MS-E2177 - Seminar on Case Studies in Operations Research

Cost-Efficient Defence Against Unmanned Aerial Systems

Project Plan

Case Group Patria

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1 Background

The rapid development of unmanned aerial systems (UAS) has transformed modern warfare and security dynamics. The use of commercial drones in modern warfare has led to an asymmetric situation where these threats can inflict damage on high-value military targets. This cost imbalance necessitates the development of countermeasures that provide effective defense while maintaining economic viability.

In this setting, our client Patria is interested in exploring cost-effective defense solutions against unmanned aerial systems, considering the Finnish operational environment. The Finnish environment poses unique opportunities and constraints due to it is four-season climate, dense forests, and vast, sparsely populated areas. The aim of this project is to identify balanced countermeasures that optimize spatial coverage, resource allocation, and operational effectiveness, particularly against tactical-level threats such as small drones with limited range and payload.

Patria is a government-owned Finnish defense, security, and aviation company specializing in armored vehicles, weapon systems, and aerospace solutions. It provides advanced defense technology, life-cycle support, and training services for military and security forces worldwide.

2 Objectives

The central objective of this project is to identify cost-effective methods of protecting a company-sized troop against small drones. To achieve this, simulations of different defensive scenarios are created and ran.

3 Tasks

There are tasks that contribute to achieving the objectives. First tasks are to identify methods and tools of identification and elimination of threats. Next, the effectiveness and cost of these methods and tools are estimated. Validation for these estimates is provided by the professionals at Patria and literature. Last task is to build simulation models based on the validated estimates. First, a simple model with one protected target is built and after this a larger model with multiple targets is assembled using the simpler model. Furthermore, the results of the simulations are examined and conclusions are drawn.

4 Schedule

The schedule is in Figure 1. The grey blocks indicate key tasks of the project and the black blocks indicate the sub tasks needed to complete for each grey block above.

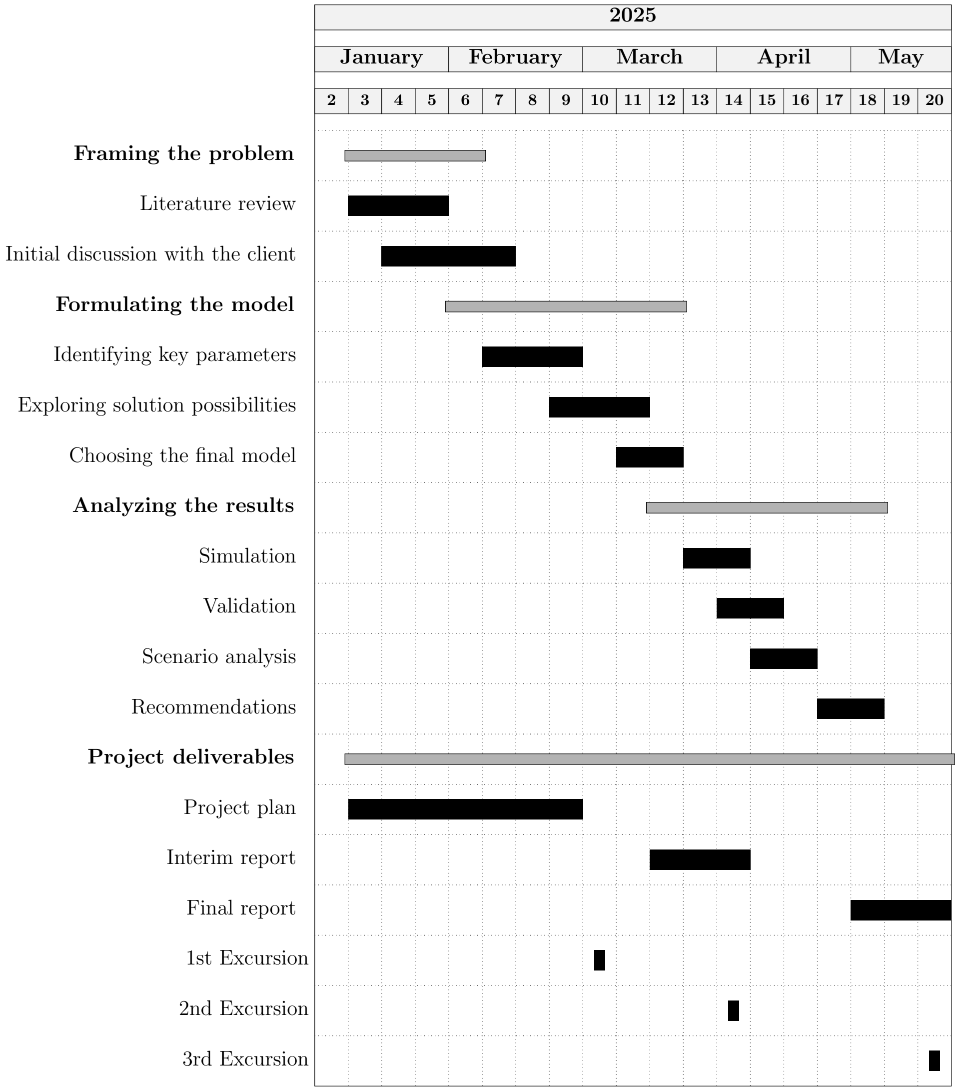

Figure 1: Initial project schedule.

5 Resources

The team consists of four M.Sc. students majoring in systems and operations research or applied mathematics. Our team has a solid background in mathematics and computer programming that are essential skills for completing the project. Our goal is to allocate tasks in a way that allows each member to leverage their strengths and areas of interest while contributing to the successful completion of this study. Regular meetings are held to ensure an even distribution of workload among team members.

We also have regular meetings with our client Patria to exchange ideas and get clarifications about the topic and data. Our main contact at Patria is Jarkko Tikka, and other experts from the client organization may be consulted for questions related to mathematical modeling and simulation. Furthermore, Professor Ahti Salo from Aalto University will provide guidance and monitor the project's progress.

The data required for cost-efficiency optimization, as well as some example scenarios will be provided by the client organization. For the simulations, Python is likely to be used due to its versatility and strong libraries for mathematical modeling and data analysis.

6 Risks

The main risks are presented in Table 1 below. For each risk, its likelihood, impact, effect and mitigation actions have been identified. The scale of likelihood and impact estimate is low, medium and high. Overall, most risks are unlikely and can be easily managed through our own actions.

Risk	**Likelihood**	**Impact**	**Effect**	**Mitigation**
Scope too broadly defined	Medium	High	The final model does not capture the problem.	Clearly define project scope with client early on. Regular scope reviews.
Communication challenges with the client	Low	High	Lack of feedback. End product may not meet client expectations.	Taking initiative in actively communicating. Regular meetings.
Overly complex mathematical model	Medium	High	Model may be computationally infeasible or difficult to interpret for decision-making.	Align the model complexity with project needs. Prioritize interpretability and feasibility.
Team member inactivity	Low	Medium	Project is not completed on time due to increased workload for other team members	Regular meetings. Good communication and scheduling of project tasks
Insufficient public data	Medium	Medium	Model does not accurately reflect cost-effectiveness in reality	Consulting the client about the assumptions. Using easily adjustable parameters
Unrealistic threat assumptions	Medium	High	The model may not simulate real-world UAV threats accurately.	Validate assumptions with the experts at the client organization. Use real-world data when possible.

Table 1: Risks associated with the project, along with their likelihood, impact, effects, and mitigation actions.