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USING DISCRETE EVENT SIMULATION TO EVALUATE THE IMPACT OF LAYOUTS AND RESOURCE ALLOCATION IN PACKAGING SYSTEMS

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ABSTRACT

A manufacturer was considering a temporary operation in a constrained space. Simple calculations showed a possible bottleneck at the dock doors. An alternative was to build a connector to an adjacent warehouse, at significant capital expense, to improve flexibility and throughput. A discrete-event simulation was built to evaluate the benefit of investment in the connector. The model demonstrated the material handling constraint and that the connector had payback potential.

1 INTRODUCTION

Our customer needed to quantify the maximum attainable throughput under various new and potential operating conditions within the building. Secondly, they needed to understand what impact an expected production level had on the tight vehicle network. Simulation was the right tool to analyze these challenges due to the various layout and staffing options. We chose FlexSim because of its ability to manage vehicle tasks and configure and manage experiments. Haskell assessed the constraints and inefficiencies in the areas of resource (people) availability, material movement, and shipping/receiving operations and experimented with the system to understand the impact of proposed capital projects.

2 PROJECT PROFILE – CAN PACKING

This existing building was previously scheduled to run a cumulative ~1,600 cans per minute to supplement other sites in the customer's network. This only required them to run up to three of their four packaging lines at any given time. Under the new temporary operation plan, the facility had to increase production to 2,500 cans per minute or 15.9 pallets each hour using all four lines. This level of production had never been attempted at the site, so there was very little data availability. The impact that this change had on storage and dock doors was measured with a set of static calculations in a simple model. This model confirmed potential risks in key metrics like trips per hour and pallet throughput required. To determine the impact of these risks, a simulation model was developed to account for randomness in the lines' performance and the different factory layouts being considered, which was crucial to estimate the productivity of forklift drivers and the resultant throughput.

This facility only had two dock doors to service all the inbound and outbound materials. We modeled and tracked the dock doors' status over time, which proved the need for additional capacity. On the existing building, there was no space for an additional dock, but there was a storage warehouse located next door that helped alleviate the storage and throughput dilemma. Unfortunately, the warehouse connection required some significant capital expenditure, so we needed to quantify its return on investment to help the customer make an informed decision.

3 SIMULATION SYNOPSIS

The simulation model contained 50 processors (which represented equipment centers), 200+ pallet storage positions, and roughly 70 staging positions for immediate material consumption. Because the model was purpose-built for material handling by forklift, we modeled each individual packaging material that was required in the production process for its impact on the driver. Machine centers on the packing lines

randomly required repairs and, as designed, should follow up these repairs with temporary surges in their consumption rate to rebalance the line and return to steady state. This constraint required that forklifts respond to requests when they were made as opposed to following a given schedule. In the real system, forklift drivers relied on radio communication to establish ordering of tasks. To model this, we gave each material a nominal priority value that was decided based on its planned consumption rate. Some equipment centers were able to signal high-priority tasks when their inventory dipped critically low. Along with material delivery, the model had to balance other tasks assigned to the forklift drivers, such as loading machines, cleaning, breaks, and trash collection.

The simulation included four lines, each with five SKU-specific inputs and two shared inputs, for a total of 22 inputs that required precise inventory control to keep the lines running constantly. Because each inbound trailer of materials had limited capacity, and storage within the facility was limited, the inventory model became a key constraint. Without careful system-wide inventory monitoring, the system could not run optimally and would even lock up the model due to product being unavailable.

4 RESULTS AND ANALYSIS

Haskell found through experimentation and meta-modelling that without a connection to the additional warehouse, the loading and unloading at the two dock doors became a system bottleneck, which resulted in a maximum throughput on the packaging lines of ~250 pallets per day. We found that investing in the connection to another warehouse could lead to another ~30 pallets per day, or +8%. In the meta-model, we were able to condition the predicted throughput on the use of the connecter. Without the connector, the model showed no improvement after five active forklifts; however, with the connector, additional forklifts led to higher throughput. As a side effect, increasing forklifts increased congestion at key points. We identified one intersection as a potential risk with a predicted 90.4 forklift trips per hour and suggested additional safety measures and traffic management in those areas.

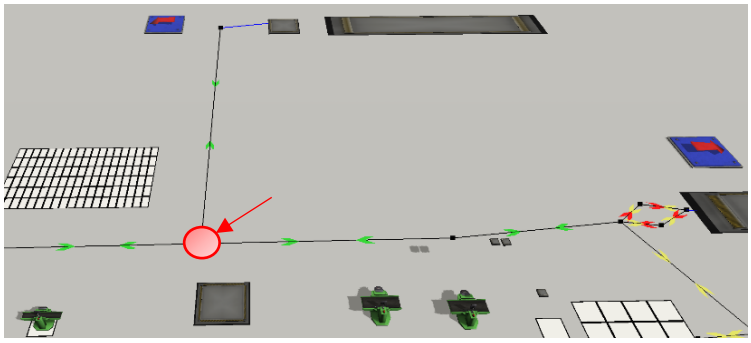

Figure 1: The intersection where traffic from the other warehouse must enter and exit, avg. 90.4 trips/hr.

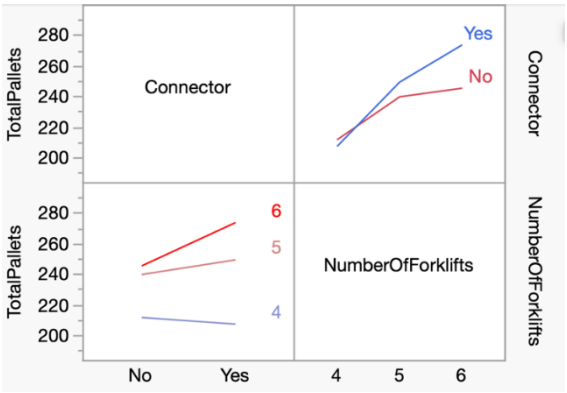

Figure 2: Interaction profiler of connector and number of forklifts. The top right panel indicates that without the connector additional forklifts offer significantly lower marginal gains.