CAMBODIAN MINE ACTION CENTRE (CMAC)

MECHANICAL MINE CLEARANCE IN CAMBODIA

Presented by: Roath Kanith
Position: Director of Training, Research & Development Department
Presented date: Tuesday 09th/9/2008

CONTENT

- Chapter 1: CAMBODIA Background
- Chapter 2: CMAC Background
- Chapter 3: Technologies employed by CMAC
- Chapter 4: Mechanical Demining Machine employed by CMAC
- Chapter 5: Mechanical Demining Equipment tested by CMAC
CHAPTER 1

CAMBODIA BACKGROUND &
THE BACKGROUND OF MINE/UXO PROBLEM IN CAMBODIA

CAMBODIA BACKGROUND

- Location: Indochina – South of China (sandwich between Vietnam and Thailand)
- Size: 181,035 sq.km
- Current Population: Approximately 14 Million people
- Capital: Phnom Penh (Approximately 1.4 Million People)
- Famous world heritage: Angkor Wat
- Glorious day: 9th – 13th Century (Khmer Empire)
- Turmoil path: The invasion of Mongolia in Asia (late 13th Century), Internal conflict, Lost of territory, and under French control from 1863 - 1954

BRIEF HISTORY OF LANDMINE/UXO PROBLEM IN CAMBODIA

- WORLD WAR II (Allied dropped bomb to chase the Japanese out of Cambodia)
- FRENCH INDOCHINA WARS (Struggle for independent from France): pre 1954
- VIETNAM WAR – Border infiltration to disrupt the VC supply line and B-52 carpet bombing (Operation MENU)
- 1979 – 1998: Guerrilla war through out Cambodia
Mine/UXO problem in Cambodia

UXO POLLUTED AREA:
- PERIOD: 1970-1979 (BORDER WAR WITH VN)
- QUANTITY: UNKNOWN

UXO POLLUTED AREA:
- PERIOD: 1979-1989 (CIVIL WAR)
- QUANTITY: UNKNOWN

TOTAL LANDMINE QUANTITY IN CAMBODIA:
- SOURCE A: APPR. 10 MILLIONS LANDMINES
- SOURCE B: BETWEEN 4-6 MILLIONS

UXO POLLUTED AREA:
- PERIOD: 1970-1975
- BOMB FROM US PLANES: >500,000 TONS (10%-15% UXO)
- GROUND ROCKET, MORTAR, SHELLS... (UNKNOWN QUANTITY)
## LANDMINE/UXO Problem in Cambodia - Summary

<table>
<thead>
<tr>
<th>Polluted Areas in Cambodia</th>
<th>Landmines</th>
<th>Land Ordinance (UXO)</th>
<th>Air Ordinance (UXO)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>West</strong></td>
<td>HIGH</td>
<td>MEDIUM</td>
<td>LOW</td>
</tr>
<tr>
<td><strong>East</strong></td>
<td>LOW</td>
<td>MEDIUM</td>
<td><strong>HIGH</strong></td>
</tr>
</tbody>
</table>

## Chapter 2

CMAC Background
THE BACKGROUND OF CMAC

- 1979: Cambodia-all-female demining team established (to clear agriculture land in eastern part of Cambodia near Vietnam border) – people republic of Kampuchea military engineer
- 1991: Peace treaty signed in Paris end civil war but Khmer Rouge continue arm struggle
  - Refugee return from camp in Thailand
  - Resettle at their hometown (polluted by landmine/UXO)
- 1991: Mine clearance training unit (MCTU) – UNAMIC
- 1993: Mine clearance action centre (cmac) – UNTAC + Royal Government of Cambodia
- Currently cmac employed:
  - More than 2000 very experienced staff: more than 90 percent at field
  - Mine clearance machine: brush cutter, demining machine
  - Mine detection dog (MDD)
  - UXO detection dog (EDD)
  - Sophisticated demining technology, standard operating procedure (sop)
  - And much more....

CMAC STRUCTURE

Staff: 2,300
CMAC productivities

Area cleared by CMAC

Survey Marking by CMAC

- More than 4,000 sq. km are contaminated area
- Between 30 – 40 sq. km clearance capacity in Cambodia.
- Deadline is near → Promote survey marking and area reduction

Average Productivity = 1.2 ha/person/year

Figure in 2008 is a projected figure.

CMAC productivities (Cont.)

AP mine found by CMAC

AT mine found by CMAC

UXO found by CMAC

Average Productivity: 64 items (mine/UXO)/person/year
PART III

TECHNOLOGIES EMPLOYED BY CMAC

METAL DETECTOR

<table>
<thead>
<tr>
<th>No.</th>
<th>Metal Detector Type</th>
<th>Quantities, set</th>
<th>Made from</th>
<th>Deployment date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mine Lap F1A4</td>
<td>2378 Sets</td>
<td>Australia</td>
<td>Since 1997</td>
</tr>
<tr>
<td>2</td>
<td>Bomb Locator Value</td>
<td>15 Sets</td>
<td>Germany</td>
<td>Since 1997</td>
</tr>
<tr>
<td>3</td>
<td>Ebinger UPEX 740M</td>
<td>62 Sets</td>
<td>Germany</td>
<td>Since 2000</td>
</tr>
<tr>
<td>4</td>
<td>Ebinger 421C</td>
<td>60 Sets</td>
<td>Germany</td>
<td>Since 2004</td>
</tr>
<tr>
<td>5</td>
<td>Mine Lap F1A4 UXO</td>
<td>24 Sets</td>
<td>Australia</td>
<td>Since 2005</td>
</tr>
<tr>
<td>6</td>
<td>Mine Lap F3</td>
<td>12 Sets</td>
<td>Australia</td>
<td>Since 2006</td>
</tr>
<tr>
<td>7</td>
<td>Sera (deep search)</td>
<td>6 Sets</td>
<td>Italic</td>
<td>Since 2007</td>
</tr>
<tr>
<td>8</td>
<td>FEREX UXO/deep search</td>
<td>6 Sets</td>
<td>Germany</td>
<td>Since 2007</td>
</tr>
</tbody>
</table>
BRUSH CUTTER (MANUAL)

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Quantity</th>
<th>Since</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass Cutter, RM311</td>
<td>3</td>
<td>1997</td>
</tr>
<tr>
<td>Grass Cutter, Honda GX31</td>
<td>97</td>
<td>2003</td>
</tr>
<tr>
<td>Grass Cutter, RM385</td>
<td>3</td>
<td>2004</td>
</tr>
<tr>
<td>Grass Cutter Machine</td>
<td>2</td>
<td>2005</td>
</tr>
<tr>
<td>Grass Cutter, Honda GCAG</td>
<td>12</td>
<td>2006</td>
</tr>
</tbody>
</table>

MINE DETECTION DOG (MDD) & EXPLOSIVE DETECTION DOG (EDD)

- **Mine Detection Dog (MDD):**
  - Long Leash
  - Short Leash
- **Explosive Detection Dog (EDD):**
  - Short Leash

- Acquired: Since 1997 (Green Dog)
- Deployment: Since 2000
- Current Quantity: 60 Dogs (52 – MDD + 8 EDD)
- MDD target: 25,000 sq.m (from 2000)
- EDD target: 30,000 sq.m (from July 2007)
BRUSH CUTTER (⇒ DEMINING MACHINE)

- Japanese – Made
- Status: Brush Cutter + Demining Machine

<table>
<thead>
<tr>
<th>Machine</th>
<th>Quantity</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Hitachi EX 150BC</td>
<td>2</td>
<td>2000</td>
</tr>
<tr>
<td>2 Hitachi ZX 160</td>
<td>23</td>
<td>2003</td>
</tr>
</tbody>
</table>

PART IV

MECHANICAL DEMINING MACHINE
EMPLOYED BY CMAC
DEPLOYMENT RESOURCES

- 2001 – 2003: 4 Brush Cutters (2 Komatsu)
- 2003 – 2005 (June): 12 Brush Cutters
- July 2005: 26 Brush Cutters

BC TEAM STRUCTURE

The Team Structure:

<table>
<thead>
<tr>
<th>Time</th>
<th>Operators</th>
<th>Deminers</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-2004</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004-2006</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006-Present</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- BC role: Support Deminer
- BC role: Open Access route & Clear Small task
- BC role: Open Access route and clear medium task
BC PERFORMANCE

Cuts dense veg. 25,000 sq.m/month (21 workday x 7 hours ops.)
Can grab a heavy and long object (up to 6m)
Cuts medium veg. 35,000 sq.m/month (21 workday x 7 hours ops.)
Could work on dangerous contaminated area
Cuts light veg. 45,000sq.m/month (21 workday x 7 hours ops.)
Can recover itself from soft ground
Can work on 25 Degree slope

BC PERFORMANCE (CONT.)

Can engage in AP clearance activity
BC assists in EOD work
Can destroy any AP and immune to AP blast.
Note: Operator is safe from double stack AT blast under attachment
BC could withstand Anti-Tank RPG
BC could withstand Mortar 60mm

Dig hole to identify deep UXO
Lift heavy UXO into truck
BC DEPLOYMENT

- 1 BC + 4 Deminers; Productivity: 2ha/month
- 1 BC + 1 Platoon (25 deminers); Productivity 3ha/month
- 1 BC + 2 LLD; Productivity: 3ha/month
- Could assist in Socio-economic development of the area.
- Multi-function: could be able to clear fragments by using attached magnetic tool
- Support area reduction

COMMON PROBLEM FOUND WHILE USING BC

1. Cutting bit holder is broken
2. Seal is broken due to dirt & dust
3. Arm or Bucket cylinders are damaged due to fallen tree
4. Hydraulic central joint is damaged due to BC hit tree stump
5. Rack is damaged due to overwork
6. Track is damaged due to long trekking & AP explosion
7. External hydraulic host is damaged due to tree branch
DAMAGED CAUSED BY RECOVERY FROM BEING STUCK IN SOFT GROUND

1. AC compressor
2. Air Filter
3. Starter
4. Radiator
5. Engine

PROBLEM DURING FIELD REPAIR/MAINTENANCE

CMAC MECHANICIAN (ON-SITE REPAIR)

Items put the ground
Items put wood
PART V

MECHANICAL DEMINING EQUIPMENT TESTED BY CMAC

Relationship between technology and achievements

High density of vegetation

Vegetation elimination

Vegetation removing system (BC)

Major constraints in Mine Clearance Operation

Explosive Detection Technology (MDD, EDD)

Mechanical demining machine
- Demining Machine (Anti-Personnel Mine, Anti-Vehicle Mine)
- UXO clearance machine (cluster bomb, <80mm)

Fragment elimination techniques/tools

High density of fragment

FRAGMENT ELIMINATION EQUIPMENT (MINE DETECTOR)
TECHNOLOGIES TESTED BY CMAC

- Test and trial of Flails from Finland
  - March 1998 – early 2002

- Test and Trial of Rhino
  - December 1999 – May 2000

- Test and Trials of Brush Cutters
  - 1999 – 2005

- Multi-tools bucket
  - Ongoing

- Test and Trial of Mechanical Demining Machine (MDM)
  - 2006 (phase I)
  - January – November 2008 (Phase II)

MULTI-TOOL SHIFTER BUCKET

- US – Made
- Status: In research & Evaluation
TEST AND EVALUATION OF MECHANICAL DEMINING MACHINE
- PHASE I

MECHANICAL MINE CLEARNCE: PHASE I

- MANUFACTURERS:
  - KOMATSU (1 MACHINE),
  - HITACHI (2 MACHINES)
  - KAWASAKI (1 MACHINE LATER WITHDREW)
- JAPAN AGENCY: JICS
- EXECUTIVE AGENCY: CMAC
- TEST LOCATION: SIEM REAP (Por Pel - 1h drive) & BATTAMBANG (O DAUNPOV – 1h drive)
- TIME: MAY – DECEMBER 2006
- TESTS:
  - PERFORMANCE
  - SURVIVABILITY
  - ACCEPTANCE
  - TRANSPORT
  - REPAIR/MAINTENANCE
KEY PARTICIPANTS

HITACHI – SWING TYPE

KOMATSU

HITACHI – PUSH TYPE

CMAC RESEARCH: FACILITY

• Test site (Survivability & Performance) at Siem Reap province
• Test site (Acceptance test) at Battambang province
MECHANICAL MINE CLEARANCE TEST & EVALUATION

- Test criteria:
  - Performance test
  - Acceptance test
  - Survivability
  - Repair/maintenance
  - Transportation

1. Clearance quality in dry, wet & bush conditions (10cm, 15cm, 20cm and mix depth)
2. Clearance productivity (sq.m/h)
3. Fuel (Litre/h)
4. Maintenance
5. Transportation
6. Machine/operator survivability (detonating AT mines under the bucket/drum)

TEST SITE FACILITY AT SIEM REAP

ENTRANCE TO TEST SITE

DRY LANE

LIGHT BUSH

CMAC R&D FACILITY (SIEM REAP, CAMBODIA)

WET LANE
PHASE I TEST RESULT OF DEMINING MACHINE

Damaged firing pin

Damaged mine

SHIP I TEST RESULT OF DM - EXAMPLE

CLEARANCE PRODUCTIVITY RATE, SQ.M/HOUR

CLEARANCE QUALITY OF AP MINE BY SWING MACHINE, PERCENTAGE

CLEARANCE QUALITY OF SWING MACHINE, SQ.M/LITER

EXAMPLE - TEST RESULT OF DM
TEST AND EVALUATION OF MECHANICAL DEMINING MACHINE - PHASE II

MECHANICAL MINE CLEARNCE: PHASE II (Integration test)

- Manufacturers: Komatsu (1 machine), Hitachi (2 machines)
- Machine: Upgraded version
- Japan agency: JICS
- Executive agency: CMAC
- Test location: Battambang (Rattanak Mondul district – 1h Drive)
- Tool participated: Manual, MDD (LLD) and BC.
- Machine deployment: March, April – November 2008
- Test: integration test (the integration of mechanical mine clearance and Deminer, metal detector, brush cutter & MDD)
- Test site selection: Suspected area (The lowest risk area)
R&D phase II - Productivity

- Cleared area: 182 ha
- AP: More than 1,500 pieces (T72, T69, AT, IP)
- Komatsu: More than 20ha
- Hitachi Push type: More than 20ha
- Hitachi Swing type: More than 20ha
- AT accident: 2 times (Hitachi push & Swing types)
ACCIDENT & MINE FOUND AT TEST SITE

- Many T72 mines are found in Baboo area (nearby the creek)
- Depth is more than 20cm
- Some place, there are 2 layers of AP T72. Clearance method:
  1. Manual
  2. BC
  4. BC
  5. Manual

Dead cow found in Minefield

Cow’s leg is blown off by AP mine

Villager is plowing the field

T72 – is cleared by BC (2 layers)

Improvised mine (fertilizer) is found in Minefield

ACCIDENT – PUSH TYPE

- Accident date: 02nd April 2008
- Victim: Demining machine – Hitachi Push type
- Explosion: 2 AT + 2 Rocket (Improvised)
- Result: Partially damaged the flail; Operator is OK.

Villager plowing the field

Improvised mine (fertilizer) is found in Minefield

Demining machine – Hitachi Push type

AT and Rocket (Improvised)
ACCIDENT – SWING TYPE

- Accident date: 21\textsuperscript{st} April 2008
- Victim: Demining machine – Hitachi Swing type
- Explosion: 2 AT
- Result: Partially damaged the attachment; Operator is OK.

RESULT

\[ C_i = \sum (F,M,R,T,O,Dep)/(S) \]

Where,
- \( C \) – Clearance cost per m\(^2\)
- \( i \) – Type of the machine
- \( F \) – Fuel cost
- \( M \) – Maintenance cost
- \( R \) – Repair cost
- \( T \) – Transport cost
- \( O \) – Operator cost
- \( Dep \) – Depreciation cost of the machine
- \( S \) – Area cleared by the machine

CLEARANCE COST VARIED: $0.1 - $0.2 / SQ.M
Manual demining platoon working at the same condition and at the same duration, the platoon would produce the following result:
- **Without the assistance from Komatsu demining machine**, the platoon could clear 160,000m².
- **With the assistance from Komatsu demining machine**, the platoon could clear 385,148 m².

Thus, the **Komatsu Demining machine could indirectly boost the productivity of the manual demining by 241% or 2.41 times**.

### 6.3 The Direct Impact of the Komatsu Demining Machine on Mobile Platoon

If the Komatsu machine is attached to a platoon of deminer, in each month, this integrated clearance team would produce the following result as shown in table below:

<table>
<thead>
<tr>
<th>Tool</th>
<th>Quantity</th>
<th>Duration</th>
<th>Total Productivity</th>
<th>Productivity per month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demining Machine</td>
<td>1</td>
<td>9 Months</td>
<td>243,172 m²</td>
<td>46,344 m²/month</td>
</tr>
<tr>
<td>Manual Demining</td>
<td>1</td>
<td>9 Months</td>
<td>365,148 m²</td>
<td>46,144 m²/month</td>
</tr>
<tr>
<td>1 Platoon + 1 Komatsu demining machine</td>
<td></td>
<td></td>
<td></td>
<td>96,770 m²/month</td>
</tr>
</tbody>
</table>

**The integration of Komatsu Demining Machine with Manual Demining Platoon could clear 96,770 m² per month**.

Photos:
- Photo 14: Before mine clearance (zone step out)
- Photo 15: After clearance from field
- Photo 16: Before mine clearance (zone step on)
- Photo 17: After clearance (People are planting crops, not dormining)
CMAC COMMENTS ON MDM

• BC is best used as Brush Cutter and top surface AP clearer. To become MDM, it has to:
  – Increase size and length of bit holder
  – Increase power of motor (slower but more powerful)
• Tiller attachment is more productive and less maintenance than flail attachment
• Excavator system has more functions and user friendly than any other system (such as bulldozer system)
• Mechanical Demining Machine shall not weight more than the maximum load of the bridge in mine/UXO contaminated area (maximize mobility)

THANK YOU FOR YOUR ATTENTION