# MS-E2177 - Seminar on Case Studies in Operations Research, Assessment of design options for border control

Finnish Defence Research Agency - Project Group

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March 28, 2023

# Contents

# 1 Background

Our client, The Finnish Defence Research Agency, is a multidisciplinary research and development organisation that provides advanced research, development, testing, and evaluation services for defence. The Agency concentrates on strategy, military science, behavioral sciences, and several different technologies. The need for this project origins from Finland's desire to prepare for hybrid influence activities that exploit migration and increase border safety (Ministry of the Interior (2022)).

In this project, we assess the design options for border control to increase border safety. The border between Finland and Russia is mainly forest without major population centers. We focus on preventing illegal border crossing in these rural areas, where border control is currently scarce. In these areas, the options to increase border safety are for example, fences, sensor systems, patrols with different vehicles, aircrafts, and unmanned aerial vehicles (UAVs).

Base setting for our model comes from the Finnish geography near the Russian border. Figure 1, shows that highway 6 partly advances near the Russian border. This setting, where the highway is near the border, with no border crossing spots near, is the basic setting for our assessment. Moreover, we limit our model to include forest terrain solely.


**Figure 1:** Highway 6 in Finland.

## 2 Objectives

The main objective of the project is to provide analysis of cost effectiveness of different methods in border control and give suggestions for optimal portfolios for different budget levels. To achieve this, our goal is to simulate multiple border control scenarios with varying available resources, and estimate expected efficiency with the simulation results. Out of the different objective categories that were presented, the focus on our project will be on managing resources for countering state sponsored illegal border crossings of immigrants as a hybrid warfare tool.

A simplified illustration of the base scenario can be seen in figure 2. In the scenario, a number of immigrant groups will be shipped near the border of the target country. The immigrants cross the border and attempt to reach a larger main road. If they do, it is assumed that they have escaped the border control's reach. A border patrol attempts to catch and detain as many of the immigrant groups as possible before they reach the main road, utilizing all available information that is gathered.

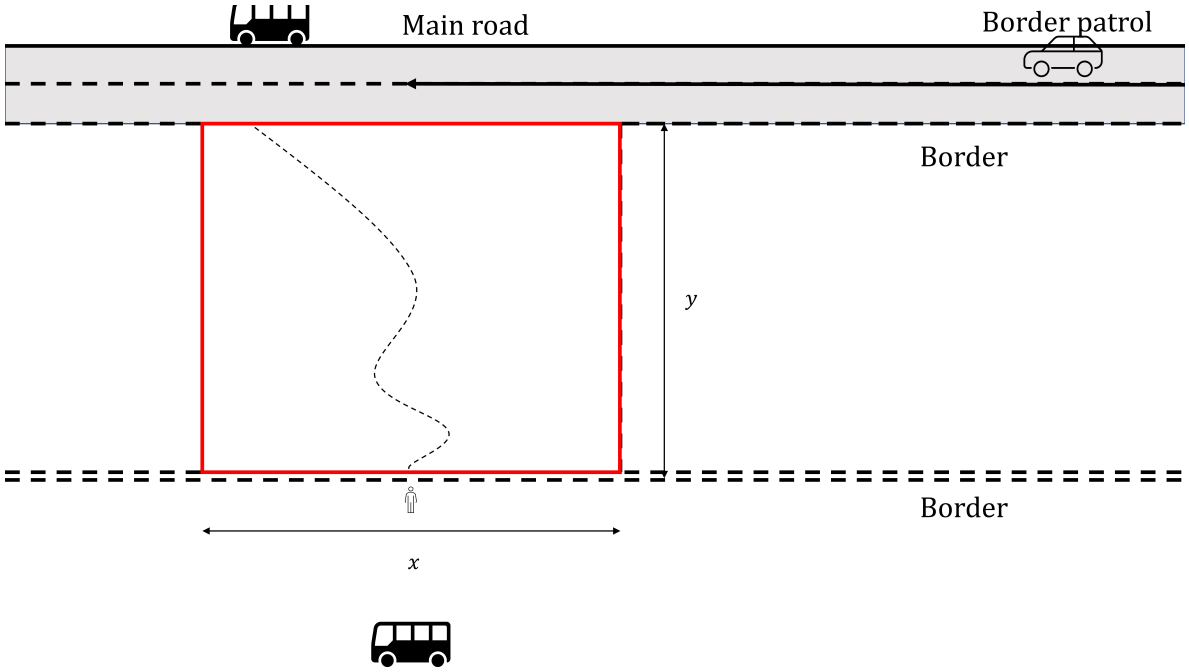


**Figure 2:** A simplified illustration of the base scenario that will be simulated and analysed.

The simulation consists of a set of observation devices, a set of groups of immigrants attempting to escape to a main road and ultimately disappear into the main land, and a set of border control personnel attempting to detain those groups. Other methods that could aid with border control can be explored as well, such as barriers or deforesting certain areas to make observation more effective. The observation devices could include various cameras, radars, drones and potential other methods to gain information to both alert border control personnel and give further information of the whereabouts of the targets. The simulation will be parameterized by all the explored border control methods so that it will be possible to examine all the different parameter combinations (in order to get the data for analysis).

When analyzing the outcomes of different simulated scenarios, the relevant measures are effectiveness and cost: how many people could be caught from all the immigrants that attempted the crossing, and how much funds have been allocated to the resources that aided the border control in the scenario.

Although the main focus is on the state aided hybrid warfare scenario, the secondary objectives will be explored as well, time permitting. These include scenarios where a person is lost in the forest and enters Finnish territory by accident, and smuggling of goods using commercial technology, such as

drones.

# 3 Tasks

The tasks in this project can be divided into four partly overlapping phases, which are: research, project planning, implementation and report writing.

We start by reading existing literature about border control. Many military academies have done research around this subject which may help building our model. After this we familiarize ourselves with the existing border control tools and try to approximate how much their use costs on a longer period. Besides this, we also need to find information about how a border control squad works on a task, to be able to simulate their behavior.

After finishing the research phase, we plan how to implement the projects code. This includes designing the model architecture and the simulation algorithm. We decide how the environment around the border is implemented; how different terrains are simulated; what kind of border control tools are used and how they function in the simulation; how border officers and illegal border crossers move; how the simulations are rated against each other. These interconnected tasks require us to take a holistic view about the simulation.

Once the model architecture and plan for the simulation algorithm now been planned, we build them. Here we need to divide the work into smaller parts that can be worked on simultaneously by multiple people and can be combined easily when they are ready. These include the core simulation algorithm —the part that calculates a single iteration of the simulation — and the larger simulation calculator which calculates the different simulation options with the use of the core simulation algorithm and the budget constraint calculator.

Lastly, we can start to calculate different border situations with different budget constraints. The simulation results are plotted into a easily digestible format. Finally, after we have gotten all the needed result, we write the final report about our findings for the Finnish Defense Research Agency.

# 4 Schedule

The deliverables of this project will happen in the following schedule:

- Presentation of project plans, 10 March
- Presentation of interim reports, 14 April
- Presentation of final reports, 12 May.

We seek to complete the research phase before the presentation of project plan. Next, we begin to shape the implementations architecture in the project planning phase. This should be completed by 24 March. After that, we have 5 weeks for the implementation. This should be ready 28 April. Noticeably, we have the interim report 3 weeks into the implementation phase. There, we should have already some ready code and a good understanding of the implementation to present. Lastly, we work the last two weeks on the final report that will be submitted 10 May.

# 5 Resources

Our team has a backround in mathematics and operations research. All of our team members are majoring in Systems and Operations Research. Through our minors we have knowledge of various topics such as business analytics, computer science and creative sustainability. Our suitable knowledge and experience on programming and computer science is essential to create the simulation software. Python is a likely choice for the programming language for the software, due to easy access and multiple useful packages. Personal computers will be used for the simulation, but university provided computing services will be used if more computing power is required.

Our contact in The Finnish Defence Research Agency is Dr. Esa Lappi, who will give us guidance throughout this project. Esa works as a Chief Representative of Defence Technical personnel and a Docent title in the Finnish National Defence University. Professor Ahti Salo from Aalto University will assist us and monitor our progress.

Only public sources of information will be used in this project. Existing literature for our topic can be found from Naval Postgraduate School, various military academies and Ministry of the Interior (Pulat (2005),Koslowski and Schulzke (2018), Cory (2018)). Literature can be found regarding border control and individual design options—UAV's, sensors, etc.

# 6 Risks

Below in Table 1 are the possible risks for this project. We lists different risks, their expected effects, their probabilities and impacts on a scale of Low/Medium/High, and finally the steps we will take to mitigate the effects of these risks and decrease their probability. In summary, most of the risks presented here have a low probability of realization, and are simple to mitigate with our own actions.

**Table 1:** List of risks for the project

| Risk | Effect | Probability | Impact | Prevention |
|---|---|---|---|---|
| Poorly defined scope | Too much work to do, client is unhappy about results | Low | High | Regularly discuss with client on results thus far and possible improvements and/or other areas of research |
| Insufficient public data | Model does not accurately reflect reality | Medium | Medium | Spend sufficient time in searching for data, make otherwise robust model |
| Team member inactivity | Increased workload for other team members to stay on schedule | Low | Medium | Communicate within the group, project leader communicates with course personnel if challenges arise |
| Communication issues towards client | No feedback for model, harder to update | Low | Medium | Try to communicate actively, leave sufficient time before deadlines to allow for delays caused by communication issues |
| Model is too complicated | Issues in computational tractability | Low | Medium | Vigilantly simplify model, use supercomputers to assist in calculations |
| Lack of capabilities | We are not able to complete the model | Low | High | Have a clear schedule and scope, ask for help from course personnel or client if issues arise |

# References


Bettina J. Cory. *Re-Casting the U.S.-Mexico Border Security Net.* PhD thesis, Naval Postgraduate School, 2018.

Koslowski and Schulzke. *Drones along Borders: Border Security UAVs in the United States and the European Union.* PhD thesis, University at Albany & University of York, 2018.

Halil Pulat. *A Two-Sided Optimization of Border Patrol Interdiction.* PhD thesis, Naval Postgraduate School, 2005.

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