Whitepaper

Get Your Truckers **Moving**

Simulating Operations Helps Choose Best Loading/Unloading Scenario

In the United States, economies have shifted away from agriculture and manufacturing industries to service systems. Consumers are demanding more customizable products, lower prices and faster delivery. Market competition has left only those who can stay afloat.

As a result, a company's supply chain has become a critical competitive differentiator. Management of supply chains has been evolving rapidly over the last few years due to the inception of Industry 4.0, where businesses adopt automation technologies and data exchanges using internet of things (IoT), advanced robotics, sensors, etc. Moreover, industries have emphasized increased sustainability, which leads to new challenges in designing an efficient system.

Logistics and transportation come into the limelight when minimizing supply chain costs and improving responsiveness. Transparency Market Research (TMR) conducted a study and estimated the value of the current logistics market to be approximately $8.1 trillion. TMR also projected this number would grow to $15.5 trillion by 2023. In 2014, the U.S. logistics market was estimated at $1.45 trillion, which was approximately 8.3 percent of the country's GDP. Moreover, warehousing and transportation accounted for 95.4 percent of the U.S. logistics market.

Logistics in Warehouses

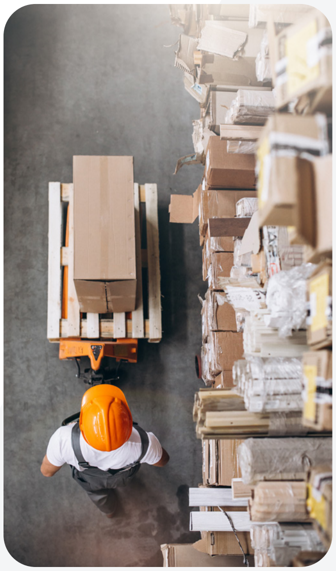
Inbound logistics plays a crucial role in the warehouse receiving process, which typically involves three stages, namely, check-in of inbound trucks, loading/unloading of goods and shipping/checkout. Advancements in technology can accelerate and optimize these processes.

Warehouses, especially those with an attached manufacturing facility, have a large number of trucks arriving during peak hours. This results in long waiting times for trucks to check in, leading to a myriad of problems that include delayed production, delayed shipment, idle resources (trucks and drivers), wasted fuel and greenhouse gas emissions. According to the U.S. Environmental Protection Agency, a truck idling for one hour emits 26.5 grams of carbon monoxide, 3.5 grams of volatile organic compounds, 33.7 grams of nitrogen oxides and 3.5 grams of total hydrocarbons, causing environmental damage and climate change. Moreover, the supply chain cost is directly impacted by receiving operations through annual detention fees, a penalty that shipping carriers assess to companies that hold the truck and driver beyond an agreed upon time.

Most of the previous literature focuses on challenges of receiving operations at marine terminals, which have a substantial amount of trucks arriving to load and unload goods. Common practices to minimize waiting lines entering facilities involves implementing appointment systems and scheduling trucks to arrive during off-peak hours.

While these measures may be appropriate for maritime terminals, a number of reasons mean they are not always easy for warehousing facilities to apply. First, the Department of Transportation (DOT) places strict regulations on the number of consecutive hours that truck drivers can operate. Second, drivers are given an appointment window during which they are scheduled to arrive. Many drivers arrive at times that feel comfortable for them. When drivers match their appointment times with the DOT regulations, many wind up arriving at the facility simultaneously. In addition, warehouse and production operations control when drivers arrive at the facility. Thus, the long waiting lines at check-in are still a problem at many large warehousing facilities.

Industry and universities often collaborate to tackle such challenges. This article describes one such collaboration, which facilitated the design, development and evaluation of several scenarios to optimize inbound logistics, reduce operating costs and ensure sustainability.



The Case of a Busy Warehouse

In collaboration with a multinational consumer goods company in the United States, we developed a comprehensive approach to explore the scenarios and identify practical solutions to improve check-in operations. The company has numerous warehouses and distribution centers, both in the United States and across the globe.

During peak hours at this particular site, more than 200 trucks enter a warehouse per hour and wait an average of one to two hours. In 2016, the company paid more than $1.75 million in detention fees to shipping carriers. Typical of any warehouse practice, the trucks entering the facility are first checked in and are then loaded or unloaded by one of the following procedures:

Drop and hook procedure: The trucks arrive with a loaded or empty trailer, drop it at the warehouse and pick up another loaded trailer before leaving the warehouse. The warehouse can load the trailer at its convenience (uninterrupted value chain), and it minimizes the chances of detention fees because loading and unloading time is negligible.

Live load procedure: The trucks enter the warehouse facility with an empty trailer and wait at an assigned docking station for loading.

For this study, one of the company's sites in the United States was chosen for two main reasons. First, the company received notices from the city government that its trucks queueing on government roads created traffic congestion for the public. Second, unlike other sites, this location experiences high waiting time for check-in, as it processes approximately 10 percent more trucks per week than other sites. The process flow map shown in Figure 1 illustrates the receiving operations at the current facility.

The warehouse under study has two entrances, namely a main entrance and a secondary entrance. The main entrance has two lanes and is operated by one check-in staffer, who obviously can only process one truck at a time.

The secondary access has only one lane and uses radio-frequency identification- based (RFID) automated processing for faster check-in. The trucks arriving with empty trailers are processed at the main entrance, and the trucks carrying materials into the facility are processed at the secondary entrance.

However, in case of an RFID failure, trucks carrying materials have to be rerouted to the main entrance for check-in processing, adding further congestion to the system. Once processed into the facility, each truck performs a different procedure (live load or drop-and-hook procedure) based upon the truck type. Upon completion, the trucks are scaled out (weighed) and can leave the facility.

Computer Simulation Model Visualizes Future Operations

To understand and visualize this warehouse's operations and quantify the impact of potential alternatives, we developed discrete event simulation models. Further, the DMAIC (define, measure, analyze, improve and control) methodology, a data-driven quality strategy, was used as a framework for systematic project management, as shown in Figure 2.

We extracted six months of data pertaining to truck arrivals and loading/unloading operations from the company's warehouse management system (WMS). These data were then processed, analyzed and fitted to theoretical distributions. A major challenge of this problem is modeling feasible scenarios to improve the existing modus operandi. Furthermore, the proposed alternatives must be easy to implement and have a short payback period. To do this, current warehouse check-in practices were studied.

Check-in practices can be broken down into manual and automated categories. Manual check-in procedures have a worker who processes each truck into the facility after verifying its details. On the other hand, it is a common practice to implement RFID technology at the entrance for automated check-in. Typically, RFID check-in processes are two to three times quicker than a manual check-in process.

However, it becomes complicated and expensive to install, operate and maintain the RFID tags for warehouses that receive goods from thousands of different trucks. Moreover, there is a probability of failure of RFID technology, which can be caused by outdated equipment, reflection of RF energy and fast-moving trucks.

We evaluated the strengths and weaknesses of the current check-in process by interacting with the warehouse staff (or subject matter experts) and developed different options that were feasible for improving the check-in operations. The alternatives can be grouped into two decision levels, namely, capacity management and queue processing. Capacity management deals with the addition of a new resource (or technology) or using current resources more efficiently, while queue processing decisions use priority rule to specify the order in which an arriving truck is processed.

We came up with three proposed alternative scenarios. Their descriptions follow, and the scenarios are in order of easiest to implement to most complex to implement.

Scenario 1. Hiring an additional worker: Two check-in staffers at the main entrance would let the facility use both lanes and process two trucks simultaneously, using the entrance's full capacity. This easy and quick solution does, however, add an additional worker's salary.

Scenario 2. Prioritizing trucks with the longest docking time: Trucks expected to spend the longest time inside the facility are prioritized first. For example, trucks that adopt a live-load procedure are given higher priority compared to trucks that use the drop-and-hook procedure.

Warehouse Management Needs a System

The importance of logistics to modern business operations is exemplified by the projected growth of the global warehouse management system market.

Valued at approximately $1.35 billion in 2016, analysts expect the market to grow by 13.5 percent through 2025, reaching a market value of $4.2 billion, reported the media website Digital Journal.

The need to constantly upgrade WMS software to make sure data remains secure, combined with regular maintenance, testing and software improvements, help drive the demand for these services, according to the website.

This alternative can be implemented by adding a staging area (unused land outside and near the facility) to hold and process the incoming trucks in order of their priority. Since the free time (i.e., time to hold a truck at the warehouse without incurring any detention fee) is almost similar for all trucks irrespective of their loading or unloading procedure, processing trucks with longer loading and unloading times first could reduce the average time spent waiting at the facility. This, in turn, reduces the number and amount of detention fees paid.

This solution is feasible but requires a staging area and additional investment, either staff or an automated queue management system for processing trucks based on their priority.

Scenario 3. Routing trucks to the entrance with the shortest expected waiting time: In this scenario, the trucks are routed to the entrance with the shortest expected waiting time. The processing speed of each entrance lane may vary depending on its check-in practice (manual or automated). Therefore, this scenario avoids the unbalanced utilization of the entrance lanes as well as reducing the truck waiting time.

Nevertheless, it requires a substantial initial investment to equip all the trucks with the required technology (e.g., RFID tags) as well as an automated queue management system.

Analysis and Managerial Implications

The simulation model for the baseline (current process) and alternative scenarios were developed and executed for 100 replications. The expected detention fee, greenhouse gas emissions and implementation costs are estimated to evaluate and compare the different scenarios.

Scenario one, hiring an additional operator at the main entrance, performs well with respect to all the measures analyzed in Figure 3. However, these improvements come at a cost. While this scenario does not require an initial investment, it requires a substantial variable cost of an additional check-in employee. Over the years, this variable cost will accumulate and is the major drawback of this alternative.

Similarly, scenario two, which processes trucks based upon priority, achieves the goal of eliminating waiting lines at check-in facilities when compared to the current operations. In comparison to all other scenarios, this alternative results in the longest waiting time to enter the facility and, in turn, emits the most greenhouse gases.

As mentioned previously, this alternative requires additional space for a staging lot to accommodate trucks as they wait to enter. The reassignment of currently owned land for staging will result in an initial fixed cost, as this staging lot requires an additional employee or automated check-in system to process the complexity of truck arrivals and priorities with warehouse operations.

Since there is a variable cost of $45,000/year associated with an additional employee, automation would be a recommended solution. An automated kiosk requires an initial fixed cost of $20,000 and needs little to no annual maintenance. Another factor to address is the learning curve of staff and truck drivers with the new automated technology. As a result, this system would require more effort than scenario one.

Scenario three performs marginally better than scenario one with respect to detention fee savings and greenhouse gas emissions. This is expected because the secondary entrance (RFID technology implemented) has a much faster processing time than the main entrance, providing the necessary congestion relief to minimize the waiting lines into the facility.

However, this alternative does not come cheap. It requires buying an RFID tag for every truck that would enter the facility in addition to a queue management system, which would route trucks to the entrance with the shortest expected waiting time. The queue management system has a variable cost of $12,000 per year, and RFID tags are approximately $20 per truck. RFID tags do have a price range, and the more expensive tags lower the chance of RFID check-in failure.

Since the tags must be purchased for every truck that will enter the facility, the initial investment cost of this scenario is high. Besides, implementing this scenario will be much more of a challenge than other alternatives because it requires the consensus of different shipping carriers who must adopt the RFID technology.

In conclusion, scenarios one and three, both dealing with capacity management, minimize the annual detention fees paid to carriers as well as greenhouse gas emissions. However, scenario one is a much more feasible solution in terms of initial investment cost, payback period and complexity of implementation. It significantly reduces the waiting time to enter the facility at the expense of an additional check-in employee. Scenario two, which proposes routing trucks into the facility based on priority, is the least preferred option to reduce annual detention fees paid to carriers and greenhouse gas emissions. Nevertheless, this solution provides the possibility of an automated system, which would eliminate the variable cost for the facility.

Scenario one would provide the best short-term solution since it is quick and easy to implement, and scenario three should be considered as a possible long-term solution. While the initial investment cost for scenario three is relatively expensive, it is highly scalable and can be implemented companywide. Also, automated technology may become more practical as years pass, making it more attractive.

This project illustrates how industry and academia can collaborate to bridge the gap between theory and practice as well as achieve mutual benefit. Students and researchers have an opportunity to use their knowledge to contribute to a reallife industry problem while enhancing their technical skills. On the other hand, industry partners get effective analytical solutions and hone their competitiveness by partnering with academic institutions.

Reference

https://www.iise.org/ISEMagazine/details.aspx?id=47414