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## **EXPERIMENTAL ANALYSIS OF THE HELICOPTER DITCHING**

### **ABSTRACT**

The paper presents the method and results of the model tests of helicopter ditching, aimed at adaptation of the helicopter's construction for marine missions. The experiment, realized by Maritime Advanced Research Centre S.A. (CTO) required elaboration of dedicated measurement stand, and solving a number of specific technical problems resulting from the necessity of assuring the repeatability, and required accuracy of the measurements and scalability of the results. Such kind of experiment is not a standard task of a hydrodynamic model testing institution, so it brings an innovation in the testing methodology. The paper presents the details of the test stand and the model itself with rotating rotor, design of the experiment, as well as an overview of the results and main conclusions.

### Keywords:

rotorcraft, helicopter, ditching, scale model test

### **INTRODUCTION**

The analysis presented in this paper is a part of wide test campaign aimed at modification of an optionally piloted helicopter to maritime mission performance. The analyzed helicopter to be adapted for maritime missions is the PZL SW4 (Fig.1). The research conducted by CTO S.A., related to hydrodynamics, included:

- evaluation of the ship motions, to be used as an input data for the modified autopilot, as well as for realistic modelling of the ship in the simulations of helicopter onboard operations;
- evaluation of the ship airwake, to be used as an input data for the helicopter simulator;

- evaluation of the helicopter stability and motion response to waves with taking into account the emergency flotation system, both in intact conditions, as well as for critical failure modes;
- evaluation of accelerations, pressure impulses, and fuselage motion during ditching in waves.

The scope of the CTO S.A. activities included design of the emergency flotation system.

This test campaign was the custom and unconventional task realized for aerospace industry by Maritime Advanced Research Centre CTO S.A., therefore it presented a substantial challenge in respect of model design, development of test stand, as well as planning of the experiment. The paper is thus focused primarily on the experiment methodology. The results of ditching tests are also presented, and main conclusions are drawn.



Fig. 1. PZL SW4 helicopter  
source: *Konflikty.pl*, Łukasz Golowanow

## **BACKGROUND – PRECEDING RESEARCH**

Hydrodynamic tests and computations carried out in order to provide necessary input for modification of the helicopter for maritime missions included the items listed below.

1. Evaluation of the ship motion response to waves, aimed at quantitative prediction of the helideck motion. The experiments included both predictions of the vessel response in irregular waves, as well as evaluation of response amplitude operators (RAOs) for motion. The RAOs, including both amplitude and phase characteristics of the vessel motion, allow simulating the vessel motion in the flight simulator for arbitrary wave spectrum. Moreover, tracking the vessel motion by the helicopter autopilot's sensors before landing allows sufficiently accurate prediction of the helideck position, and velocity at the moment of touchdown [1]. The ship selected for tests is the Oliver Hazard Perry class frigate.



Fig. 2. Oliver Hazard Perry class frigate – actual geometry and model for tests in waves

2. Evaluation of the ship airwake, an input for the flight simulator. Accurate representation of ambient velocity field over the helideck, defined by three mean velocity components and turbulence characteristics, is crucial for realistic simulation of the landing on a vessel. The velocity field data were obtained primarily from CFD, and their reliability was verified based on wind tunnel model tests.

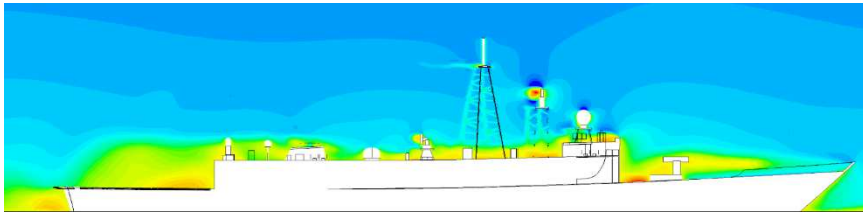


Fig. 3. Axial velocity field resulting from CFD analysis

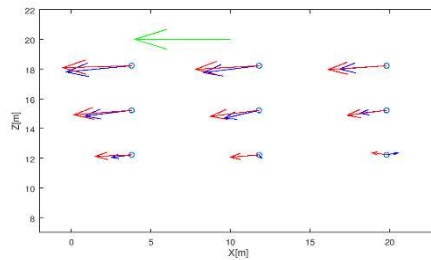


Fig. 4. Experimental validation of the airwake evaluation: wind tunnel model and comparison of computed and measured velocity field (red – CFD, blue – experiment)

3. Design of the emergency flotation system. The system consists of two identical floats, mounted to the skids of the helicopter. They are divided into five compartments (Fig. 5), and considered failure modes consist in

loss of single compartment. The goal of the optimization was to minimize trim and heel angles for most unfavourable failures. Verification of the designed geometry was carried out by means of numerical computations with MAXSURF Hydromax software, and by model tests (Fig. 6)

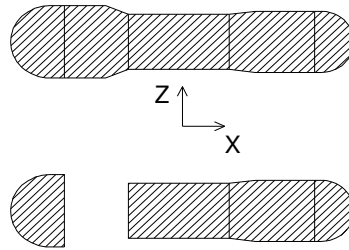


Fig. 5. Geometry of the floats (top), example of failure mode (bottom)



Fig. 6. Computational and model scale experimental verification of the flotation system design

4. Evaluation of the helicopter stability, and motion response to waves. The model manufactured in scale 1:8 from PCV foam and PET was used in the experiments aimed at evaluation of the helicopter stability and motion in waves. The main point of interest was the risk of the contact of main rotor, and tail rotor with the water [2].



Fig. 7. Experimental evaluation of the helicopter motion in waves in model scale

### MODEL DESIGN FOR DITCHING TESTS

The initial intention regarding the helicopter model design was to use the same model in motion response tests, and in ditching tests. The model was designed to be extremely lightweight, with stiffeners made of PCV foam, and shell plating made of PCV. Such a construction allowed varying both total mass, as well as location of centre of gravity (CG), and moments of inertia in wide range. Total mass of full scale helicopter varies between 1000 and 1800 kg, and the longitudinal CG location in the range of  $\pm 0.125\text{m}$ . The construction allowing controlling both the CG location, and the moment of inertia for specified mass is presented in Fig. 8 below.



Fig. 8. Interior the model fitted for stability and motion response tests

The construction presented above successfully met the requirements of the stability tests and the tests in waves, where the acceleration values are low to moderate. However, for the ditching tests, characterized by impact loads on the shell plating and very high acceleration values, the model turned out to be not sufficiently robust. Moreover, the elasticity of the external surface was too

high to allow reliable measurement of pressure impulses. For that reason, it was decided to build another model, with the fuselage made of 15mm plywood. Such a model was sufficiently rigid and extremely robust, at the cost of elasticity in modelling the loading condition. The mass of the fuselage with rotor and instrumentation was corresponding exactly to maximum loading condition, and the required location of CG was achieved by proper distribution of the instrumentation inside the fuselage. The fuselage design with instrumentation (accelerometers, pressure sensors and markers of the 6DOF motion tracking system) is presented in figures below.



Fig. 9. Model fuselage – dismantled and assembled



Fig. 10. Pressure sensors

The presented model design allowed also easy access to the data acquisition system located in the fuselage.

One of the crucial requirements for the ditching tests was the modelling of the main rotor rotation, which is important to reproduce correctly the gyroscopic reaction acting on the fuselage when the direction of the rotor's angular momentum changes rapidly at the moment of water entry. The Froude scaling laws apply to the ditching tests, and the most obvious approach to model the rotor would be then to scale the rotation rate and the moment of inertia. The scaling factors resulting from the Froude similarity are:

for rotation rate:  $n_{model} = n_{full} \cdot \lambda^{0.5}$

for moment of inertia:  $I_{yy\_model} = I_{yy\_full} / \lambda^5$

where  $\lambda$  is the scale factor.

The actual rotation rate of the full scale rotor is 437.3 rpm (7.29 rps). An attempt on modelling the rotor according to these formulae revealed considerable problem resulting from the fact that the rotor rotation in the model tests is inertial – there is no propulsion. High rotation rate at model scale (20.6 rps) results in high drag – so that the rotation rate is reduced by as much as 50% within one second. Thus, there is in fact no control of the rotor rotation rate during the experiment. The proposed solution consisted in modelling only the angular momentum of the rotor, without exact modelling of the rotation rate, and the moment of inertia. The moment of inertia was considerably increased (by the factor of approximately 3.5) which allowed reducing the rotation rate by the same factor. Reducing the drag and increasing the inertia allowed maintaining approximately constant rotation rate of the main rotor during the experiment. The moment of inertia was maximized by replacing the lightweight rotor blade tips with metal ones. Quantitative parameters of the rotor model are listed in the table below.

Table 1. Parameters of the rotor model

Quantity	Full scale	Result of direct scaling	Actual value at model scale
Rotation rate [rpm]	437.3	1236.871	350
Moment of inertia [kgm <sup>2</sup> ]	450.0	0.0137	0.0485
Angular momentum [kgm <sup>2</sup> s <sup>-1</sup> ]	20607	1.779	1.779

The rotor head was manufactured of aluminium, with the adapter for external drive. The blades were manufactured of balsa wood, with carbon composite stiffeners and bronze tips. The rotor model details are presented in Fig. 11 below.





Fig. 11. Rotor model

### MODEL TEST STAND

Besides appropriate model of the helicopter, the ditching test requires preparing the model test facility to assure required initial conditions of the ditching. These include:

- horizontal speed;
- vertical speed;
- pitch angle;
- yaw angle;
- main rotor rotation rate.

An initial approach to the design of the measurement stand consisted in using long tracks (slipway) with adjusted angle; varying the angle allows controlling the ratio between horizontal and vertical speed, while the height of release point allows controlling the velocity magnitude in the moment of water impact. An example of using this approach for ditching tests was described e.g. by Thompson [3], and the idea is presented in Fig.13. Preliminary design studies revealed two serious drawbacks of this approach, i.e.:

- regardless the shape of the helicopter support structure on the moving carriage, it is not possible to avoid collision between this structure and rear parts of the helicopter; in other words, when the carriage stops, and the helicopter is released, its tail would hit the supporting elements; in presented example, this problem was solved by using complex mechanisms in the carriage, allowing the supporting elements to get out of the helicopter's way immediately after it is released; this solution is also presented in Fig.12;

- as the helicopter is accelerated due to gravity only, reaching the required speed takes relatively long time, which makes it more difficult to control the rotor speed during touchdown.

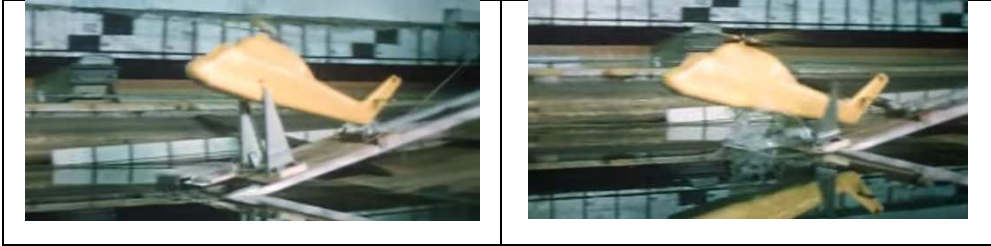


Fig. 12. Ditching model tests featuring tracks

After further studies, and design iterations, the approach described above was abandoned, and an alternative one was used, in which the helicopter is held by rotor head only (Fig.14). The fuselage is also held loosely by the tail fin to prevent rotation.



Fig. 13. Measurement stand for ditching model tests, details of releasing mechanism

In this approach, the initial horizontal velocity is controlled directly by moving carriage, and the initial vertical velocity is controlled by adjusting the height of release point. Details of the releasing mechanism (in "open" position") are presented in Fig.13.

The experiment is executed according to the following sequence:

1. The model is held by the rotor head, the rotor is rotating, and the fuselage is standing still; the fuselage is also held by the tail fin to prevent rotation.
2. The model is accelerated to required speed with constant acceleration.
3. The model moves horizontally at constant speed; during this steady motion, the model is released. It is important from the point of view of proper operation of the releasing mechanism to allow the mechanism, and the model move in parallel for some time to let the model fall down gently.
4. The carriage is slowed down, and stopped.

### EXPERIMENT REALISATION AND RESULTS

Complete matrix of the experiment parameters is presented in Tab. 2. Definition and convention of initial pitch and yaw angles is presented in Fig.16.

Tab. 2. Parameters of the experiment

Horizontal speed [m/s]	Initial pitch angle $\alpha$ [deg]				Initial yaw angle $\beta$ [deg]			
	0	5	10	15	0	10	20	
5	0	5	10	15	0	10	20	
10	0	5	10		0	10	15	20
16	0	5	10		0	10	15	

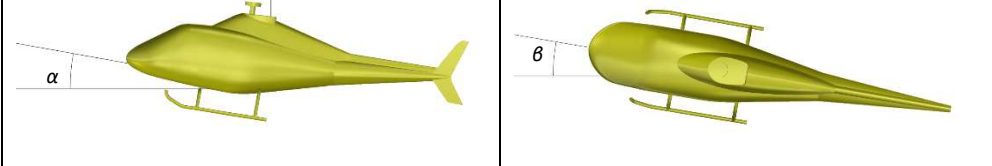
  


Fig. 14. Definition and convention of initial pitch and yaw angles

The ditching is realized in regular waves of large slope (1:10), and the amplitude of 2m. The required initial vertical speed of the helicopter is **1.52 m/s**, which corresponds to **0.537m/s** at model scale. However, due to the fact that the vertical speed of the model is driven by gravity only, and no lift is generated on the rotor, this condition requires that the model is released only 15mm over the water surface, while the wave amplitude reaches 250mm at model scale. Thus, a compromise was applied, i.e. the model was released from lowest possible position, in which the wave crests are touching the skids, but there is no risk of

damage of the launching device. The vertical speed at the moment of touching the water surface by the fuselage is resultant, and equal to 1.8m/s at model scale, i.e. **5.1m/s** at full scale. The results are then conservative in respect of maximum pressure impulses and accelerations.

The location of the impact point was selected according to the following criteria:

- maximum wave slope, resulting in maximum longitudinal acceleration when the helicopter is hitting the wave surface;
- the point located as close to the crest as possible, to minimize the initial vertical speed.

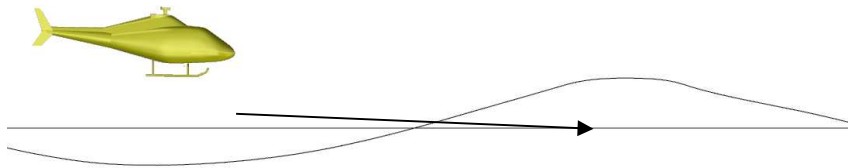


Fig. 15 Initial setup of the model experiment – sketch

Visualization of the ditching for lowest, and highest analyzed horizontal speed is presented in Fig.16. At 5m/s, the helicopter slows down very quickly, and starts following the wave motion, while at 16m/s, large momentum allows the helicopter breaking through the wave crest, get airborne again for a while, and only then, after second impact, the fuselage motion turns into free floating, following the wave motion.

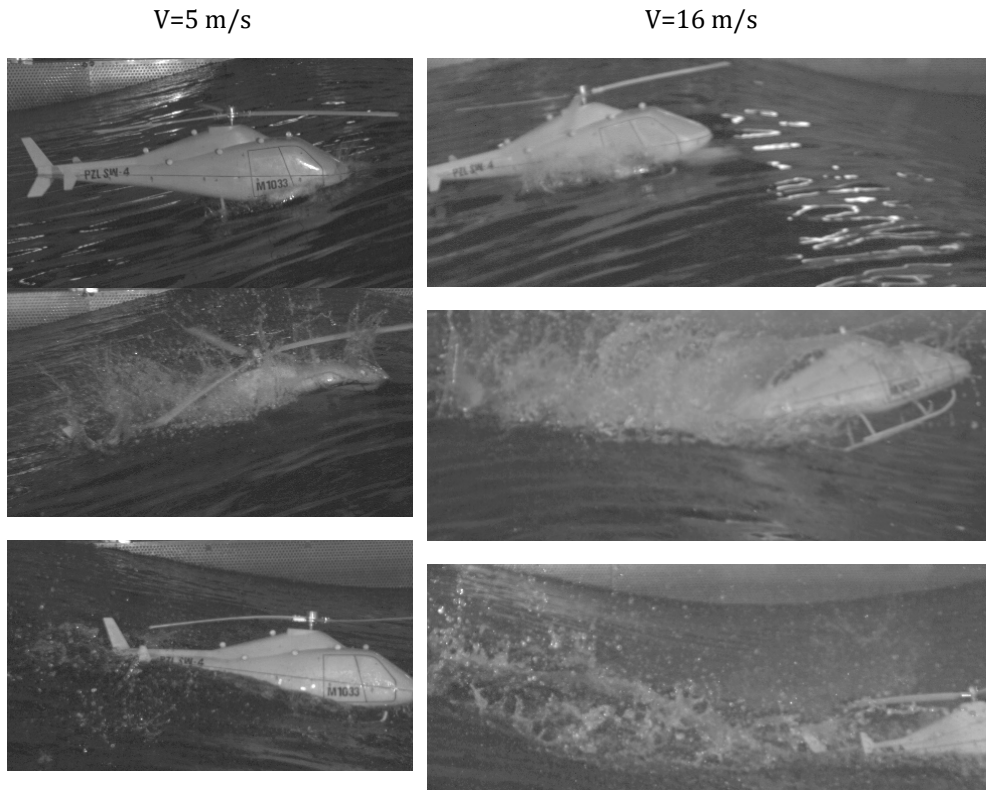


Fig. 16 Examples of ditching model tests at lowest and highest analysed horizontal speed

The phenomena presented above are also reflected in the time series of vertical acceleration at the location of pilot's seat (Fig.17). For low initial horizontal speed (top), the phases of the experiment are clearly visible. At the beginning, the acceleration varies periodically at rotor's rotation frequency due to minor imbalance in the rotor propulsion. After releasing, the measurement shows constant value of the acceleration of gravity. Large peak occurs after impact, and then the acceleration starts oscillating around zero, with visible influence of the wave motion, and local disturbances, resulting e.g. from the contact of the rotor blades with water. At the highest speed, the most important difference consists in the occurrence of second peak of acceleration – lower, but of the same order of magnitude (Fig. 17, bottom). Typical shape of the pressure peak measured during the water impact is presented in Fig. 18. The pressure was recorded in two locations on the bottom part of the fuselage; the location of the

sensors is presented in Fig.10. It is visible that the achievable sampling frequency (1kHz) is an absolute minimum for this kind of measurements.

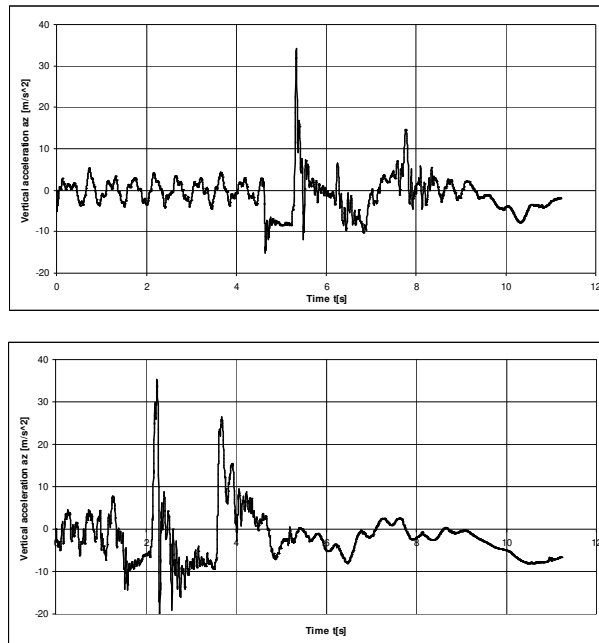


Fig. 17 Vertical acceleration in the pilot's seat location – low speed (top), and high speed (bottom)

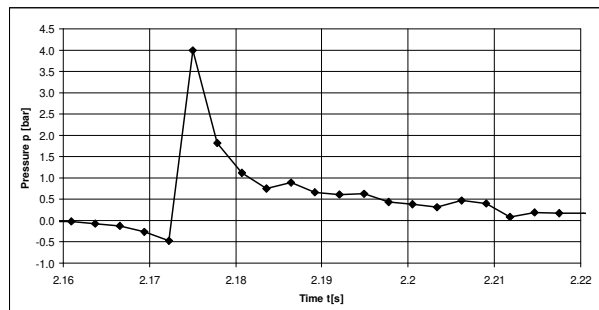


Fig. 18 Example of the pressure record

Summarizing the maximum acceleration, and pressure values for entire test matrix allows identifying the following general tendencies:

1. Initial horizontal speed strongly influences maximum longitudinal acceleration; other parameters, i.e. initial angles of pitch and yaw, have no significant influence on longitudinal acceleration.
2. On the other hand, no clear dependence between initial horizontal speed, and maximum vertical acceleration is visible.
3. Maximum lateral acceleration increases with increasing initial yaw angle, especially for higher speeds.
4. There is no significant and unequivocal influence of the initial pitch angle on maximum acceleration values.
5. It is clearly visible that large initial pitch angle (10 or 15 degrees) strongly reduces the pressure on the front gauge (No.1).

## CONCLUSIONS

Experience with the preparation of the experiment, and the results of the helicopter ditching tests yield the following conclusions:

- modelling the rotor rotation without propulsion requires careful design of the rotor model, to maintain approximately constant rotation rate, and to avoid the damage during the contact with water; in presented case, increasing the moment of inertia, and reducing the rotation rate at model scale turned out to be efficient;
- the launching device, in which the external rotor drive is the only supporting point, caused problems with the control of initial vertical velocity; a compromise was applied, leading to conservative prediction of acceleration and pressure impulses; the results are thus valuable primarily as a reference for CFD validation;
- low influence of initial pitch, and yaw angles on maximum accelerations was observed;
- however, increasing the initial pitch angle allows reducing the pressure impulses in the front part of the fuselage.

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## **MANAGING A MILITARY UNIVERSITY – SELECTED ISSUES**

### **ABSTRACT**

The presented material covers issues related to managing a military university as a special type of organization. On the one hand, it is a research and didactic structure, on the other, it is a military unit supervised by the Minister of National Defense. The functioning of this interesting, from the point of view of management sciences and quality of construction, subject to military canons and common law, including those relating to the space of operation of universities in general. A privileged place in the publication is occupied by issues that relate to the management of a military university, taking into account its characteristic structure for this type of organization, its resources and individual qualities of management. At the same time, innovative management methods and techniques are essential for all content included in the publication, which today seems to be necessary to be implemented in any modern and well-managed organization.

### Key words:

management, organization, military university, higher military education, management of military university

*Commanders of all ranks!  
The commander is not the nature of the rights, but the duties.  
Only a commander who does his duty  
in relation to subordinates, and superiors,  
deserves respect, and the title of a commander.  
An officer, and a non-commissioned officer  
should not be characterized, but must  
have courage, spiritual, and physical endurance,*

*dedication, and willingness to risk.  
Apart from these features,  
my basis for the assessment of commanders  
will show constant care for the existence of a simple soldier.*

Commander of the "Pomorze" Army  
Major General Władysław Bortnowski

## INTRODUCTION

Military universities are an element of higher education, and with the entry into force in 2005 of the Law on Higher Education, they became its inherent, and unbreakable link. Before that date, they operated as universities in a certain, conventionally named, closed, military environment, functioning somewhat alongside other civil Polish universities, creating an undoubted system. This state of affairs was associated with numerous discrepancies, e.g. the nature of the basic organs of higher education institutions, and their competences, the procedures used, the content of education, and in some cases problems with the recognition of professional titles. The year 2005 was a peculiar breakthrough in the development of military universities, which since then, when it comes to widely understood scientific, and educational procedures, including professional titles, and academic degrees, are treated equally with all other entities included in this system. Regardless of the above, military universities differ from others, for example, in that, in addition to the functions of a teaching, and research institution, they are assigned the role of a military unit. Thus, in the organizational structure of a military university there are two conventionally accepted levels. The first one relates to university management (rector), the second one is related to the implementation of tasks in the military sense (commandant). This duality of the professional role performed results from the fact, that each military university, apart from the function of a research and teaching center, is also a military unit, and is subject to the nomenclature and rules like other structures of this type present in the Ministry of National Defense. Such a justified solution results from the provisions of the Act of November 21, 1967 on the universal obligation to defend the Republic of Poland<sup>278</sup>. Military colleges are supervised by the Minister of National Defense

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<sup>278</sup> Art. 3 sec. 5 of the Act of November 21, 1967 on the universal obligation to defend the Republic of Poland, Journal of Laws of 2019, item 1541 as amended d.

<sup>279</sup>, however, due to the multiplicity of structures subordinate to the minister, they were subordinated to the Secretary of State at the Ministry of National Defense through the Director of the Department of Military Education <sup>280</sup>. Hence, the name of the Rector-Commandant for the first person at a military college was used.

The adopted standards should enable, on the one hand, the efficient fulfillment of research, and teaching functions by universities, and on the other hand, other tasks resulting from their typically military purpose. Both specified functions are performed in a continuous manner, and require extensive experience and competences, which include aspects of both the knowledge, and application of "research and teaching" procedures, as well as experience in command of elements (sub-units, divisions, ships, military aviation organizational units), the so-called "Linear", occurring in the structures of the Polish Armed Forces. Such high requirements result in certain limitations in the selection of rectors of military universities appointed by the Minister of National Defense from among active, or former professional soldiers<sup>281</sup>. Moreover, the rector may be a person who holds at least a doctoral degree. Nevertheless, additional requirements in relation to qualifications for this position may also be specified in the university statute, of which entry into force depends on the decision by the supervising minister approving it<sup>282</sup>.

The article separates the introduction, five content-related parts, and the ending. The first part contains the justification, and methodology of the research undertaken in the context of managing a military university. The next part unifies the most important concepts from the point of view of the study. The essence of this part of the work is to establish, and adopt the terms command, management, and direction for further consideration. The tasks, and duties of the rector-commandant of a military university are another element of the entire study. The contents presented in this part show the tasks, duties, and competences of the Rector-Commandant from the point of view of the applicable acts of general law, military regulations, and the university statute. The fourth substantive component of the publication is a presentation of the military university as an

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<sup>279</sup> Announcement of the Minister of National Defense of 30 October 2018 on the list of organizational units subordinate to or supervised by the Minister of National Defense (MP of 2018, item 1104).

<sup>280</sup> Ordinance No. 20 / MON of the Minister of National Defense of November 6, 2020 amending the ordinance on the organizational regulations of the Ministry of National Defense (Journal of the Ministry of National Defense of 2020, item 178).

<sup>281</sup> Art. 438 sec. 1 of the Act of July 20, 2018 Law on Higher Education and Science (Journal of Laws of 2018, item 1668, as amended).

<sup>282</sup> Art. 24 sec. 1 and art. 441 of the Act of July 20, 2018 Law on Higher Education and Science.

organization, as understood in the sciences of management, and quality. An important place in the analysis of the above issue is taken by a diagram presenting selected elements of the organizational structure of a military university. The fifth, and last substantive part of the publication is Managing a military university – selected aspects. It indicates some selected elements that should be taken into account when holding managerial positions at a military university. Most of the discursive considerations relate to the highest decision-making level of this organization, trusting that they will contribute to the continuous improvement of the already good condition of these important research, and teaching centers. In the final part, one presented the ending regarding the management of a military university in modern reality, quoting a fragment of the order of the "Pomerania" Army Commander – Major General Władysław Bortnowski – March 1939 – as a special way of showing care for his subordinates.

### **JUSTIFICATION AND METHODOLOGY OF THE UNDERTAKEN RESEARCH**

The main reason for taking up the analyzed issues are the constant changes in the broadly understood social reality, which, in my opinion, must be taken seriously in order to meet the fundamental goals of higher military education. Comprehensive preparation of officer cadres for the implementation of tasks related to the defense of the state against current, and future threats is not possible, *inter alia*, without a proper, systemic approach to managing military universities. These issues are undoubtedly influenced by the entry into force of the Law on Higher Education and Science<sup>283</sup>, which should be treated as a certain challenge, and opportunity for the functioning of military universities, and higher education in general.

With regard to the proposed issues, it seems reasonable to try to answer the following problems: What model / system / method of managing a military university would be adequate to properly fulfill its contemporary role? What necessary actions should be taken to properly, rationally, and effectively use the university's potential? What relevant competences, and skills should core management have? How to shape, and develop the competences of employees of military universities in the face of emerging challenges, and threats? The presented problems must be reflected on the level of systemic, and well-thought-out activities that will be implemented in a permanent, and rational manner. Any unjustified departure from the adopted rules, and model solutions is inappropriate, as it may cause the system to become unstable, and destabilized.

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<sup>283</sup> The Act of July 20, 2018 Law on Higher Education and Science.

A deviation from the adopted regulations once made may cause an undesirable avalanche reaction.

In this work, I made use of many years of experience, which I acquired during my military service at a military university, the General Staff of the Polish Army, and the Department of Science and Military Education of the Ministry of National Defense. Considerations undertaken, *inter alia*, based on the achievements of management, and quality sciences, they result from theoretical aspects, but also from practical premises. The main discursive premise of the study was to fill the absenteeism in the literature on the subject of works related to the management of a military university due to its specific essence of operation. However, the study is not about the functioning of the entire higher military education, but about a very important part of it, without which the goals of the superior system cannot be achieved. Thus, no study has been prepared so far that would be dedicated to the efficient management of a military university from the perspective of its dual nature and, *inter alia*, its significant contribution to the maintenance, and development of the defense potential, and state security. The analyzed issues are legally sanctioned, which is presented above in the publication. The practical context also deserves attention. First of all, it is about increasing awareness of the importance of certain actions taken by relevant decision-makers for the proper functioning of the structure. They are often overlooked, and / or underestimated, and their relationship to an efficient system is undeniable. An able-bodied leader must see the necessity to combine the functioning "model of conduct" with the goals of the institution he leads. This is the second important, practical aspect of the operation of the military college. Only the coherence, and logic of conduct (management), the ability to combine goals with practical activities through the prism of the university's greatest capital – people, enables the implementation of tasks, and meeting possible challenges, and threats. Another, third practical premise, relates to the effective improvement of the functioning of military universities, and the construction of innovative, modern, perfectly managed structures that are so important from the point of view of the development of the state, and its security.

Taking up the issues included in the material required the use of many scientific methods, which include: analysis, analysis of documents, and comparative studies. The analytical methods used made it possible to separate more complex things, or phenomena into details in order to better, and more non-superficially investigate them. In addition, the analysis of documents has found application in gathering information on the studied issues, and has become invaluable, among others, to analyze the content of legal acts, and other documents constituting the basis for the functioning of military universities. In turn, I used the comparatist method at every stage of the research. It enabled



scientific exploration in the field of searching for affinities that could show the influence of one element on another, and their possible mutual dependencies, similarities, and differences. I used this method to compare the content of selected literature items relating to the subject matter. During the research process, it was necessary to refer to such cognitive processes as synthesis, abstraction, generalization, and inference. To a large extent, I used my own professional experience, which I gained over a dozen years as a person directly related to the functioning of higher military education. The knowledge gained during participation in national, and international projects with the participation of bodies from various foreign academic environments turned out to be valuable, where there are systemic solutions different from the Polish ones.

Due to the adopted limitations, the publication attempts to analyze issues related to the management of a military university only with regard to the highest decision-making level of this structure.

### **UNIFORMATION OF THE ESSENTIAL CONCEPTS APPLIED**

As it was noted at the beginning, a military university consists of two integral parts that constitute its internal system, i.e. the conventionally named university element (research and teaching), and a military element (military unit). So it is not a typical military structure, nor is it a classical university. This organization combines the two analyzed types of institutions. In the first case, the rector-commandant performs the function of the university rector, similar to those performed by the heads of other civil, and public universities. The second function, on the other hand, is related to holding the position of "commandant" within the meaning of military regulations. It seems justified to continue the research process, and to maintain the continuity, and consistency of the study, it seems to resolve, and establish the basic concepts adopted for further considerations, which I do in the rest of my work.

An analysis of the literature dealing with the issue of command allows us to notice various approaches to its essence. There is no doubt that they changed with the evolution of the development of the army, and its use in various conflicts, the use of new technologies, and weapons, as well as the transformations that took place in the broadly understood art of command. The last dozen years, or so has been a period in which many military practitioners, and theorists considered command in terms binding for the developing management sciences (currently a scientific discipline: management, and quality sciences). Therefore, it was more, and more often analyzed, and compared through the prism of the notions: leadership and management. Taking into

account the above, it seems reasonable to clarify the indicated terms, and to adopt definitive categories for the purposes of this study.

According to J. Zieleniewski, *directing* is understood as *an activity aimed at causing other things to function in accordance with the purpose of the person who directs them*<sup>284</sup>. L. Krzyżanowski specifies *directing* as *(...) influencing the organization with the use of established rules (procedures) for its members (elements), also in order to achieve the intended goal, but it may take the form of: administration (the source of power – the right to influence the organization are the formal competences of the manager acquired with the selection, appointment, or appointment to the role of administrator); management (the source of power is the right to dispose of the resources that determine the functioning of the organization, especially resources of particular importance for the functioning of the organization, and the fate of its elements)*<sup>285</sup>.

On the other hand, *management* is a *type of control in which the title to exert influence on hierarchies, and value systems, interests, and aspirations, as well as attitudes, and organizational behaviors of the directed results mainly, but not exclusively, from the possession, or the fact that the manager has material, and energy resources, or nominal information, and information of particular importance for the functioning, and development of the organization, or the management's belief that the manager has the possibility of acquiring these resources*<sup>286</sup>. The authors of the textbook *Organization and Management* state that *management is a sequence of activities that are functions of planning, stimulating, organizing, and controlling, which are arranged in specific patterns of organizational processes (usually in information, and decision-making systems), and are fulfilled by management units, and managerial positions*<sup>287</sup>.

J.A.F. Stoner, R.E. Freeman, D.R. Gilbert, Jr. unify that *directing (management) is the process of planning, organizing, leading, and controlling the work of organization members, and using all available resources of the organization from achieving its goals*<sup>288</sup>. Despite the interchangeable use of the terms *management* and *direct*, it should be noted that J.A.F. Stoner, R.E. Freeman, D.R. Gilbert, Jr. treat the latter in a broader sense. You can direct, or manage,

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<sup>284</sup> J. Zieleniewski, *Organizacja zespołów ludzkich*, PWN, Warsaw 1982, p. 380.

<sup>285</sup> L. Krzyżanowski, *Podstawy nauk o organizacji i zarządzaniu*, PWN, Warsaw 1994, p. 208.

<sup>286</sup> Ibidem, s. 207.

<sup>287</sup> A. Stabryła, J. Trzcieniecki (edit.), *Organizacja i zarządzanie*, Akademia Ekonomiczna, Kraków 1986, p. 132.

<sup>288</sup> J.A.F. Stoner, R.E. Freeman, D.R. Gilbert, Jr., *Kierowanie*, Polskie Wydawnictwo Ekonomiczne, Warszawa 2011, p. 20.

a company, but it's not usual to talk about managing a school football team<sup>289</sup>. Similarly, he notices these dependencies, among others L. Krzyżanowski, J. Zieleniewski, and J. Michniak, consciously distinguishing between these two concepts, while pointing out that directing is one of the forms of management, therefore it is a narrower concept<sup>290</sup>. The latter also defines *management in a military organization*, which he sees as *a managerial activity consisting in setting goals, and causing their implementation within the formalized organizational structures of the command system, and above all in the production (securing) of staff services, but also in training, etc.*<sup>291</sup>

Consistently to the adopted procedure and presentation of the definitions of the terms *management and leadership*, it is necessary for further analysis to present the meaning of the concept of *command*. NATO's Glossary of Terms and Definitions makes it clear that *command is the power given to a person in the armed forces to direct, coordinate and control military formations*<sup>292</sup>. J. Michniak clarifies that *command is the basic form of military management, based on the right to comprehensively shape all elements of combat readiness, and capability in relation to soldiers directly and indirectly subordinate to them, and thus to prepare them comprehensively in peacetime for all kinds of operations, and to manage them during their implementation in times of peace, crisis, and war*<sup>293</sup>. R. Kuriata states that *command is a special, due to the scope, type of management consisting in designing, and organized informational, and decision-making interaction, with feedback implemented by commanders, and other command bodies, on the subject of combat potential in the time preceding, and during armed combat. persistence, aimed at the best possible preparation of this potential for combat, maintaining it in combat readiness appropriate to the situation, and using it to win a victory over the opponent by making him submissive, or smashing him in armed combat*<sup>294</sup>. The authors of the selected terms in the field of *command and management* define this concept as *a decision, and information process through which the commander imposes his will, and intentions on his subordinates, and within which, assisted by his staff, plans, organizes, coordinates, and directs*

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<sup>289</sup> Ibidem.

<sup>290</sup> L. Krzyżanowski, *Podstawy nauk o organizacji i zarządzaniu*, p. 393; J. Michniak, *Dowodzenie i łączność*, AON, Warszawa 2005, p. 18.

<sup>291</sup> J. Michniak, *Dowodzenie i łączność*, p. 18.

<sup>292</sup> *AAP-6 (2017) Słownik terminów i definicji NATO*, Bruksela 2018, p. 110.

<sup>293</sup> J. Michniak, *Dowodzenie w teorii i praktyce*, AON, Warszawa 2003, p. 15.

<sup>294</sup> Za: J. Kręćkij, J. Lewandowski, *Organizacja dowodzenia na poziomie strategicznym i operacyjnym*, Oficyna Wydawnicza AFM KAAF, Kraków 2015, p. 14.

*the activities of his troops through the use of standard operating procedures, and all available means of communicating information*<sup>295</sup>.

As the authors of the *Command Organization* rightly point out at the *strategic and operational level*, the presented concepts of command link them with the unit in the person of the commander. At the same time, the contents of the command include the laws, principles, and methods of action developed in the history of human development, generalized, tested, and thus elevated to the rank of objective laws operating independently of human will. In command, these rights are used creatively by the commander who, supported by his staff, exercises command functions on the way to the effective achievement of the objectives of operations. Therefore, the command, as a whole of the purposeful activity of the commander, and his command organs, must be carried out within a clearly defined command system, ensuring high combat readiness, and proper preparation of troops for the forecasted actions. The noticed fundamental difference between command, and control concerns the scope of power held by the military commander in relation to subordinates. Therefore, it should be considered as justified as possible, that command is almost identical with management, and therefore can be treated as a specific form of management<sup>296</sup>.

Therefore, command is a special type of management. It is worth adding that it is confirmed by the scope of the formal authority possessed by commanders towards their subordinates, as well as the characteristic, and specific mode of carrying out tasks resulting from orders. An unquestionable category is also proper care for the health, and life of soldiers under his control, and military equipment. Therefore, on the basis of the analysis of the proposed definition of various authors, this view, following J. Kręcikij and J. Lewandowski, is binding<sup>297</sup>. On the basis of the considerations so far, in order to carry out the research process, I also assume *that the management of a military university results from the formal appointment of a person to the position of rector-commandant by the minister of national defense. It is a process of planning, organizing, leading, and controlling that influences the achievement of the goals of the university. It takes place with the use, and observance of established principles, rules, and procedures, while maintaining an appropriate level of internal communication, and openness to innovative activities enabling the permanent development of the institution. At the same time, the rector-commandant is responsible for the results of the university, which is understood as, inter alia, care*

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<sup>295</sup> M. Strzoda (edit.), *Wybrane terminy z zakresu dowodzenia i zarządzania*, AON, Warszawa 2002, p. 15.

<sup>296</sup> J. Kręcikij, J. Lewandowski, *Organizacja dowodzenia na poziomie strategicznym i operacyjnym*, p. 16.

<sup>297</sup> Ibidem.

*for the financial condition, equality of employees in relation to the professional development system, having an appropriate scientific category, development of scientific research, creation of new, innovative fields of study, development of international cooperation in terms of teaching and research, proper improvement of officers, as well as training, and preparation of candidates for professional soldiers (cadets) for the implementation of tasks in official positions in the Ministry of National Defense, technical modernization, as well as ongoing construction investments, and repairs.*

The governance of the university must therefore be carried out in a way that involves all members of the academic community in achieving common goals. Only this approach will enable further successes, and have an impact on the continuous development of the structure, and its employees. Important in the functioning of a university is the ability of its employees to adapt the university's strategy in terms of emerging challenges, and threats. It is worth remembering, that an important issue is the result of the so-called satisfied customer, which in this case are the Polish Armed Forces, or more broadly – the Ministry of National Defense. When analyzing the proposed approach to the term management, we see that it is strongly rooted in the specific culture of an organization, which consists of common goals and values, specific principles, and norms of conduct, and behavior.

### **TASK AND DUTIES OF THE RECTOR-COMMANDANT OF A MILITARY UNIVERSITY**

The implementation of projects in the position of rector-commandant is closely related to the provisions of the law relating to both "military" reality, and those resulting from the Law on Higher Education and Science<sup>298</sup>, as well as acts, and documents related to this area of operation of a higher education institution. Considering the fact that the Rector-Commandant is also the commander of a military unit within the meaning of the Act on the Universal Duty of Defense, his main duties include:

- determining the course of service and life in a university (military unit)<sup>299</sup>;
- performing tasks related to the participation of universities in combating natural disasters, and liquidating their effects, protecting property,

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<sup>298</sup> Ustawa z dnia 20 lipca 2018 r. Prawo o szkolnictwie wyższym i nauce.

<sup>299</sup> Regulamin Ogólny Sił Zbrojnych Rzeczypospolitej Polskiej, SG WP, Warszawa 2014, p. 25 – Annex to Decision No. 445 / MON of the Minister of National Defense of 30 December 2013. (Journal of 2013, item 398)

search operations and saving, or protecting human health and life, as well as in the implementation of tasks in the field of crisis management;

- cooperation with other authorities, and entities in matters related to state defense;
- implementation of development programs of the Polish Armed Forces;
- planning, organizing, and conducting military training;
- planning, and organizing the use of universities in the state of defense readiness in the time of crisis, and war<sup>300</sup>.

On the other hand, according to the Law on Higher Education and Science, the rector's tasks include in particular:

- representing the university;
- university management;
- preparing the draft statute and the university strategy project;
- reporting on the implementation of the university's strategy;
- performing activities in the field of labor law;
- appointing people to perform managerial functions at universities, and their dismissal;
- conducting personnel policy at the university;
- creating studies at a specific field, level, and profile;
- establishing doctoral schools;
- running the university's financial management;
- ensuring compliance with the regulations in force at universities<sup>301</sup>.

It is worth noting that the rector gives the organizational regulations of the university, is the chairman of the senate, takes care of maintaining order, and safety at the university, and ensures safe and hygienic working, and education conditions, in particular by providing appropriate infrastructure, and conducting training<sup>302</sup>. Moreover, the competences of the Rector-Commandant include:

- taking actions to ensure proper conditions for the functioning of the Academy, and meet the social and living needs of students, doctoral students, and employees of the Academy;
- establishing a material and financial plan after consulting the senate;

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<sup>300</sup> Prepared on the basis of art. 11a paragraph. 2, 11b paragraph. 2, 11c paragraph. 2, and 13c of paragraph 1. 2 of the Act of November 21, 1967 *on the universal obligation to defend the Republic of Poland*.

<sup>301</sup> Art. 23 sec. 2 of the Act of July 20, 2018r. *Prawo o szkolnictwie wyższym i nauce*.

<sup>302</sup> Art. 23 sec. 3, art. 31 sec. 1, art. 50 sec. 1, art. 51 sec. 1 of the Act of July 20, 2018. *Prawo o szkolnictwie wyższym i nauce*.

- determining the budget provision in force until the material, and financial plan is established;
- determining the number, properties, and competences of vice-chancellors;
- defining the scopes of responsibilities of persons directly subordinate to him;
- exercising supervision over the organization of the functioning of adequate, effective, and efficient management control;
- supervising the cooperation of the Academy with scientific, and economic institutions in the country, and abroad;
- appointing permanent, or ad hoc rector's committees, rector's spokespersons, and appointing, and dismissing proxies;
- directing professional soldiers to individual organizational units appointed to positions in teams working at the Academy<sup>303</sup>.

The tasks, duties, and competences of the rector-commandant presented above show their considerable scope. It goes beyond the "normal" tasks of holding the position of unit commander, and the ability to command subordinate personnel. In addition to the responsibility for people, and military equipment, the protection of the complex, etc., they are associated with the entire sphere of action and thinking, which, for the sake of simplicity, will be called as specific tasks in relation to the functioning of a military university. In connection with the above, the rector-commandant must have the appropriate capabilities to properly perform the tasks entrusted by the minister of national defense.

## MILITARY UNIVERSITY AS AN ORGANIZATION

Each functioning organization, just like a military university, can be viewed from different perspectives. The best known approach represented, among others, by T. Pszczołowski, A.K. Koźmiński, and W. Piotrowski, and A. Czermiński, M. Grzybowski, and K. Ficoń, one should consider the organization

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<sup>303</sup> *Statut Akademii Marynarki Wojennej im. Bohaterów Westerplatte*, Gdynia 2019, pp. 8-9 – Annex to the announcement of R-C of PNA No. 1 of September 16, 2019.; Por.: *Statut Wojskowej Akademii Technicznej im. Jarosława Dąbrowskiego*, Warszawa 2019, pp. 9-16 – Annex to the Announcement of the Rector of the Military University of Technology No. 2 / WAT / 2019 of October 9, 2019.; Por.: *Statut Akademii Sztuki Wojennej*, Warszawa 2019, pp. 10-17 – Annex to Resolution No. 59/2019 of the Senate of the Academy of Martial Arts of September 11, 2019.; Por.: *Statut Lotniczej Akademii Wojskowej*, Dęblin 2019 – Annex to Resolution No. 14/2019 of the Senate of the Aviation Military Academy; Por.: *Statut Akademii Wojsk Lądowych imienia generała Tadeusza Kościuszki*, Wrocław 2020, s. 13-20, - Announcement No. 1/2020 of the Rector - Commander of the Academy of Land Forces named after General Tadeusz Kościuszko, of October 7, 2020.

in the factual, functional, and attribute sense<sup>304</sup>. An organization in a factual (objective) perspective is a certain object that is quite simply distinguishable, and different from other objects due to its distinguishing features, which are characteristic only to it. As the authors of *Podstawy organizacji i zarządzania* rightly point out, *an organization, in the material sense, is an institution, or a functional group consisting of intentionally organized groups of people, and things. It involves real (material and physical) processes, and management, which include information, and decision-making activities*<sup>305</sup>. Therefore, taking into account the above, it should be noted that an organization is an intended product of a human who has been created for a specific purpose, and consists of elements (parts) that are necessary for its proper functioning, assuming the continuity of relations between them, and the external environment of a diverse nature.

In the context of attributes, the organization in question is a feature that distinguishes complex objects, called organization. This means, that this feature may belong to various items to a different degree, i.e. they may be organized to a greater, or lesser degree. For example, an army platoon is more organized than a bridge circle, although we consider both sites to be organizations<sup>306</sup>. A. Czermiński, M. Grzybowski, and K. Ficoń note that the organization in the attribute sense exposes the properties of the considered organization – positive, or negative, significant, or irrelevant, etc. In the attribute sense one say that something is well, or badly organized, or the organization is efficient, or inefficient, effective, or ineffective, economical, or wasteful, etc. For example: the reason for the failure to complete a combat task was a defective organization of cooperation between aviation and ships<sup>307</sup>.

On the other hand, organization in the functional sense is a process consisting in the deliberate grouping of people, and things in such a way that they efficiently achieve the assumed goals. It is therefore organizing, that is, an activity consisting in creating an organization, and deliberately coordinating activities, work, and service<sup>308</sup>. D. Jemielniak, and D. Latusek claim, that

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<sup>304</sup> T. Pszczołowski, *Mała encyklopedia prakseologii i teorii organizacji*, Ossolineum, Wrocław-Warszawa-Kraków-Gdańsk 1978, pp. 150-151; A. K. Koźmiński, W. Piotrowski, (edit.), *Zarządzanie – teoria i praktyka*, Wydawnictwo Naukowe PWN, Warszawa 2006, p. 29; A. Czermiński, M. Grzybowski, K. Ficoń, *Podstawy organizacji i zarządzania*, Wyższa Szkoła Administracji i Biznesu w Gdyni, Gdynia 1999, pp. 29-30.

<sup>305</sup> A. Czermiński, M. Grzybowski, K. Ficoń, *Podstawy organizacji i zarządzania*, p. 30.

<sup>306</sup> See T. Pszczołowski, *Mała encyklopedia prakseologii i teorii organizacji*, Ossolineum, Wrocław-Warszawa-Kraków-Gdańsk 1978, pp. 150-151.

<sup>307</sup> A. Czermiński, M. Grzybowski, K. Ficoń, *Podstawy organizacji i zarządzania*, p. 30.

<sup>308</sup> Ibidem.



organization in the functional sense is a process of organizing, constant introduction of a specific order, or chaos<sup>309</sup>.

The genesis of management development shows that organizations have been analyzed many times, and in addition, in various aspects. An approach comparing the organization to an efficient machine is known in the literature on the subject, which was often equated with the optimization of individual work processes, and the search for ways to constantly improve their effectiveness. This view showed, and interpreted the organization as a special machine that was designed by a man, always operated in a predictable manner, and allowed for improvement through minor activities related to its maintenance, or replacement of minor elements. It is therefore a certain system designed, and functioning rationally, meeting specific goals. The question is whether an organization, including a military one with "civilian" attributes, can operate in such a predictable way? It is worth noting at this point that in management sciences, the so-called sociological perspective introduced a different view of understanding the organization. Referring to the metaphor of an organism that carries out specific tasks, it assumed that it consists of parts fulfilling certain own functions, and constantly maintains relations (exchange) with the environment of the organization. A very important issue of such a structure – completely opposite to the rational approach (of the machine) – is its constant, and not fully controlled development. This approach shows the organization as a natural system that strives to maintain a balance in its relations with the environment<sup>310</sup>. Of course, these are not only perspectives that include organizational issues in their content. However, due to the limitations, and assumptions made, in the further part of this publication I will not make further analyzes in the scope relating to the perspectives of considering the organization.

Taking into account the previous considerations, it should be concluded that a military university, as understood by the organization, is a socio-technical entity of a hierarchical, and organized nature. This finding allows us to interpret the organization as a set of structured, and interrelated technical and social elements. Thus, an organization treated as a certain superior system consists of several smaller elements (subsystems). For further considerations, therefore, I assume that the subsystems of an organization (military university) include the following areas (Fig. 1):

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<sup>309</sup> D. Jemielniak, D. Latusek, *Zarządzanie: teoria i praktyka od podstaw. Ćwiczenia*, Wyższa Szkoła Przedsiębiorczości i Zarządzania im. Leona Koźmińskiego, Warszawa 2005, p. 16.

<sup>310</sup> See W.R. Scott, *Organizations: Rational, natural, and open systems*, NJ: Prentice-Hall 1987, p. 52.

- goals and values, defining the mission that the organization performs “outside”, that is, in the environment in which it operates, and “inside”, that is, towards its members. Goals understood as sets of specific goals have a hierarchical composition. Long-term, costly, and particularly important goals for the development of the organization are called strategic goals. These, in turn, define the field of specific activities, and undertakings described by tactical, and operational goals;
- psychosocial, which includes the participants of the organization (people), their motivations, attitudes, values, culture, and social bonds between them. People are the most important component of any organization. The remaining subsystems of the organization are secondary, artificial, defined, and created only as instruments of action;
- organizational structure, treated as a set of elements of a given system (individual workstations, organizational cells, and units), and the links between them. These ties are called organizational ties. This subsystem includes formal rules for the division of tasks, powers, information, authority, and responsibility in the organization;
- technical, which includes technologies used in the organization, technical skills (know-how), simulators, trainers, machines, devices, buildings, and their equipment. This subsystem is also comprised of developed operating techniques in terms of general algorithms, and procedures. They include, among others decision-making process, and organized action cycle;
- management, which includes the mechanisms of coordination, and reconciliation of other subsystems in the decision-making processes<sup>311</sup>.

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<sup>311</sup> Por.: A. K. Koźmiński, W. Piotrowski, (edit.), *Zarządzanie – teoria i praktyka*, p. 30 ; R. Krupski, *Podstawy organizacji i zarządzania*, I-BiS Wydawnictwo, Wrocław 2004, pp. 17-19.