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VIRTUAL 3D TRAINING KIT AS A TOOL FOR SUPPORTING THE TRAINING PROCESS

Abstract. The article presents a modern IT tool, a virtual 3D training kit for training in the operation, maintenance and diagnostics of military devices and equipment. The structure of the training device and available training modes are described. A reference is made in the summary to a potential scope of training sessions with the use of the device described.

Keywords: military equipment maintenance, training, training device, virtual training device.

1. INTRODUCTION

The military devices and equipment currently in service in the Polish Armed Forces feature very modern, sophisticated vehicles and equipment where solutions from the fields of automated propulsion systems, mechanics, armaments, mechatronics, optoelectronics or IT are applied. This equipment must be operated by highly qualified personnel and it requires appropriate logistic support. Continued improvement of skills, using direct hands-on training, and technical support means - training devices, simulators, training stations, etc. - are indispensable. One of the major criteria for selecting the type of training is the relationship between the level of attained skills and the cost of training.

Conducting training in the operation, maintenance and diagnostics with the use of real equipment often entails high costs of equipment operation, risk of equipment damage and endangering the users' health and life. Low availability and costly operation of equipment may lead to the reduction of the number of trainees. Hence, as far as allowed by technical and financial restraints, training and simulation devices of various degree of sophistication and technical advancement are used on a large scale in the processes of training, both in Poland and abroad. Rapid development of this type of equipment has been closely linked in recent years with the huge technological progress in the areas of computer technology and computer graphics.

OBRUM has for many years been exploring the topics of training equipment. OBRUM's most notable achievements include a wide range of equipment, from relatively simple training devices for the T-72 JAGUAR/PT-91 TWARDY tanks [1], a comprehensive simulator for the training of T-72/PT-91 BESKID – 3 tank crews [2], a heavy equipment operation simulator [3] and a system for training the crews of the wheeled personnel carrier ROSOMAK [4], [5] to the currently developed virtual training devices [5], [6]. The establishment of the Simulator Department at OBRUM in 2013 has resulted in a rapid development of modern simulator projects, including projects on virtual 3D training devices, which are being successfully put into service with the units of the Ministry of National Defence.

2. VIRTUAL TRAINING DEVICE

The virtual 3D training device described herein is designed for training in the operation, maintenance and diagnostics of military devices and equipment.

The proposed mode, manner and scope of the training enable:

- improve safety in operating and conducting maintenance;
- improve the effectiveness of training, while reducing its cost;
- conducting introductory or refreshment (periodical) training without the need to use original equipment units;
- improve the reliability of the equipment being operated or maintained;
- increase the attractiveness and comprehensibility of the training content and scope.

The use of virtual training devices, designed for instructing basic maintenance operations, preparatory procedures and operational safety procedures, enables attaining the best results at relatively low cost of training.

2.1. Structure of the training kit

The 3D virtual training kit is supplied in the form of a set comprising a dedicated application designed for the equipment, machine, device, etc. and instrumentation that enables conducting the training on operation and maintenance.

The kit, in addition to the virtual training device, includes:

- instructor's computer set (laptop computer, docking station, display, mouse, keyboard, earphones);
- projector;
- display screen;
- large format monitor;
- trainees' computer sets (laptop computer, docking station, display, mouse, keyboard, earphones);
- safe storage system for laptop computers and tablets.

The core elements of the 3D virtual trainer are the faithfully reproduced, three-dimensional models of machines and devices the operation, diagnostics and maintenance of which is the subject of the training. The spatial geometry of the models is reproduced at such level of detail that enables study of the structure and functions of equipment. However, in view of the sensitive nature of the data (military equipment), the record format of the model should prevent its duplication or transfer of the geometry of the visualized object. In order to meet this criterion, the geometry must be represented in a discrete form, i.e. a spatial raster consisting of volumetric elements (voxels). This technique, unlike surface (polygon mesh) or edge modelling (segments and curves), provides a secure geometry representation that makes it difficult to extract any structural data of subassemblies below the user-defined level of detail.

Spatial models (divided into individual parts, such as bolts, nuts, switches, etc.), combined with an intuitive interface, allow for a variety of interactions, including:

- removal and replacement of subassemblies;
- moving, rotating, illuminating and hiding or revealing parts;
- displaying the view of the device in various modes: context, framework, x-ray;
- making cross sections;
- creating explanations in a selected style.

Fig. 1 shows a screen presenting the device in a context view mode.

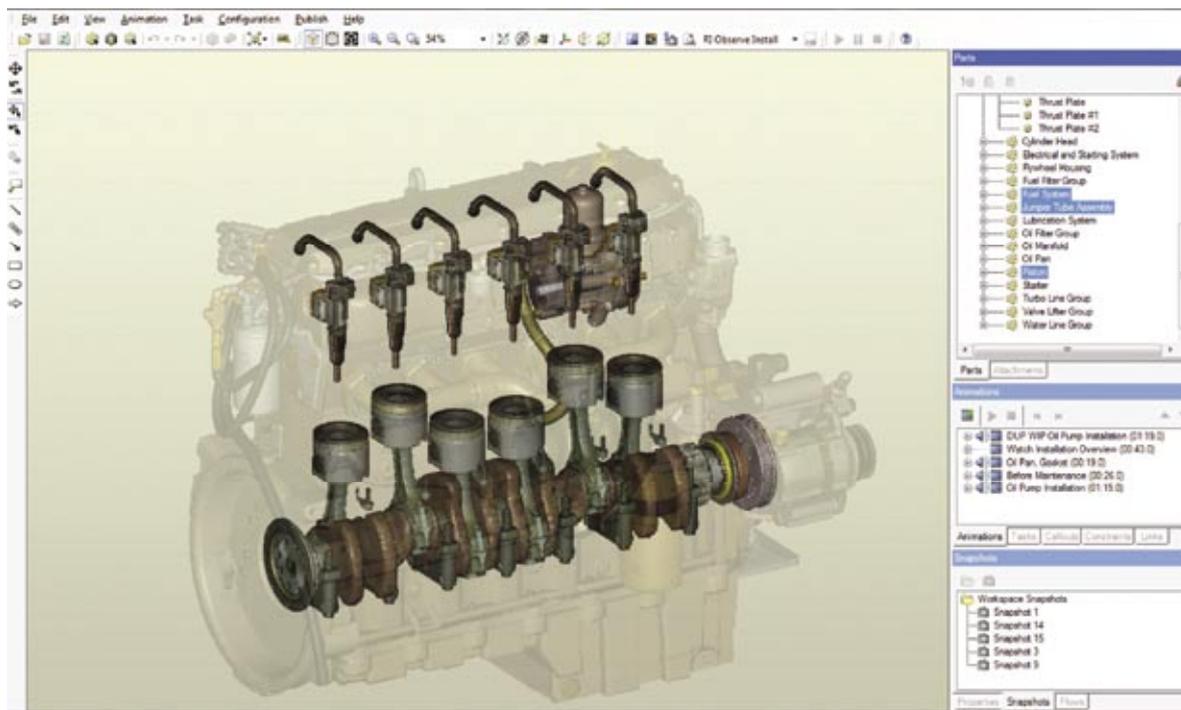


Fig. 1. Context view mode of the device

The process of training with the use of virtual trainers is based mainly on the learning of practical activities. Trainees may train on their own and at their own pace and as often as necessary, receiving immediate feedback in the form of remarks and tips on correctly performed activities or mistakes made. The software included in the virtual 3D trainer consists of two modules:

- client-user module;
- instructor module.

2.2. User module

The client's module is developed as an application that enables viewing the training material (content provided) made available both on an e-learning site and on a local server. There are four operating modes of the virtual 3D trainer browser:

- viewing;
- training;

- practising;
- testing (verification of the acquired knowledge).

2.2.1. Viewing mode

In the viewing mode the trainees may study the structure of assemblies, subassemblies and parts. Individual assemblies and subassemblies may be disassembled down to individual parts. This solution enables a thorough study of the structure of the equipment, the nomenclature used, and provides maintenance services with the capability of finding spare parts by Uniform Material Index (UMI) numbers that identify [6] a product or service within the IT system of the national defence department.

2.2.2. Training mode

In the second mode, the training mode, the user becomes familiar with the operating and maintenance procedures of the military equipment incorporated in the training device. All operations are presented, as is the case with the viewing mode, with the use of the developed virtual 3D model. In procedures illustrating how to replace or repair a particular subassembly or part, the user receives instructions on the operations to be executed. At the same time the user also receives information on how to perform individual procedures, detailed information on, for example, tightening torques, as well as information on the safety rules to be followed in a given procedure. All these instructions are displayed on the screen and read by the lecturer. The user can, at any moment, pause, rewind or continue the procedure.

Fig. 2 shows a screen presenting the creation of an animated disassembly of a device for the "training mode".

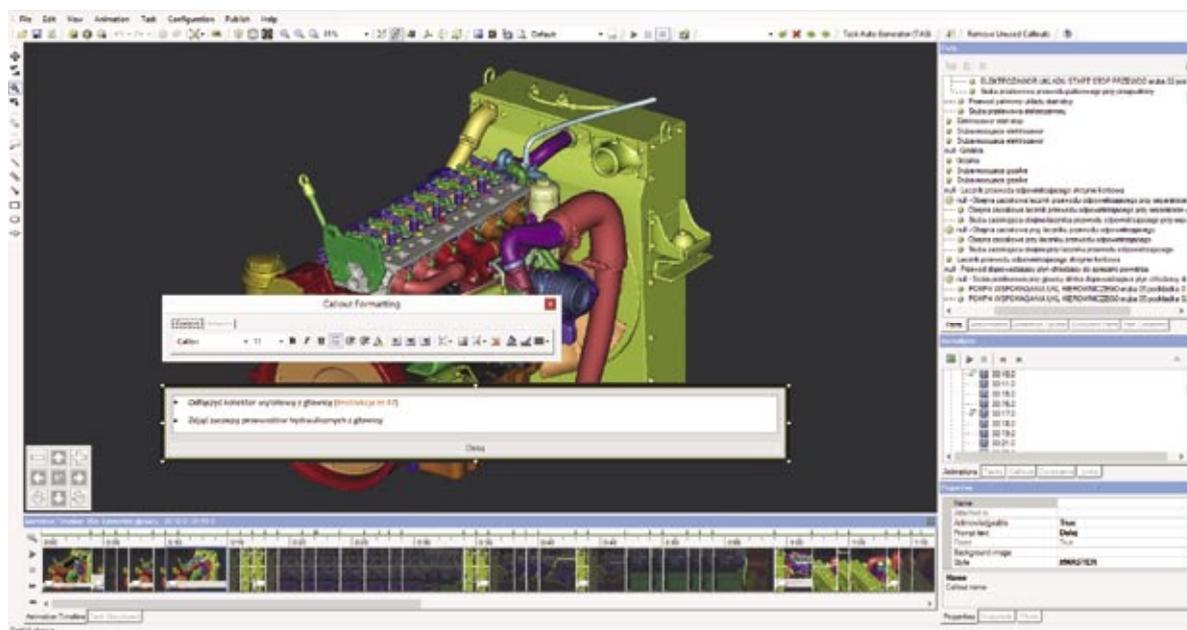


Fig. 2. Creating an animated disassembly (training mode)

scenarios and create and add new ones based on the provided spatial models of objects using dedicated application modules. These modules enable entering and modifying data in an intuitive and uncomplicated way so that persons with basic Windows skills can handle them. In addition, the software enables attaching instruction manuals in the form of electronic documents (Microsoft Office, Adobe PDF, Microsoft Power Point formats), and enhances the lectures with animations that illustrate the interactions between the components discussed.

The subject matter experts can modify the operating and maintenance procedures and remotely conduct training using the e-learning platform of the National Defence Ministry, ensuring a rapid transfer of information in a comprehensive manner. Software for the instructors has an intuitive interface that is friendly for users with experience in MS Office applications, by using the timeline to quickly build and then edit courses using key views, sections, descriptions, multimedia content, etc. The incorporated IT system supports the instructor in preparing smooth-flowing animations using the spatial model of a device, automatically and smoothly joining individual scenes by means of view transition animations. Virtual trainer software enables, by means of instructor application, setting an interactive 3D model of a selected object in the selected mode (exploration, testing or learning a specific procedure). The instructor module allows the target client (user) to update, modify, and expand the implemented application with further instructions, thus extending the scope of the training, such as when deploying a new or upgraded version of equipment.

3. SUMMARY

The virtual 3D training kit described in the article enables accomplishing training tasks that include, among other things:

- learning the construction of individual assemblies, subassemblies and parts of equipment;
- learning the procedures of assembly and disassembly of individual assemblies, subassemblies and parts;
- learning the operating principles of individual systems and units;
- learning the safety rules of operation;
- becoming familiar with the set of used and recommended tools and instruments;
- practising the acquired skills by carrying out procedures on a virtual model of the equipment;
- verifying the skills and knowledge acquired;
- searching part databases by unique name or identification number;
- making objective assessments of the trainee's skills and knowledge and document and record these assessments in an automated manner.

Learning with the use of virtual trainers is based on practical activities, which enables achieving the training objectives in a shorter time than with other methods. The attractive and varied form of presenting and verifying the knowledge of the trainees, the learning rate is significantly improved. Virtual training devices provide a proven method of increasing productivity and efficiency of work the first time the trainee operates the real equipment. This

also has a strongly advantageous impact on personnel safety when operating the equipment and conducting maintenance.

Remarks made and conclusions drawn from the first stage of operation of the virtual training devices developed by OBRUM's Simulator Department:

- Virtual 3D Training Device MK-44 BUSHMASTER [8];
- Virtual Training Device for the engine of JELCZ 442.32 [9],

and implemented at the Logistics Training Centre in Grudziądz have fully confirmed all the above advantages.

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