Józef Wrona, BEng, PhD, Eng.
Jarosław Dąbrowski Military University of Technology
Faculty of Mechanical Engineering
Institute of Machinery Equipment Engineering

3. ANNEX to the Application

A single-field publication cycle authored or co-authored by the habilitation candidate:
Environment and application concept as determinants for predicting the design of military and civilian land platforms

Warsaw 2019

TABLE OF CONTENTS

1. Name and surname 3
2. Diplomas and academic degrees 3
3. Information on employment in scientific units 3
4. Indication of the achievement resulting from art. 16 sec. 2 of the Act of 14 March 2003 on academic degrees and title 4
5. Discussion on other scientific-research, organizational and didactic achievements 31
   - 5.1. The activity carried out before obtaining a PhD degree 31
   - 5.2. Scientific and research activity carried out after obtaining a PhD degree 32
   - 5.3. Information about didactic achievements 41
   - 5.4. Elements of professional development 43
   - 5.5. Prizes, distinctions and decorations received 43

1. Name and surname

Józef Wrona

2. Diplomas and academic degrees

Obtained title: **Master of Science, Bachelor of Engineering**

Military University of Technology, Faculty of Mechanical Engineering

Field of study: Mechanics and Machine Building

Specialty: Engineering Machines

Master's diploma thesis: *The project of a universal carrier for airport maintenance equipment*

Thesis supervisor: Col. Jan Krasuski, DSc, BEng, Military University of Technology, Prof. nzw. WAT

Dissertation defense date: 1985

Obtained degree: **Doctor of technical sciences (PhD)**
Military University of Technology, Faculty of Mechanical Engineering
Scientific discipline: Design and Maintenance of Machines
Specialty: Heavy Duty Machines
PhD thesis: The influence of support on loads exerted on working tool and displacement of a single-bucket excavator chassis
Thesis supervisor: Col. Stanisław Konopka, DSc, BEng, Military University of Technology
External reviewer: Prof. Dionizy Dudek, DSc, BEng, Wrocław University of Science and Technology
Internal reviewer: Prof. Tadeusz Przychodzień, DSc, BEng, Military University of Technology
Dissertation defense date: 1998
Work awarded with the 3rd level Rector's Award for the doctoral dissertation - 1999.

3. Information on employment in scientific units

- 1994 - 1999 - Military University of Technology, WAT - scientific and didactic assistant, Institute of Machine Building, Faculty of Mechanical Engineering, Military University of Technology

- 1999 - 2004 - Military University of Technology, WAT - research and didactic adjunct, Institute of Machine Building, Faculty of Mechanical Engineering, Military University of Technology

- 2013 - 2016 - Military University of Technology, WAT - research and didactic adjunct, Department of Machine Building, since 2014 - Institute of Machine Building, Faculty of Mechanical Engineering, Military University of Technology, Plenipotentiary of the Director of the Institute for Scientific Cooperation

- 2013 - Industrial Institute of Automation and Measurements, PIAP - assistant professor, Director's Plenipotentiary of the Institute for Designs in the Field of Defense

- 2016 - Director of the Institute of Machine Building, Faculty of Mechanical Engineering, Military University of Technology

4. Indication of the achievement resulting from art. 16 sec. 2 of the Act of 14 March 2003 on academic degrees and academic title, and on degrees and title in the field of art
(Journal of Laws No. 65, item 595, as amended):
As the achievement presented after receiving the doctoral degree, constituting a sign*ificant contribution to the development of the scientific discipline Design and Maintenance of Machines* specified in art. 16. sec. 2 of the Act, I consider a single-field publication cycle under the general title:

Environment and application concept as determinants for predicting the design of military and civilian land platforms

The cycle of monothematic publications making up the indicated scientific achievement includes:

1. Konopka, S., **Wrona, J.**, 1998 The problem of supporting hydraulic single-bucket excavators, Military University of Technology Bulletin 47 (4), 69-79, 50%
2. Konopka, S., Kuczmarski, F., Sławiński, A., **Wrona, J.**, Model of support of single-bucket excavator. Part I. Determination of the model of support for single-bucket excavator. Archive of Mechanical Engineering, Vol. XLVI, 999.3, Warsaw, 25%
3. Konopka, S., Kuczmarski, F., Sławiński, A., **Wrona, J.**, Model of support of single-bucket excavator. Part II. Model of dynamics of single-bucket excavator with outriggers. Archive of Mechanical Engineering, Vol. XLVI, 999.3, Warsaw, 25%
4. Kuczmarski, F., **Wrona, J.**, 1999 *Structure of the measurement system and methodology for testing the performance of the elementary section of the mine clearing flail, Experimental methods in the construction and operation of machines.* Wrocław, Szklarska Poręba, 50%
5. Bartnicki, A., Kuczmarski, F., Marecki, P., Typiak, A., **Wrona, J.**, 2000 *The research model of the dynamic-impact mine clearing flail and power transmission unit solution for the engineering and road machine.* 12th Scientific Conference. Drive, Control, Automation of Work Machines and Vehicles. Rynia k./Warszawy, 20%

6. Przychodzień, T., Marecki, P., Sprawka, P., **Wrona, J.**, 2003 *Field tests of the effectiveness of loads exerted on anti-tank mines,* Systems: journal of transdisciplinary systems science 8 (sp.), 419-427, 25%
7. Przychodzień, T., **Wrona, J.**, Sprawka, P., 2003 *Laboratory studies on the dynamic impacts on mines laid in soil*, Systems: journal of transdisciplinary systems science 8 (sp.), 434-443, 33%
8. Konopka, S., Kuczmarski, F., Sławiński, A., **Wrona, J.**, 2004 *Algorithm of construction of single-bucket excavator motion equations*, Archive of Mechanical Engineering 51 (1), 27-39, 25%
9. Czapla, T., **Wrona, J.**, 2013 *Technology development of military applications of unmanned ground vehicles*; Studies in Computional Intelligence 481, Vision Based Systems for UAV Applications, pp. 293-309, Springer-Verlag, DOI: 10.1007/978-3-319-00369-6_19, 50%
10. Bartnicki, A., Łopatka, M. J., Śnieżek, L., **Wrona, J.**, Nawrat, A. M., 2014/1/1 *Concept of implementation of remote control systems into Manned Armoured Ground Tracked Vehicles; Innovative Control Systems for Tracked Vehicle Platforms,* Springer International Publishing, pages 19-37, DOI: 10.1007/978-3-319-04624-2_2, 20%
11. Jan Czarnowski, Adam Dąbrowski, Mateusz Maciaś, Jakub Główka, **Józef Wrona**, October 2018 *Technology gaps in Human-Machine Interfaces for autonomous construction robots, Automation in Construction, Volume 94*, Pages 179-190, https://doi.org/10.1016/j.autcon.2018.06.014
12. Budny, E., Szynkarczyk, P., **Wrona, J.**, 2017 *Unmanned Ground Military and Construction Systems Technology Gaps Exploration.* The 34th International Symposium on Automation and Robotics in Construction, National Taiwan University of Science and Technology (NTUST), ISARC 2017, Taipei , Taiwan, 2017, Proceedings, Published by Tribun EU, sro, Brno, ISBN: 978-80-263-1371-7, 33%

Copies of the publications can be found in Appendix 5. Whereas the list of all publications that were published after obtaining PhD degree (52 – including academic book) can be found in Appendix 4.

The scientific problem I investigated in my study focused on the impact of both the environment and the application concept on the accuracy and manner of tasks performed by selected military and civilian land platforms. The study was aimed at predicting how to model the structure of the platforms performing tasks in a variety of undetermined environments, treating each platform as a part of the operator-platform-environment system. The deformable substrate was seen as the most significant element of the environment in the study.

The research has been divided into two stages. In the first stage, I studied the ground, being an element of high significance for my research and a scientifically demanding component of the broadly understood environment. The focus, in this stage, was put on how the ground affects load creation, and thus the design of selected machines. In the second stage of the study, I examined the influence of the application concept of selected military and civilian land platforms on modeling their structures. The scientific goal of the first stage of the research was to determine the impact of the substrate on the workload of a single-bucket excavator as well as on the structure and load exerted on the mine-clearing flail and the selected land platform carrying it. The ground was assumed to be an important and scientifically complex element of the machines operating environment. Thus, the scientific goal of the first stage of my scientific activity was to determine the influence of the ground on the loads and, as a consequence, to predict the design of selected military and civilian land platforms.

The scientific goal of the first stage of research was realized by developing a model of a single-bucket excavator, where, in the vertical support plane, the model of the support-ground system developed within the framework of the doctoral dissertation was used. As part of this research stage, a model of a mine-clearing flail was developed with indications made to the factors determining the design of the flail carrier.

The scientific goal of the second research stage was to determine the impact of the application concept on predicting the design of military and civilian land platforms, including prediction of techniques and technologies relevant to the tasks implemented by these platforms.

The scientific goal of the second stage of scientific research was reached by developing a methodology for predicting techniques and technologies of designing the structures of military and civilian land platforms. The purpose of their application was the main determinant in this process.

Continuing the research carried out as part of my doctoral thesis, I investigated the problem of the ground and support of working machine - considered as a support-substrate system [1,2,3], and their influence on creating load on the working tool of a single-bucket excavator, and thus the design of its executive mechanisms.

The work [1] indicates operational requirements affecting the development of hydraulic single-bucket excavators. Among others, the increase in the accuracy of performed works, the introduction of new technologies and the reduction of the operator's effort required to operate the machine are specified. These studies inspired me to investigate how the concept of the application and use of a given military or civilian land platform and associated technological requirements affect the very design of these platforms. I made an attempt to answer that question in the second stage of my scientific activity.

In the majority of research works concerning the analysis of work processes of working machines, the assumption is made that the machine's chassis remains stationary. Such an approach, in the case of analyzing the working equipment kinematics, is justified by the assumption that the load on the working tool, which accompanies the soil mining process, is a static one. However, from the point of view of a dynamic analysis, not including the machine support factor in the study leads to no account given to the quantity and quality of its impact on the loads and displacements of the working machine. Studies focus on determining the required accuracy of single-bucket hydraulic excavators resulting from the character and size of the displacements of the chassis [1]. They allow to state that, depending on the type of the support (rubber wheel, track, support), displacement may occur causing variable loads on the working machine. This, in turn affects the parameters of the support and the construction of executive mechanisms.

This constitutes a considerable problem which has not been so far studied at various ground properties, and with varying shapes, spacing or size of the supports. The results of the research carried out on single-bucket excavators and investigating the role of the support placed on a deformable ground pointed to a considerable interaction between ground and type of platform support (wheel, track, support), especially in autonomous machines (automated or remotely controlled), [1]where the interaction affects loads on the working tool and, as a result, the accuracy of work. The influence of the ground on its contact surface with the support was analyzed, trying to obtain the smallest displacement of the chassis, affecting the accuracy of the work performed. It was pointed out that further work should be aimed at developing a simulation model of the support system that would fill the existing gap in the dynamic models of single-bucket excavators used so far. This I realized and presented in the works [2] and [3].

In the published works, when analyzing the dynamics of the excavator, one has assumed a rigid, non-deformable or perfectly elastic support. Such approach in studies on automated excavators performing high precision work is not very adequate though. Thus my attempt to develop a model of the support of a working machine on the example of a single-bucket excavator set on a deformable ground [2, 3].

Already at the stage of writing my doctoral thesis I analyzed several, both simple and complex rheological models of supports. Next, based on the results of experimental and simulation tests, I adopted a rheological model of the support, taking into account elasticity, dry friction and viscotic damping, i.e. Hooke-Newton-Saint Venant -I model (HNS–V–I) [2]. In this model, elasticity was replaced by an elasticity-related function which gives a better representation of the hysteresis loop in comparison to traditional experiments. To measure the accuracy of such approach we used a quality indicator, illustrated as the absolute value of the difference between the areas of hysteresis of ground and support deformation obtained in simulations and experimental tests [2].

The HNS-V-I model modified this represents the elasticity, as an elasticity-related function, damping and dry friction in the support system (ground with the support). Their manifestations that can be stated externally are: hysteresis, vibration damping and dissipation of energy (Fig. 4.1).

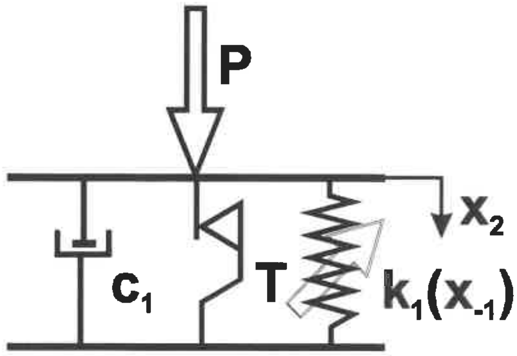


Fig. 4.1. Rheological model of the support-ground system of a single-bucket excavator [2]

The total deformation of the x_2 model under the influence of the load ***P*** is equal

$$x_2 = a \cdot \left(\frac{\operatorname{sgn} b \cdot T - P + k_1 \cdot x_0 + c_1 \cdot x_{-1}}{k_1(x_{-1}) + c_1} \right) + (1 - a) \cdot x_{-1} \tag{1}$$

where the coefficients ***a***and***b*** are defined by the relations (2) and (3):

$$a = \begin{cases} 0 \Rightarrow |b| \langle T \\ 1 \Rightarrow |b| \geq T \end{cases}, \tag{2}$$

$$b = P - k_1(x_0 - x_{-1}) + c_1(x_{-1} - x_{-2}), \tag{3}$$

whereas the constant stiffness coefficient ***k*** was replaced by the stiffness function $k_1(x_{-1})$

$$k_1(x_{-1}) = w_1 + w_2 \cdot (|w_3 - x_{-1}|)^{w_4}, \tag{4}$$

where for (1), (2), (3), (4):

P- load (strength from testing of experimental support),

x_2 - initial displacement of the support,

x_0 - initial displacement of the support,

x_{-1}, x_{-2} - value of the support displacement in the previous calculation steps,

w_1, w_2, w_3, w_4 - coefficients of elasticity function $k(x_{-1})$,

c_1- damping factor,

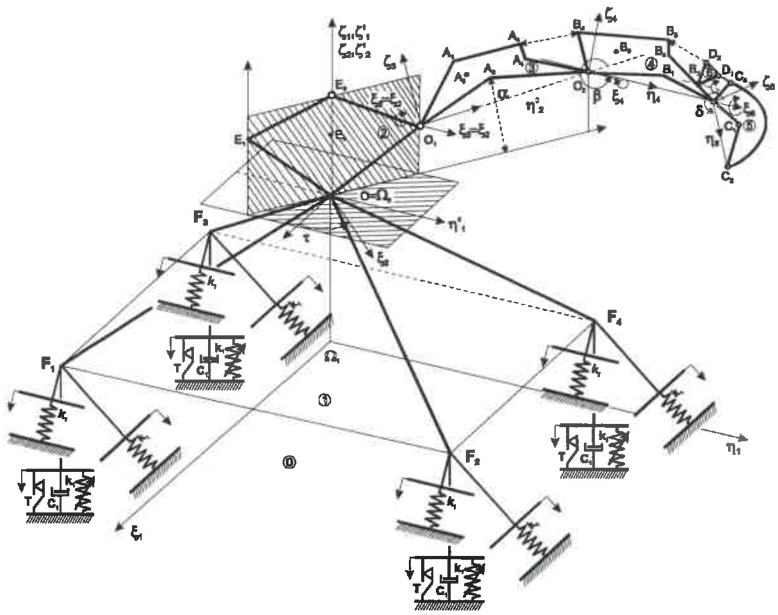
T - dry friction force.

The analysis of the results of simulation and verification tests confirmed the correctness of the formulation of the support-ground model and the usefulness of its implementation in a simulation model of a single-bucket excavator equipped with a support system [2].

The material, knowledge and experience acquired in the process of writing my doctoral thesis became the foundationfor creating the model of dynamics of a single-bucket excavator with a support system, where the support-ground model was described by the Hooke-Newton-Saint Venant-I model and implemented in support points, in the vertical plane [3] (Fig.4.2).

The excavator consists of six segments, connected with each other by six ties. The dynamics of the entire system (according to the vector method) is represented by a matrix equation (5). Newton's and Newton-Euler's equations were formulated for the description of linear and angular displacements respectively [3].

The comparison of the results of the simulations with the results obtained from tests of hydraulic single-bucket wheeled excavator with an experimental support system confirmed the correctness of the simulation results of the developed excavator model with the results obtained during the real object tests [2].



$$\begin{bmatrix} \boldsymbol{M} & \boldsymbol{B}^T \\ \boldsymbol{B} & \boldsymbol{0} \end{bmatrix} \begin{bmatrix} \dot{\boldsymbol{h}} \\ -\boldsymbol{\lambda} \end{bmatrix} + \begin{bmatrix} \boldsymbol{b} \\ \boldsymbol{0} \end{bmatrix} = \begin{bmatrix} \boldsymbol{g} \\ \boldsymbol{\gamma}^* \end{bmatrix} \qquad (5)$$

Fig. 4.2. Model of a single-bucket excavator with the implemented model of the Hooke - Newton - Saint Venant-I support-ground system – [3]

The analysis of the simulations and experimental tests made it possible to assess the influence of support on the displacement of the chassis in selected phases of a single-bucket excavator working cycle. Knowledge of support characteristics proves important in the process of designing working machines and affects the development of their structures and control processes.

The results of the conducted research have led to the following conclusions:

- the ground type, being an element of the land platforms' working environment, implies their design
- knowing specific ground and object characteristics makes it possible to choose a proper support surface for the land platform and to ensure that its maximum displacement will not affect the accuracy of earthworks
- the type and characteristics of the ground affect the load put on the boom cylinder when actuating force is applied to directional control valve during fast lowering of the working tool. In other cases, this impact is small, which points to relatively high damping properties of the excavator's hydraulic system
- the results of the presented works should, already at the design phase, lead to a more precise determination of the parameters of support systems of the manufactured working machines. This should improve the accuracy of the work carried out, bringing better both technological and economic results.

In the further part of the scientific activity, I used the experience gained during the study on the developed model [3] to propose a new method of formulating equations for determining system motion. It combines the advantages of the system motion equations within the Euler's parameters [3] with a classical approach of building equations based on Lagrange equations of second kind. This is how the concept of creating an algorithm for generating platform motion equations in generalized coordinates based on Lagrange equations was developed, the main ideas of which are presented in the work [8] on the example of a spatial model of a single-bucket excavator.

As part of the work, I developed an algorithm for forming motion equations for the single-bucket backhoe model using the Lagrange multipliers technique. It was assumed that the excavator is a system of rigid bodies connected by rotational ties of 10 degree-of-freedom. (Fig. 4.3) The essence of the algorithm consists in reducing the procedure of forming the system motion equations to multiplication of particular matrices and thus eliminating the need for analytical or numerical determination of subsequent derivatives of kinetic and potential energy of the system with respect to coordinates and generalized velocities. An algorithm generated this way can be the basis for building a numerical program for analyzing the dynamics of the excavator system. The presented method of generating Lagrange equations can be generalized and applied to other multi-link systems, including land platforms. This will allow more effective planning of their design taking into account various concepts of application. Moreover, the approach presented in article [3] may be also applied in studies concerning systems based on the support-ground model.

The first stage of research focused around the problem of dynamic and static impact on mock-up anti-tank mines with installed internal force and displacement sensors, laid in soil. The mines were devoid of combat values but reflected real shapes and masses. [6,7].

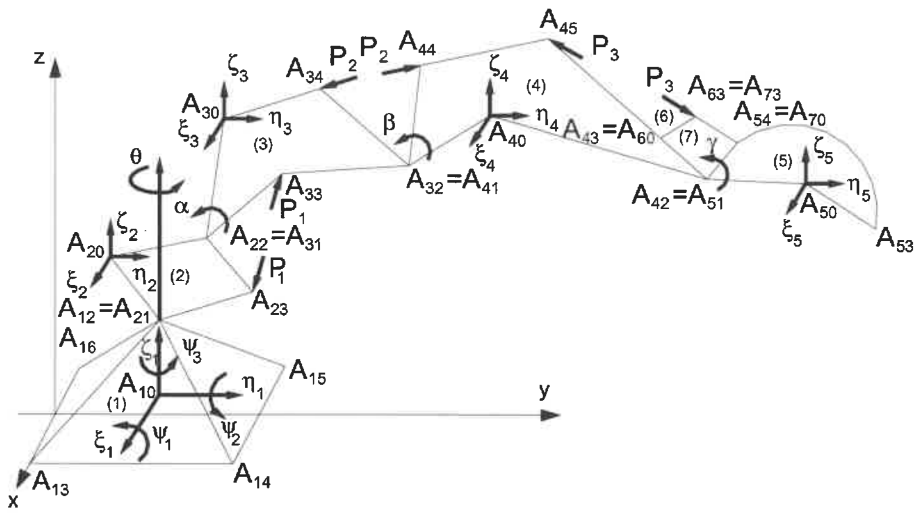


Fig. 4.3. Functional diagram of a single-bucket excavator mechanical system [8]

While studies [1,2,3] discussed the support-ground system model without considering the quantitative contribution of these two components, in the studies [6, 7] it was assumed that the obtained characteristics reflect the nature of soil displacement under the influence of static and dynamic loads. Both polygon [6] and laboratory [7] tests determined the influence of soil type and some of its parameters on transferring applied static and dynamic loads from the ground surface to the mine. The developed laboratory stand [7] enabled examination of the influence of the type, state of compaction and thickness of the soil layer above the mine on the load transfer to its cover.

My contribution to the study involved designing a research stand, developing research methodology and analyzing the results. The metal container was filled with soil with specific properties. The mock-up mine dummy was placed in the ground at a known depth and was equipped with a force sensor and a vertical displacement sensor of the igniter as well as elements for measuring the vertical displacement. On the surface of the ground, a pressure plate with a force sensor and displacement sensor of the plate was placed over the mock-up mine. The load was exerted on the system with the use of a hydraulic press (Fig. 4.4).

The collected research material was used to determine the influence of the soil type and its humidity on the following:

- displacement of the igniter mechanism of the mine model;
- displacement of the igniter mechanism - spring deflection of the mine model as a function of external load;
- displacement of the pressure plate as a function of external load;
- spring deflection of the igniter mechanism of the mine model as a function of displacement of the pressure plate;
- load of the mine model as a function of the external load.

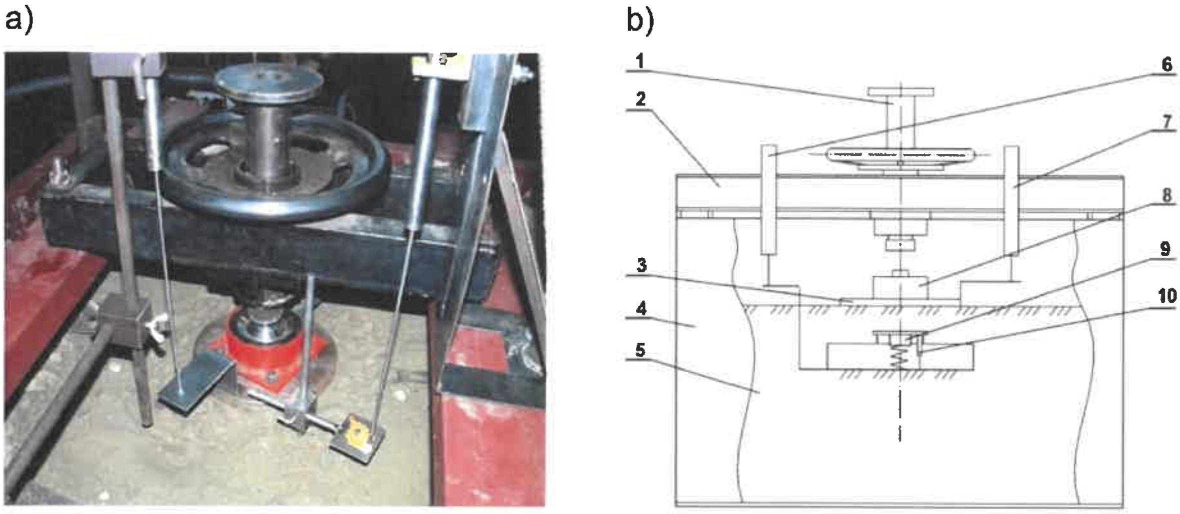


Fig. 4.4. Stand for testing static impacts on mines placed in soil [7]: - scheme: 1-hydrostatic system, 2-mounting frame, 3-pressure plate, 4-test case, 5-ground, 6-vertical displacement sensor of the mine, 7- pressure plate displacement sensor, 8-load sensor of the ground-mine system, 9-sensor of the force in mine, 10-sensor igniter's vertical displacement sensor [7]

In the work [6] I determined the effect of soil type and its humidity on displacement of the igniter mechanism - spring deflection in the mock-up mine and displacement of the pressure plate under various external loads. The results of these test were used as a basis to determine the ratio of external load transfer K_s to the upper plate of the mobile mock-up mine, defined as the ratio of the force inducing spring deflection within the ignition mechanism to the external force applied to the pressure plate. The tests have shown that it is possible to experimentally determine the numerical values of this coefficient for different mine setting conditions and the characteristics of its igniter mechanism.

The analysis of the obtained results made it possible to formulate the conclusion that both the type and humidity of the soil are the parameters determining the possibilities of load transfer - determining the external load, which should be applied to the given surface in order to obtain the appropriate displacement of the mine igniter mechanism.

Determination of the K_s coefficient describing the transfer of external load to the mock-up mine cover, taking into account the type and condition of the soil and its thickness above the mine, enables selection of parameters and assessment of the efficiency of the mine clearing flail, which was used in further research.

The most commonly used method of mine clearing involves creating mechanical impact on the mines in order to detonate, destroy or remove them from the area being cleared. Thus, the following research was aimed at developing a method of generating a dynamic impact on mines, in particular with the use of clearing flail, affecting mines and their igniter mechanisms [4].

Having analyzed the functioning of the clearing flail and selecting the SŁ-34 bulldozer as the carrier of the elementary section of the mine clearing flail, the bulldozer's working tool and hydraulic power supply system were modified (Fig. 4.5). The supporting structure of the section was made of steel sheet and placed on the "DROTT bucket" working tool [4].

Thanks to the modification of the hydraulic system, it was possible to use a directional control valve, controlling the hinged part of the bucket to control the drive of the elementary section. The shaft with flail impactors was driven by the type 2126 hydraulic engine (3), through a two-stage belt transmission.

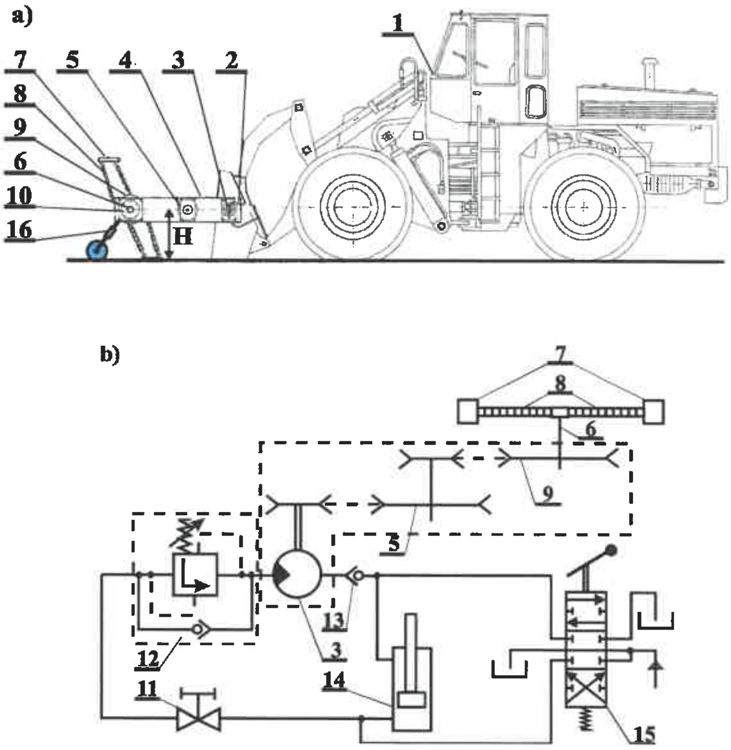


Fig. 4.5. Scrapedozer equipped with an elementary section of mine clearing flail: a - general view, b - diagram of the hydraulic system: 1 - SŁ-34 scrapedozer, 2 - hydraulic lines, 3 - hydraulic motor, 4 - load-bearing structure, 5 - intermediate pulley , 6 - drive shaft, 7 - impactor, 8 - ladder chain, 9 - drive pulley, 10 - shielding cover, 11 - shut-off valve, 12 - flow regulator, 13 - check valve, 14 - DROTT bucket closing actuator, 15 – directional control valve, 16 – jockey wheel [4]

The experience and knowledge acquired during the formulation of the rheological model of the support-ground system of a single-bucket excavator, helped me develop a general model of the impact generated by the impactor on the mine (6):

$$\mathbf{P_M(t)=f[v_N, m_B, h_M, K_B, K_{GR}, K_M,]} \tag{6}$$

where: $\boldsymbol{P_M(t)}$ - vertical component of the force acting on the mine,

$\boldsymbol{v_N}$ - vertical component of the impactor's speed when making contact with the ground,

m_B - the weight of the impactor,

h_M - mine burial depth

K_B- parameters of the impactor (surface, shape),

K_M - parameters of the mine (surface, elasticity, damping and equivalent weight of the igniter mechanism),

K_{GR} - soil parameters (type, moisture, ...).

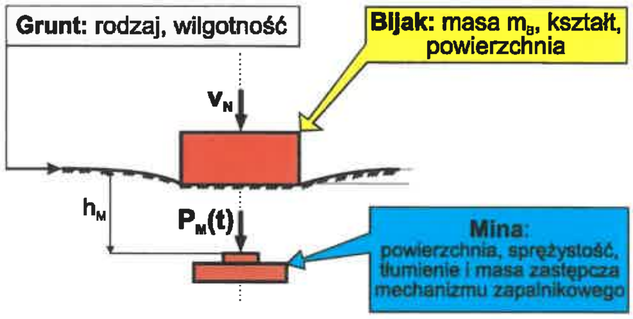


Fig. 4.6. General model of the impact of the impactor on a mine laid in soil [4]

The following values were measured during the tests:

- speed of the vehicle equipped with the mine clearing flail;
- pressure at the inlet of the hydraulic engine;
- height of the flail shaft axis over the ground level (H - Fig. 4.6);
- mine burial depth (h_M - Fig. 4.6);
- rotational speed of the flail shaft;
- distribution of vertical component of the impactor's force when making contact with the ground for different thickness of the soil layer above the mine.

The aim of the research was to select the parameters of the flails to obtain the best possible effectiveness of their operation and to adapt the structures of selected machines used in mine clearing with the flail.

I have designed a measurement system for studying mine clearing flail (Fig. 4.7), which has been described in [4]. The field studies focused on the behavior the impactors of the proposed model of the elementary section of the experimental mine clearing flail with dynamic impact on mock-up anti-tank mines [6]. The tests of loads generated on the soil during the impact of the flail impactors involved using a specifically designed sensor.

The field tests were divided into two stages. In the first one, the mock-up mines planted at a depth of 0.01m were statically loaded. The research used Sł-34 scrapedozer and BAT-M high-speed bulldozer, which moved at low speed in the axis of the mines set. In the second stage, the mock-up mines laid in the soil were subjected to dynamic loads generated by the impactors of the elementary section of the flail installed on the bucket of the Sł-34 scrapedozer (Fig. 4.7).

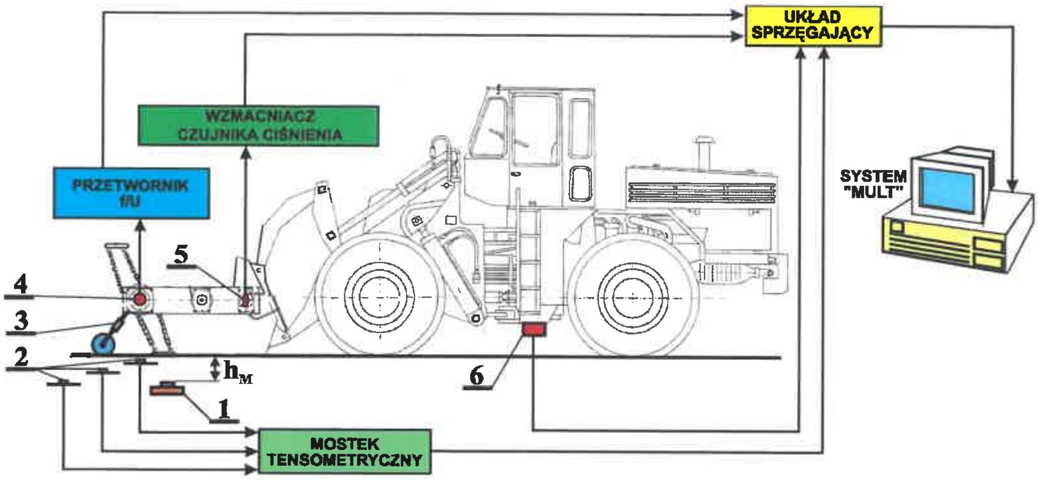


Fig. 4.7. Measurement system used for testing mine clearing flail mounted on the SŁ-34 scrapedozer: 1 - mock-up mine, 2 – plates with strain gauges, 3 – jockey wheel beam, 4 - flail shaft axis, 5 - hydraulic motor [4]

During the second stage, two types of impactors were investigated. The first phase involved examining impactors with a rectangular shape of the contact surface. After analyzing the results of the research, the decision was made to change the shape and weight of the impactors. This was achieved by using balls with a lead interior. The purpose of these actions was to obtain pressures on the upper plate of the igniter mechanism of the mock-up mine sufficient to cause its displacement by approx. 11mm, thus activating the landmine.

In the work [6] I described the research methodology and analyzed the research results. I observed a significant influence of both the thickness of the soil and the nature of its loads on its displacement and therefore the displacement of the igniter mechanism of the mock-up mine. This allowed to determine the optimal parameters for designing the construction of the flail used in demining.

My contribution to the research on mine clearing trails included development of a model of influence of the impactor on a mine buried in the soil, construction of the flail and its adaptation in the base carrier - SŁ-34 scrapedozer. As part of this process, I made changes in the hydraulic system, designed and built a drive transmission unit, providing power to the elementary section of the flail, and made changes in the "DROTT bucket" design of the base carrier on which the load-bearing structure was placed. In addition, I developed the research methodology, and took part in field testing and analysis of the results of these tests, which were presented in the paper [6].

The results of these works contributed to the development of the concept of adapting the Engineering and Road Machine for the implementation of mine clearing tasks by installing a mine clearing flail on its structure (Fig. 4.8) [5].

The Engineering and Road Machine is used for building roads that allow troops to move on off-roads, earthworks (for building hideouts, shelters, command posts, making and liquidating slopes, antitank ditches and trenches), fortification dams, as well as for evacuation, rescue and reloading works. The Engineer-Road machine was constructed on the basis of the T-72 tank [5].

Working equipment and hydraulic system of the Engineering and Road Machine were adapted for a new application concept. The flail was mounted on the vehicle's blade and connected to the hydraulic system using a special quick coupler. In the new application, the blade also served as a shield to protect the vehicle against severed impactors.

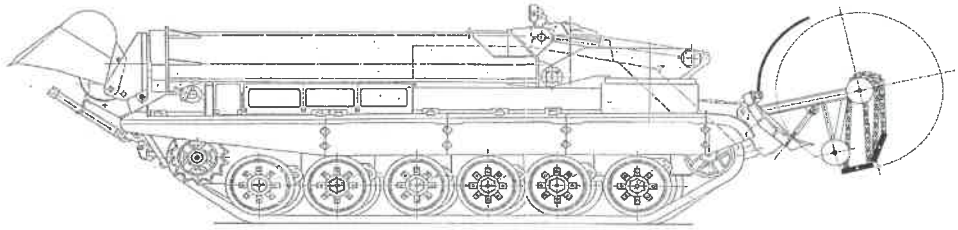


Fig. 4.8. General view of Engineering and Road Machine with mounted flail [5]

Thanks to the adaptation of the hydraulic system, it was possible to use a directional control valve, controlling the lifting and lowering of the manipulator boom to control the flail drive (Fig. 4.9).

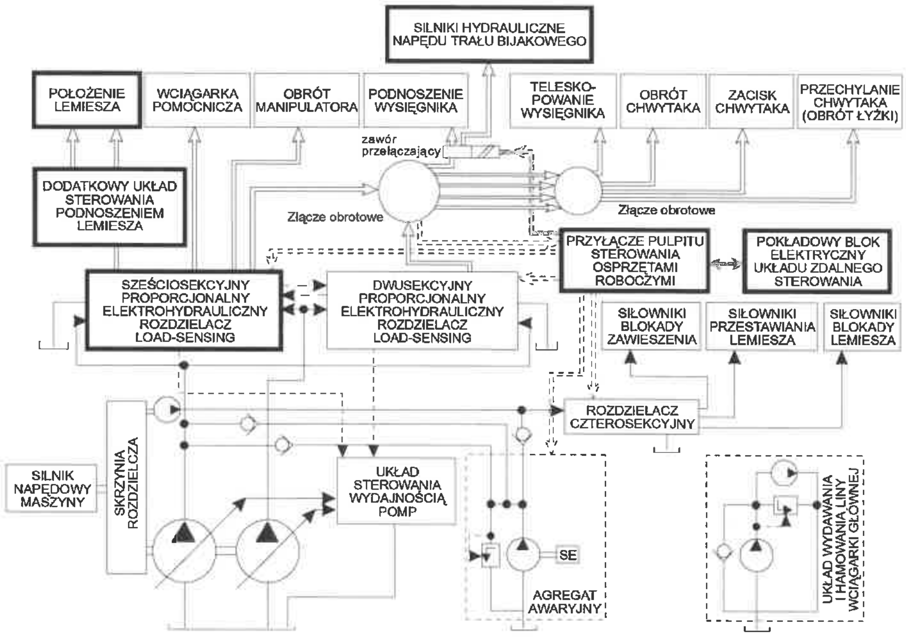


Fig. 4.9. Block diagram of the Engineering and Road Machine hydraulic system with installed flail drive [5]

The flail shaft was driven by two hydraulic motors with a total power of 140 kW. Impactors were attached to the shaft on ladder chains. The need to have impactors make contact with the ground in a parallel position determined the selection of attachment points and the length of the chains.

In order to ensure the possibility of using the Engineering and Road Machine bulldozer, a three-point suspension system was designed to allow it to be tilted in a plane perpendicular to the direction of travel (Fig. 4.10). It consisted of two lower levers (4), used to control the position of the working tool and two upper levers (3) connected, by means of joints, to the intermediate frame (8), on which the blade was suspended by means of a cylindrical joint shaft (2).

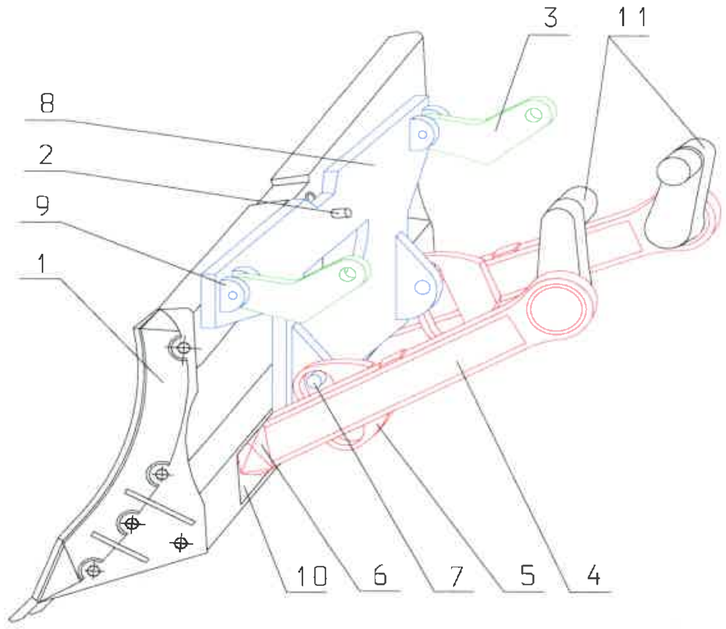


Fig. 4.10. Scheme of the designed three-point blade suspension system in a Engineering and Road Machine : 1 - blade; 2 - cylindrical joint shaft; 3 - upper lever; 4 - lower lever (drive); 5 - blade guide with circular cut; 6 - spherical cap; 7 – guide pin; 8 - intermediate frame of the blade; 9 - hold; 10 - hole made in the blade; 11 - cranks [5]

The working tool of the vehicle was driven by two hydraulic system cylinders. Their pistons were mounted on crank pins (11), mounted in slide bearings in brackets welded to the bottom of the machine chassis. The cylindrical part of the crank set in the bracket featured multisplines with mounted drive levers (4). The other end of the lever ended with a spherical cap (6) placed in the holes (10) in the lower part of the blade box. A special element (5) with a circular cut was welded to the drive lever, enabling movement of the guide pin (7) of the intermediate frame. Two brackets were welded at the head of the vehicle's frame, to which upper levers (3) were attached with bolts. The other end of these levers was connected by bolts to holds (9) welded to the intermediate frame. The intermediate frame (8) featured a rotably suspended blade (1), secured by means of a cylindrical joint shaft (2). This allowed for positioning the blade perpendicularly to the longitudinal axis of the vehicle. The movement of the piston rods was transmitted to the levers (4) by rotating cranks (11). The spherical caps (6) were placed in the holes of the blade (10), which allowed for its rotational movement around the joint shaft (2). The intermediate frame (8) on which the blade was suspended could only move up, down or remain stationary. In order to maintain the assumed kinematics, the maximum angle of heel of the blade was limited to approximately 10^0. In addition, it was possible to control the position of the blade with one lever while the other remained still. The deflection of the control levers relative to each other, however, could not exceed 12^0.

Changes in the hydraulic system adapting it to controlling the working movements of the mine clearing flail included the following steps:

- using an additional blade position control system (Fig. 4.11);
- implementation of an additional directional control valve in the system of lifting and lowering the blade, directing hydraulic oil to engines driving the shaft of the flail.

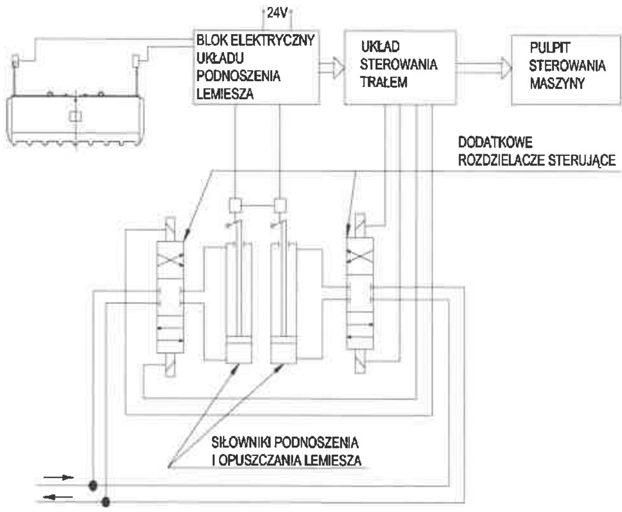


Fig. 4.11. Scheme of an additional system controlling blade position [5]

My contribution to adapting the Engineering and Road Machine to performing demining tasks with the use of mine clearing flail consisted in adaptation of the previously developed and tested flail for blade of the Engineering and Road Machine. In addition, I participated in the modernization of the hydraulic system and adaptation of the blade for the new application, being performing tasks of dynamic mine clearing [5].

This stage of research brought the following conclusions:

- the thickness of the soil layer affects the loads transfer to the ground-mine system. The displacement of the igniter mechanism of the mock-up mine is determined by the nature of the loads, which affects the design of this type of equipment;
- under certain environmental conditions, the soil transfers dynamic loads more efficiently than the static ones;
- the rotational speed of the rotor affects not only the energy of the impactors, but also the accuracy and efficiency of mine clearing. Moreover, it is dependent on the speed of the machine-carrier of the flail and energy lost during the impact;

- the effectiveness of the impactors depends on their shape - the smaller the area of the contact surface of the impactor on the ground, the smaller the effective weight of the impactor required, which translates into the design process of this type of equipment, including their construction;
- changing the application concept of the machine implies changes in its construction, including changes in its executive mechanisms and driving systems.

The aim of this stage of my scientific activity was achieved by developing a support-substrate model of a single-bucket excavator and then a model of a single-bucket excavator, in which the developed model was applied. The results of this stage of study include: formulating an algorithm that can be the basis for building a numerical program for analyzing the dynamics of a single-bucket excavator; developing a general model of mine clearing flail and determining the influence of the substrate, being an important and scientifically demanding component of the operational environment of the machine; defining application concept as a determinant for machine construction.

In the second stage of my scientific activity, I studied the relation between the application concept of machines and planning their design. The scientific goal of the second stage of research was implemented by developing methodology of predicting techniques and technologies of designing military and civilian land platforms, with their application concept constituting the main determinant for their construction.

This stage of research began with systematizing the problem of land platforms, focusing on autonomous platforms. The assumption was made that they are a natural example of a situation where the designing process is determined by the application concepts as these machines take over human tasks by achieving further levels of autonomy. I took part in organization of the current state of knowledge and perspectives for the application of unmanned technologies for military land vehicles [9]. This work describes the beginnings and evolution of unmanned technology, starting with solutions based on remote control up to fully autonomous systems. Next, the classification and an overview of currently produced and developed systems as well as prospects and development directions of unmanned land vehicles were presented (Fig. 4.12). It was found that there is a large impact of the application concept and new technologies on the design of unmanned ground vehicles. Weapons used in asymmetric warfare, as for example with the use of so-called improvised explosive charges, determine the requirements for these vehicles, and thus their design. Technological development allows the vehicles to carry out missions so far performed by man. However, when designing these platforms, it is important to develop a methodology for determining critical technologies, the so-called technological gaps, which was carried out in the works [11,12].

The scientific goal of the second stage of research was also realized by defining the method of designing the construction of selected military and civilian land platforms determined by their application concept. The key element in this area of my research was the concept of using unmanned platforms to carry out the tasks previously performed by manned platforms, which consequently resulted in changing the design of both their executive mechanisms and control systems. The first way to achieve this approach was to install remote control systems in manned armored ground vehicles

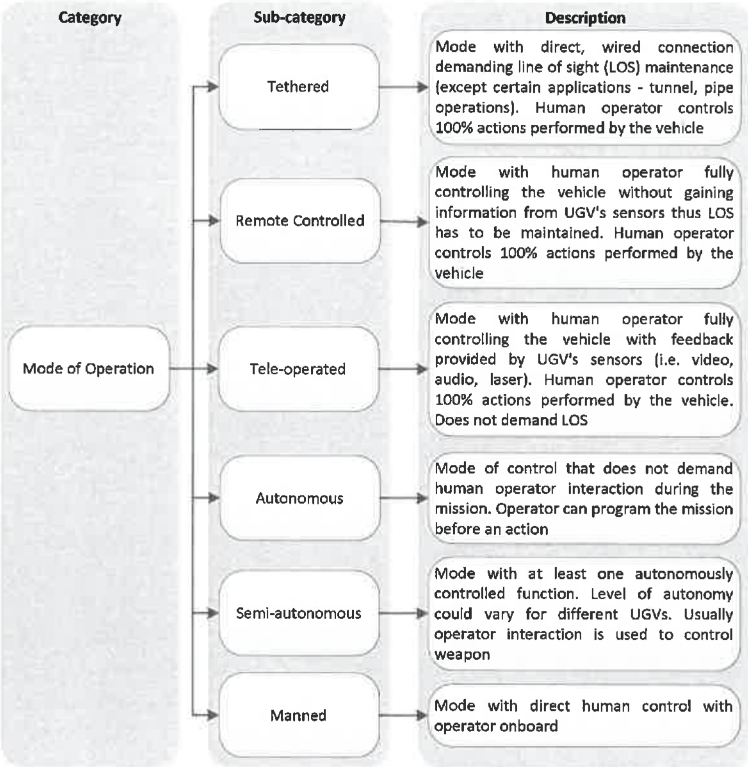


Fig. 4.12. Classification of unmanned platforms based on operation mode [9]

so that selected concepts of their use in a life-threatening environment could be realized without human participation[10]. It was accepted, and later proven in the works [11] and [12], that the development of techniques and technologies is a condition for the formulation of new Concepts of Operations (CONOPs) of military vehicles by changing their design and enabling the implementation of new Operational Requirements (ORs) so that new tasks can be carried out. Already the process of defining the needs related to defense capabilities and, in the case of civil environment, market research, determine the functionality of machines fulfilling the needs outlined in the works [11] and [12]. The paper [10] considered scenarios of using platforms for such tasks as mine clearing, overcoming obstacles, crossing the river bottom, which have an impact on their design (Figure 4.13). It was assumed that the implementation of tasks in selected scenarios requires the development of a universal remote control set that would change the concept of use of a base vehicle through making it autonomous, which in turn would lead to increase in efficiency of robotic platforms (Figure 4.14).

The remote control system was implemented in two vehicles. The T-72 tank was selected for adaptation for a remote execution of selected military missions, such as mine clearing whereas the WZT-3 technical security vehicle was chosen for the task of crossing the river bottom. I also participated in the development of scenarios that were presented in the paper [10].

The task of passing the river bottom and mine clearing operation had a distinct impact on the modeling of the operator-vehicle-environment system, while diversifying the control system.

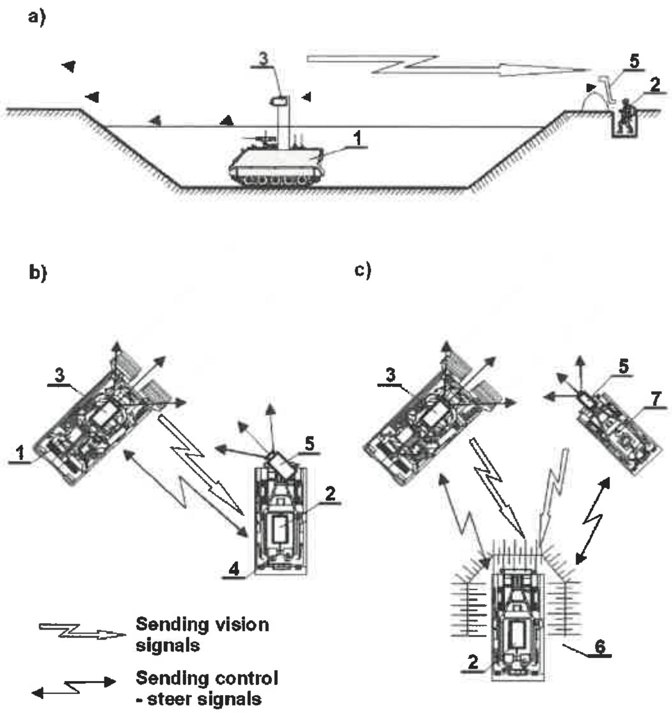


Fig. 4.13. Examples of application concepts of remote controlled land platforms: a) controlled from an external control point - an observation point, e.g. when the vehicle overcomes a water obstacle along the bottom, b) controlled from a mobile platform, e.g. passing a narrow minefield or removing and neutralizing dangerous objects, c) control with the use of a mobile observation platform used as a non-mobile control point, e.g. when passing a large minefield: 1 - unmanned ground vehicle, 2 - operator, 3 - observation cameras, 4 - mobile observation platform, 5 - outdoor cameras or other terrain recognition devices, 6 - stationary control point of unmanned land platforms, 7 - unmanned observation platform [10]

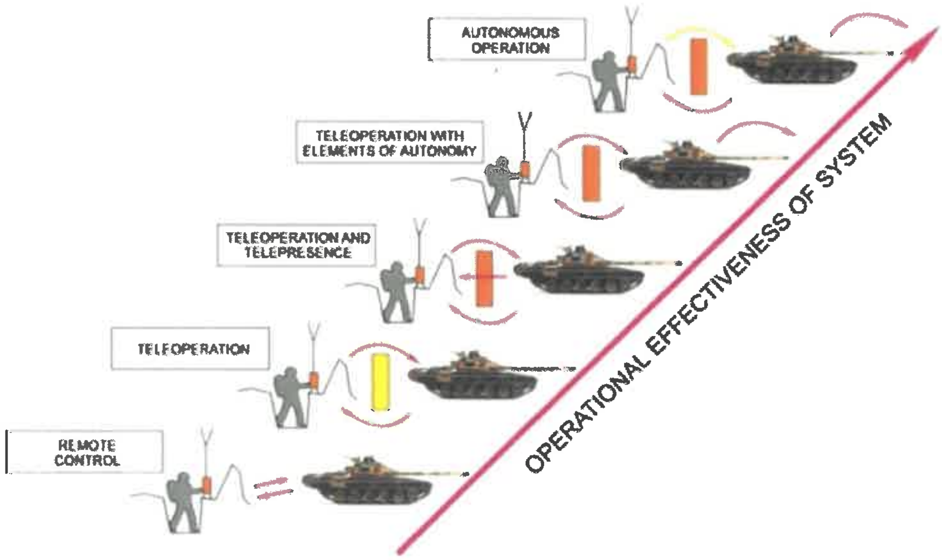


Fig. 4.14. Level of robotization and effectiveness of the tasks performed [10]

During the implementation of the tasks under the adopted scenarios, three variants the "operator - WZT 3 Vehicle - environment" system structure was proposed: direct control by the operator, computer support of work of the operator on the vehicle and remote control (Fig. 4.15).

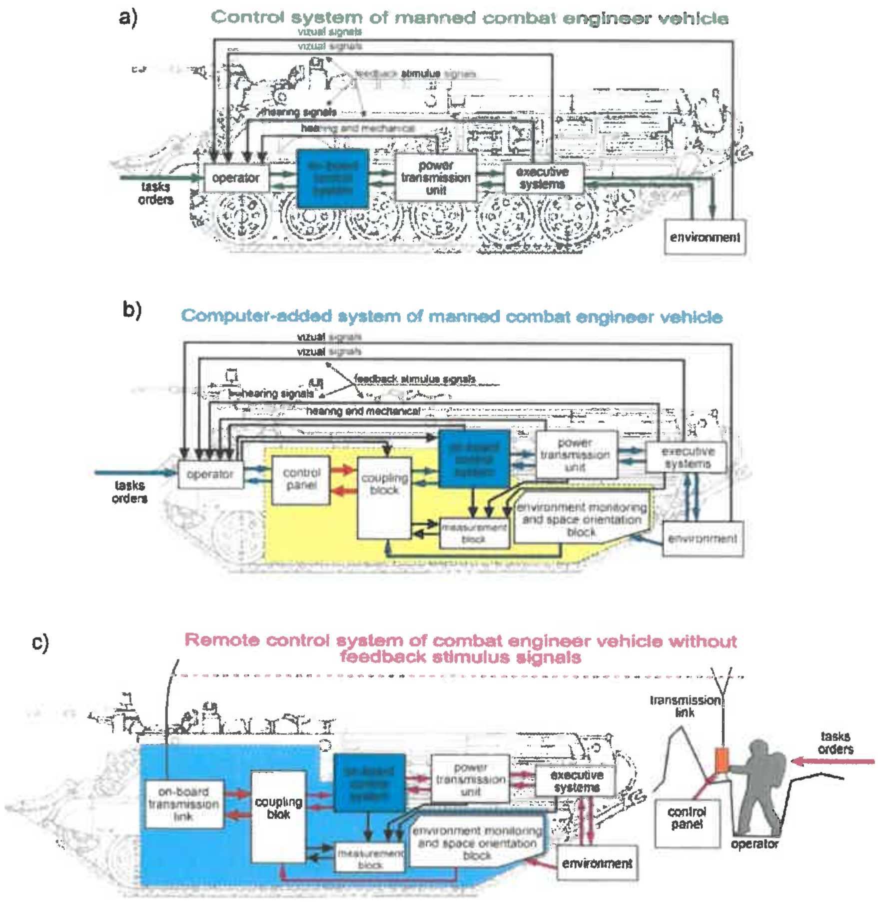


Fig. 4.15. Schemes of the "Operator – WZT-3 Vehicle - Environment" system in the case of: a) direct control by the operator, b) computer support of the operator, c) remote control of the vehicle [10]

Having defined the assumptions for the construction of the remote control system [10], I took part in the development of a functional diagram of such a ground vehicle system (Fig. 4.16). This scheme was the basis for the development of a remote control system for both the T-72 tank and WZT-3 technical security vehicle.

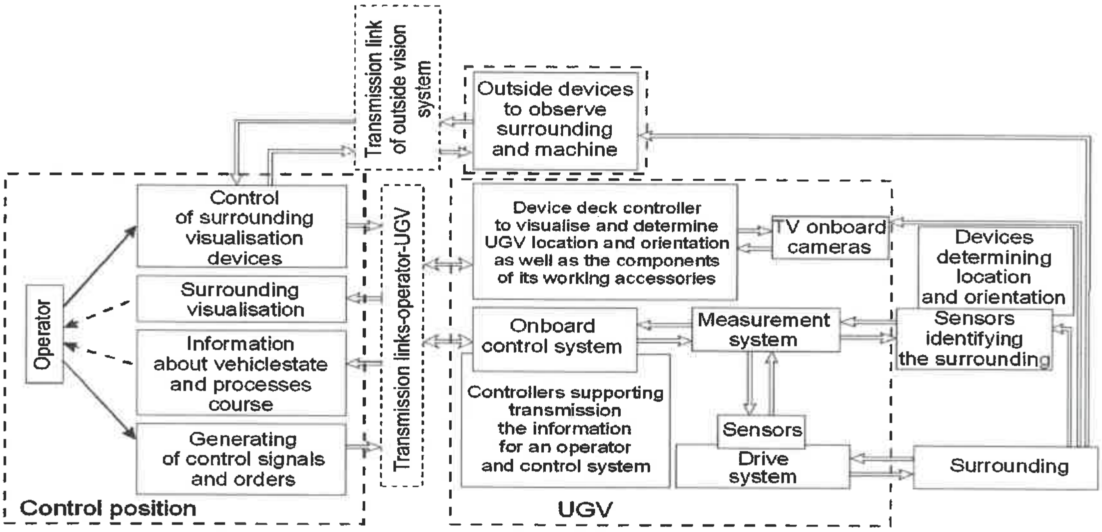


Fig. 4.16. Functional diagram of a remote control system for unmanned land platforms [10]

In the further part of the work, I designed and implemented executive mechanisms in the operator's cabin of the WZT-3 technical vehicle and in the T-72 tank, which significantly changed the structure of the vehicle control system, adapting them to perform tasks in remote control mode, as shown in Figures 4.17, 4.18, 4.19.

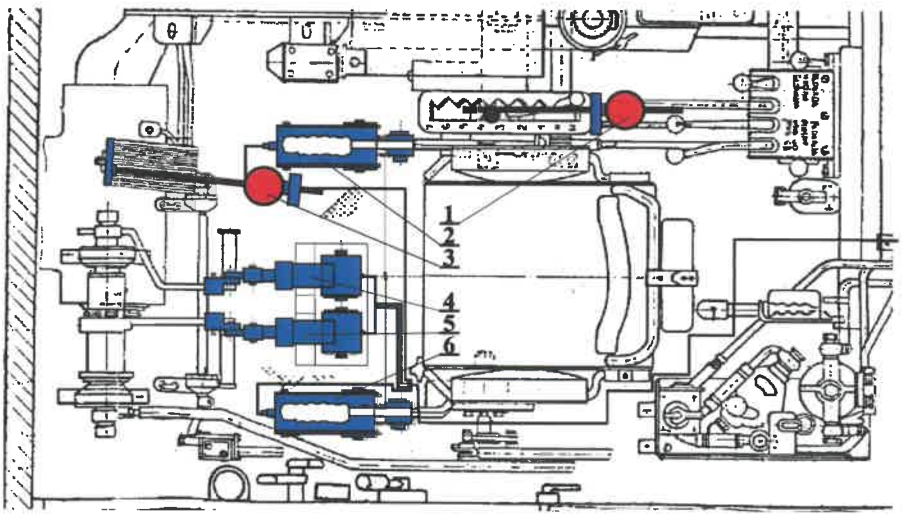


Fig. 4.17. Top view of the WZT-3 technical vehicle operator cabin with elements of the executive block of the remote control system: 1 - electromechanical control mechanism of the gear lever, 2, 6 - mechanisms of pneumatic steering of turn levers, 3 - electromechanical engine speed control mechanism, 4 control mechanism of the pneumatic brake lever, 5 - control mechanism of the pneumatic clutch lever [10]

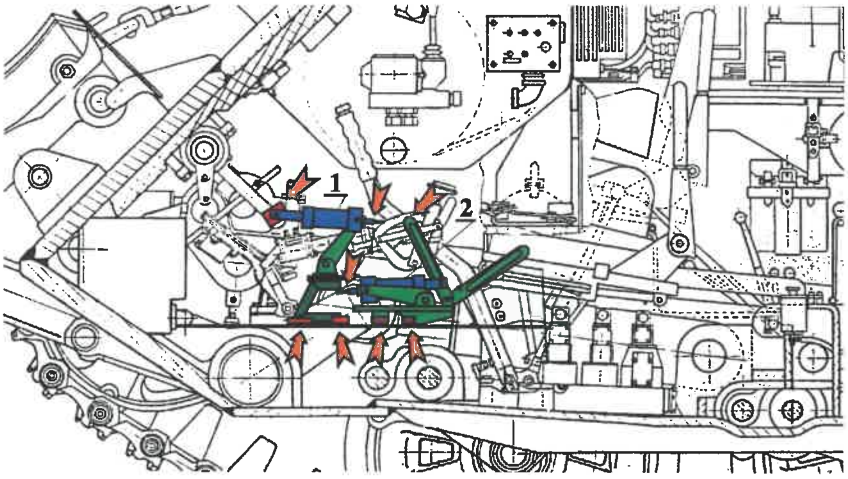


Fig. 4.18. Side view of the WZT-3 cabin together with the mechanisms of the executive control block of the remote control system: 1 - mechanism for controlling the position of the clutch lever; 2 - steering lever control mechanism [10]

a) b)

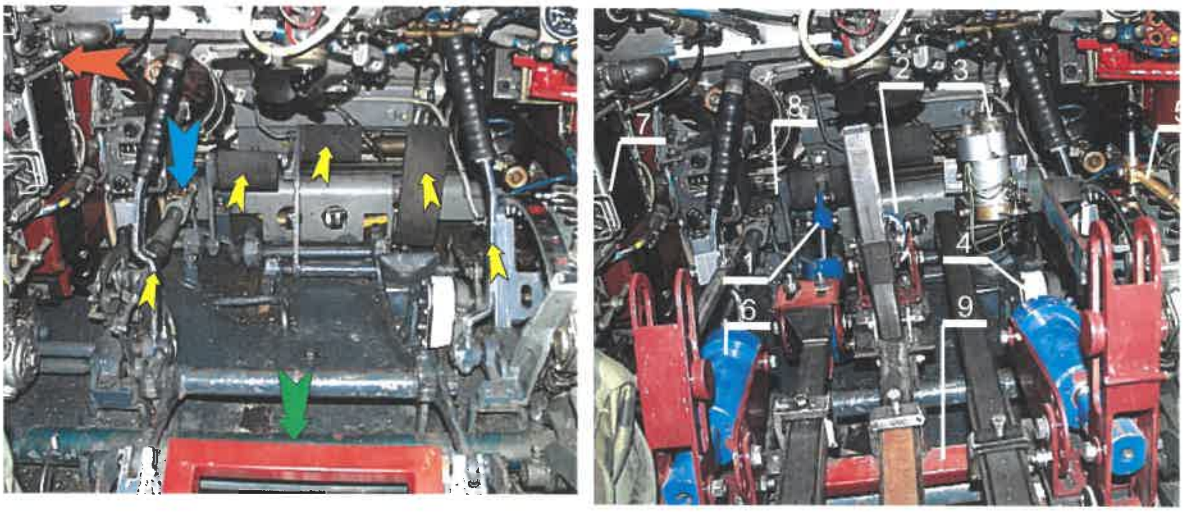


Fig. 4.19. View of the operator's cabin of the T-72 tank: a) without elements of the executive system of the remote control, b) with elements of the executive system of the remote control: 1 - mechanism of pneumatic control of the clutch lever, 2 - mechanism of pneumatic control of the brake lever, 3 - mechanism of electromechanical engine speed control, 4, 6 - mechanisms of pneumatic steering lever control, 5 - mechanism of electromechanical control of gear lever, 7 - test indications board, 8 - air valve, 9 - carrier frame inserted in place of driver's - operator's seat [10]

Both in the case of the technical security vehicle and the T-72 tank, the manned steering versions of the vehicles featured a mechanical steering system of the turn, brake, clutch, gear shift and engine speed levers, that is not susceptible to operation in the remote control mode. For this reason, it was necessary to carry out adaptation works.

For that reason, I developed the concept of changing the structure of the control mechanisms of these vehicles. I developed and implemented executive mechanisms of the so-called executive block in the operator's cabin.

Electropneumatic executive mechanisms were used to control the brake, clutch and turn levers, with electromechanical ones to control the gearshift and engine speed levers in the executive block.

The choice of pneumatic drive was supported by possibility of its connection to the onboard pneumatic system of the vehicle, possibility of quick assembly and disassembly by using quick couplers and relatively small dimensions of pneumatic cylinders, generating sufficient forces on the piston rod. PT-90 pneumatic cylinders, typically used in TW 92 mine ploughs, were used to control the brake, clutch and planetary mechanisms steering levers. The cylinders used for controlling planetary steering mechanisms levers ensured free movement of the levers from the neutral to the front most position, while the cylinders controlling the clutch and brake levers ensured full disengagement of the drive system and braking of the vehicle. The gearshift lever and the engine speed control lever were driven by electrically modernized UT-6D electromechanics. The reason for this choice was to get a simple effect of "selecting" individual gears. The electric system for controlling gear changing and engine revolutions featured elements that simulated changes to the positions of individual levers. Thanks to that the signals transmitted to the controller allowed for automatic execution of certain operations or blocked them in case of erroneous commands made by the operator.

In order to improve the assembly of the electro-pneumatic executive mechanism, suitable mounting elements were welded to the floor of the operator's cabin, which did not negatively affect the use of the vehicle in the event of dismantling the remote control system. When situating individual elements of the electro-pneumatic cylinder, the available spaces and elements in the operator's cabin were used. The other elements of the system are located outside the mechanic - driver compartment. The vehicle can be used after a partial disassembly of the remote control system and disconnection of the executive mechanisms. Such solutions were already part of the current development trends of land platforms, whose main determinants are modularity and open architecture.

I also took part in the development and construction of a test stand for verification and validation of remote control systems for vehicles adapted for automatic and remote control for minefield mine clearance (T-72) and river bottom crossing (WZT-3) [10]. The work also presents selected results of these tests and their analyzes.

Already at this stage of the research, a distinct interaction was observed between technological availability and the possibility of tasks execution by the machines through their appropriate design, matching the type missions they were to carry out.

The experience gained at this stage of research was found useful not only in my further scientific, but also organizational and didactic activity.

This stage of my research continued with examination of the influence of the application concept on the prediction of designing military and civilian land platforms, through the choice of techniques and technologies relevant to the specificity of given tasks implemented by these platforms. The realization of this goal took the form of developing a methodology for predicting techniques and technologies for designing military and civilian land platforms, treating their application concept as the main determinant of this process.

Consequently, the subsequent studies [11, 12] focused on answering the scientific question of whether it is possible to develop a methodology for finding technological gaps of unmanned military and civilian machines. That would prove crucial in formulating new Concept of Operations (CONOPs) and planning design of military and civilian platforms so as to enable implementation of new Operational Requirements (ORs) of the former and meeting market needs of the latter.

The work [11] describes operational requirements needed for the analysis of unmanned military systems. The analysis aimed to define which technological areas should be developed to meet these requirements and whether this approach can be applied in the case of construction machinery. The material presents technological gaps identified by comparing Operational Requirements with current technologies which can be applied in military and construction equipment. Next, actions were defined whose implementation will contribute to dealing with the defined technological gaps. The described actions concern research and development initiatives needed to meet Operational Requirements both at the battlefield and at the construction site. The ultimate goal was to create new abilities in these two areas of important human activity.

I have created a diagram for the process of planning techniques and technologies used in designing military and civil unmanned land platforms (Fig. 4.20). The diagram shows individual steps within the methodology, defined and implemented also for unmanned construction machinery. I have also established the associated terminology whose creation was the result of the experience gained during the implementation of the project at the European Defense Agency on the topic: *Unmanned Ground Systems Landscaping and Integration Study (UGS-LIS)*. Treating the application concepts as the main determinant of planning technologies used in the design of these platforms, it was assumed that Operational Requirements for the platforms used in the given field (Field Requirement) result directly from these concepts.

Defining both technological and non-technological objectives in these areas and determining challenges along with the way of their evaluation were the basis for formulating the methodology of prediction of the so-called technological gaps. These significantly affect the task implementation process carried out by these platforms, assuming that the task executed within the application concept is to be fully autonomous [11].

I further investigated this problem by focusing on developing a methodology for determining technological gaps not for the entire machine, but for Machine-Operator Interfaces (M-OI) important from the point of view of remote control of autonomous construction robots [12]. The aim of the research was to develop a scientific tool that would help to plan technologies and allow to create new designs, thus increasing the functionality of new devices that are the interface between the operator and the unmanned land platform performing tasks in a diverse operational environment of the battlefield or construction site. The research also aimed to answer the scientific question of whether the operational requirements for unmanned ground vehicles can affect the technological areas of Machine-Operator Interfaces. Furthermore it was an attempt to find out whether the presented methodology for defining technological gaps can be applied to both military and civilian applications of robots performing engineering support tasks of the battlefield and construction robots. Such methodology of identifying technological gaps and Operational Requirements based on previous research was developed [12]. Based on the key elements of the UGS-LIS project (Fig. 4.21), I developed a methodology for planning techniques and technologies of Machine-Operator Interfaces for autonomous construction robots necessary to meet the requirements set for these devices [12].

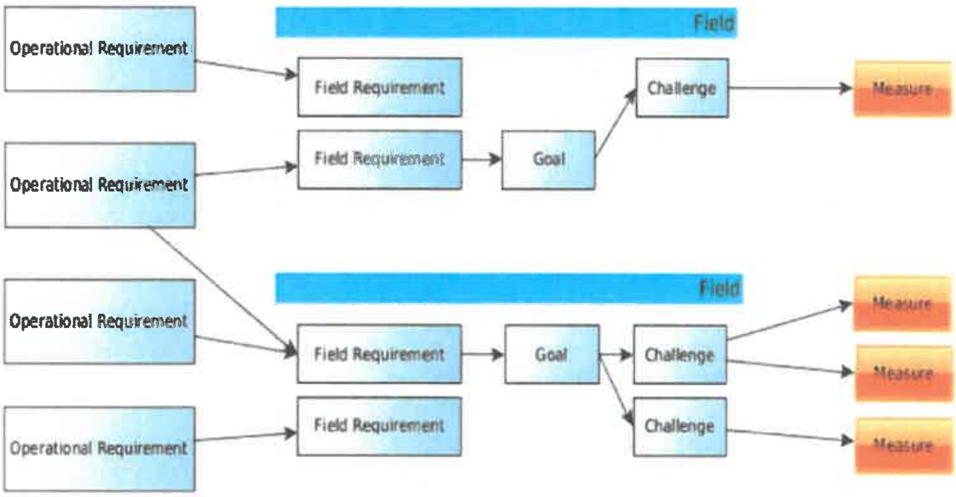


Fig. 4.20. Diagram of the process of planning techniques and technologies for designing military and civil unmanned land platforms [11]

The requirements should be defined for a specific application area. In this case, it is the technological and non-technological area of the Machine-Operator Interface. The requirements should result from the analysis of the state of technology and technological gaps, which prevent meeting the requirements of M-OI in the assumed application concepts. In order to properly analyze the available technologies and technological gaps, the following tasks should be carried out:

- formulate a list of areas in autonomous operations,

- formulate requirements for these areas,

- determine which of these requirements can be met by using available technologies and which after obtaining new technologies that will be the objectives of the process,

- for each objective, identify technological gaps, whose covering will ensure that the requirements for M-OI are met.

The next step is to determine the availability of technologies necessary to meet the requirements. An important element of this step is to distinguish between "state of play" and "state of art" technologies. The former relates to already developed technologies whereas the latter concerns technologies being developed. In the case of this methodology, the so-called technological gaps are understood as all technologies from the "state of art" area, including disruptive and emerging ones.

Once the technological gaps are identified, they should be evaluated in terms of their impact on meeting the requirements (critical technologies), complexity, and availability (disruptive, emerging). Non-technological aspects of meeting the requirements are also considered.

Further action involves identifying the challenges and measures to be taken to bridge the defined technological gaps.

The next step is to define tasks for the research and development area as well as research and development initiatives needed to achieve the required levels of technology development. Optimally, the developed technology should make it possible to meet the requirements of M-OI. Additionally, a road map to develop the technology should be presented.

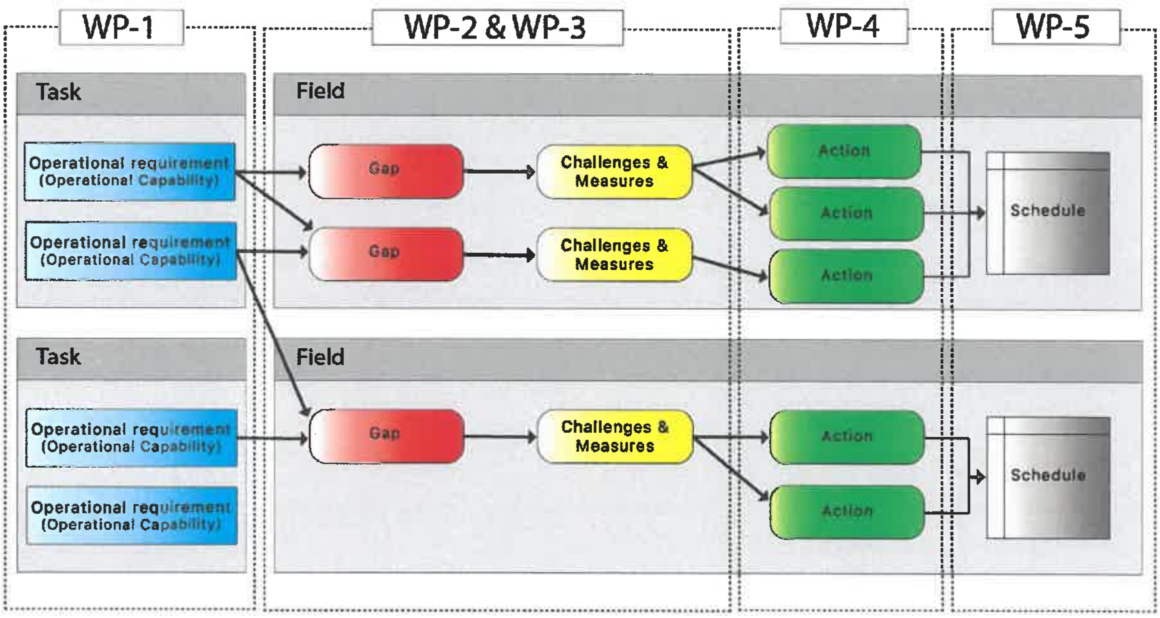


Fig. 4.21. The structure of research carried out as part of the UGS-LIS project [12]

The work [12] presents some scenarios regarding military and civilian platforms as well as the results of research carried out in accordance with the adopted methodology regarding the identification of technological gaps that hinder the use of unmanned land vehicles in realization of specific scenarios. I also proposed a method of analyzing the determined technological gaps in the context of carrying out missions/tasks (autonomous operations and functionalities) in accordance with the adopted methodology. I also presented a plan of meeting technology needs, whose development will enable the implementation of these missions/tasks in the area of Machine-Operator Interfaces. Next, I showed selected aspects and goals resulting from the requirements, showing their impact on technological gaps that have been identified and presented. Six groups of autonomous operations and functionalities were identified that could be associated with the prepared list of gaps in the Machine-Operator Interface area. I developed conclusions from these analyzes and formulated final conclusions. The analysis of the research results showed that the presented methodology can be applied to both military unmanned land vehicles and civil construction robots.

Summarizing the study on the influence of the land platforms' application concept on planning their design, the following conclusions were made:

- the use of unmanned land platforms in the human environment and other machines determines their structure and systems, including systems of environmental perception, navigation and security. That, in turn implies the use of advanced electronic, mechanical and hydraulic technologies, ensuring greater precision, efficiency and diagnosing capabilities of the systems. Considering that such platforms will work with people and other machines, their behavior must be stable and secure. Current algorithms are tested in a variety of environments, however, adopting them in the construction industry enforces the development of more advanced algorithms and technologies, including AI-based control technology. Currently existing algorithms prove insufficient for meeting the Operational Requirements for Machine-Human Interfaces;

- it is possible to develop a methodology for planning techniques and technologies used in military and civilian land platforms, treating their application concept as the main determinant of this process;
- it is possible to meet the operational requirements for unmanned military and civil ground vehicles, provided that critical technologies are developed that could be defined using the proposed methodology;
- it is necessary to study all possible solutions for various configurations of manned and unmanned ground vehicles, including armored vehicles, in various application concepts carried out in various operational environments and scenarios. Lack of standards and necessary regulations generates the need to conduct works on their establishment both in the national and international area. The works need to be carried out mainly at the operational level and aim at achieving interchangeability and compatibility. Moreover, they should help develop technologies allowing to meet the requirements of modular manned and unmanned systems characterized by open architecture;
- modules of individual systems should be characterized by the simplicity of their interchangeability so that they can be quickly adapted to the next tasks. They should be reliable and effective, comply with the same standards and procedures as well as be characterized by dual-functionality;
- the new generation of manned and unmanned tactical vehicles should derive from the need to acquire new defense capabilities, precisely developed Concepts of Operations (CONOPs) and resulting Operational Requirements (ORs), taking into account the military point of view and technological capabilities. Therefore, these processes should be supported by research on new technologies, which are critical for obtaining further defense capabilities. They should be implemented to a new generation of platforms and be included in their Life Cycle Management (LCM);
- it is important to develop methodologies of unified qualification tests that are consulted with producers and end users. New research methods for autonomous systems should also be developed.
- analysis of the results of the conducted research indicates that the application concepts affect the design of unmanned ground vehicles, generating the need to

develop critical technologies, including breakthrough technologies (the so-called disruptive technologies) and those that are currently unknown, (the so-called emerging technologies).

The scientific goal of the second research stage was to examine the impact of the application concept on the design of military and civilian land platforms. Methods used in this process include modeling techniques and technologies relevant to the implementation of tasks by these platforms.

This goal was achieved by developing a methodology for predicting techniques and technologies for designing structures of military and civilian land platforms, where their use is treated as the main determinant of this process.

The main original elements of my scientific activity include:

- model of dynamics of a single-bucket excavator with a support system, where the model of the support-ground system has been described by the Hooke-Newton-Saint Venant-I model and implemented in support points, in the vertical plane [3];
- algorithm for generating platform motion equations in generalized coordinates based on Lagrange equations, with the main ideas presented in the work [8] on the example of a spatial model of a single-bucket excavator;
- model of the impact of the impact or on the mine (6), which takes into account the influence of the substrate on its construction and which was used to design the construction of the mine clearing flail. The model was then examined [4] and implemented into the Engineering and Road Machine[5];
- modifying the hydraulic and executive system and control of the Engineering and Road Machine, resulting from the change of its application concept as a mine clearing vehicle [5];
- concept of designing the construction of land platforms depending on their application concept together with the design of the remote control system for selected land platforms [10];
- methodology of predicting techniques and technologies of designing military and civilian land platforms, where the application concept is treated as the main determinant of this process [11,12].

The subject matter of my research is currently valid in national and international activities undertaken during the design of new generations of unmanned and manned land platforms. Bearing in mind the high impact of the platforms' application concept and a growing number of tasks they perform in an increasingly complex scenarios of an even more complex operating environment, the new tendency in the platform design is the concept of open architecture and modularity. Future platforms are characterized by the ability to quickly reconfigure so as to allow relatively quick adaptation to the tasks carried out within the framework of the application concept in a given operational environment.

The works I presented determine the direction of my further scientific work. I will continue the work within activities undertaken in the Laboratory of Predicting Off-road Mobility of Land Platforms. The research will focus on the study of the soil as a deformable substrate, on which land platforms move, but also treated as an excavation material. One of the tasks will be to develop a soil model that takes into account both its type and moisture content, seen as the main determinant of load transfer. It could then be used in a modified support (wheels, tracks, walking system) -ground model, with a clear distinction made between quantitative and qualitative role of the support and ground. The next task will be to determine the model of interaction between such a formulated soil model and the developed model of support. The original character of the approach will also consist in developing a methodology and research concept as well as designing and making or obtaining tools that will be used for measuring soil strength taking into account its moisture content.

The developed soil model, with its diversity and humidity seen as the main parameter determining its load capacity, will be used in the support-ground model. It will be used during construction of models of ground vehicles and their natural environment in order to develop a numerical tool for predicting the traffic portability of both manned and unmanned ground vehicles, including armored and armed ones.

Table 4.1

A comparison of the number of quotations, number of articles and the Hirsch index values according to various databases of scientific achievements

No.	Database	Number of publications to cite	Number of citations	Value of the h-index
1.	Web of Science (2015 - 2018)	3	2	1
2.	Scopus (2013 - 2018)	5	26	2
3.	Google Scholar Citations (1998 - 2018)	20	33	3

5. Discussion on other scientific-research, organizational and didactic achievements

5.1. The activity carried out before obtaining a PhD degree

I graduated from M.C. Skłodowska High School in Skawina in 1980. This year I passed my entrance examinations to the Military University of Technology and began studies at the Faculty of Mechanical Engineering.

I graduated from the Military University of Technology in 1985, obtaining a master's degree in mechanical engineering with the specialty of engineering machines.

After graduating from the university, I started my service in 1174 military unit in Dęblin, first as a platoon commander-lecturer, and then as a commander of a school company.

In 1989, I was officially transferred to the Military University of Technology for the position of the Chief of Engineering Machinery Park at the Department of Working

Machines (KMR) (since 1994 the Institute of Machine Building and since 2006 the Department of Machine Building) of the Faculty of Mechanical Engineering. While performing duties in this position, I conducted laboratory classes in the following subjects: Construction machines, Machines for building airports, Hydraulic and pneumatic devices, Machines for road and bridge construction.

Since 1990 I have been involved in the works carried out at the KMR Engineering Equipment Construction Department for automation and remote control of engineering machines.

In 1991 I started conducting lectures, exercises and laboratory classes in the subject: Cranes and transportation devices.

Starting 1992, I have run lectures and workshops in the subject of *Operation of military mechanical vehicles*, and since 1994 *Construction record*. In 2002 and 2003 I conducted workshops concerning *Basics of machine construction*. I run lectures, workshops, laboratory classes and problem workshops in the subject *Road-fortification machines* as well as lectures and workshops on *Fundamentals of construction and operation of engineering machines*.

In 1994, after completing the Pedagogical Education Course, I was transferred to the post of assistant.

In 1997, having completed the course, I passed the 3rd level English exam.

In 1998 I defended my doctoral thesis in the field of technical sciences, in the discipline: construction and operation of machines, specialty: working machines, on *The influence of support on loads exerted on the working tool and displacement of a single-bucket excavator chassis*. The paper analyses methods of supporting chassis of earthworks and reloading machines. It is also a study of their computational models as well as dynamics models of selected working machines, where focus was put on the ground-suspension interaction and rheological models of soils. The preliminary tests were carried out on a circular hydraulic single-bucket excavator with support. Other tests investigated the experimental support. The results of these tests were used to build a model of a single-bucket excavator support, where non-linear characteristics of soil elasticity, dry friction and damping were introduced together with a block of support load control. An algorithm for building a support model and a simulation program for testing the support model were developed. Simulation tests of the support model were carried out. The model was later verified during the experimental test of the support system constructed and installed in the K-406A1 excavator. Its impact on the loads put on working tool and displacement of the excavator's chassis was investigated. A model of a hydraulic single-bucket excavator including support was built and simulation tests were carried out.

5.2. Scientific and research activity carried out after obtaining a PhD title

Among other activities, I participated, in the implementation of the following works: PBG No. 022/WAT/98: *Development of a remotely controlled route clearance vehicle*, PBG No. 061/WAT/98: *Modeling working machine operation in a teleoperator system*, PBW 505/01: *Current state and development directions of techniques in the field of loading and unloading systems in land forces* (own research project), PBG No. 415/WAT/2001: *Testing the efficiency of mine-clearing and development of construction and methods used for operation of dynamic-impact mine-clearing flail*, statutory research work No. 630/2001: *Developing remote and automatic control systems for engineering machines*, own research work No. PBW 765/2002: *Modeling engineering machines as controlled objects for the needs of autonomous development of their control processes*.

I have actively participated in over fifty scientific meetings and conferences, including more than thirty international ones (attached).

I participated in the organization of about ten international scientific conferences and several conferences in Poland, including the initiation and organization of the first editions of the *Research in the field of defense technique and technologies* Scientific-Industrial Conference.

My scientific interests focused mainly on the study of the influence of the ground and the application concept on the design of land platforms, with particular reference to military engineering machines.

Since 1999 to the present, I have been involved in the works of NATO RTO and currently of NATO STO. In the years 1999-2001, I was a member of the Working Group AVT-049B focusing on studies over unmanned vehicles (UV) for Land Military Operations operating within the framework of the NATO Research and Technology Organization. I participated in a working meetings in Ottawa (Canada), Braunschweig (Germany), Ankara (Turkey), in 1999, 2000 and October 2000 respectively, where I presided over one of the sessions and gave a speech on *The concept of remote controlled heavy mine clearance vehicle*. I also participated in the work of the SAS Working Group - 097 - Task Group SAS-RTG-097 on: *Robots Underpinning Future NATO Operations*.

In 2001, I was the laureate of a scholarship competition organized under the NATO Advanced Fellowships Program. Between 12/06 and 01/12. 2001 I completed a research internship at Purdue University in West Lafayette, USA as a visiting scholar. As part of this scholarship, I participated in the conduct of research works and didactic classes. Additionally, I took language course on *Idiomatic Usage of English Language, Technical Writing* and participated in a language course at Lafayette Resource Adult Academy, obtaining a Certificate of Achievement.

According to NATO STANAG 6001, my current knowledge of English is at level 3433.

In 2004, I was sent to serve in the Armament Policy Department at the Ministry of National Defense as the Chief Specialist for International Scientific Cooperation. After the reorganization of the Ministry and the establishment of the Department of Military Science and Education (DNiSW MON) in 2007, I continued to serve in this position. In the years 2004-2009 I was the National Coordinator of NATO RTO[1] and the National Point of Contact for Research and Defense Technologies in the European Defense Agency, EDA[2]. In 2009-2013, acting as the Deputy Director of the

[1] NATO Research and Technology Organization, RTO was established in 1998, primarily to coordinate the activities of NATO member states in the field of defense research and technology in order to secure the Alliance's needs in this area. The document defining the role and tasks of RTO is its statute (RTO Charter). Since 2012, this entity has adopted the name NATO Science and Technology Organization, STO.

[2] The European Defense Agency (EDA) was established on July 12, 2004 in order to "support Member States in their efforts to improve European defense capabilities in the field of crisis management, with the task of supporting the European Security and Defense Policy (ESDP) in its current form, and also taking into account its further development".

Department of Military Education, I also held the position of the National Director for Defense Research and Technology, Deputy National Armaments Director, Undersecretary of State in the Ministry of Defense for Armaments and Modernization, Poland's representative in the EDA Steering Board and a voting member in NATO RTO Research and Technology Board (since 2012 the NATO Science and Technology Board of the NATO Science and Technology Organization) and a member of the NATO Chief Scientist Advisory Council. In the country, I was the Chairman of the Steering Committee for research and development works within the area of state security and defense at the National Center for Research and Development, NCRD. In the years 2009-2010, I was a member of the Defense and Security Research Team at the Ministry of Science and Higher Education, the representative of the Minister of National Defense. At EDA I was a member of an international team that developed the European Strategy for Defense Research and Technology. In the years I was a member of the Management Committee of the European Defense Agency Program on *Protection of the Army* and Program on *Innovative Concepts and Emerging Technologies - ICET* in the years 2008-2012 and 2009-2013 respectively. In the years 2009-2012, I represented the Undersecretary of State for Armaments and Modernization in the Ministry of National Defense in the EDA Program Council. The program, being implemented in OCCAR[3], focused on *European Secured Programmable Radio.*

During this period of my activity at the Ministry of National Defense, I was responsible for establishing scientific and scientific-technical policy, coordinating the implementation of scientific research and Long-Term Requirements for the Republic of Poland in the field of defense techniques and technologies. The area of my competence covered initiating and coordinating scientific and scientific-technical activities in all Ministry's research and development facilities in the field of defense techniques and technologies. My actions were based on medium and long-term plans for the development of the Armed Forces and consisted in the development and updating of *the long-term plan for the development of priority research areas in technologies and defense technologies for years ... .* My other duties included coordination of the Ministry's cooperation with domestic and foreign institutions operating in this area, with particular emphasis on the NATO Research/Science and Technology Organization and the Directorate for Research and Technology of the European Defense Agency. I undertook actions to increase the effectiveness of research projects carried out as part of international cooperation. This goal was achieved by harmonizing international scientific and research projects with the needs

---

The Agency has four basic functions: development of defense capabilities; cooperation in armament matters; working to strengthen the Defence Technology and Industrial Base and for the creation of an internationally competitive European Defence Equipment Market; as well as **promotion of joint research and technological development**. EDA's primary area of activity is not related to tactical and operational issues. EDA does not take voice in matters concerning defense policy and strategy. Poland, together with other 23 countries, has been a member of EDA since its establishment.

[3] Organization conjointe de coopération en matière d'armement (OCCAR), meaning Organisation for Joint Armament Cooperation - was created in 1996 for the implementation of armament programs in cooperation with European countries. Since 2001 (ratification of the founding convention) OCCAR has legal status. Currently, OCCAR has six Member States: Germany, Belgium, Spain, France, Italy, and the United Kingdom. Five other European countries participate in OCCAR programs without having the status of a member state: the Netherlands, Turkey, Poland, Sweden and Finland. OCCAR manages the budget of procurement in the field of armaments at the level of 40 billion euros and the annual operating budget of 3 billion euros. The highest decision-making body within OCCAR is the EDA Steering Board, composed of Member States' Defence Ministers.

of the Armed Forces of the Republic of Poland, increasing the scale of participation of the Ministry of National Defense in international scientific and research programs as well as programs and national projects implemented under the budget of the Ministry of National Defense and Ministry of Science and Higher Education, including National Center for Research and Development (NCRD). The actions undertaken resulted from the objectives of the *Strategy of the Ministry of National Defense activities in the field of defense research and technologies*, which was signed by the Minister of National Defense in February 2011, and which I co-authored.

My most important organizational and technical achievements in this period include increasing the share of Polish scientific and industrial entities in scientific works carried out for the defense and security of the state at home and abroad, including works carried out in the NATO Organization for Defense Research and Technology (NATO RTO) and in the European Defense Agency (EDA).

During this time, I participated in the government (ordering party) management of 57 programs and projects implemented in Poland and abroad, which were financed from the Ministry of Defense's budget. Table No. 4.2 shows the names of these programs and projects. Their description belongs to the so-called sensitive information.

Table 4.2

Research and development projects financed from the Ministry of National Defense budget implemented in the country and the European Defence Agency (EDA)

No.	PROJECT NAME
financed by the Ministry of Defense (part 29 National Defence Chapter 75204, 85195) implemented in the country	
1.	Determination of the possibility of landing the PPK SPIKE (anti-tank projectile) sets and 98 mm towed mortars with ammunition.
2.	The concept of uniform integrated training in the field of Tactical Data Transmission Systems LINK for the Polish Armed Forces.
3.	Development of a demonstrator of technologies offered by the SandBox IT analysis station.
4.	Demonstrator of technical analysis technology of satellite communication signals in Inmarsat system, standards B, M, mini - M, F.
5.	Development of a demonstrator of measuring station technology for testing modern "Tempest" class devices.
6.	Development of a demonstrator of the simulator technology for practicing defense against attacks in cyberspace.
7.	Developing a demonstrator of technology used in the stand for monitoring unauthorized devices/ IEEE 802.11 standard Wi-Fi networks
8.	Development of the technology of a hydrogen fuel cell-based reserve electric power supply of the submarine
9.	Development of powder and deactivation packets technologies replacing

	previously used SFM packages.
10.	Development of an optoelectronic sensor for detecting explosives.
11.	Development of a technology for producing a multilayer composite based on high-strength fibers
12.	Development of polarimetric radar technology for landmine detection.
13.	Development of technology for dynamic military vessels demagnetization.
14.	Development of technology for detection and positioning of mine-like objects in seabed sediments.
15.	Development of technology for detecting contamination with paralytic and convulsive agents with the help of chemical-enzymatic tests using individual detectors of dry contamination.
16.	Development of technology of imitative war toxic agents for devices for fast detection and identification of chemical contamination.
17.	Attack and defense methods against user impersonalization and unauthorized editing of messages in unencrypted telecommunications lines.
18.	Development of a measurement stand and testing procedure for assessing the effectiveness of laser-eavesdropping prevention methods and creating a demonstrator of the technology.
19.	Development of a stand for measurements and analysis of electromagnetic emanation from analogue and digital screen monitors in the visible band and creating a demonstrator of the technology.
20.	Development of a mobile measuring station for "On-Site-Testing" and implementation of the technology demonstrator.
21.	Development of a small unmanned rotorcraft (DBWA) demonstrator.
financed by the Ministry of Defence (part 29 National Defence Chapter 75204, 85195) implemented in the European Defence Agency (EDA)	
A-Category Ad-Hoc Programs/Projects[4]	
Military Protection - Joint Investment Program on Force Protection. (JIP FP)[5]	

[4] The A-Category Ad Hoc Program/Project is established by the EDA Steering Board at the request of one or more member countries, or by the EDA Head. All Member States should participate in it. As part of the A-Category Program, Projects are implemented by entities who have received the highest expert ratings and get approved for funding (not necessarily from all Program countries/participants) by the Program Management Committee. A common budget is formed to be managed by the Program Management Committee with the support of EDA.

[5] On November 13, 2006 at EDA, the Defense Ministers of the Agency member states decided to establish an A-Category Ad Hoc Program on *Force Protection* with the budget, made up of contributions from its participants. The budget of this Program was 54.93 million EURO. Participating countries include: Austria, Belgium, Cyprus, Czech Republic, Estonia, Finland, France, Greece, Ireland, Germany, Spain, the Netherlands, Slovakia, Slovenia, Sweden, Poland, Portugal, Hungary, Italy and Norway as the so-called "Third country", not being a member but cooperating based on an appropriate agreement signed with EDA. Poland, like Germany, reported its contribution of 10 million

1.	Advanced helmet and devices for individual protection, AHEAD.
2.	Mulit Sensor Anti Sniper System, MUSAS.
3.	Sniper Positioning and Detection, SNIPOD.
4.	Air Defense High Energy Laser Weapon, ADHELW.
5.	Wireless Robust Link for Urban Operations, WOLF.
6.	Acoustic Urban Threat Detector for Improved Surveillance Capabilities, AUDIS.
7.	Distributed and Adaptive multisensor FusioN Engine, DAFNE.
8.	Data Fusion in Urban Sensor Networks, D-FUSE.
9.	Multi Sensor Data Fusion Grid for Urban Situational Awareness, MEDUSA.
10.	Asymmetric Threat Environment Analysis, ATHENA.
11.	Capability Study to Investigate the Essential Man-Machine Relationship for Improved Decision Making in Urban Military Operations, CARDINAL.
12.	European Urban Simulation for Asymmetric Scenarios, EUSAS.
13.	Intelligent Control of Adversary Radiocommunications, ICAR.
14.	Smart Information for Mission Success, SIMS.
Joint Investment Program on Innovative Concepts and Emerging Technologies (JIP ICET)[6]	
15.	Explosive detection-Spectroscopy, Terahertz technology And Radar, ESTAR.
16.	SAR-based Augmented Integrity Navigation Architecture, SARINA.
17.	Helicopter Fuselage Crack Monitoring And Prognosis Through On-Board Sensor Network, HECTOR.
18.	Synthetic Aperture Radar for all weather penetrating UAV, SARAPE.
B-Category Ad-Hoc Programs/Projects[7]	
1.	Fluorescence Applied to Biological Agents Detection, FABIOLA.
2.	European Secured Software Defined Radio, ESSOR.
3.	The Establishment and Management of a Common Database of B-agents.
4.	Unmanned Ground Tactical Vehicle, UGTV.

EURO and was along France (12 million EURO) the largest financial contributor of the Program. Poland has achieved the so-called industrial return of approx. 85%.

[6] A Jointly Invested A-Category Program on *Innovative Concepts and Emerging Technologies - ICET*. The decision to create this Program was made during the meeting of the EDA Steering Board composed of the Defense Ministers, which took place on 26 May 2008 in Brussels. The Program was attended by 11 European countries: Cyprus, France, Greece, Spain, Germany, Norway, **Poland**, Slovakia, Slovenia, Hungary and Italy. Its budget amounts to € 15.58 million. Poland participated with the amount of 0.72 million EURO and has achieved the industrial return of approx. 130%.

[7] One or more EDA member countries inform the EDA Steering Board of their intention to establish an B-Category Ad Hoc Program/Project. Each Member State can join the Program/Project. Projects under the B-Category Program are implemented by all countries that contributed to the Project's budget, or a Call for Proposal is launched by the Agency and then the countries that created the Project budget select the Contractor.

5.	Network Enabled Armoured Fighting Vehicles.
6.	Active Protection System Study for Armoured Fighting Vehicles.
7.	Military Disruption tolerant NETworks, MIDNET.
8.	COgnitive RAdio for dynamic Spectrum MAnagement, CORASMA.
9.	The Establishment and Management of a Common Database of B-agents, DATA BASE OF BIO AGENTS.
10.	Soldier Centric Identification System.
11.	Non-Lethal Weapon.
12.	Fast Sampling of explosives for standoff detection of IEDs, FaSap – X.
13.	Protection of land vehicles against IEDs.
14.	Unmanned Maritime Systems for MCM, UMS.
15.	TACTICal Service oriented architecture, TACTICS.
16.	Biological Equipment Development and Enhancement Programme, BIO EDEP.
17.	Soldier Centric Identification Systems, SCIS.
18.	Non Lethal Capabilities, NLC.

The results of research and development projects financed from the Ministry of National Defense budget implemented in the country and the European Defence Agency (EDA) presented in the Table No. 4.2 due to the so called "sensitive information" are characterized by very limited possibilities to be published. Moreover, the works conducted in European Defence Agency have to fulfill the records of: COUNCIL DECISION 2011/411/CFSP of 12 July 2011 defining the statute, seat and operational rules of the European Defence Agency and repealing Joint Action 2004/551/CFSP and their later equivalents. It also limits possibilities to use so called "Foreground Information" – the final knowledge – thereby possibilities to publish the final results of these projects.

Furthermore, I participated in creation of provisions of the law on financing science and law for the National Center for Research and Development. I also contributed to the work for the National Research Program, in the part concerning the area of security and defense. I introduced the concept of Technological Readiness Levels into the Polish legal system.

I participated in the works on changing the system of establishing, implementing and supervising research and development works established in the field of defense and security at the National Center for Research and Development.

Having completed my professional military service in 2013, I was employed at the Military University of Technology as a research and didactic adjunct at the Department of Machinery Equipment Engineering (since 2014 Institute of Machinery Equipment Engineering) acting as the Plenipotentiary of the Director of the Institute of Machinery Equipment Engineering, for Scientific Cooperation at the Faculty of Mechanical Engineering, Military University of Technology. In addition, I was the Plenipotentiary of the Director for Defense Projects at Industrial Institute of Automation and Measurements. (from 2014 as an adjunct).

In 2016, the Rector-Commandant of the Military University of Technology appointed me to the position of Director of the Institute of Machinery Equipment Engineering, Faculty of Mechanical Engineering, which I hold till present.

In the years 2014-2016 I managed the research work of UGS-LIS/ PIAP MUT GMV 11439/13, European Defense Agency, EDA concerning *Unmanned Ground Systems Landscaping and Integration Study*, 2014-2015, WAT, PIAP, GMV.

I am currently involved in the implementation of research work PBR 15-132/2014/WAT, financed by the National Center for Research and Development, on *Medium Platform (800 kg class)*. This project is being carried out in NCRD for the benefit of state security and defense under competition No. 4/2013. It is one of six projects submitted by the consortium under the program on *The Family of Unmanned Land Platforms for application in security and defense systems.* Additionally, I participate in the implementation of *Multi-purpose, hybrid engineering vehicle* project.

I supervised the work of PBS No. 936/2016 entitled: *Development of construction and production technology and the effectiveness of teleoperation systems of Unmanned Land Platforms*. It has been finished in December 2018. Currently, I supervise the work of PBS nr 23-893 on *„Development of design and manufacturing technologies and efficiency of Unmanned Ground Platforms support to tools"*.

In addition, I participate in the works of the AVT (Applied Vehicle Technology) Panel in NATO Science and Technology Organization (NATO STO). Together with an US representative I co-chaired Working Group AVT-241/RSM-022 on: *Technological and Operational Problems Connected with UGV Application for Future Military Operations* and took part in the work of the AVT-ET-148 Group on: *Next-Generation NATO Reference Mobility Model (NRMM) Development* of the AVT Panel. I am the co-author of the report on the implementation of this undertaking. I participated in the work of the NATO STO Working Group AVT-248/RTG on: *Next-Generation NATO Reference Mobility Model (NG NRMM) Development*, which also includes the context of Unmanned Land Platforms and was a continuation of the works carried out in NATO STO ET-148 Group. The AVT-248 has been finished in December 2018. There is a Final Report on 518 pages. I also took part in the NATO STO Working Group AVT-308 on: Cooperative Demonstration of Technology on Next-Generation NATO Reference Mobility Model Development. Currently, I work on establishment of national project based on NATO STO AVT-248-RTG.

During NATO STO AVT Panel Business Meetings in 2018, in Torino, Italy and Athens, Greece I proposed establishment of new activity on: „Technology Trends in Manned and Unmanned Armoured Ground Vehicle" that was approved by AVT Panel Voting Members during Plenary Session in December 2018, in Athens as AVT-ET-196. I was appointed as a Co-Chair and Poland as a Lead Nation.

Currently I am also a Member of Exploratory Team AVT-ET-194 of Panel AVT NATO STO nt.: "Mobility Assessment Methods and Tools for Autonomous Military Ground Systems".

In 2014, I participated in the organization and implementation of the International Military Robots Workshop ELROB 2014, (June 23-27, 2014).

I also participate in the work of the Polish Technological Platform of Unmanned Systems and the Statute of the Polish Technology Platform for Unmanned Systems.

I participated in the work on the establishment of the INNOSBZ- *Strategic Research Agenda* Sector Program, developed by the Polish Technological Platform of Unmanned Systems and the Polish Institute of Technology in cooperation with the Polish Platform for Homeland Security. I consequently took part in the preparation of the Feasibility Study of this Sector Program.

As part of my activities within the country, I participated in the work on establishing the National Program for Unmanned Systems/National Robotic Strategy.

As part of the international activities, I took part in the work on establishing the European Defense Agency program on: *IED Detection Program.*

I also participated in the work on the formulation of the document: *Policy Guidance - Autonomy in Defense Systems,* developed under the program with 19 NATO and EU member states under the auspices of MCDC (Multinational Capability Development Campaign) led by NATO Headquarters Supreme Allied Commander Transformation (HQ SACT). As part of the continuation of the last initiative, I am a representative of the Military University of Technology in work on the use of autonomous ground vehicles.

In conclusion, in the years 1998-2003 I participated in the implementation of 9 scientific and research works. In the years 2004-2013, working in the Ministry of National Defense, I participated in the management of 57 government (ordering party) programs and projects implemented in the country and abroad. In the years 2013 - 2015 I supervised the research work carried out in the European Defense Agency (EDA) on: *Unmanned Ground Systems Landscaping and Integration Study, UGS-LIS / PIAP / MUT GMV 11439/13.* Currently, I am managing a team implementing one national scientific-research work and two other teams carrying out two research projects implemented in EDA as part of the IEDDET (Improvised Explosives Devices Detection) Program. The latter focus on: *UGV stand-off multi-sensor platform for IED component detection (MUSICODE), no. B 1465 GEM3 GP / MUSICODE* and *Vehicle Mounted Early Warning for Indirect Indicators for IEDs, No. B 1465 GEM3 GP / VMEWI3*, in the period 2017 - 2020.

Additionally, at the Military University of Technology, I was appointed to participate in the work of the Interdisciplinary Task Team. The Team is responsible for negotiating with external entities the terms of cooperation in the field of research and development carried out by the basic organizational units of the Military University of Technology.

I was a member of the Program Council of the Center of Advanced Technologies of Security and Defense of the Silesian University of Technology.

I am a member of the Scientific and Program Board of the *Szybkobieżne Pojazdy Gąsienicowe* journal, published by the Research and Development Center of Mechanical Devices "OBRUM" Ltd. in Gliwice.

In 2016, I once again became the representative of Poland in *Science and Technology Board of NATO Science and Technology Organization, NATO STO* and in 2017, I became a voting member of the AVT Panel of the NATO Science and Technology Organization.

I have received letter (attached) from *NATO Science and Technology Organization Office of the Chief Scientist* to recognize my significant achievements in relation to the *NATO Science and Technology Organization (STO)*, hard work and dedication into many *NATO Science and Technology (S&T)* activities during twenty years of my participation, first in *the NATO Research and Technology Organization (RTO)* and more recently in the *NATO STO*, and the results I achieved have benefited both Poland and NATO S&T. The letter signed by *Chairman of Science and Technology Board*, NATO Chief Scientist.

In 2017 I became a member of the Board of Directors of *International Association for Automation and Robotics in Construction.*

In 2016, I became a member of the Senate of the Military University of Technology and Vice-Chairman of the Senate Committee for Development and Cooperation.

Since 2017, I have been a committee member of the Faculty of Mechanical Engineering of the Military University of Technology for the quality assessment of theses.

In 2017, I was appointed a member of the Scientific Council of the prof. Józef Kosacki Military Institute of Engineering Techniques in Wrocław.

During inauguration of academic year 2017-2018 at Faculty of Mechanical Engineering of the Military University of Technology, I gave the lecture on: *Unmanned Ground Platforms – the state of play and development tendencies in the context of the current and future applications.*

During the meeting of Scientific Board of Ośrodek Badawczo-Rozwojowy Urządzeń Mechanicznych "OBRUM" sp. z o.o., that was held in Gliwice, on 4th December 2018, I gave the lecture on: *The chosen issues concerning activities in Poland, NATO and EDA in the area of defence science and technology.*

During symposium on "*Modelling in Mechanics*" organized by Mechanical-Technological Faculty of the Silesian University of Technology that was held in Ustroń, 23rd-27th February 2019, I gave the lecture on: *New Generation NATO Reference Mobility Model.*

I have reviewed two articles for the journal of Automation in Construction on: *Robotic Autonomous Systems for Earthmoving with Military Applications* and *Development of a Cognitive Untunneling Multi-View System Based on Visual Momentum and Saliency for Teleoperators of Heavy Machines.*

5.3. Information about didactic achievements

Since 1989, (with a break for professional military service in the Ministry of National Defense between the years 2004-2013), I have been working in the Department of Mechanical Engineering at the Military University of Technology. I am actively involved in carrying out didactic, scientific and research tasks. Since 2013, I have also been involved in publishing works, working at the Industrial Institute of Automation and Measurements PIAP. In 1991 I started conducting lectures, exercises and laboratory classes in the subject: Cranes and transportation devices. Starting 1992, I have run lectures and workshops in the subject of *Operation of military mechanical vehicles*, and since 1994 *Construction record*. In 2002 and 2003 I conducted workshops concerning *Basics of machine construction*. I run lectures, workshops, laboratory classes and problem workshops in the subject *Road-fortification machines* as well as lectures and workshops on *Fundamentals of construction and operation of engineering machines*.

In the years 1992-2003 I conducted over 3,000 hours of didactic classes.

In 1994, I took the Pedagogical Education Course.

In 2001, as part of the already mentioned NATO Advanced Fellowships Program, I participated both in the implementation of research works as well as in the conduct of didactic classes. This resulted in the fact that, after returning from the United States in the academic year 2002/2003, I was directed to an English course (500 hours) preparing to conduct scientific and didactic activities in English. Currently, I use this ability to conduct classes in English with both Polish and foreign students.

After re-employment as a research and didactic adjunct at the Military University of Technology, starting 2013 I run classes in: Machines, Machinery, Middle Transport and Lifting Devices, Machinery, Reloading and Middle Transport Devices, Engineering Systems in Mobile Applications (for Master's students), Hydraulic Systems in Mobile Applications (under the ERASMUS program). I personally prepared the program and all materials used in the didactic process. In total, in the years 2013-2018 I carried out 1614 teaching hours.

In the years 1999-2003 I was the supervisor of 5 theses, 4 transitional projects and 2 graduation papers at postgraduate studies. I made 8 thesis reviews. I supervised 2 student practices. Between 2013 and 2017 I was the thesis supervisor of 6 theses I made 1 thesis review. During my didactic activity I was many times a member of the Diploma Exam Committee.

I am the co-author of the script: *Fundamentals of Construction and Operation of Engineering and Construction Machines* - WAT, Warsaw, 2002 (p. 413).

Since 2016, having been appointed to the position of the Director of the Institute of Machine Building of the Mechanical Engineering Faculty of the Military University of Technology, I have been actively involved in the development of the Institute's didactic base. I am the initiator of the construction of the WAT Mobile Robots Center (about 3000 m2) being currently implemented. The Center's aim will be to support the didactic process and scientific research. I have personal input in the scientific and didactic development of the Institute's staff. Besides, I am involved in acquiring young scientific employees, both civil and military.

As the Director of the Institute of Machinery Equipment Engineering, I am the supervisor of the following specialties: engineering-construction machines and road machines. In 2016, I initiated opening inter-faculty first degree studies in the field of Automation and Robotics with the specialty: *Construction and control of unmanned platforms and robots*. This field of study will be provided by two organizational units of the Military University of Technology, i.e. the Faculty of Mechatronics and Aviation and the Faculty of Mechanical Engineering. The next stage of activities would incorporate first and second degree military studies, with their program developed in agreement with the Ministry of National Defense and with appropriate personnel support. The Ministry will also help obtain robots that are part of the military equipment.

In 2016, I received the Minister of National Defense Award for didactic achievements in 2015.

At the meeting of the AVT NATO STO Panel, which took place in Turin, Italy, on April 16-20, 2018, I initiated talks with a US representative about the cooperation of the Military University of Technology and a selected American military academy for the purpose of implementation of *Transatlantic NATO Master of Science Program in High Mobility Vehicle Engineering (MS-HMVE).*

5.4. Elements of professional development

12/06/2001 – 01/12/2001 - *scientific internship within NATO Advanced Fellowships Program, at Purdue University, West Lafayette, Indiana, USA*

27/02/2001 – 03/03/2006 - a course at the Military Institute of Communication in Zegrze on the subject of *Requirements Generation, International Defense Acquisition Resource Management Program* organized by *The Naval Postgraduate School, Monterey, California* on behalf of the United States Of America

04/04/2011 - 08/04/2011 – an improvement course in *Good practices of unit management based on management control standards for the public finance sector and the requirements of the Public Finance Act in this respect*, National Defense University, Warsaw

27.09.2018 training course on: *Employment relationship of university/academy workers in the light of Law 2.0 – comparative analysis and adaptation of existing employment relationships to the new Law.*

5.5 Prizes, distinctions and decorations received

1990 Bronze Medal of Merit For National Defense

1990 Bronze Medal of the Armed Forces in the Service of the Fatherland

1994 Silver Medal of Merit For National Defense

1999 3rd degree Rector's Award of the Rector of the Military University of Technology for the doctoral thesis on *The influence of support on the load put on working tool and displacement of the single-bucket excavator chassis*

1999 Bronze Cross of Merit

2000 Silver Medal of the Armed Forces in the Service of the Fatherland

2002 laureate of the scholarship competition, organized by NATO under the Advanced Fellowships Program. Semi-annual internship as a visiting scholar at Purdue University, West Lafayette, Indiana, USA

2003 Gold Medal of Merit For National Defense

2003 Rector's Honorable Award for: *Development of didactic aids for the subject "Fundamentals of construction and operation of engineering machines"* (team distinction)

2005 Silver Cross of Merit

2009 Gold Medal of the Armed Forces in the Service of the Fatherland

2011 Golden Cross of Merit

2014 Dean's Award of the Dean of the Faculty of Mechanical Engineering of the Military University of Technology "*For the development of design and control systems for unmanned land platforms*"

2016 Award of the Minister of National Defense for didactic achievements in 2015