Proceedings of the 2025 Winter Simulation Conference
E. Azar, A. Djanatliev, A. Harper, C. Kogler, V. Ramamohan, A. Anagnostou, and S. J. E. Taylor, eds.

SAFETY AND PRODUCTIVITY VALIDATION THROUGH FAST ITERATIVE DISCRETE-EVENT SIMULATION WITH A LIGHTWEIGHT INDUSTRIAL SIMULATOR

Takumi Kato[1], Zhi Li Hu[1], and Rafael Suarez[2]

[1]R&D, Hitachi America, Ltd., Santa Clara, CA, USA
[2]Hagerstown Plant, Hitachi Rail USA, Inc., Hagerstown, MD, USA

ABSTRACT

Enhancing operational efficiency while ensuring worker safety is a key objective in industrial system design. It is particularly important in environments where human workers and forklifts share the same physical space. Rolling stock factories often include warehouse areas that manage both large and small parts, relying on a combination of workers and forklifts to perform material transport. These warehouses play a critical role in supporting production by executing kitting operations, which represent the initial step in the assembly process and demand significant coordination and time management. This study employs discrete-event simulation (DES) to evaluate the efficiency and safety of various warehouse layout and process configurations prior to implementation. A lightweight industrial simulator, built on the Rapid Modeling Architecture (RMA), enabled rapid iterations of simulation-based analyses and supported effective decision-making before physical changes on the factory floor.

1 INTRODUCTION AND PROBLEM SETTING

Improving efficiency and safety is an important goal in industrial settings, particularly in areas where workers and forklifts operate in the same space. Rolling stock factories often include warehouses where large and small parts are stored and transported using both workers and forklifts. One of the main tasks in these warehouses is kitting, where parts are gathered and prepared for assembly. Kitting is the first step in the production process, and it takes time and careful planning to ensure everything is ready on schedule. If the layout or workflow is not well-designed, it can lead to delays and safety risks. Our focus of analysis is the warehouse responsible for providing all the parts necessary for rail car production. Simulating potential design plans is essential because physical layout changes are costly, time-consuming, and risky in active warehouse environments.

2 RMA-BASED DES FOR FAST ITERATIONS AND LAYOUT IMPROVEMENTS

We used discrete-event simulations to test different warehouse layouts and workflows. Since it required multiple iterations of discussions and model updates, we employed a lightweight simulator with the RMA that significantly abstracts components while preserving essential details (Kato and Hu 2025), as illustrated in Figure 1. This helped us find an efficient and safe design before making any physical implementations.

3 KEY RESULTS

3.1 Heat Map of Human-Forklift Collision Risks

We have performed multiple scenarios of simulations and recorded the places where human workers and forklifts became too close to each other. Figure 1 shows the simulated collision risk heat map. We identified the riskiest location and developed a countermeasure, which is to reduce the number of racks.

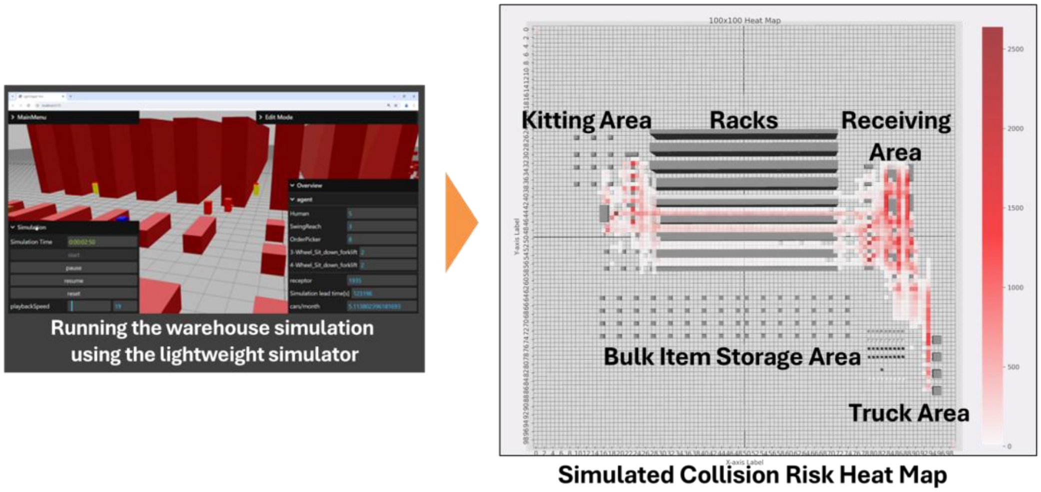

Figure 1: An overview of the lightweight simulator and the generated risk heat map for the warehouse area layout design.

Episode	Simulation Inputs [# of Agents]					Time	Activity Rate [%]				
	Workers	FL Type A	FL Type B	FL Type C	FL Type D	[hour]	Workers	FL Type A	FL Type B	FL Type C	FL Type D
1	25	7	7	2	2	6.1	0.91	0.56	0.50	0.21	0.19
2	20	6	6	1	1	7.8	0.89	0.52	0.46	0.33	0.30
3	24	6	6	1	1	6.9	0.83	0.58	0.52	0.37	0.34
4	30	3	3	1	1	8.9	0.52	0.91	0.82	0.29	0.26
5	34	3	3	1	1	9.0	0.45	0.90	0.80	0.29	0.26
6	34	4	4	1	1	6.9	0.59	0.88	0.79	0.37	0.34
7	24	4	4	1	1	7.3	0.79	0.83	0.74	0.36	0.32
8	25	4	4	1	1	7.5	0.74	0.81	0.73	0.35	0.31
9	25	4	4	1	1	7.6	0.73	0.80	0.71	0.34	0.30
10	26	4	4	1	1	7.4	0.72	0.83	0.74	0.35	0.31
11	26	4	4	1	1	7.1	0.75	0.85	0.76	0.36	0.33
12	27	4	4	1	1	7.3	0.70	0.84	0.75	0.36	0.32
13	28	4	4	1	1	7.1	0.70	0.87	0.77	0.37	0.33

Figure 2: An overview of the lead time and the varying number of agents.

3.2 Performance Evaluation with Scenarios Varying the Number of Forklifts and Human Workers

We evaluated various scenarios involving different numbers of human workers and multiple types of forklifts. Results are shown in Figure 2. A shortage of certain forklift types was found to create a bottleneck in the kitting process. By analyzing activity rates (i.e., utilization) and lead times, we identified the optimal number of each forklift type and human workers to achieve target performance. Numbers in orange are finalized values; numbers in green cells indicate lead times that meet the performance goal.

4 CONCLUSION

Using fast, iterative discrete-event simulations, we gained useful insights that helped validate and improve the warehouse design of a rolling stock factory for greater safety and efficiency.

REFERENCES

Kato, T., and Z. L. Hu. 2025. "Rapid Modeling Architecture for Lightweight Simulator to Accelerate and Improve Decision Making for Industrial Systems." *IEEE International Conference on Automation Science and Engineering (CASE)*, August 17–21, 2025, Los Angeles, California, USA.