MODIFICATIONS OF MID ENGINEERING AND ROAD VEHICLE

Abstract: The paper presents versions of the MID engineering and road vehicle modernized by OBRUM and used by engineering troops. A vehicle is described, made for a Malaysian customer, which is based on the units of the MBT PT-91 M tank, and the scope of work is presented for adapting the vehicle to the needs of peacekeeping missions. Modification of the control system of the vehicle is also described, as well as other modifications performed on existing vehicles after a long period of use in view of the requirement to improve the level of advancement of the component units.

Keywords: engineering troops, engineering equipment, combat engineer tank, engineering and road vehicle, MID

1. INTRODUCTION

The engineering and road vehicle (MID) is classified as a combat engineering tank [1], [2]. During the many years of its research and development activities, OBRUM developed two designs of combat engineer tanks: KLON and MID. MID was a structure that was fully developed and put into short-lot production in 1996 at OBRUM [1], [2], [3], [4]. The basis for designing the vehicle prototype was the recovery vehicle WZT-3. By adopting this basis, the new design attained a high level of compatibility of the new vehicle units with those of existing vehicles: T-72 tank and WZT-3 recovery vehicle. MID is a tracked vehicle which, with its attachments, allows performing a wide range of engineering tasks. The principal tasks associated with battlefield engineering support include:

- troop movement support;
- construction of barriers and abatises;
- other earth work;
- mechanization of load handling;
- recovery and evacuation tasks.

The design of the machine, built on a tracked chassis with tank equipment components, allows performing tasks under harsh battlefield conditions, such as:

- within zone of direct and indirect enemy contact;
- conditions of radiation and/or chemical contamination of terrain;
within zone of mass destruction by nuclear and conventional weapons;
under harsh terrain and weather conditions;
in the zone of natural and environmental disasters;
during peacekeeping missions.

The MID design, developed at OBRUM in the final years of the 20th century, with a very high level of innovation, was a fully proprietary solution of OBRUM's engineering and technical staff. Comparison of tactical and technical specifications with Western designs of engineer tanks placed MID among world's most advanced equipment. Fig. 1 shows the MID engineering and road vehicle during operation.

Fig. 1. MID engineering and road vehicle during field operation

In the work on the concept of the prototype, two versions of the solution for the hydraulic drive for attachments were considered:

- version one with Dubax (Dubnica, Slovakia) pumps and control system components;
- version two with Rexroth system configured by OBRUM.

Upon assessment of specifications and functional capabilities, version one was rejected due to inability to attain maximum soil digging force related to the force applied on the excavator scoop tooth and to ripper tooth penetration into soil. In the developed MID prototype the applied drive mechanism for rotating the manipulator jib consisted of two counteracting hydraulic cylinders and a planetary gear enabling horizontal rotation of the jib by 270°. Eventually (for the production version) the adopted slewing mechanism included a rotary hydraulic motor and planetary gear with the rotation angle limited to 270°. The decision was dictated by the possibility of using the hull with the slewing mechanism in the design of the future recovery vehicle. This solution was adopted when developing WZT-4 vehicle for the Malaysian client. In addition, when developing the new crane K-20, apart from the MID slewing mechanism, use was made of the following features:
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- geometric configuration and casting of crane shaft welded into the hull;
- slewing bearing (full compatibility between MID, MID-M, WZT-4);
- slewing brakes assembly.

We may assume that the developed MID vehicle could be used as a platform for military engineering and recovery vehicles and for civilian applications for eliminating the effects of natural disasters.

The provision of a wide range of working attachments in the MID vehicle, such as dozer blade (straight and V arrangement), main and auxiliary winch, manipulator with interchangeable attachments (excavator scoop, ripper tooth, grabber jaw, rope sling), gas and electrical cutting and welding equipment, load-carrying body and towing bar, and ability to operate additional hydraulic attachments (hydraulic hammer, hydraulic drill rig, hydraulic shear) enable carrying out a wide range of engineering support tasks in the modern battlefield and equipment and crew recovery tasks.

2. UPGRADEABILITY

To ensure complete implementation of tasks in the modern battlefield using the results of studies and analyzes of trends in the development of working attachments, future modernization paths were defined. The upgradability of the MID vehicle that extends the range of possible tasks by providing new attachments was described in detail in the literature [2], [3], [6]. Concept designs developed at OBRUM at various times called for fitting the MID vehicle with additional attachments and equipment:

- dozer and minesweeping gear;
- electromagnetic minesweeper;
- set of clear lane markings;
- excavator/grabber/ripper head;
- versatile towing coupler.

However, offers presented by OBRUM for implementing development projects related to the tasks described above have not translated into acquiring financial support.

The advancement of the MID design has been appreciated by military experts from UK. The British Ministry of Defence invited OBRUM to participate in a tender to develop an engineer tank as part of the FET (Future Engineer Tank) project, in two versions:

- tank for carrying and laying bridges spans or fascine (TITAN);
- engineer tank (TROJAN) with optional telescopic or foldable boom and pallet for carrying and automatic deployment of two sets of fascine for crossing trenches and narrow gaps and towing Pearson trailers with engineering equipment.
Other participants of the first bidding stage included:

- VICKERS, UK (manufacturer of Challenger 2 tanks);
- GKN Defence (manufacturer of Piranha and Warrior armoured carriers) and MAK, Germany (manufacturer of armoured carriers).

OBRUM proceeded to tender with a British partner - BAE Systems.

The participation of a Polish research centre in a British R&D project was a huge sensation in England [7], [8] and was even subject to the intervention in the British Parliament of British industry representatives concerned about the potential loss of jobs.

The task to be performed by OBRUM was a great challenge for the engineering staff. This was the first time a company from the former East Bloc carried out a development work for a NATO member. At that time Poland has only been seeking admission to NATO.

Working with its British partner BAE Systems, OBRUM developed a Feasibility Study which was highly rated and well received by the customer. Eventually, in the subsequent stage, development work was commissioned to British Vickers.

The design work carried out during the FET project was an inspiration for OBRUM's engineering staff to analyze the existing solutions, especially in the area of controlling hydraulic working systems. The control system [10], developed in the 1990s, was at the time modern and it was the first one in the former Warsaw Pact countries, it was based on power hydraulics using control solutions with load sensing pressure compensation and proportional hydraulics. The design of the portable control panel included modern components and control elements, based mainly on analog technology. Nevertheless, the dynamic development of automation, including digital systems and a whole range of modern sensors (pressure, position, level, etc.) operating under new communication network standards, prompted OBRUM to launch modernization work [9] on the MID vehicle in 2001. The work covered a new concept of hydraulic control, electric control and introduction of diagnostic system elements. The hydraulic system was redesigned, a programmable controller was included, and CANbus-compatible non-electric quantity transducers were used. A series communication link between the control panel and the control board was introduced. As a result of the work carried out, the MID engineering and road vehicle, thanks to modern solutions, has become more user-friendly. The changes introduced definitely increased the competitiveness of the machine in this class of equipment. The modernized MID is a vehicle with much improved specifications.

3. THE MALAYSIAN CONTRACT

After several meagre years, the Polish arms industry, as a result of intense efforts on the international armaments market, won, in 2003, a contract [11] for the supply of armoured equipment. BUMAR concluded a contract for delivery of armoured equipment for the Malaysian army. The basic subject of delivery under the Malaysian contract was a special version of the Polish main battle tank marked PT-91 M. This tank was developed on the basis of a PT-91 tank in a design version developed according to the requirements submitted by the Malaysian client, with a large contribution of components from Western armament companies. The main contractors were "Bumar-Ląbędy" and OBRUM. The contract included the delivery of three MID-M engineering and road vehicles. The concept on which the
The contract was based on compatibility of all vehicles, and particularly of the base chassis, with regard to vehicle component parts, units and equipment. The contract covered the following types of tracked vehicles:

- main battle tanks PT-91 M;
- recovery vehicles WZT-4;
- engineering and road vehicles MID-M;
- support bridges PMC – LEGUAN;
- vehicle for driver training and training stands.

The basic element, common to all vehicles, was the tracked chassis of the PT-91 M tank. The novelty for the contractors [11] was the requirement to pass tests by the main battle tank PT-91 M, which was the necessary condition for proceeding with the manufacture of the other vehicles. Fig. 2 shows a MID-M on BUMAR's stand during the International Defence Industry Exhibition MSPO in Kielce in 2009.

![MID-M engineering and road vehicle](image)

**Fig. 2. MID - M engineering and road vehicle**

The Malaysian client has set high technical and performance requirements and imposed a multi-stage mode of control and acceptance processes. Tests and trials were carried out in the presence and with the participation of Malaysian officers both in Poland and in Malaysia. The MID - M engineering and road vehicle has passed all tests and is still used today by the Malaysian Army.

### 4. ADAPTING THE MID VEHICLE TO PEACEKEEPING MISSION TASKS

The participation of Polish armed forces in international peacekeeping and stabilization missions in Iraq and, later, in Afghanistan showed the need to equip the contingent with land vehicles to protect soldiers from the effects of attacks, especially those involving improvised explosive devices (IEDs) [12]. HMVE class vehicles, acquired by the
Polish Military Contingent from the US Army, did not meet the requirements of contemporary battlefield.

In search of other solutions, the Polish Ministry of National Defence decided in 2008 to modernize two MID engineering and road vehicles for the troops stationed in Afghanistan. The decision to choose MID was determined by functional features of the vehicle:

- high level of crew safety – resistance to shelling;
- ability to conduct engineering tasks "under" armour, without leaving the vehicle;
- ability to carry out work with the use of attachments: handling or moving suspected objects and equipment and transportation thereof to a detonation or neutralization site.

Based on the specified requirements [13], OBRUM has developed and manufactured a modernized variant [14] of MID which included:

- a vision system;
- air conditioning;
- power generator with alternator.

The vision system enables observation of the working field of the boom and of the area behind the vehicle. In addition, the vehicle terminal recorded the image using a set of cameras, which enabled study of the actions performed. Fig. 3 shows the installation of the rear observation camera.

![Camera installed in the rear of the MID hull](image-url)
The installed air conditioning system was supposed to reduce the inconvenience for the crew in the vehicle under harsh external conditions, the climate prevailing in Afghanistan. The additional power source in the form of a power generator was intended to supply the air-conditioning system and on-board devices when the main engine was not running. The adaptation made [14], [15], [16] was based on the design of systems devised as add-on equipment to minimize the impact on existing structure of the MID vehicle. All the work carried out was verified during factory tests, but after re-analysis by the logistics services of the Ministry of National Defence of all the conditions related to the place of operation and required maintenance service, the modified engineering and road vehicles were not transferred to Afghanistan and remained with the 1st Brzeska Combat Engineer Brigade. New operating features of the MID vehicle acquired after its modernization can be useful under other conditions or for other purpose than Afghan mission.

5. FURTHER DEVELOPMENT WORK

OBRUM's experience in the implementation of projects related to engineering support of the battlefield (combat engineering tank) and completed works related to supporting obstacle crossings (DAGLEZJA bridges, PMC-90 tracked vehicle-launched bridge, WMI base chassis) and competences of OBRUM's research and engineering staff allow for further modernization of the MID vehicles:

1. Mobility improved by:
   - use of elastomeric pads on the first, second and last pair of road wheels. The solution proposed was applied and verified in MG-20, WZT-4 and MID-M vehicles.

2. Improved efficiency of cooling system in the power transmission system:
   - separation of hydraulic oil cooler from the cooler package. Adoption of the solution applied in WZT-4 (separate cooler with fan installed on hull side - original design by OBRUM) is advisable.

3. Improved durability of working attachment operation:
   - implementation of cutting edges in the excavator scoop and dozer, like in MID-M;
   - implementation of main winch WH-30 with highly flexible hydraulic drive (like in MID-M) with a hydraulic overload mechanism introduced instead of previous mechanical mechanism. Better prevention of cable from breaking due to elimination of time delay mechanical overload system from the kinematic train. The WH-30 winch is OBRUM’s original design successfully implemented in WZT-4.
   - introduction of pull force (force acting in the cable) measurement at the measurement bolt in reversing wheel at the hull bottom;
   - modernized software and control for auxiliary winch.

4. Expansion of existing concept designs to create prototypes, e.g.:
   - hydropneumatic suspension (developed concept for modernization of the T-72 with rocker arm and hydraulic and gas chamber of the same length as the T-72 rocker arm) with the possibility of changing ground clearance and locking - extremely important features when working with dozer equipment and boom.
It should be borne in mind that the assumed life cycle of the vehicle is thirty years, while the MID vehicles developed and produced at OBRUM have been in operation for almost twenty years. Therefore, it is advisable and even necessary to launch a new project - new research and development work aimed at developing a completely new construction using, among others, existing concept designs [17] or solutions offered by OBRUM for the Arabic [18] or Indian market (ARJUN project).

6. MODIFICATION OF CURRENTLY OPERATING MID VEHICLES

The MID engineering and road vehicles manufactured by OBRUM in the years 2000 - 2005 have entered into service in the Polish engineer troops and are still in use. After long years of operation the vehicles require, after periodic inspections, successive modification works, including the replacement of parts and units the service life of which has expired. Part of these tasks lies beyond the capabilities of military repair workshops and is performed by OBRUM. In recent years (2016-2017), OBRUM accepted orders and concluded contracts [19], [20] for overhauls, repairs and modifications of selected units and/or systems of MID vehicles. The completed works included, among others, modifications to the hydraulic system and the introduction of hydraulic blocks controlled using the CAN bus.

The electrical system has also been modified by installing a controller for controlling vehicle operation and hydraulic system operating parameters. Vehicle modification also included modern solutions applied in control systems, such as encoders and linear position sensors.

HMIs (Human Machine Interfaces) have also been modified. The new interfaces have been equipped with graphical displays showing the current hydraulic system parameters, alerts on exceeding the safety levels, as well as information about failures. The modified HMIs improve the operator's working comfort by providing detailed information on the status of the system and by improving operating safety.

As part of routine repairs of worn-out subassemblies, for example, the dozer system has been replaced, the main winch has been repaired, the engine has undergone an overhaul and the DEUGRA fire suppression system has been repaired.

7. SUMMARY

The design of the MID engineering and road vehicle, developed at OBRUM, even though almost 20 years from have passed since the implementation of its production, still does not differ, in terms of the applied solutions, from the modern equipment of engineering troops. Current repairs and overhauls, including replacement of parts and units (available from current market production), allow for the further use of the equipment by the Polish engineering troops. This applies to the products manufactured by OBRUM and operated by the Malaysian army. This proves the high level of the design developed by the engineering and technical staff of that time, while the MID engineering and road vehicles are still OBRUM's reason to be proud.
8. REFERENCES


[19] Contract no. 89/05/16/74/P/2016 OBRUM sp. z o.o. dated 4.05.2016. (OBRUM unpublished documents).