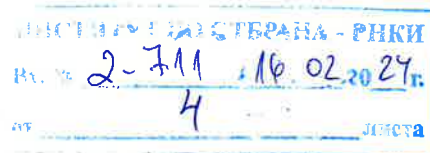




**"G. S. RAKOVSKI" NATIONAL DEFENCE COLLEGE**



## **OPINION**

by Col. PhD eng. Sevdalin Ivanov Spassov  
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**for the PhD thesis of eng. Alexander Genchov Ranov**

on topic: "A Model for Routing and Traffic Control of an Autonomous Combat  
Platform",

submitted for the acquisition of the educational and scientific degree "doctor"

in the field of higher education 5. "Technical sciences",  
Professional direction 5.2 "Electrical Engineering, Electronics and Automation"  
Scientific specialty "Automated information processing and management  
systems"

2024

## **1. Relevance and significance of the developed scientific problem**

There is no doubt the relevance of the problems of creating autonomous means of transport in modern conditions. A number of known results of tests and trial operation of similar autonomous (unmanned) platforms in the civilian sphere have been published. In the military sphere, the applications of autonomous platforms could be and are already in practice used in the performance of certain combat and logistical tasks. Information from current military conflicts shows various successful attempts and the growing importance of using autonomous platforms with different levels of autonomy operating in air, water or land environments. For example, in the conflict in Ukraine, both sides massively use air and sea drones with varying degrees of autonomy, but with surprisingly high efficiency.

## **2. Evaluation of the scientific results and contributions of the dissertation work**

The author's awareness of the subject of the dissertation is demonstrated, using generally recognized and some of the most recent publications in the field of research. The list of used literature, containing 14 sources in Bulgarian and 97 in English, testifies to the large volume of information processed in the research.

It shows the author's knowledge and use of a variety of mathematical apparatus such as matrices, integral and differential calculus in the analysis of the investigated processes such as route parameters, determination of coordinates of an object in space, movement parameters, compensation of systematic errors from measurements, digital filtration.

The author has proven the following through field experiments: first, the approach to digital filtering in controlling the speed of an autonomous combat platform has been tested in its part of experimental determination of operating characteristics; second - the algorithm for detecting unmapped obstacles is tested in a specially created test environment; and thirdly - the method of compensation of deviations in the readings of a magnetometric sensor is tested by applying spatial graphic analysis on experimentally obtained data.

Through a simulation experiment, the routing model is validated in a developed test software application.

Scientific and scientific-applied results are reduced to enrichment and further development of existing knowledge, proof of existing and new facts, as well as application of the results in practice. The scientific results and

contributions in the dissertation enrich and extend the scientific-theoretical and practical settings of routing models, the mathematical model of the state vector of an autonomous platform, and the digital filtering approach in speed control of an autonomous combat platform.

I accept the following contributions as scientific and applied:

1. On the basis of a mathematical analysis, information structures "passability matrix" and "visibility matrix" were defined. A model for processing information structures with the result "hidden movement matrix" in autonomous combat platform routing is synthesized.

2. By applying the routing model, an algorithm was developed for drawing up a transport plan of a ground autonomous combat platform, without using an existing road network and in the conditions of hidden movement in relation to a known enemy observation post.

3. A mathematical model of the state vector of an autonomous platform is developed. A closed-loop feedback control model for motion speed is proposed.

4. An analysis of the sources of errors in the processing of primary sensor data from an inertial navigation module was performed. An original approach for implementing digital filtering in speed control of an autonomous combat platform is proposed. The approach has been tested in its part of experimental determination of operating characteristics.

5. A method for compensation of deviations in the readings of a magnetometric sensor designed to determine the azimuth in the direction of movement of an autonomous combat platform is proposed. The method was tested by applying spatial graphic analysis on experimentally obtained data.

I accept the following contributions as applicable:

1. A mathematical apparatus was defined for deriving the dependences "slope" and "visibility" using a digital model of the height of the earth's surface.

2. The routing model is validated in a developed test software application. Graphical and numerical results are presented, confirming the working ability of the model.

3. An algorithm was developed for the detection of unmapped obstacles using "computer vision" methods. The algorithm was tested in a specially designed test environment.

4. An experimental set-up was created for conducting model studies, and energy characteristics during movement of a physical model of an autonomous

platform were recorded. On the basis of the energy characteristics, a methodology is proposed to determine the possibilities for the implementation of a given route.

The scientific results and contributions are the work of the doctoral student and are correctly reflected in the abstract.

### **3. Critical notes**

It would be good to give a working definition of the term "control" for labor purposes (which probably copies the English verb "control") and matches the meaning of the term "management". Since there are many terms and designations in the work, and although they are explained when they are first mentioned, it would still be appropriate to create a list of abbreviations, terms, and designations.

The mentioned notes are of a recommendatory nature and they do not diminish the merits of the dissertation work..

### **4. Conclusion**


The PhD thesis on the topic "Model for routing and control of the movement of an autonomous combat platform" with author Alexander Genchov Ranov can be defined as an up-to-date, in-depth and complete work with scientific and applied contributions and meeting the requirements of the Law on the Development of Academic composition in the Republic of Bulgaria.

### **5. Evaluation of the PhD thesis**

Bearing in mind the scientific results achieved in the dissertation work, I give a positive assessment and propose to the scientific jury to award Alexander Genchov Ranov the educational and scientific degree "doctor" for the developed work on the topic "Model for routing and control of the movement of an autonomous combat platform". in the field of higher education 5. "Technical sciences", professional direction 5.2 "Electrical engineering, electronics and automation", scientific specialty "Automated systems for information processing and management".

14.02.2024

Col. Ass. prof. PhD

 Spassov