# Abstract

## Intelligent Scheduling of UAV Mission Tasks Using Algebraic-Logical Meta - Modeling under Dynamic Operational Constraints

This dissertation addresses the problem of intelligent scheduling of logistics tasks performed by a fleet of Unmanned Aerial Vehicles (UAVs) operating under conditions of dynamically changing airspace availability, temporal and spatial constraints, and operational disruptions affecting resource availability and task feasibility. The considered problem belongs to the class of complex dynamic and multi-constrained decision-making problems, for which existing optimization and heuristic approaches exhibit limited adaptability in environments requiring near real-time decision making.

The main objective of the dissertation was to develop a formal modelling framework and adaptive control methods for UAV task scheduling processes, enabling both the generation and dynamic reconfiguration of operational schedules under changing environmental and resource constraints. To achieve this objective, an original formalism based on Algebraic-Logical Meta-Modeling (ALMM) was proposed. The formalism enables the representation of the scheduling process as a discrete multi-stage decision-making process with explicitly defined states, decisions, transition functions, and admissibility constraints.

A significant scientific contribution of the dissertation is the development of a cascade of algebraic-logical models enabling the modelling and dynamic reconfiguration of UAV fleet scheduling processes under conditions of varying resource and airspace availability. The proposed structure comprises a base scheduling model and its successive extensions incorporating time-slot allocation mechanisms, shared air corridor management, time-window constraints, and dynamic schedule reconfiguration in response to operational disruptions occurring during mission execution. The resulting modelling architecture ensures formal consistency of the decision-making process while preserving modularity and scalability.

Based on the developed formalism, a set of algorithms was designed for schedule generation, state trajectory construction, and local re-optimization. The proposed mechanisms enable adaptive reconfiguration of the future segment of a schedule without the need to recompute the entire global plan. This approach significantly reduces the computational cost of reconfiguration and enables the application of the developed solution in online decision-support systems.

The proposed approach was validated both in a simulation environment and under conditions closely resembling real-world operations. Experimental studies included scenarios involving limited availability of air corridors, UAV failures, task cancellations, and the dynamic arrival of new logistics requests. The obtained results confirmed the ability of the proposed approach to preserve the formal correctness of the scheduling process, adapt effectively to changing operational conditions, and maintain a high level of task execution efficiency.

A comparative analysis against representative methods reported in the literature demonstrated that the proposed approach achieves scheduling performance comparable to classical optimization, metaheuristic, and hybrid methods while providing significantly shorter response times to operational disruptions and full interpretability of the decision-making process.

The obtained results confirm the dissertation thesis that Algebraic-Logical Meta-Modeling constitutes an effective formal foundation for modelling and adaptive scheduling of UAV fleet operations under conditions of dynamically changing airspace and resource availability. The developed solution provides an original contribution to the field of intelligent decision-support systems for autonomous transportation systems and extends the application domain of ALMM technology to dynamic scheduling and decision-process reconfiguration problems. The presented results may serve as a foundation for future research concerning the integration of the proposed formalism with UTM/ATM systems, disruption prediction mechanisms, and multi-agent system architectures.