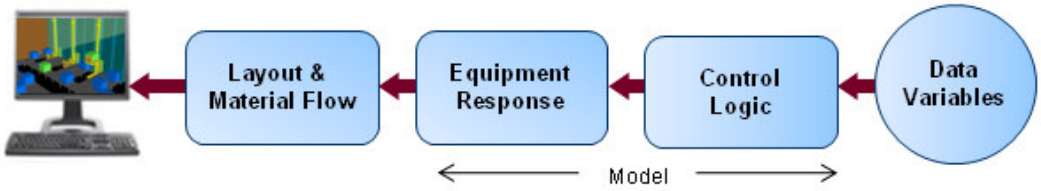
Simulation Resolves Constraints in Grocery Order Fulfillment System

Scope of Work
The work described in this paper included developing a computer simulation model of the material handling system (ASRS, conveyors, and fork truck operations), verifying the model, conducting experiments, and modifying the model to eliminate constraints discovered in the analysis process.

Model Development Process
HK follows a structured approach to simulation model development and verification to ensure that the model is a valid representation of the system. It includes an appropriate level of detail both in statistical accuracy and in animation for debugging, validating, and presenting model results. The model was written in the AutoMod 12.2 simulation language. It includes detailed representations of the system equipment, controls and operations.



Standard Simulation Process

Simulation Objectives
The purpose of the simulation analysis was to:

- Design a simulation model to reflect the proposed system configuration
- Determine if the configuration met average and peak system throughput requirements
- Identify potential constraints in the system design under various activity scenarios and develop solutions to eliminate the constraints

System Overview

Fork trucks deliver loads to one of four input stations on the main floor of the system. The loads are conveyed to a vertical reciprocating conveyor (VRC), raised to an upper level conveyor system, and then conveyed to the ASRS for storage. The loads are subsequently retrieved from the ASRS storage rack and delivered to pick faces on two picking levels in the rack structure.

In Full Load Output mode, pallet loads are retrieved from the ASRS rack and delivered to the upper level conveyor system, conveyed to a single VCR, lowered to the main floor and conveyed to the load output station. Fork trucks remove the loads from the system.

The ASRS consists of 12 aisles of double-deep storage racks with one storage and retrieval machine (SRM) per aisle. Each aisle has one pick-up stand and one deposit stand. Both are located at the front end of the system, at the upper level conveyor system. The SRMs deliver loads to two tiers of pick faces in the rack. Pickers travel through the pick aisles, building mixed-case pallets to fulfill store orders.

Since the system stages replenishment pallets for picking, distribution of activity across the lifts and aisles is not uniform. Rather, it is dependent on the inventory slotting and picking rates at the pick faces. The system must also handle pallets at an alternate VRC if any one of the four VRCs is temporarily out-of-service.

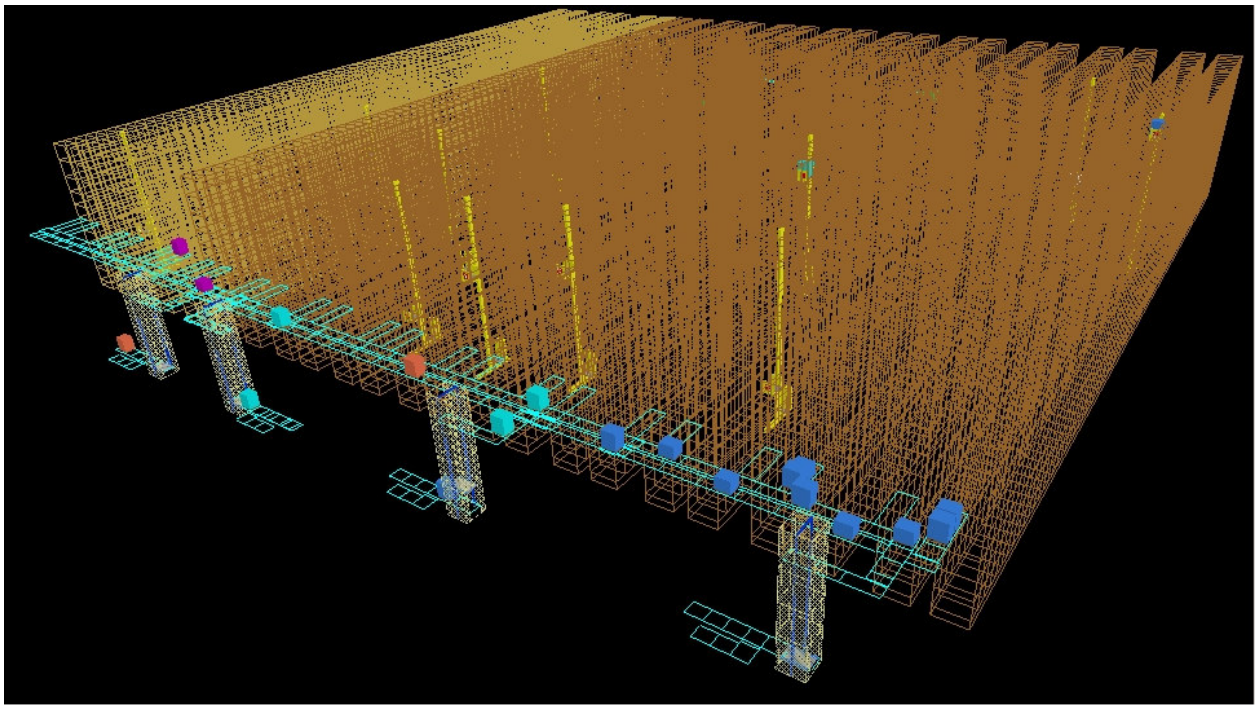
Summary of Results

HK conducted numerous experiments with the model, analyzing the performance of the material handling system for different distributions of load arrival at the lifts and load storage in the ASRS. Observing the animation showed that, in certain scenarios, throughput rates were inhibited by transient congestion on the upper conveyor sub-loops that caused pallet backups at the VCR input conveyors.

These results led to development of revised SRM work rules to prioritize storing inbound loads at the P&D over delivering replenishment loads to the pick faces. The revised rules reduced the number and duration of the backups, but did not completely eliminate their impact on fork truck unloading.

The model was further modified with additional pallet queuing positions at the lift conveyor inputs. This further reduced the impact of the remaining incidences of congestion.

In this final configuration, the model met the throughput requirements for both normal and peak activity.



Final System Configuration