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Road Verification and Clearance in Eastern Angola: **The DCA Approach**

The anti-tank mine threat on access roads in eastern Angola is the greatest impediment to infrastructural rehabilitation, economic recovery and social development in that area. The authors discuss the method and equipment used by DanChurchAid to verify and clear roads in Moxico and Lunda Sul provinces.

by Marcel E. Durocher and Anders Jansson [DanChurchAid]

During three decades of internal conflict, much of Angola's infrastructure was destroyed. Within Moxico and Lunda Sul provinces, the constant ebb and flow of military forces left the majority of bridges destroyed, a high number of principal routes 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 Moxico provinces 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 major and minor access roads was determined to be a far greater impediment to the repatriation of refugees, relocation of internally displaced persons, rehabilitation of infrastructure and distribution of essential supplies to isolated villages.

Because there was no road-verification capacity in Moxico and Lunda Sul provinces, DCA investigated existing verification and detection systems that had been or were being used elsewhere. A system similar to the Kinematic Induction Magnetic Survey, developed by UXB AFRICA in 2002 to verify roads in the Temporary Security Zone along the border between Eritrea and Ethiopia, was deemed appropriate.[1] 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).

Figure courtesy of Marcel Durocher

Figure 1: DCA wide-area detection system.

Figure courtesy of Marcel Durocher

Figure 2: WADS electronic control module.

The DCA WADS was built in the Republic of South Africa with the assistance of Regis Trading International. Its arrival in Luena, Moxico 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 kilometres (133.3 miles) of preliminary road surveys in 45 hours in Moxico province. More than 28,000 targets were detected during the surveys and approximately 1,812,300 square metres (448 acres) were searched down to a depth of one metre.[2] The combined WADS-RCT operation successfully completed two days of acceptance field trials in the Luena area in mid-November 2005 and was accredited by the *Comissâo Nacional Intersectorial de Desminagem e Assistência Humanitarian*/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 reacquisition
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 recorded during a reconnaissance survey. The data collected during this phase is stored 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 modular in nature and the sensor arrays can be set up with one to eight Ebinger Upex 740 sensor coils in different configurations, depending on road attributes, the type of survey task and the nature of the mine threat. In Moxico and Lunda Sul provinces, 5.5–7.5 metre-wide sensor arrays in the 1.0-metre by 1.0-metre and/or 0.5-metre by 0.5-metre configurations are adequate for most road survey tasks.[2]

At a survey speed of five kilometres per hour (three miles per hour), metal-jacketed anti-tank mines, fragmentation mines and some of the larger anti-personnel mines, such as the PMN and PPM-2,[3] are easily and consistently detected by sensors in the 1.0-metre by 1.0-metre configuration. Survey speeds of up to 10 kilometres per hour (six miles per hour) are possible if only large metal-jacketed 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 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-array parameters such 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 events 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-feed 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. A3 or A4 work maps 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 swath width in the example is approximately 9.0 metres. The search depth was approximately one metre. A cross-section of the subsurface volume in which a TM-46 anti-tank mine[4] can be detected by a 7.5-metre wide six-coil (1.0-metre by 1.0-metre configuration) sensor array is shown in pink in Figure 3.

Digital copies of the work 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 Psion Dataloggers for use by reacquisition teams to navigate to the targets.

Sensor and target locations, road attribute event 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 BD-132, 12-channel GPS receiver and Omnistar Psion 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 Datacorder is used to navigate to within 20 centimetres (8 inches) of the target location.

The cart-mounted GPS antenna allows the reacquisition team to safely approach to within two metres of the targets (Figure 4). After the team reaches the target location, a nonmetallic red 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 the work 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).[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 drifts are less than one metre, whereas between 11:00 and 17:00 they range between zero 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 1 percent of the position fixes were more than one metre from the station location.

Offsets between where the target is supposed to be located and where it is actually located were recorded for 962 surface targets spread over approximately nine kilometres (about six miles) of road. Ninety-nine percent (952 targets) were within one metre of their calculated positions. Ten targets (one percent) were at distances greater than one metre from the calculated positions. On the basis of the above data, it was decided to conduct survey and reacquisition activities only during the 5:00–11:00 window and to use a 2-metre by 2-metre search box.

Target investigation and clearance. The pinpointed and marked targets are investigated by the road-clearance team. The presence of the target within the search box laid down by the reacquisition team is confirmed by using handheld metal detectors (Figure 7). If the target is on the surface, the nature of the target and the threat level are assessed and the target is subsequently removed or neutralized by the manual deminer. If no targets are located within the search box with the handheld detectors, the search box is then searched with a Upex 740 large loop detector (Figure 8) and the exact position of the target is marked.

Buried targets are investigated using an armored mini-excavator (Figure 9) and manual deminers. Small buried targets are localized, marked and then directly excavated. The spoils are then spread out on the ground beside the excavation and inspected by a manual deminer. After the target has been localized, neutralized and removed, the hole is filled in and the excavator moves on to the next target.

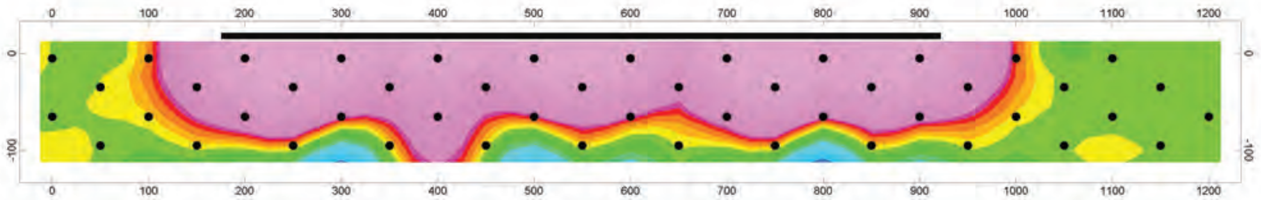

Figure courtesy of Marcel Durocher

Figure 4: Cross-section of subsurface volume in which a TM-46 anti-tank mine can be detected when using a 7.5-metre-wide six-sensor array. Sensor array standoff distance is 60 centimetres (24 inches). Horizontal station separation is 100 centimetres (39 inches) and vertical station separation is 33 centimetres (13 inches).

Figure courtesy of Anders Jansson

Figure 4: RCT reacquisition team marking a buried target location.

Figure courtesy of Anders Jansson

Figure 5: RCT reacquisition team navigating to a target using work maps and DGPS.

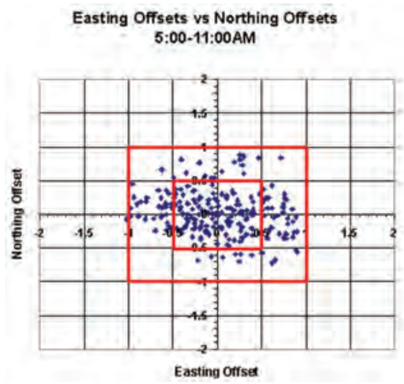

Figure courtesy of Marcel Durocher

Figure 6: Plot showing the variability of DGPS data.

Figure courtesy of Anders Jansson

Figure 7: Manual deminer investigating a surficial target.

Figure courtesy of Anders Jansson

Figure 8: Manual deminers locating a deep target.

Figure courtesy of Anders Jansson

Figure 9: Armored mini-excavator used to investigate buried targets.

When investigating deep targets or suspected anti-tank mine targets, the targets are marked as shown in Figure 10. The target is then investigated by excavating a V-shaped trench on the outside of the marking sticks on dirt roads or painted lines on asphalt roads.

The excavations, the area between the excavations and the spoils are checked by a manual deminer (Figure 10) with a handheld metal detector to confirm the target location and to determine if additional excavation is required. The manual deminer then investigates the target by approaching it laterally using manual demining methods. Once the target has been identified, neutralized and removed, the excavation is filled in and the excavator moves on to the next target.

Even with a 2-metre by 2-metre search box for each target, the area requiring additional treatment for the above-mentioned mine types is reduced by 98 percent. Using this methodology, the eight-person RCT has been able to verify and clear up to two kilometres (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 WADS team resurveys the road segment. System configuration and survey parameters during the road resurvey 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-Lucusse 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 investigation with the mini-excavator. It is clear that by reducing the number of scrap-metal targets requiring investigation by 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:

Figure courtesy of Anders Jansson

Figure 10: Manual deminer investigating a deep target.

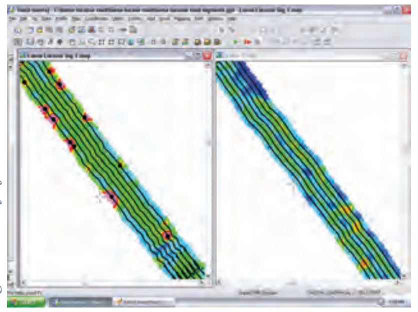

Figure courtesy of Marcel Durocher

Figure 11: Example of initial survey (left) and post-clearance quality-assurance survey (right). Reference point is "+" symbol in center left.

- Carrying out mechanical and/or manual pre-survey 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 intrusive interventions
- Increasing the number of road-clearance teams

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Anders Jansson was born and raised in Denmark. He has seven years of experience with the Royal Danish Engineers in Denmark and Bosnia including five years of mine-risk education, explosive ordnance disposal, and mechanical and manual demining experience with the Danish Army in Denmark and Bosnia and nongovernmental organizations in Sri Lanka and Angola.

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News Brief

Explosive-sniffing Goats Avoid Offending Muslims

PHOTO COURTESY OF GEVA ZIN

In an effort to protect security forces in the Muslim world, 29-year-old Geva Zin, an Israeli K-9 security trainer, turned to an unconventional ally. Zin began training goats to detect explosive materials in vehicles and on citizens examined at checkpoints.

Dogs, although prevalent and adept at explosive detection, are offensive to many Muslims because they are considered unclean. Security forces around the world were often left with the choice of offending local Muslim populations or exposing humans to incredible risk at checkpoints. Zin's work sought to solve that problem by using one of the most common animals in Muslim life—the goat.

Zin already has had great success training dogs and even miniature pigs to detect explosives and uncover mines, but goats offer a unique solution to security situations in the Muslim context. First, there is a decreased chance of security forces humiliating Muslims with searches by dogs. Second, goats are able to search every suspect and vehicle. Third, their use protects lawmen by allowing them to keep a safe distance. Finally, because goats are prevalent in many parts of the world, their presence in most situations is unobtrusive—dogs were often denied entry to mosques, private homes, and areas containing Muslim holy books.

Zin's goats are trained much like dogs, sitting when they detect explosives to alert a nearby handler that a person or vehicle should be searched more carefully.