REFERENCE DOCUMENT 1

THE VOODOO SYSTEM, MINE-PROTECTED VEHICLES (MPVS), WIDE AREA DETECTION SYSTEM (WADS) AND VEHICULAR ARRAY MINE DETECTION SYSTEM (VAMIDS)

Road clearance using the Voodoo System

Developed by MgM (Menschen gegen Minen), the Voodoo System in Angola has been used successfully for approximately ten years. From May to September 2006, the combination of mechanical demining machines and mine detection dogs accounted for 93.1 per cent of the total area cleared by the operator of the system in Angola.

It must be understood from the outset that the Voodoo System is not designed to be used on all-weather paved or tarmac roads. In Angola, where MgM is conducting clearance, the hazard exists on what could best be described as tracks, the use of which can often be interrupted by wet weather and the rainy season. Typically the "roads" are meandering tracks. These roads simply make use of local soil material and in good dry weather they can be used by heavy transport vehicles, buses and lighter vehicles. Nevertheless, these roads are a part of the National Secondary Road Network and their clearance does have a large impact on the local population.

In Angola, the major mine hazard on roads is from anti-vehicle mines. The most difficult mine to deal with is generally the South African No. 8 minimum-metal mine. This mine was designed with all of the metal components in the base of the mine which makes it undetectable by most metal detectors. The mine density is extremely low – usually just a few anti-vehicle and anti-personnel mines in 50 km or more of road. The location of these mines can often be predicted by experienced technical survey teams and by the assistance of the local population.

In spite of the very low density and the predictability of the location of the mines, the statement of work agreed between the National Inter-Sectoral Commission for Demining and Humanitarian Assistance (CNIDAH) and MgM stipulates that the entire length of road will be graded. This is to ensure that the entire road is covered during the process and that the road surface is considerably improved, allowing much more effective use.

The statements of work further stipulate that the road must be left in such condition that the mine action authority can easily traffic the road to conduct QA inspections. This means that road construction is a significant part of the road clearance process. Culverts are constructed, expedient bridges are built, and so on, all at the expense of efficient mine clearance. This does, however, immediately provide an important road link for the area. Movement of displaced persons, humanitarian aid and goods and people can take place as soon as road clearance is completed. The economic and social benefit of this process cannot be overlooked and therefore this "road construction" element is an integral part of the road clearance work.

Picture 1. A cleared dirt track.

The Voodoo system is really a process that combines many elements, including: planning; survey; clearance using machines, dogs and manual deminers; quality assurance/control; and record management. Basic operating principles include the following:

General priorities are established annually by the national mine action authority for Angola, CNIDAH. One of the high priorities recently has been to provide road access to the many population nodes without access to primary roads. This is so that the Election Commission has access to the maximum number of people for forthcoming elections. Opening of these secondary and tertiary roads are an ideal job for the Voodoo clearance system.

Provincial mine action authorities play an important part in selecting priority tasks. A strong relationship has been formed between MgM and the authorities and effective liaison between the two helps coordinate clearance plans and priorities.

Planning future operations makes some use of the Landmine Impact Survey but the most detailed information comes from the provincial authorities for technical survey.

Execution of operations depends largely on local conditions and there is a strong reliance on individual demining team leaders conducting the clearance. The team leader is responsible for determining which equipment, personnel and resources are used for a particular clearance task. He/she also has the authority to apply changes on the ground and to request additional assistance if needed. SOPs provide guidelines but the detailed execution is left to the demining team leader.

Decisions made by the team leader include what mix of personnel, equipment, and resources will be used and what follow-on procedure will be used to ensure the ground is clear, i.e. mine detection dogs, manual deminers or a combination both.

The motor grader

The motor grader is the primary piece of equipment used in the Voodoo road clearance operations. It provides the largest increase in productivity and has proved itself over the years as a safe and effective machine. Under normal conditions, MgM uses a planning figure of 3 to 5km per day for an 8m-wide road. This does not include follow-on procedures with dogs and/or manual demining teams. When conditions are good for grading, the limiting factor is usually the number of dogs available for follow-on.

The grader’s armour aims to ensure absolute protection of the operator, and to guarantee the integrity of the engine from a detonation blast. Numerous anti-vehicle mine detonations have occurred over the years and there has been no serious injury to any operator. Some minor armouring of vulnerable components has been done, such as rerouting hose lines and occasionally, providing small armoured protective enclosures. The vast majority of detonations during operations are at the rear tandem wheels of the grader.

2. A motor grader used in the Voodoo System.

Operator vision was carefully considered with the placement and size of vision ports. Large openings allow the operator to easily observe the blade, the movement of the soil in contact with the blade, and the berm that is created when the soil moves off the end of the blade.

The ROTAR sifter

The ROTAR sifter is used in the Voodoo System to process the windrows of soil cast to the side of the road by the grader operation. It can also be used to process soil piles or windrows that have been created by bulldozers and other earth-moving equipment in suspect areas.

3. A ROTAR sifter in the Voodoo system.

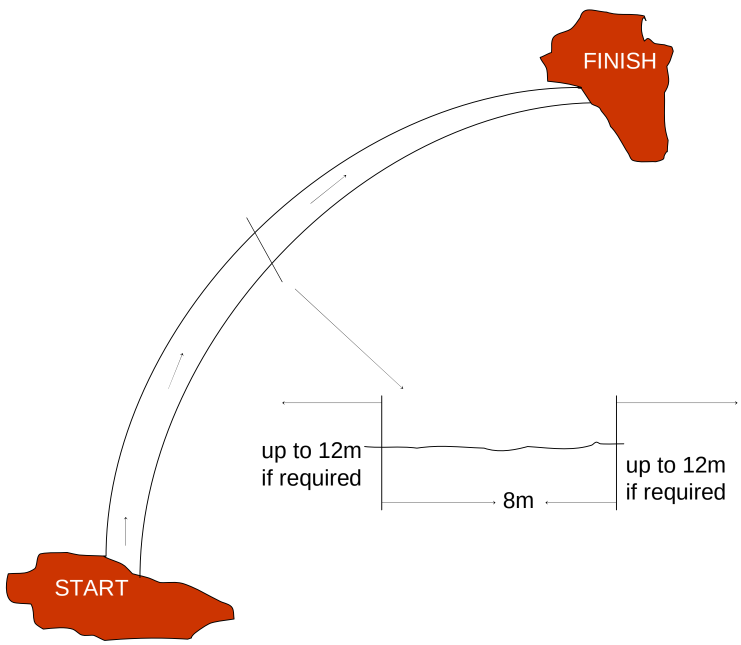
Mulchers

The Mulcher HEC MAXX 2 is used by the Voodoo System to assist manual clearance, mine detection dogs and mechanical operations. This is another piece of commercial off-the-shelf equipment, adapted slightly for demining operations. The most effective configuration to date has been installing the mulcher on the arm which normally has a backhoe bucket fitted to it and installing the sifter where a front-end loader bucket is normally installed (*see Chapter 3*).

4. The MAXX v2 machine with mulcher attachment.

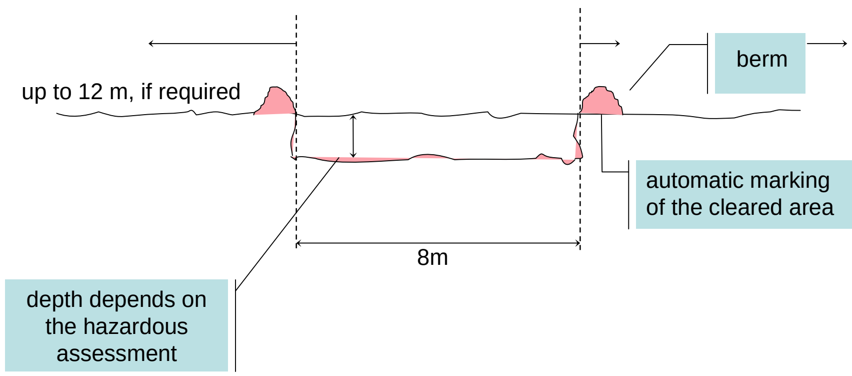
Operating procedures for the system

Picture 5 gives a general view of a typical road project. The start and finish are recorded using a GPS and progress is recorded by simply maintaining a log of the distance travelled along the road or track. The statement of work will define the area that must be cleared (typically an 8m width of road) and the distance to be investigated left and right of the road or track. The investigated area is also defined in the statement of work and might be specified when an additional width must be covered to cater for activities such as follow-on road construction project.



5. A stylised 'typical' road project.

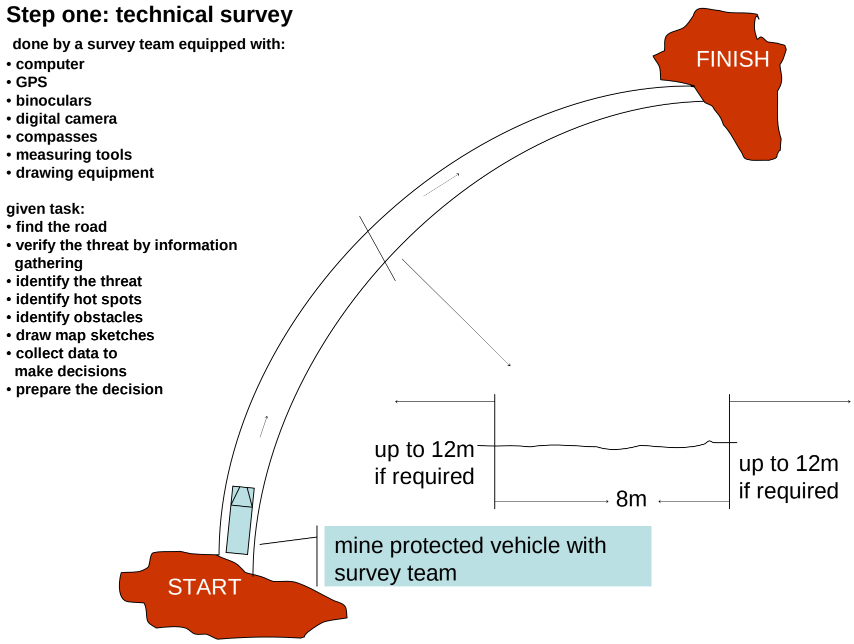
Picture 6 shows a typical cross-section of a road after the grader has made its passes along the road. The depth that the grader scrapes to depends on the hazardous assessment for the particular segment of road and can be varied according to the hazard. Where the likelihood of mines is low, the grader will scrape shallower. Where the likelihood of mines is high the grader will scrape deeper. The berm on each side of the road was created by the spoil scraped from the road surface and cast to the side of the grader blade. This berm automatically creates a very effective marker for the cleared area of the road. The berm is not permanent but is reported to remain clearly visible for approximately one year and can withstand most erosion that occurs during the rainy season.



6. Typical cross-section of a road after grader passes.

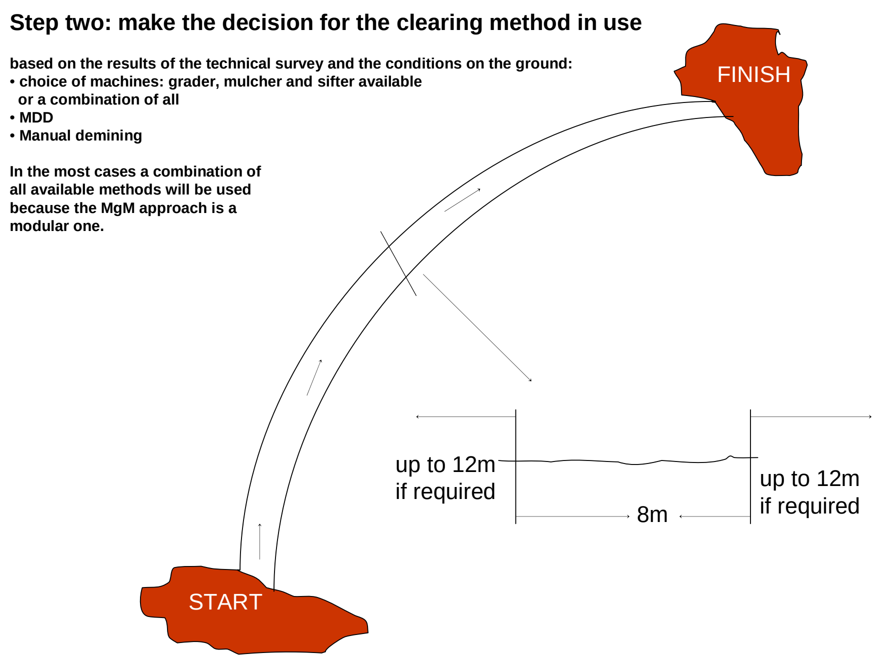
The eight steps typically followed when using the Voodoo System for road clearance are:

Step One: Technical survey is conducted using fairly standard methods and equipment. A mine-protected vehicle is the preferred mode of transport.



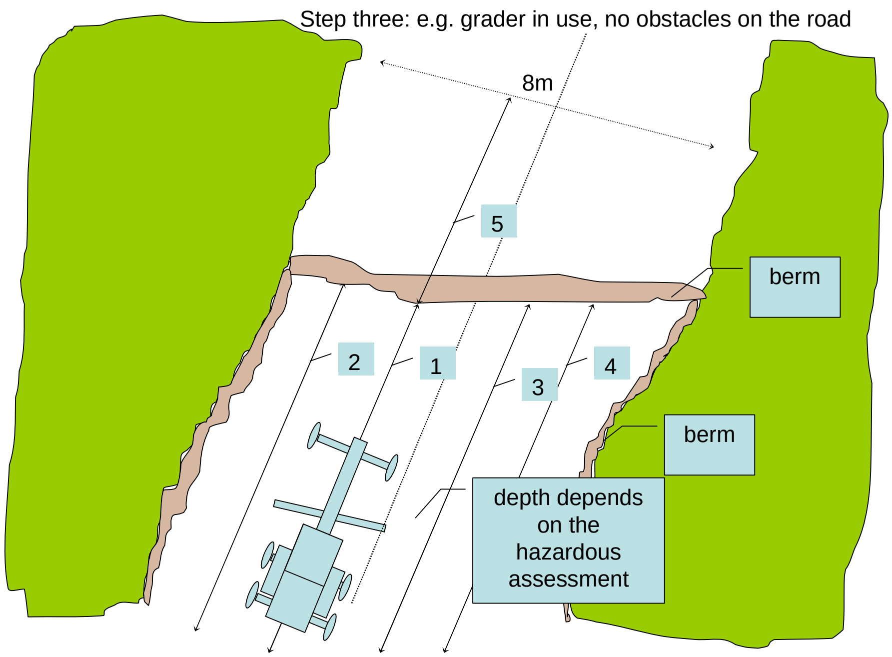
7. Step One

Step Two: A decision is made, based on the technical survey, on what the composition of the road clearance team should be, the equipment required, and any logistical, administrative, or medical requirements for the operation (*see picture 8*).



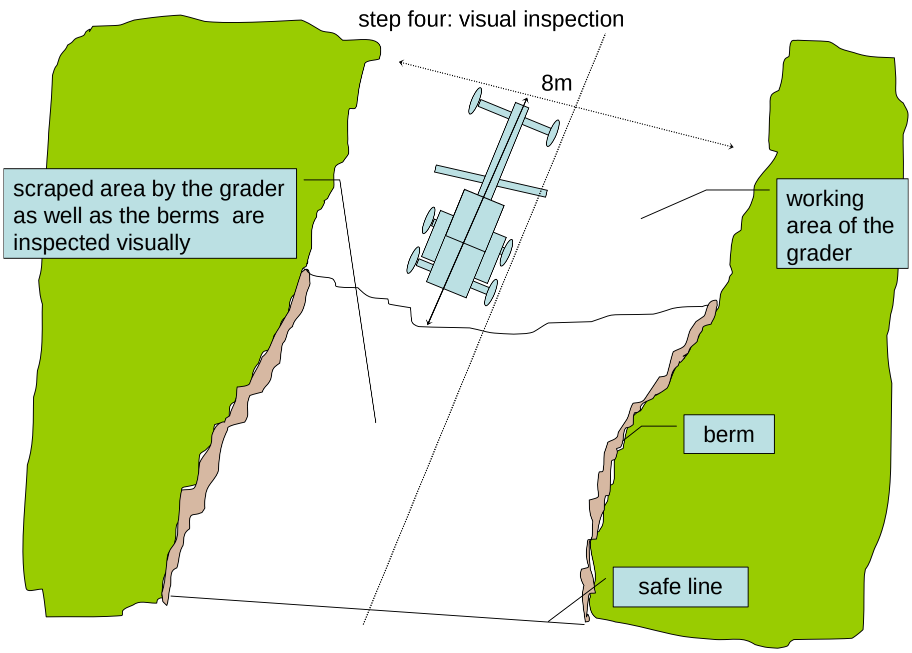
8. Step Two

Step Three: Typically the grader is used initially. It normally makes four passes with the blade to create a nominal 8m-wide track. The berms created leave a clear mark of where the grading has taken place.



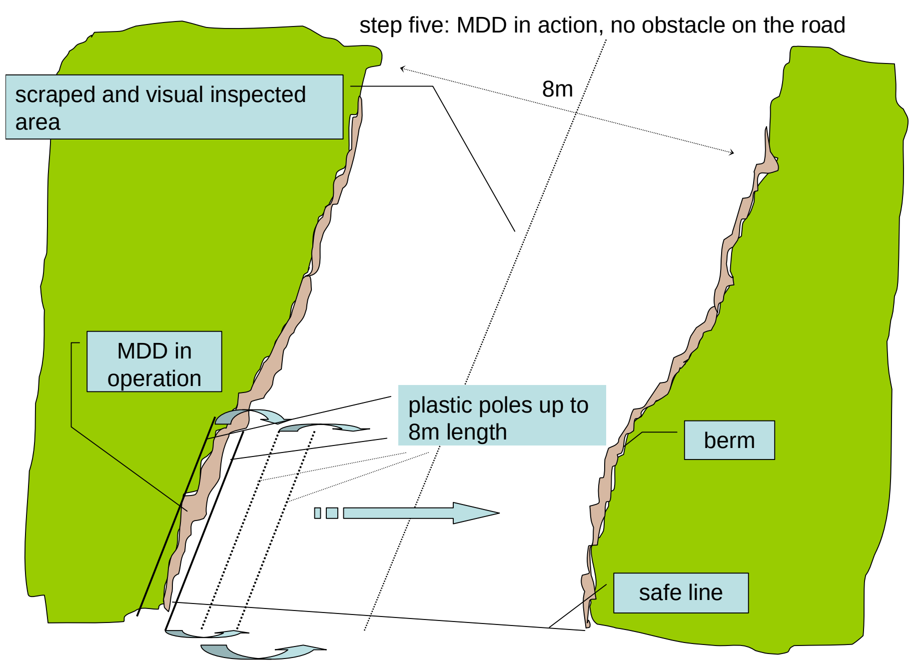
9. Step Three

Step Four: If no mines have been encountered during the grading process, a further visual inspection is made by deminers on foot. They follow the wheel tracks of the grader for an added degree of safety.



10. Step Four

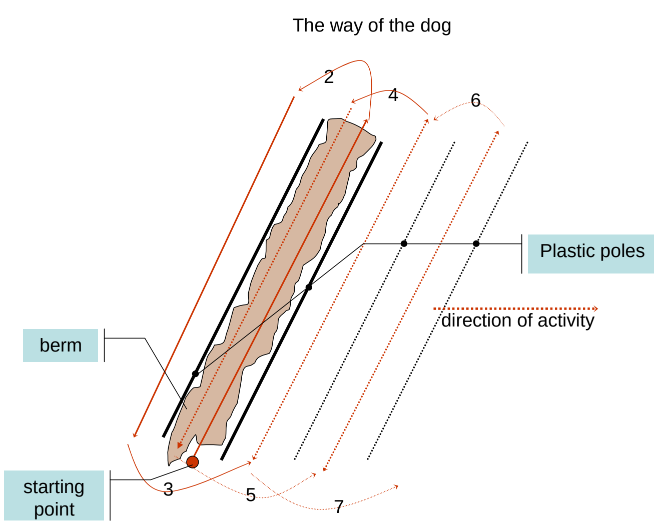
Step Five: Normally dogs are used to follow-on the visual inspection. They follow the grader's work by two or three days to allow the disturbed soil to stabilise and permit any mine scents to migrate to the surface. Two plastic poles, approximately 8m long, laid 1m apart in the direction of the road clearance, are used to guide the dogs and to keep track of the areas checked by the dogs.



11. Step Five

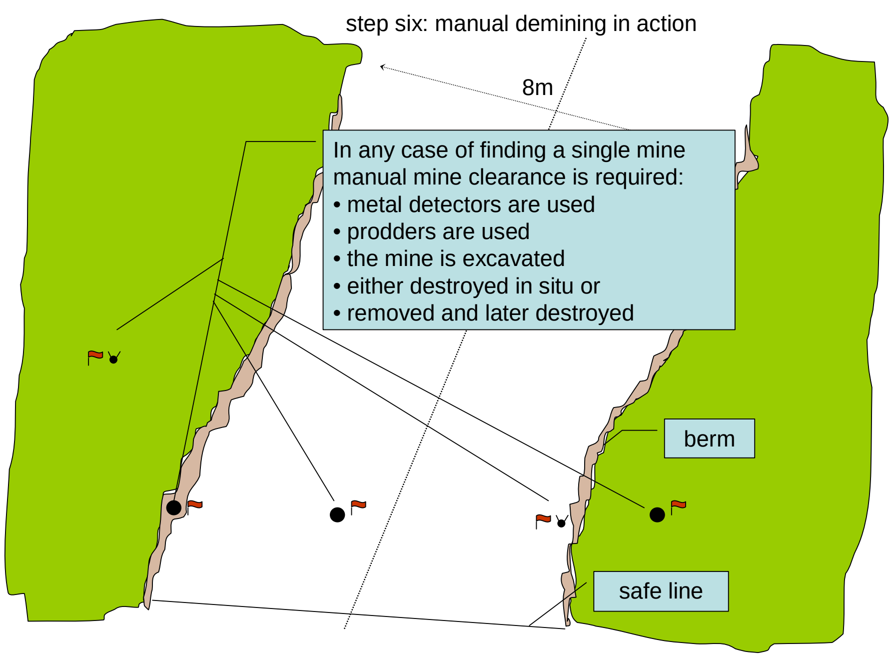
Each dog (*see picture 12*) is kept on a 10m leash and under the constant supervision of a handler. The path followed by the dog is illustrated in picture 13. The plastic poles are moved in leap frog fashion after each area between the poles is cleared. The left berm of the track is investigated first and then the dog proceeds across the road until the entire road surface has been checked. If a dog encounters a suspected mine he sits and waits until the handler marks the area that the dog has indicated.

12. A mine detection dog searching.



13. The path of the MDD.

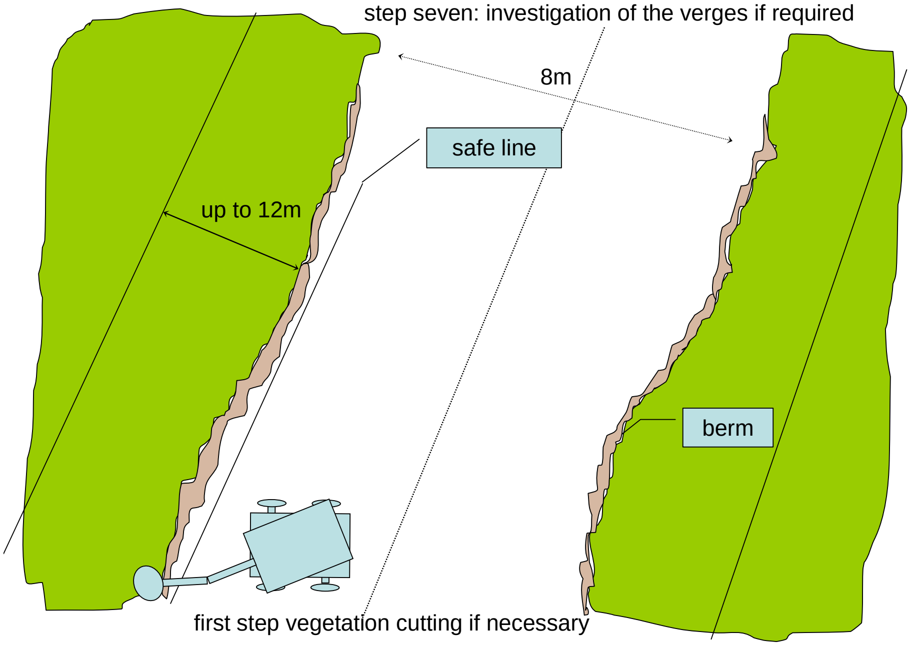
Step Six: A manual deminer then typically checks the area with a metal detector and prodder and will excavate any suspect items. When it is stipulated that the verges are to be investigated, heavy vegetation will be removed with a mulcher working from the road surface previously cleared. The width of the verge to be investigated will be stipulated in the statement of work. This will require the additional steps of Steps Seven and Eight.



14. Manual checking of the area.

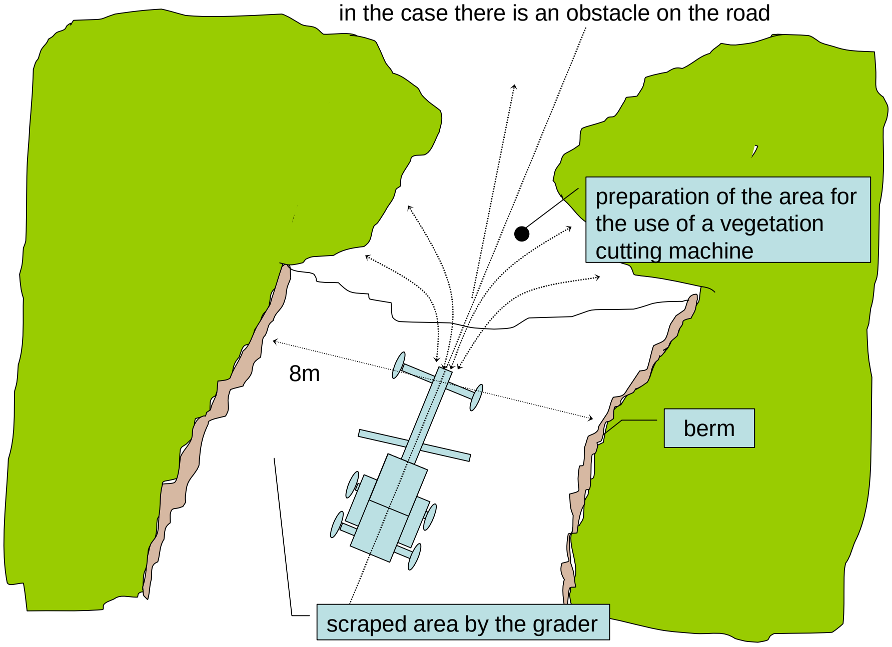
Step Seven: Vegetation is removed, if necessary, by a mulcher working from the cleared area.

Step Eight: Mine detection dogs then investigate the verges beyond the berm. Note that they work at right angles to the cleared road.



15. Investigation of verges.

There are variations in the above procedure. For example, picture 16 illustrates what happens if an obstacle, in this case heavy vegetation, is encountered. The grader proceeds to scrape the full 8m width of road as far as possible. It then scrapes the road in a series of passes to the maximum extent possible. The area scraped is then visually inspected. The area is further investigated by mine detection dogs.



16. Procedural variation in case of obstacles.

After the area to the obstacle has been scraped, inspected visually, and investigated by the dogs, a mulcher can be deployed to remove the obstacle. After the vegetation has been removed to permit grader operation, the grader continues to clear the road to the normal 8m width, and the process continues.

Concluding remarks

Motor graders are the key element in the Voodoo System. They are the preferred vehicle for road clearance. Notably, mine clearance goes hand in hand with road construction.


17. MgM road clearance in Angola.

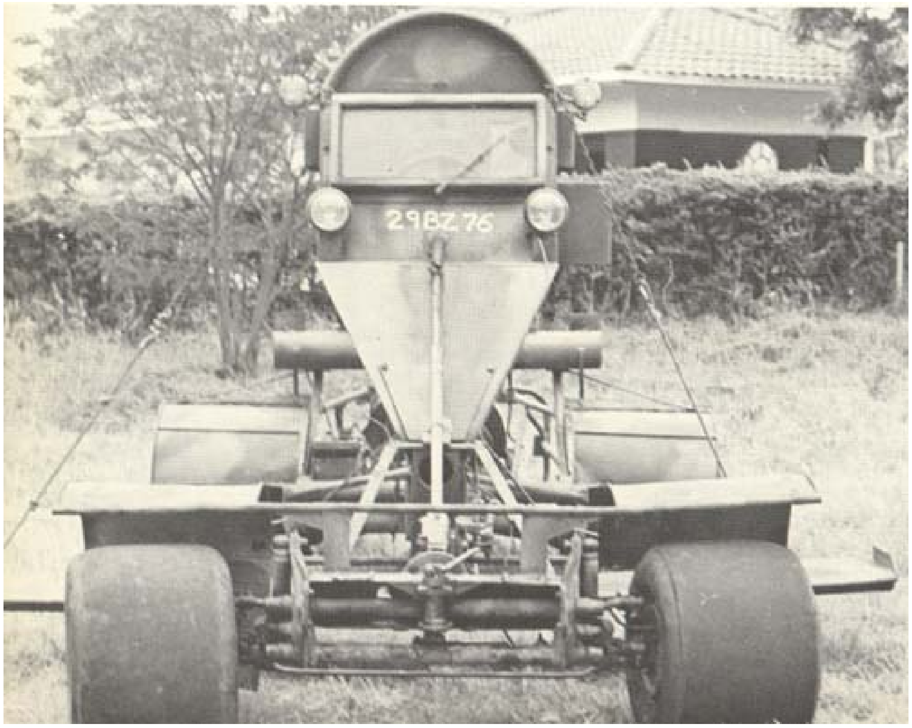
The Voodoo system performs well if the combination of tools is operated in accordance with the conditions on the ground. The possible time-lag between the grader in use and the follow-on MDD as well as manual mine clearance can become the main weakness of the system. A high density of mine threat can dramatically slow road clearance. The right combination of tools and their appropriate application on the ground are the key contributors to good performance.

MINE-PROTECTED VEHICLES

Mine-protected vehicles (MPVs) are vehicles specifically designed to protect the occupants and equipment from the effects of a mine detonation. In mine action, the designation MPV is normally associated with vehicles originally designed as armoured military personnel carriers. MPV are commonly used during survey and detection operations often on roads, where they can carry equipment such as detector arrays or vapour sampling devices, or push or pull a roller. They are typically equipped with steel wheels that can be used for hazard reduction, technical survey and area reduction on roads.

A variety of vehicle-mounted detector systems has been developed over the years. In the 1970s, the South African and Rhodesian militaries developed some of the earliest functional vehicle-mounted detection systems, which contributed greatly to the ability to detect mines on roads, thereby increasing safety on these roads. As effective data-recording of the detection signals was not yet developed, all of the systems were based on a direct reading, or "locate and immediately remove" methodology.

The Rhodesian military designed a prime mover that provided a footprint light enough to drive over anti-vehicle mines without detonating them. They prototyped a system called the "Pookie" (*see picture 18*), which was successfully employed to locate metallic anti-vehicle mines during the decolonialisation war. As the detection system was mounted directly beneath the armoured vehicle, a considerable amount of nullifying of the detector system would be required to exclude the vehicle hull from interfering with the detector arrays. The sensitivity would be sufficient to locate larger metal mines such as the Russian TM-46 and TM-57, but smaller mines and minimum-metal mines would be missed.



18. The Pookie vehicle

The South African military developed a number of vehicle-mounted systems, eventually producing the “Meerkat” vehicle) as part of the “Chubby” system. This vehicle also used an under-body detection array and was followed by engineers to clear any suspect signals. As with the system used on the Pookie, the detection capability was primarily towards larger, metallic mines due to the under-body coils.

19. The Meerkat vehicle.

This shortcoming and a system to follow up, or “proof” the road was incorporated. The lead vehicle for this system, called the “Husky”, towed a column of weighted detonation trailers with off-set tyres. The Chubby system became standard issue for the South African National Defence Force and is still in use. The Chubby system has been adopted by the militaries of various countries.

20. The Chubby system.

HALO Trust also acquired the Chubby system and employed the Meerkat in Eritrea. Recognising the drawbacks of the under-body mounted detection system, HALO contracted Ebinger to design a front-mounted system incorporating the UPEX-740 detector that could be operated by a single person. The system incorporated a single detection loop mounted on a wooden fold-up frame, wired to a control and warning box in the cab.

21. The Chubby Meerkat LLD front detector.

After calibration, the operator would simply drive at between 5 and 7 km/h until the warning bell sounded. The operator would immediately stop the vehicle and try to centre the front-mounted coils over where the signal would be the strongest, without driving over that point. Once the spot was identified, a clearance team could be brought forward to clear that point.

WIDE AREA DETECTION SYSTEM (WADS)

Based on UXB's experiences with a road clearance system in Eritrea in 2001, in 2004 DanChurchAid contracted Regis Trading (South Africa) to construct a modular wide area system for road clearance in Angola. The system was completed in late 2004 and named the **W**ide **A**rea **D**etection **S**ystem (WADS). The system was deployed to Angola in early 2005 and has since been moved to Denmark for minefield clearance on the Skallingen peninsula.

WADS employs the Ebinger UPEX-740 large loop as the detection system. The synchronisation of the UPEX coils is controlled through standard Ebinger hardware and software, and fed into a standard laptop computer. Tracking of the detection and vehicle progress is done by an OmniStar wide area DGPS system. The WADS is mounted on an MPV (South African Samil 20 "Rhino") as the prime mover.

22. The WADS

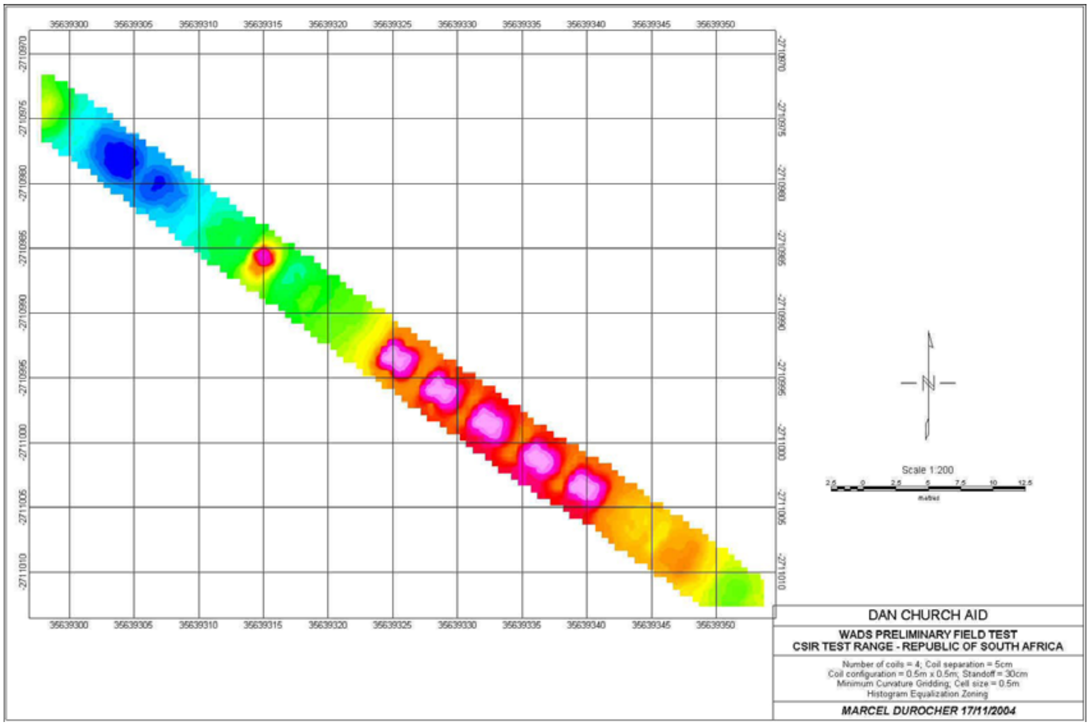
A clever modular mounting system has been constructed that allows the WADS to use up to eight UPEX coils in various configurations and sensitiveness. A series of electric winches raise and lower the unit with minimal effort. The mounting system is quickly adjusted to cover search swaths as small as 3m, or up to 8m if needed, including extending the detection swathe into a road verge. Search speed ranges from 5 yo 10 km/h, depending on terrain.


23. The WADS in travel position.

The system can be retracted into a travel position in approximately 30 minutes, which allows self-transport at speeds up to 80 km/h on improved roads and 30-50 km/h on unimproved roads. This reduces transport time between sites, and boosts productivity.

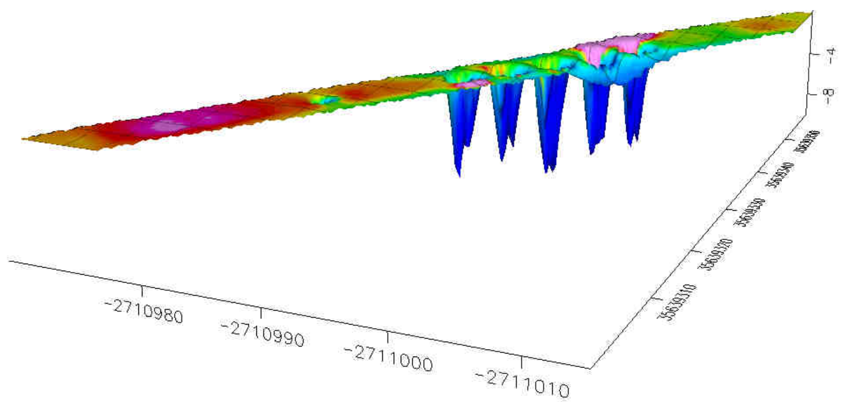
When using the UPEX coils in 50x50cm configuration combined with the upgraded software, the sensitivity is substantially increased and some minimum-metal mines can be located. During tests in South Africa, the WADS reliably generated strong signals against a surrogate Chinese Type 72 anti-vehicle fuze and the ITEP LO test source. However, other minimum-metal targets such as the South African R2M2 anti-personnel mine and No. 8 anti-vehicle mine were not located. DanChurchAid did, however, abandon the set-up and coil configuration designed to locate minimum-metal mines because of the huge number of false positives generated by the system.

Standard metallic anti-vehicle mines, such as the TM-46/57 series, can be located at depths of 1m or more with every configuration of the coils, as can common UXO items. Smaller items, such as PMN series anti-personnel mines, are reliably located at depths between 10 and 20cm using the smaller 50x50cm coil configuration.



24. Reading of five surrogate AVMs, 2D view.

The generation of clearance maps has been improved with upgraded data processing and GIS software. Highly accurate 2D and 3D maps are possible, making it easier to locate and estimate the depth of the suspect signal. The diagrams here are of five surrogate metal anti-vehicle mines and another suspect is shown approximately 10 metres to the north-west of the mines. The mapping system allows for an effective area reduction process that accelerates the clearance with less labour.



25. Reading of five surrogate AVMs, 3D view

Reacquisition of the signals is accomplished with a hand-held GIS system similar to other systems. The method for employment is improved by use of a handcart to mark the suspect signals. The antenna has been forward-mounted on the cart, allowing it to be positioned closer to the signal. Once located, a coloured flag is dropped through chute to mark the spot.

The advantage of the WADS system is its flexible width search path with the ability to increase sensitivity for smaller items like anti-personnel mines, or expand the coils and for deep-buried anti-vehicle mines. The system provides an accurate geophysical map with coordinates as part of the permanent record and extra channels have been included in the operating system to incorporate other sensors as technologies develop.

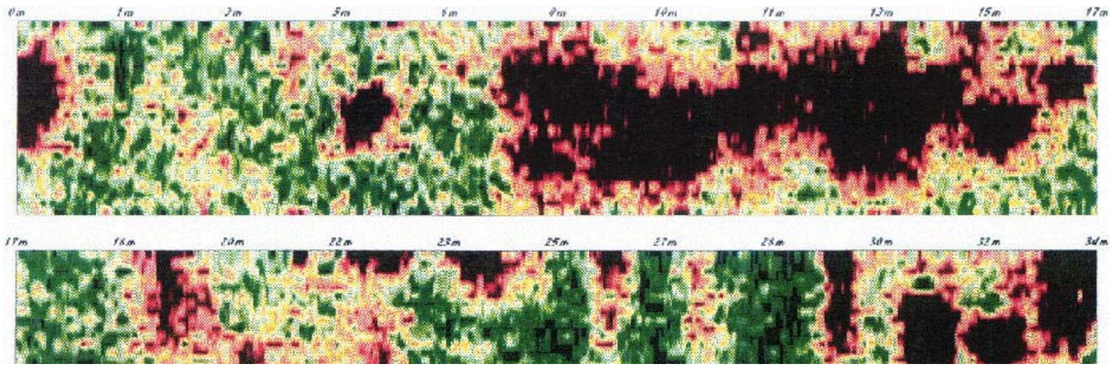
VEHICULAR ARRAY MINE DETECTION SYSTEM (VAMIDS)

As part of a United States demining research and development project in the mid-1990s, Schiebel detection systems developed a system called the Vehicle Mounted Mine Detector (VMMD) and developed it into the Vehicular Array Mine Detection System (VAMIDS). The original US Army Night Vision and Electronic Sensors Directorate (NVESD) version was mounted to a skid-steer for prototyping and has since been mounted on MPVs.

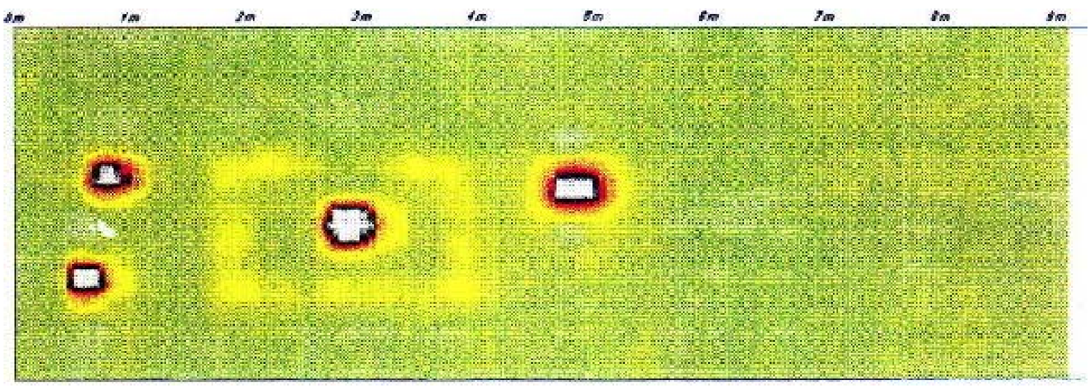
The system works on electromagnetic principles; incorporating an array of PSS-19/2 mine detector heads in a modular array. Early versions were mounted to the front of a vehicle, with the data from each detector head fed into an on-board computer. The hardware assembly can accommodate between eight to 48 detector heads in the array, allowing it to be expanded or reduced as needed. The system underwent considerable testing and upgrades, both at NVESD and with MECHEM.

26. The NVESD prototype version mounted to a skid-steer.

Earlier versions of the geophysical mapping were quite cluttered and difficult to discriminate between clutter and a suspect item. Considerable progress was made on future versions and the maps became much easier to understand.



27. Early VAMIDS geophysical mapping.



28. More recent VAMIDS mapping results.

The measurements at the side of the map made progress easy to follow once the baseline was established at the correct location. This allows for an effective area reduction process that accelerates the clearance with less labour.

The software and data-recording system does require specialised training to operate, however it does ***not*** require a trained geophysical specialist to analyse the survey results, a substantial benefit when highly trained staff are few.

29. VAMIDS mounted on a mine-protected vehicle, in service with MECHEM.

Mechem adjusted the power supply to the detection coils and mounted them on a 2m-wide durable rubber matting (expandable to 8m if needed). The entire detection array is mounted on a well-designed, swing-arm assembly that allows employment to either side or directly behind the vehicle. This system offers many advantages, such as contouring to the road surface and minimising the standoff between the detection coils and the ground, which provides better reception of the eddy currents being returned and therefore increased sensitivity when searching for smaller items. Search speed ranges between 5 and 10 km/h, terrain dependent.

The disadvantage is that as handheld detector heads are used as the coils (PSS 19/2), the detection depth is limited to between 50 and 70cm against larger items such as metal-cased anti-vehicle mines. The system currently being employed does not have a GPS/DGPS interface system and relies on an odometer tracking unit for time/distance recording. This method simplifies the generation of the clearance maps: but it limits the use of the mapping data from the survey, and alignment of parallel search paths must be done visually.

The VAMIDS map is based on a straight linear-distance measurement and does not contain any global positioning coordinates: to relocate the signals the clearance team must start from the same "known point" where the VAMID started and accurately measure the distance travelled between signals. Loss of a measurement during the course of the clearance involves returning to the known point and starting again.

The final clearance map and road data cannot be imported into the national GIS database. While this is not a requirement, it has proved extremely useful when available. Both Mechem and

NVESD have mounted the VAMIDS on protected vehicles. The Mechem system has been working in Eritrea, the Democratic Republic of Congo and Sudan for several years.