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Tractor Accessorized Zerriest Series II (TAZ II)



Capabilities Demonstration

September 10-11 and October 2-3, 2001

United States Army
Communications-Electronic Command
Research, Development & Engineering Center
Fort Belvoir, Virginia 22060-5806

Night Vision & Electronic Sensors Directorate (NVESD)
DoD Humanitarian Demining Research & Development Program

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DISCLAIMER

The technology in this report was evaluated under the Department of Defense Humanitarian Demining Research and Development Program. The information contained in this document is strictly based on the capabilities demonstration and not a technical evaluation of this technology. The purpose of this report is to provide an overview of the capabilities of this system to organizations involved in humanitarian demining activities. DoD does not endorse this technology or company and makes no warranties or representations concerning the use of this product. Interested agencies are encouraged to contact the contractor directly for equipment availability and current pricing. The Department of Defense points of contact, however, would appreciate any and all feedback on equipment use and suitability.

INTRODUCTION

Background

The United States Department of State estimates that 80-110 million mines litter the world, the majority of which were deployed during the last 15 years. Many people are killed and wounded annually, mostly innocent civilians. Mines prevent growth and development in emerging or rebuilding countries, impede repairs to infrastructure, disrupt humanitarian aid shipments, and destroy the morale of civilians living close to the minefields.

Several efforts are underway that address the current landmine problem. The United States established the Demining Assistance Program to initiate research and development into cost-effective demining techniques. The Department of Defense Humanitarian Demining Research and Development Program at Night Vision and Electronic Sensors Directorate (NVESD), Fort Belvoir, VA is tasked with executing this program.

In one response to this tasking, commercial companies were invited to provide a capabilities demonstration of their mechanical equipment that can suitably address either one or both of the mine and/or the vegetation problems in Humanitarian demining operations. The purpose of this system capabilities demonstration was to obtain information on non-developmental Mechanical Mine and/or Vegetation Clearing Systems that can demonstrate some or all of the following capabilities. 1) Support a variety of interchangeable tools capable of performing the diverse tasks involved with working in landmine suspect areas, i.e., mulchers, sifters, grinders, rakes, etc. 2) Clear a minimum of 200m²/hour of light to medium vegetation and cut 10cm diameter trees and brush. 3) Be capable of on-road and off-road operations in all types of weather and terrain. 4) Be capable of self-transport (less attachment) for distances less than 30km without destroying roads or bridges. 5) Be capable of destroying or removing landmines by grinding, sifting, raking, flailing, etc. 6) The system must be transportable, reliable, maintainable, and logistically supportable in third world mine affected countries. 7) Demonstrate the feasibility of protecting the system and operator, if applicable, with appliqué armor to withstand a blast equivalent to a .56kg (TNT) bounding fragmentation mine at 2 meters.

The Timberline Environmental Services demonstrated the performance capabilities of the Tractor Accessorized Zerriest Series II (TAZ II) on 10 - 11 September, and 2 - 3 October 2001 at NVESD/CM (countermine) test site. **The information in this report is strictly based on the capabilities demonstration and not on a technical field evaluation of this technology.**

System Description

The TAZ II is a large tracked Caterpillar Corporation vehicle (325B L Excavator) with a specialized vegetation cutting attachment developed by Timberline Environmental Services. See graphic 1. Timberline Environmental Services has been involved in vegetation clearance for nearly 23 years, supporting both civilian and military organizations. Military support missions have dealt primarily with unexploded ordnance (UXO). By utilizing the Caterpillar base carrier, the TAZ II System has the worldwide product support of the Caterpillar Corporation. The system is capable of masticating all vegetation ranging from light grasses to large trees, as well as excavating the ground. For demining purposes, this tool could be used in conjunction with other tools (rakes, magnets, rollers, etc.) to clear large areas of vegetation, allowing deminers and dogs to completely clear the area and perform quality assurance. The TAZ II is not currently armored or remote controlled to provide safety to operators, but could conceivably be modified to have these capabilities.

Graphic 1 – TAZ II



Demonstration Site Description

The TAZ II capabilities demonstration was conducted on NVESD/CM test site. In an effort to minimize the variety of conditions found at the NVESD/CM test site, the vegetation and terrain are characterized into four categories. The categories range from easy (1) to very difficult (4) as listed below:

Category 1 (Easy)	Category 2 (Moderate)	Category 3 (Difficult)	Category 4 (Very Difficult)
Light vegetation with minimal saplings up to 3cm diameter	Moderate vegetation with sparse brush and saplings up to 6cm diameters	Moderate vegetation with brush, saplings and trees up to 10cm diameter	Heavy vegetation with dense brush, saplings and trees greater than 10cm diameter
Fairly level terrain with minimal ruts	Level to light rolling terrain with some ruts	Rolling terrain with lots of ruts	Steep hills with lots of ruts, very rugged terrain
Minimal debris and obstacles	Some debris and obstacles	Moderate debris and obstacles	Heavy debris and obstacles

Table 1 – Four categories of vegetation and terrain.



Picture 2 - Category 1, Easy



Picture 3 - Category 2, Moderate



Picture 4 - Category 3, Difficult



Picture 5 – Category 4, Very Difficult

SYSTEM DEMONSTRATION

The Timberline Environment Services provided documentation of and/or demonstrated capability of TAZ II in the following areas: transportation and transportability; operations and operational mobility; maintenance and maintainability; technical data; manpower and personnel; training and training equipment; and system safety. Each capability of the system presented was reviewed, documented and assessed. The system demonstration began with the arrival of the TAZ II to NVEDS/CM test site and ended with the departure of TAZ II.

Transportation and Transportability

The TAZ II was transported to the test site on a “low-boy” trailer in one piece as seen in graphic 6, below, therefore, assembly of the system prior to operations was not required. TAZ II was driven off of the trailer and with a quick pre-operations check the system was ready for operations. The TAZ II is transportable by truck, rail or vessel. However, due to its weight and width, many restrictions are imposed on its truck transport in the U.S. This is an issue that must be considered in relation to demining efforts in third world countries that have poor road and bridge infrastructure. A support package could easily be moved in a standard 20 or 40-foot ISO container, depending on the contents of the package. The system is a rugged tracked system and is mobile in most conditions, but very steep hills, slopes or rocky conditions would affect its maneuverability.



Graphic 6 – TAZII on trailer

Specifications and Dimensions

The TAZ II system is composed of a Caterpillar 325B L (circa 1996) and a custom made cutter head. The overall specifications/dimensions are as follows:

- Shipping Height: 3.27-m
- Shipping Length: 10.29-m
- Shipping Width: 3.08-m (with standard tracks, also available in wide track)
- Shipping Weight: 29,346-kg
- Operating Reach: 7.69m

Operations and Operational Mobility

The TAZ II demonstrated its cutting ability against all four categories of vegetation and specific trees of varying sizes and hardness. Also, TAZ II demonstrated its excavating ability against hard compacted ground with the same cutting head. The results are as follows.



Graphic 7 – Cat. 1 – before cut



Graphic 8 – TAZ II cutting Cat. 1



Graphic 9 – Cat. 1 after cut



Graphic 10 – Cat.1 grass clippings from TAZ II. The clippings ranged from 5cm-20cm with the majority of clippings around 15cm.

Category 1: TAZ II cut 2500m² in 84 minutes with a cutting rate of 29.76m²/minute. It had some minor difficulties with ravines and elevation changes. TAZ II cleared the vegetation but left the ground with patchy spots of grass up to 20cm in height. TAZ II left the site in varied condition, from bared ground to vegetated spots, with the majority of the site covered in light layer of vegetation clippings. The clippings ranged between 5cm-20cm in length, with the majority of the cut vegetation around 15cm in length. A skilled operator is needed for terrain with many slope changes. The TAZ II was able to cut the light vegetation, but with difficulty. The system was too much of an overkill and the results were patchy. The time needed for the results achieved was not spectacular. TAZ II had to do two passes over the grass to get satisfactory results because of the wind flattening the vegetation down. The operation of the cutter head was smooth (no jerky, shaking motion of the machine.) The cutter head did not throw vegetation over 4 meters. TAZ II required a full 180° sweep, which resulted in a large clearance path, in order to be efficient.

Category 2: Category 2 site contained predominately of sumac intermixed with other saplings and grass, as shown in graphic 11 on the next page. The sumac stood up to 3m tall. The TAZ II cut 357m² of category-2 vegetation in 11 minutes, achieving a cutting rate of 32.45m² per minute. The TAZ II swept the area twice in the time taken but did not achieve a clean enough result for the deminers or the dogs to follow. The ground would probably require a second cut or more time taken during the first one. The vegetation could have been cut cleaner and closer to the ground if the driver had taken more time. Some of the saplings were flattened down and were not cut. TAZ II scattered the mulch in and around the site as shown in picture 12. The condition of the ground after the cut was very coarse with stubbles ranging from .3-.6m high. The site contained no significant pieces of mulch, but a pile of mulched was left by TAZ II as shown by the red arrow in graphic 13. TAZ II mulched this type of vegetation better than grass. The system operated with very quick and smooth motion. The cutter head did not require much maneuvering since the ground was predominantly flat (~90% level). The TAZ II system showed good potential for this vegetation category.



Graphic 11 – Cat. 2 before cut



Graphic 12 – TAZ II cutting Cat. 2



Graphic 13 – Cat. 2 after cut

Category 3: This site contained sumac and medium size trees on hard and dry ground, as shown in graphic 14. Also contained in this site were some trees up to .3m in diameter and a tree grouping of .3m by .6m across the diameter. TAZ II cut category-3 vegetation in 21 minutes covering an area of 562m² and achieving a cutting rate of 26.76m²/minute. TAZ II mulched most of the vegetation and left the remaining stubbles around .1-.3-m in height. TAZ II left the site with a thin layer of mulch and some tree limbs and trunks that were not mulched up, as shown in graphic 17. The tree limbs and trunks ranged from .3m to 2.8-m in length. The quality of ground clearance was acceptable for the dogs and the deminers to follow with demining activities, as shown in graphic 18. However, another cut would eliminate most of the stubbles, but was not necessary. The TAZ II performed the best in this category of vegetation, which contained less sumac and more medium size trees with some grass amongst them.



Graphic 14 – Cat. 3 initial cut



Graphic 15 – Cat. 3 during cut



Graphic 16 – Cat. 3 during final cut



Graphic 17 – Cat. 3 un-mulched limbs



Graphic 18 –Cat. 3 after cut

Category 4: TAZ II cut 168m² in 53 minutes with a rate of 3.17m² per minute, which is significantly less than the other three categories. This site consisted predominantly of pine trees with some oak and poplar trees intermixed, shown in graphic 19. The trees were matured and estimated to be up to 18m in height and .38m in diameter. A highly skilled operator would be needed for this category more than any other. The TAZ II operator cut the small trees 1/3 up the trunk and then mulched them down. Taller trees were cut higher up at ~5.5m above the ground (3/4 of TAZ II's maximum reach). The operator cut the trees within .6m of the ground to improve his visibility before cutting closer to the ground. The masticating head applied significant ground pressure and impacted the ground in order to mulch up the stumps, particularly those stuck in dips in the terrain. The mulch ranged in length from 1 to 20 centimeters, with the majority around 15cm. The trunks and vegetation that fell into the ditch were not mulched very well. Some of the significant remaining pieces of trunks and branches were 3m in length. The very large tree trunks slowed the cutter head's rpm's down and at times, stalled the cutter head. This did not limit TAZ II's ability only increased the amount of time required to cut the trees. Overall, the TAZ II did a satisfactory job cutting category 4 vegetation.



Graphic 19 – Cat. 4 before cut



Graphic 20 – Cat. 4 during cut



Graphic 21 – Cat. 4 after cut

Tree Cutting: TAZ II masticated four trees of varying hardness and height. Graphics 21-28 on the next page are pictures of the trees before and after they were cut. All of the trees' tops were cut off as high up as possible and then the remaining trunks were mulched down to the ground. The treetops were not mulched up. The amount of time that TAZ II took to cut off the top and mulched up the trunk was recorded for each tree. Table 2, below, displayed the tree type and dimensions, and the time the TAZ II took to cut down the trees.

Tree/hardness	Height (~)	Diameter	Time (min:sec)	Comments
Pine/soft wood	18.5m	.31m	4:50	The wood was splintered into chards.
Poplar/medium hard wood	33.8m	.31m	8:00	TAZ II shredded the tree to chips/dust. TAZ II cut the tree with the cutting head perpendicular to the tree and had to stop cutting a dozen times to build up rpm's.
Oak/ hard wood	30.8m	.38m	6:00	The cutter head was at a 45° angle and did not require stopping to build up the rpm. The tree was shredded to chips/dust.
Pine/ soft wood	7.7m	.21m	0:59	TAZ II quickly reduced the tree to splintered mulch almost in one motion.

Table 2 – Tree cutting



Graphic 22 – Pine Tree
.31m in diameter



Graphic 23 – Poplar Tree
.31m in diameter



Graphic 24 – Pine Tree
.21m in diameter



Graphic 25 – Oak Tree
.38m in diameter



Graphic 26 – Cut Pine Tree



Graphic 27 – Cut Poplar Tree



Graphic 28 – Cut Pine Tree



Graphic 29 – Cut Oak Tree

While operating the cutter head perpendicular to the poplar tree, the operator had to stop operations several times allowing the cutter head to build up speed. This problem appeared to be solved later by holding the head at a 45° angle while cutting the oak tree. Timberline said that faster times could be achieved if sharper blades were used. The current blades were old and dull in anticipation of ground excavation. Dramatic differences were seen in the TAZ II's ability to handle .21m verses .31m diameter trees. Although the TAZ II system may not be as fast as other systems when working with extremely large trees, it does handle all tree sizes and can also excavate the ground to minimize the remaining stumps.

Excavation: TAZ II conducted five trials to demonstrate its excavation ability.

The first four excavations were of the standing ground and the last excavation was of a wooden block buried in the ground. The first four trials were conducted on hard dry ground consisting of sandy loam soil with little vegetation. The cutter head needed modification prior to excavation. The side skids were removed so the cutter head could impact the ground. To excavate an area, the operator positioned the mastication head at the right corner of the area, activated the mastication head, swept the hydraulic arm across the left and then the right of the area and repeated this motion digging deeper into the ground with each sweep. The TAZ II cleared the soil from within the area by chewing up the soil and pushing the soil to the left and right side of the excavated area. Also, a lot of the masticated soil was thrown into the air. A 2cm layer of fine powdery

dust covered the excavated area. The TAZ II left a pile of dirt around the excavated area. Data recording of the first four excavations is listed in table 3 below. For the first four trials, the TAZ II excavated a total volume of 7.97m³ soil in 20.59 minutes with a rate of .39m³/minute.

Trial	Area (meters ²) (Length X Width)	Depth (Meters)	Time (Minutes)	Rate (Meters ³ /Minutes)
1	2.44 x 3.76	.15	2.18	.63
2	1.98 x 3.95	.23	4.08	.44
3	1.76 x 4.15	.28	6.00	.34
4	1.87 x 4.60	.32	8.33	.33

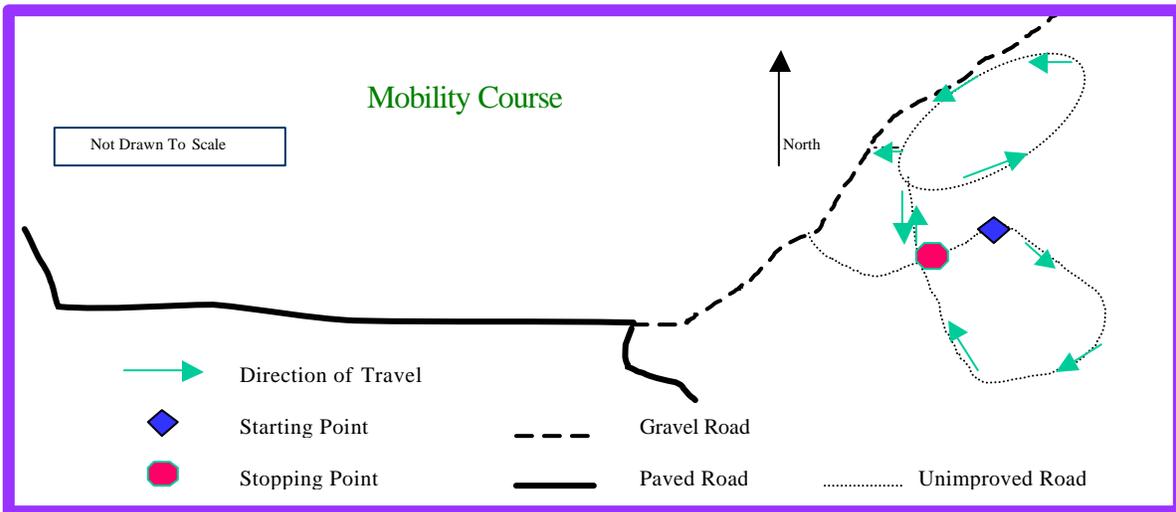
Table 3 – Ground Excavation Demonstration

The fifth trial was the excavation of a 10x10x15cm treated lumber block that was buried 15-centimeter below the ground. This block represented a buried mine, however since it was buried the day of the excavation, the ground surrounding the block did not have time to harden as if in an actual minefield. In this excavation, the operator centered the mastication head on the spot where the mine was buried and then activated the head. The TAZ II pushed the block down deeper than where it was originally buried and rotated the block 45° from its original orientation. This probably would not have occurred if the block had been in the ground for a longer period, in which the soil would have become compacted around the block. TAZ II masticated the block in tiny pieces. Only three significant pieces of the block were found and the largest piece was the size of 3x3x12cm chip. The TAZ II ended up digging down 45cm before the demonstration was stopped.

The TAZ II is not suited or designed for excavation of large areas of ground. It works satisfactory if the mine location is known prior to digging. During excavation the dirt was not removed easily from the hole being dug. Thus, the same dirt was being dug again and again. Timberline said that the chains used to reduce debris being scattered could be replaced with a plate that would improve TAZ II's ability to push the dirt out of the hole.

Overall Operations Summary: The TAZ II was capable of cutting all vegetation from grass to large trees. It was most effective against the category-3 vegetation. It also has the unique ability to cut vegetation in hard to reach areas such as, berms, ditches and ravines. The removable rails on the bottom of the cutter head assisted the operator with clearing vegetation without too much excavation of the ground. Although TAZ II can excavate the ground, it should be limited to small areas. The most notable point about the TAZ II system is that it can perform a variety of tasks. The TAZ II system was limited more by time than anything else. It can perform all the tasks required, but the quality of the results can be improved if the operator was given more time. The style of the cutter head appears to be rugged enough for a third-world country and does not require significant skill or tools to change the knives.

Operational Mobility: A designated mobility course was laid out for this portion of the demonstration. This course consisted of rugged dirt trail and improved secondary road with a few dips and hills. The route was approximately 3.0km long (see graphic 30 below.) TAZ II completed the route in 42 minutes at a pace of ~0.07 km/minute and scored a 3 for this task. TAZ II can transverse any terrain with slopes less than 40°. Obstacles and vegetated/wooded areas are not a problem for this machine, and it can create most paths needed for self-propelled transportation. The major concerns about this system towards mobility are its extremely slow speed, the destructive nature of its steel treads, and its weight in extremely muddy or soft ground. Speed is not so much of an issue in demining operations, however for long distances, the TAZ II should be transported by other means of transportation. Theoretically it can run on paved road surface without significant damage. However, with repetitive travel over the same stretch of road, the road will eventually break down due to the cleats in the tracks and the weight of the vehicle. The system can travel on solid dry, slightly damp and extremely muddy ground. However if the mud is 1 meter or more deep, there is a good possibility that the TAZ II could get stuck due to its weight.



Graphic 30 – Mobility Course

Maintenance and Maintainability

The TAZ II vehicle is a standard Caterpillar system and should be supportable around the world. The vehicle has an operator and a maintenance technical manual, which outlines the daily, 10 hour, 50 hour, etc. service requirements. It is assumed that a parts manual is available from Caterpillar. No documentation of support equipment was provided, but materials handling equipment, air compressor and standard tools would be required, as a minimum. The contractor estimated that a 6-month support package (minus the support truck) would cost approximately \$25K. For a 40 hour week OPTEMPO, the contractor estimates 425 gallons of diesel fuel would be required.

The special cutting head does not have a technical manual or parts manual to determine level of effort to support it, however, most of the parts for the cutting head are repairable or are considered consumable. It is assumed that simple servicing of cutting knife (blade), cutting disc and bearing repair/replacement would be required, as a minimum. Because of the proprietary hydraulic and electrical configuration used to run the cutter head, Timberline would require one of their mechanics to install the cutter head system onto the Caterpillar vehicle. Most general maintenance can be done on the cutter head with one or two people. Timberline demonstrated that two people could change a cutting knife in 6 minutes as shown below in graphic 31. The following tools were used during the knife changing demonstration: a sledge hammer, a large socket wrench, a pry bar, a solid round stock, and a small mallet. The tools are shown in graphic 32 below.



Graphic 31 – Knife changing demonstration



Graphic 32 – Tools used in demonstration

The TAZ II daily maintenance can be performed by one person in 10-15 minutes. The daily maintenance consisted of a walk around where the operator looked for oil leaks, cracks, and loose parts. Next, the oil level was checked as well as the water level. The engine was given a visual inspection for abnormalities. The oil level for the cab swing, the fuel level, and the hydraulic levels were all checked. Finally, all of the mirrors were cleaned prior to use.

Technical Data

The technical data on the Caterpillar excavator can be obtained from the Caterpillar Corporation. The technical data for the cutter head is considered proprietary.

Manpower and Personnel

Operation of this system is not difficult for someone familiar with using heavy equipment. For normal operations, one person can effectively operate and maintain the TAZ II system. However, in demining operations, an additional person would be needed as an observer and/or an assistant.

Training and Training Equipment

Because Timberline has been in the business of offering a service rather than selling a product, they have not adequately developed a training program or materials for the TAZ II system. However, they stated that they could quickly have a training program put together if a market for their product appeared.

Trainees should have experience with heavy equipment/tracked vehicles operation and maintenance. A minimum of two operator/maintenance trainees should be provided by the host nation or demining organization. Some maintenance actions require at least two people and if more help is needed, other personnel of the demining organization could provide assistance. All training can take place in a field environment and no special facilities for training are envisioned. No training documentation is available other than the vehicle operator and maintenance manual, but the primary training aid would be the system itself (hands on training). Timberline envisioned that minimum training would consist of a one week, hands on training, followed by verification of proficiency, and then advice and assistance as needed. The amount of training time needed is dependent on the trainees' abilities.

System Safety

Timberline has not developed armor for their TAZ II system because there has not been a demining market for their product as yet. Blast testing on this system was not conducted. The system safety evaluation was based on an engineering assessment. If the TAZ II system were shipped to a mine environment, the cab would require additional metal plating and polycarbonate glass for the protection of the operator. Also, the distance between the cutter head and the cab provides an added means of protection for the operator. The hydraulic lines would also required protection from the mine blast fragments. The TAZ II system has the potential of stopping antipersonnel mine blast and bounding mines, but the TAZ II will not withstand antitank mine explosions.

TAZ II SYSTEM SUMMARY

The TAZ II system is a large Caterpillar track vehicle with a specialized mastication head designed by Timberline Environmental Services. This system is manually operated and capable of clearing all vegetation ranging from light grasses to large trees. Even though the system is capable of grass cutting, cutting grass is an inefficient way to use this system. The TAZ II is best suited for masticating small to medium size trees. It demonstrated a clearance rate of approximately 1600m²/hour of the category 3 vegetation.

TAZ II is neither suited nor designed for excavation of large areas of ground. However, it can excavate small areas and demonstrated an excavation rate of approximately 23.4m³ of soil in one hour.

The TAZ II is not currently armored or remote controlled to protect the operators from mine blast fragments, but could conceivably be modified to have these capabilities. Once armored this system could be used in demining operations to perform a variety of tasks including area reduction, vegetation clearance along routes, ravines, berms and ditches, large area clearance, neutralization of tripwire antipersonnel mines and quality assurance. The use of TAZ II in antitank mine infested areas is not recommended.

TAZ II can traverse most terrain with less than 40-degree slopes. Obstacles and wooded/vegetated areas posed no problems for the TAZ II.

The TAZ II system performed satisfactory and was problem-free when clearing areas with extreme vegetation and rugged terrain conditions.