Canadian International Demining Corps

CIDC

Canine Countermine

REPORT ON DEPLOYMENT AND MONITORING OF BDM48 – THAILAND

Project commencement July 12, 2001 through completion March 31, 2002

Contents

Submitted April 12, 2002

Overview

This report summarizes CIDC's observations and analysis of the performance of the BDM48 Demining Equipment developed by ProMac Manufacturing Limited of Duncan, British Columbia. In terms of operational data, it covers the period August 15, 2001 through March 31, 2002, during which time the equipment was deployed in demining operations by the Thailand Mine Action Centre (TMAC) through its Humanitarian Mine Action Unit 1 (HMAU1) at Nong Ya Kaoh (on the Thai side of the Thailand/Cambodia border).

As was to be expected, TMAC encountered a learning curve in integrating this new piece of kit into its operations. However, following an initial period of adjustment, satisfactory levels of productivity were reached on a relatively consistent basis.

For conditions encountered at Nong Ya Kaoh, the BDM48 had the capacity to operate in four separate modes:

1. Tree and brush clearing;
2. Soil disturbance/ground preparation (to a depth of 20 centimeters per TMAC SOPs.);
3. Termite mound leveling; and
4. Mine-destruction.

As it transpired, TMAC deployed the equipment in modes 1, 2 and 3 but did not utilize the BDM48 in *mine-destruction* mode. Consequently, we are not in a position to report any data or offer an opinion on the equipment's productivity for *mine-destruction* taskings.

During the period for which data was collected, the BDM48 operated on 100 days out of a possible 129 days. It cleared (or prepared) over 110,000 square meters of land at an average rate of almost 400 square meters per hour. During five separate operating days we recorded productivity at 1,000 square meters per hour (four times in *tree and brush cutting* mode and once in *termite mound leveling* mode). This was the best level of hourly performance achieved. The best productivity achieved in *soil disturbance/ground preparation* mode was 800 square meters per hour (achieved on three separate occasions).

Allocation of effort

	Hours	%	Sq. Mts.	%
Tree and brush cutting	221.5	80%	90,480	82%
Soil disturbance / ground preparation	43.5	16%	12,855	12%
Termite mound leveling	11.5	4%	6,879	6%
	276.5	100%	110,214	100%

Operating totals	Hours	Sq. Mts.	Sq. Mts. per hr.
Tree and brush cutting	221.5	90,480	408
Soil disturbance / ground preparation	43.5	12,855	296
Termite mound leveling	11.5	6,879	598
	276.5	110,214	399
Average operating hours per operating day	2.8		

Throughout the monitoring period, the BDM48 experienced no serious malfunctions. Downtime due to maintenance and mechanical problems was within acceptable limits.

In the context of conditions at Nong Ya Kaoh, and the operational framework of HMAU1, CIDC's opinion is that productivity levels of at least 500 square meters per hour should be sustainable on a consistent basis over the long-term.

In conclusion, the equipment and its operators functioned well, and the BDM48 has been readily accepted by TMAC as a key component in its demining *toolkit*.

Chronology and summary of activities and methodology

Events prior to project implementation
This assignment followed an extensive period of development of the BDM48 by ProMac and testing by the Canadian Centre for Mine Action Technology (CCMAT). It also followed a decision by the Department of Foreign Affairs and International Trade (DFAIT) to donate the equipment to TMAC.

The operator compartment and vulnerable exterior areas of the BDM48 were armour plated in January 2001. Blast testing was conducted at the Defence Research Establishment Suffield (DRES) between February 23 and 26, 2001. Tests included the simulation of AT mine strikes by using 7.5 kg of C4 explosive and AP mine strikes using 200 gram explosives.

After transportation to Thailand a combination of operator training and further testing was conducted by ProMac, CCMAT and TMAC at Nong Ya Kaoh (HMAU1) between April and June 2001. For testing, conducted during the period May 24 to 29 2001, M14 mines plus Mechanical Reproduction Mines (MRMs) – Type 72A were used. A total of 96 trials were carried out in a variety of soil conditions, vegetation and terrain. The M14s and MRMs were placed at depths ranging from 0 to beyond 20 cm. All devices except two buried to a depth of 20 cm. were either neutralized or detonated. Further details may be available from CCMAT.

CIDC was contracted to act as liaison in the donation of the BDM48 by Canada to TMAC, and to conduct a six-month monitoring program to assess the performance of the equipment in field use by TMAC. CIDC and DFAIT signed a contribution agreement relative to this assignment on July 12, 2001.

Project preparations

CIDC's Operations Officer traveled to Thailand in mid-July 2001 to finalize terms for the donation of the BDM48 to TMAC, and to establish the six-month monitoring program to assess the "live" performance of the equipment.

Tasks undertaken by CIDC's Operations Officer during this phase included:

- Recruitment and training of a Thai national as Program Monitor (Ms. Arunotai Nantawan commenced her duties on 23 July, 2001 and completed her assignment on March 31, 2002).
- A complete physical inventory of all equipment and consumables was taken and compared with the list of equipment delivered to Thailand by ProMac.
- Operational and maintenance & servicing training for the BDM48 operators.
- Development and testing of preliminary monitoring procedures and report formats.
- Reaching agreement with TMAC regarding the terms under which the equipment was being donated, and the respective responsibilities of TMAC and CIDC.

CIDC's Executive Director arrived in Thailand on August 9, 2001. Based on a review of operations during early-August, reporting formats were revised and finalized for full implementation effective August 15, 2001.

Highlights of project agreement between TMAC and CIDC

Stated objectives:

1. CIDC to supply to TMAC equipment comprising: Case 9040B Armoured Excavator, BDM48 ProMac Brusher Deminer, Blast Suppression Adaptor Assembly and ancillary parts and supplies.
2. CIDC to provide training for TMAC equipment operators.
3. TMAC and CIDC to refine and develop SOPs.
4. CIDC to monitor and record the performance of the equipment.

Respective roles and contributions:

TMAC and CIDC divided their respective areas of responsibility. TMAC being responsible for:

- Taskings;
- Custody of the equipment;
- Maintenance;
- Personnel to operate the equipment;
- Fuel, lubricants, fluids, spare-parts and consumables;
- Positioning of the equipment and its transfer between operating sites; and
- Administrative and communications support.

CIDC was responsible for:

- Procurement of the equipment, and hand-over to TMAC;
- Training programs for TMAC operators; and
- Monitoring and reporting performance.

TMAC and CIDC were jointly responsible to refine and develop SOPs, implementing joint administrative procedures, and resolving other issues.

General provisions:

- DFAIT and CIDC provided no insurance or warranty, and accepted no liability for the equipment or its performance.
- TMAC and CIDC were each responsible for their respective costs and financial records.
- The term of the agreement was for six months commencing July 16, 2001.
- It was agreed that TMAC shall enjoy continued custody and ownership of the equipment beyond the term of the agreement for the indefinite future.

Field monitoring

The Program Monitor physically observed daily operations and recorded for each day:

- A summary, by activity, of operating and non-operating hours.
- Measurements of areas (square meters) worked by the BDM48 (broken down by terrain and vegetation categories – see below).
- Engine hours, parts consumed, fuel and lubricants consumed, etc.
- Certain costs incurred.
- General observations.

Land was categorized according to the following variables:

1. Topography (or slope)
    - Category A – Essentially flat land
    - Category B – Moderate incline
    - Category C – Severe incline
2. Vegetation
    - Category 1 – Bare soil / grass
    - Category 2 – Thick grasses / brush
    - Category 3 – Trees / brush (including bamboo)
3. Climate conditions
    - Wet
    - Dry

The results obtained were summarized on a monthly basis, aggregated for the full project duration, and analyzed in this and previous reports.

At the request of TMAC, CIDC extended the monitoring assignment from its originally scheduled completion date in mid-January to March 31, 2002. In addition, CIDC provided TMAC with its data collection and reporting formats, and the Program Monitor trained TMAC personnel so that they may continue to collect and analyze productivity indicators, as required, in future.

Formal handover

Formal presentation of the BDM48 equipment and related accessories was made to TMAC on January 23, 2002 by the Canadian Ambassador to Thailand, Andrew McAlister. The full equipment list is annexed hereto.

Utilization

Modes of operation

Despite suggestions that TMAC might deploy the BDM48 in *mine-destruction* mode, the equipment was used exclusively as a ground preparation tool (*tree and brush cutting* for 80% of the time and 82% of areas cleared, *soil disturbance /ground preparation* for 16% of the time and 12 % of areas cleared, and *termite mound leveling* for 4% of the time and 6 % of areas cleared).

TMAC's typical mode of operation was to deploy the BDM48 as the initial tool for vegetation clearance. This was usually followed by a process of clearing away cuttings and debris using TMAC's SDTTs prior to the tasking of manual and canine units in the prepared areas.

Potential enhancement

Based on his observations of operations at Nong Ya Kaoh in January 2002, ProMac's *Manager, Sales and Technical Attachment Products* advised that overall productivity would be enhanced if an additional tool was supplied. He noted that in addition to the deployment of an SDDT unit to collect cuttings and debris, the BDM48 Head was itself being used to pile brush. ProMac stated that the BDM48 Head was not designed for this purpose and advised that its utilization in this manner was counter-productive. ProMac's recommendation was to equip the unit with a grapple attachment that would simplify and speed up the collection and removal of cuttings and debris. ProMac stated that this would also obviate the need for an SDDT unit to work along side the BDM48. The recommended attachment is pictured below and can be supplied with a *Quick Change* system that would facilitate easy interchangeability in the field. The cost of the attachment was quoted by ProMac at $16,490 plus taxes, freight and modest installation adaptations. It should be noted that, to date, no steps have been taken to procure or supply this attachment.

ProMac recommended additional attachment

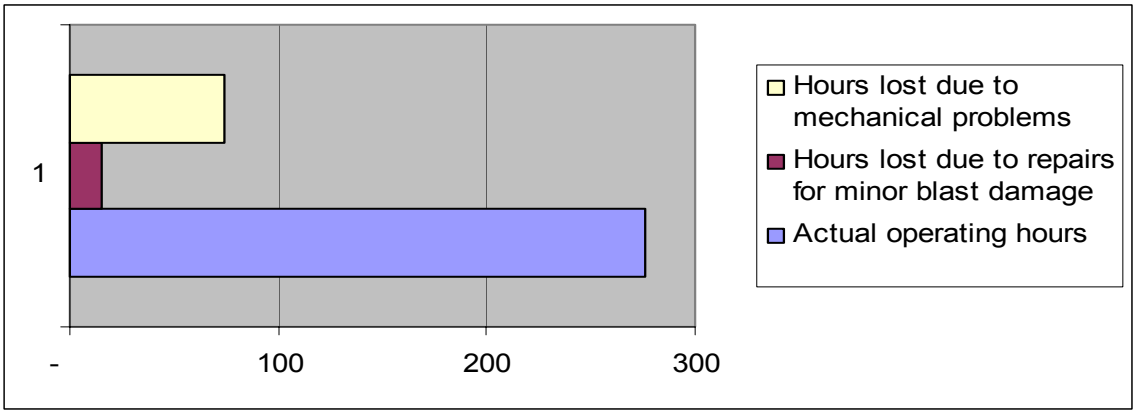
Inappropriate usage of the BDM48

Another observation made by ProMac in January 2002 was that the BDM48 Head was often being used for pushing down trees. They cautioned that such use was inconsistent with design criteria and caused unnecessary wear and tear on the equipment. Accordingly, a recommendation was made to TMAC to cease utilizing the BDM48 in this manner.

Blast experience
Although the BDM48 was not deployed in *mine-destruction* mode, it did successfully detonate two unidentified AP mines during *tree and brush cutting* operations. These detonations caused no injuries to personnel, the blast suppression system functioned as designed, and damage sustained by the equipment was consequently minor.

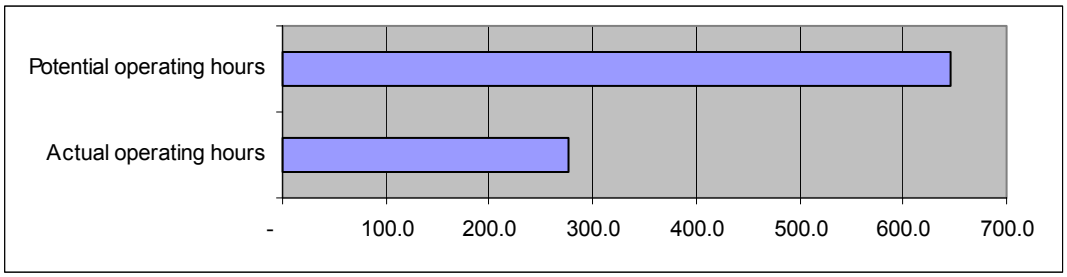
Downtime and underutilization
A total of 89 hours was consumed on mechanical problems and minor repairs and modifications. Initially, the need to identify local repair facilities and an element of operator inexperience contributed to the time lost on these matters.

Month	Description of main mechanical problems	Hours lost
Aug	Not applicable.	-
Sep	Repairs to broken hydraulics lines.	9
Oct	Minor repairs necessitated by mine-strikes.	15
Nov	Not applicable.	-
Dec	Recurrent engine failure due to contaminated fuel. Filters replaced.	36
Jan	Repairs to broken hydraulics lines.	1
Feb	Replacement of drive belt and bearing. Upgrading of plating.	28
Mar	Not applicable.	-
Total		89



The total of scheduled operating days during the assignment was 163, but 34 operating days were consumed by TMAC's emergency response to an incident at the ammunition storage facility in Pak Chong in October and November 2001. The BDM48 was not deployed at Pak Chong but could not operate at Nong Ya Kaoh in the absence of other elements of HMAU1.

Out of the remaining possible 129 operating days the BDM48 was utilized for an average of 2.8 hours per day on 100 days. Optimum sustainable utilization of the BDM48 within the context of HMAU1's operational framework is considered by CIDC to be 5 hours per day for 6 days per week.



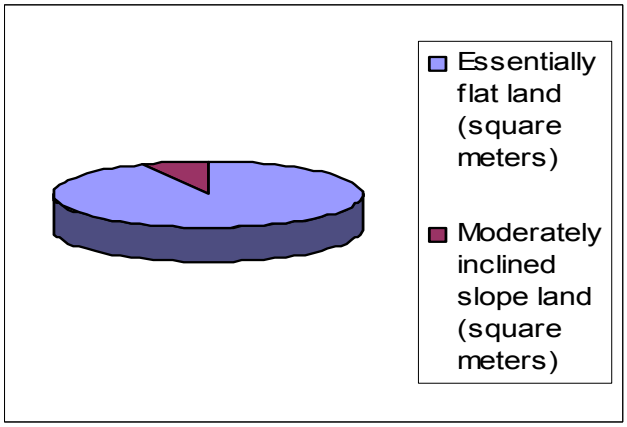
There were two basic reasons why the equipment was not more fully utilized. The main reason was the fact that the BDM48's productivity rate significantly outpaced that of TMAC's manual and canine demining units. As a consequence, it was often left idle while the manual and canine demining teams caught up with clearance work in areas previously prepared by the BDM48. Secondly, at least in the early stages, it was often difficult for TMAC to maintain adequate safety distances between the BDM48 operating areas and those occupied by manual and canine teams. As a consequence, BDM48 operations were sometimes restricted to periods when the manual and canine teams were non-operational.

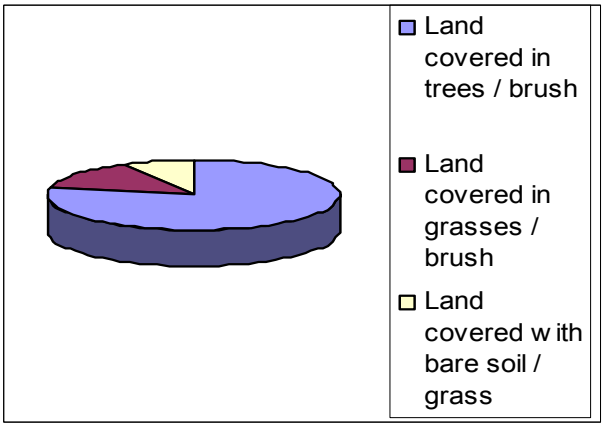
Performance

Performance measures were recorded in terms of hours of operation, square meters cleared and productivity (i.e. square meters per hour) for various categories of land.

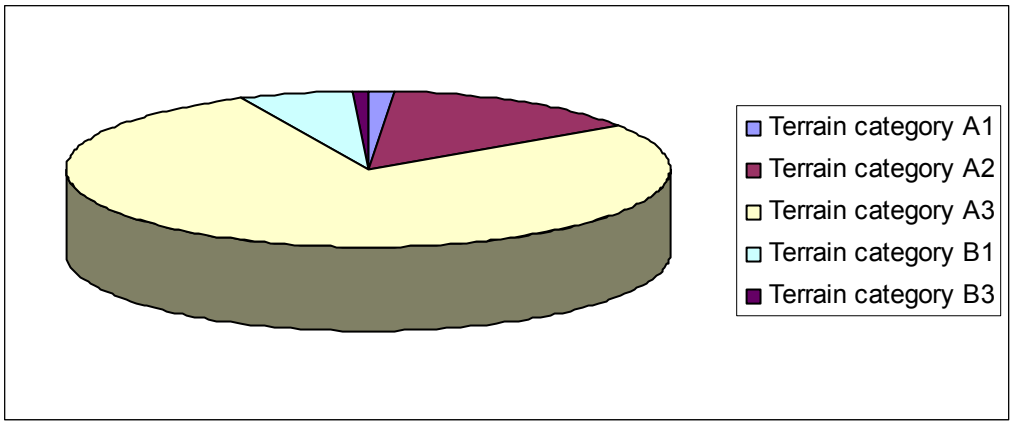
Ground conditions

Ground conditions encountered in the HMAU1 area of operations typically comprised flat land with thick vegetation and trees (including bamboo), and numerous termite mounds. The BDM48 proved capable of efficiently clearing virtually all forms of vegetation encountered. It operated exclusively in dry conditions, and landform encountered at the Nong Ya Kaoh demining sites included no severe inclines. Operations during the period under review were conducted 93% on *essentially flat* ground and only 7% in areas with *moderate incline*. Vegetation encountered was 78% *trees/brush*, 14% *thick grasses/brush*, and only 8% *bare soil/grass*.



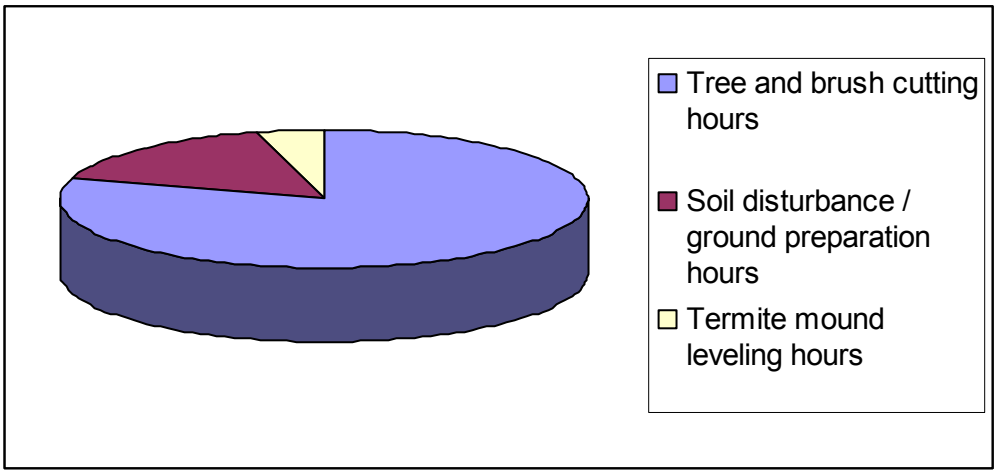


The breakdown of area clearance/preparation by terrain category was:

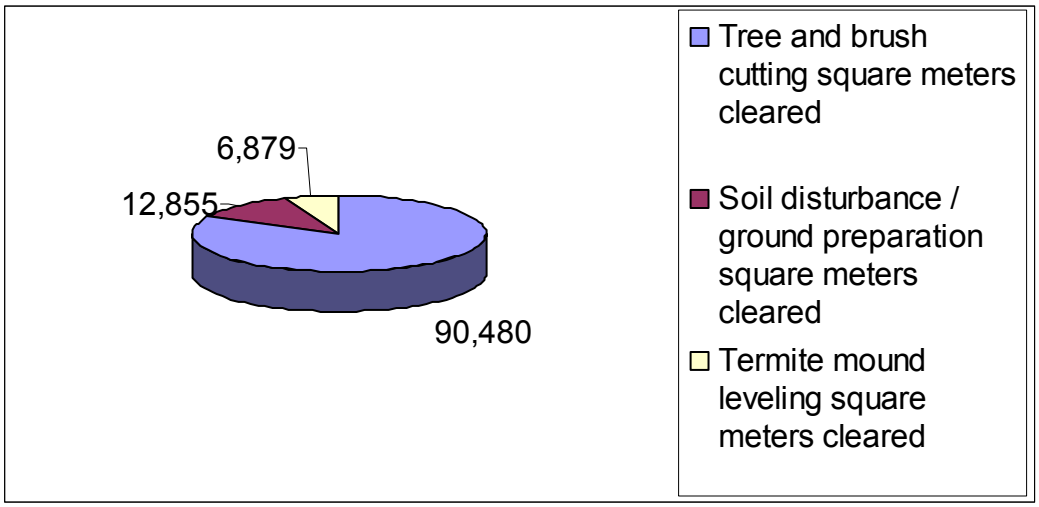


Performance (in terms of area cleared per hour of operation) on *soil disturbance/ground preparation* tasks was, on average, equivalent to about 73% of the productivity achieved in *tree and brush cutting* tasks. Productivity initially reported for *termite mound leveling* was inconsistent. However, March 2002 reports for this mode indicate average productivity of 570 square meters per hour, (ie: reasonably in line with recent average productivity in other modes).

The following tables and charts illustrate various aspects of performance measured



Tree and brush cutting hours	221.5	80%
Soil disturbance / ground preparation hours	43.5	16%
Termite mound leveling hours	11.5	4%
Total operating hours	276.5	100%

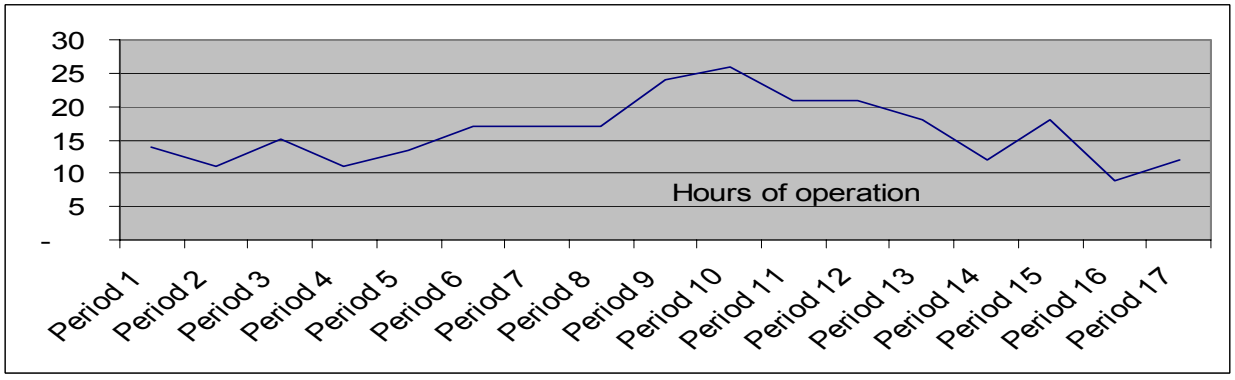


Tree and brush cutting square meters cleared	90,480	82%
Soil disturbance / ground preparation square meters cleared	12,855	12%
Termite mound leveling square meters cleared	6,879	6%
Total square meters cleared	110,214	100%

Trends and assessments of potential

We have analyzed performance trends for each of the three modes of operation. In all cases, the results indicate generally improving trends in respect of productivity per hour of operation. However, hours of utilization peaked in mid-January 2002. It should be noted that the latter stages of the project (January through March 2002) coincided with two significant ceremonies or demonstrations that undoubtedly added extra impetus to clearance efforts. Nevertheless, these occasions did provide ideal opportunities to assess more optimal performance data.

Trend analysis was performed both in terms of quartiles and for successive periods of six days of operations.



Performance by quartile - tree and brush cutting			
	Hours	Sq. Mts.	Sq. Mts. per hr.
First	46.5	5,580	120
Second	56.5	22,100	391
Third	94.0	43,700	465
Fourth	24.5	19,100	780
	221.5	90,480	408

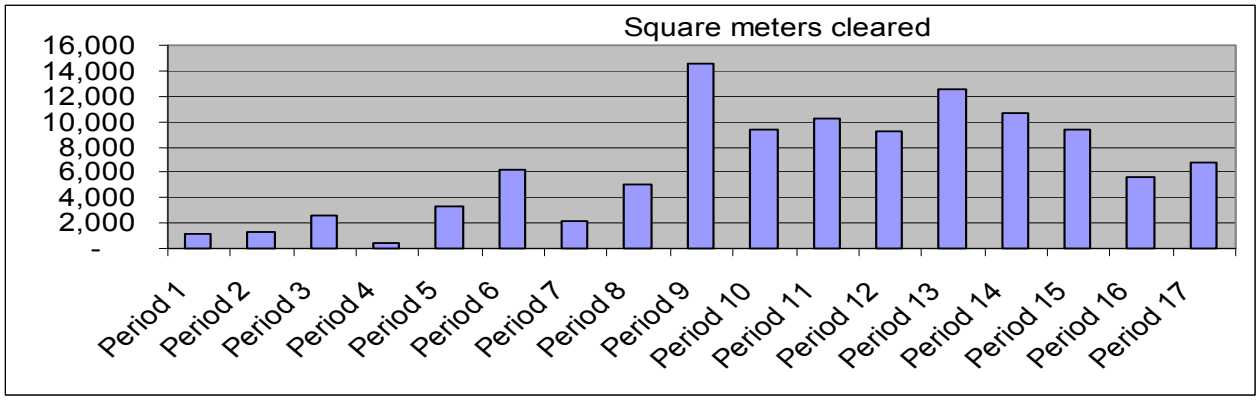
Performance by quartile - soil disturbance/ground preparation			
	Hours	Sq. Mts.	Sq. Mts. per hr.
First	10.0	455	46
Second	11.5	1,800	157
Third	-	-	-
Fourth	22.0	10,600	482
	43.5	12,855	296

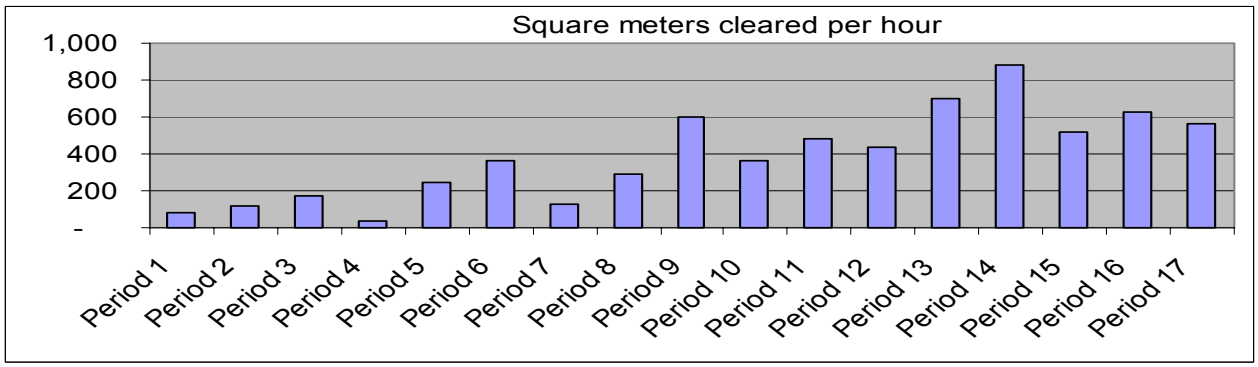
Performance by quartile - termite mound leveling			
	Hours	Sq. Mts.	Sq. Mts. per hr.
First	-	-	-
Second	2.0	54	27
Third	-	-	-
Fourth	9.5	6,825	718
	11.5	6,879	598

Performance by quartile - combined operations			
	Hours	Sq. Mts.	Sq. Mts. per hr.
First	56.5	6,035	107
Second	70.0	23,954	342
Third	94.0	43,700	465
Fourth	56.0	36,525	652
	276.5	110,214	399

Trends observed over 17 periods of 6 days of operation per period:

Combined operations (per six day operating periods)			
	Hours	**Sq. Mts.**	**Sq. Mts. per hr.**
Period 1	14.0	1,090	78
Period 2	11.0	1,290	117
Period 3	15.0	2,550	170
Period 4	11.0	405	37
Period 5	13.5	3,354	248
Period 6	17.0	6,200	365
Period 7	17.0	2,100	124
Period 8	17.0	5,000	294
Period 9	24.0	14,500	604
Period 10	26.0	9,400	362
Period 11	21.0	10,200	486
Period 12	21.0	9,200	438
Period 13	18.0	12,600	700
Period 14	12.0	10,600	883
Period 15	18.0	9,300	517
Period 16	9.0	5,625	625
Period 17	12.0	6,800	567
Totals and average	276.5	110,214	399





One area of analysis that produced somewhat surprising results was the comparison of productivity according to operating shift duration. Intuitively, we had expected that overall productivity would improve for longer shift durations where advantages could accrue from greater task continuity. As is evident from the analysis below, such a pattern did not exist. Indeed there is some evidence in the results analyzed for January to March 2002 that suggests operator fatigue may become a factor when shift duration exceeds three hours. However, there are numerous variables that may have impacted or distorted those results, and consequently we don't believe we are in a position to draw conclusions in this regard.

Performance by daily length of shift operating hours – for project duration			
	Hours	**Sq. Mts.**	**Sq. Mts. per hr.**
Less than 2 hours	25.0	8,844	354
Between 2 & 3 hours	63.5	26,760	421
Between 3 & 4 hours	78.0	30,380	389
Between 4 & 5 hours	57.0	20,730	364
5 hours and more	53.0	23,500	443
	276.5	110,214	399
Averages	2.8	1,102	399

Performance by daily length of shift operating hours in 2002			
	Hours	Sq. Mts.	Sq. Mts. per hr.
Less than 2 hours	9.0	6,125	681
Between 2 & 3 hours	27.0	19,100	707
Between 3 & 4 hours	51.0	27,700	543
Between 4 & 5 hours	33.0	14,500	439
5 hours and more	47.0	22,100	470
	167.0	89,525	536
Averages	3.0	1,628	536

CIDC suggests that minimum performance targets for TMAC, in the context of conditions at Nong Ya Kaoh and the operational framework of HMAU1, should be:

	Hours	Sq. Mts.	Sq. Mts. per hr.
Daily	5	2,500	500
Weekly	25	12,500	500
Monthly	100	50,000	500
Annually	900	450,000	500

Fuel, parts and consumables consumption, and routine running costs

Due to the fact that TMAC did not have a budget for fuel and consumables for the BDM48, CIDC supplied the fuel and paid certain amounts for repairs and consumables throughout the assignment. TMAC will ensure that adequate funds are budgeted for these routine running costs in future. The unbudgeted costs incurred by CIDC in this regard were:

Cost category	Baht	Cdn.$ equiv.
Fuel	115,128	4,264
Hydraulics fluids, lubricants and other consumables	6,610	245
Parts and repairs	14,809	548
	136,547	5,057
Exchange rate used: Baht27=$1		

A reconciliation of fuel costs (averaging about Cdn.$0.52 per litre) with aggregate recorded litres consumed lends credence to the reported fuel consumption rates and engine hours reported as follows:

Fuel consumption	**Litres per hr.**
Tree and brush cutting	29.9
Soil disturbance / ground preparation	24.8
Termite mound leveling	26.5
Average	28.9

Reconciliation of engine hours	
Engine hours at commencement on August 15, 2001	3,217.0
Engine hours on completion on March 31, 2002	3,506.0
Engine hours run during period under review	289.0
Operating hours reported	276.5
Engine hours in excess of operating hours	12.5
Discrepancy percentage (attributed to downtime running)	4.5%

The most significant maintenance problem encountered was the chaffing and failure of hydraulic lines on the boom caused by a combination of operator error (in the early stages) and insufficient protection by wrapping of the lines in vulnerable areas. With the input of ProMac, remedial action was taken.

The BDM48 stood up well against the two AP mine blasts sustained, although a small number of *teeth* on the drum unit had to be replaced. Routine repairs and replacement of *teeth* were carried out by the operators without difficulty, and the rate of wear and breakage of *teeth* was considered to be within normal parameters for the conditions encountered, and considering the relative inexperience of the operators during early stages of the project.

Other maintenance procedures were generally satisfactory, although ProMac did find it necessary to re-emphasize to the operators the importance of a number of regular routines such as greasing certain key components of the equipment.

Taking together the costs associated with inventory consumption and the cash running costs paid by CIDC, the average cost per engine hour of running the BDM48 (excluding any allocation of maintenance labour costs for the equipment operators) was Cdn.$28.46, as detailed below. However, no major maintenance work was performed during our assignment, and given the number of hours operated by the equipment during the duration of the project (276.5 operating hours and 289 engine hours) an element of deferred maintenance has accrued for which costs are not yet quantifiable.

Accordingly, it should be anticipated over time that hourly running costs will be greater than the recorded $28.46.

Breakdown of hourly running costs		
Fuel	$	14.88
Hydraulics fluids & lubricants		1.57
Repairs and parts consumed		12.01
	$	28.46

Parts and consumables inventory consumption

Item Description	Unit cost Baht	Used	Expense Baht	Expense Cdn.$ equiv.
Case Kim Wipes 12 Rolls	1,488	1	1,488	55
Hose C/W 20-26JICFX20JICF	10,948	1	10,948	405
Fuel Filter Kit	508	1	508	19
Case Drain Filter	326	1	326	12
Pilot Filter	695	1	695	26
Pins	44	3	132	5
Plates	568	1	568	21
20 ltr Pails 15/40 Oil	1,346	2	2,692	100
Cans WD 40	113	8	904	33
5 1/2" Ny-ties	4	30	120	4
9KG 88 Gouging Welding Rod	4,768	1	4,768	177
2.3KG 64020 UNICROM	5,631	1	5,631	209
Bits	873	10	8,730	323
Bits	745	8	5,960	221
Wedge	1,178	9	10,602	393
Belt	9,522	1	9,522	353
15J215 Bearing Set	15,304	1	15,304	567
			78,898	**2,922**

Acknowledgements

CIDC wishes to acknowledge the important contributions to the project made by the following:

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Maj. General Gitti Suksomstarn
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Project data remains on file and may be made available, as appropriate, to approved interested parties.

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