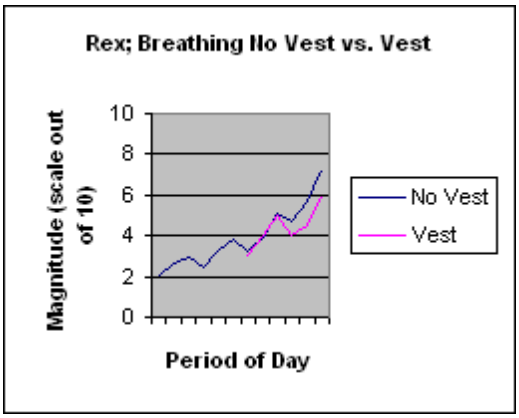

Soves; Speed No Vest vs. Vest
Magnitude (scale out of 10)
10
8
6
4
2
0
Period of Day
No Vest
Vest

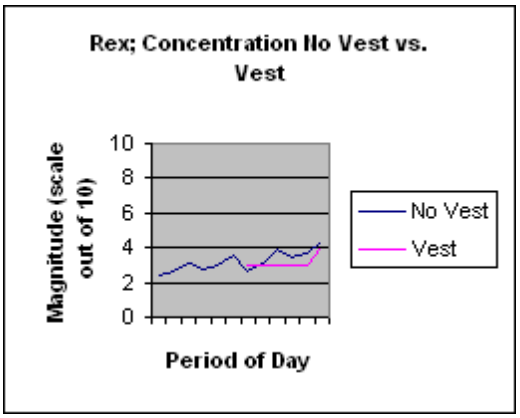

Alexa; Breathing No Vest vs. Vest
Magnitude (scale out of 10)
10
8
6
4
2
0
Period of Day
No Vest
Vest

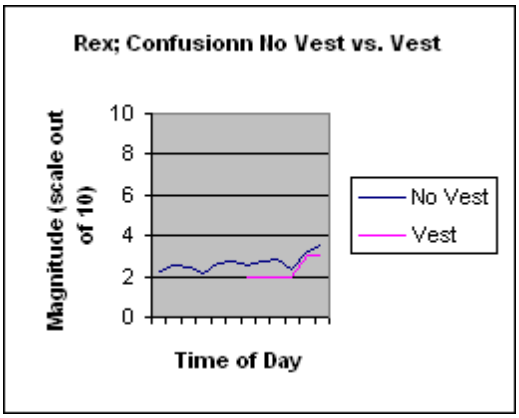

Alexa; Concentration No Vest vs. Vest
Magnitude (scale out of 10)
10
8
6
4
2
0
Period of Day
No Vest
Vest

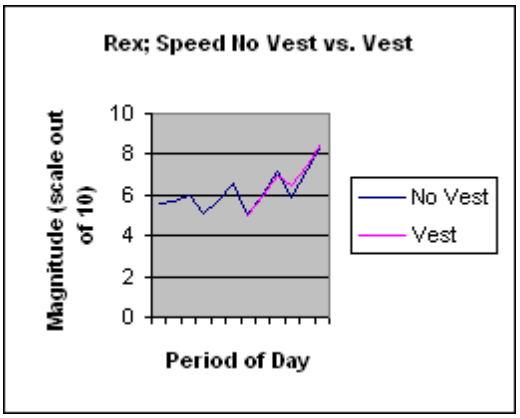

Alexa; Confusion No Vest vs. Vest
Magnitude (scale out of 10)
10
8
6
4
2
0
Period of Day
No Vest
Vest


Alexa; Speed No Vest vs. Vest
Magnitude(Scale out of 10)
10
8
6
4
2
0
Period of Day
No Vest
Vest


Rex; Breathing No Vest vs. Vest
Magnitude (scale out of 10)
10
8
6
4
2
0
Period of Day
No Vest
Vest


Rex; Concentration No Vest vs. Vest
Magnitude (scale out of 10)
10
8
6
4
2
0
Period of Day
No Vest
Vest


Rex; Confusionn No Vest vs. Vest
Magnitude (scale out of 10)
10
8
6
4
2
0
Time of Day
No Vest
Vest


Rex; Speed No Vest vs. Vest
Magnitude (scale out of 10)
10
8
6
4
2
0
Period of Day
No Vest
Vest

Annex F : PMDesign and Handler observations

PMDesign
Cassette
Log

aug. 11
cassettes initially hydrated around aug. 11

aug. 13
Vest fitting with Rikki. Cassettes were still cool after 15-20mins, consider making evaluation trials longer drying cassette begins @ 9:48, outside on wood, partially cloudy
cassettes wet but shrinking, temp approx 15 ℃ at 10:08
cassettes used were inside charging for 3 days and were not refrigerated. Just kept in the same container.

aug. 19
takes days for cassettes to dry out

aug. 20
Cassettes applied right after box set up approximately 10:12am, though no noticeable effect
after box, cassettes still cool at 10:30 get new cassettes made
cassettes essentially dry by time return to kennel, just enough moisture to maintain the enlarged crystals. Could see the individual crystals.
put cassettes in oven at 100 ℃ for 1/2hr, then left in oven over night
hung cassettes on clothesline overnight after leaving out in sun for a few hours. Crystals almost completely dried out by 2pm following day

Aug-22
put two very dry cassettes in water at 1:45, few hrs later less absorption then previous hydrations

Aug-23
cassettes being used on DCD010 are semi-spent, will replace tomorrow
DCD001 wickaway cassettes still plump.
by 12:10 Sule dogs cassettes were not wet at all. Probably because crystals worn out, and just about 15 ℃ to the touch

Aug. 24
abdomen location of DCD cassettes noticeably cooler than rest of body
Zika's dogs chest cassette much warmer than abdominal
gave Zika's dog Alex new cassettes before walk back to kennels at 12:14

Aug-25
wickaway cassettes good in terms of maintaining their charge.

Aug-27
very cool day, no real need for the vests but had handlers put them on anyway.

injection of vitamins this morning, dogs energy is usually high following injections

Aug-30

Zika and Sule in different areas. Zika's area cool and a lot of shade. Sule's partial shade.
Zika chest cassette very large wickaway with four smaller wickaway cassettes. Sule had four medium sized lycra for chest and abdomen.
Zika's vest may have been absorbing more heat on walk back to kennels than Sule's vest and cassettes were black as well.

Sep-02

cassettes losing charge

Sep-06

at some point control cassette fell out of harness from the shade, into the sunlight , so temp may be higher than normal (11:30).
Now putting control cassette in shade on the ground in shade at the time when dogs are resting in shade before walk to kennels (12:19) for approximately 20mins Fanny panting while in shade with some cassettes after 4th box.
Sule's neck cassette was really plump

Sep-07

control cassettes not the same as some of the DCD cassettes. ie. Cassettes could potentially retain more or less water, more or less heat capacity
another breezy but sunny day approx 20 degrees
Sule's neck cassette fat wickaway
Sept. 6 and Sept. 7 final temps are same, but Sept. 6 just walk from Section 4, Sept. 7 4th box and walk to kennels.
Sept. 7 lower starting temp more time, sept. 6 higher starting temp less time.

Sep-08

Fanny has too much room in the neck still.

Sep-09

Brand new cassettes!!!
Less new cassettes as compared to the last crystal change.
All cassettes including control lycra today.
very windy, but put protected control cassette as much as possible from active convection
Dog always rests in shade, ground temp lower than ambient, thus, may cause heat transfer from cassette to ground, decreasing measured temperature change.
Exposure to sun might also be reason for chest cassettes higher temperature readings.

Sep-14

8:30 overcast, but sun is peaking through clouds.
9:00 sun is now out and it is hot.
9:15, cloudy again, now it's cool
10:00, testing finished, Blue team deployed, except for Damir and Soves.
probably around 15 degrees and very breezy, however dogs returning to kennels from Section 4 still have tongues all the way out.

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   PO Box 86
   Sydney, NS B1P 6G9

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   (overall security classification of the document, including special warning terms if applicable)

   UNCLASSIFIED

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4. AUTHORS (Last name, first name, middle initial. If military, show rank, e.g. Doe, Maj. John E.)

   Canadian International Demining Corps and PMDesign

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   30EF02

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   W7702-04-R012

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   DRDC Suffield CR 2005-168

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A limiting factor in the use of mine detection dogs (MDDs) is high ambient temperature on stamina and performance. PMDesign has developed a set of dog cooling devices (DCDs) to be worn by MDDs. With the support of the Canadian Centre for Mine Action Technology and Public Works and Government Services Canada, a test and evaluation program was devised jointly by PMDesign and the Canadian International Demining Corps. The program aimed to collect and analyze empirical data on the efficacy of the DCDs. Field testing was conducted at CIDC's working dog training facilities in Bosnia and Herzegovina. The DCD trial and evaluation involved the collection of subjective and qualitative observations, suggestions and opinions expressed by experienced handlers, through a standardized questionnaire, and quantitative means of evaluating the devices' effectiveness. During the trial period from July to September 2004, maximum daily temperatures varied from 32.5 to 37.4 degrees ºC and average relative humidity varied from 50 to 59 %. Individual temperature differences between the DCDs and the control cassettes varied from 1.2 to 3.9 ºC for the three dogs. Evaluation of the averaged performance of all four MDDs, showed a small to moderate increase in performance for the dogs wearing the DCDs during the early part of the day, followed by a decrease in performance during the middle part, followed by a small increase during the last. Given the subjective nature of the evaluation, it is not clear if the differences are significant. The DCDs proved to be quite durable and the cooling materials exhibited no impact on the environment, as expected.

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. Identifies, 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.)

dog cooling vest, landmine detection, humanitarian demining, mine detection dogs