Multiobjective Framework for the Efficient Design of Automated Guided Vehicles Systems via Discrete Events Simulation

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INTRODUCTION

- With many challenges faced by healthcare systems around the world, Automated Guided Vehicles (AGVs) have seen some potential applications in healthcare facilities to support peripheral nursing and logistical activities in hospitals. [1]
- AGVs have the potential to support time-sensitive and resource-intensive activities within the OT complex. The deployment of AGVs in a large OT complex are confronted with a variety of challenges.

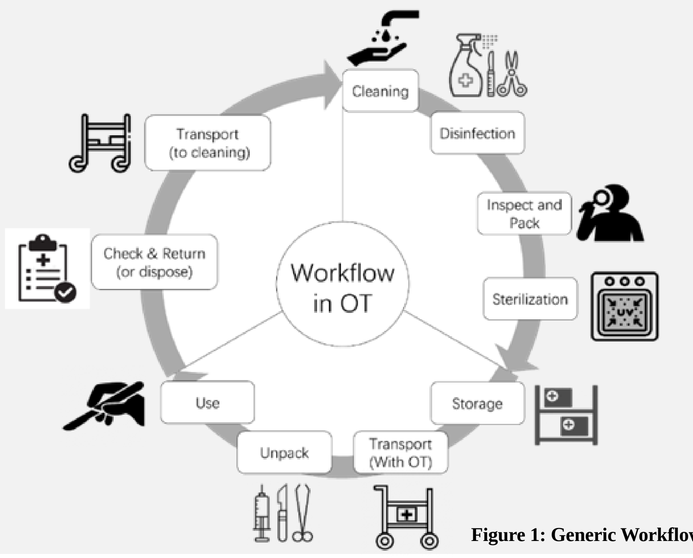


Figure 1: Generic Workflow of an OT

OBJECTIVES

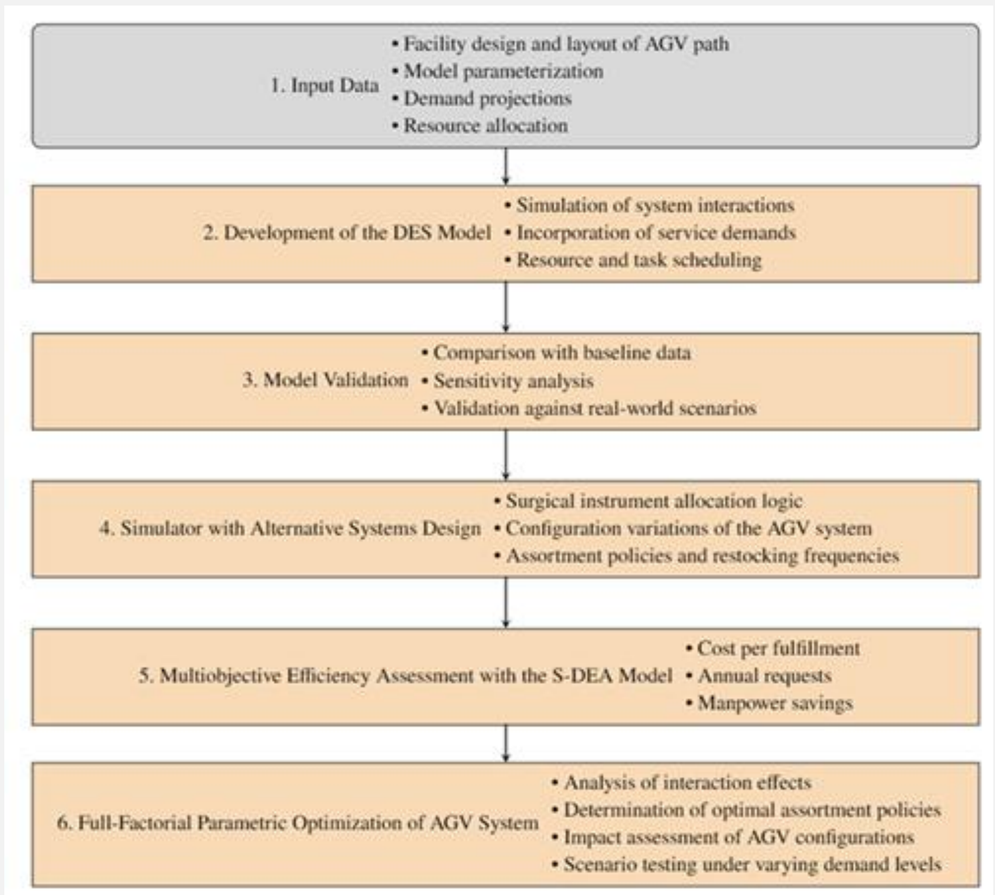
The objective of this study was to develop a framework for the efficiency evaluation of AGV systems deployed in existing OTs which have **limited options for docking and routing**.

a. **Discrete Event Simulation (DES)** will be applied to deal with detailed policy and operational constraints specific to the use case for the SH. [2]

b. **Descriptive analysis** will be used to identify the optimal AGV configuration and assortment algorithm.

METHODOLOGY

The framework was developed, compared, and optimized through 6 steps as summarized below.



To develop the DES model, the OT Complex layout, conveyance time of nurses, frequency of requests and AGV specifications were implemented in AutoMod™ as shown in the layout.

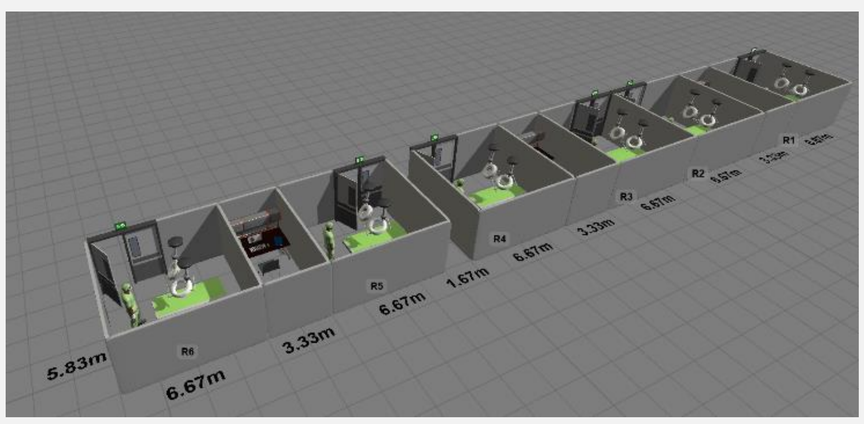


Figure 2: 3D layout of the OT

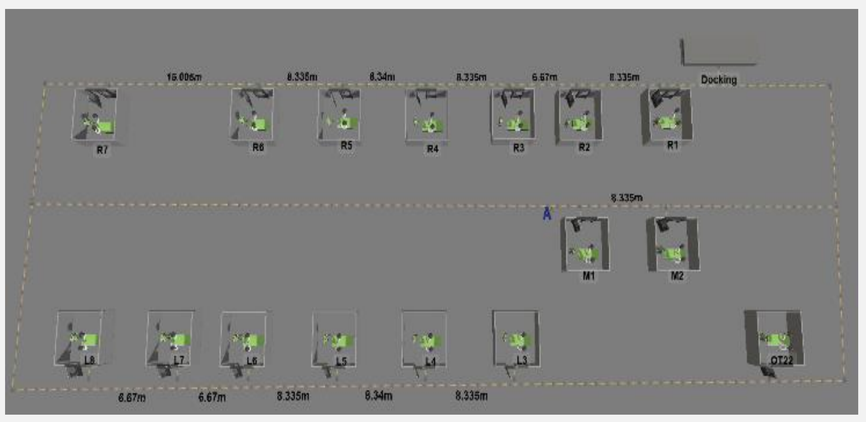


Figure 3: Schematic of the OT Layout

- The system design factors included:

a. the assortment algorithm (basic and improved)

b. the number of AGV deployed

c. the restocking frequency per day.

- Four demand scenarios were assessed across the various system designs.
- The S-DEA model was executed for the above design configurations and demand scenarios. In total 96 simulation runs were created in this full factorial design of experiments.

RESULTS

a. The improved assortment policies significantly impacted efficiency scores under higher demand. With 2 AGVs, efficiency scores did not vary significantly across demand scenarios. However, with higher demand, 3 AGVs significantly improved efficiency scores.

b. Even if main effects were not significant, interaction effects between assortment policies, AGVs, and restocking frequencies were significant for higher demand scenarios (5X and 10X).

c. Interaction effects were insignificant for lower demand scenarios (1X and 2X) at $p<0.001$. Significant interaction effects were observed for assortment policy*number of AGVs interactions at higher demand scenarios (5X and 10X).

d. Under the high demand scenarios, the increase in efficiency was significant at higher restocking frequencies when there are less AGVs. With more AGVs, the increasing restocking frequencies led to a decline of the efficiency score.

Demand 1X (Baseline)	Demand 2X	Demand 5X	Demand 10X

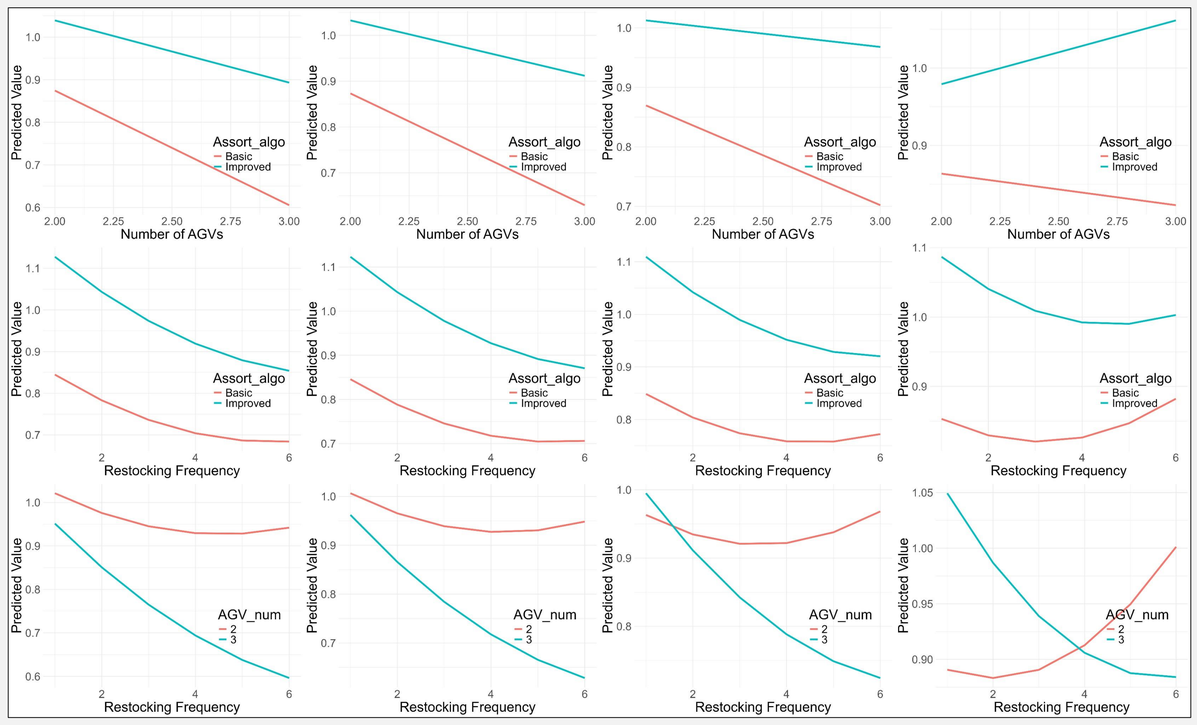


Figure 4: Interaction effects plots for demand scenarios (top row: number of AGV*Assortment policy; second row: restocking frequency*assortment algorithm; third row: restocking frequency*number of AGVs

CONCLUSION

- This study presents a detailed framework which utilize DES model to evaluate the efficiency of AGV deployment in an existing OT complex with limited routing and docking options.
- This study gains significant improvement on the efficiency of OT logistics system which potentially enhances direct healthcare services.
- This study also offers practical implications on the optimization of AGV systems in OTs in healthcare facilities by assessing key factors.

References

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2. I. F. A. Vis, "Survey of research in the design and control of automated guided vehicle systems," *European Journal of Operational Research*, vol. 170, no. 3, pp. 677–709, May 2006, doi: 10.1016/j.ejor.2004.09.020.

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