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# METHOD OF ADAPTIVE COMPONENT-BASED DESIGN OF UNMANNED AERIAL VEHICLES SUITABLE FOR MILITARY MISSIONS

*The dynamic evolution of hybrid warfare conditions has led to the emergence and large-scale deployment of a new technological instrument of war – UAV swarms. This trend has created a variety of military application domains for UAVs, including strike, reconnaissance, decoy drones, and others. Designing new UAVs from scratch is time-consuming, which poses a critical challenge under wartime conditions. Therefore, it is **relevant** to conduct research into modern design methods capable of ensuring the rapid development of new UAVs through the adaptation of existing baseline components for constructing the required UAV system architecture in the chosen direction of military application. This study focuses on a set of models aimed at accelerating UAV development projects by adapting baseline components. The **key objectives** include: conducting a systems analysis of project activities required for adapting UAV architecture to new military applications; justifying the selection of UAV design alternatives suitable for a new component-based architecture; assembling a development team capable of designing a new UAV for specific purposes within a short timeframe; and modeling the sequence of project activities required to adapt UAV component-based architecture to emerging military operational requirements. The research utilizes a range of **mathematical methods and models**, including: systems analysis for adaptive project activities related to UAV development; component-based UAV design method; lexicographic ordering for ranking design alternatives; expert evaluation techniques for identifying the most rational UAV configuration; targeted search method for optimal developer team formation using integer (Boolean) programming; and simulation modeling to plan the sequence of project activities for adapting UAV component architectures to new military applications. The following **results** were achieved**:** a systems-based representation of UAV project activities using a component-oriented approach was developed; the selection of a rational UAV architecture adapted to new military requirements was substantiated; a qualified development team capable of rapidly executing a UAV design project has been selected, with consideration of design-related risks; and a multi-agent model has been developed to facilitate planning of project activities aimed at adapting the UAV's component architecture tailored to specific mission profiles. **Conclusions:** the findings of this study provide a scientific foundation for developing modern component-based UAV architectures for a variety of military applications; it ensures rapid execution of adaptation projects for existing UAV architectures to meet new application requirements and supports the formation of competent development teams under time and risk constraints. This contributes to improved military defense capabilities on the battlefield. The **scientific novelty** of the proposed approach lies in the creation of an adaptive design methodology grounded in the component-oriented paradigm. This enables the creation of new UAVs through the adaptation of existing architectures for specific military purposes and the formation of a development team capable of fast project execution in wartime conditions.*

***Keywords:*** *UAV component adaptation; component-based architecture; rational design selection; lexicographic ordering; expert evaluation; development team formation; multi-agent modeling, project activities.*

## 1. Introduction

Modern warfare has led to the emergence of technological innovations that have transformed the architecture of military operations on the battlefield [1, 2]. The introduction of various types of UAVs with different purposes – reconnaissance drones, strike drones, interceptor drones, and others – which are integrated into drone swarms to perform military tasks, enables improvements in operational and tactical actions and establishes a new level of offensive missions through the use of successive waves of strike drone swarms [3, 4]. However, this requires the adaptation of existing UAVs to the new conditions of military deployment in contemporary hybrid warfare. This brings forth critical challenges related to the development of UAV architectures capable of functioning effectively under new military circumstances [5, 6]. Consequently, there is an urgent task to reduce the development cycle of new UAVs under constraints of time and cost.

### 1.1. Motivation

To dislodge the enemy from frontline positions, it is necessary to create a kill zone by forming an aerial shield on the battlefield using a drone swarm [7, 8]. This gives rise to a multitude of functional and control tasks that UAVs must be capable of performing, such as swarm formation, division into combat groups, swarm flight management, coordination, synchronization of movements, and more [9, 10]. The range of existing tasks continues to expand and requires the implementation of new hardware and software solutions for drone operation under dynamically changing military conditions [11, 12]. There is a growing need to integrate technological innovations and explore new architectural solutions to ensure successful UAV adaptation to changing operational requirements. The compression of the R&D–pre-production–mass production cycle must be carried out under the conditions of modern warfare. Structuring the UAV architecture as a set of components – relatively isolated elements with clearly defined and standardized interconnections – will enable the creation of diverse structural configurations by recombining these elements, allowing for the rapid development of new drones tailored to emerging operational applications [13, 14]. This work addresses the urgent task of modeling new architectural solutions for the effective deployment of drones in military missions.

### 1.2. State of the Art and problem statement

There are a number of challenges associated with planning project activities aimed at identifying new design solutions for UAV development under the dynamically changing military conditions on the battlefield. Some of these challenges have been partially addressed, but new ones continue to emerge and must be considered to ensure the effective development of UAVs using innovative design approaches:

1. The use of novel design approaches that enable the reduction of UAV development cycles [15, 16].
2. The necessity for rapid adaptation of existing architectural solutions in response to technological innovations of modern warfare (digital technologies, intelligent design, 3D printing, etc.) [17, 18].
3. Time and cost constraints in UAV development under current wartime conditions [19, 20].
4. The problem of the rapidly expanding functional scope of UAV applications (strike drones, reconnaissance drones, etc.) [21, 22].
5. The presence of a large number of manufacturers employing diverse design methodologies for UAVs [23, 24].
6. The lack of unified software capable of fully supporting the automation of project activities related to the development of new UAVs [25, 26].
7. Difficulties in supplying the required components for UAV production in the necessary quantities [27, 28].
8. The absence of sufficient experience among developers in designing UAVs for various military applications [29, 30].

This list is not exhaustive, as new challenges continue to emerge in the context of modern hybrid warfare. It underscores the urgency of developing new approaches to the design of UAVs intended for a wide range of military missions.

The analysis of publications addressing the aforementioned set of challenges highlights the complexity of UAV development and the urgent need to find new solutions for the rapid adaptation of existing UAVs to evolving use cases in the context of modern warfare. This necessitates further research aimed at establishing new design approaches that will enable the reduction of UAV development cycles.

This publication presents potential solutions to a subset of these challenges, including:

− a systematic rationale for project activities related to the adaptation of UAV architecture to new battlefield conditions;
− the development of a set of potential design solutions for the creation of new UAVs;
− optimization of time and cost in project activities to enable rapid UAV development;
− the development of simulation models for planning project activities aimed at adapting UAV structures to new directions of military deployment.

The study conducts a systematic formulation of adaptation-oriented project activities for the development of a new component-based UAV architecture. Structural analysis is applied to generate a range of alternative UAV architecture configurations in order to identify the optimal one for a given project. Expert qualitative assessments provided by military professionals are used to guide the selection of appropriate architectural solutions. UAV development options are ranked to identify those best suited to specific project objectives. An integer (Boolean) programming method is employed to determine the composition of the development team. A simulation model is developed to analyze the timeline of project activities involved in creating a new UAV.

The application of these methods makes it possible to develop UAVs for new missions by adapting component-based architectures to the changing requirements of military operations.

### 1.3. Objectives and methodology

A contradiction arises between the urgent need to rapidly integrate new technological innovations into UAV architectural solutions for military missions and the inadequacy of existing methods, as well as the absence of models that would enable the development of

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drones for various military applications through the adaptation of component-based UAV architectures.

The objective of this study is to develop a set of mathematical and simulation models that support the planning of project activities aimed at adapting existing UAV architectures to changing conditions of military deployment.

To achieve this objective, the following research tasks must be addressed:

1. Conduct a system analysis of the measures required to plan project activities related to the adaptation of existing UAV architecture to new operational conditions.
2. Generate a set of potential adaptation scenarios for UAVs based on the component representation of the system's architecture.
3. Develop an optimization model for selecting an appropriate team of developers for the design and adaptation of a new UAV.
4. Create a simulation model for analyzing and planning project activities focused on adapting UAV architecture for a new direction in military deployment.

The structure of the article is organized as follows:

Section 2 is devoted to a system-level analysis of project activities for adapting UAV architecture to new operational applications.

Section 3 presents a structural analysis of the component-based UAV architecture aimed at its improvement.

Section 4 focuses on the formation of a development team responsible for adapting the UAV component architecture.

Section 5 is dedicated to the modeling of the sequence of project activities for adapting the component UAV architecture.

Section 6 discusses the scientific results and presents them as a methodology, emphasizing the practical significance of the conducted research.

Section 7 concludes the article by summarizing the findings and outlining prospects for future research and the development of an applied information technology solution.

## 2. System analysis of activities required for planning project activities aimed at adapting existing UAV architectures to new operational conditions

The use of UAVs in modern warfare has led to a transformation in the architecture of combat operations. The systematic deployment of drones enables the formation of an active aerial defense shield, as well as the execution of wave-based swarm attacks, thereby enhancing the combat effectiveness of troops on the battlefield. Contemporary drones are capable of striking enemy targets not only near the front line but also deep within operational territory. This allows for the expansion of the Kill Zone, which prevents the enemy from advancing due to the increased risk of destruction. Strikes using various types of drones have become one of the key tactics for dislodging enemy forces from occupied positions. The diversity of drone types (reconnaissance, strike, decoy, etc.) used in different military roles has grown significantly and now plays a crucial role in supporting infantry on the battlefield. The dynamic nature of changing combat conditions necessitates the development of new drones with characteristics that allow them to adapt to new operational contexts. However, designing these systems from scratch does not allow for the rapid deployment of urgently needed units.

One of the modern design approaches involves representing UAV architecture as a component-based structure. In this approach, a foundational set of components is created and continuously expanded. These components can be recombined in various ways to construct new architectures suited to emerging military applications. By minimizing the need to develop new components from scratch, and instead adapting existing ones, structural solutions for new UAVs can be formed. This significantly shortens the development cycle and accelerates the transition to serial production. Consequently, there is a critical need to adopt component-based design methodologies in response to the dynamic shifts in combat requirements. Adapting existing components for new UAV architectures requires the formation of a new system design strategy based on a component-based structural representation. A set of systematic actions is proposed for creating a component-based UAV architecture tailored to emerging military applications (e.g., wave-based swarm drone attacks). A key stage in this process is the formation of a comprehensive base of components, which will subsequently be used to generate various architectural configurations. To this end, a database of existing UAV designs should be established, and the components of these systems must be standardized for use in adaptation-focused design activities. A team of developers is tasked with expanding the set of base components when certain elements are missing from a new project. Another team, oriented toward a specific UAV development project, adapts the architecture using the existing component set. These teams aim to accelerate project execution through the efficient adaptation of base components. Planning the sequence of developer actions in new projects is essential for ensuring the success of UAV development initiatives. The systematic representation of the UAV design process using a component-based approach includes:

1. Development of a component-based UAV architecture using a base set of components.
2. Identification of potential adaptation measures for adjusting the component-based architecture to new usage scenarios.
3. Selection of rational configurations for UAV creation by adapting base components.
4. Formation of a development team that ensures the rapid execution of the UAV project.
5. Planning of the project activity sequence for creating the new UAV component architecture.

This list of design activities related to the adaptation of UAV component architectures is not exhaustive and may be expanded to meet evolving military needs in modern warfare.

The methods and models explored in this study can also be applied to the development of other types of military technology, such as electronic warfare systems, air defense systems, and missile technology. This ensures rapid project execution under wartime conditions.

In summary, this section presents a system-level analysis of design activities using a component-based approach that enables the adaptation of existing UAV structures to new military roles. The subsequent sections of this publication will focus on the development of models that ensure the timely execution of UAV projects tailored to emerging military applications in modern warfare.

## 3. Generation of a set of possible UAV adaptation variants based on component representation of the system architecture

The use UAVs in various domains of military application necessitates rapid response to changing conditions of combat operations on the battlefield. This, in turn, demands the development of new functional and architectural solutions. The full-cycle development of new UAVs for each new application domain requires significant time and leads to increased project risks. The component-based approach enables the construction of UAV system architectures for new applications through the combination and integration of a set of relatively independent components. Components that do not fully meet the new operational requirements are subject to adaptation.

In this context, it is essential to analyze potential structural solutions within the project aimed at developing UAVs using a component-based system architecture. The component-based approach relies on two development teams. The first team is responsible for forming and expanding the base set of components. The second team develops the new UAV architecture by selecting and integrating components from the base set that are most suitable for the specific mission profile. Some of the selected components may require adaptation to meet the specifications outlined in the technical requirements for the new UAV.

Let us perform a multi-option analysis of the component-based UAV architecture, accounting for the potential adaptation of its components. For illustrative purposes, consider the following base set of four components used in UAV construction:

1. Airframe;
2. Avionics;
3. Payload;
4. Control system.

The complete set of variants for conducting possible adaptation activities for a new direction of UAV application can be obtained using a binary counter. ($n=4$, $K=2^n=16$):

| | | |
|---|---|---|
| 1. 0000 | 9. 1000 | |
| 2. 0001 | 10. 1001 | |
| 3. 0010 | 11. 1010 | |
| 4. 0011 | 12. 1011 | (1) |
| 5. 0100 | 13. 1100 | |
| 6. 0101 | 14. 1101 | |
| 7. 0110 | 15. 1110 | |
| 8. 0111 | 16. 1111. | |

Let us define the component structure of the UAV architecture as follows: the first position corresponds to the airframe, the second to avionics, the third to payload, and the fourth to the control system. In this context, a "0" indicates the use of a baseline component in the new UAV without any modifications, while a "1" denotes the need for adaptation of the baseline component to meet new operational requirements. For example, variant 7 implies that adaptation is required for the avionics and payload components to align with the new application conditions of the UAV. The airframe and control system can be utilized in their baseline configurations without modification.

We shall conduct an analysis of all feasible adaptation variants of the component architecture for a new military application (e.g., a strike UAV). Let us assume that a technical specification (TS) assessment has been conducted by military experts for the design of the new UAV. It is necessary to analyze potential adaptation scenarios using the following evaluation criteria:

1. Proximity of the UAV design variant to the new operational requirements defined in the TS – P.
2. Time required to complete adaptation-related project activities for the new UAV – T.
3. Risk associated with executing the UAV development project involving adaptation activities – R.
4. Cost of designing the new UAV – W.

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To facilitate qualitative assessment (convenient for military experts), we introduce a linguistic variable zik to represent the values of the evaluation criteria. Here, the subscript «i» denotes the i-th possible adaptation variant of the UAV, while «k» corresponds to the k-th evaluation criterion. The qualitative values of the criteria will be expressed using letters of the Latin alphabet:

$$z_{ik} = \begin{cases} \text{A – high rating;} \\ \text{B – good rating;} \\ \text{C – satisfactory rating;} \\ \text{D – low rating.} \end{cases} \quad (2)$$

It is also necessary to account for the priority of the evaluation criteria when assessing potential adaptation variants of the UAV component architecture for new military operational conditions. Let us assume the following order of importance: in first place is proximity to operational requirements (P); in second place is time (T), which is critical for the rapid development of UAVs; third is the project risk (R); and fourth is the design cost **(**W). In the illustrated example, we consider four baseline components (n=4). Let us suppose that, for the military, the **payload** is of utmost importance in the development of a strike UAV, along with the associated **modification of the airframe**.

Military experts provided the following assessments for the possible adaptation variants of the UAV component architecture:

| | | |
|---|---|---|
| 1. DADA | 9. BABA | |
| 2. DADB | 10. BBCB | |
| 3. BABA | 11. ABAB | |
| 4. BBBB | 12. ACAC | (3) |
| 5. DADA | 13. BBBC | |
| 6. DBDB | 14. BCCC | |
| 7. BBBC | 15. ACCC | |
| 8. BCBC | 16. ADAD. | |

In the resulting set of variants, based on expert military assessments of the indicators (P, T, R, W), there exist options with very low evaluation scores (denoted as D). These variants will be excluded from further consideration as non-promising. Thus, a reduced list of viable UAV design options for the development of a strike drone, using component adaptation, is obtained:

| | | |
|---|---|---|
| 3. BABA | 11. ABAB | |
| 4. BBBB | 12. ACAC | (4) |
| 7. BBBC | 13. BBBC | |
| 8. BCBC | 14. BCCC | |
| 9. BABA | 15. ACCC. | |
| 10. BBCB | | |

To identify the UAV design options with the best indicator evaluations (P, T, R, W), we will apply the lexicographic ordering method, similar to how words are arranged in a dictionary.

As a result, we obtain:

| | | |
|---|---|---|
| 11. ABAB | 7. BBBC | |
| 12. ACAC | 13. BBBC | |
| 15. ACCC | 10. BBCB | (5) |
| 3. BABA | 8. BCBC | |
| 9. BABA | 14. BCCC. | |
| 4. BBBB | | |

Here, three options (11, 12, and 15) demonstrate the highest proximity evaluations (P) to the requirements outlined in the technical specification for designing a strike UAV. Therefore, these options can be utilized for conducting project activities aimed at adapting the component architecture of the UAV to operational conditions as a strike drone. The most favorable is option 11, which is characterized by the following:

A – highest proximity to the project's technical requirements;

B – project duration evaluated as “good”;

A – minimal project risk;

B – project cost evaluated as “good”.

Thus, in this section, the task of analyzing possible variants for conducting adaptation activities has been posed and solved, aimed at forming a suitable component architecture of the UAV system. The use of the component-based design approach is substantiated, as it enables the rapid development of the required UAV structure for a new purpose through the adaptation of existing basic components. A set of evaluation indicators for adaptation options was established based on military expert assessments. A set of tuples with qualitative evaluations of the indicators was generated and lexicographically ordered to select the most suitable options for adapting the UAV's component architecture.

## 4. Development of an optimization model for selecting the appropriate development team for a new UAV

To carry out the development of an UAV suitable for new military operational conditions, it is necessary to form a team of developers capable of performing the required project activities aimed at enhancing the component architecture of the UAV. Given that these activities must be completed rapidly and under wartime constraints, the formation of the development team must satisfy the following criteria:

1. Time (T) – the time required to perform project activities for adapting the UAV's component architecture to new operational requirements – T.

2. Risk (R) – the risk associated with the successful completion of the project.

3. Cost (V) – the financial cost of carrying out the project activities.

Depending on the complexity and novelty of the project activities, the formation of the development team may involve several project groups. Therefore, for the adaptation of the j- th component of the UAV system, it is possible to assign from one to $m_j$ developers. The total number of possible combinations for the team composition will be:

$$K = 2^{m_j} - 1. \tag{6}$$

This leads to the problem of selecting a rational composition of the development team, taking into account the values of the indicators (T, R, V). To solve this problem, we will apply integer (Boolean) programming, which enables a targeted search for optimal solutions from a set of alternative options in various application domains. We introduce a Boolean variable $x_{jk}$, which takes the following values:

$$x_{jk} = \begin{cases} 1, \text{ if the adaptation of the} \\ \quad j-\text{th component is performed} \\ \quad \text{by the } k-\text{th development teamj;} \\ 0, \text{ in another case.} \end{cases} \tag{7}$$

Then, for the adaptation of the j-th component to new military application conditions, taking into account the Boolean variable $x_{jk}$, the indicators will be represented as follows:

$$\begin{aligned} T_j &= \sum_{k=1}^{2^{m_j}-1} t_{jk} x_{jk}, \\ R_j &= \sum_{k=1}^{2^{m_j}-1} r_{jk} x_{jk}, \\ V_j &= \sum_{k=1}^{2^{m_j}-1} v_{jk} x_{jk}, \end{aligned} \tag{8}$$

where $t_{jk}$ – the time required to perform the adaptation work on the j-th component of the UAV system by the potential k-th development team;

$r_{jk}$ – the risk of successful execution of the adaptation work on the j-th UAV component by the k-th development team;

$v_{jk}$ – the cost of project activities for adapting the j-th UAV component by the k-th development team.

Let M denote the total number of basic components of the UAV architecture that are subject to adaptation (as discussed in Section 3).

Then, the overall indicators (T, R, V) can be expressed as:

$$\begin{aligned} T &= \sum_{j=1}^{M} \sum_{k=1}^{2^{m_j}-1} t_{jk} x_{jk}, \\ R &= \sum_{j=1}^{M} \sum_{k=1}^{2^{m_j}-1} r_{jk} x_{jk}, \\ V &= \sum_{j=1}^{M} \sum_{k=1}^{2^{m_j}-1} v_{jk} x_{jk}. \end{aligned} \tag{9}$$

To ensure the rapid execution of adaptation activities for the UAV system architecture components under new military operational conditions, it is necessary to achieve minT:

$$\min T, T = \sum_{j=1}^{M} \sum_{k=1}^{2^{m_j}-1} t_{jk} x_{jk}. \tag{10}$$

It is necessary to take into account the constraints related to acceptable risk levels and the cost of performing the project activities:

$$\begin{aligned} R \le R', R &= \sum_{j=1}^{M} \sum_{k=1}^{2^{m_j}-1} r_{jk} x_{jk}, \\ V \le V', V &= \sum_{j=1}^{M} \sum_{k=1}^{2^{m_j}-1} v_{jk} x_{jk}, \end{aligned} \tag{11}$$

where $R', V'$ – the acceptable levels of risk and cost for conducting the project activities.

Thus, in this section, the task of forming a development team for a new UAV system through the adaptation of basic components to new military requirements has been formulated and solved. A targeted search for the optimal composition of the development team was conducted using the method of integer (Boolean) programming. The key indicators for selecting the appropriate team were established: time**,** risk, and cost. Given the necessity to ensure rapid execution of adaptation tasks for the creation of a new UAV architecture, time was selected as the primary criterion, which must be minimized in order to accelerate the development of the new UAV

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## 5. Simulation model for the analysis and planning of project activities related to the adaptation of UAV architecture for a new military purpose

The planning of a project aimed at adapting a UAV to new military operational conditions requires a comprehensive investigation of the entire sequence of project activities involved in developing the system. It is essential to consider that, due to wartime conditions, the development of the UAV must be accomplished within a short timeframe. This creates an urgent need to analyze how to reduce the duration of project activities to ensure the timely delivery of UAVs to military units. Therefore, a dynamic analysis of the activities related to the adaptation of the component architecture was conducted within the project framework for the development of a UAV for a new application. To support this, a simulation model in a multi-agent representation was developed using the AnyLogic platform. The model consists of the following agents:

1. Agent "Formation of component set".
2. Agent "Development of basic components".
3. Agent "Creation of component architecture".
4. Agent "Formation of expert evaluations".
5. Agent "Adaptation of basic components".
6. Agent "Selection of UAV adaptation variant".
7. Agent "Formation of development team".
8. Agent "Optimization of adaptation time".
9. Agent "Project risk assessment".
10. Agent "Simulation results".
11. Agent "Simulation management".

Figure 1 presents the structural diagram of the multi-agent model.

Let us briefly consider the sequence of actions for conducting simulation modeling. Initially, a set of components is formed as a database comprising existing UAV developments (Agent 1). Subsequently, the component architecture for the new UAV purpose is created (Agent 3). The next step involves generating a set of adaptation variants for the UAV component configuration. These options are then analyzed, and the most appropriate one is selected for the implementation of project activities (Agent 6). This selection process utilizes expert opinions from military specialists (Agent 4). Following this, the components requiring adaptation are identified (Agent 5). In cases where the development of new components is necessary within the UAV system, Agent 2 is engaged. The subsequent step involves the formation of the development team (Agent 7). The selection of developers is influenced by the need for rapid project execution (Agent 8), taking into account design-related risks (Agent 9). The final stage involves analyzing the simulation outcomes (Agent 10). The overall simulation process is coordinated through Agent 11.

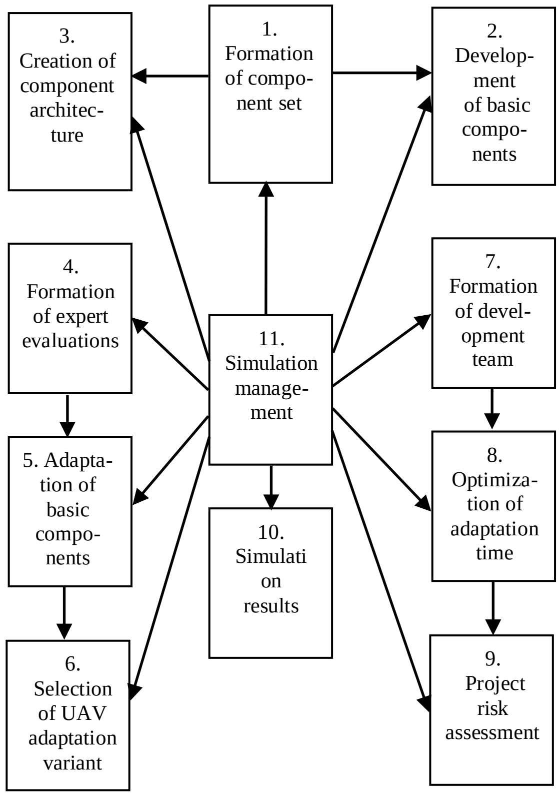


Fig. 1. The structural diagram of the multi-agent model

Key outcomes of the simulation include:

- total duration required to complete the UAV adaptation project for its new military application (e.g., the development of a strike drone);

- time required to design the new component architecture for the UAV;

- time allocated for adapting the existing basic components;

- time spent on developing new components;

- time required for forming the development team;

- the impact of risk factors on project execution.

Thus, this section addresses the task of creating a simulation model for temporal analysis of project activities related to the adaptation of the UAV component architecture to new military applications. A multi-agent model was developed using the AnyLogic platform. The simulation results facilitate efficient project planning for UAV adaptation in response to new military requirements. This approach ensures the timely execution of UAV development projects and supports the rapid deployment of effective UAV systems in the battlefield environment.

## 6. Discussion

A systematic representation of project activities aimed at adapting an unmanned aerial vehicle (UAV) system to new military applications (strike drones, anti-air drones, swarm drones, etc.) has been developed. To enhance the efficiency of the design process, a component-based approach was employed, enabling rapid formation of a new UAV architecture through the selection and combination of appropriate components from a set of foundational modules. Key components requiring adaptation to meet new operational demands were identified using expert evaluations. A set of adaptation options for the UAV component architecture was generated, considering criteria such as proximity, time, risks, and costs. The selection of appropriate adaptation options was carried out using qualitative assessments provided by military experts, combined with lexicographic ordering of alternatives. The task of forming a development team for implementing the UAV adaptation project for a new application domain was addressed. The team was selected based on their capacity to rapidly implement the project – an essential consideration under conditions of martial law Simulation modeling was applied to analyze the timeline of design activities related to adapting the UAV system for a new mission profile.

The proposed research methodology includes the following key stages:

1. System-level representation of developer activities for adapting the UAV's component-based architecture to new military applications.
2. Construction of a component-based UAV architecture derived from a set of foundational components.
3. Selection of the optimal adaptation scenario for the UAV's component-based architecture.
4. Formation of a development team to ensure timely project execution.
5. Time-scaled modeling of design activities related to the adaptation and development of a new UAV.

The relevance of the proposed approach lies in the urgent need to accelerate the development of new UAV systems tailored for emerging military tasks.

A comprehensive model set has been developed, enabling effective planning of UAV architecture adaptation projects. This set facilitates rapid project execution through the application of modern component-based design strategies. Consequently, the proposed approach is deemed both timely and effective for the development of UAVs with diverse military applications.

Future research will focus on improving the applied information technology for modeling project activities related to the rapid adaptation of the UAV component architecture to new application domains, which will enhance the combat effectiveness of military forces on the battlefield.

## 7. Conclusions

The conducted research enables the planning of project activities aimed at adapting the component architecture of a UAV system for use in a new military application domain, specifically:

1. To establish an adaptive-component approach for designing a new UAV.
2. To develop the architecture of a new UAV using a component-based representation.
3. To justify the set of components requiring adaptation for deployment in a new operational context.
4. To select a rational option for implementing adaptation actions within the UAV's component architecture to create a new system.
5. To form a UAV development team capable of rapid project execution.
6. To carry out the planning of adaptation-related project activities using simulation modeling.

The scientific novelty of the research lies in the development of an adaptive design methodology based on a component-oriented approach. This enables the creation of new UAVs through the adaptation of existing architectures to specific military purposes and facilitates the formation of a development team capable of ensuring fast project implementation under wartime conditions.

Thus, the main contribution of this research can be summarized as follows:

The proposed model set provides a scientifically grounded framework for planning project activities aimed at adapting the UAV component architecture to new military application areas. It ensures effective project execution while accounting for potential risks. This approach guarantees rapid development of new UAV systems in the context of dynamic changes in battlefield conditions and enhances the effectiveness of defense operations.

**Contribution of authors**: system analysis of the UAV adaptation process to a new application direction – **Oleg Fedorovich**; formation of the UAV component architecture – **Leonid Malieiev;** optimization of UAV structural solutions – **Yevhenii Polishchuk**; modeling of project activities – **Tetyana Pisklova**.

### Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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## Data availability

The manuscript has no associated data.

## Use of Artificial Intelligence

The authors confirm that they did not use artificial intelligence methods while creating the presented work.

All authors have read and approved the published version of this manuscript.

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## МЕТОД АДАПТАЦІЙНОГО КОМПОНЕНТНОГО ПРОЄКТУВАННЯ БЕЗПІЛОТНИХ ЛІТАЛЬНИХ АПАРАТІВ, ПРИДАТНИХ ДО ВИКОРИСТАННЯ У ВІЙСЬКОВИХ МІСІЯХ

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Динамічна зміна умов проведення гібридної війни призвела до створення та масштабного використання нового технологічного інструменту війни у вигляді рою БПЛА. Виникли різні напрями військового застосування БПЛА (ударні дрони, дрони-розвідники, дрони-імітатори, тощо). Проєктування, з нуля, нових дронів потребує немалого часу, що є критичним в умовах військового стану. Тому, **актуальне** проведення дослідження у використанні сучасних методів проєктування, які зможуть забезпечити швидкість створення нових БПЛА, шляхом адаптації існуючої множини базових компонент щодо формування потрібної архітектури

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комплексу БПЛА, у обраному напрямку військового застосування. **Предметом** дослідження є комплекс моделей, за допомогою якого можна забезпечити швидкість виконання проєкту створення БПЛА, на основі адаптації базових компонент. **Завдання,** які необхідно вирішити: системний аналіз проєктних дій щодо адаптації архітектури БПЛА до нового напрямку військового призначення; обґрунтування вибору варіантів проєктування БПЛА, для проведення адаптаційних дій щодо створення нової компонентної архітектури; формування команди розробників, спроможних, за короткий час, розробити БПЛА нового призначення; моделювання послідовності проєктних дій щодо адаптації компонентної архітектури БПЛА для нових військових умов застосування. Використані **математичні методи та моделі**: системний аналіз щодо проведення адаптаційних проєктних дій зі створення нового БПЛА; метод компонентного проєктування БПЛА; метод лексикографічного впорядковування варіантів; використання експертних оцінок, для вибору раціонального варіанту проєктування БПЛА; метод цілеспрямованого пошуку оптимальних рішень щодо створення команди розробників БПЛА, з використанням цілочисельного (булевого ) програмування; метод імітаційного моделювання для планування послідовності проєктних дій щодо адаптації компонентної архітектури БПЛА до нового напрямку військового призначення. Отримані наступні **результати:** запропоновано системне представлення проєктних заходів щодо створення БПЛА, з використанням компонентного підходу; обґрунтовано вибір раціонального варіанту архітектури БПЛА адаптованої до нових вимог військових; проведено вибір команди розробників БПЛА, спроможних швидко виконати проєкт створення нового БПЛА, з урахуванням ризиків проєктування; створена мультиагентна модель, яка дозволяє планувати проєктні дії щодо адаптації компонентної архітектури БПЛА до нового напрямку призначення. **Висновки:** результати проведеного дослідження дозволяють науково обґрунтувати створення сучасної компонентної архітектури БПЛА різного призначення; забезпечити швидкість виконання проєкту адаптації існуючої компонентної архітектури БПЛА до нового напрямку застосування; сформувати потрібну команду розробників до створення БПЛА в умовах обмежень, за часом, та ризиків проєктування. Це дозволить підвищити обороноздатність військових на полі бою. **Наукова новизна** запропонованого підходу пов’язана зі створенням адаптаційного методу проєктування з використанням компонентного підходу, що дозволить розробляти нові БПЛА шляхом адаптації існуючої архітектури до потрібного напрямку військового призначення, сформувати команду розробників для забезпечення швидкості виконання проєкту в умовах воєнного стану.

**Ключові слова:** адаптація компонент БПЛА до нового напрямку застосування; компонентна архітектура БПЛА; вибір раціонального варіанту проєктування; лексикографічне впорядковування варіантів; експертне оцінювання; створення команди розробників; мультиагентне моделювання проєктних дій.

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