

**REVIEW**  
**from research adviser for dissertation work**  
**Keribayeva Talshyn Bakytzhankyzy**

*"Development of a control system for an unmanned aerial vehicle based on Smart technology", submitted for the degree of Doctor of Philosophy (PhD) in the specialty 6D071400 "Aviation Engineering and Technology"*

**1. Relevance**

The relevance of the dissertation research is related to the direction of "Digitalization of transport and logistics", which is one of the priority areas in the State Enterprise of the Republic of Kazakhstan "Digital Kazakhstan". In the programs of "digitization" and digital transformation of many states, the key areas are: robotization, the introduction of technologies into SMART control systems, neural technologies, unmanned aerial vehicles (UAVs). The development of unmanned vehicles is divided into three main areas: consumer, industrial and military. In the management of the UAV, it became necessary to create an external control of the positioning of the UAV along the entire programmable flight path and external diagnostics of the technical condition of the UAV. UAV control based on SMART technologies generates many problems and tasks that need to be addressed for the first time. It seems possible to solve these problems only with the use of formal methods. It is necessary to formalize the process of controlling the movement of an unmanned aerial vehicle under conditions of parametric uncertainty of control factors, develop SMART models for an integrated assessment of the quality of the organization of production and operation of unmanned vehicles in conditions of systemic parametric fuzziness, develop a model for assessing the quality of control of an unmanned object, taking into account the feedback link, and a number of other tasks.

**2. Scientific results within the requirements for qualifying scientific works.**

In the work of Keribayeva T.B. the problems of modeling the processes of assessing the quality of control and management of unmanned vehicles based on SMART technology are considered and solved.

The management process is considered as a digital integrated system consisting of functional and supporting components. The target functional implements the planned operation of the system along a programmable trajectory. System software solves programmable tasks. The point expert significance of vector elements, control agents is determined. In this vector, as a result of the analysis of the reporting documentation of enterprises, the five most informative indicators were identified: technical support; mathematical software; software; level of investment; staff qualifications. Since the vector represents information by its nature related to fuzzy data, the mathematical apparatus of fuzzy sets was chosen and an integrated model of control quality was developed. A simulation model for assessing management risks was developed, taking into account the feedback link, a simulation model for optimizing maintenance and repair of aviation equipment. The correctness of the developed models and algorithms



repair of aviation equipment. The correctness of the developed models and algorithms was tested by a computer experiment. The degree of adequacy of the newly developed models was assessed according to standard criteria of statistical reliability.

All proposed formal models and technical solutions are made at a high scientific level, which is confirmed by the high level of publications on the research topic.

### **3. The degree of validity and reliability of each scientific result (scientific position), the conclusions of the applicant formulated in the dissertation**

Methods and results of dissertation research, scientific hypotheses and provisions, conclusions are sufficiently substantiated and reliable. A significant amount of modern scientific literature and statistical reporting in the subject area of research has been studied, on the basis of which conclusions and research objectives have been formulated. To implement the planned list of tasks, the following were developed: a methodology for theoretical research and a methodology for conducting experimental and statistical research. The Law of the Republic of Kazakhstan "On Ensuring the Uniformity of Measurements" dated June 7, 2000 N 53-II was studied in detail. The analysis carried out allowed the author to propose mathematical models for assessing and predicting the reliability of control under the conditions of statistical uncertainty of decision-making parameters. In the process of modeling, such branches of mathematics as probability theory and mathematical statistics, regression and correlation analysis, fuzzy set theory, simulation modeling, agent modeling were used. The appropriateness of the models proposed by the applicant is ensured by following the system methodology, the basic provisions of the theory of probability and mathematical statistics, using standard data processing software. For computer simulation, in order to assess the statistical reliability and quality of the developed models, a special set of software applications was used. Computer simulation made it possible to reveal the system properties of the control process as a function of the statistical parameters of modeling agents. To develop practical recommendations for the technical implementation of the functional devices of the system, laboratory studies were carried out. Circuit solutions based on modern element base were investigated. The circuit composition of Arduino - Raspberry Pi has been studied. The experiment showed the validity of the model solutions proposed by the author, their compliance with the results of experimental verification, under conditions adequate to real ones.

### **4. The degree of novelty of each scientific result (scientific position), conclusions and conclusions of the applicant formulated in the dissertation**

The main new scientific results of the dissertation work are the scientific provisions formulated and proven in the dissertation, the novelty of which lies in the fact that for the first time developed:

1. Mathematical model and algorithm for controlling the movement of an unmanned aerial vehicle under conditions of parametric uncertainty of decision-making agents;



2. Model for calculating the parameters of the phase shifter in the system of electromagnetic launch of unmanned aerial vehicles;

3. Neural SMART model of integrated assessment of the quality of organization of production and operation of unmanned vehicles in conditions of systemic parametric fuzziness with expert decision making;

4. Simulation model and algorithm for assessing the quality of control of an unmanned object, taking into account the parametric and functional uncertainty of the feedback link;

5. Conceptual model for optimizing and improving the quality of maintenance and repair of unmanned aerial vehicles.

#### **5. Assessing the internal coherence of the results achieved**

The title of the dissertation corresponds to the passport of the specialty and its content. The dissertation and the results obtained are characterized by internal unity: the goals and objectives of the study are clearly formulated, and it is shown that each result is obtained when performing a specific task and serves to achieve the set goal of the study. All results are logically interconnected, that is, they are achieved consistently and are necessary. The logic is clearly traced, reflecting the unity of the theoretical constructions of the dissertation and the practical results of the work.

#### **6. Personal participation of the author in obtaining the results presented in the dissertation.**

The results of the scientific research presented in the dissertation were carried out by the author independently. It should also be noted that part of the research and production and technological data were implemented and received at LLP "Petroecocenter-logistics" by Keribayeva T. B. were personally performed: problem statement, formulation of research objectives, development of software for the management and decision-making system, planning and implementation of experimental and computer experiments, development of recommendations for the implementation of research results obtained personally by the author of the dissertation.

#### **7. The relevance of the obtained results to the solution of the corresponding problem of theoretical and practical significance.**

The totality of income in the work of theoretical and experimental results allows us to solve the actual problem of effective management of the quality of control of unmanned aerial vehicles. To calculate the assessment and forecasting of risks within the framework of a Smart object at the design and operation stage, a special mathematical and algorithmic control of the provision has been developed. Practical accuracy of results in achieving control efficiency in the field of control of unmanned aerial vehicles using SMART technologies, taking into account parameters and functional uncertainty.

**Confirmation of the completeness of the publication of the main provisions, results findings and conclusions of the dissertation.**

According to the results of dissertation research, Keribayeva T.B. 15 papers were published, including: 11 articles published in scientific magazine, including 2 articles published in a foreign magazine, which is included in the Scopus database, 5 articles published in proceedings of international scientific conferences, 3 articles in magazine recommended by the Control Committee in the field of education and science of the Ministry of Education and Science of the Republic of Kazakhstan.

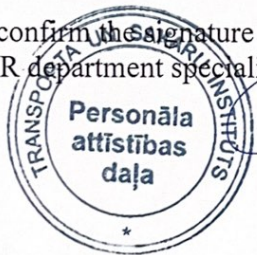
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03.10.2022

I confirm the signature of A. Medvedev  
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*Ilze Duncāne*  
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