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**Outbound Network Simulation for Staples, Inc.**

A Major Qualifying Project Report

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Degree of Bachelor of Science

By

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## **Abstract**

In this project, an Arena-based simulation model of Staples' current shipping process in Southern California was created and compared to a scenario with fulfillment center (FC) synchronization in which boxes were not processed until all orders for that day were received. Our simulation results indicate that FC synchronization is not a viable option given current incoming box volumes and processing times. This simulation model can be used as a baseline for evaluating other shipping alternatives in the future by Staples.

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# 1 Introduction

Since its start up in 1986, Staples Incorporated has grown into one of the most recognizable names in office supplies. Consumers ranging from the single home office worker to entire companies to the can purchase supplies at one of the local Staples retail stores, or order them online. This MQP will deal with the online orders and how they are transported from Staples to the consumer. More specifically, the outbound network that Staples relies on to deliver supplies from its FCs (fulfillment centers) to its SDOs (service delivery operations) was be defined, and analyzed in this project (Callery, 04OCT06).

The whole outbound network will not be analyzed, as WPI has neither the time nor the money to send its students to FC's and SDO's all over the country in order to gather information. Instead, only the Southern California network was modeled in a simulation program called Arena in order to find any potential cost cutting measures. Modeling this systems was a large part of this MQP, with consideration being paid to the following areas:

- FC Wave-Sort-Load – the three main phases that an order goes through in a fulfillment center. First, the orders are sent out in waves, and they are picked and put into boxes. Secondly, these orders are sorted by which SDO they are going to, and are finally loaded onto a tractor trailer truck.
- Line haul – the transportation from FC to SDO on a tractor trailer truck.
- SDO Sort-Load-Return – upon arrival to the SDO, the tractor trailer is unloaded, and the packages that it contains are sorted into specific routes for distribution from the SDO by smaller, more numerous trucks. After this, the smaller trucks are loaded up, and they go to their routes to deliver their packages (Callery, 20SEP06).

After the current system was modeled in Arena, a scenario which will be explained later called FC synchronization was tested to see if it is an improvement over the current process.

The reason that outbound network simulation is being done for Staples is because their famous one day delivery guarantee is directly affected by this network. If Staples' delivery system isn't efficient enough, deliveries will not make it to consumers on time. This is unacceptable for Staples as missed deliveries lead to frustrated customers who might decide to purchase their office supplies elsewhere (Plourde, 29AUG06). Outbound network simulation is also being conducted in order to find any new methods or processes that can make Staples' delivery service more profitable. Another reason why this simulation is being performed is to provide the two WPI students who are creating this report with practical experience.

By the end of this project, the authors gained experience in data collection and verification, simulation modeling and analysis, process improvement and of course, the general experience of dealing with a large company such as Staples. The WPI academic program stresses practical application of academic material learned in the classroom, with the MQP the final big step for soon to be graduating undergraduates (WPI, 2006).

The main function of the simulation is for Staples to receive a working and functional baseline model to be utilized for future projects with the Southern California network as well as gain information about the possibility of implementing a FC synchronization model.



## **2 Background and A Preliminary Study**

### **2.1 Corporate Profile**

Staples breaks its business into three segments: North American Retail, North American Delivery and International Operations.

North American retail is comprised of 1,539 stores throughout the U.S. and Canada. The typical Staples superstore is around 20,000 square feet and is complete with a selection of over 7,000 products, a Copy & Print Center, a UPS Ship Center, Build-to-Order computer capabilities as well as internet kiosks which allow customers to shop on Staples.com so no customer leaves without finding what they were looking for. Major cities like Manhattan, Boston, and San Francisco also have smaller store formats, called Staples Express (Staples, 2006).

North American Delivery is the segment that this project will be focused on. It encompasses Staples Contract, Staples Business Delivery and Quill. Staples Contract is Staples' fastest growing business. It serves both mid-sized and Fortune 1000 companies through Staples Business Advantage and Staples National Advantage respectively. Contract has "procurement contracts" with each company at the lowest total delivered cost to them. "For two years in a row, Staples Contract Division has been certified by J.D. Power and Associates for delivering 'An Outstanding Customer Service Experience'" . Staples Business Delivery is a combination of Staples.com and Staples' catalog businesses which serves small to medium sized companies. Staples' 29 fulfillment centers and fleet of 800 delivery trucks are a major part of what handles Staples Business Delivery. Staples.com has 45,000 products available to customers who can browse through in the comfort of their home or office.

Quill Corporation is an office supplies direct marketer which was acquired by Staples in 1998. Quill and Quoll.com are a separate brand which also serves small to medium-sized businesses. “Quill is known for top-notch customer service and highly effective marketing to vertical industries such as the legal, medical and educational professions.” (Staples, 2006)

Staples is now all over the world including Belgium, Germany, the Netherlands, Portugal, the United Kingdom, and China. The Chinese operations are based in Beijing and Shanghai, and include a retail showroom in Shanghai and its e-commerce site [english.oa365.com](http://english.oa365.com). It supplies many of the Chinese government departments as well as many companies with office supplies. Staples runs 262 stores in its European group. Some of those stores are under the name Staples Office Centre, which also has a delivery business (Staples, 2006).

## **2.2 Staples History**

The nest egg for the creation of Staples by Tom Steinberg happened over the fourth of July 1985. Tom’s printer ribbon had broken and unable to find a store that he could purchase one from, he came up with the idea for an office supplies superstore. Ten months later the first Staples retail store opened its doors.

Staples made it easy for the average consumer and small business to get office supplies at prices that prior to Staples inception were only available to large companies through contracts. In the two years following its opening many copy cat stores popped up around the country, but due to high competition from a few, only three remain today.

Today Staples has expanded from a retail-only corporation to offering catalogs, and e-commerce sites. These offerings are also available in a majority of the globe as Staples has gone international (Staples, 2006).

Staples has not only changed in terms of the media in which they offer their products and the places they are able to reach, they have also adjusted their goals. They are not only focused on price and selection, but have adapted to the fast-paced demanding world in which we live by making it easier for businesses to buy products. The stores are easier to utilize. The higher-demand items like ink and paper are at the front of the stores where people can easily find them. They also guarantee that they will have the type of ink or toner cartridge the customer needs in stock. Associates are schooled on how to make each customer's trip to the store as productive and quick as possible so they can get on to other things. As they say, their ultimate "goal – [is] for every customer after every purchase to think... Staples, that was easy". Up to this point that kind of focus on customer satisfaction has lent itself well to maximizing the bottom line. In 2005, Staples's profit reached \$16.1 billion (Staples, 2006).

### **2.3 Outbound Network**

A successful company is often distinguished from an unsuccessful company on how efficiently it gets its product to the consumer. Nowhere is this more applicable than in companies such as Staples, which promise next day delivery on office supplies purchased online. In order to achieve this promise, Staples must have an efficient shipping network capable of handling a great amount of volume in the shortest time

possible. This has been achieved by creating a series of FCs (Fulfillment Centers) and SDOs (Service Delivery Operations) that handle a customer's order (Plourde, 29AUG06).

### 2.3.1 Fulfillment Centers and Service Delivery Operations

When a customer places an order on Staples' website, the order is sent to the proper regional FC. At this FC, workers pick the ordered products in waves and then ship them to the more localized SDOs. These large trucks from the FCs are broken down into smaller trucks that have a designated route to deliver to (Plourde, 29AUG06).

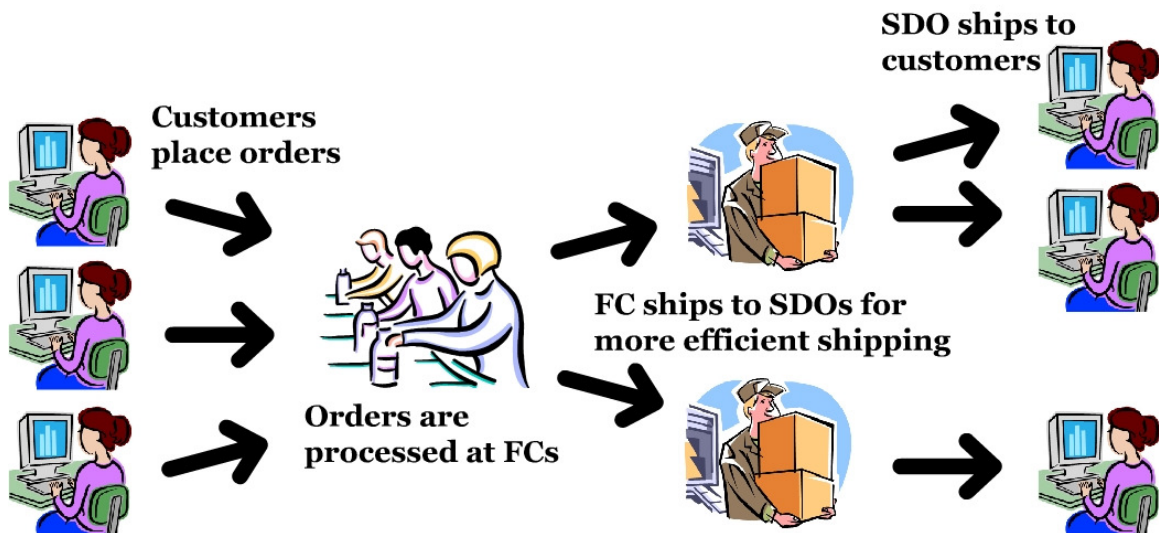


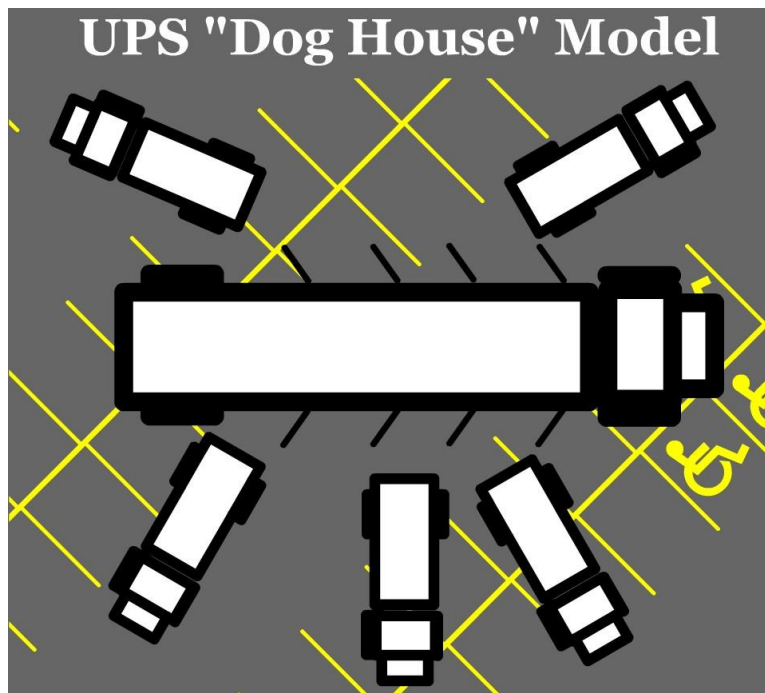
Figure 1: Staples order filling process diagram

Pallets are unloaded from trucks from back to front in SDOs that are essentially empty buildings.

### 2.3.2. The UPS "Dog House" Model

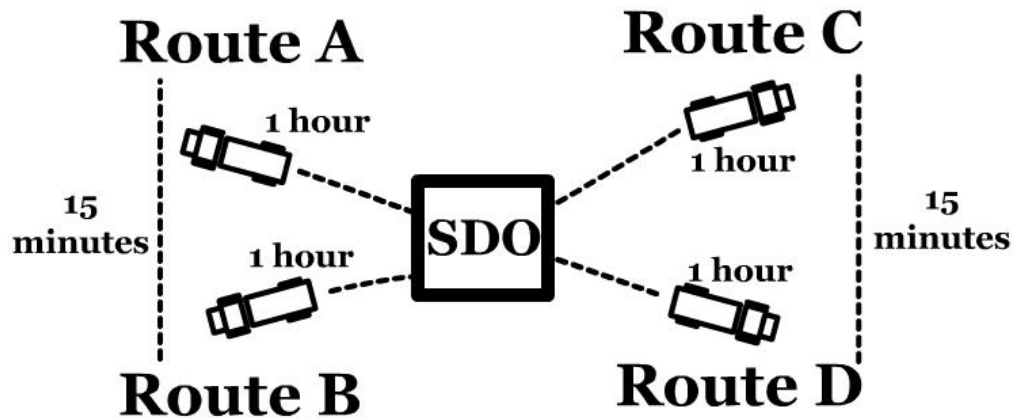
Part of the process in this project was nailing down the actual scope of the project. For the first month or so of this project's life, it was supposed to deal with considering the implementation of the UPS dog house model and simulating the operations with it in place.

UPS (United Parcel Service) currently utilizes trucks, which they call “Dog Houses,” that have side doors on the container. These doors allow multiple access points to the stored pallets versus the one entry and exit point and thus allow for easier access and quicker unloading. They also allow UPS to unload a tractor trailer virtually anywhere given that there’s enough space to perform the unloading. This means that UPS doesn’t need to rent empty buildings to perform unloading, and instead can move what is essentially a mobile SDO to the most efficient location for unloading. Such locations, such as a large parking lot, not only saves UPS the money that would have been used for a lease, but also allows Staples to be more efficient in their delivery routes.



**Figure 2: UPS doghouse model**

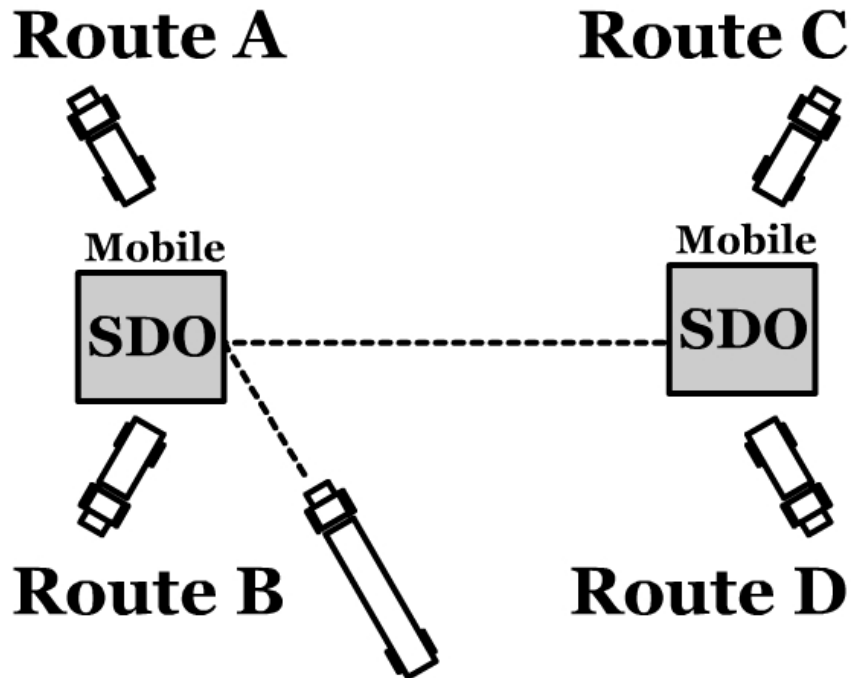
Let’s say, for example, that one particular SDO is in charge of four different delivery routes of equal significance. Each of these routes takes their drivers an hour to get to, and it takes 15 minutes to travel from Route A to B, and Route C to D.



**Figure 3: SDO location diagram**

Now, it would make sense to put one SDO between the two busy routes so the trucks only had to travel about 7 or 8 minutes to their routes, but in this case it is not economically viable, and one SDO must service the four routes. This may be because the money saved on fuel, maintenance on the vehicle, and the driver's wages doesn't outweigh the large amount of money that it takes to rent a building every month (Callery, 04OCT06). Realizing the potential to profit in such situations, UPS came up with their own model, which would allow the large truck driver to make stops to unload boxes on busy routes that are closest to one another.

In the UPS model, the amount of time that the smaller truck drivers would spend getting to their route would be significantly reduced because instead of going back and forth from SDO to route, the SDO would come to them. This decreases "windshield time" (time spent simply driving from location to location), gas costs and maintenance costs on the vehicle. Also, this method saves UPS from having to lease large buildings which were traditionally used to load and unload boxes.



**Figure 4: Movable SDOs**

Staples is in the process of testing such a concept to see if the potential savings could justify the cost invested for them (Plourde, 29AUG06). We were not involved in the testing of this idea, because it did not fit well into a potential operational change that could be simulated.

### **2.3.3 Visit to Putnam FC**

The Capstone project's focus is solely on their southern California network, but due to our location on the east coast, we observed the operations of the Putnam FC. The Putnam isn't exactly like any other Staples FC, including in Southern California, due to differences in the size of the building, location and number of orders processed. However, it is still a Staples FC and there are inherent similarities which we learned from observing in person.

The first thing that takes place when a customer's order is being processed at the FC is a pickticket is created which represents an order. The pickticket has the shipping

label on it. The computer system organizes the orders based on the carton size and the number of items in the order. It also sets when the waves (a wave is when a group of orders is printed and sent to the floor for processing) are to begin.

Next clothes pins are attached to the boxes which the orders will be shipped in. The clothes pins indicate the level of priority of the order. In descending order of importance, the colors are as follows: red, blue, yellow, green, and white. From there the computer system sorts the boxes to different parts of the warehouse based on what items are in the given order.

At this point workers “pick” by looking at a given box, and putting the appropriate items in the box. The worker is responsible for fulfilling their own work, as well as checking the work of the previous worker. Color coding is utilized again here to indicate the level of experience of the previous employees. Employees who have more than a year experience use blue or black ink, workers with less than six months use red, and employees who have worked for more than six months but less than a year use green ink.

At the end of the process line, quality control workers check the green and red inked work as well as the last picker if he/she isn't a green or red. Boxes that have mistakes are reprocessed. After this, the orders are put onto conveyor belts which sort by the destination, and the boxes are placed on trucks for shipment.





**Figure 5: The conveyor belt just before boxes are loaded onto the trucks.**

Restocking is taking place before during and after orders are being processed. Everyone assisting in restocking has a handheld scanner either in the truck, or on the floor. Each worker scans the item that they are restocking as well as the bar code on the spot that the item is going.



**Figure 6: Items that have been restocked**

### **2.3.4 Visit to North Reading SDO**

Much like the Putnam FC, the North Reading SDO isn't an exact representation of the SDOs in the Southern California network. We observed the operations of the

North Reading SDO, one of the more busy and efficient SDOs in the Putnam network. Although different in some ways, all SDOs are run based on the same principles delivering the same types of orders.

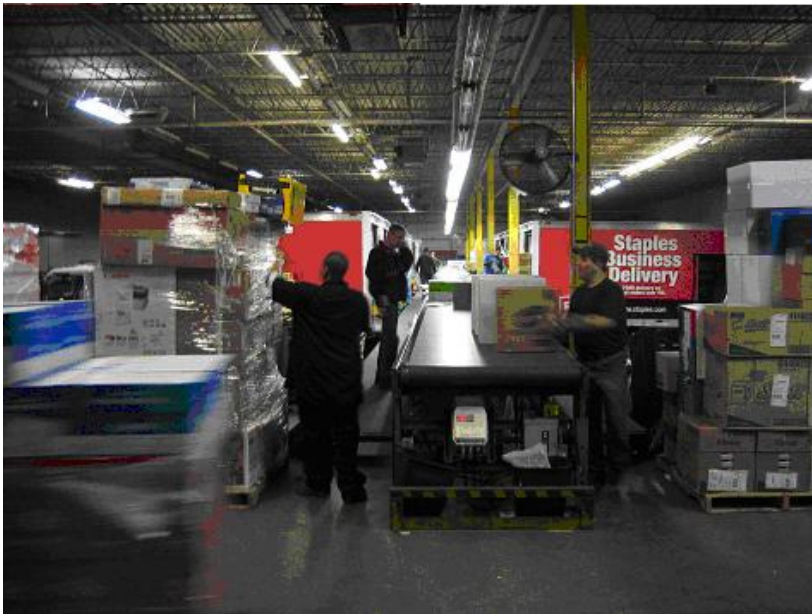
The North Reading facility handles both office supply orders as well as furniture orders, but our main focus is on the office supplies. In our simulation, we will be ignoring the furniture shipments in the Southern California network anyway. The furniture trucks are sometimes used to transport some of the office supplies if the given truck has time or is in the area when there is a particularly high volume of shipments to be made that day. The supply trucks make about 50-60 stops while the furniture trucks only make about 20.



**Figure 7: One of the delivery trucks at the North Reading SDO**

Between 8:30 and 9:00 a.m. each day the SDO gets volume predictions for the upcoming night. 60-70% of the boxes they get from Putnam are on a floor loaded trailer.

Previously everything was palletized; the new system allowed Staples to eliminate a line haul to North Reading, which saves time and money. There are roughly 800 pieces on each line haul, and each piece is scanned into the building, and then scanned again as it is going onto its truck.



**Figure 8: Workers processing boxes**

There are 25 trucks available to be used at the facility. Each worker loading the delivery trucks is responsible for 3-4 trucks. An entire Putnam delivery is processed in 45 minutes.

Route Optimization software is utilized after the orders are in to Putnam. Each driver gets a route when they come in, and he/she then goes about planning out the order of the stops they will make.



**Figure 9: Mailboxes where drivers get their routes**

The SDO terminal manager gets manager daily and weekly volume reports and reviews how the facility is handling the shipments and where they need to improve/adjust.

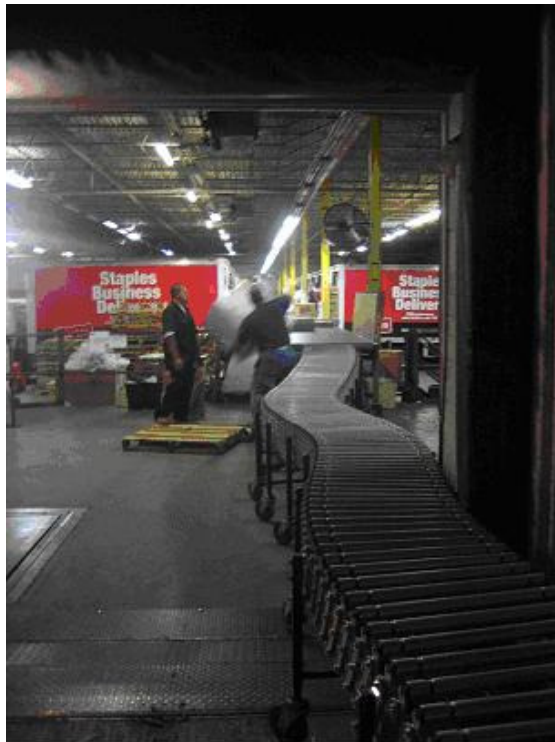
The drivers for the most part stick to one area of the northeast region. This allows them to familiarize themselves with the people they are delivering to, and the route itself. At times drivers are asked to cover for other drivers or go to towns they are not familiar with. The turnover amongst the drivers is much better than the workers inside the SDO, drivers have an 8% turnover rate whereas the other workers' is "atrocious". There are 49 associates, 30 drivers in North Reading. The drivers that leave the earliest are the ones with the longest "stem time" or time to their destination/shipping area. Drivers typically leave at 6:15, 6:30, or 7:00 a.m. each day. There are two delivery people per truck.

Besides the regular orders which come in from Putnam, the SDO has to deliver on average 10-14 pallets a day of paper to businesses. The North Reading SDO also ships for United, a company just down the street, but that is only about 2-3% of what they do.

There is a storage area where they keep some orders for customers if the customer decides that they don't want their order right away.

Another service the SDO performs is repackaging some of the products that show up in damaged boxes. Especially with the floor loaded line hauls, the bottom row of boxes gets damaged quite a bit. It "happens all the time" according to Bill Dunn. The drivers don't want to deliver anything that is damaged because many of the customers they are delivering to are regulars. So the associates will repackage the orders at the SDO.

At the current time the floor loading is not sorted in anyway until it gets to its respective SDO. The SDOs like North Reading have to sort based on what side the truck is on initially, and then as the boxes get onto the conveyor, they are sorted onto their respective trucks. Flex belts are used in the trucks to load and unload product.



**Figure 10: Flex belt that connects the line haul to the conveyor belt**

There are shelves in the trucks representing the different towns that the truck will be delivering to that day.

## **2.4 Process Description**

Staples guarantees next day deliveries for all orders placed before 5pm. This means that their process has to be highly efficient. The process starts with a consumer placing an order(s), which come in throughout the day. On a typical day, Staples gets 50% of their orders before 1pm. Orders drop at the FC that is responsible for the area that the order came from. At the FC, workers pick and pack the product(s) for the order. The shipments are ultimately shipped via Staples' own fleet of trucks, or by third party couriers. The major courier that Staples uses is UPS. Staples uses an algorithm to determine whether or it is less costly to ship the order via Staples own fleet, or a courier like UPS. Eighteen-wheelers take all of the orders from the FC, some go to courier Service Delivery Operations (SDO), some to Staples Managed SDOs (SMSDO). An SDO is a "cross dock" which is an empty shell where nothing is stored, but packages are readied to be transported. Once at a SMSDO, the trucks drive into or up against the outside of the SMSDO, to be unloaded by workers. The packages are then packed onto smaller delivery trucks that are usually inside the SMSDO. From there, the packages are on the way to be delivered to the customer.

## Staples SDO Model

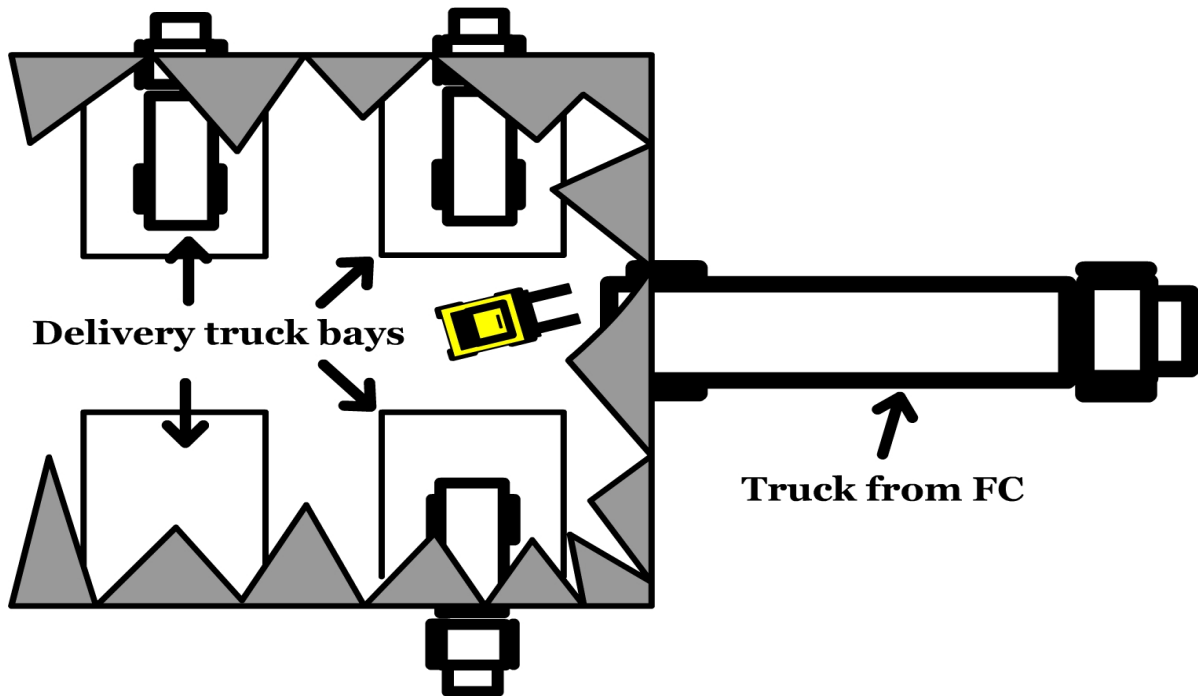


Figure 11: SDO Diagram

The shipment times are what drive everything in the FC, and the couriers become a priority in the afternoon into the evening because they are the first shipments to leave the FC. The departure times (cut times) of the eighteen-wheelers depends on several time constraints, the amount of time it takes to:

- get to the assigned SMSDO
- unload the eighteen wheelers
- load the smaller delivery trucks
- the amount of time it takes the delivery trucks to get to their assigned neighborhoods
- the amount of time it takes for the delivery trucks to complete their routes so that the customers get their orders the next day

Example:

Below is an example of the factors affecting the cut times. If trucks have to leave an SDO by 7:30am, an SDO takes 2 hours to unload a tractor trailer, and it takes 2 hours to get from FC to SDO, then that tractor trailer needs to leave an FC by 3:30am.

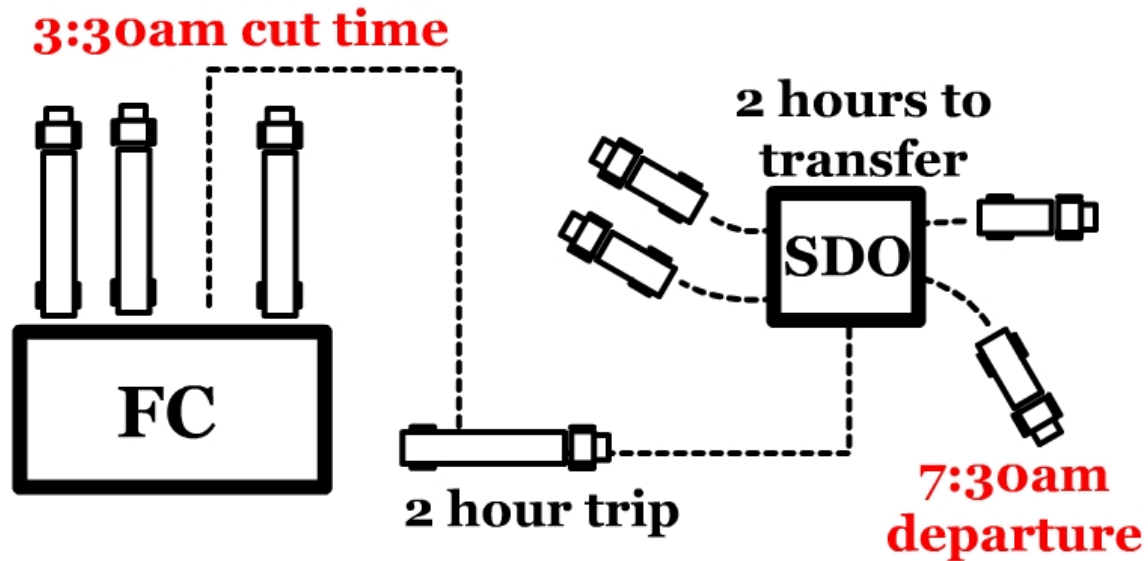


Figure 12: Outbound process map.

If a package fails to get into the tractor trailer by the cut time, then it is considered a “leave behind”, and Staples must call that customer and notify them that their package will not be there the next day (Callery, 04OCT06).

When cut time is approaching for example for UPS shipments workers focus on picking the UPS packages and putting them in the appropriate truck. In other words UPS becomes the top priority when its cut time approaches (Plourde, 29AUG06).

There are many different configurations of SMSDOs. Some have conveyor systems inside so packages can be moved mechanically and put on the appropriate truck. There are also a varying number of docks to which eighteen-wheelers can drive up to. Some SMSDO have the delivery trucks inside, some have them outside.



## **3 Literature Review**

### **3.1 Staples Supply Chain**

Staples has many vendors that supply them with their products, a list too long to mention. Since Staples is all over the country, they have contracts with different vendors in different regions to cut down on shipping costs. This also allows them to be able to order items and get them in a shorter amount of time than if the supplier was in a different part of the country (ContactCenterWorld, 2005).

Staples customer base is highly segmented and spread. “Staples has an extremely diverse customer base,” says Devon Whitney-Deal, customer service development manager at Staples. “The Staples customer service group receives several thousand inquiries each month. The customer feedback includes questions about products and services, suggestions, compliments, complaints, and other inquiries” (ContactCenterWorld, 2005). The company keeps track of their huge and diverse customer base by utilizing a tool called KANA, a software tool that manages the information as well as feedback of their customers. Staples customers range from massive corporations to individuals looking for small amounts of office supplies. Every ethnicity, and income level buys from Staples, since it is affordable, and everyone needs office supplies to conduct business (ContactCenterWorld, 2005)

Staples also employs CommerceHub, which is a “leading supplier of supply chain integration management solutions for multi-channel retailers” (CommerceHub, 2003). CommerceHub is a universal connection platform that helps Staples integrate its suppliers in an efficient manner, reduce its inventory costs, and therefore enhance its customer service.

One can imagine that if a company has many different suppliers, ordering appropriately can get very challenging, but with the help of CommerceHub, Staples adds new suppliers and interacts with its past partners effectively. "To meet our stringent inventory cost reduction goals and customer service requirements, we thoroughly reviewed several top supplier integration and order management vendors," said William Golden, Vice President Wholesale Merchandising at Staples, Inc. "CommerceHub clearly has the technology and team to help us achieve our objectives with our drop-ship suppliers, and we're very pleased to partner with them" (CommerceHub, 2003). "This new partnership also validates the industry's trend towards virtually owned inventory" adds Frank Poore, CEO of CommerceHub.

Staples, like many of today's companies realize that any inventory that is being stored in warehouse is not being moved, which means it is costing the company money. Thus Staples tries to have as little inventory as possible. Staples supply chain works in unison with the orders they get for their products. As the orders come in, Staples stays ahead by ordering their own products from their suppliers so that they will have enough to fill their customers orders. CommerceHub expedites this process so that it is as efficient as possible with applications that simplify order management and provide real-time visibility and control over transactions, so Staples can improve their fulfillment center performance, while reducing costs (CommerceHub, 2003).

### **3.2 A Description of Logistics and its Significance**

The characteristics of a company's logistical network are very different now than they were in the past. When discussing logistics, one can break it up into the three

general categories of warehousing, materials handling, and packaging. Nowhere are the differences more apparent than in that of the warehouse operations. The role of the warehouse used to be as a holding area for goods. Now warehouses hold products for the least amount of time possible. Companies try to stay ahead of their supply schedule, while keeping minimal amounts of products for an extended period of time. Holding goods stops the flow of goods, which costs money (Coyle, 2003).

Warehouses are very important for companies. They have many different functions that are essential to running a smooth operation. Their strategic locations allow for full truckloads of supplies to be sent reasonably short distances rather than having less than full truck loads to be sent long distances (which is obviously very inefficient).

Warehouses also centralize goods, which allow firms to have their varying product parts (product mixing) to be on hand in one place rather than having to fill orders from many different places. Cross-docking is something that Staples utilizes in their SDOS that facilitates product mixing. Products are brought to the building by trucks, and then instead of being put into storage, they are placed on appropriate trucks. Warehouses also prevent orders from not being filled by having inventory on hand and smooth in case of transportation delays, strikes, etc (Coyle, 2003).

The basic warehouse and material handling operations are receiving, put-away, order-picking, shipping, and storage. Receiving involves an inbound carrier that is supposed to arrive at a pre-determined time and drops the products off on the dock. The put-away is the process of taking the items and moving them into the storage area. Order-picking is the process of workers taking out the products ordered and placing them into a carrying container. Shipping is the last process in which the items are moving.

The items are moved from the staging area to the loading dock into a truck for shipment. The other warehouse operation is storage, where additional inventory is stored in a specified area of the building (Coyle, 2003).

The role of packaging is very significant as well in the logistics network. Packaging allows the handlers to identify what the product is inside, and where it is supposed to go. Packaging is also supposed to allow for safe handling. There are several other factors that a company has to take into account when deciding on packaging types. They obviously want a package to be efficiently handled, which means having an appropriate size, shape and weight. They want the package to be customer friendly, so the package should be integrated with the customer's material handling equipment (Coyle, 2003).

Overall, the logistics network is a very important function of the company because without it the company wouldn't be able to move its goods.

### **3.3 Characteristics of other Companies' Distribution Processes**

As mentioned earlier, Staples SDOs aren't always equipped with conveyor systems, which can be very beneficial for the company utilizing them, as Avon Product's Inc. found out. Avon ships a plethora of cosmetics, and had been using the same shipping dock conveyor system for 25 years. The system had trouble with large amounts of product, and could simply not handle some of the newer packaging mixes. An upgrade to the system was an obvious need.

Management's goals in installing a new conveyor system were to upgrade the technology so that it could handle new packaging mixes, reduce labor costs, and raise its

throughput from the current level of 55 packages per minute. Avon used the services of its long time partner, Tech Conveyor, who were briefed on Avon's goals, and its environment. Avon experienced much higher sales during the fourth quarter than any other quarter so it needed to be especially efficient and not slow down during this time of year.

The implementation began in earnest soon after Avon approached Tech Conveyor. Tech put in ArmorStart motor controllers, which can be placed on the machine it controls; this minimizes space requirements. The new system also included a DeviceNet network that allows for communication between the workers manning the controls. Tech Conveyor ended up installing 5,100 feet of new conveyor lines (MHM, 2006).

The results of the new conveyor system were better than Avon could have hoped. They increased their throughput to 120 packages a minute (from 55), and reduced the amount of space taken up by the equipment by 60%. These improvements resulted in fewer workers having to work overtime, a more flexible workplace, and as a result, the bottom line was helped. The material handling system at Avon is now much more flexible, efficient, and productive. Avon was so happy with the results, they plan to install new conveyor systems in their distribution facilities (MHM 2006).

Currently, Staples does not do a lot of sorting within their fulfillment centers. They sort based on what truck each order should go on, but they don't place those packages in any particular order inside the trucks.

A sporting goods company called Sport Chalet used a similar amount of sorting until recently. The sorting and picking processes of a company determine how fast it is

able to get products onto its stores' shelves. Sport Chalet's picking and sorting processes were lacking. "We used to send all footwear— men's, women's and kid's—all together on a pallet. It was a big hassle at the store level because a lot of it would go to the back room," recalled Steve Belardi, Vice President of logistics. "They were touching every carton. It was crazy." (MHM, 2006)

Sport Chalet has more than 40 stores located mostly in California, they are growing quickly, announcing plans to open 4-8 more stores within the next year. With \$350 million in sales, a figure which has grown by about 10% each year, Sport Chalet had to do something with their distribution to accommodate the growth. They decided to centralize several distribution facilities into one, huge 325,000 square foot distribution center in Ontario, California.

In addition to centralizing its operations, Sport Chalet overhauled its picking and sorting practices. Their goal was to have product shipped and packaged by the department in the retail store that they would be sold, so that products were ready to be placed on the shelf once they got to the store. They instructed their 110 permanent employees and over 60 temps at the distribution center to follow the new set of practices, which are:

- Computer system at the beginning of the day prioritizes orders for the stores being picked that day based on truck departure times.
- Items are separated by the department in the store that they will be in
- Workers go around with specially designed carts, six sections, each representing a different store

- The workers follow the info on the “RF” guns which scan boxes and give information on the destination of the box and the products that it should have in it.
- When a box is full, it is sent down the conveyor, and another box is picked up and filled with the appropriate products. (MHM, 2006)

The process is called continuous batch picking, and has resulted in higher efficiency, in fact a 12-13% improvement. "We're very efficient at picking because we're not wasting much motion. Once we go through the pick path, we're basically picking everything that's needed for those six stores," says Belardi. "In the old world we had to do six walks up and down the aisle." (MHM, 2006)

### **3.4 Process Improvement**

Process Improvement is the goal of this project as well as the goal of many objectives run by companies throughout the world every day.

“In today's global business environment, being efficient and providing quality products and services are vital to staying competitive. Companies must eliminate inefficiencies, monitor productivity, and continually improve their operational performance in order to keep pace” (Hedrick, 2007). There are four components to operational improvement: optimized processes, labor standards, training, and productivity tracking software.

Over time, processes tend to grow and those running them don't change them because they worked fine before the increased production, why change? Bottlenecks and delays result from this lack of change, which slows workflow and process times and drives up costs. Companies don't achieve optimal productivity levels and have higher operating cost for that reason.

Optimized processes help companies:

- Reduce costs
- Eliminate non-value-added steps
- Raise quality
- Improve workflow
- Increase productivity (Hedrick, 2007)

Setting good and fair labor standards is the next step in process improvement. Engineered labor standards are a scientific method of providing fair and reasonable productivity quotas. Creating these standards encompasses measuring different work functions and using workload information to determine reasonable completion times.

When developed properly, labor standards provide:

- Quantifiable productivity measurement
- Unbiased quotas
- Foundation for effective incentive program (Hedrick, 2007)

To determine and implement labor standards, time studies need to be conducted with operators that perform their jobs every day. Gained from this are precise time standards for completing tasks. “Labor standards help companies to measure all workers on an equal footing and provide management with the means for effective performance measurement, feedback, and incentives programs” (Hedrick, 2007).

It is important for companies to provide associates with adequate training to achieve the productivity standards by which they are measured. Proper training helps



employees to achieve their productivity quota and provides them with the ability to sustain the desired level of productivity over time. Training also provides companies with:

- Quality and productivity improvement
- Consistent results
- Ability to sustain performance (Hedrick, 2007)

Productivity tracking software is used by almost every major manufacturing company in the United States (including Staples). Now, more than ever, companies are looking for ways to do more with less. “Effective measurement and reporting are essential components of any productivity improvement initiative and are the foundation for effective accountability and incentives programs” (Hedrick, 2007). Many tracking software packages, allow users to track performance for areas such as productivity, quality, training, safety, and attendance. Some of the benefits of using productivity tracking software is:

- Cost reduction
- Time savings
- Performance visibility for multiple facilities and departments
- Quality improvement
- Improved labor scheduling
- Ability to use discipline, rewards and incentives programs (Hedrick, 2007)

These solutions deliver improved productivity and quality, reduced costs and increased profits.

Designing new processes and altering the existing ones is part of today's business environment. Companies have to keep changing to stay competitive and to deliver on their promises to their customers.

Process Improvement is usually applied bottom up: existing processes are mapped and ways to eliminate waste, re-work, duplication, hand-off are developed from that. Re-engineering is usually applied top down: setting ambitious processing targets in support of new business models. The final management decision balances "risk against deliverables all set within the context of business environmental imperatives"(Checkland).

### **3.5 Simulation**

"Simulation is a modeling and analysis technique used to evaluate and improve dynamic systems of all types. It has grown from a relatively obscure technology used only by a few specialists to a widely accepted tool used by decision makers at all levels in an organization." (Harrel, 2000)

Simulation can be an extremely valuable tool for large companies such as Staples, depending on how effective the simulation is. Different simulation programs, models and consultation firms offer a variety of services and a corresponding price tag. If you want to model a process that's happening inside a manufacturing plant, an AutoCAD plug-in such as FactoryCAD could do the job adequately. (UGS, 2006) If you want to model the effect of implementing a new transportation network on a company that operates on a

global scale, you would have to invest more time and money for an accurate simulation (Progress Group, 2006). Choosing the right simulation means finding a service or product that both meets your expectations for finding possible outcomes and saves you money in the long run. There are a host of simulation programs and services available to companies such as Staples, but for the task at hand, we are going to use a program called Arena.

### **3.6 Arena**

Arena was designed to model systems, which can encompass any group of actions that are all somehow related to each another. A local supermarket could be its own system or an entire airport could be a system, it all depends on how many details you want to include. These systems can be represented in either physical or logical (mathematical) models (Kelton, 2007).

A physical model is tangible, and somehow simulates the different processes within a system. Physical models can range from scale models of facilities to simulated cockpits which serve as flight simulators. A logical model on the other hand, can be a computer simulation program that does the calculations with mathematical formulas. Arena would fall into the latter category (Kelton, 2007). These types of programs operate on a variety of rules, formulas and scenarios that a user can determine in order to achieve the best simulation for the given system. According to Arena, there are three dimensions by which simulations can be classified:

- Static vs. Dynamic – time does not play a factor in static, but does in discrete models.

- Continuous vs. Discrete – the state of the system in a continuous system can vary continuously over time, while a discrete model only has certain points where changes can occur.
- Deterministic vs. Stochastic – a model with a strict set of inputs is deterministic, while stochastic models at least have some inputs that are completely randomized (Kelton, 2007).

Determining which simulation is needed can be determined by looking at the system that's being modeled. A system that involves the natural world would be continuous due to all the random events taking place, while a system of a manmade facility object such as a warehouse that operates on specific times (start of the work day, scheduled machine maintenance, etc.) could be discrete (Kelton, 2007).

Arena is extremely flexible and allows for the above scenarios to be implemented in a system. The program itself is hierarchical: you can do anything from code your own formulas in C++ at the lowest level to utilize commonly used constructs and templates for different types of companies at the highest level (Kelton, 2007).

## **4 Methodology**

### **A term:**

- visited the Putnam FC and observed operations there while at the same time hearing about what type of operation was going to be simulated
- reviewed past Staples MQPs paying special attention to the outbound network
- received the student version of Arena and began learning basic modeling techniques and some of the nuisances of Arena so we would be as prepared as we could be for modeling the actual process when the time came

- Gathered background information on staples, simulation, the ups “doghouse model” and logistics

**B term:**

- continued working with student version of Arena while waiting for professional version to arrive
- Visited the Putnam FC once again for a more focused tour of the outgoing packages
- Also visited the North Reading SDO
- Gathered data of the Putnam network
- Project scope was changed to a different area of the country (southern California) and topic (FC synchronization) rather than UPS doghouse model
- Gathered data for the Southern California network and began analyzing the data sets to determine averages, distributions, or schedules

**C Term:**

- Continued gathering and analyzing data
- Researched process improvement
- Simulated the baseline model (see section 5 for description) as well as FC synchronization
- Analyzed the simulation results

## **5 Simulation and Results**

### **5.1 Baseline Model**

A baseline model of the current process by which orders are created, assigned to delivery routes, processed at the FC, line hauled to SDOs (Hubs), and sorted and loaded

by route onto delivery trucks was used to compare against a different scenario of FC Synchronization (Eddy, 08DEC06).

For all of the inputs in the model, data was accessed and analyzed by the MQP group or by Jim Callery and Victoria Eddy. Either a distribution, an average, or a schedule was taken from the analysis and for the averages a standard normal distribution was assigned. There are many inputs/simulation processes incorporated in the baseline model. They are as follows:

1. **Box Volume** – The number of boxes to be processed on a particular day – To be modeled with a normal distribution and input parameters determined by analysis on Box Count Data. The box count data is a huge spreadsheet with box volumes for every half hour of the day. Two weeks of data is represented.

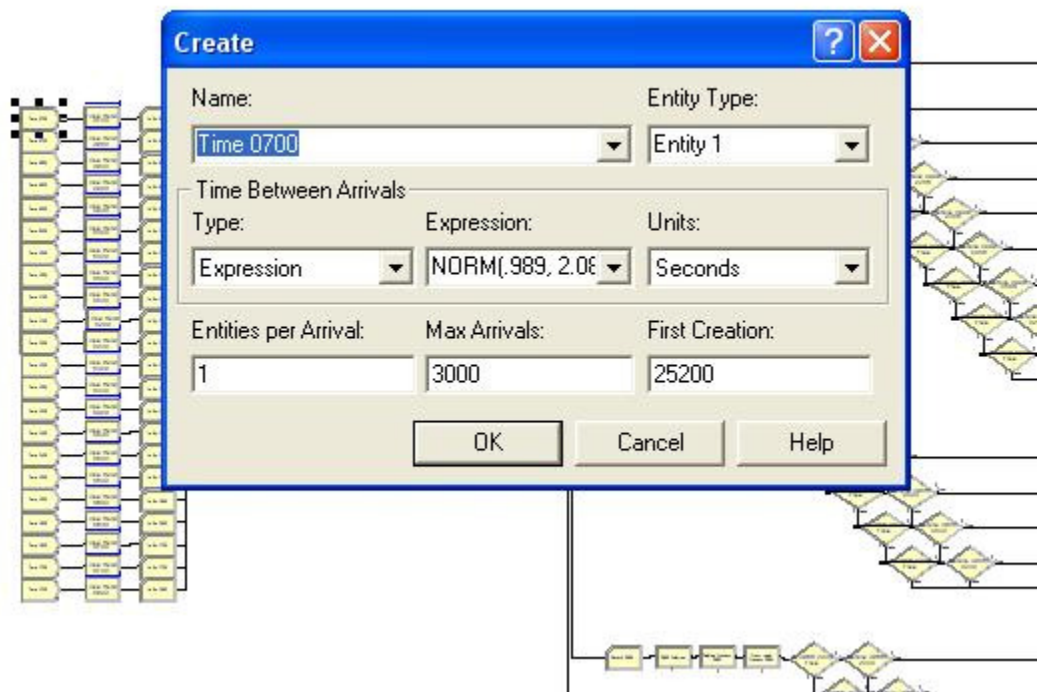


Figure 13: A screenshot of the box volume input parameter selected in Arena.

2. **Box Create Time** – The time of day each box is first available to be processed in the FC – Distribution on “BP Total” data provided by Ontario, California FC. Boxes available will be set to zero during “off production hours”. During production a multinomial distribution is used to determine which hour/half hour of the day each box first becomes available. Parameters based on the percentage of boxes that were available throughout the day in the Ontario data set. The chart below shows a graph of the data used. As one can see, before the production time, the average number of boxes available is less than 7.5, during production its more than 7.5 and less than 18, and after production its greater than 18.

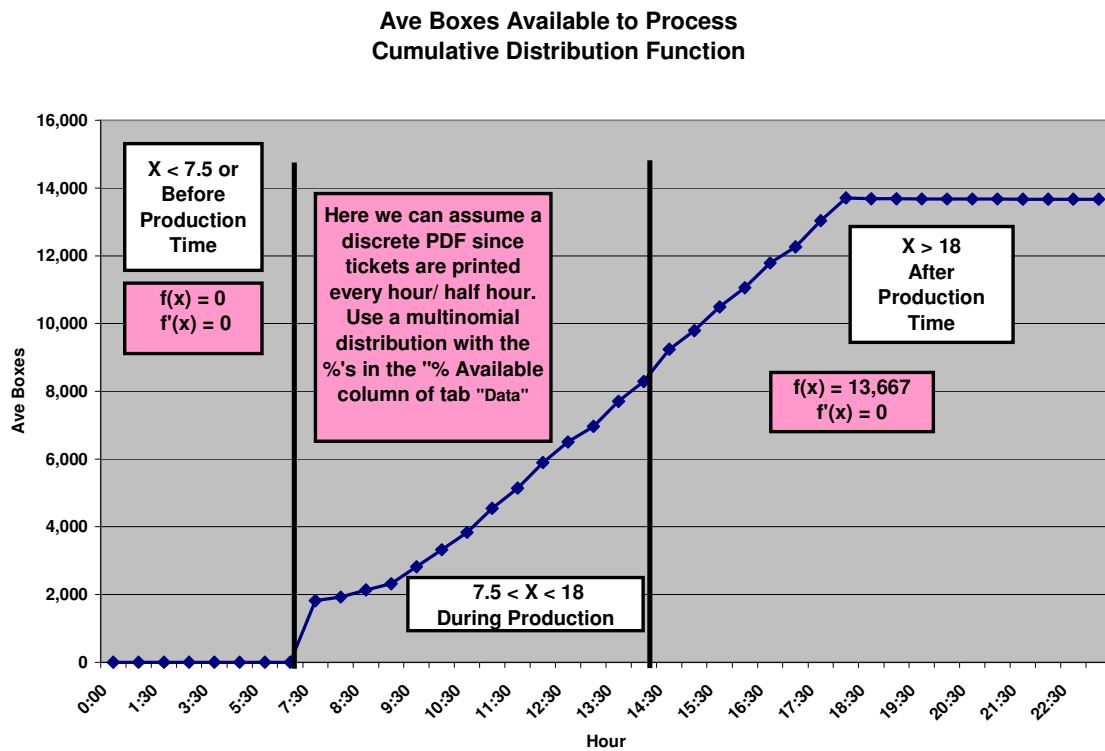


Figure 14: Box create time graph.  
(Eddy, 08DEC06)

3. **Hub Assignment** – Designates which hub boxes for each order must travel to. Multinomial distribution is utilized with % chance that a given order will be assigned to a particular hub/SDO, the percentages are based on historical data. The data source is again the box count data. The averages were assigned as follows: 27.04% for Ontario, 10.36% for Glendale, 9.31% for San Diego, 22.68% for Fullerton, 14.54% for Phoenix. Ontario is an “embedded” SDO, which means it is attached right to the Ontario FC.

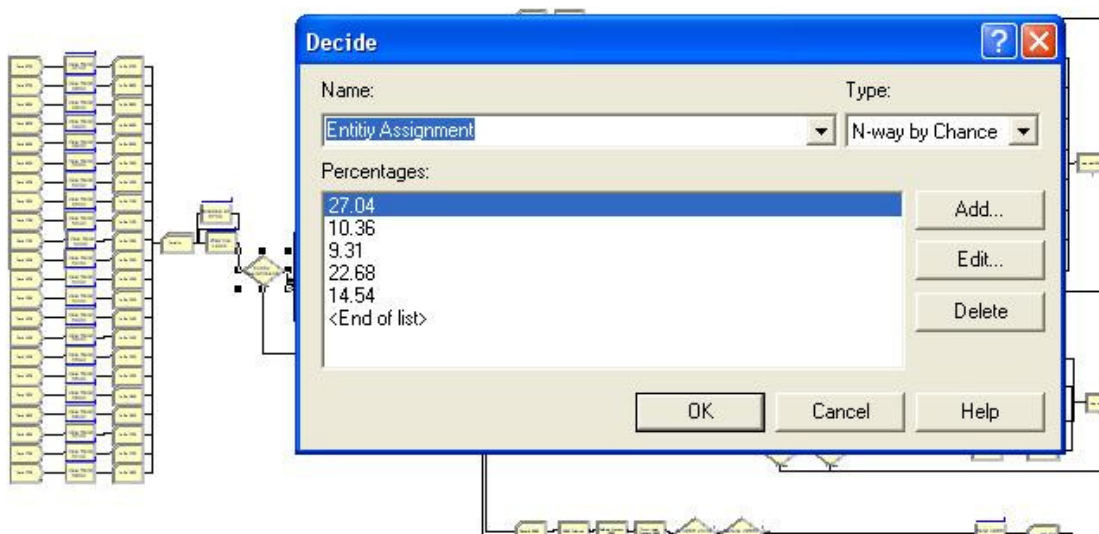
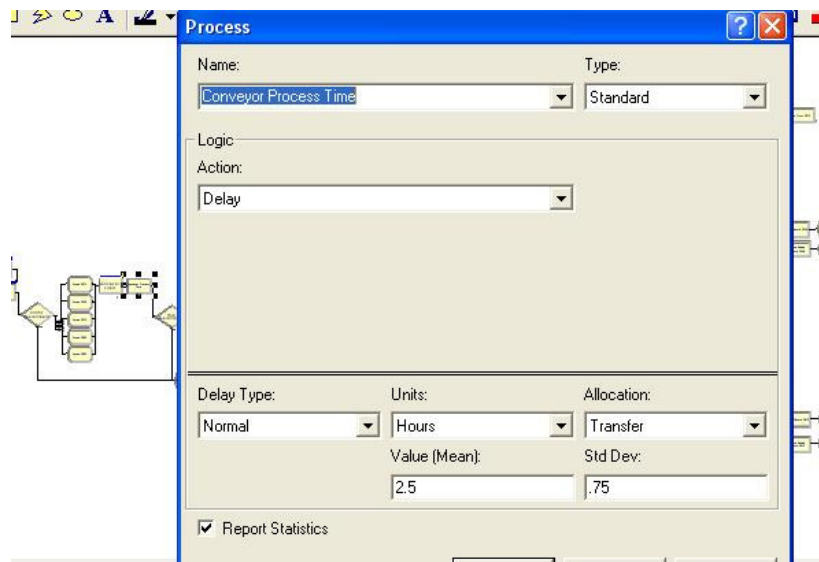


Figure 15: The hub assignment input parameter selected in Arena.

4. **Conveyor Process Time** – Cycle time for each box from induction onto conveyor to exit of shipping lane. 2.5 hours with a .75 standard deviation was the average used based on data from an Atlanta FC simulation (Atlanta is similar to Southern California) which the group did not have direct access to. The conveyor has a



maximum capacity.

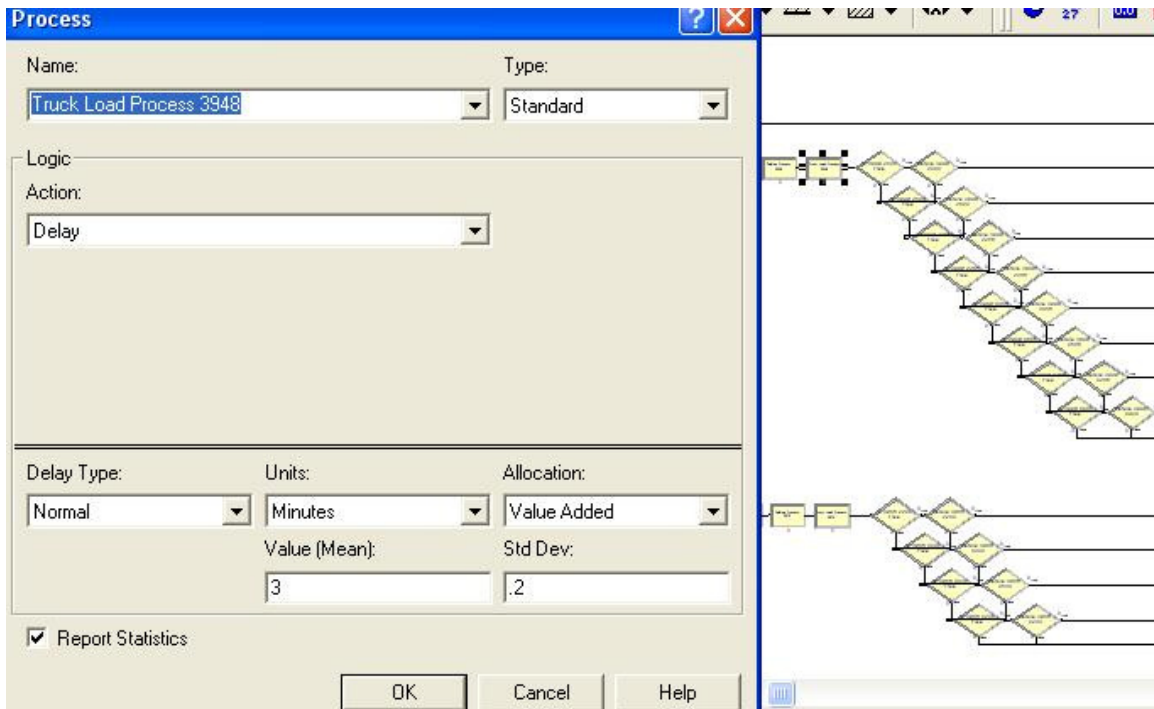


**Figure 16: Conveyor Process time selected in the model. The input adds time to the total and holds up the boxes in the system.**

5. **FC Sort** – Process time for boxes to be sorted and palletized by route at the FC.

For the baseline model, the time is set to 0, since all sorting will be done at the SDOs. FC sort allows for the pallets to be put onto the trucks in negligible amount of time at the SDO since all the sorting is already done.

6. **FC Load** – Process time for boxes to be loaded onto line haul. For both the baseline model and FC synch a 3 minute average was used as the time to load, with a standard deviation of 12 seconds.



**Figure 17: Truck Load Process screenshot from Arena.**

7. **Line Haul Travel Time** – Time it takes each line haul to reach the designated SDO. Constants were determined from looking at schedules and arrival times over a 3 month period for each SDO. 40 different trips for each SDO from the FC to find a constant that was accurate.

21-9985

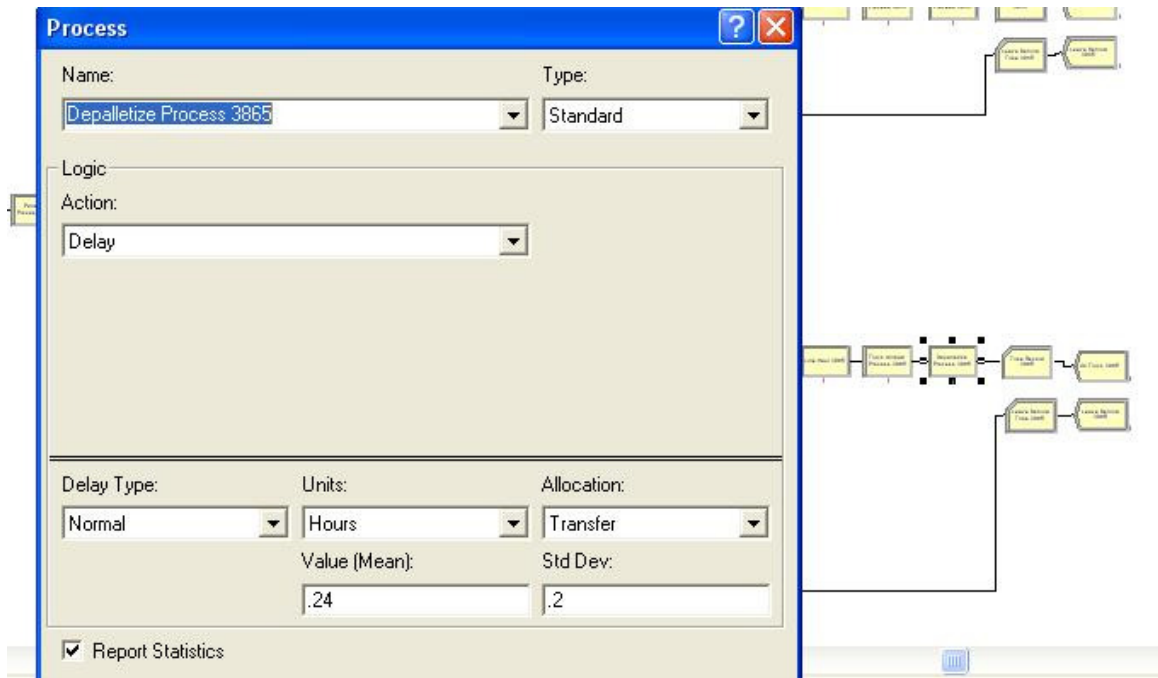
## Driver Schedule

osser@teamscully.com

SDO	Destination GLENDALE FULLERTON	Departure Times			Arrival Times		
		Driver @ FC		Actual	Plan	Actual	On-Time
		DEPART	CERR	2015		2045	
		DEPART	CERR	1645		1700	X
3948	Glendale #1	2015	2145	2100	<del>2245</del>	<del>2200</del>	X
3865	Fullerton #1	1930	2145	2115	<del>2230</del>	<del>2200</del>	X
3948	Glendale #2	1930	2215	2200	<del>2315</del>	<del>2300</del>	X
3865	Fullerton #2	2145	2230	2245	<del>2315</del>	<del>2330</del>	X
3948	Glendale #3	2245	2345	2359	<del>0045</del>	<del>0100</del>	X
3865	Fullerton #3	2315	0045	2359	<del>0130</del>	<del>0045</del>	X
3948	Glendale #4	2330	0015	0030	<del>0115</del>	<del>0130</del>	X
3865	Fullerton #4	0015	0100	0125	<del>0145</del>	<del>0215</del>	
3948	Glendale #5	0115	0245	0215	<del>0345</del>	<del>0315</del>	X
3865	Fullerton #5	0215	0245	0250	<del>0330</del>	<del>0335</del>	X
3948	Glendale #6	0215	0315	0300	<del>0415</del>	<del>0400</del>	X
3865	Fullerton #6	0245	0345	<del>0400</del>	<del>0430</del>	<del>0445</del>	X

Figure 18: A sample of the data used to determine line haul travel times.

8. **SDO Sort** – Process time for boxes to be unloaded and sorted by route. For the FC synch scenario, it will be set to 0, since all sorting will be done at the FC.
9. **SDO Load** - Process time for boxes to be loaded onto delivery trucks. In our model, this is actually represented by the unloading of the line hauls and depalletization process. The time for loading the trucks is enclosed in those two inputs. Parameters for this distribution in reality vary by SDO based on the process of the SDO. (Configuration of the building, conveyor vs. no conveyor, material handlers on staff, number of trucks that can be loaded at one time).



**Figure 19: SDO Load**

However, to simplify things an average time of .5 hours with a standard deviation of .2 hours was used for the unloading of the line hauls and a .24 and .2 respectively for depalletization, which are the two inputs that make up the models load process at the SDOs.

## FC Baseline Simulation Process Map

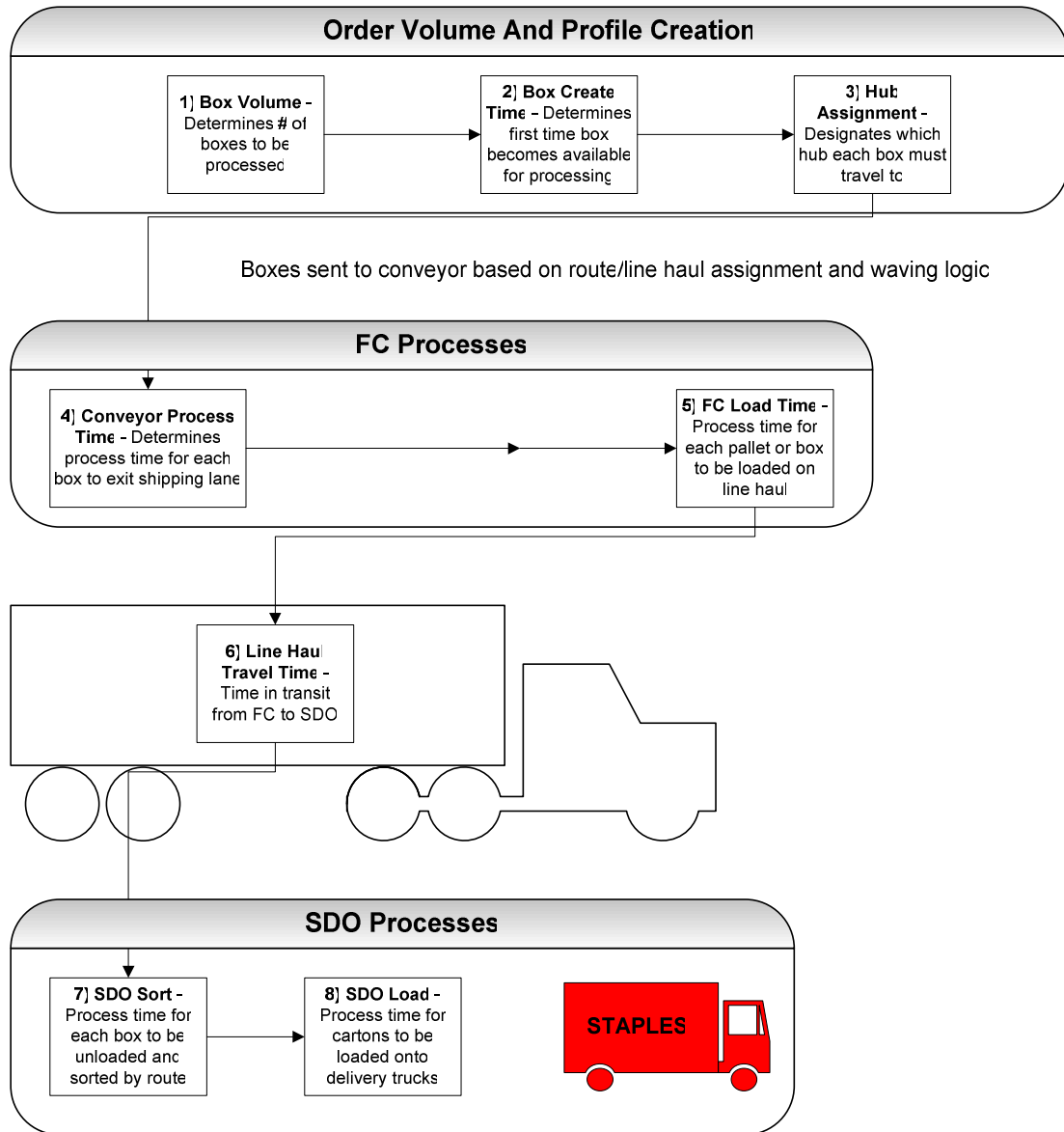


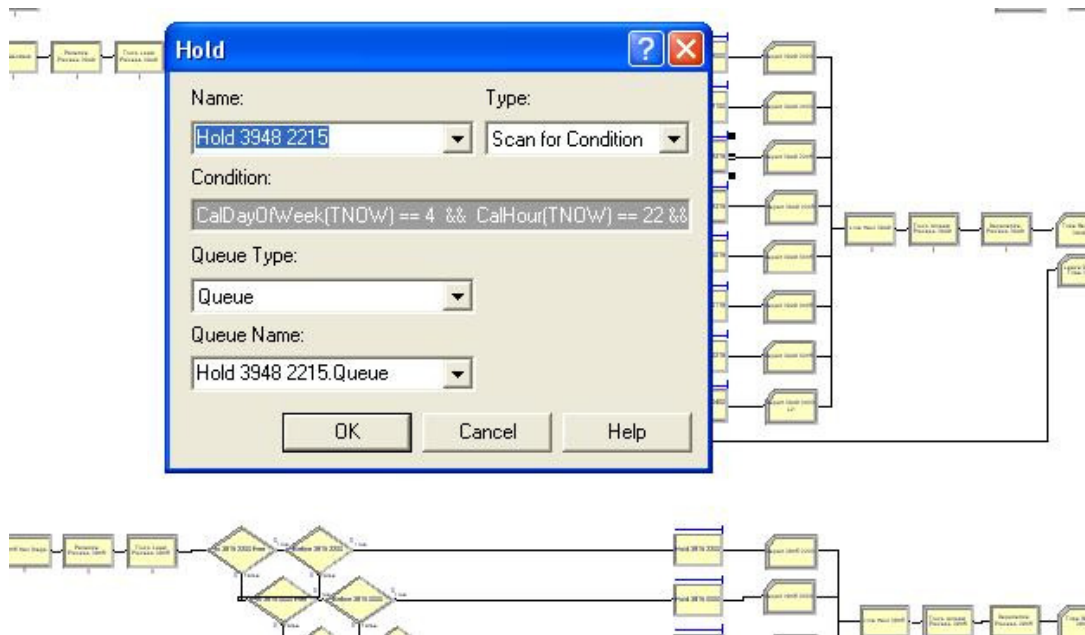
Figure 20: A process map of the baseline model summarizing the inputs.

(Eddy, 08DEC06)

### Other Model Inputs:

- **Hub Cut Times:** Time at which a designated line haul must depart the FC en-route to the designated SDO. The cut times follow the schedules that were looked

at for line haul travel time. An average schedule was determined and used for the model.



**Figure 21:** This shows the hub cut times: 3948 is the SDO and 2215 is the time that the truck will for that SDO.

- **Boxes Per Pallet** – The average number of boxes per pallet was set at 45. This number was chosen by Jim Callery based on data that he looked at.
- **Pallets Per Truck** – The number of pallets per truck was determined to be 20. Therefore the maximum number of boxes on a truck is 900.

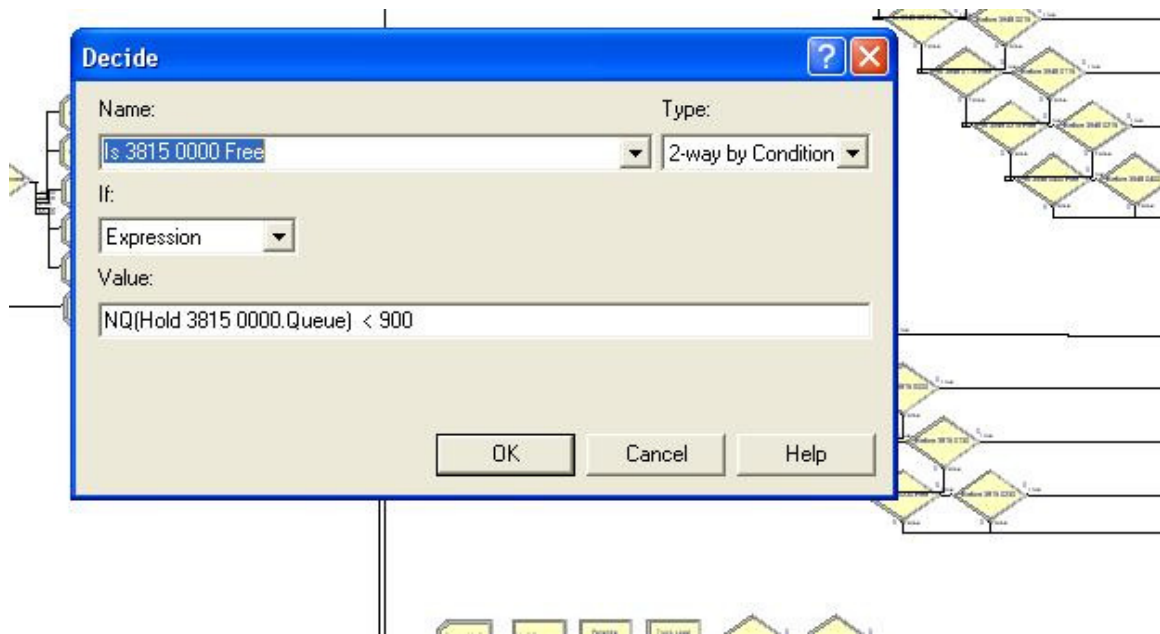
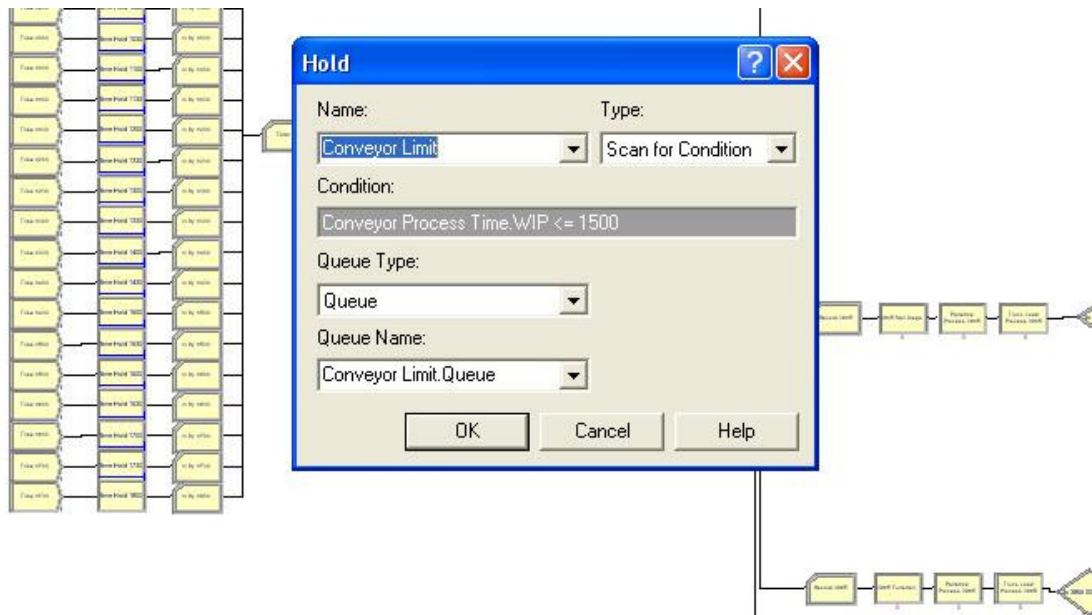


Figure 22: A decision module: when the given truck fills up to 900 boxes, the orders go to the next truck.

- **Maximum Conveyor Capacity** – Every conveyor system in the FC’s has a “magical number” of boxes such that any increase beyond this number significantly increases the chances that the conveyor will jam. For this simulation the number was set at 1500.



**Figure 23: Maximum conveyor capacity module**  
(Eddy, 08DEC06)

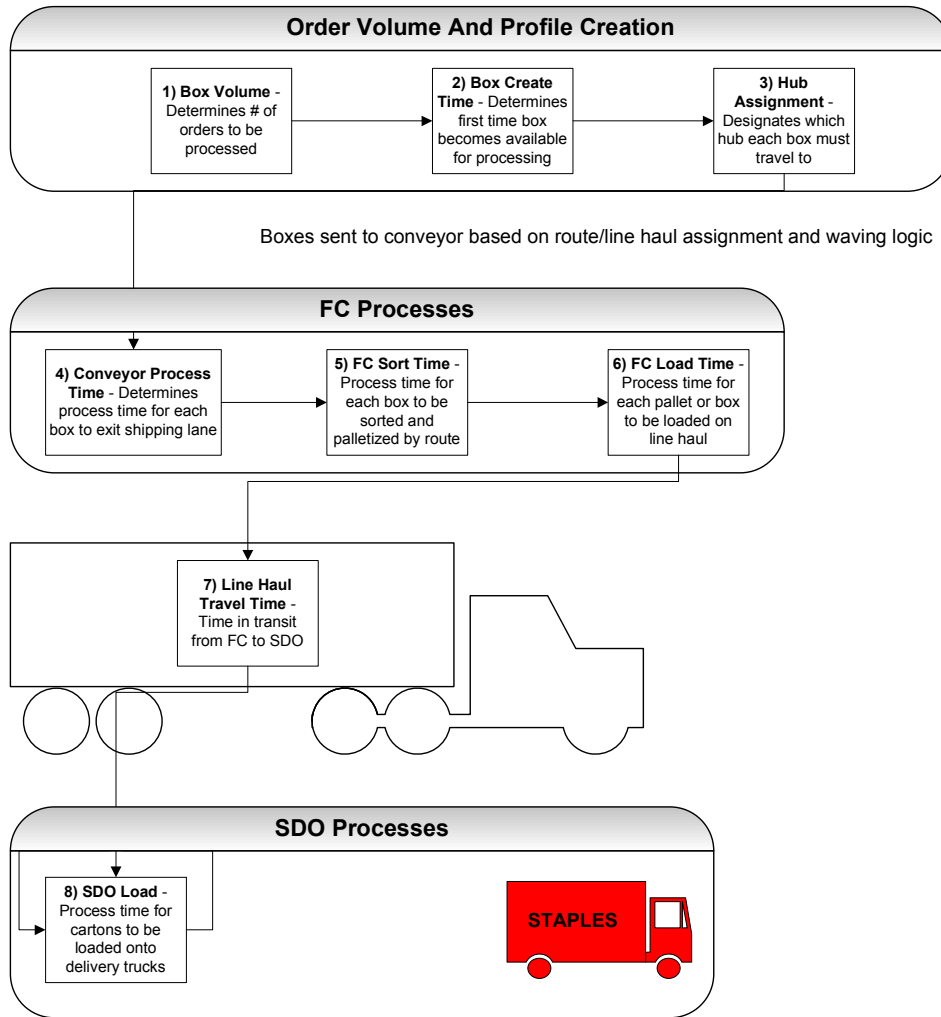
## 5.2 FC Synchronization

The scenario that we compared the baseline model to as already mentioned is FC synchronization.

In the FC Synchronization scenario, no orders are processed until all orders to be processed that day are received (5 pm). Orders are then be assigned to routes in order to optimize load balancing. Once assigned routes, orders can then be processed on the FC conveyor. Upon exiting the FC shipping lanes, boxes are then be sorted and palletized by route. Sorting by route at the FC saves time and space requirements at the SDO's and eliminates last minute load balancing, while promoting better driver productivity. (Eddy, 08DEC06)



## FC Synchronization Simulation Process Map



**Figure 24: A process map of FC synch summarizing the inputs.**

### Model Output

For both models, the output measure was the number of leave behinds. Leave behinds was chosen because it is a great measure of the efficiency of a given process. Every leave behind represents an order that is not filled, and potentially an unhappy customer that will think about switching office suppliers. The number of trucks that left

on time was considered, but in the end it was decided that all trucks would leave on time with or without full capacity.

### 5.3 Results

The results for our simulation were not unexpected. They show that the baseline model where boxes are being processed throughout the day is much more effective than the FC synch scenario where they aren't being processed until all the orders are in at 5 pm. The charts below summarize our results in terms of the number of leave behinds for each of the non-embedded SDOs.

#### Baseline Model

SDO	Average	Min. Average	Max. Average
San Diego	22.9667	10	40
Fullerton	1.8333	0	8
Phoenix	34.4667	19	51
Glendale	0.6333	0	3

**Table 1: Baseline Model**

#### FC Synchronization

SDO	Average	Min. Average	Max. Average
San Diego	453.33	389	521
Fullerton	855.3	764	953
Phoenix	693.13	626	766
Glendale	748.33	626	815

**Table 2: FC Synchronization**

One thing that is interesting to note is that the two SDOs with the lowest number of leave behinds in the baseline case have the highest number of leave behinds in the FC synch case. This is because they are the smaller SDOs, they are less equipped to handle a lot of orders. When you hold the orders to be processed until 5 pm, it forces them to try and process a lot in a short time and they simply can't handle it.

The number of leave behinds was the only output measure we used because of the assumptions that we used. We might have used the number of trucks leaving on time if we had more time to do the simulation. As it was, we assumed that all trucks would leave as scheduled, and that any boxes that didn't make it onto the trucks were considered leave behinds unless they were put onto another truck going to the same SDO.

As was already said, the results were not unexpected due to the fact that the baseline model has a huge "advantage" over the FC synch since it starts processing boxes first thing in the morning rather than at 5 pm. The FC synchronization model does show how close Staples would come to being efficient if they did try such a thing- that is, not close at all.

## **6 Conclusions and Recommendations**

Our conclusion is fairly simple: FC synchronization is not a viable option for Staples based on our simulation in the format that we utilized it. However, the model that we created is not worthless just because it didn't discover a better way of operating yet. "Yet" is the key word, because Staples can now use our approach and the work we put into building the model. They can build a model with software that they support based on our assumptions, inputs, and process mapping with their own software and take it further to try new scenarios and make alterations to the model and see how it reacts.

For example, the cut time for all orders could be moved up from 5 pm to 3 pm or earlier to see if that will decrease the number of leave behinds. 5 pm is the current time at which Staples guarantees next day delivery. Changing such a time would ultimately change the demand curve for Staples, and could negatively impact their business. If a person wants to make an order at 4pm and they can't get it next day from Staples, but they can get it from some other company, they could bring their business to that other company. Therefore we suggest that Staples offer some sort of extra incentive to order before the chosen cut off time, like a discount. The feasibility of this suggestion would have to be tested, and surveys should also be taken to gauge the reaction that such a change would create from the customer base.

There are several other things that Staples could test to see the impact with a model like ours. One of them is seeing how much increasing the conveyor capacity and cycle time. In other words increase conveyor productivity, and then calculate if the benefit is worth upgrading the conveyor or hiring more workers to work it.

Changing the line haul schedule and route waving is another scenario that should be considered. Changing which routes are processed first at the FC and the schedule of which hubs/routes the shipping lanes are dedicated to throughout the day can have a great impact on the number of delivery trucks that are completed by their scheduled departure time. For example SDO's with extremely long line haul travel times may need all of their routes/line hauls processed in the first wave of the FC in order for their delivery trucks to be completed on time.

The demand curve and cut time are examples of constraints. Our project centered around simulation, which is often used just as an information tool rather than a step

towards implementation. Staples goal for our project turned into them wanting us to build a functional model for them to be able to use in the future for other considerations. For this reason, we did not have many constraints in our project. Staples is a giant company that is doing quite well with tons of capital, so any project that they choose to take on that will be beneficial for the future for the most part they can afford.

Our project did center around one specific area which was deemed a possibility for FC synchronization by the people at Staples. However, it is possible that without this constraint, had we chosen a different region for our simulation, that with a different cut time, FC synchronization would be a viable option. The Stockton, London and Charlotte networks were all considered originally when deciding what network would be the most appropriate to simulate, so another suggestion we would make is for Staples to simulate these areas as well with different cut off times.

Another decision made for us at the outset of the project was the type of software we would use. Arena is a highly functional and effective simulation tool, but neither of us were experts at using it, and neither were any of the people at WPI nor Staples. This restricted our progress in simulation to a great degree because the only people that we could ask questions to was each other. We did end up getting a little help from the Arena people, but that is a delayed process.

We didn't have any interaction with any of the employees at the SDO and FC we visited, and we did not consider the limits of their skill, or attention, we simply used averages for the amount of time for each of their functions with in the network. Had we more time, we would have factored in how productive workers are at certain times of the

day, and under what conditions do they work best. Looking into that would be another suggestion we would make to Staples.

In conclusion, our main focus was fulfilling the goal that was given to us by Staples: create a functional model of the current process in Southern California that can be utilized in the future while testing the theory of FC synchronization. We succeeded in doing so, now it is up to Staples to take our approach and utilize it to find and implement measures that would raise efficiency and or cut costs.

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