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The following article describes the development of the new Mini MineWolf mine-clearing machine. The machine is remote-controlled and allows for clearance without risking the lives of deminers. With successful results in Balkan countries like Bosnia-Herzegovina and Croatia, the new Mini MineWolf has proven itself to be reliable tool in helping clear the region of landmines.

Since May 2004, MineWolf Systems has accumulated 7.4 million square meters (1,829 acres) of demining experience in the Balkans with its mechanical mine-clearing machine, the MineWolf. Based on this operational experience and substantial user feedback from Norwegian People's Aid, which operates with us in the region, the special physical, technical, logistical and economical demands of mine clearing in dispersed rural areas was recognized. The requirements for these special circumstances had ramifications not only on machine design, but also on supply chain, transport issues and cost, and resulted in a major new design, the Mini MineWolf.

The first remote-controlled unit was delivered to Bosnia-Herzegovina in May 2006 where the Bosnia-Herzegovina Mine Action Centre accredited the machine and NPA put it through rigorous trials in Brčko. The results fully met MineWolf Systems' and NPA's demanding expectations: 5000–10,000 square meters (5,979–11,960 square yards) of clearance per day depending on terrain and vegetation.

Based on the good results in Bosnia-Herzegovina, five months later the commercial company Tornado d.o.o. deployed a second unit. This machine also achieved accreditation by the Croatian Mine Action Centre through testing. The results of the accreditation test are summarized in this paper.

Size Matters

In regions such as Bosnia-Herzegovina, where hostilities ceased over 10 years ago, demining efforts initially focused on high-priority clearance tasks crucial to economic activity: roads, airports and urban areas. This left numerous scattered pockets of smaller, second-priority suspect areas in remote regions. Demining of these dispersed areas has now become a priority.[1] In order to support these tasks with mechanical preparation, a small and compact solution was needed. For tasks of less than 60,000 or 80,000 square meters (71,759 or 95,679 square yards), the deployment of a large-area clearance machine is logistically complicated due to the transport requirements of the large machines; it is also economically unattractive due to the large associated fuel, transportation, personnel and supply-chain costs.

Guaranteed Results over Irregular Ground

Scattered minefields in rural areas still inhibit post-war recovery and economic advancement of agricultural

communities, which make up a majority of the area of Bosnia-Herzegovina. They also present an array of challenging terrains: wooded areas, dense vegetation, marshlands, irregular and rocky ground and slopes. For humanitarian-demining purposes, this type of terrain is more reliably cleared via a tiller system where dense vegetation, hard ground, tree stumps and rocks can shield a mine from a flail. The tiller system of the Mini MineWolf delivers guaranteed soil depth penetration up to 25 centimeters (10 inches), a guarantee not offered by flail systems.[2] This soil-depth penetration is an important aspect to assuring quicker and more reliable manual verification.

Getting to Work

Access roads to remote rural areas are often primitive and unpaved, presenting an obstacle to oversized and heavy convoys. Once in the mine-contaminated region, irregular and muddy ground can also quickly trap non-tracked demining equipment.

What is required to meet this challenge is a robust, inexpensive-to-operate, easily and rapidly transported solution for clearing smaller geographically dispersed minefields in a variety of terrains. Additionally, a self-contained maintenance and spare-parts package is required to maximize operational days in remote areas and minimize the reliance on an external supply chain.

In response to these requirements, MineWolf Systems developed a remote-controlled mechanical demining machine, the Mini MineWolf. It weighs 8.1 metric tons (9 U.S. tons), which is a smaller, lower-cost version of the 25.5-metric ton (28.1-U.S.-ton) MineWolf that has been operating in the Balkans since 2004. The Mini MineWolf was designed to meet the following challenges:

- **Easily transportable.** The Mini MineWolf is built to fit into a standard 20-foot container or on the back of a medium all-terrain truck with tiller attached (see photo, above right).
- **Minimal reliance on external supply chain.** The container itself comprises a mobile workshop that can transport the Mini MineWolf as a single unit. The container is fitted with a generator and a workbench and contains a compressor, welding equipment and other tools required to maintain and implement any necessary repairs on-site. This additional equipment reduces downtime and increases efficiency.
- **Operation in challenging environments.** The Mini MineWolf is a tracked system suited for use with a variety of vegetation, mud, weather and irregular terrain. It is especially effective against dense vegetation.
- **Guaranteed ground penetration.** Unlike flail systems, the tiller provides a reliable depth penetration of up to 25 centimeters (10 inches) in a wide variety of difficult terrain.
- **Patented tiller design minimizes blast damage.** The Mini MineWolf excels in terms of reliability and survivability. The open basket design allows a mine blast to dissipate through the tiller, avoiding or minimizing damage.
- **Guaranteed coverage.** Because of its rotation speed, ground speed and clearance depth, the Mini MineWolf tiller operation guarantees an effective and reliable clearing process that is unobtainable using common flail systems. A tight predefined penetration pattern makes sure even the smallest anti-personnel mines are hit (see image, lower right). A modular design also allows easy replacement of chisels.

Shipping in standard, 20-foot container. *Photo courtesy of MineWolf Systems*

Open tiller design to minimize blast damage. *Photo*

Testing and Accreditation

courtesy of MineWolf Systems

To verify the performance claims previously described, the Mini MineWolf was successfully tested and accredited by BHMAC in May 2006, followed by mandatory testing and accreditation by CROMAC for operation in Croatia. Testing was carried out 16–18 October 2006, at the Cerovac test site for demining machines near Karlovac. The goals of the test were successfully achieved, and can be summarized as follows:

- Determine general technical characteristics of the machine and of the working tool.
- Determine the soil-processing depth for different types of soil and the speed of motion of the machine.
- Determine the effectiveness and survivability against live AP mines (PMA-1A, PMA-2, PMA-3, PMR-2A, PROM-1[3]).
- Determine machine endurance during repeated AP mine activation.
- Determine the efficiency and effectiveness of the remote-control device.
- Determine possibilities of using the machine in mine-suspected areas.
- Determine possibilities of machine use in different types of soil, terrain gradients (horizontal and vertical slope), as well as for vegetation clearing.
- Determine the necessary machine logistics, servicing and maintenance requirements.

AP Mine Activation and Survivability Results

On 26 October 2006, testing was conducted with AP mines at the test site for demining machines. The following results were achieved:

PMA-1A. Five mines were placed at the planned depths (5, 10, 10, 15 and 20 centimeters)[4] and a four-meter[5] distance, and armed with appropriate fuses.
Result: The machine activated all mines; neither the working tool nor the machine was damaged.

PMA-2. Five mines were placed at the planned depths (5, 10, 10, 15 and 20 centimeters)[4] and a four-meter[5] distance, and armed with appropriate fuses.
Result: The machine activated all mines; neither the working tool nor the machine was damaged.

PMA-3. Five mines were placed at the planned depths (5, 10, 10, 15 and 20 centimeters)[4] and a four-meter[5] distance, and armed with appropriate fuses.
Result: The machine activated all mines; neither the working tool nor the machine was damaged.

PMR-2A. The first mine was placed in front of the machine at around an eight-meter[5] distance and armed with the appropriate fuse.
Result: The tiller activated the mine, leaving shrapnel marks on the machine and work tool but not affecting operation of the machine. The second mine was placed in the same manner.
Result: The tiller activated the mine; neither the working tool nor the machine was damaged.

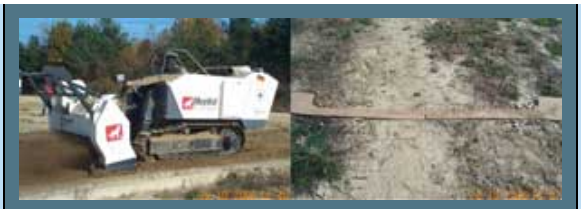
PROM-1. The first mine was placed and prepared for tripwire activation.
Result: The tiller activated the mine, leaving shrapnel marks on the machine and work tool, but not affecting operation of the machine. The second mine was placed and prepared for pressure activation. Result: The mine was activated by the machine; neither the working tool nor the machine was damaged.

Other Performance Aspects

The value of a small, remote-controlled machine for a demining program has to be measured in various dimensions in addition to mine-activation and blast survivability. Clearing results must also be evaluated in terms of quality, quantity and costs:

- **Quality**
  - Minimum 20 centimeters (8 inches) of constant ground

penetration (achieved; see image, far right)
    - Effective clearance of dense vegetation (achieved)
    - Easy maneuvering around buildings, trenches and trees (achieved)
    - Ability to climb steep gradients (proven)
    - Low ground pressure in muddy terrain to avoid getting stuck (proven)
    - Stable, mature technology resulting in minimum downtime due to design flaws or technical problem (the machine design is based on a proven, larger version)



Mini MineWolf on topsoil land (left) and depth results via fiberboard (right). *Photo courtesy of CROMAC*

- **Quantity**
    - Good clearance capacity (the machine achieved more than 500,000 square meters [124 acres] on various terrains within 91 days of operations [average performance between 600 and 1,500 square meters (between 718 and 1794 square yards) per hour])
- **Costs**
    - Low running costs (although costs for oil, filters and service of the Mini MineWolf are comparable with other machines, 90 percent of the running costs are determined by the running costs of the working unit, i.e., flail or tiller. After clearing the first 500,000 square meters [124 acres] with NPA it became evident that the tiller of the Mini MineWolf can be operated at less than 20 percent of the running costs of a flail system in comparable size and output.)

Operation by National Personnel

In order to deploy a machine in the most efficient and sustainable way, competent personnel recruited from the national program are needed in all areas of a demining organization. This assures long-term operational support via residents who also retain demining and equipment know-how long after foreign trainers leave.

In addition to operation of the machine, further tasks include:

- Collecting relevant information during task assessments by a survey team to identify machine relevant areas.
- Realistic planning, taking into consideration the specific ground and vegetation conditions resulting in a good performance average estimate.
- A good and sustainable training program allowing locals to educate future staff.

During the assembly of the Mini MineWolf at the factory in Germany, a Bosnian mechanic was involved and trained on supporting the machine in the field. He subsequently trained four additional operators and another service mechanic after the machine arrived in Bosnia.

Conclusion

After successful accreditation in the Balkans, an EU Force in Bosnia-Herzegovina (EUFOR) delegation, including Lt. Col Jonsson, Chief of Countermines, visited the NPA Brčko site to view the Mini MineWolf. The delegation's response was extremely positive and supportive of the original concept for the Mini MineWolf. EUFOR was particularly impressed with the power, productivity and general construction of the Mini MineWolf. To date, the Mini MineWolf has exceeded expectations regarding performance and no faults have been identified in the design. The depth control has been tested on both dry and wet terrain and is functioning perfectly to ensure a continuous ground penetration of up to 25 centimeters (10 inches).

Based on the success of the Mini MineWolf deployment in Bosnia-Herzegovina, Croatian-based Tornado d.o.o., one of the top three demining companies in the Balkans, also became convinced of the reliability and high output of the Mini MineWolf for smaller and more dispersed jobs. After training by MineWolf staff, Tornado deployed a Mini MineWolf for demining projects in northern Croatia in October 2006.

Biography

Christoph Frehsee is a Senior Technical Advisor with MineWolf Systems. Responsible for products and service, his field of expertise is to set up sustainable mechanical support and training infrastructures. He has gathered mine-action experience in Bosnia-Herzegovina, Croatia, Jordan, Serbia and Sudan.

Endnotes

1. "Bosnia and Herzegovina Mine Action Plan for 2006" BHMAC, Available at http://www.bhmac.org/danes/slike/down/Plan_2006%20-DRAFT.pdf. Accessed 7 June, 2007.
2. Hartley, David. "The Truth About Flails," *Journal of Mine Action*, Issue 7.3, December 2003, http://www.jmu.edu/cisr/journal/7.3/focus/hartley/hartley.htm. Accessed 7 June, 2007.
3. For more information on each of these munitions, see the Mine Action Information Center's "Munitions Reference." Available at http://www.jmu.edu/cisr/_pages/research/munitions.shtml. Accessed 9 April 2007.
4. Five centimeters equals approximately two inches.
5. One meter equals approximately three feet.

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