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A SIMULATION-BASED VEHICLE FLEET SIZING PROCEDURE IN AUTOMATED MATERIAL HANDLING SYSTEMS: AN APPLICATION TO A DISPLAY FAB

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ABSTRACT

This study proposes a simulation-based optimization framework and its application to vehicle fleet sizing in automated material handling systems (AMHSs). The framework comprises two stages: simulation calibration and optimization. The simulation calibration adjusts the simulation input parameters using field observations to obtain a more reliable simulation model. The simulation optimization determines the best number of vehicles to minimize flowtime under performance constraints based on the calibrated simulation. We validated the framework through application to a display fabrication plant in South Korea. The framework effectively modulates the fleet size in response to material flow and exhibits stable performance in the real-world AMHS.

1 INTRODUCTION

An automated material handling system (AMHS) is a crucial component for process automation and efficiency enhancement in semiconductor and display fabrication plants (fabs) (Kang et al. 2025). Among various operational decisions in AMHSs, determining the number of vehicles is critical, as it directly influences delivery performance and system congestion (Chang et al. 2014). To address this problem, we propose a two-stage framework for vehicle fleet sizing procedure that integrates simulation calibration and optimization. The calibration stage adjusts calibration parameters to align the simulation model based on field observations. The optimization stage uses the calibrated simulation model to determine the number of vehicles that satisfies performance constraints. The proposed framework is applied to a display fab in South Korea to demonstrate its effectiveness in modulating vehicle fleet size according to material flow and ensuring delivery performance in real operations.

2 PROPOSED FRAMEWORK

The proposed framework for vehicle fleet sizing procedure is shown in Figure 1. The framework consists of two stages: simulation calibration and optimization. The first stage performs parameter calibration to align the simulation model with the real-world AMHS. The second stage uses the calibrated simulation to determine the number of vehicles that satisfies performance constraints.

The simulation calibration stage adjusts the calibration parameters θ to enhance the reliability of the simulation model. The simulation outcomes $y_S(x, \theta)$ are compared against field observations $y_F(x)$ from the real-world AMHS. The parameter calibration module adjusts θ to minimize the deviation between simulation outcomes and field observations.

The simulation optimization stage determines the number of vehicles that satisfies performance constraints based on the calibrated simulation model. The calibrated simulation model evaluates delivery performance across vehicle fleet sizes. The best number of vehicles x^* is applied to the real-world AMHS to ensure delivery performance requirements.

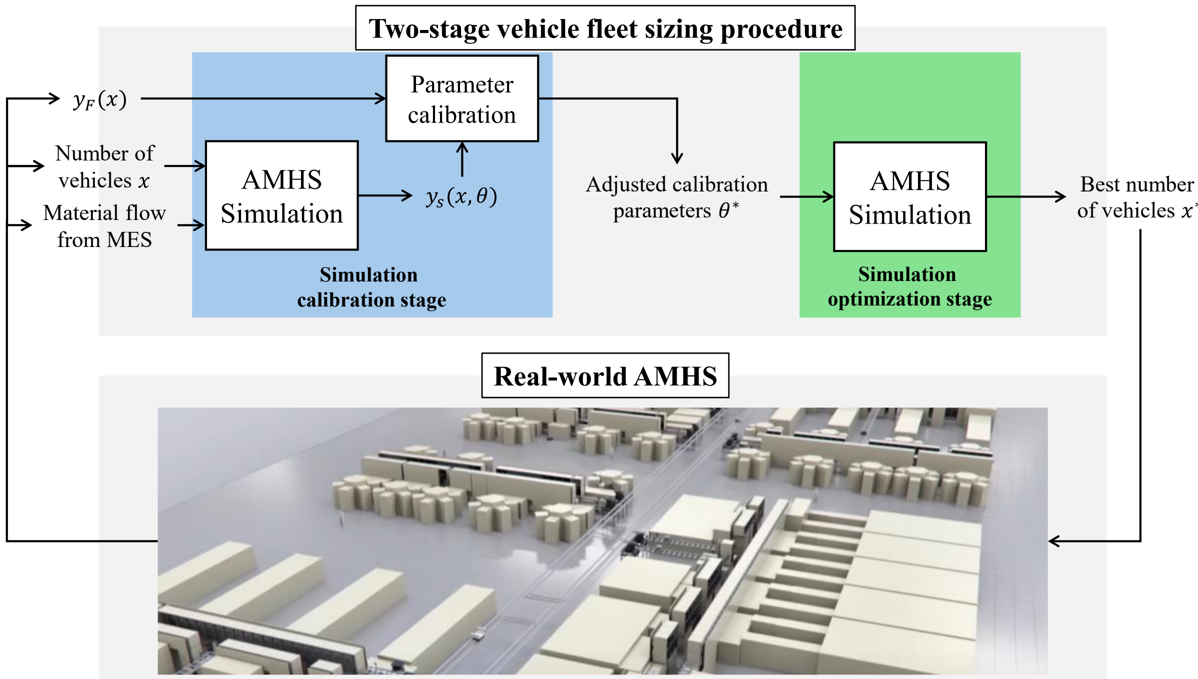

Figure 1: The proposed framework: Two-stage vehicle fleet sizing procedure.
(*Real-world AMHS* image source: Daifuku, https://www.daifuku.com/ (*accessed on July 21, 2025*)).

3 APPLICATION TO REAL-WORLD AUTONATED MATERIAL HANDLING SYSTEM

We validate the proposed framework through application to a display fab in South Korea. They build a simulation model with Tecnomatix Plant Simulation by Siemens. The calibration parameters include the maximum speeds of vehicles on straight rail, curved edge, acceleration, and deceleration. Bayesian optimization (Kang et al. 2024) is used to adjust calibration parameters based on field observations. The best number of vehicles is determined to minimize flowtime under constraints on vehicle utilization. The framework has been applied to the site, where it has effectively modulated the fleet size in response to daily material flow and maintained stable flowtime and vehicle utilization in the real-world AMHS.

ACKNOWLEDGMENTS

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