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Mathematical Model of The Implementation Process of Flight Task of Unmanned Aerial Vehicle in The Conditions of External Impact

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ABSTRACT

The method of mathematical formalization of technical processes using the graph approach of GERT-structures is investigated. It was determined that for mathematical modeling of the process of performing a UAV flight task in the conditions of external influences, it is advisable to use a stochastic GERT-network structure. The main features, advantages and disadvantages of mathematical GERT-modeling are considered. This approach allows defining arbitrary functions and probability density distributions of random variables under conditions of uncertainty of these characteristics for the system as a whole. The division of the flight process of the UAV into stages with expert evaluation of the input data at each of the stages made it possible to determine the distribution function of the random variable of the execution time of the flight task of the UAV under external influences.

A GERT-network for the performance of a UAV flight mission under external conditions is presented. Taking into account a number of the most important components of the flight task implementation process allowed to bring the prototype of the process in question as close as possible to the actual conditions for the performance of the task set by the UAV and to improve the accuracy of the simulation results.

Solved the problem of the mathematical formalization of the Gert network for the performance of a UAV flight mission under external conditions. The results of the formalization of the steel are the expressions for calculating the density and the distribution function of the random variable of the execution time of the UAV task.

The analysis and research of the obtained results of modeling. It was revealed that the practical value of the developed model is the ability to predict the process of performing the flight task of the UAV, based on the given characteristics of external influences (intensity, probability, etc.).

The results obtained allow for a more in-depth analysis of the individual stages of the flight task, and are designed to help improve the quality and efficiency of UAV control under external conditions.

Key words: unmanned aerial vehicles, cyber-attacks, mathematical model, GERT-network, autonomous flight mode.

1. INTRODUCTION

Now the pilotless aircraft is one of the most perspective directions in aviation. So according to the analytical company Teal Group, till 2020, the size of the market of unmanned aerial vehicles (UAVs) will grow to 15.1 billion US dollars [1] [23]. At the same time the increase in productivity and decrease in the sizes of the microprocessor equipment, use of perspective telecommunication tools gives the chance to pilotless development acceleration complexes and expansion spheres and industries of their use. At the same time, increase in demand for the UAV and also their use in a number of difficult and important tasks, both in civil, and in military spheres, significantly increases interest in these technical complexes by malefactors. Especially cases of cyber-attacks of active spoofing (interception of management) became frequent. This fact once again confirms need of improvement UAV protection systems.

It is necessary to notice that works in this direction are conducted, and there is a number of the productive offers directed to minimize losses of spoofing cyber-attacks. However, these works have local character, and affect the solution only of a private problem of reflection of cyber-attack. At the same time formal problem definition demands an integrated approach in the UAV's flight task solution. It's included: performance of a task in the stationary (normal) mode; solution to the problem of intellectual recognition of potential external impacts; introduction of autonomous positioning in space algorithms, etc.

To solve such complex of difficult tasks, high-quality mathematical formalization and effective information support of developers becomes one of important factors.