Road Verification and Clearance in Eastern Angola: The DCA Approach

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Mining Clearable Survivable Vehicle

Based on the success of the multi-tool-attachments concept used in the SDTT, the HD R&D Program invested in the Mantis mine- and vegetation-clearance system. As its platform, the Mantis uses a modified and enhanced 6x6 farm tractor capable of operating a number of specialized and commercial off-the-shelf implements to address some of the vegetation clearing, soil preparation, area reduction, quality assurance, and mine removal and neutralization problems in humanitarian-demining operations. The system is equipped with front and rear power take-offs, standard three-point latches in the front and rear, and a loader frame. The tractor was modified, armored, and restructured under contract to the HD R&D Program by Pearson Engineering Ltd.

The purpose of developing a system such as the Mantis is to provide deminers with a mine-survivable vehicle that has multiple functions and is based on a COTS technology (i.e., John Deere farm tractor). The tractor has been armored, fitted with a 180-degree rotating driver's cab and anti-personnel/mine-survivable SETCO wheels with an innovative wheel-hub interface incorporating a dowel and plate design. This design allows the wheel to separate from the axle in the event of an anti-tank mine detonation, thus reducing the shock effect through the axle. This is the prime mover for a suite of COTS and specialized implements generally used by the construction and earth-moving industries but also applicable to humanitarian requirements. Along with the mine-removal tool kit the Mantis and its complementary tools underwent a thorough performance evaluation conducted by the HD R&D Program staff members and supported by engineers from the United Kingdom under the auspices of the International Test and Evaluation Program for Humanitarian Demining. For the soil and vegetation within the environment where the testing occurred, the results of the performance-demonstration assessment show the Mantis and its demining and area-preparation tools can prepare an area for demining, remove anti-personnel mines and leave an area ready for quality-assurance probing and subsequent use.

Based on the positive results from the evaluation, the HD R&D Program deployed the Mantis to Nicaragua in spring 2005 for an operational field evaluation. Under the direction of the Nicaraguan Army Demining Units, the Mantis is currently performing in a minefield 6 kilometers (4 miles) long with Class II (medium to severe) vegetation and terrain near the town of Jinotepe. In the first four months of operation in Nicaragua, the Mantis removed 9,600 kilograms (21 tons) of metal with the magnetic attachment and cleared 64,050 square meters (16 acres) of land (clearing vegetation, and cultivating and sifting soil). NADU members also reported the blast-resistant SETCO tires were extremely effective in encounters with PMN mines,\(^1\) not incurring any damage to the tires even when hit. In addition, the roller attachment has encountered and demolished 10 PMN mines and the cultivator has unearthed numerous UXO items. To date (in combination with the Hitachi excavator), NADU members have removed 14,529 mines and cleared 436,175 square meters (110 acres) of land for further manual and mine-detection dog quality assurance. In fact, after the mechanical clearance process with the Hitachi and Mantis, five mines remained in the entire area. Further investigation is underway to determine why these mines were left in the ground. Early indications suggest the mines were outside of the area worked by the machines, their fuses were non-functioning, or they were deeply buried.\(^2\)

In the right conditions, mechanical de- mining with versatile mechanical systems such as the SDTT and Mantis allow for fast, safer and more efficient mine clearance. However, minefield locations and conditions often preclude the use of such machines. For example, the Mantis is not intended for use in minefields with the threat of anti-tank mines. The Nicaraguan mechanical-clearance effort has not proven to be completely effective because of this fact. However, with continued effort in developing operating procedures and development of attachments for multi- tool systems like the Mantis and SDTT, the HD R&D Program is confident the SDTT and Mantis, with their associated tools, will provide the humanitarian-demining community with highly reliable, cost-effective systems augment current databases of de- mining tools and expand area-reduction and demining capabilities.\(^3\)

Figure 1: DCA wide-area detection system.

Figure 2: WADS electronic control module.

The DCA Approach to road verification and clearance in eastern Angola is comprised of five stages: 1. Road reconnaissance; 2. Road survey and target definition; 3. Target prioritisation; 4. Target investigation and clearance; 5. Quality-assurance survey.

During three decades of internal conflict, much of Angola’s infrastructure was destroyed. Within Angola and Lunda Sul provinces, the constant eb and flow of military forces left the majority of bridges destroyed, a high number of principal roads mined and access to towns and villages restricted because of defensive minefields.

In 2004, DanChurchAid conducted a general assessment of the mine situation within Lunda Sul and province in eastern Angola. Even though many areas were impacted by minefields obstructing construction or hindering agriculture, the ever-present anti-tank mine threat on the main and minor access roads was determined to be a fast-grocer impediment to the repopulation of refugees, relocation of internally displaced persons, re-establishment of infrastructure and distribution of essential supplies to isolated villages.

Because there was no road-verification capability in Angola, the DCA investigated existing verification and detection systems that had been or were being used elsewhere. A system similar to the Kinematic Induction Magnetic (KIM) vehicle developed by UBX AFRICA in 2002 to verify roads in the Temporary Security Zone along the border between Eritrea and Ethiopia, was deemed appropriate.\(^4\) In mid-2004, DCA decided to fund the design, construction and testing of a second-generation wide-area detection system (WADS), which was to be used in conjunction with a road-clearance team (RCT).

The DCA WADS was built in the Republic of South Africa with the assistance of Regis Trading International. Its arrival in Lunda, Mozambique province, in June 2005 was followed by the recruitment and training of the WADS team and the RCT and the WADS static and dynamic system calibrations. In October 2005, the WADS conducted 214.5 kilometers (133.5 miles) of preliminary road surveys in 45 hours in province, Mozambique. More than 28,000 targets were detected during the surveying (approximately 1,812,800 square meters (468 acres) were searched down to a depth of one meter.\(^5\) The combined WADS-RCT operation successfully completed two days of acceptance field trials in the first months and was accredited by the Comissão Nacional Intersectorial de Deminagem e Assistência Humanitária/United Nations Development Programme.

DCA Approach

The DCA approach to road verification and clearance in eastern Angola is comprised of five stages: 1. Road reconnaissance; 2. Road survey and target definition; 3. Target prioritisation; 4. Target investigation and clearance; 5. Quality-assurance survey.

Road reconnaissance. Prior to undertaking survey, verification or clearance activities along a given road, DCA compiles available data on the conflict history in the area and mine incidents along the road to determine the nature of the threat. Road and road-environment attributes impacting subsequent activities such as road type, road width, road-surface condition and degree of vegetative encroachment are second in a reconnaissance survey. The data collected during this phase is recorded in a geographic-information-system database and is used to produce WADS and RCT work plans and maps.

Road survey and target definition. Roads are surveyed using the vehicle-mounted DCA WADS. The system is pictured in Figure 1: it is mounted on a trailer and the sensor array can be set up with one to eight Ebinger Upex 740 sensor coils in different configurations, depending on terrain and survey task, to delineate survey task and the nature of the mine threat. In Mozambique and Lunda Sul provinces, 5-75 meters wide sensor arrays in the 1.0-metre by 1.0-metre and or 0.5- meter by 0.5-metre are consistent with measurement surveys.

At a survey speed of five kilometers per hour (three miles per hour), metal-anti-tank and magnetic fragments mines and some of the larger anti-personnel mines, such as the PMN and PIM-2, are easily and consistently detected by sensors in the 1.0-metre by 1.0-metre configuration. Survey speeds of up to 10 kilometers per hour (six miles per hour) for metal-anti-tank targets are being sought. Minimum-metal mines cannot be consistently detected with this configuration.

Incoming data streams acquired during the receiver phases of the Tx/Rx cycles of the sensor coils are acquired by in-vehicle electronic

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\(^{1}\) NADU is accredited by the UN Assistance to Visually Impaired the Commission on the Rights of the Child, the UN Committee on Economic, Social and Cultural Rights, and the UN Human Rights Committee.

\(^{2}\) NADU encountered various UXO items such as RGD-5 fragmentation rounds, early indications suggest the mines were outside of the area worked by the machines, their fuses were non-functioning, or they were deeply buried.\(^2\)

\(^{3}\) See Endnotes, page 113

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control units and subsequently routed to an analog-to-digital converter. The digital-sensor data streams are captured by Ebinger MonMX data-acquisition software running on a laptop computer. One differentially corrected GPS data stream from the Omnistar Differential GPS system is also routed through the analog-to-digital converter and is subsequently acquired by the MonMX software. The in-vehicle electronics module is shown in Figure 2.

Sensor team parameters are as number of sensors, sensor-coil configuration, sensor-array configuration, and longitudinal, lateral and vertical GPS-sensor offsets are pre-survey inputs. The location and nature of road environmental researches that adversely affect the quality of the survey data are recorded on a Psion Datalogger and incorporated into the database as warning flags.

The MonMX software provides a real-time display of sensor-coil acquisitions and system location. The electromagnetic and GPS data files saved by the MonMX software are subsequently merged and saved into a single geo-referenced data file for later processing by the Ebinger DLMX software.

The GeoSoft Oasis Montaj software is used for data processing and target selection. For a given road segment, one to five kilometres (0.6 to three miles), all of the geo-referenced data files are merged into a single database that is subsequently edited to remove erroneous data entries caused by satellite data-fed reception problems. Warning flags are inserted where road environmental events, such as large metal items on the side of the road or obstacles such as trees and bicycles, negatively impacted sensor-coil performance.

The merged and edited data is processed using appropriate mathematical algorithms, and targets are defined. A 3 x 3 metre work map of the surveyed road sections showing the location of all of the sensor readings, target locations, warning flags and a Universal Transverse Mercator grid are produced for use by the re-acquisition and clearance teams.

The data used to create work maps was obtained using a 7.5-metre-wide six-sensor array. The total search width in the example is approximately 1.6 metres, or one metre of each side of the target. A cross-section of the subsurface volume in which a TM-46 anti-tank mine can be detected is shown in pink in Figure 3. The work map of the digital maps along with tables containing all the relevant information about the targets are downloaded into an RCT field computer for further analysis using Environmental Systems Research Institute’s Geographic Information Systems software. Target location files are also uploaded into Omnistar Pion Dataloggers for use by reacquisition teams to navigate to the targets.

Sensor and target locations, road attribute data collected during surveying activities, and target attribute data collected during reacquisition and clearance activities are also incorporated into a GIS database for further analysis and the production of thematic maps.

Target reacquisition

Target reacquisition is carried out by a two-person team that is part of the RCT. One of the team members is equipped with an Omnistar RD-133, 12-channel GPS receiver and Omnistar Pion Datalogger, which contains target coordinates for a given section of road. When receiving differentially corrected satellite data, sub-metre accuracy is possible and the Psion Datalogger is used to navigate to within 20 centimeters (8 inches) of the target location.

The care-mounted GPS antenna allows the reacquisition team to safely approach to within two metres of the target. After the team reaches the target location, a non-magnetic metal marker is placed on the ground surface. The second team member then marks a 2-metre by 2-metre search box around the target marker by placing red and white triangular shaped markers at each corner of the search box. He also assists in the navigation to the different targets using maps, and records the time of the target reacquisition and several key GPS position-fix parameters such as the number of satellites and Position Dilution of Precision (PDOP) values (Figure 5).

The rationale for selecting a 2-metre by 2-metre search box is based on GPS data recordings at the DCA GPS base station in Luena and on offsets recorded during target reacquisition activities. GPS readings were collected over a period of five days in September 2005 to monitor daily variations in DGPS position fixes. Between 5:00 and 11:00, the position shifts are less than one metre, whereas between 11:00 and 17:00 they range between seven and four metres. Position-fix offsets for 2,190 readings in the 5:00–11:00 window are presented in Figure 6. Ninety-nine percent of the position-fixes are within one metre of the station location. Less than one percent of the position fixes were more than one metre from the station location.

Figures 3 and 4

In 2006, several options are being considered to improve the productivity of the RCT. Some of the options under consideration include:

- Week-long target monitoring
- Development of situational awareness for the above-mentioned mine types is reduced by 98 percent. Using this methodology, the eight-person RCT has been able to verify and identify up to 2,500 targets (one mile) of road, or 18,000 square metres (four acres) of land, per day.

Quality-assurance survey. After completion of clearance activities for a given road segment (five to 10 kilometres) the WMD team resurveys the road segment. System configuration and survey parameters during the road survey activities are exactly the same as during the initial road survey. Maps from the two survey runs are compared to determine if all targets have been removed. A 50-metre section of the Luena-Lusunucua road is presented as an example in Figure 11. Missed targets and targets for which the collected target attribute data is not satisfactory are re-investigated by the clearance team. The two map sets, as well as the digital data for the two surveys, are saved for future reference.

Future Plans

In a 10-kilometre (six-mile) stretch of surveyed road containing 1,296 targets, 82 percent were comprised of loose scrap metal on the road surface, 15 percent were comprised of scrap metal embedded in the road surface and 3 percent were buried in the road base and required multiple investigations with the mini-excavator. It is clear that by reducing the number of scrap-metal targets requiring investigation by the RCT, the RCT will result in significant productivity gains. In 2006, several options are being considered to improve the productivity of the RCT. Some of the options under consideration include:

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Carrying out mechanical and/or manual presurvey road treatments to reduce the amount of loose scrap-metal on the road surface

Combining new explosive detection technologies with the WADS and/or incorporating them in RCT procedures to reduce the number of targets requiring time-consuming manual interventions.

Increasing the number of road-clearance teams. The authors would like to thank DanChurchAid for assistance in the preparation of the manuscript and for permission to publish this article.

Endnotes

An Alternative Perspective, Weight [from page 10 ]

1. "We'd like to introduce The Great Plague of London - a simulation game by Full-Tilt Productions." 16/2/2004,

2. The term for this is the so-called "pre-plunder advice" such as the late Princess Diana. Of course, the celebrities who lend their endorsements are compensated. However, are they doing so for the love of the cause or are they doing so for see if they are doing so for free to ensure the longevity of their image? The answer is clear, being compensated is a great way to get into international relations, military ally, they can save the world from bad things, and the logos are expressing their financial condition in the long run. Are recognised benefactors of fame is that it makes think they can get away with being in the judge of complex matters when they are not poor. Are compensated is that the fees of their image? It makes him think that celebrities lend money to lend money to the celebrity medium to some extent. Why would celebrities lend money to lend money to the celebrity medium to some extent?


4. For example, reflecting public demands, politicians advocating by them who essentially report to the present administration in the US, are involved with the problems with landmines that persist from conflicts in “peace.” See Rutherford, op. cit., 189.


6. For example, in 1987, the UN Secretary General, Javier Pérez de Cuéllar, through his Resolution 426 (1987), called for an immediate halt to the use of landmines. See UN Resolution 426, 1987.

7. "Life support” means that the Ugandans have to provide vehicles for their newly trained landmineclearers. See Rutherford, op. cit., 189.

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