Night Deliveries Capstone Project

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ISYE 6341 & ISYE 6342: Supply Chain Capstone Project

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EXECUTIVE SUMMARY

This report provides a description of the night deliveries capstone project. The main deliverable of the project is an assessment that evaluates the feasibility of performing off-hours deliveries from the client's distribution center to its stores and a roadmap for future implementation.

The client is a home improvement supplies retailing company that sells tools, and home décor products. Their headquarters and distribution center are in Panama City. The company distributes to its own stores using third party independent drivers which haul freight either in direct trips or by performing multistop deliveries.

Some of the main challenges which have motivated the company to study the feasibility of off-hour deliveries include heavy traffic congestion in the city during daytime peak hours, lack of receiving areas for trucks at stores which causes blockage of client parking spots during working hours, impacts upon the availability of product at stores because assistants pivot between unloading trucks during the day, tending to clients, and storing product, which the company estimates is responsible for 15% of stockouts.

Industry research regarding off-hour deliveries reveals that this can be performed either with staffed off-hour deliveries or unassisted off-hour deliveries. Unassisted off-hour deliveries mean that no staff is needed at the stores to receive shipments, while staffed deliveries depend on staff located at each of the stores which is costlier, but it is a safer option. Regarding the necessities of the company, staffed off-hour deliveries were chosen for this project.

Our approach to the challenges the company is currently facing include a methodology which involved the analysis of GPS and operational data, designing night delivery scenarios, and comparing the costs and benefits to evaluate the feasibility of implementing the best night delivery scenario.

The first set of input data for the project included the extraction and analysis of delivery trucks GPS data, the analysis of the history of orders done by city stores, and measure the times that assistants take to unload trucks and store merchandise in customer shelves. The night delivery scenarios were built using the Waze planned trips functionality, and the costs were calculated for labor transfers, electricity costs, the cost of transportation, and a security guard at stores.

The report ends with a brief outlook at the potential the night time deliveries project has not only for the sponsor organization but for a city in general, in this case Panama City. It is indeed feasible for sponsor company to perform off-hour deliveries because it yields a 2% increase in the net income for the city stores and various intangible benefits. Many other companies can benefit by implementing this which could mean less trucks during the day, less traffic, and an increased standard of living for citizens.

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COMPREHENSION AND BACKGROUND

This section gives a description of the sponsor organization, a brief explanation of its storage and distribution operations, and the challenges it faces while performing deliveries during daytime peak hours. Even though the project is directly concerned with transportation, it inevitably has an impact across the storage and distribution operations of the company.

COMPANY DESCRIPTION

The sponsor organization for the capstone project is a home improvement supplies retailing company that sells tools, and home décor products. It offers its customers the highest quality and variety in construction finishes, hardware and other items to meet the basic needs of home projects.

DISTRIBUTION FACILITIES

The company currently has one distribution center in the eastern part of Panama City which is divided into specific warehouses. Warehouse number one stocks medium sized items while warehouse two stocks larger sized items such as wood, steel, ceramics, granite, and more. Warehouse three is used for dispatches of small boxes containing small items, which is done via an OSR shuttle.

PICKING AND OUTBOUND INVENTORY MANAGEMENT

The company's current warehouse management system has a module that manages each of its stores' inventory replenishment automatically. The company uses an order up to inventory level policy for each item. Every night, the WMS checks inventory levels for each SKU across all the stores and requests orders to those SKUs that have fallen below the order up to inventory level.

During the first shift in the morning an employee who oversees the WMS orders organizes the pickers and sends the orders to be picked in picking waves. The picking waves are organized by groups of stores which is based on their relative proximity to each other.

For warehouses 1 and 2, there are six picking waves every day and each wave have a specific time for picking. While pickers pick and bring the products to the staging area, a supervisor double checks the items with the orders from the WMS and the stores they are going to and organizes the staging area per store. When there is enough product to form a pallet for one store, the assistants in the warehouse are directed to organize the products in the staging area into a pallet and wrap it with plastic. When a picking wave is completed, the assistants wrap in plastic the last remaining products into a full or half pallet depending on the amount of remaining product.

For warehouse 3, picks are placed into red boxes using both the OSR shuttle semi-automatic picking and storage system in conjunction with a fast pick area staffed by picking assistants. The red boxes are then moved into a staging area classified by store which are then loaded into trucks. The trucks

for warehouse 3 are loaded both with store specific orders and multi-store orders. These multi stop routes are usually decided on the spot depending on the stores that have made orders for that day, and on the relative proximity of these stores, and the number of red boxes each truck can carry.

DISTRIBUTION

The company outsources distribution of merchandise from their DC to the stores to independent drivers. These drivers arrive to the DC every day at usually the same time and they will wait until they are assigned a specific store to distribute to. The drivers are currently paid by the trip and the tariffs vary in relation to how far the store is and how much capacity the driver's truck has. The company currently has a matrix with fixed prices to stores based on different truck capacities.

As explained in the previous section, the distribution process starts with inventory replenishment, picking and staging, and later when they have enough pallets to fill a truck for a specific store, outbound supervisors will let one of the drivers know that he is the one who will take the products.

Dispatches to stores from warehouse one and two are usually a direct trip per store and they involve open trucks carrying mostly pallets or construction materials. Warehouse 3 dispatches are usually multi stop routes and they dispatch items in a common red box with a barcode to facilitate the transportation and storage of product in the DC and the stores. The trucks that dispatch from warehouse 3 are closed trucks to protect the red boxes.

RECEIVING AT STORES

Currently there is no set time for when a truck will arrive from the DC to each store. A truck's arrival time from the DC will vary depending on the WMS inventory replenishment module and the availability of merchandise to fill up a truck going to a store.

At the stores there are usually two supervisors that oversee receiving and checking product into the store's inventory database. If the products come from warehouse 3 in red boxes, they will scan the boxes and an assistant will help unload and store the products. If the products arrive from warehouse 1 and 2, they will scan documents and manually check the pallets for the specified quantity of products in the documents. Also, assistants scan each product coming from a pallet to cross check it with the database. To unload these trucks from warehouse 1 and 2, an assistant with a forklift is needed.

CURRENT CHALLENGES

Vehicular traffic in Panama City during daytime working hours impacts the company's distribution to its stores, which in turn has effects upon the availability of items at store shelves, availability of client parking spots, and on delivery times to stores. This has motivated the company to consider performing off-hour product delivery to all its stores.

The company doesn't have its own fleet of trucks, as explained in the previous section, and this fact coupled with peak hours traffic causes trucks that come from the DC to arrive at various times during the day to stores, which means store assistants must be ready to pivot between tending to clients at the store, unloading trucks and then storing merchandise in shelves.

The company estimates that daytime receiving at their stores is partly responsible for a 15% of stockouts across all their stores, which is the product that has already been delivered to the store but has not been placed in the shelves for clients to buy yet. Stockouts translate to lost sales since clients that don't find the product they were looking for might buy it somewhere else.

Part of the reason this happens is because assistants unload trucks and tend to customers at the same time during the day, which causes product just unloaded from trucks to stay in the warehouse of the store for extended periods of time, where it is gradually placed in customer shelves throughout the day. This in turn also impacts customer service because not enough staff might be available to tend to customers since they are unloading freight.

This practice has caused many of the home improvement stores, which are the ones that receive most of the small items and red boxes to have small groups of red boxes in the store aisles, which is both inconvenient for clients and makes sections of the store seem disorganized.

The company believes that performing night time deliveries will permit store assistants to fully focus just on storing product during the night, tend to clients during the day and therefore reduce the percentage of stockouts and increase customer service.

Another current challenge regarding daytime deliveries is that many of the stores do not have set locations or the necessary infrastructure for trucks to park while unloading freight. This causes many parking spots to be unavailable for clients during the day, which varies from store to store, but at the end it translates to some lost sales due to customers not finding a place to park. Again, night time deliveries would mean there wouldn't be trucks taking customer parking spots during the day.

Dispatching trucks during the day not only contributes to traffic, but also affects the company's on-time delivery of products. In this case it takes far longer for a truck to make a delivery during peak hours than during the night when there is almost no traffic. Also, if orders are not delivered on time, this causes many trucks to arrive at similar times at the store, which means that a queue of trucks is formed, delaying the unloading, storage, and replenishment processes all while having to serve customers.

OBJECTIVE, SCOPE AND JUSTIFICATION

Traffic congestion in Panama City during working hours affects the delivery process of companies to all its stores. This has motivated the sponsor company to consider deliveries of merchandise outside regular hours.

This project's objective was to perform an assessment of the feasibility, benefits and costs of implementing off hour deliveries from the company's distribution center to its stores located in Panama City.

The project scope consisted in performing the evaluation of 21 stores located in Panama City, for deliveries made from warehouses 1, 2 and 3. The project had a duration of 2 and a half months and finished by the end of July 2018.

ASSUMPTIONS AND LIMITATIONS

- There were not any recommendations nor changes suggested for the current picking and reordering processes and hours for performing these.
- This project assumes that there is enough space in the staging area of each warehouse to keep picking during the day and leave all the products packed, staged and ready to be loaded into the trucks in the night.
- There is no seasonality in the demand of the sponsor company. This was discussed with the sponsor company and then checked with the 4 months of order history data.
- The company wants to distribute and restock merchandise during off-hours.

INDUSTRY AND ACADEMIC RESEARCH

Industry research was conducted to understand what the current best practices in industry are and what might work for the sponsor company regarding night deliveries.

According to a study performed by the Rensselaer Polytechnic Institute (2013)1, shifting daytime truck deliveries to outside normal business hours has the potential to reduce traffic.

The program performed by RPI called NYC deliverEASE, which launched in 2011, enlisted nearly 150 restaurants, grocery stores, retailers, and other businesses in Manhattan to accept their freight deliveries between the off-hours of 10:00 PM and 6:00 am.

In the NYC deliverEASE program, the benefit to restaurants and their supply chains was evident, since this potentially meant that every morning as soon as the restaurant or store opened, they would have their fresh ingredients available right away.

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[1] RPI News. "Off-Hour Truck Deliveries in Manhattan Reduce Traffic, Empower Business Owners." *Rennselaer Polytechnic Institute*, 16 Sept. 2013, news.rpi.edu/content/2013/09/16/hour-truck-deliveries-manhattan-reduce-traffic-empower-business-owners.

Night time deliveries come with its share of challenges to store owners however. NYC deliverEASE had truck drivers use keys to drop off goods at the stores, restaurants and then lock up, which means that from a security perspective this would be a challenge in countries where everything must be checked. These types of deliveries in academia and industry are known as unassisted deliveries.

When night deliveries are performed there are benefits not only for the involved companies but also to citizens in general. One of the central aspects of these deliveries is that the benefits to cities are found in that congestion caused by the deliveries is moved to off-hours.

The study done by RPI also adds that the benefits to companies not only stop at the speed at which trucks reach their destinations. In the study, with unassisted off-hour deliveries, trucks had the flexibility to park faster at each store, including using client parking, which made the unloading time faster. In the NYC deliverEASE program, the time spent at each stop was reduced from 2 hours to 30 minutes. Additionally, truck speeds were twice as fast during off hours.

Ljubičić and Pavlović (2015)[2] expand upon the topic of unassisted deliveries but also include the concept of staffed deliveries. Staffed off-hour deliveries imply additional staff needed to accept nighttime shipments. This requires additional cost of labor and night work, but it is the safer option.

On the other hand, as the name suggests, unassisted off-hour deliveries are the ones in which no staff is needed to deliver the shipments at night. For this option there are far lower operation costs, but higher risk of goods being stolen.

There are several options to perform unassisted off-hour deliveries, there is the double-door system in which the driver that makes the delivery is provided with a key to an outside door which leads to a storage area separated from the rest of the facility. The driver can unload the goods in this small storage area without having access to the rest of the facility.

There is the "key method" in which the driver is provided with a key that lets him or her leave the goods at a specific location. The "electronic password method" in which the driver is provided with an electronic password defined by the facility's owner, which lets the driver enter the facility to drop the items and the "electronic doorman system" in which a remote operator, assisted by security cameras and a radio system, may give access to drivers into the facility if they pass ID requirements.

Based on what the sponsor company needs, this project approached the night time delivery assessment using staffed deliveries and it will be explain in detail what needs to be considered for this project and for future night time delivery assessment projects.

[2] Ljubičić, Hana, and Jovana Pavlović. *URBAN LOGISTICS SYSTEMS AND NIGHT GOODS DELIVERY*. 2nd Logistics International Conference, 2015, *URBAN LOGISTICS SYSTEMS AND NIGHT GOODS DELIVERY*.

METHODOLOGY

The methodological approach presented in Figures 1 and 2 was designed and applied to address the challenges the company is facing regarding the evaluation of implementing night time deliveries.

The approach primarily involves the extraction and measurement of key company data to then proceed to build night time delivery scenarios based on the company's current capacity. After the delivery scenarios are built, their feasibility is tested from an economic perspective and from a capacity perspective. After this, the most feasible scenario and an implementation roadmap is recommended, showing the estimated measured economic impacts and intangible benefits based on the company's current structure and processes.

The squares in the figures below represent the activities in which data was processed. The slanted diamonds represent the outputs of each activity.

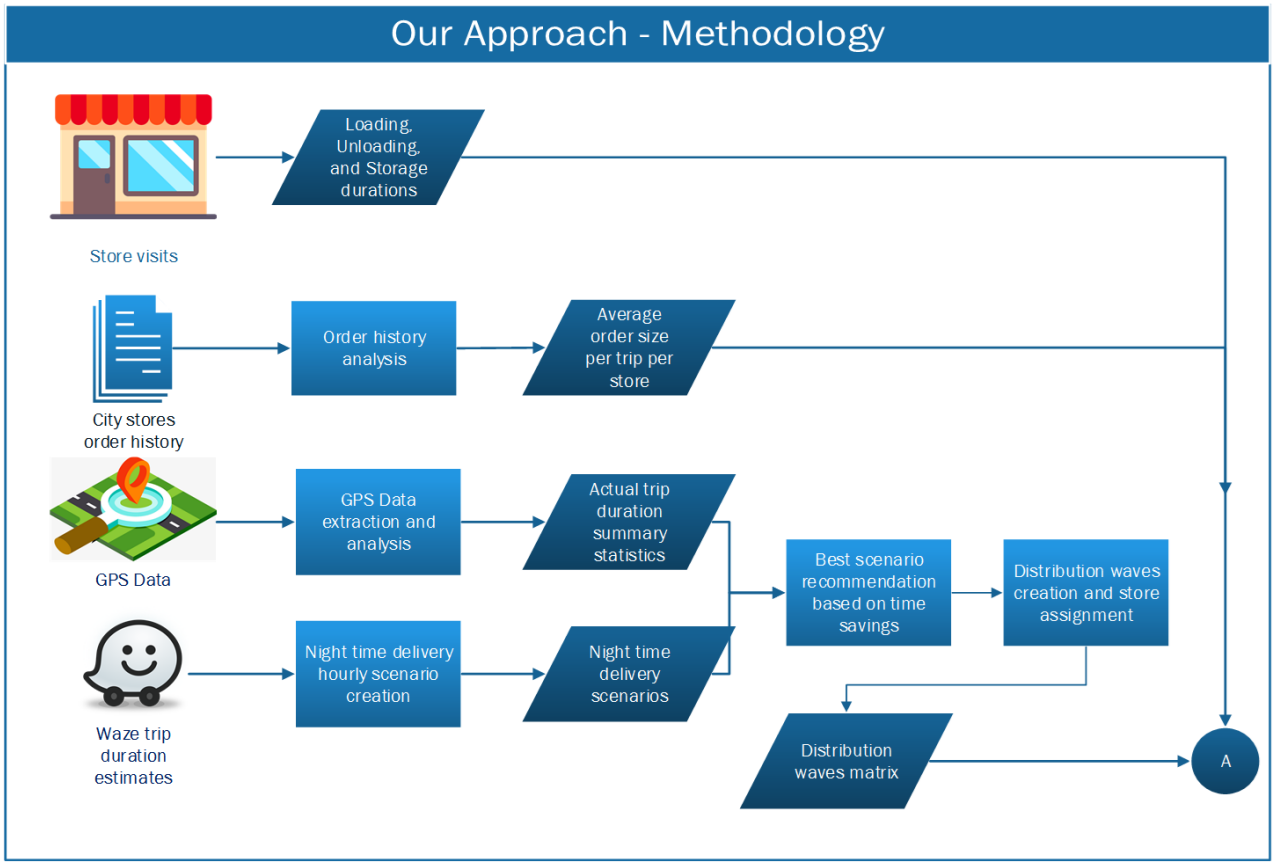

Figure 1: Methodology part A

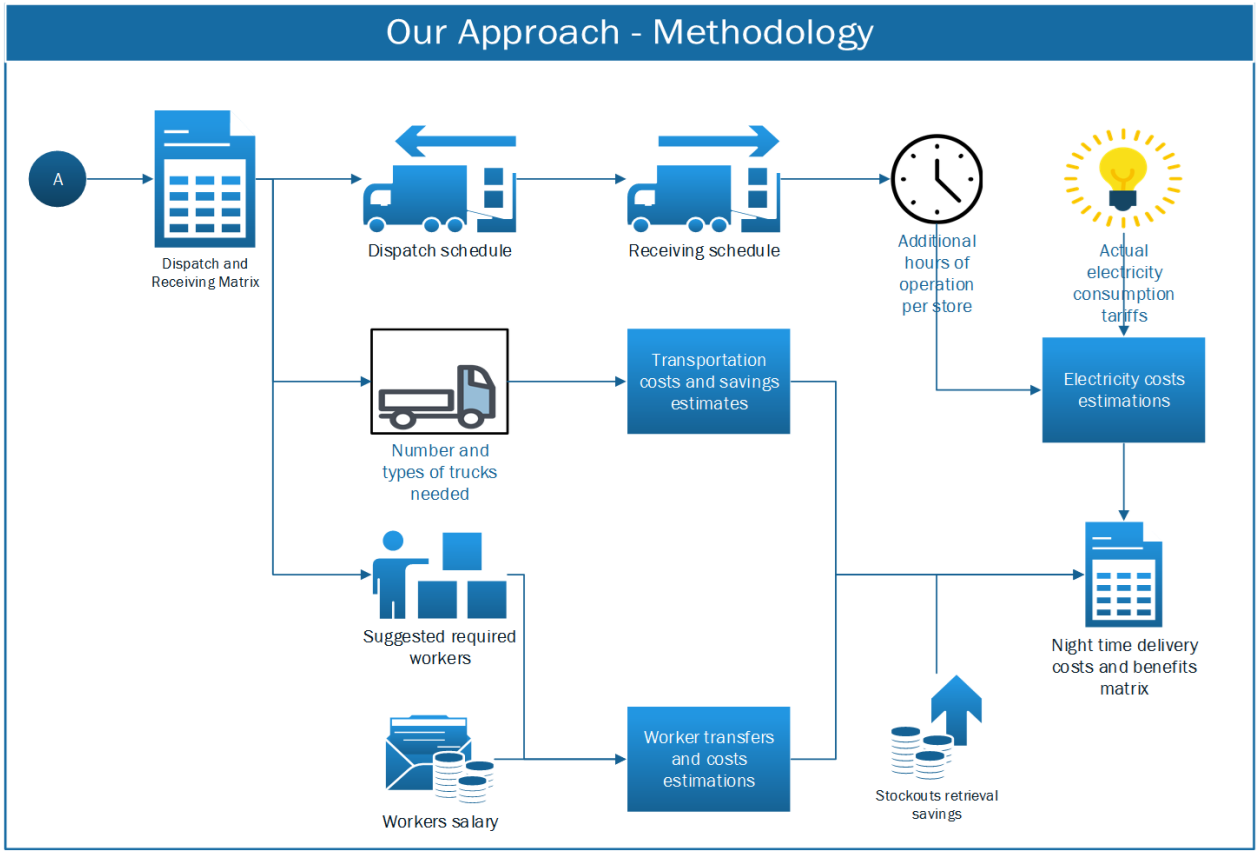

Figure 2: Methodology part B

VISITS TO DISTRIBUTION CENTER AND STORES

One of the first activities that was realized was to visit the company's distribution center and some of the city stores to understand the processes of picking, dispatching, unloading and storing merchandise from DC to stores. The most important part in this step was to analyze any potential roadblocks to night time delivery, document the dispatching and receiving processes and measure the loading, unloading and storing times in the stores and in the DC.

An important part of this step was to get to know the stakeholders of the company at key positions related to this project. Contact was made with those in charge of the dispatching of the trucks, the person in charge of receiving products in the store, the warehouse supervisor and the human resources department. These contacts would proof to be of great help later when more information was needed.

The DC was visited first to understand the process of how the company restocks its stores. Most merchandise that is stored at the DC, is imported from various places and based on its size and type of product it will be stored in either warehouse 1, 2 or 3. Later as the WMS checks inventory and makes the orders for the stores, pickers organized in waves per store, pick up the merchandise and leave it on the staging zone. In the staging zone, assistants assemble the merchandise into pallets for each store. These pallets are then loaded into trucks going to specific stores.

After the visit to the DC, nine of the stores in the city were visited to gather key information. The process of receiving merchandise from the DC, the storage, and display of the merchandise in the stores was analyzed. The time it took assistants to unload trucks, both pallets and red boxes, and the time that assistants took to store product was measured. It was identified that trucks most of the time take the space of parking available for clients. Storage capabilities, and the roles and responsibilities of employees in the stores was also considered during these visits.

ANALYSIS OF GPS DATA FOR CURRENT DISTRIBUTION DURATIONS

The next step was to measure the actual driving times from the DC to stores. An efficient way to do this is to get GPS historic data of the trucks, and then analyze a representative period, in the case of this project it was 4 months, to have a robust sample. If GPS is not available in the trucks, then it is recommend doing manual testing of driving time. This exercise may take longer and might be less robust than having GPS data, but it will still work if enough samples are collected.

Currently around 60% of the sponsor company's independent drivers have a GPS enabled truck which was used to track their routes and analyze data. The available GPS data, which was from February to May 2018, was analyzed to get crucial information such as average driving time from the DC to each store, average times each truck spends at each store being unloaded and average return time. For warehouse 3 multi stop trips, the average driving time between stores of the trips that were repeated 3 or more times during the 4-month data period were considered and calculated.

The GPS data was cleaned and analyzed using the "Pandas" module from Python, to get each trip duration when the trucks left the DC, when it arrived at the store, when it left the store, and when it arrived back at the DC. After coding two different approaches, one for direct trips to stores and one for multi stops, the data was then exported to MS Excel and Tableau to organize and visualize it. Appendix A shows the Python code that was used to extract, clean and process the raw GPS data.

The processed data was then mounted into the Minitab 17 statistical package to find the mean and standard deviation of trips from DC to every store. These values were further cleaned to take out the outliers from the analysis. Many of the outliers corresponded to abnormal behavior in deliveries such as trucks staying at gas stations for extended periods of time.

These results were used to calculate the average time the company spends distributing to each store, and then later used as a point of comparison with the different night time delivery scenarios.

ORDER HISTORY ANALYSIS

Analysis of the historical order data is important to be able to understand demand patterns for each of the stores. These demand patterns can then be extrapolated to estimate the time it takes to load trucks at the DC and unload and store merchandise at each store, based on the measurements taken in the store visits.

The average order size that each of the city stores requests was calculated based on the historical order data requested to the company. Spreadsheets which contained the number of pallets and red boxes being sent to each store for a period of five months were analyzed and summarized.

To build these summaries, first the raw data had to be cleaned using MS Excel. There were reports received for historical orders made to warehouse 1 and warehouse 2. Since the historical orders contained the country wide orders, filters were included in the cleaning of the data to only account for orders made from each of the city stores.

Other important summaries that were extracted include how many drivers on average travel to each store, the average size of trucks being sent to every store, and the frequency between orders.

CREATION OF SCENARIOS FOR NIGHT TIME DELIVERIES

To measure how much time it would take to deliver at different hours during the night, the user-data driven GPS navigation software platform Waze was utilized. Waze was chosen instead of Google Maps or others since Waze is the most used software for directions and avoiding traffic in Panama. As research suggested, Waze utilizes user-data to measure current traffic conditions, but it also stores this data and uses statistical approximations to show drivers how much time any future drive might take them. Waze "takes into account expected traffic conditions based on smart algorithms, aggregated traffic history and predictive analysis". [3] Therefore, it was deemed appropriate to utilize Waze's planned trip functionality to create the scenarios.

Six scenarios were chosen to measure and calculated the driving times. In the scenarios it was assumed that the trucks will be leaving the DC at these times: 2:00 am, 3:00 am, 4:00 am, 6:00PM, 8:00PM and 10:00PM.

The plan trip option from the Waze website[4] was used to calculate the driving times from the DC to each store in the city and the driving time back for each scenario. The wait time of the truck was calculated at each store by using the times measured from the visits to the stores. The average unloading time per pallet and red box was multiplied by the average amount of pallets and red boxes distributed to each store to calculate realistic wait times.

[3] Engadget. (2018). Waze helps you plan future trips based on expected traffic. [online] Available at: https://www.engadget.com/2016/03/16/waze-planned-drives-ios/ [Accessed 2 Aug. 2018].

[4] https://www.waze.com/livemap

RECOMMEND A NIGHT DELIVERY SCENARIO

In this step, the main goal was to compare the actual delivery durations vs the various scenarios to find improvements. If time savings are encountered in this step, then the project should continue. After time savings are acknowledged, a scenario or a series of scenarios needs to be recommended. This will vary greatly between companies, but some of the concepts that must be considered are found below.

- Working hours of the stores and distribution center of the company.
- Willingness of employees to work in the proposed scenarios.
- The recommended scenario should have enough time before and after, to account for various delivery waves and possible delays.

CREATION OF DELIVERY WAVES TO APPROXIMATE AND DEVELOP A SIMULATED NIGHT TIME DELIVERY SCENARIO.

When the proposed scenarios are agreed upon between all involved stakeholders, the approximation of an average delivery night shift was created. This approximation took as an input the times from the recommended scenarios, average volume of products to each store, the average time to unload a truck and store the products at each store.

With these inputs, a matrix was created in which the number of trucks is minimized considering that these trucks do multiple trips per night. A truck could go on a trip and be back at the DC to pick up more products to be delivered to another store. This will depend on how much time it takes per store, but the truck drivers should increase their efficiency from the alternative of delivering at regular hours. From this matrix, the number of employees needed at each store and at the DC with their working hours can also be calculated. Appendix B shows an example of the calculations that this matrix performs.

Based on the recommended scenarios, the number of drivers that the company needed to deliver was minimized. To accomplish this, three waves of delivery were created, in which the city stores were evenly divided as shown in Figure 3. This allows to minimize the number of drivers needed, and each driver will complete 3 delivery trips per night of work.

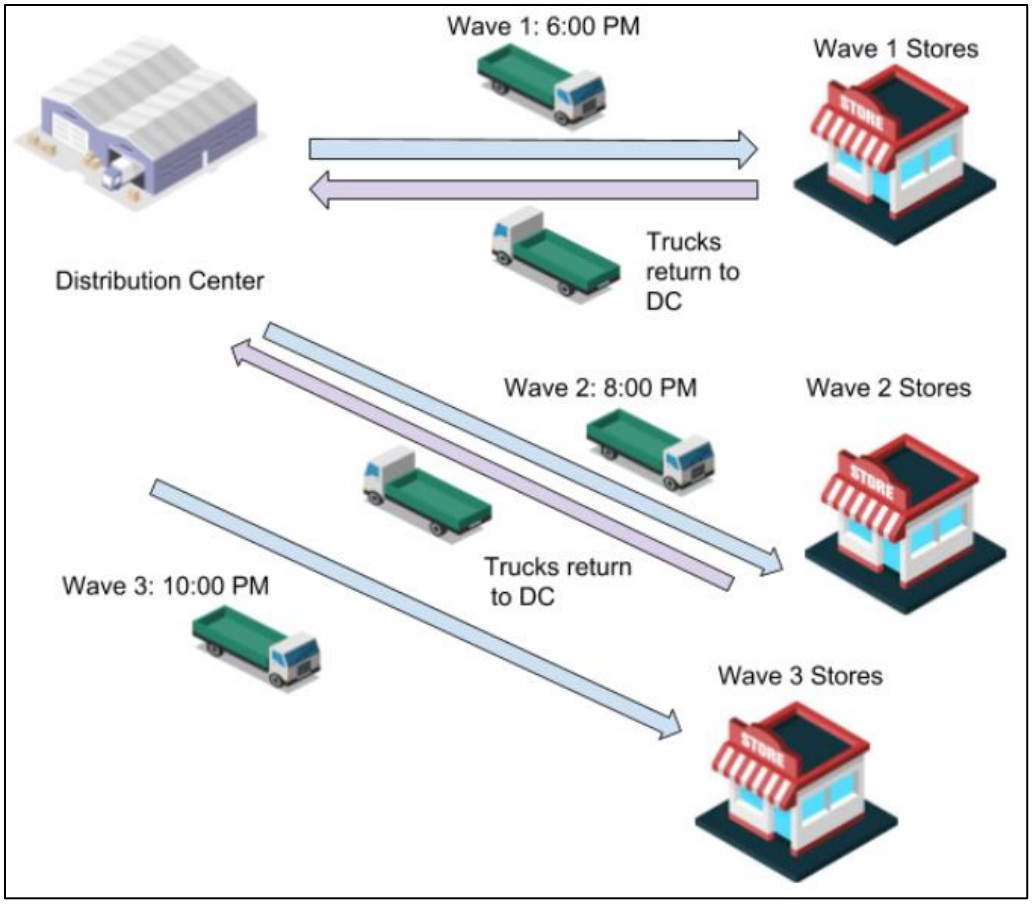

Figure 3: Illustration of distribution waves

A matrix was built to allocate stores to each wave. The matrix contained the total time of delivery for each store in each wave proposed, and then MS Excel solver was used to minimize the total distribution time by allocating stores to a specific wave. All waves have the same number of stores, and the number of products moved was also balanced between waves.

With these waves structured, the average number of pallets and red boxes ordered for each store was used to calculate the specific number and size of trucks needed. This is only to move the average amount of products daily but since there's not much of a seasonality or peaks in this business, it works fine as an approximation. The amount of time it will take to load pallets and red boxes into trucks was calculated from the time measurements taken from the visits to stores. Then a random coefficient between 10-15 minutes was added to the departure time of the first wave to consider for any delay. The data measured from Waze was added to determine the time the trucks should be arriving at the stores, how much time they will stay there depended on the number of pallets and red boxes each store receive on average and when will they be back for the loading of the second wave at the DC was also taken from waze. This exercise was repeated all the way through the three waves and for all stores, reusing the drivers to minimize the total number needed. Appendix B also shows a snapshot of the matrix with all this data input into it.

With average unload and storage time per pallet and red box, it was estimated that the number of employees needed in each store and at the DC so that the night shift will not be more than 7 hours long. It is important to cap the night shift at 7 hours, because in Panama there is a law that states that people working in night shifts cannot work more than 7 hours without being paid overtime. Overtime night shift in Panama is 75% extra of the total salary per hour, and the sponsor company should avoid this cost.

Enough assistants were recommended at stores and the DC to let the 7-hour shift finish around 1 hour and half earlier in the average night approximation to account for any delay or increase in the number of products being stored.

TRANSPORTATION COSTS CALCULATIONS

To measure the transportation savings or costs, the actual payment method to the drivers needs to be considered. If the payment method is salary based, savings can be estimated by the reduction in the number of drivers needed to deliver the same amount of merchandise. The same happens if the payment method is a daily fee, the savings can be estimated by the reduction in the number of drivers. If the payment method is per trip made by the drivers, then there needs to be a discussion on how to modify this payment method to convert the time savings into financial savings. Any other payment method would have to be analyzed in depth by the person in charge of the project.

The sponsor company pays their drivers per trip, which makes it easier for them to control the efficiency of the drivers. If the drivers are inefficient, they are only paid for what they accomplished. The problem that was encountered with this is that if they wanted to translate the time savings from the night deliveries into financial savings, they would have to change their payment method. Five different payment methods were proposed but only one was recommended.

LABOR COSTS CALCULATIONS

Labor costs were calculated based on the suggested number of workers needed to perform night deliveries. These numbers were extracted from the approximations calculated in the previous sections.

CALCULATION OF NUMBER OF WORKERS NEEDED TO PERFORM NIGHT TIME DELIVERIES

The calculation for workers needed to perform night time deliveries started with the assumption that workers from every store and the distribution center can be transferred to the night shift and additional workers would only be hired if necessary. This means that for every store and the distribution center the current availability of different types of workers was considered; specifically of general assistants, forklift operators, and receiving supervisors to transfer some of these current employees into the night shift.

Table 1 shows an example of the analysis that was performed for each of the stores to consider how many workers could be transferred and how many had to be hired because there are not enough. If the % of transferals were greater than 50%, then additional hiring would be considered. The

exemption to this was with receiving supervisors, since all receiving activity would be moved to the night, then even if all receiving supervisors were required, there wouldn't be any needed during the day.

	General assistants			Receiving supervisors			Forklift operators		
Store	Suggested	Actual	% of transferals	Suggested	Actual	% of transferals	Suggested	Actual	% of transferals
Store A	4	11	36.36%	1	2	50.00%	1	2	50.00%

Table 1: Evaluation of worker transfers

The number of assistants depends mainly on two factors:

1. The number of workers needed is just the necessary amount so that all the incoming night time deliveries received by any given store in the city have been restocked before 1:00 AM.
2. The time that workers take to unload, load and store freight is based upon the initial duration measurements taken at the stores.

Under these assumptions the number of workers was calculated for every store and for the distribution center.

CALCULATION OF COST DIFFERENTIAL FOR NIGHT TIME DELIVERIES WORKERS

While Panama legislation does not require workers to be paid more if working in the night shift, it is common practice in the industry to give an incentive to workers for night work known as a shift differential.

The shift differential varies from place to place and from country to country, however the calculation of it depends on the workers' hourly wage. The example followed in this project corresponds to practices performed by the Department of Labor of the United States. In this source, it is shown that the amount of an additional $1.00 over the initial hourly wage is used in practice to incentivize workers. [5]

In this project, and after talking to the sponsor, the amount used as the shift differential was of $0.50.

ELECTRICITY COSTS CALCULATIONS

When measuring and analyzing cost for night time delivery, electricity costs are vital. Since dispatching at night means that the DC needs to be open and running, there is going to be extra electricity costs added. Also, if night delivery is going to be assisted, then the electricity costs for the stores also needs to be considered. An important point in this analysis is to understand how much

[5] Department of Labor of the U.S. "Wage and Hour Division (WHD).

electricity the distribution center and stores are consuming right now and how much will they consume the extra night hours.

To measure the extra cost of electricity the sponsor company actual electricity consumption of each of their stores and the distribution center was utilized. There are two electrical companies in Panama that supply energy to the different stores in the city. These two companies charge different rates per kilowatts per hour and those rates were used to calculate the hourly cost of energy consumption per store. After calculating the hourly cost of energy consumption, the hourly cost was multiplied times the number of extra hours that each store is going to be open. With that result it was calculated the daily energy cost and subsequently the monthly energy cost. The extra hours that the stores are opened are all based on the demand of the store, the time it takes to unload and store the items, and the number or workers that each store will have.

SECURITY COSTS CALCULATIONS

Security is one of the most important aspects when transitioning to off hour deliveries. Security will depend on where are the stores located, if the night time deliveries are assisted or unassisted, and the risks the company is willing to take.

For the sponsor company stores at night, with less people working there, they are prone to theft, so it is imperative to have a security guard at every store. To measure the security cost, research was conducted by calling a company that provides security services in Panama. That company provided the rate they charge monthly for having a security guard at one location. With that it was able to get the total cost of security if a security guard is needed at each of the stores in Panama City.

RESULTS

CURRENT DISTRIBUTION DURATIONS FROM DC TO STORES

Figure 4 shows the results for the data extracted from the GPS data. This data was then used in the following calculations to find the best scenario as mentioned in the methodology.

The blue bars indicate the time it takes on average for trucks to get to each store, the red bars how long they are processed for the unloading to happen, and the yellow bar indicates the average time it takes for trucks to return to the distribution center.

Using these types of graph, it is easy to tell which stores are the ones that are taking the longest to being distributed to on average and be able to pinpoint stores which would be impacted positively the most from a night time delivery implementation.

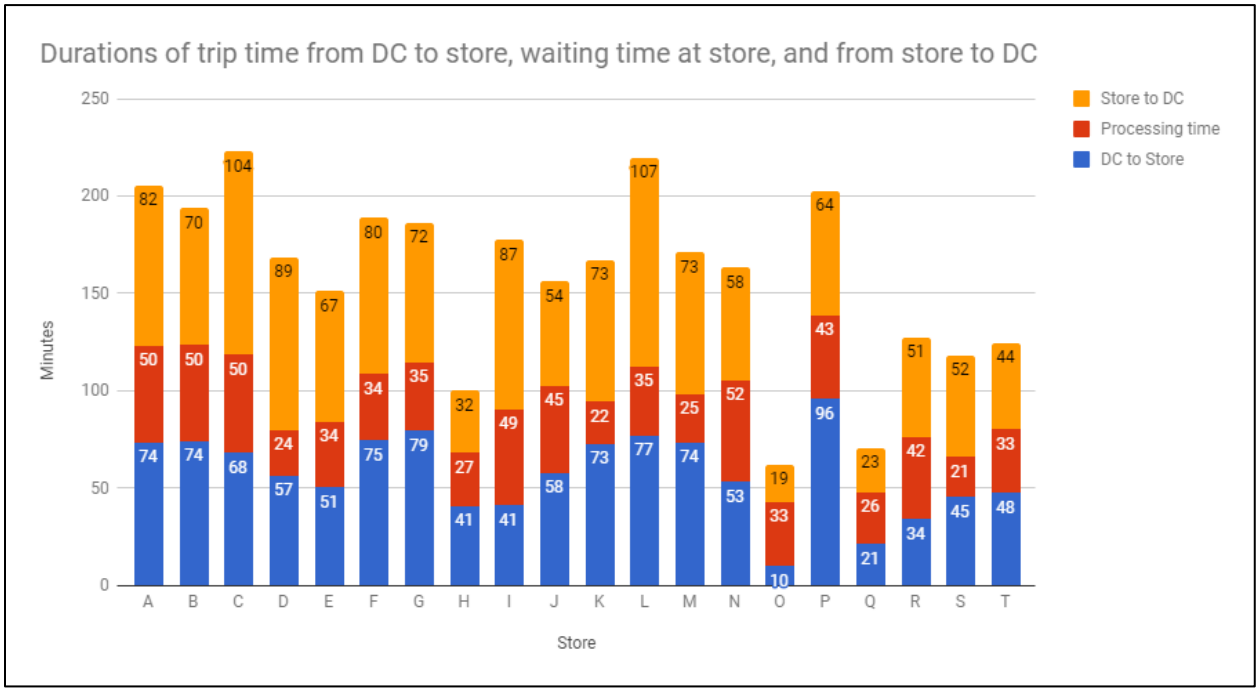

Figure 4: Average driving, processing, and return trip times to city stores

AVERAGE ORDER SIZES FOR CITY STORES

Figure 5 shows one of the resulting graphs for the average order size of pallets received by stores. It is shown that some of the stores order almost 20 pallets on average per day, while others order less. All the resulting averages both for pallets and boxes sent to each store were used in the distribution approximations.

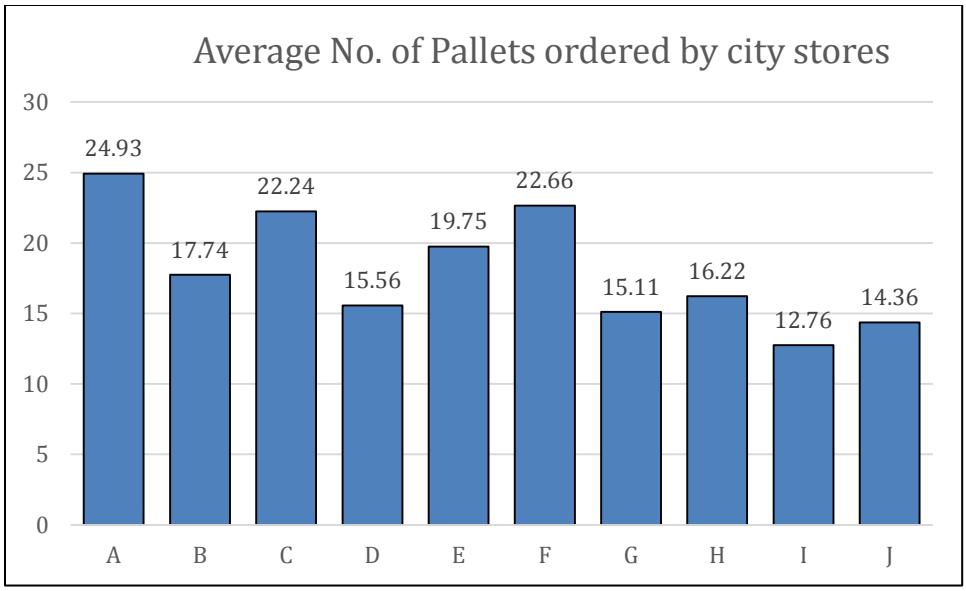

Figure 5: Average pallet order size for city stores

NIGHT DELIVERY SCENARIOS RESULTS

Figure 6 shows the results for the total durations in hours of direct trips and multistop trips to each of the city stores. For comparison purposes this calculation assumes that all trucks leave the distribution center at the same time, and their time durations are added. The blue bar considers all multistop trips, the orange bar direct trips to the stores that manage small – medium sized items, and the grey bar the direct trips to the stores which handle the bigger items.

It is shown in the graph that all the proposed night delivery scenarios take almost half the time in duration when compared to the actual durations, with the 8:00 PM scenario showing an overall time saving of 44 hours approximately.

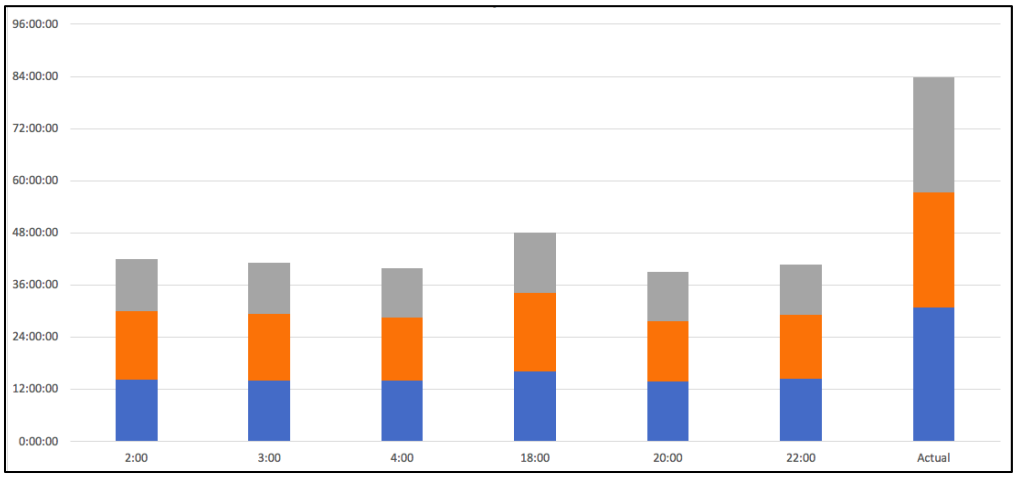

Figure 6: Night deliveries scenario comparisons

NIGHT DELIVERY SCENARIO RECOMMENDATION

With the actual times for delivering to each store and the time it took to deliver in various scenarios at night calculated from Waze, all the scenarios were compared to the actual times. Overall, the company could reduce their average daily distribution time in half in most scenarios, which corresponds with what was found in the academic research. The scenario with the most savings was 8:00 PM, and this made sense because by 8:00 PM traffic has gone down significantly and public construction in the area where the distribution center is located begins around 10:00 PM.

6:00 PM was the scenario that presented the least amount of savings, because around this time there is still traffic in Panama City from rush hour. Still some of the delivery times for stores for the 6:00 PM scenario were not that long when compared to the average duration to each store. These stores were specifically the ones that were closer to the distribution center. It was recommended that the 6:00 PM, 8:00 PM and 10:00 PM would be the scenarios to use to deliver at night. The specific reasons being the following:

- 8:00 PM was the scenario with the most savings in time.
- These scenarios were easier to implement into the current DC and stores schedule because they will begin delivering right after the DC and some stores closed. This reduces the stress on employees on finding a ride to work and home because it is still relatively early and there is public transportation for them. The stores do not have to close completely before the night shit personnel arrives.
- These scenarios also have enough time in between them for the drivers to do 3 trips per night of work. This will help the company minimize the amount of trucks they need to distribute their products to their city stores.

TRANSPORTATION COSTS

The first method proposed was to pay the drivers a monthly salary. This brought great financial savings because of the reduction on the number of drivers needed but it also had some disadvantages. Currently the drivers are the owners of the trucks, and if they become an employee of the sponsor company under contract salary, it could be difficult to convince them to lend the sponsor company their trucks. Another disadvantage is that the drivers could become less efficient, thus eliminating any time savings created by moving deliveries to the night shift.

The second payment method proposed on paying the drivers a daily fee of work. This fee varies per type of truck driven and should only be paid in full if the drivers complete all their scheduled deliveries for the night. If one driver does not complete his scheduled deliveries, then he will be paid a percentage of the total daily fee. This way it becomes easier to control the efficiency of the drivers. The daily fees were created by studying how much the current drivers earn per day right now. Drivers usually do 1.4 trips per day on average, but some of the best drivers do up to 2 trips per day on average. To reward the best drivers with an incentive for providing their services at night, the average daily earnings of 2 trips per day was added a 20% increase to create the night shift fee. This fee provides higher pay to all drivers and brings financial savings to the company.

In the third payment method it was proposed to reduce the total earnings of the drivers by 25% per day, specifically for the ones that completed 3 trips per night. This might seem counterproductive, but still drivers are earning way more than what they earn right now averaging 1.4 trips per day. There is also financial savings for the company in a decrease of 25% of the total delivery cost. One of the biggest disadvantages of this scenario is that the company will have to be creative in the way they explain this to the drivers. They cannot simply say that they will cut the drivers pay by 25%, because the drivers know the actual tariffs and probably won't agree to this, even when they are making more money because their work becomes more efficient.

For the fourth payment method, the tariffs for the second wave of work were removed. This means that a driver will complete all three waves and will get paid the actual tariffs for the first and third wave. Drivers will still earn more than what they earn on average today, but some efficient drivers might be earning the same and doing more work. This method as method 3, would be challenging for the company to explain to drivers.

Payment method 5 is basically the same thing as method 4 but the difference is instead of removing the tariff of wave 2, it will remove the tariff of wave 1. This scenario provides the drivers on average with more money than method 4 because wave 1 tariffs are lower than wave 2 tariffs. It suffers from the same disadvantages from method 3 and 4, that it will be complicated to reach an agreement between drivers and the company.

The final recommendation of the payment method to the drivers was payment method 2. This scenario will provide a daily tariff that is paid in full if the drivers complete their schedule deliveries, and partially if not.

This scenario allows for the best drivers to earn more than what they are earning now and for the company to reduce their transportation expense in about 20%. This also helps the negotiation process, because the company can still make the drivers bring their own trucks and pay their daily fee based on the type of truck they drive.

Also, the company will be able to reduce the number of drivers needed and keep the best ones. As stated before, the drivers will earn 71% more per day on average than if they completed 1.4 trips and 20% more per day than if the completed 2 trips. Two extra employees were added which will oversee checking the driver's performance during the night deliveries. This can ensure that the drivers are monitored and hurried up if they are taking too long to complete a delivery.

LABOR COSTS

The results for this section are shown in Table 2 which shows the number of workers that can be transferred and those that must be hired.

Operator	Transferred	Need to hire	Suggested number
General assistants	99	3	102
Receiving supervisors	25		25
Warehouse supervisors	3		3
Forklift operators	27	4	31
Total	**154**	**7**	**161**

Table 2: Suggested total number of workers needed for night deliveries

After meeting with the client, the proposed shift differential was decided upon, and applied to every possible worker that could be transferred to the night time shift.

The decision to transfer workers and hired the suggested amount in Table 2 results in an additional 10% of warehouse labor costs.

ELECTRICITY COSTS

After calculating the monthly energy consumption for each store and the distribution center, the sponsor company suggested that they expect that during night hours only light and machinery will consume energy. Light and machinery accounts for around 32% of the total energy consumption, so the hourly cost of each extra hour is just 32% of the hourly cost of each hour during the day.

SECURITY COSTS

The total monthly security costs, which include a security guard working the night shift at every store accounted for approximately the same amount of costs as that of labor, that is, 10% of current warehouse labor costs.

REDUCTION IN STOCKOUTS AND INVENTORY DISCREPANCY

Many companies face stockouts and inventory discrepancy, and some of the reasons of this may be that procedures are not followed correctly, bad forecasting and inventory management.

The sponsor company hired a consulting firm to analyze how much stock outs were in their stores in Panama City. After the consulting company went to various store over the course of two months and measured stockouts and the reason for them, they came to an interesting conclusion. Of the clients that did not find the product in the store, 45% of them went to another branch store of the company to buy it and 55% went to competing stores or lost interest in buying the product.

The reason for the stockouts was divided into three categories: 40% of the stockouts were due to the products being available in the stores warehouse but was not in display in the store, 30% was that there was inventory discrepancy; inventory was available in the stores, but the system showed they did not have any in the store. The other 30% was the other way around, there was inventory in the system database but not in the store and the WMS failed to place restock orders for these items.

This project will mostly help the 40% of the stock outs that are in the stores warehouse but not in display in the store. Since delivery and storage will be done during the night time, products should be 100% stored and stock in shelves by the time the stores open the next day. Since most stores receive daily shipments from the DC, there should be a reduction of this 40% of stockouts. The inventory discrepancy can also be reduced by better control and following of processes by the assistant receiving and storing products.

From the store visits it was found out that sometimes due to time constraints and inefficiencies, assistants do not scan all the products they receive, and this will create a discrepancy between the system and the items available at the store. If there is better control and assistants follow the correct processes of receiving products, this stockouts percentage can also be reduced. Also, since receiving and storing products will be the only responsibility of the night shift employees, time constraints and other responsibilities taking them time shouldn't be an issue.

BENEFITS AND COSTS RESULTS

After placing all the savings and costs together in the benefits and costs matrix of implementing night time deliveries, it was shown that a monthly net income of 2.0% in relation to city stores income is achievable considering the assumptions made in this project. While it is indeed clear that there are other costs that can be included in this study, the fact that there are possible savings make the implementation of night time deliveries more attractive.

INTANGIBLE BENEFITS

Most of the stores do not have space for the trucks to park and unload the merchandise. Usually trucks take up several parking spots that are meant for customers, and with limited parking space this creates problems for customers. With off-hour deliveries trucks will arrive at times that the store is not serving customer and will not take any parking spot meant for customers.

When products arrive during service hours, sales assistants oversee storing the items in the shelves. While they are doing this, they do not have enough time available to serve customers that are trying to find products around the store. Another problem that might happen is that sales assistants serve customers, but do not restock the shelves. This creates the problem of having the item in the store's warehouse but not displayed. If products arrive at night, sales assistant will have plenty of time to serve customers during service hours and other assistants will focus on restocking the shelves with products during night time.

Some items arrive in red boxes which are given to the sales assistants for them to restock the shelves with those items. When they are not able to do that right away, those red boxes are left stacked sometimes blocking the aisles and not allowing customers to walk freely through them. The idea with night deliveries is that assistants restock the shelves immediately during the night, so when customers arrive the next morning all the shelves have items and the red boxes are not blocking any aisle.

When trucks arrive during the day, people working at the warehouse that also have other tasks to do might not be able to unload the truck right away. A truck could wait several minutes even up to hours before someone starts unloading it. If the truck arrives at night, the only job warehouse attendants are going to have is to unload arriving trucks. By focusing on just doing this, trucks can be unloaded quickly and there is no time wasted waiting.

Traffic in Panama is usually heavy especially during peak hours. A big part of the traffic is caused by large trucks that circulate around the city during the day. By doing deliveries during the night, a large amount of those trucks will be off the streets during peak traffic times. This will alleviate traffic congestions and allow a better flow of cars around the city.

Measuring and implementing processes is going to be easier because workers will not be doing multiple tasks at the same time. Tests on the processes of receiving and storing products will be easier to conduct during the night time delivery because it won't affect clients while they shop.

Inventory will be easier to track thus diminishing the discrepancies in inventory that the company has been experiencing in its stores. Fixing inventory discrepancies might cause an increase in the stores' sales.

ROAD MAP FOR IMPLEMENTATION

The last deliverable was a high-level roadmap that showed the steps the company needed to take to implement this successfully. The roadmap was divided into three phases

PHASE 1

Assign or hire an employee to lead the implementation of the night time deliveries. This person should be an industrial or supply chain engineer preferably, and his duties will be to talk to all the areas involved in the delivery process. He should do some testing, measure times and provide a detail plan for the implementation steps with dates and milestones.

Go over the new salaries increment for employees working the night shit and their transition with human resource area. Also check with them the new payment method for drivers. Make sure they are on the same page as the other areas involved in the process and that they approve of the changes.

Start the implementation with the stores from the first wave. Since the stores in the first wave are close to the DC, it should be easier to control and make changes. Also, the DC won't have to open till late hours in the night because serving the 6:00 PM wave 1 stores won't take them long. It was suggested that they tested with the wave 1 stores for at least a month before moving to other stores.

PHASE 2

Negotiate with suppliers the new delivery hours for the stores. The company wishes to move all their delivery from the DC and from suppliers to a night shift. The company was given the estimates of the best times for the suppliers to deliver to each store. With this information, the company can negotiate with their suppliers and come to an agreement that satisfies both parties.

Start the night time deliveries with the second and third wave. Once the testing from wave 1 is finished and adjustment have been made, and the suppliers have agreed on delivering at night, the company should continue to move all their remaining stores to the night shift.

PHASE 3

After a few months into the new delivery times, the company should measure its level of stockouts once again to find out if they have been reduced due to the night time delivery initiative. Also, the company should see if there is an increase in sales and find ways to measure if its correlated to the reduction in stock outs.

Document the dispatching and receiving processes and the time they should take. The documenting of the detailed processes involved in dispatching products from the DC and receiving and storing them at the stores will benefit the company because if they wish to become more efficient and improve their processes, these should be correctly documented first.

After the documenting of the processes has finished, the company can investigate ways of improving the current processes with new equipment, changes in the processes and adding or reducing their workforce in each store. Since the delivery and receiving of products has moved to the night shift, tests can be performed on these processes without affecting sales or clients. If an improvement is found, this should be tested in stores and if the tests come positive, then it should be changed permanently in the documentation of the processes until a better improvement is found.

CONCLUSIONS

It is feasible for the sponsor company to implement night time deliveries to all its city stores and there are clear associated economic and intangible benefits.

The economic benefits outweigh the costs, resulting in an estimated increase of 2.0% in yearly net income in relation to sales resulting from city stores. Intangible benefits include opportunities for better customer service, process improvement, availability of parking space, focused sales assistants. Overall it is recommended that the sponsor company continues with the implementation of this initiative.

The potential of this project is to be used as an outline for other companies and help alleviate traffic in Panama. The night time deliveries project has the potential to have an impact in city logistics and the country, not just for the sponsor company of this project. One of the central aspects of night time deliveries is that it not only benefits business owners but also citizens in general since the congestion caused by these deliveries is moved to off-hours.

Many local distributors have played with the idea of performing off-hour deliveries, but the consensus is that while it is apparent that from an operational perspective there will be benefits, it is also true that doing deliveries at off-hours is more expensive. The core of the matter is that it is not known by how much. This project would serve as a guideline for other companies to evaluate this matter and see what challenges and benefits there is to performing night deliveries, an initial talking point.

As shown in this project, off-hour or night time deliveries are feasible for our sponsor organization. The potential is that a similar implementation roadmap can be applied to other companies, which in turn could lead to many companies mobilizing their distribution to off-hours and reducing daytime traffic in the city of Panama.

In a more general sense, off-hour deliveries do lead to reduced daytime traffic congestion, which in turn benefits local citizens, tourists, mass transportation and improved mobility in general. On an aggregate level there is a better quality of life for citizens, and increased efficiencies for the participating companies.

APPENDIX A

The MS Excel spreadsheet which estimates the hours and number of assistants needed per store is shown below. This is the "Receiving and Dispatch Matrix". This spreadsheet depends on two parts, one of them are the dispatches from the distribution center, and the second part is the receiving part.

The spreadsheet is built in a way that allows for the dynamic changing of hours according to the number of assistants assigned per store. The initial time that was considered to start loading trucks at the DC was 5:30 PM. This spreadsheet covers all three waves, and their associated times.

				Type of truck (positions)		
	Average number of pallets	No. of loading assistants	No. of suggested trucks	12	10	7
Store A	8.58	1	1		1	
Store B	8.86	1	1		1	
Store C truck 1	22.24	1	2	1		
Store C truck 2	22.24	1		1		
Store D truck 1	15.56	1	2		1	
Store D truck 2	15.56	1				1

Figure 7: Dispatch section - No. of trucks

Figure 7 shows the initial calculations for the number of trucks based on the average number of pallets that each store orders on average. Store C and D for example require two trucks since they order a greater number of pallets on average.

	Average no. of pallets per truck	Estimated time to load/unload per truck	Time at which truck is loaded	Random factor	Time at which truck leaves DC
Store A	8.58	0:24:44	5:54:44 PM	11.00	6:05:44 PM
Store B	8.86	0:25:33	5:55:33 PM	14.00	6:09:33 PM
Store C truck 1	11.12	0:32:04	6:02:04 PM	15.00	6:17:04 PM
Store C truck 2	11.12	1:04:08	6:34:08 PM	10.00	6:44:08 PM
Store D truck 1	7.78	0:22:26	5:52:26 PM	14.00	6:06:26 PM
Store D truck 2	7.78	0:44:52	6:14:52 PM	10.00	6:24:52 PM

Figure 8: Estimated times of departure from DC

Figure 8 shows the estimated times of departures for each truck, the times at which the truck should be loaded, a random factor, and the estimated time when the truck leaves the distribution center.

Truck trip average time	Time at which truck arrives at store	Unloading time	Time when truck leaves store	Return time	Time when truck is back at DC
0:15:00	6:20:44 PM	0:24:44	6:45:29 PM	0:15:00	7:00:29 PM
0:10:00	6:19:33 PM	0:25:33	6:45:06 PM	0:10:00	6:55:06 PM
0:06:00	6:23:04 PM	0:32:04	6:55:08 PM	0:07:00	7:02:08 PM
0:06:00	6:50:08 PM	0:32:04	7:22:11 PM	0:07:00	7:29:11 PM
0:19:00	6:25:26 PM	0:22:26	6:47:52 PM	0:30:00	7:17:52 PM
0:19:00	6:43:52 PM	0:22:26	7:06:18 PM	0:30:00	7:36:18 PM

Figure 9: Estimated times of trucks arriving to stores, unloading and return times

Figure 9 shows the times when trucks arrive to the stores approximately, their average unloading times calculated from the number of pallets each truck is carrying and the measured speeds of unloading. This part of the spreadsheet also shows the estimated return times, which take these trucks and load them for the second wave. This calculation also happens with trucks returning from the second wave on to the third wave.

		Deliveries from Distribution center			Deliveries from local providers		
	No. of Pallets per truck	Storage starts	Time to store pallets	Merchandise is store	Storage starts	Time to store pallets	Merchandise is store
Store A	8.58	6:45:29 PM	01:25:54	8:11:22 PM	8:11:22 PM	01:25:54	9:37:16 PM
Store B	8.86	6:45:06 PM	01:28:42	8:13:47 PM	8:13:47 PM	01:28:42	9:42:29 PM
Store C truck 1	11.12	6:55:08 PM	01:51:19	8:46:27 PM	8:46:27 PM	01:51:19	10:37:46 PM
Store C truck 2	11.12	8:46:27 PM	01:51:19	10:37:46 PM	10:37:46 PM	01:51:19	12:29:06 AM
Store D truck 1	7.78	6:47:52 PM	01:17:53	8:05:45 PM	8:05:45 PM	01:17:53	9:23:38 PM
Store D truck 2	7.78	7:06:18 PM	01:17:53	8:24:11 PM	8:24:11 PM	01:17:53	9:42:04 PM

Figure 10: Estimated times of arrival and unloading

Figure 10 shows the first part of the receiving side, it considers the times when storage of merchandise starts both for shipments from the distribution center and considering those from local providers. The storage times are sequential, that is, the number of assistants assigned is not storing trucks in parallel.

Another of the assumptions that this calculation considers is that providers arrive at the same time than those trucks from the distribution center. Deliveries from local providers start being loaded after those from the distribution center are finished though.

	Red boxes deliveries			
	No. of red boxes	Time when truck reaches store	Time duration for red box unloading	Hour when truck leaves store
Store A	34	6:22:50 PM	0:19:50	6:42:40 PM
Store B	30	6:21:30 PM	0:17:30	6:39:00 PM
Store C truck 1	18	6:04:00 PM	0:10:30	6:14:30 PM
Store C truck 2				
Store D truck 1	13	7:01:05 PM	0:07:35	7:08:40 PM
Store D truck 2				

Figure 11: Receiving - Red box trucks

Figure 11 shows the last part of the spreadsheet, which considers receiving red boxes at each store. The calculations are performed in the same manned than with pallets, and the estimations are calculated for the times when the red box trucks reach the stores, the unloading times, and the hours when these trucks leave the stores.

	Storage of red boxes start	Time to store red boxes	Merchandise is stored	General assistants	Receiving supervisors	Forklift operators
Store A	9:37:16 PM	1:13:17	10:50:33 PM	3	1	1
Store B	9:42:29 PM	1:04:40	10:47:09 PM	3	1	1
Store C truck 1	12:29:06 AM	0:38:48	1:07:54 AM	3	1	1
Store C truck 2				3		
Store D truck 1	9:42:04 PM	0:28:01	10:10:06 PM	3	1	1
Store D truck 2				3		

Figure 12: Number of workers needed and storage of red boxes

Figure 12 shows the right end of the spreadsheet, where the number of workers per truck are assigned, and the hours change dynamically according to the number placed here. The left part of Figure 12 also shows the times when the storage of red boxes starts and the times when they are all stored.

This spreadsheet covers all the city stores, all the necessary trucks, and the suggested workers.