

Aalto University
MS-E2177 - Seminar on Case Studies in Operations Research

Optimizing bus parking to enhance electric bus usage

Project plan

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1 Background

Public transport bus service is a very competitive line of business in Finland. The government uses competitive tendering to choose their bus providers, and this forces private companies to stay competitive in a field like this where regional natural monopolies naturally form. Bus companies like our client Koiviston Auto need to be efficient with their time and resources to stay competitive.

One way this is done is switching to electrical buses, which are not only more ecological to use but also more economical because of the high fuel consumption of big vehicles, such as buses and the rising oil prices. Electrical buses do come with a major flaw; they are quite impractical to charge effectively given very high usage in transit during the work day. Charging can take several hours, and chargers are very expensive. Due to this, bus companies work with limited charging capacity and are forced to plan the charging optimally.

In this project we focus on how to optimally plan the parking of the buses in a depot such that all electric buses have sufficient amount of charge when they are to leave the depot for their routes. The plan should be robust against uncertainty in the arrival times of the buses and disruptions like buses breaking down or being out of commission for other reasons.

2 Objectives

The main goal of the project is to automate the process of developing an allocation plan for each bus to the client's bus depot in Jyväskylä. To date, this has been done around three times a year by hand, which takes up a lot of time. This allocation plan should be robust against the many uncertainties associated with the problem of parking buses at the depot. A poorly developed plan hurts the business and the day-to-day operations of the bus drivers when one cannot access the bus they need since it is, for example, blocked by other buses ahead of it in the depot.

The project is to be carried out utilizing mathematical methods such as optimization with a thorough sensitivity analysis to ensure robustness of the allocation plan against the many uncertainties, like the stochastic arrival times of the buses to the depot or disruptions like traffic accidents, malfunctions, etc., associated with the problem. The goal of the project is to develop a ready-to-use mathematical model, which the client can use to develop robust allocation plans for their depot.

3 Tasks

3.1 Scoping the problem and literature review

First, we need to become familiar with the problem. We analyze it from all relevant angles, know all the variables and what we seek to accomplish in this project. This will be done with several meetings with the client discussing all relevant aspects. In addition, we will visit the bus depot in Jyväskylä and talk about the problem with the people who have been struggling with manual labor and ineffective depot utilization due to poor planning in the presence of uncertainties. These discussions help us reduce the scope of the problem and make the project manageable in the given

time frame of the course.

We get the relevant data on bus routes, like departure times, route lengths, specifications of the bus depot and the buses in it from the client. In parallel with scoping we conduct a thorough literature review getting familiar with similar topics tackled previously in the literature. The literature review covers different optimization models for similar problems, but also some alternate approaches.

3.2 Problem formulation and developing the optimization model

With the thorough literature review, we formulate the optimization problem. We construct the model with the programming language Julia developed especially for scientific computations including optimization. This Julia program will read a given schedule for the bus routes, specifications regarding different types of buses and how many there are of each at disposal and, most importantly, what are dimensions of the bus depot.

3.3 Sensitivity analysis

Finished optimization model will be run on real data. Extensive sensitivity analysis will be conducted on the allocation plan the model outputs. This analysis shows how robust the allocation plan actually is and assuming satisfactory results we will have successfully developed a ready-to-use optimization model for the client.

3.4 Deliverables

In addition to the tasks above, there are some deliverables to be produced in this course, i.e. project plan, interim report and final report. These deliverables will be presented to the course staff, other students and some of the companies also taking part of this seminar course.

3.5 Responsibilities

Like in most group projects everyone cannot do everything, and therefore we will all specialize in something but everybody will still be involved in all different tasks of the project. Esa, Julia and Anton will focus mainly on the mathematical programming with Julia. Olli-Pekka and Elias will focus on the data processing and communication of the different parts of the code base in addition to the visualization of the solutions. Sensitivity analysis will be conducted by Elias and Olli-Pekka. Lastly everybody will contribute to the deliverables, but Julia and Elias will be mainly in charge of this.

4 Schedule

The project schedule is in Figure 1, with the tasks discussed in the previous section. Most of the exact times might change as, for example, amount and weeks for meetings with the clients. Generally, in January and February we used most of the time to scope the problem and research similar topics in the literature and discuss the project with the client. In March and April, we will build the model and test it. At the end of April and in the beginning of May we write the report, wrap up the project, and deliver the built model to the client.

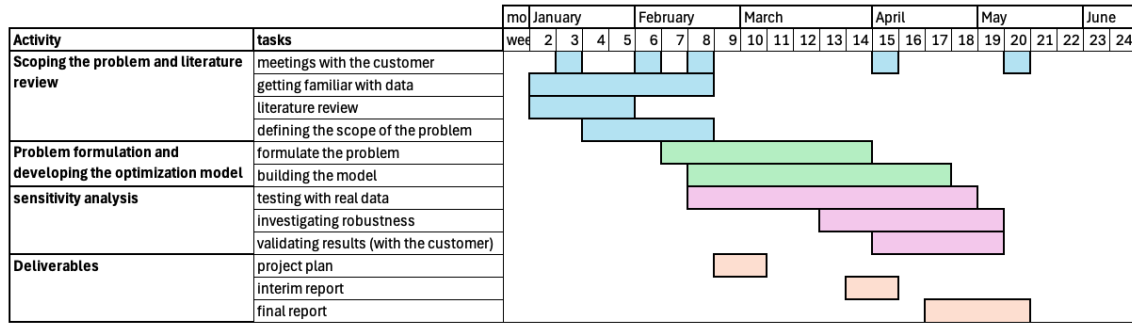


Figure 1: The planned schedule for the project.

5 Resources and material

5.1 Team

Our team consists of five M.Sc. students majoring in Systems and Operations Research. We have a strong background in mathematics and problem-solving, which are essential skills for successfully completing this project. Additionally, we have knowledge in industrial engineering, management, and computer science through minor studies. Our programming and computer science skills enable us to develop the simulation required for this project

5.2 Contacts

Our primary contacts at Koiviston Auto are Joonatan Honkamaa and Mikko Alanko. Joonatan is currently writing his thesis for Koiviston Auto and has a background in Systems and Operations Research. Mikko is the Chief Development Officer at Koiviston Auto and has over a decade of experience in the transportation industry. Our academic supervisor, Professor Ahti Salo, provides feedback and guidance throughout the project. He assists us in overcoming challenges and ensures that our approach aligns with best practices in the field. We will have regular meetings with both our client and our professor to track progress and refine our work.

5.3 Data

Koiviston Auto has provided us with relevant data on bus routes, departure times, route lengths and specifications of the bus depot. They also share their industry expertise and offer feedback that helps shape our approach. Additionally, they arranged us a visit to the bus depot in Jyväskylä, where we had the opportunity to ask questions from the depot staff.

5.4 Literature

To strengthen our project, we conduct a literature review to explore similar problems in previous research. This review will focus primarily on different optimization models applicable to our problem, as well as alternative approaches. Hamdouni et al. (2007) serves as our initial framework, which we will adapt and refine as needed.

6 Risks

The project has multiple risks which would affect the quality of the final model. Most of the risks relate to the poor communication between stakeholders. For this reason, during the project, clear communication is one of the key priorities. This includes communication in the project group and with the client. Other risks are related to technical aspects of the project and how the project objectives are defined and understood. The most relevant risks are listed below in Table 1 with ways to reduce the likelihood of them.

Table 1: Identified project risks and mitigation actions.

Risk	Effect	Likelihood	Impact	Mitigation
Problem is too complex or multi-objective to solve with one model	Project may not deliver a usable solution for the client	Medium	High	Define core problems at the start; expand scope only if time allows
Implementation is not completed properly for the client	Client cannot use the model effectively	Low	High	Communicate implementation requirements and expectations clearly throughout
Communication problems with the client	Final solution may not meet client needs	Low	High	Maintain proactive communication; clarify requirements early
Unrealistic assumptions	Model may not deliver on promised outcomes, leading to disappointment	Low	Medium	Set clear, realistic expectations and communicate limitations throughout
Lack of time	Model may be incomplete or unreliable	Low	High	Stick to the schedule and adapt quickly to any delays
Unsuitable data	Model may not reflect real-world use cases	Low	High	Request additional data promptly when gaps are identified
Communication issues within the team	Work may become misaligned or inefficient	Medium	Medium	Project manager ensures clear and consistent internal communication

References

Hamdouni, M., Soumis, F., Desaulniers, G., Odile, M., and van Putten, M. (2007). Parking buses in a depot with stochastic arrival times. *Transportation Science*, 40(3):502–515.