Advanced Practical 2024-2025

Operations Research Case

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Students form teams with maximal 3 members and sign up in Canvas by the end of Week 1 (June 8).

On Thursday 5 June, an academic lecture on writing will be given after which you get a writing assignment of composing a (proposal) report of max 750 words (2 A4 pages) in which you describe your project, its societal relevance, its scientific challenges, real occurrences or applications, and possibly other issues. You can use this report as introduction of your final report. This proposal report is to be uploaded in Canvas in Word format (see the file converttex2word.pdf in Canvas). Due Thursday 12 June.

During the lecture / tutorial hours we can discuss questions that you may have, and hear your progress. The output of the project consists of (i) a written report, and (ii) a presentation. The report is to be uploaded in Canvas ultimately Tuesday 24 June. The presentations will be held on Wednesday 25 June. Tips and requirements of the report in separate files will be available in Canvas.

Dock Assignment in the warehouses of KLM Cargo at Schiphol Airport

1. Background

KLM Cargo provides air freight services for major logistics companies such as DHL, Amazon, and PostNL. At its warehouse, trucks arrive to either deliver outbound shipments or pick up inbound shipments using 30 available loading docks.

Current Operations
All 30 docks are currently active. A dock is considered active if it is operational and staffed for the entire day. Each active dock requires one worker for a full 24-hour shift. The labor Cost is computed as follows: €10 per hour per worker, i.e., €240 per day (€10/hour × 24 hours).

Truck Handling Procedure
If an active dock is available upon truck arrival, the truck is served immediately. If all docks are busy, the truck joins a First-Come-First-Served (FCFS) queue.

Dock Operations
Docks can be left unused (closed) for an entire 24-hour day.
Closed docks do not require any crew and thus incur no labor cost.
If a dock is to be active, it must remain open for the entire day. Dock schedules can be adjusted only once per day.

Assumptions:
To ensure service quality, a waiting cost of €10 per hour is applied, calculated based on the average waiting time of all trucks during the week. Trucks cannot be postponed to the following week for service; therefore, any trucks remaining unserved by the end of Sunday are outsourced to an external company at a cost of €20 per truck. The system is reset to empty at the start of each Monday.

Objective:
The manager consider to manage the daily number of docks to open, aiming to minimize the total daily operational costs throughout the upcoming week while maintaining service quality. Specifically, the objective is to minimize the overall labor costs for active docks, the average waiting cost of all trucks, and the outsourcing costs.

Data for Analysis

To support this decision-making process, the manager has provided one year of historical data, which includes:

1. Truck interarrival times
2. Truck loading/unloading durations
3. The arrival day of each truck

Your report should address the following:

1. Visualize the Historical Data, and discuss the trends or patterns that are observed in truck interarrival and service times
   Hint: check for seasonality or periodic patterns by visualization, for example, histogram, line chart, boxplot.
2. Model the Arrival Process and introduce how truck arrivals are represented in your simulation. Explain and justify your approach.
   Hint: after identifying some patterns in answering question 1, now try to fit some stochastic distribution to the interarrival time. You can use Q-Q plot to visually check the fit of the distribution, use K-S test to rigorously test the fit of the distribution. After finding the right distribution for your data, estimate the parameters of the stochastic distribution.
3. Model the Service Times. What distribution will you use to model (un)loading times? Why is it appropriate? Please provide statistical analysis to justify it.
   Hint: Same as the hint for question 2.
4. Build a discrete event simulation to evaluate the operational cost under the current dock plan for the coming week, given the system is empty for now. Can you validate your simulation model?
   Hint: from question 2 and 3, the distributions of interarrival time and service time are known. Using these estimations to build DES to estimate the overall cost during one week.
5. Propose an Improved Policy. That is, recommend a new dock plan that lowers total cost for the coming week based on evaluation from DES.
   Hint: You can follow the steps below to search for a better policy: Based on your observation from the arrival rates (question 2), service rates (question 3), waiting time (question 4), propose a new policy. Then run the DES to evaluate the new policy. If the new policy works better than the current policy, then the algorithm can stop;

otherwise, propose a new policy and iterates the above steps until you find a better policy than the current one.

You are free to use any other search algorithms you learnt from other course to find an improved policy.