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A Sustainability-Centric Methodology for the Shunt-In Shunt-Out Problem

The EU plans to double rail freight traffic by 2050, both to cut pollution emissions and to mitigate congestion by shifting traffic from road to rail networks. One of the challenges is to minimize the high emissions and costs associated with shunting yard operations while maintaining an acceptable level of service. Due to the complexity of the problem, shunting operations are usually managed in a sub-optimal way, namely, based on practitioners' experience. In this context, this project proposes an event-based simulation framework for the shunt-in shunt-out problem exploiting Python and a Mixed Integer Linear Programming model to minimize the number of shunting operations, while considering the shunting yard timetable and the contractual constraints of the wagons. To test the effectiveness, the research considered the 2020 train timetable for freight trains in the Bettemburg Eurohub Sud Terminal (Luxembourg) and assessed different KPIs, linked both to tactical and strategical objectives (i.e., efficient wagon fleet management, to assign a smaller wagon pool to the shunting yard). Computational results show how the criteria for choosing which wagons should be taken-out from the inbound train and should be inserted into the outbound train might significantly impact the KPIs analysed, in terms of emissions of shunting locomotives (-38%), wagon fleet (-43%), time to shunt plus fixed and variable costs related to depot and shunting costs. The framework developed in the project can be easily implemented at zero cost and with multiple and new Shunt-In criteria, without prior knowledge of the shunting yard configuration. The research is the first step for an industrial software, named Shunty , that will address further issues concerning the shunting station.