Optimised Inbound Processes and Vendor Scheduling for a large retailer

By

Marco Edward Agas

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SUPERVISOR: Dr J.P. Jacobs

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Executive Summary

A large retailer has established that its vendor truck's turnaround time within its distribution centre is not entirely satisfactory. The retailer aims to decrease this turnaround time in a way that would provide the retailer to allow for an increase in throughput opportunities.

This report will first cover the introduction and background the companies involved as well as providing details of the entire process in order to give a full understanding of the large retailer and its distribution centre.

The aim of the project was to optimise the grocery inbound process within the large retailer's distribution centre by creating an improved scheduling system and minimising turnaround time (TAT) within the distribution centre (DC).

The main problem that the large retailer deals with was an inefficient vendor schedule as well as poor day-to-day activities that resulted in a large turnaround time and high labour costs. In order to solve the problem, research was conducted in the form of a literature review, which highlighted the use of a successful simulation model to address the issue.

Outputs of the simulation model provided successful measures in reducing both the turnaround time and labour costs. This was completed in the form of a new, optimised vendor arrival schedule, as well as recommendations for general day-to-day efficient activities.

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Chapter 1. Introduction and Background

1.1 Where It All Begins

This section of the report will outline the background of both the company that the student is assisting with, as well as the background of the distribution centre where the problem exists. From there, this chapter will look at the problem statement and the aim of the project. Finally, the chapter will conclude with how the process currently operates, complete with process mapping.

1.2 A background of a large retailer's Distribution Centre

1.2.1 Company Background

Imperial Managed Logistics (or IML) was established in 2013 following the consolidation of two companies in the IMPERIAL stable, namely IML and Cargo Africa. The new name creates both a power message and describes easily what they do. IML is an Imperial Company, and they offer logistics management services (IML, 2013).

IML has, for a few years, been assisting a well-established large retailer with its operational efficiencies and overall logistics management. This logistics management also entails the improvement of one of the retailer's distribution centres, located in Longmeadow, Kempton Park (shown below).

Figure 1.1 Map location of the large retailer's distribution centre (Google, 2013)

Imperial Logistics is a multi-branded logistics group (IML, 2013), and with the help of its many brands has become the number one choice when selecting a logistics partner. Imperial Logistics as a whole aims to achieve successful broad-based logistics services to its customers, but at the same time stay true to its goal: Fast Moving, Forward Thinking.

1.2.2 The Distribution Centre Background

Today, large retailers are reducing expenses by cutting down on inventory at every step of the operations process. In order for a large (country-wide) retailer to improve its efficiencies, and in turn reduce these expenses mentioned above, it must use an efficient distribution centre. According to Maria Pia Fanti et al., a distribution centre (DC) is a type of warehouse where the storage of goods is limited or non-existent (2011). Maria Pia Fanti et al. also stated, “Inbound trucks are unloaded and the loads are unpacked. Successively, the single items are sorted according to the customer requests, packed and sent to the customers by outbound trucks”. This stresses the fact that 'time is money' and therefore heavy emphasis must be placed on both in order to succeed.

Regarding the initial process, before a truck arrives at the DC, it needs to be scheduled in order for queues at the DC to be reduced. Vehicle scheduling is the key content of daily management decision-making in many large distribution centres (Zhang & Zhang 2008). It directly influences logistics distribution cost and customer service level (Zhang & Zhang 2008).

The DC that will be discussed in this report has 5 different truck types, sorted by the amount of goods they carry, that drive from the necessary suppliers to the DC. IML is the retailer's transport management partner, and is responsible for the scheduling, booking and overseeing of deliveries, and measurement of performance (IML, 2013). The retailer's warehouse employees are responsible for the physical offloading, receipt and administration of deliveries (IML, 2013). The large retailer also has a 3rd party company that verifies the goods before they are offloaded. Now that the background of the problem has been introduced, the problem statement will now be defined.

1.3 Problem Statement and Needs Requirement

1.3.1 Problem Statement

The Main problem

The intention of this project is to create an optimised vendor schedule for the grocery inbound process, and to suggest ways on improving the efficiency of the grocery inbound process within the large retailer's distribution centre.

Sub-problem 1

Create an optimised vendor schedule that will be used to optimise the grocery inbound process for the large retailer.

Sub-problem 2

Compile suggestions and recommendations for the improvement of sub-processes that the large retailer can use to optimise its grocery inbound process.

Figure 1.2 Trucks waiting in an unnecessary queue

Since the problems have now been addressed, the next section will focus on the aim of this project. The problem has now been clearly defined, however the aim of this project must now be addressed. The next section will cover the aim of this project.

1.4 AIM OF THE PROJECT

The problem of having an inefficient vendor schedule as well as a large turnaround time (TAT) has many disadvantages. One main disadvantage is that it reduces the retailer's ability to expand. An optimised vendor schedule will allow for more trucks to arrive into the DC, therefore more goods will be allowed to be sent out to various shops. This combined with minimising the time it takes to complete the inbound grocery process will in effect increase throughput and thus increase the income for the retailer. A main opportunity for the aim would be a reduction in labour costs as a result of the aforementioned problems, as less temporary staff will be needed if the process has been optimised. Therefore the aim of the project would be:

To optimise the grocery inbound process within the large retailers distribution centre by creating an improved scheduling system and minimising TAT within the DC. It must now be determined however of the importance of achieving this aim.

1.5 IMPORTANCE OF THE PROJECT AIM

Now that the aim of the project has been established, it must also be reinforced of the importance of a solution. The distribution centre is currently averaging a TAT of 5 hours, which when compared to the retailer's DC located in Cape Town, is an average of 2 hours more. This means that a potential 2 hours are wasted. It is important to see that saving this time will sufficiently improve throughput of the system and reduce the related costs as mentioned above.

The DC itself cannot be expanded physically due to already filling up all available space that it occupies, and if the retailer tried to expand on this space the costs would be immense. This further enforces the importance of the aim, as optimising the vendor schedule and improving sub-process efficiencies would relate to the retailer not needing to expand the DC in order to see an improvement in throughput.

Finally, labour costs are directly linked to optimising the grocery inbound process. The average cost per day of labour is an average of R 17 000 in the grocery inbound process. Having a more efficient process means that some of that labour can be distributed elsewhere in the DC, or even not needed at all. Shown below is an image taken showing that personnel might not always be needed if the truck is waiting to offload. The project will determine how much of the labour costs can be reduced using an optimised vendor schedule. Now that the aim of the project has been described and the importance of the aim noted, mapping of the grocery vendor arrival process will be explained.

Figure 1.3 Labour costs are an important drive for an optimised schedule

1.6 PROCESS MAPPING FOR THE GROCERY INBOUND PROCESS

1.6.1 Process Mapping Overview

The following two maps differ somewhat in that they describe two different parts of the problem. Firstly, the vendor arrival schedule must be understood in a way that will make sense to the reader. It will discuss how a vendor selection process works as well as when and how many of a certain vendor type should arrive at the DC. Next the entire grocery inbound process will be described and mapped in order to give the reader a full understanding of the process.

1.6.2 Current Vendor Schedule

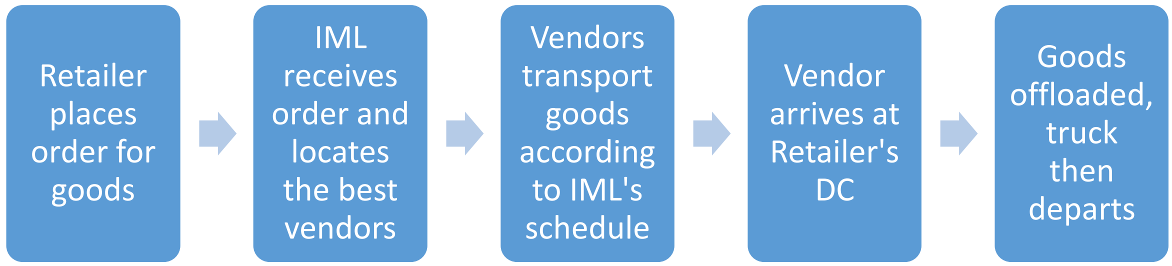


Figure 1.4 Inbound Grocery Warehouse Process

In the above illustration, a brief description of the flow of the process is shown.

1. Retailer places order for goods – the retailer contacts IML of what stock they need in order for the coming week.
2. IML receives order and locates the best vendors – IML will now acknowledge that goods need to be ordered, whereby they will contact the various vendors involved that have the goods in stock.
3. Vendors transport goods according to IML's schedule – a current vendor schedule has been setup (see below) that allocates roughly when a certain vendor truck type can and should arrive.
4. Vendor arrives at Retailer's DC – the vendor's truck will now travel from its supplier to the DC, whereby it will wait until verification that it can enter the DC.
5. Goods offloaded, truck then departs – this will be discussed in more detail below as well as in section in 1.6.3.

Shown in the figure below is a more detailed description of 5 above, which entails a vendor truck entering the DC and continuing with the grocery inbound process.

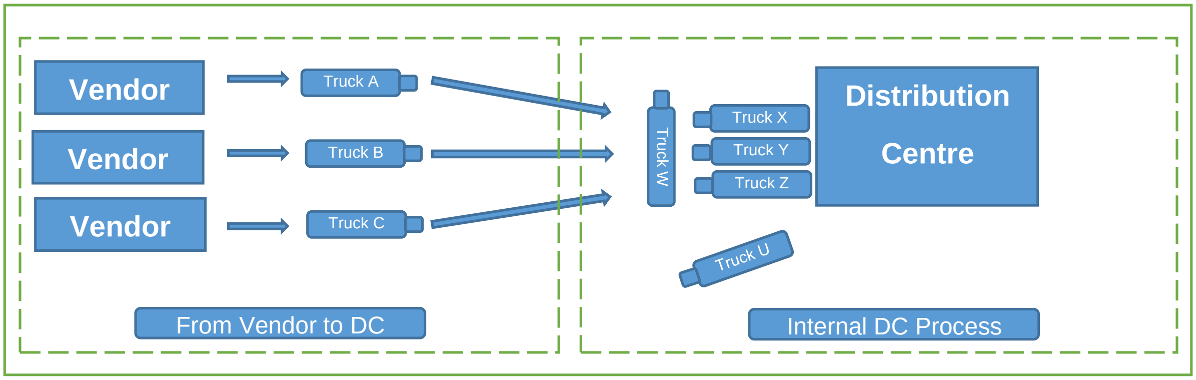


Figure 1.5 Basic Overview of the Inbound Process

As shown on the left (where the process starts), vendor trucks will leave their specified companies, where they will then travel to the DC. Once inside the DC (as shown on the left), trucks will wait if there's a queue (Truck W), where upon they will park in a free offload dock. After the offloading procedure has finished the truck will then leave (Truck U) either returning to its vendor or another specified area. To see the complete process map, see page 19.

Now that the process has been briefly mapped and explained, the vendor schedule (the primary focus) can be explained. This schedule will be the main source of information when creating the simulation, as in order to optimise the process, this schedule will need to be altered.

	Express	Normal	Complex 1	Complex 2	Complex 3	
06h00	6	2	1	1		
07h00	6	1			1	
08h00	3	3	2			
09h00	3	3	2			
10h00	3	4	1			
Lunch						
12h00	3	4		1		
13h00	2	4		1		
14h00	1	6	1			
15h00	1	7	1			
16h00		7				
Handover						
18h15		7				
19h15		7				
20h00						
Total	28	55	8	3	1	95

Table 1.1 Current Vendor Schedule

The table above shows the number of trucks to arrive per given time slot throughout the day. There are 5 truck types (Express, Normal, Complex1, Complex2 and Complex3), that are sorted by the number of pallets they can hold and how long it generally takes to offload them, as determined by IML. This schedule plans the amount of trucks to arrive per day, where each day of the week will be filled up following this template. For example, 6 Express truck types are allowed to arrive between 6h00 and 7h00 in the morning, while no Complex 1 truck types are allowed to arrive between 7h00 and 8h00. Lunch Time and Handover Time is when staff are on break, therefore no activities will take place and trucks aren't allowed to arrive during those times. The total at the bottom states the number of trucks per type that are allowed to arrive per day.

As the table shows, most trucks are scheduled for the morning, therefore the simulation model output will determine if this is in fact a smart decision or can it be optimised further. For the purpose of this project, only the truck types will be scheduled, and not the individual vendors. The simulation model that was created used the total amount of trucks as a constraint, and from there determined a more efficient schedule. In the table, that average turnaround times per truck type is shown:

Truck Type	TAT (in hours)
Express	3.33
Normal	3.92
Complex 1	5.29
Complex 2	6.06
Complex 3	7.42
Simple	3.63
Average	**5.2**

Table 1.2 Average TAT for vendor trucks

The information above was collected from data from January to June 2013. This time was recorded from when a vendor truck entered the DC to when it departed the DC after having unloaded its goods. Investigating the problem found that these times were much higher than the DC's counterpart (located in Cape Town) which averaged TAT of 3 hours. One of the aims of this project is to reduce this average turnaround time.

1.6.3 Current Inbound Yard Situation

Now that the vendor schedule has been explained, the complete process mapping can be explained in order to create a complete understanding of the grocery inbound process. The following will break down the complete process into sub-processes, starting from when a vendor arrives at the gate of the DC. For the problem being investigated, a number of observations and time studies were taken for 2 weeks in order to determine if simple, yet not necessarily easy solved, problems were highlighted.

1.6.3.1 Arrival at gate

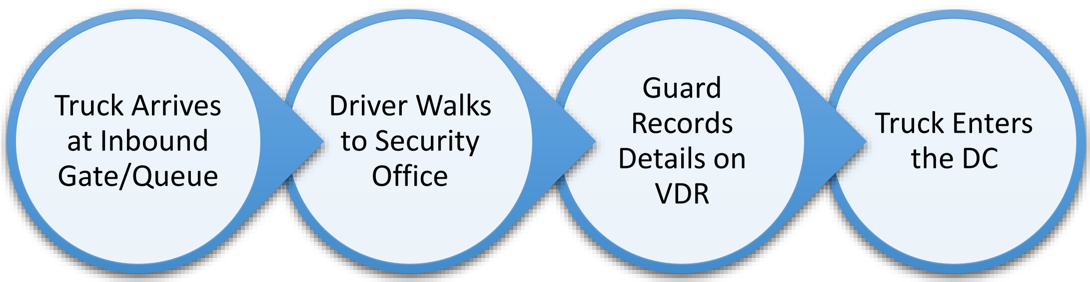


Figure 1.7 Basic Process of Truck Arrival at Inbound Gate

The process starts by the vendor arriving in the queue (if there is one), getting out of his truck and heading to the Security Office. From here the driver will hand in the invoice to the security guard inside the office, whereupon the guard will take down the time as well as the driver's particulars. This time taken is taken as the **Arrival Time.** Once the driver's details have been recorded the driver will head back to his truck. From here he will wait until a Vericon employee tells him he can drive to the Inbound Grocery docks.

In order for a truck to be granted this access, a Broco/Vericon employee that is situated at the Inbound Grocery yard must determine if a truck can be allowed into the yard. This is usually when a truck leaves the yard, which is when the Vericon/Broco employee will radio the other Vericon employee at the Inbound Gate to say that a bay is now free. From here this employee will tell the driver that he can pass through the gate.

Regarding the information capturing process, the security guard passes the invoice of the vendor as well as the VDR (Vendor Delivery Record) to another Vericon employee inside the office. This employee will now capture the **Arrival Time**, as well as various other information. When the truck passes through the gate, this employee will then capture the **Ready for Delivery** time onto the system.

Initial Comments on the Arrival process

From what was observed, this sub process is quite stable. There are no unnecessary delays between the driver arriving at the security office and the truck entering the DC. An employee is always ready to record times and input data onto the system. There is also effective communication between employees.

1.6.3.2 Arrival at Grocery Inbound bay

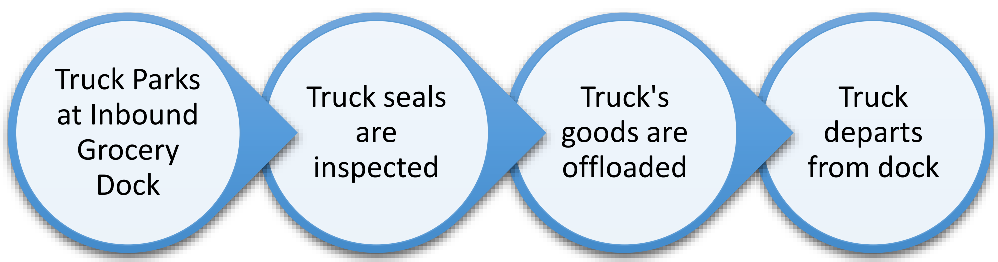


Figure 1.8 Basic Inbound Grocery Sub Process

Once the truck has permission to enter the DC, it must proceed to the inbound yard at the Grocery Warehouse. This is where the truck's goods will be inspected, offloaded and then put away. As soon as a bay is ready, the truck will park at this bay, whereby the **Dock in Bay** time will be taken. There are 9 bays available at the yard, as well as space alongside the bays in order for trucks waiting and for damaged goods to be loaded back onto trucks (see below).

1.6.3.3 Inspection Process

As soon as the truck has officially parked, a retailer inspector will check the driver's credentials, as well as the seals on the truck. Once all the seals have been verified, the inspector will take the invoice to the Inbound Clerk, whereby the clerk will partially complete a Tipping Sheet with the given data. The clerk will input the data onto 2 different systems (retailer's and Vericon) onto his/her PC.

The truck driver may now exit his vehicle and begin opening the truck's trailer in order for a more thorough inspection. The inspector checks for any missing pallets or immediate damages. Once the goods look in order, the goods may now be offloaded using forklifts.

Initial comments on the Inspection process

As seen in the time and motion studies, the average inspection time as well as offloading time is fairly constant and don't impact on the overall time of the inbound process. Observations are that if a truck is in the queue (inside the yard), that truck will wait on average of 10 minutes, which is included in the TAT.

1.6.3.4 Offload & Receiving Process

The offloading process is mainly controlled by the forklifts. Roughly 2-4 forklifts are assigned to a truck (7-10 in the inbound yard altogether), which is determined by the on-duty supervisor. The forklifts remove all the contents of the trucks, which is in the form of goods on top of pallets. The goods are placed alongside the truck, and can be moved into the warehouse (into specified lanes located at the entrance of the inbound doors) either after all goods have been removed or a few minutes before. This offloading process and the second inspection as described above can occur simultaneously.

Once all the goods have been transported to a specified staging area, the goods will be received (scanned) onto the retailer's system, and the truck may leave for the mound and wait for his documentation. The goods will either be correct or incorrect, and these two sub-processes will be described below.

Correct Goods Receiving Process

If the goods are in the correct amount and aren't damaged, the receiver will proceed in completing the Tipping Sheet, and this sheet will be handed back to the Inbound Clerk to be completed fully. The clerk will now create an AOD (Acceptance on Delivery) form. This form specifies that the goods are correct, and that the goods can be fully offloaded. The time that this form is completed is recorded as the **AOD** Time. The clerk will now proceed into the Inbound Office, where he/she will tell a mound employee (via radio) to notify the driver (provided that he is waiting at the mound) that he may leave, and hand him his necessary documentation (gate pass). If the driver is not outside (he could be in the restroom or canteen), this can lead to an increase in turnaround time as he must be found by employees.

Damaged/Incorrect Goods Receiving Process

If there is something wrong with the goods (damaged, missing, incorrect amount, etc.), the receiver will call his/her supervisor. The supervisor will then communicate with the driver of why the goods are incorrect, and can advise the goods to be placed back onto the truck or into the Sin Bin (in which case the vendor must pick up his/her incorrect goods by the following morning). The supervisor will then create a PTR (Permit To Remove) form and the goods will be rescanned by the receiver, and this form, coupled with the corrected Tipping Sheet will be given back to the Inbound Clerk. The clerk can now carry on with the Correct Goods Process as described above. The time that the PTR form is completed is recorded as the **PTR** time.

Certain vendors, called red vendors, have their goods routinely checked. This is because these vendors have often delivered stock that is either damaged or in some way incorrect. Only once all the goods have been removed from alongside the truck and placed inside may the truck driver leave with his truck, as well as documentation verifying that he has successfully offloaded his goods.

Initial Comments on the Offloading Process (External)

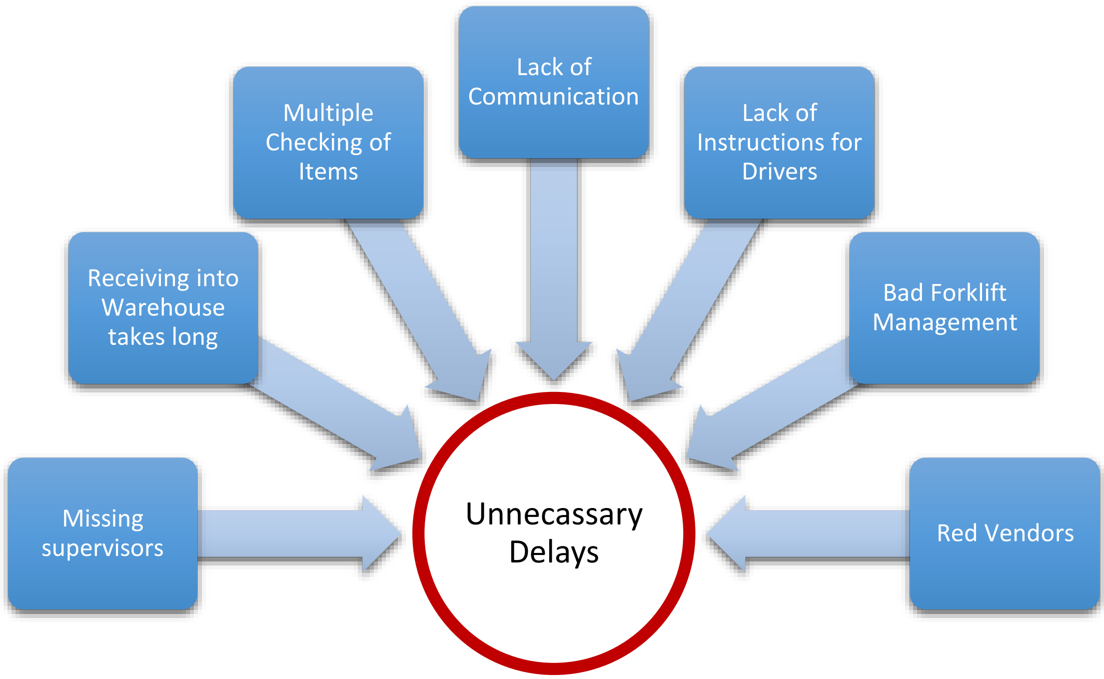


Figure 1.9 Main Offloading Observations

Shown in the image above is a brief summary of the causes of unnecessary delays. The first main observation is that stock takes a long time (over an hour), in order to be completely removed from the internal warehouse lanes (part of the receiving process). This includes the receiver receiving (scanning) the stock into the system, as well as this stock getting put away by forklifts. This leads to congestion, as the trucks outside can't offload and leave until these goods have been put away. The main cause for this is the receiving of stock, for if there is a discrepancy, a long and lengthy process follows before the process can resume. This is then followed by the time taken from when a receiver finishes receiving the stock until the forklifts begin put away.

During this process, it was also noticed that the goods were counted/scanned more than once. The first time is when the goods are inspected alongside the truck, where only the goods are counted. The second time is when the goods are in the staging area, where the receiver scans the goods. A third time can be if there is an error with the goods, and they have to be rescanned after the supervisor has verified the error and a PTR form has been created.

An arriving truck that contains discrepancies can cause major time delays. This is due to:

- Supervisors sometimes missing, especially during night shift
- The tipping sheet becoming passed on to more personnel that what is required due to lack of communication.

As shown in the image TAT for Grocery Inbound (see Appendix D),much time is spent (32 minutes) from when an AOD is ready until a driver is notified that he may leave. The times indicate the time a truck takes during each section of the process. The middle bar is where the general time is spent, and the colours reflect if the problem is treatable (green means the process is efficient, while red indicates much time is wasted. The other bars represent the middle bar however in more detail, where purple indicates much more time can be saved during that time, while red indicates the most unnecessary time wasted.

This time should be easily reduced, as when the AOD is printed, the rest of the forms are printed, stapled, and then the driver is notified via radio. However during observation, this wasn't the case. The completed documentation will often stack up until 3-5 packs are finished, and then only the drivers will be notified. Other causes are:

- Radios often going missing – can't notify mound supervisor
- Driver is missing – not aware that he can't leave his truck
- Truck missing – Inbound Office not aware that truck has already left
- Inbound Office often waits for mound supervisor to walk back and forth to check when necessary documentation is ready for the driver

Finally another observation was the impact of 'red vendors'. These vendors have been determined to be the top 5 vendors most likely to have discrepancies with their goods. This results in the PTR processed being followed, which always leads to a large impact in the receiving process time. However, nothing has been done with regards to penalties for these red vendors or even the top 10 vendors with incorrect goods. If the vendor arrived at the DC without any discrepancies at all, then the retailer wouldn't have to worry so much about reducing its receiving time as there wouldn't be any errors.

In conclusion, it can be seen that there are many areas which can be improved upon, mainly involving the receiving process. The good news is that the problems are arising from simple miscommunication, and this problem can be alleviated with fundamental communication rules as well as effective tools to streamline the process.

1.6.3.5 Departure Process

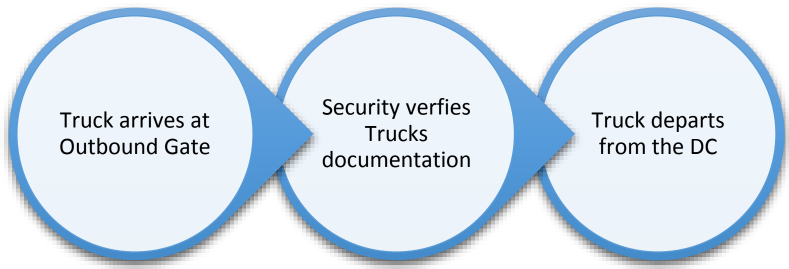
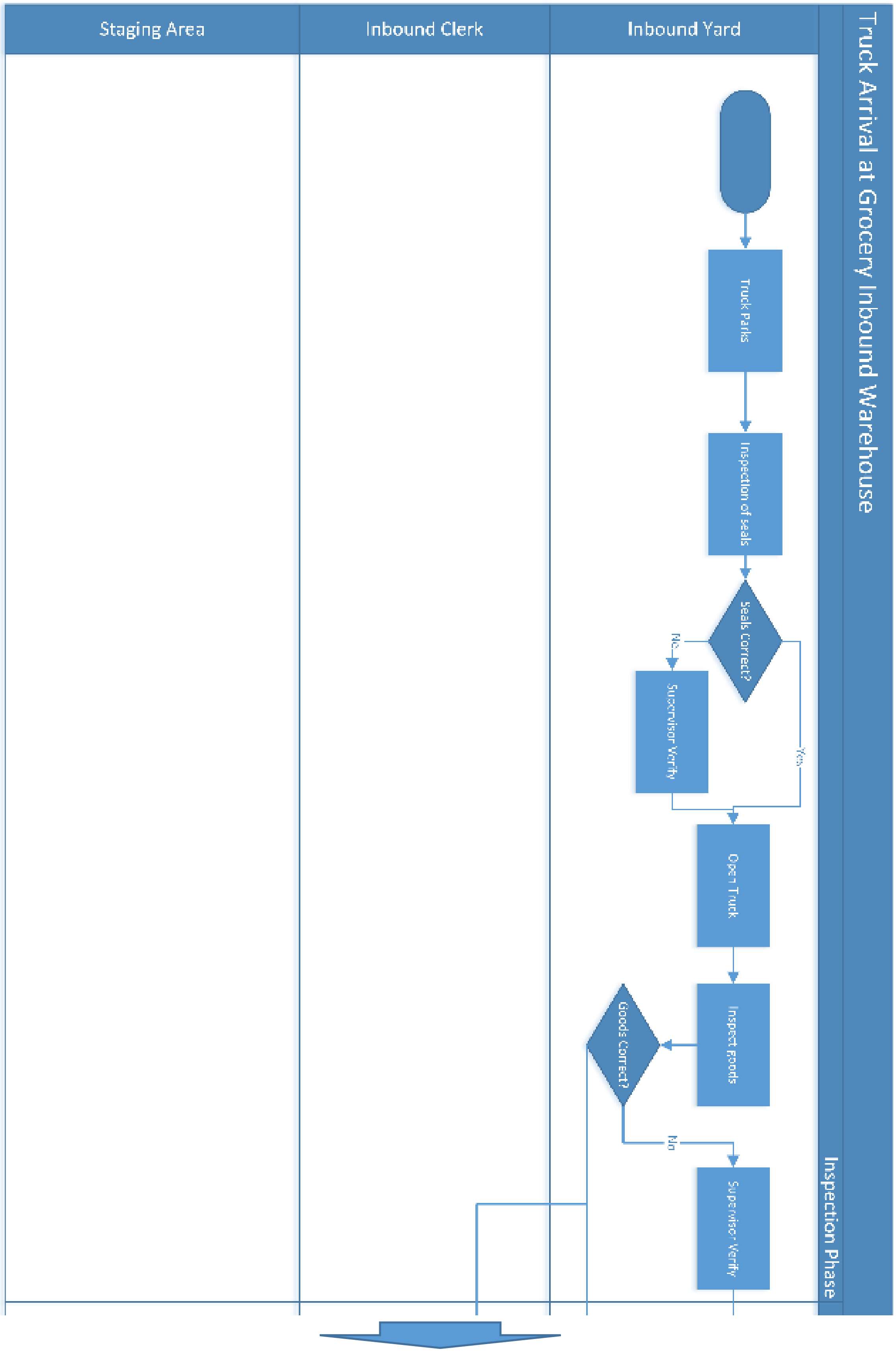


Figure 1.10 Basic Sub-Process of Truck Arrival at Outbound Gate

This short sub-process entails the truck leaving the DC. The truck arrives at the outbound gate, where the **Gate Exit** time is recorded and the security guard checks all the driver's documentation. Once the guard sees that everything is in order, the truck may depart to its next destination.

The following page is an in depth swim-lane diagram for this sub-process.


Staging Area
Inbound Clerk
Inbound Yard
Truck Arrival at Grocery Inbound Warehouse
Truck Parks
Inspection of seals
Seals Correct?
No
Yes
Supervisor Verify
Open Truck
Inspect goods
Goods Correct?
No
Supervisor Verify
Inspection Phase

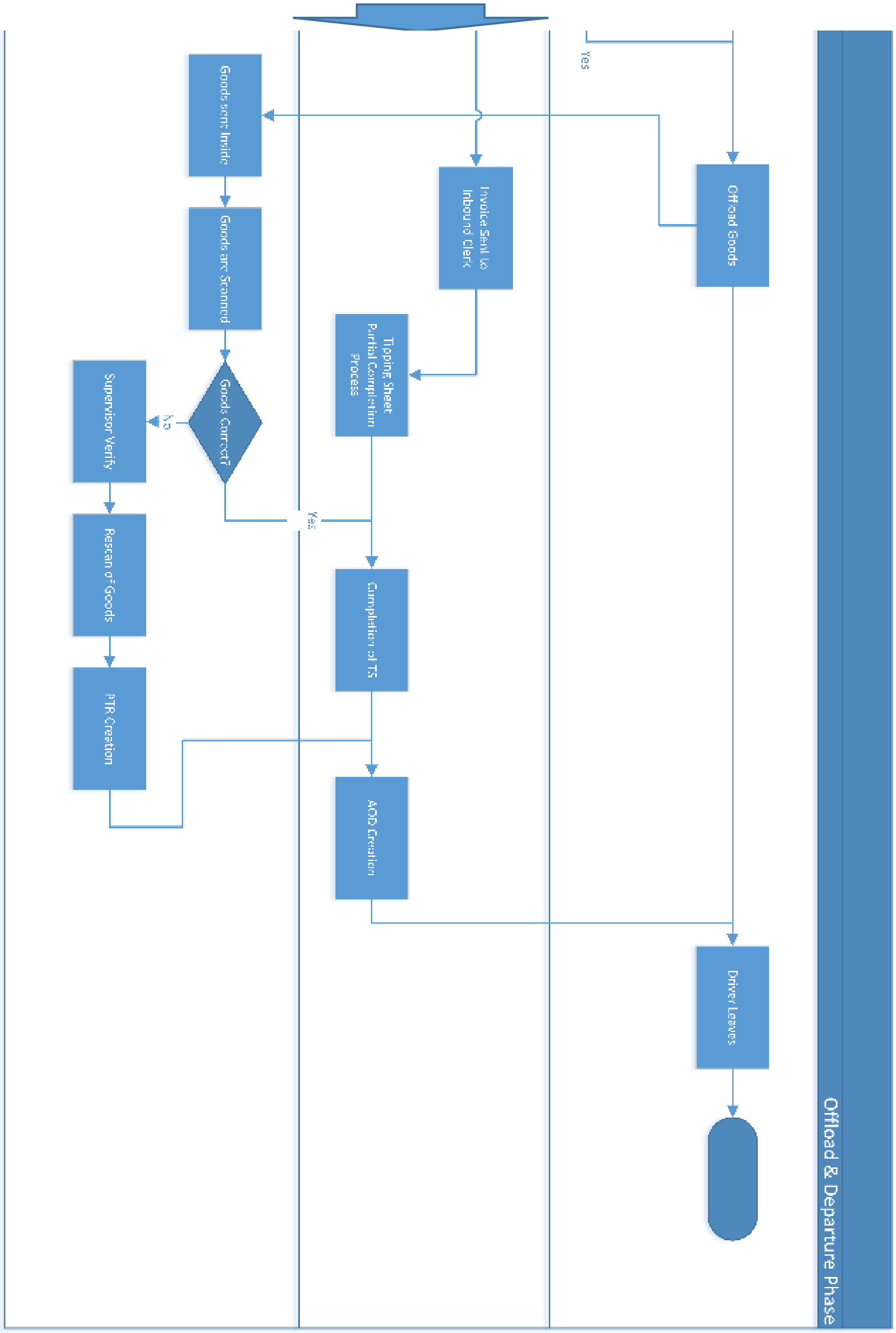
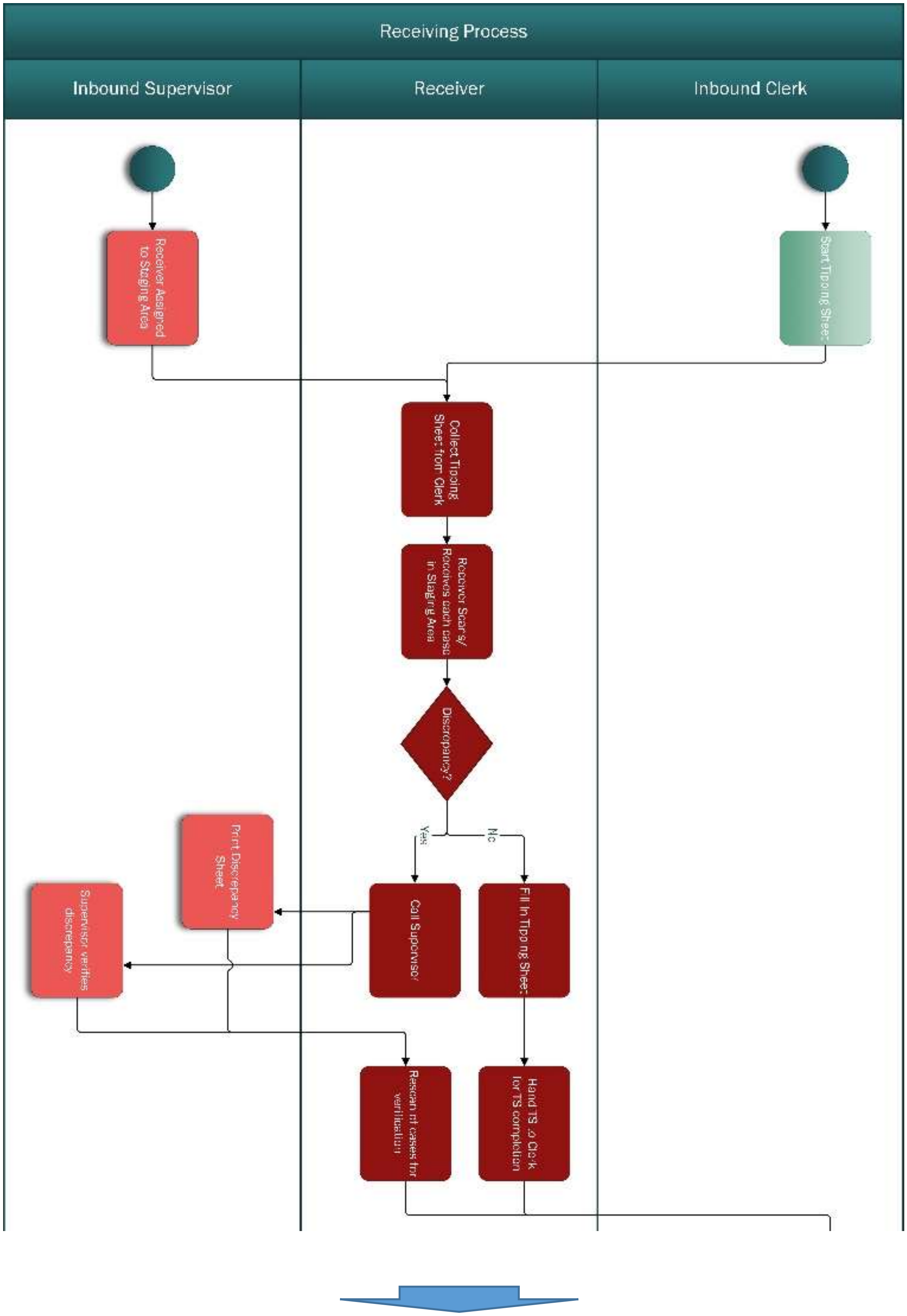


Figure 1.11 Swimlane Diagram for Grocery Inbound Sub-Process


Receiving Process
Inbound Supervisor
Receiver
Inbound Clerk
Receiver Assigned to Staging Area
Start Tipping Sheet
Collect Tipping Sheet from Clerk
Receiver Scans/ Receives each case in Staging Area
Discrepancy?
Yes
No
Print Discrepancy Sheet
Supervisor verifies discrepancy
Call Supervisor
Fill In Tipping Sheet
Rescan all cases for verification
Hand TS to Clerk for TS completion

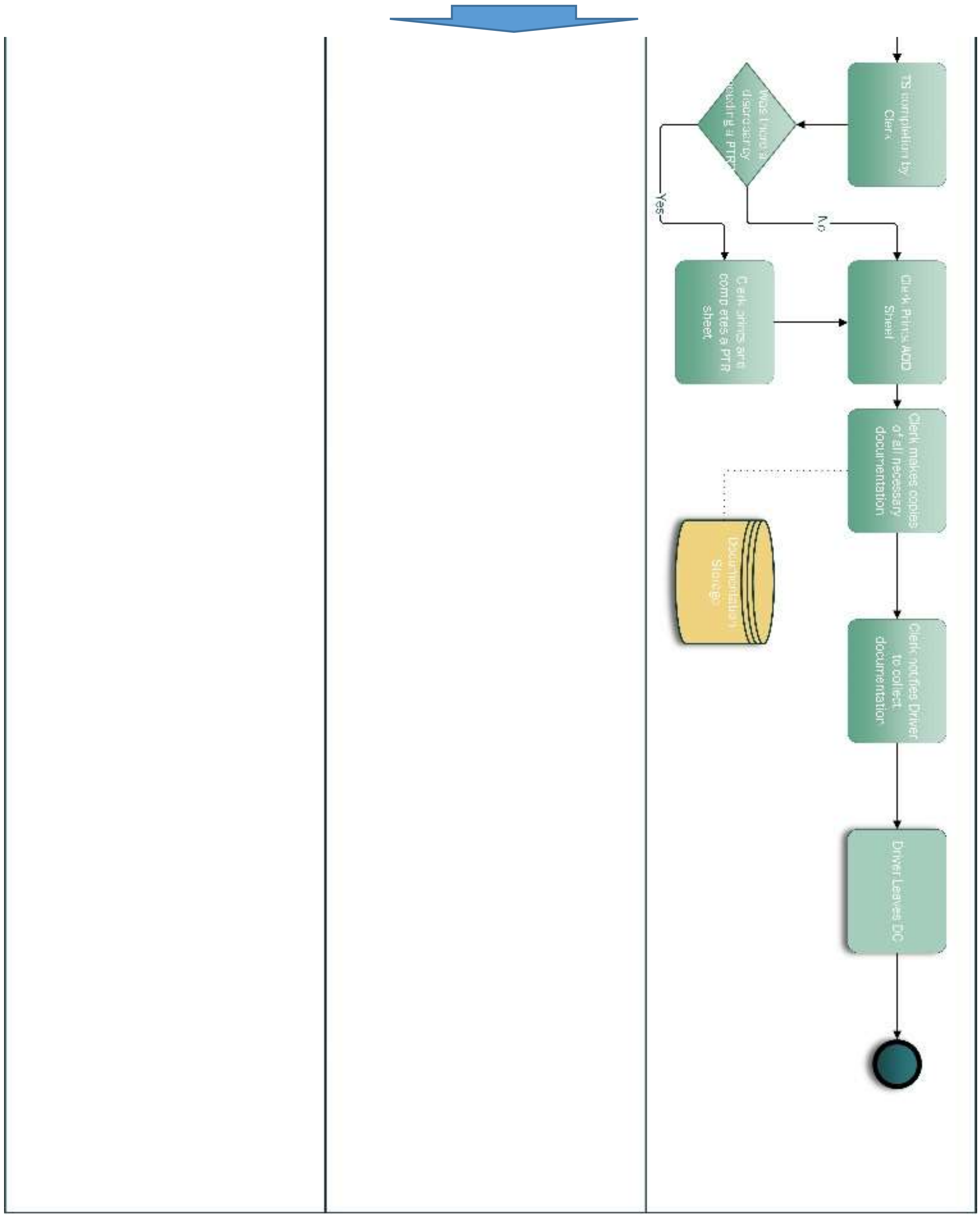


Figure 1.12 Receiving Process - BPMN Diagram

1.7 SUMMARY OF THE PROBLEM INTRODUCTION

The chapter above has described the complete background of both IML, the large retailer as well as a DC in general. It also looked at the problem definition and the aim of the project. Finally it concluded with an overall process understanding. The recommendations for the observations conducted during the process mapping will be discussed in Chapter 5. The following chapter will focus on the literature review of this project.

CHAPTER 2. LITERATURE REVIEW

2.1 INTRODUCTION TO THE LITERATURE REVIEW

There has been much research compiled in the distribution centre area of a supply chain. This has been explored mostly using LP (linear programming), MILP (mixed integer linear programming) models and simulation techniques in order to determine optimal work schedules, placement of materials, and cost reduction. This supply chain efficiency can be further narrowed down towards improving the individual DC processes.

A distribution center has evolved over the past few decades, with new technology and engineering methods being applied to improve both its efficiency and effectiveness:

> "It is different from the traditional storage facilities, in this modern commercial society; distribution center has become the business flow, logistics and information centre of chain enterprises; it is the essential facilities of function well for the chain business". (Xiangguo et al. 2011).

This literature review will focus on the two main areas of the inbound process for a large retailer, specifically the scheduling process for vendor trucks and the grocery receiving process once these trucks are inside the DC. The vendor scheduling will involve a simulation model of the process, which will aid in determining the optimal arrival times for the various vendors. The goal for the vendor scheduling would be to minimize the turnaround time within the DC, reduce labour cost and allow for future throughput expansion.

Once the schedule has been optimised, optimising the receiving process will begin. The goal for the inbound process within the DC would be to apply 'lean' concepts for identifying and eliminating waste. Some of the methods which can be implemented to maintain a low turnaround time for the goods while increasing the utilization of the warehouse resources are put-away personnel (personnel involved with the put-away process), fork-lifts, and storage aisles (Gopakumar et al. 2008). This may be optimised using the same simulation of the vendor scheduling, as well as various other simulation techniques.

The purpose of the literature review is to explore the currently known information on the subject in question. From identifying the study which the problem would most benefit from and expanding the reader's knowledge of current and past literature to application of theory.

With this in mind, this section is broken up into parts, each dealing with aspects of understanding the problem, currently available solutions, and the inputs and outputs that must be understood before a model can be properly conceived.

2.2 REVIEW OF THE LITERATURE

2.2.1 Simulation analysis of a distribution centre

Simulation is an important method and tool in many fields of engineering. In comparison, simulation only plays a minor role in supply chain management. One reason of this discrepancy is the distinctiveness of managing a supply chain as human and knowledge driven domain compared to technical or physical systems. On the other hand, in order to set the course at a crossroads, it might be useful to look and learn from simulation usage in other engineering domains.

Nowadays, people don't necessarily relate simulations to anything more than mimicking the behavior of a real-life system using computer software. There are however a few more formal definitions of the word simulation. It may be described as the creation of a computer program that signifies a certain real world system, that can be experimented on and try to predict what will happen in the future (Hollocks, 1992). Simulation can also run experiments to help understand the system's behavior or to evaluate its strategies and operations (Pedgen et al, 1990).

In short, a simulation aids in the decision-making process, which in turn reduces the risks and costs involved in a system (or project). Every year simulation techniques are becoming more and more accepted in engineering disciplines (as well as other disciplines too) as part of their daily activities in order to check if processes are running effectively and if costs can be reduced. A simulation project normally involves a sequence of steps. According to Banks & Carsen (1984), Pedgen et al. (1990), and Law & Kelton (1991), these steps can be summarized as:

- Conceptual problem formulation and analysis
- Data and information collection (most important)
- Model building
- Verification and validation
- Experiment design
- Experiment execution and results analysis
- Refinement of experiment design
- Final results analysis
- Process documentation

As highlighted above, data and information collection is of the upmost importance, and much time must be spent focusing on this. The second most important step is validation. This is to make sure that the data that has been collected corresponds with the project at hand, and the data can be easily integrated. With the current rise of supply chain complexities, everyday physical observations and regular management activities cannot provide enough problem-solving solutions, which is why a simulation model becomes such as powerful tool. The image shown below illustrates a simulation model of a manufacturing plant, displaying a key advantage of allowing the user to visualise the process.

Figure 2.1 Simulation model of a manufacturing plant (Carrabine, 2011)

Current supply chain processes make use of simulation models, as it can be placed in a variety of useful applications. The end results may differ, be listed below as stated by (Ingalls et al. 2004) are a few advantageous objectives that can be accomplished by a simulation model in relation to a supply chain:

- An improvement in performance.
- Optimal use of resources (labour, machines, etc.).
- Overall logistics improvement with the supply chain.
- Being able to determine what will happen to the system in the future if processes are altered in any way.
- Study of capacity usage, inventory levels, control logic, integration, sequencing/scheduling, bottlenecks, search for better layouts.
- "What…if analysis" – where decision policies can be rapidly tested and compared.
- Hypothesis about how or why certain phenomena happen can be verified.
- A simulation study usually shows how a system really works, in opposition to how people think it works.
- The development of a simulation model helps the company to separate controllable from non-controllable parameters and study the influence of each parameter in the system performance.
- Analysis of long time periods in short execution times.
- Problems that are usually solved by intuitive rules can be solved (and tested) formally.

Simulation models aren't just restricted to supply chains only. Public transport, supermarkets, chemical factories, amusement parks and so forth can all be improved in some way using simulation techniques. The image below shows how a simulation model can be used in almost any industry, even in the military.

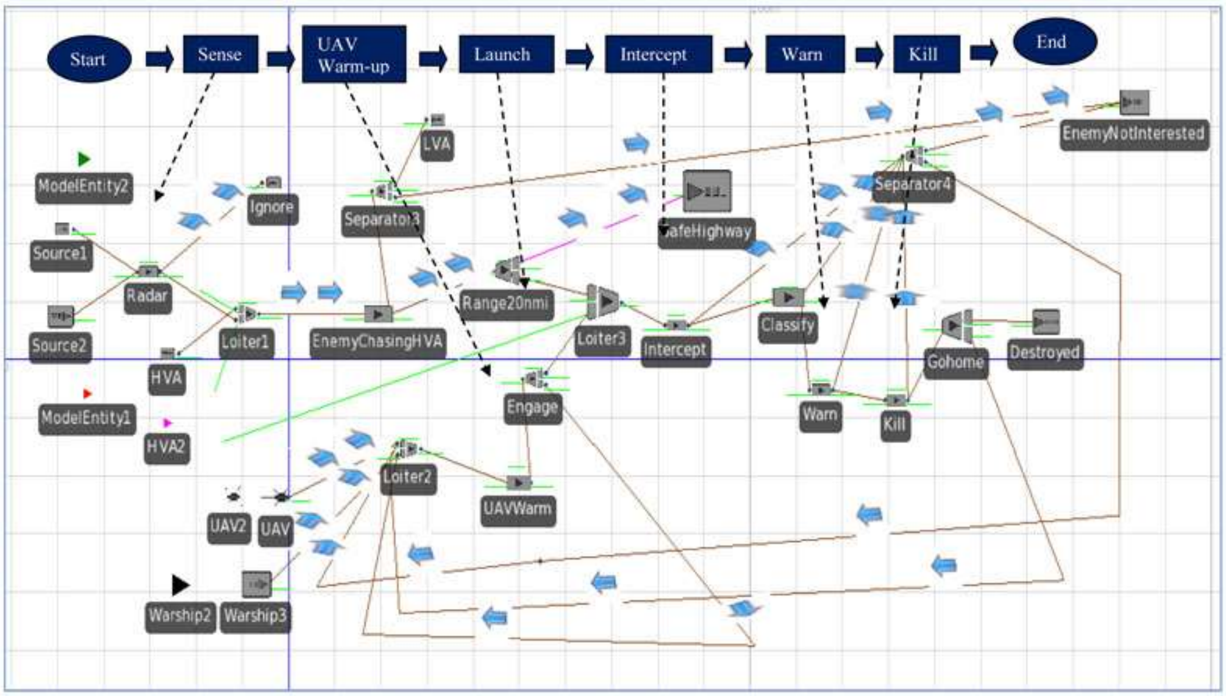
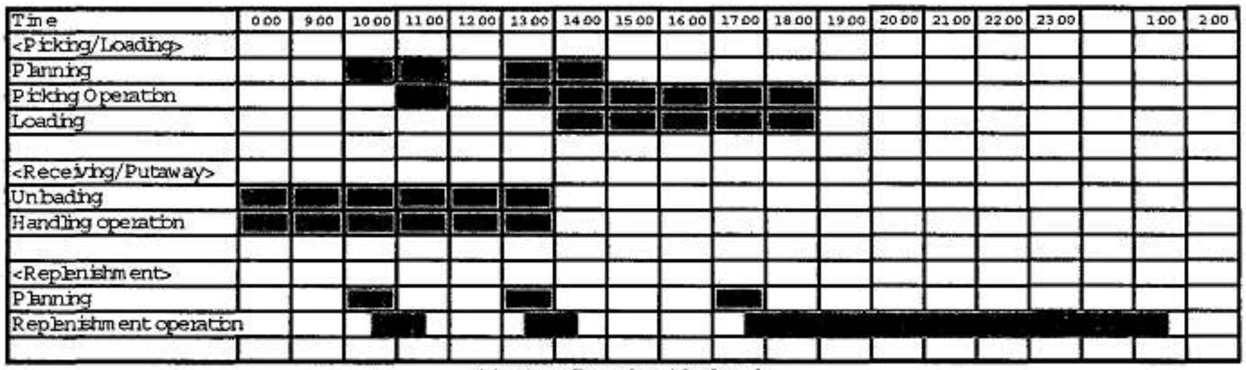


Figure 2.2 Simulation model of a military operation (Simio, 2013)

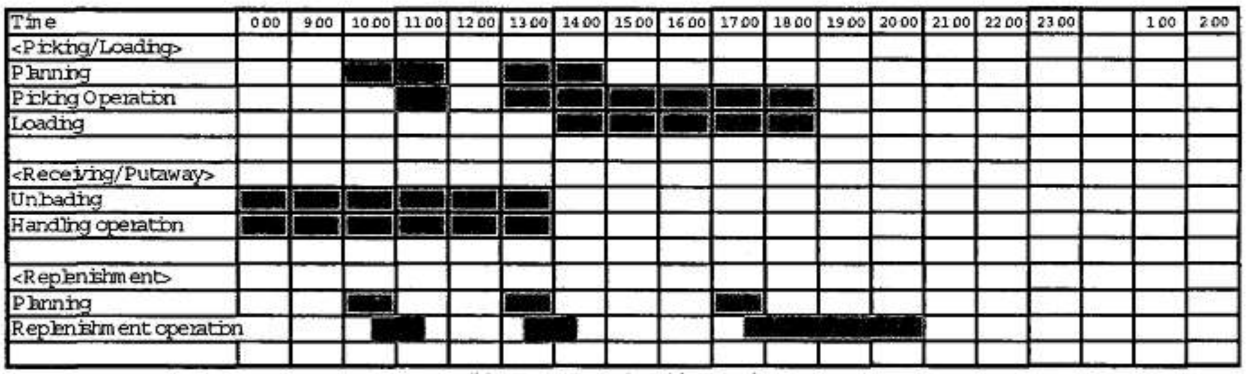
The large retailer discussed in this paper is non-automated, as a labour force with forklifts transports the goods from vendor truck to the staging area within the grocery warehouse, and no automated machines such as conveyor belts are used.

Takakuwa et al. (2000) provided useful information in improving a non-automated distribution warehouse by simulating the processes within it. Takakuwa et al. (2000) also found that simulating a non-automated warehouse is much harder than simulation Automated Storage and Retrieval System (AS/RS), as the lack of automated machinery makes material handling unpredictable and therefore more intricate.

Using simulation however Takakuwa et al. (2000) could test for example, how the number of reach-lift trucks affected the put-away process, and found that using two trucks instead of one, the ending time of replenishment operations could be improved. This is seen on the following page. A simulation such as this will help in the efficiency of the entire inbound process.



(a) One Reach-Lift Truck



(b) Two Reach-Lift Trucks

Table 2.1 Simulation Results (Takakuwa et al., 2000)

The retailer does not use any conveyors to transport goods within the DC, therefore having to rely on forklifts and reach trucks only. Liu & Takakuwa (2009) also addressed material handling issues by simulating employee scheduling, which they did so by simulating the process in order to find an optimal solution, which is seen in the illustration below. Figure 3 shows the final optimal personnel planning obtained by implementing the procedure proposed in this paper for TO-BE, 10%, 20% and 30% demand increasing situations, compared to both number of operators needed and the personnel expense for each of these situations. Type A, B and C refer to a specific skill type used during the mentioned work hours.

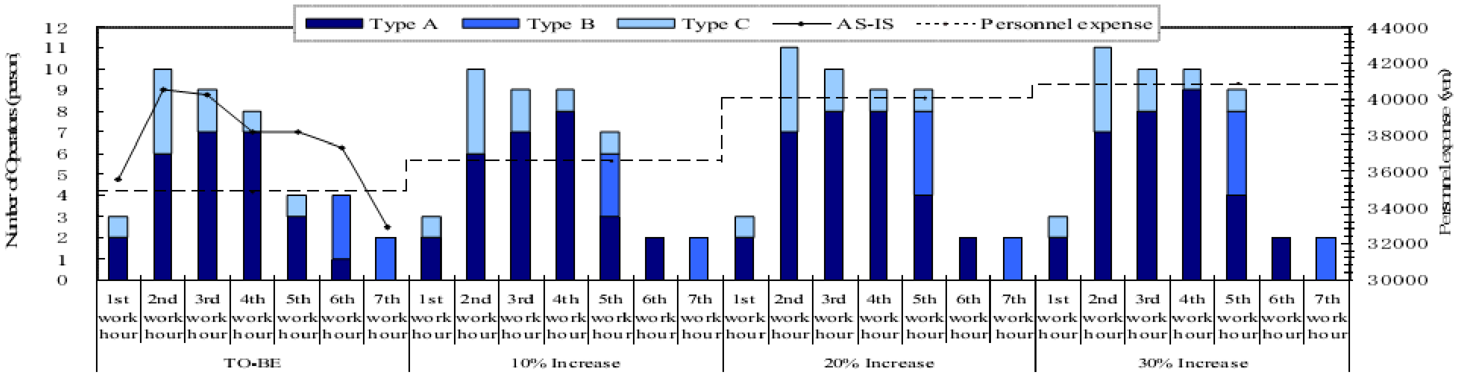


Figure 2.3 Optimal Personnel Planning for Increased Demands (10%~30%) (Liu & Takauwa, 2009)

In conclusion to the paper it showed that an optimal solution can easily be found to a problem such as personnel planning using simulation, and that a proposed method will be both practical and effective in assisting with the inbound process of a DC. However this was purely for a cross-docking centre, and therefore wouldn't be an exact fit for a standard distribution centre.

A discrete event simulation model can also be used in order to determine the impact of dock allocation algorithms. This would mean a simulation with each event occurring at a particular instant in time, and not at every time-slice and thus saving computing time. In the illustration below, it shows how a discrete event simulation model is created.

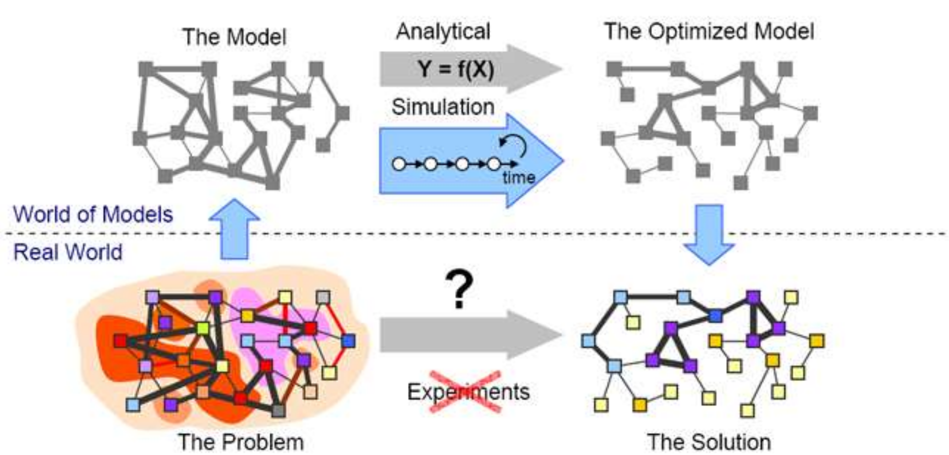


Figure 2.4 Analytical (Static) and Simulation (Dynamic) Modelling (Borshchev & Filippov 2004)

Gopakumar et al. (2008) presented that the goal of discrete event simulation models within a distribution warehouse is to reduce dock turnaround time, a dock allocation algorithm, with the inputs of product mix, volume and pre-defined storage aisle locations. The paper found that a decrease of up to 30% in the total travel distance for put-away can be achieved, without needing any more information and simply determining the optimal dock allocations for incoming trucks. The inbound process can also be improved by changing the arrival process of trucks at a warehouse, and this arrival process can be enhanced by using optimisation software (Trebilcock 2004).

There are also other sources to simulate small processes within the DC, such as when forklifts transport goods from the vendor trucks to the staging area. One of these sources is Flexsim, as Flexsim can model discrete-time system. Considering that a distribution centre and logistic systems are discrete-time systems, Flexsim is an ideal model when planning a simulation for these systems (Xiangguo et al. 2011).

Figure 2.5 FlexSim Simulation for warehouse environments (FlexSim, 2013)

Stronger relationships between supply chain partners and refining internal operations are vital for obtaining improvements in productivity and efficiency (Zhang et al. 2012). These internal operations are a key importance in this project and should be the main priority. Zhang et al. (2012)

focused on using higher level agent-based emulation framework. The paper describes high level emulation framework, an overview of a WMS (Warehouse Management System), and a case study where a high level emulation framework is used in a Warehouse Management System in a large DC. The accuracy of the simulation was compared to real life data and concluded that implementing a framework and methodology for high level emulation will address the gap in warehouse simulation between the low level PLC emulation and the high level scenario-based if-then strategic analysis. A WMS plays a key role within any DC, and therefore plays an equally important role in improving an inbound process for a supply chain.

All these simulation techniques have moved a long way since logistics and supply chain management first started, and are a great method in the search for the most optimal and successful supply chain.

2.3 SUMMARY OF LITERATURE REVIEW AND PROBLEM INVESTIGATION

In summary, the inbound process of a supply chain has room for improvement. The papers that focused on simulations however have proved to be extremely beneficial, as a simulation will be needed in the final project which will be used to find an optimal use of resources. The simulation will also help make the changes more ‘management-friendly’, as someone with little knowledge of the process will find the simulation easier to understand.

In terms of the papers focused on vendor scheduling, these papers were also found to be of great use. However all vendor problems are different and hands-on experience will be necessary in order to address the vendor scheduling for this large retailer. This might also prove to be the most important issue, as “the ‘failure’ of a supplier can result in loss of DCs replenishment and can have a major impact on the profitability of the entire supply chain” (Tanonkou, et al. 2006). This literature review was used to highlight the issues many supply chains faced, the methods that can be used to address these issues, and finally the outcomes of applying these methods.

This literature covered all the aspects of simulation. Now that the reader has a better understanding, the next chapter will describe the methodology used in finding the solution to the problem.

CHAPTER 3. METHODOLOGY

3.1 METHODOLOGY OVERVIEW

In this section, the methodology will be discussed in greater detail. Details such as the type of simulation software used, what data was used in the generation of the model and how the simulation model was created.

3.2 CHOOSING THE BEST SIMULATION SOFTWARE

The correct choice of software is imperative for the correct results. This section will look at the available information technology that is available for the purposes of this exercise in order to develop a simulation-type model.

3.2.1 Available Products

Listed below were the choices of simulation software that were deemed most beneficial to the student. Once the reader understands all the products available, the selection process will follow.

3.2.1.1 Arena

ARENA was first selected as it was used in a previous engineering module completed by the student. It has been applied extensively in many industries including manufacturing, medical, supply chain and even in the military. It has many positive characteristics including its most rewarding, its simplicity. Combining that with the advantages of UML (Unified Modeling Language), it enables someone with little simulation knowledge to construct complex models (Arena, 2013).

3.2.1.2 Any Logic

This intensive simulation software supports many new common simulation methodologies including: System Dynamics, Process-centric (also known as Discrete Event), and Agent Based modeling, making it extremely popular.

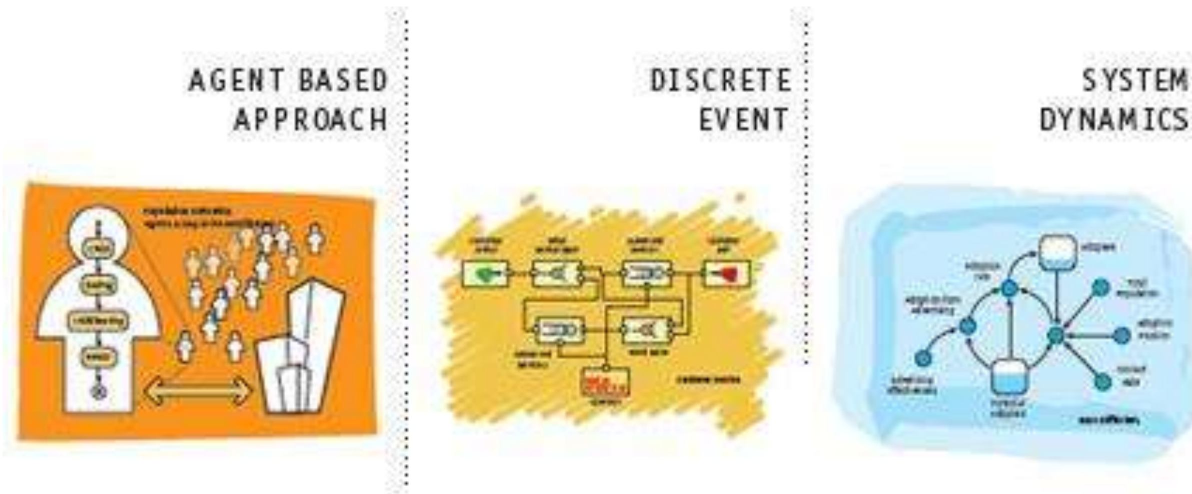


Figure 3.1 AnyLogic's Capabilities (AnyLogic, 2013)

One of the most flexible systems on the market, it allows the user to model complex and heterogeneous business, economic and social models with as much or as little detail as needed. AnyLogic also has a rich graphical interface, as well as tools and libraries that help engage the user in order to complete their given task as quickly and effectively as possible. It also supports programming within the model, allowing for more complex outcomes (such as modeling consumer behavior) (AnyLogic, 2013).

3.2.1.3 FlexSim

The next choice was FlexSim, a powerful simulation tool that is most seen in the manufacturing industry. Allowing for easy to create 3D models right from the start as well as use its built-in experimenter and OptQuest®, it's able to find the potential in any system. It allows the creation of 3D charts and graphs, exporting reports and statistics, as well as drag and drop modeling. Comprehensive help, easy-to-follow controls, as well as many other important benefits all add up to make Flexsim a very strong contender (FlexSim, 2013).

3.2.1.4 Simio™

The final choice was Simio™. Simio™ was designed from the ground up to support the object modeling paradigm. Not only that but it also allows for seamless use of multiple modeling paradigms including event and process orientation. One unique aspect is that it uses intelligent objects that are built by the users and then can be reused in multiple modeling projects. This software is also brilliant for beginners, as it allows for a drag-and-drop approach for pre-built objects in easily sharable libraries. Simio™ looks like the real system when creating a model, and this animation as well as the model logic may be created in a single step (Simio™, 2013).

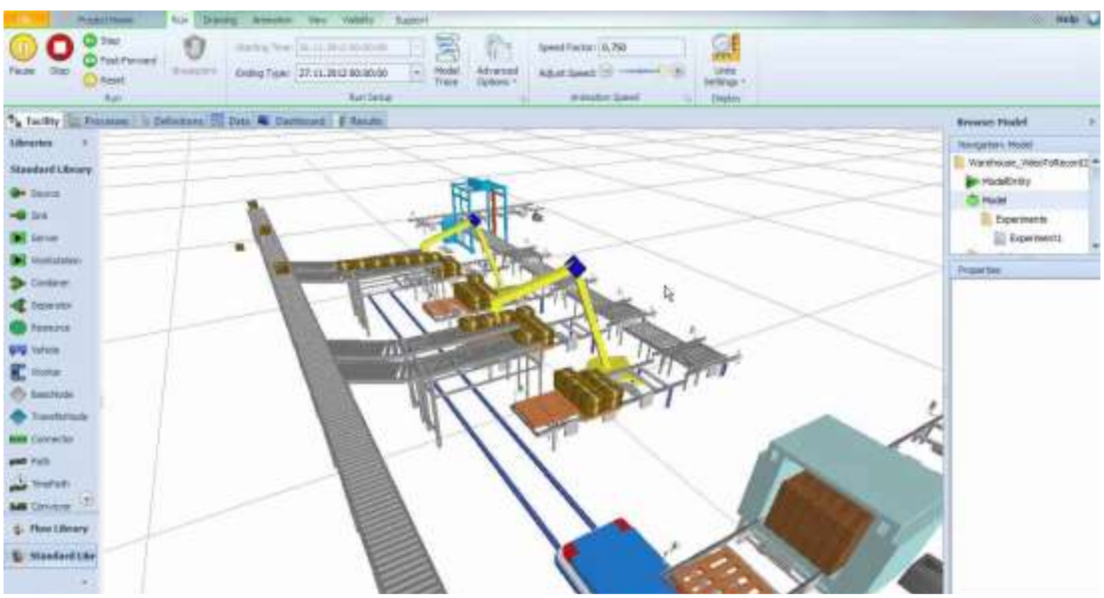


Figure 3.2 Simio™ and its user interface (YouTube, 2013)

3.2.2 Other Alternatives mentioned (but will not be used)

Programming languages can offer both flexibility and usefulness to any business. Programs can be created to suit an exact need of a client, and afterwards won't need an experts help to run the model. Programming languages such as Java, C#, Matlab, etc. can also create a program that can fully simulate a system. However for the requirements of this project, the student had limited programming experience and determined that proper simulation software will be most beneficial.

3.2.3 Simulation Software Objectives

While there may be many products available on the market, the choice of the correct simulation software must still fulfil certain criteria. Here are the most important categories when selecting the correct software (Gupta et al. 2010):

1. Affordability: this aspect refers to how affordable is the software to purchase.
2. Input/Output: this refers to how easy the user can present the data to the user, as well as quality and type of output reports generated.
3. User-Support: this criteria would evaluate the quality and type of user support that is provided by the software supplier, as this would help further the understanding of the software. This includes a variety of features such as technical documentation, demonstration software as well as other support benefits.
4. Accessibility: this refers to how easily accessible the software is for the student. A key aspect is if the software is provided at the university already.
5. General Features: these features refer to common features found in simulation software. This may include the type of simulation provided, user friendliness, ease of learning and ease of using.
6. Visual Aspects: these aspects will include all types and the quality of graphical objects provided by the software. This can include shape libraries, a network animation and zooming and panning functions.

7. Modelling Assistance: this assistance refers to online help if it is provided, warning messages within the software as well as complete libraries and templates of simulation objects.

In order to select the best software using this criteria an AHP (Analytic Hierarchy Process) will be used.

3.2.4 Using AHP to select the best software

3.2.4.1 Reasons for using the AHP method

The AHP process has been around for more than 30 years, having first being brought forward by a famous American operations researcher T.L. Saaty in the 1980s (Zhong 2004). AHP, also known as the analytic hierarchy process, allows for a powerful analysis of a system as well as the operational research behind it. AHP is a multi-criteria decision making (MCDM) method that assists the person to solve a difficult and confusing problem that has a lot selection criteria with subjective views (Ishizaka & Labib 2009). A major advantage is that it allows someone to deal with a large number of qualitative and quantitative data, then create an in-depth evaluation of the problem. Another reason it was chosen was because it put the student's subjective judgment and policy experience into a clearly defined model, and then allowing the student to create a quantifiable process.

3.2.4.2 How to apply the AHP method

Since the criteria for measuring the software (as mentioned above) has now been established, it can now be used in the AHP process. First, each category will be measured against every other category using the following scale:

Rating	Meaning (as compare to the other categories)
10	Much More Value
5	More Value
1	Equal Value
0.2	Less Value
0.1	Much Less Value

Table 3.1: AHP Ratings Table

From here, each category will be given a rating, whereby the most important category will have the highest rating, and the least important category will have the lowest rating. Next, each software option will be rated on each of these categories. The ratings will then all be combined, giving a true reading of how beneficial it will be.

3.2.4.3 Using the AHP for selecting the best simulation software

	CRITERIA WEIGHT	1	2	3	4	5	6	7	TOTAL	DECIMAL VALUE
1	Affordability	**X**	5.00	5.00	5.00	5.00	5.00	5.00	30.00	0.26
2	Input/Output	0.20	**X**	0.20	0.20	0.10	0.20	5.00	5.90	0.05
3	User-Support	0.20	5.00	**X**	1.00	1.00	0.20	10.00	17.40	0.15
4	Accessibility	0.20	5.00	1.00	**X**	5.00	5.00	10.00	26.20	0.23
5	General Features	0.20	10.00	1.00	0.20	**X**	0.20	1.00	12.60	0.11
6	Visual Aspects	0.20	5.00	5.00	0.20	5.00	**X**	5.00	20.40	0.18
7	Modelling Assistance	0.20	0.20	0.10	0.10	1.00	0.20	**X**	1.80	0.02
	COLUMN TOTALS	1.20	30.20	12.30	6.70	17.10	10.80	36.00	114.30	1.00

Table 3.2 The criteria for selecting the best software and their importance using the AHP Process

As shown in the table above, each criteria has now been giving a rating (i.e. Affordability being the most important). Now each software program will be rated against each of the criteria as shown below.

	Affordability	1	2	3	4	TOTAL	DECIMAL VALUE
1	Simio	X	5.00	0.20	5.00	10.20	0.27
2	AnyLogic	0.20	X	0.10	2.00	2.30	0.06
3	Arena	5.00	10.00	X	10.00	25.00	0.65
4	FlexSim	0.20	0.50	0.10	X	0.80	0.02
	COLUMN TOTALS	5.40	5.40	0.40	17.00	38.30	1.00
	Input/output	**1**	**2**	**3**	**4**	**TOTAL**	**DECIMAL VALUE**
1	Simio	X	1.00	1.00	2.00	4.00	0.31
2	AnyLogic	1.00	X	1.00	2.00	4.00	0.31
3	Arena	1.00	1.00	X	1.00	3.00	0.23
4	FlexSim	0.50	0.50	1.00	X	2.00	0.15
	COLUMN TOTALS	2.50	2.50	3.00	5.00	13.00	1.00
	User-Support	**1**	**2**	**3**	**4**	**TOTAL**	**DECIMAL VALUE**
1	Simio	X	2.00	3.00	4.00	9.00	0.39
2	AnyLogic	0.50	X	3.00	4.00	7.50	0.33
3	Arena	0.33	0.33	X	5.00	5.67	0.25
4	FlexSim	0.25	0.25	0.20	X	0.70	0.03
	COLUMN TOTALS	1.08	2.58	6.20	13.00	22.87	1.00
	Accessibility	**1**	**2**	**3**	**4**	**TOTAL**	**DECIMAL VALUE**
1	Simio	X	6.00	0.70	8.00	14.70	0.48
2	AnyLogic	0.17	X	0.70	5.00	5.87	0.19
3	Arena	1.43	1.43	X	7.00	9.86	0.32
4	FlexSim	0.13	0.20	0.14	X	0.47	0.02
	COLUMN TOTALS	1.72	7.63	1.54	20.00	30.89	1.00
	General Features	**1**	**2**	**3**	**4**	**TOTAL**	**DECIMAL VALUE**
1	Simio	X	9.00	2.00	2.00	13.00	0.39
2	AnyLogic	0.11	X	7.00	7.00	14.11	0.42
3	Arena	0.50	0.14	X	5.00	5.64	0.17
4	FlexSim	0.50	0.14	0.20	X	0.84	0.03
	COLUMN TOTALS	1.11	9.29	9.20	14.00	33.60	1.00
	Visual Apects	**1**	**2**	**3**	**4**	**TOTAL**	**DECIMAL VALUE**
1	Simio	X	9.00	0.80	7.00	16.80	0.41
2	AnyLogic	0.11	X	9.00	8.00	17.11	0.42
3	Arena	1.25	0.11	X	0.20	1.56	0.04
4	FlexSim	0.14	0.13	5.00	X	5.27	0.13
	COLUMN TOTALS	1.50	9.24	14.80	15.20	40.74	1.00

	Modelling Assistance	1	2	3	4	TOTAL	DECIMAL VALUE
1	Simio	X	1.00	1.00	1.00	3.00	0.25
2	AnyLogic	1.00	X	1.00	1.00	3.00	0.25
3	Arena	1.00	1.00	X	1.00	3.00	0.25
4	FlexSim	1.00	1.00	1.00	X	3.00	0.25
	COLUMN TOTALS	3.00	3.00	3.00	3.00	12.00	1.00

Table 3.3 Software simulation comparison using the AHP Process

SUMMARY MATRIX	Simio	AnyLogic	Arena	FlexSim
Affordability	0.07	0.02	0.17	0.01
Input/output	0.02	0.02	0.01	0.01
User-Support	0.06	0.05	0.04	0.00
Accessibility	0.11	0.04	0.07	0.00
General Features	0.04	0.05	0.02	0.00
Visual Aspects	0.07	0.07	0.01	0.02
Modelling Assistance	0.00	0.00	0.00	0.00
COLUMN SUM	0.374965815	0.250305527	0.323392854	0.051335805

Table 3.4 Summary Matrix of the best simulation software selection

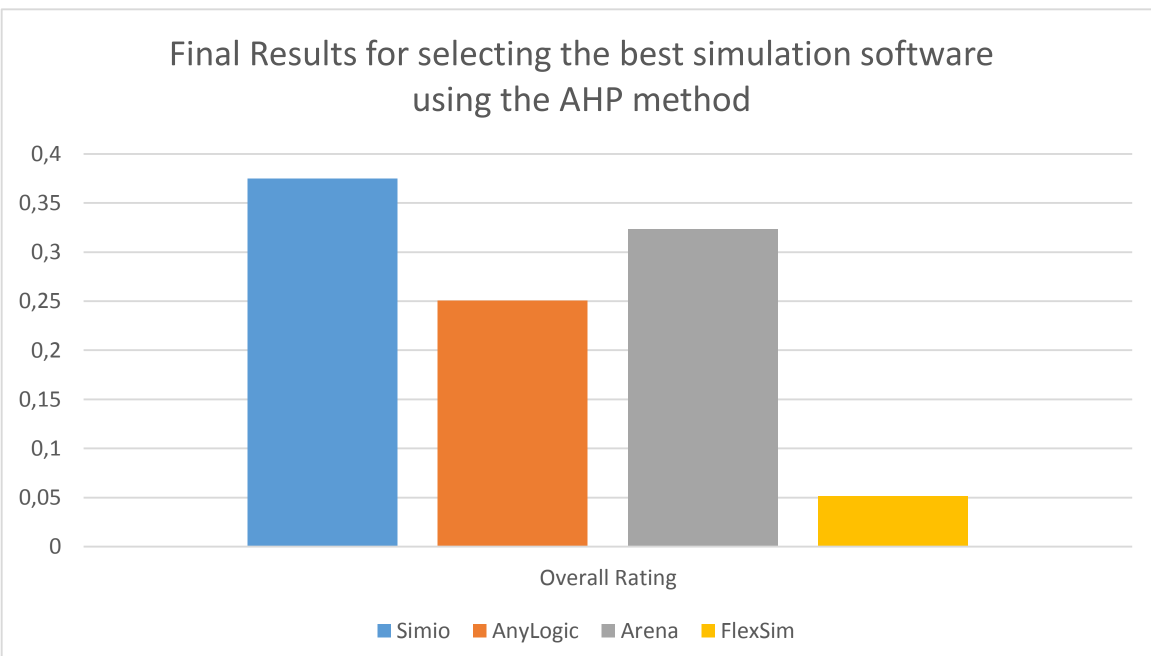


Figure 3.3 Final Results for selecting the best simulation software using the AHP method

The Summary Matrix table gives the final overall rating, which has been turned into a graph as shown above. The table clearly shows the Simio™ was the overall best choice.

3.2.5 Choice of Information System

The final software chosen as decided by the AHP method was Simio™. It scored the best overall with the highest rating (0.375). Listed below are some of most beneficial advantages that help the program score such a high rating:

- Ease of use, without the need of in-depth programming knowledge.
- Its affordable student price still allowed for almost all the important features to be unlocked.
- Being able to easily view the process in 3D is an effective tool to show people who don't have a vast knowledge of the system, and can quickly get an overview of the running processes.
- Its ability to run multiple experiments, as this will lead to finding the optimal vendor schedule necessary for this project.
- Prior knowledge of the software as it was used in a student's engineering course module.

All of these reasons, combined with the use of the comparison chart lead to Simio™ becoming the best choice for an information system.

3.3 SIMULATION COMPILATION

As the project scope is quite large, more than one method will have to be applied in order to see beneficial gains within the large DC. The inputs that will be used to calculate the results will be split into the two main areas, specifically the vendor to DC problem and optimising the Inbound Grocery yard within the DC. These inputs will be used in the simulation creation. These inputs will be allowed to be modified for future changes within the DC. All times are recorded on a 24hr period and numbers are measured in units.

3.3.1 Inbound Grocery Yard Inputs

- Truck Arrival Time: Based on arrival schedule
- Total Number of docks: 12
- Number of Trucks arriving per time slot: Based on arrival schedule
- Number of Forklifts assigned to trucks: 7-14 (day), 1-4 (night)
- Number of Forklifts assigned to put-away: between 7-14 (day), 1-4 (night)
- Number of Inspectors: 4
- Number of Receivers: 12 (day), 8 (night)
- Type of truck: Express, Standard, Complex1, Complex2 and Complex3
- Cost per personnel type per hour: Confidential, determined by the large retailer
- Operating hours: Start time (06:00), finish time (21:00) as required by the project
- Inspection and Offload Time: Triangular Distributed (Minimum 20 minutes, Maximum 60 minutes, mostly 41 minutes)
- Staging Area Put-Away Time: Triangular Distributed (Minimum 1.5 hours, Maximum 2.5 hours, mostly 2 hours)

3.3.2 Notes on Inputs

Regarding Inbound Grocery yard optimisation, the inputs will remain constant unless the retailer or IML decides to change an input at a later stage. Arrival times will be Poisson distributed, which discrete frequency distribution that gives the probability of a number of independent events occurring in a fixed time. Quality assurance techniques will also be used, such as control charts, that will help reduce discrepancies that will result in more accurate outcomes. Also, the day shift finishes at 17:00 and the night shift start at 18:15. Times for put-away, inspection and offloading were recorded during time studies completed by the student.

3.3.3 Calculations

3.3.3.1 Grocery Inbound Yard Calculations

To calculate the optimal turnaround time within the Grocery Inbound yard as well as reducing the operating expenses, a simulation model using Simio™. This simulation software, once the yard has been modelled to scale, will be able to conduct experiments and produce optimal outputs using all the necessary inputs. What makes the simulation efficient is that the inputs can be instantly changed (for example, adding in an extra offloading dock) and different outcomes (such as total expenses or personnel needed) can be determined.

3.3.3.2 Vendor Scheduling Calculations

These calculations will first need the base rules set by the Grocery Inbound yard. A Microsoft™ Excel spreadsheet will be used, in conjunction with the base rules as well as communicating with the various vendors, to determine when trucks should arrive at the DC. The trucks will be split up into each type of trucks, as well as from which vendor.

3.4 OUTPUTS

3.4.1 Grocery Inbound Yard Outputs

The outputs generated by the calculations and simulation will produce a set of base rules. These rules will determine the standard for which the inbound yard will follow. The simulation can be run weekly, and this tactical strategy will help narrow the chance of discrepancies with the model. The image shown below is the 'skeleton model' or the model that has off the visual aspects removed.

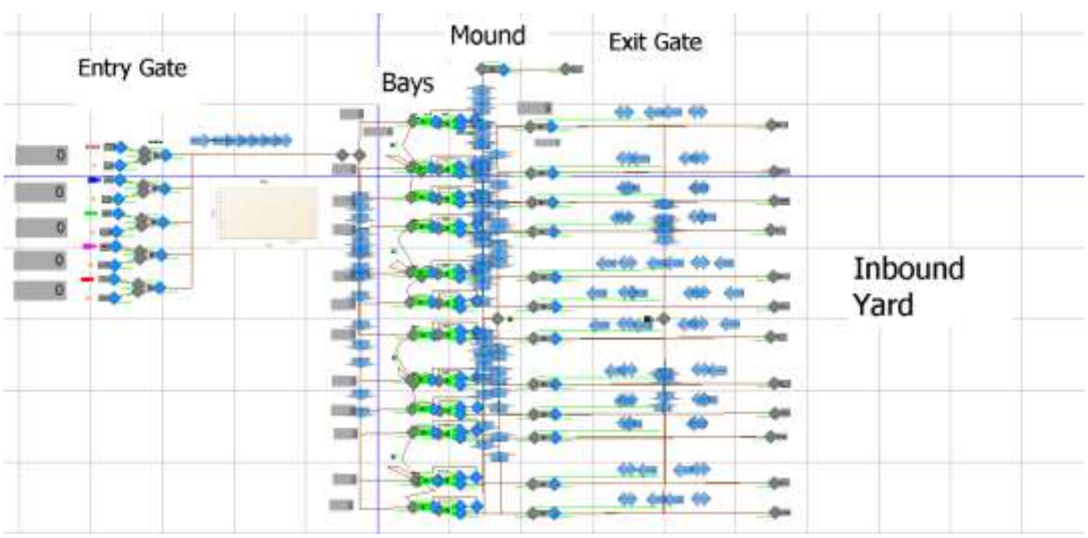


Figure 3.4 Basic structure of the grocery inbound process simulation model

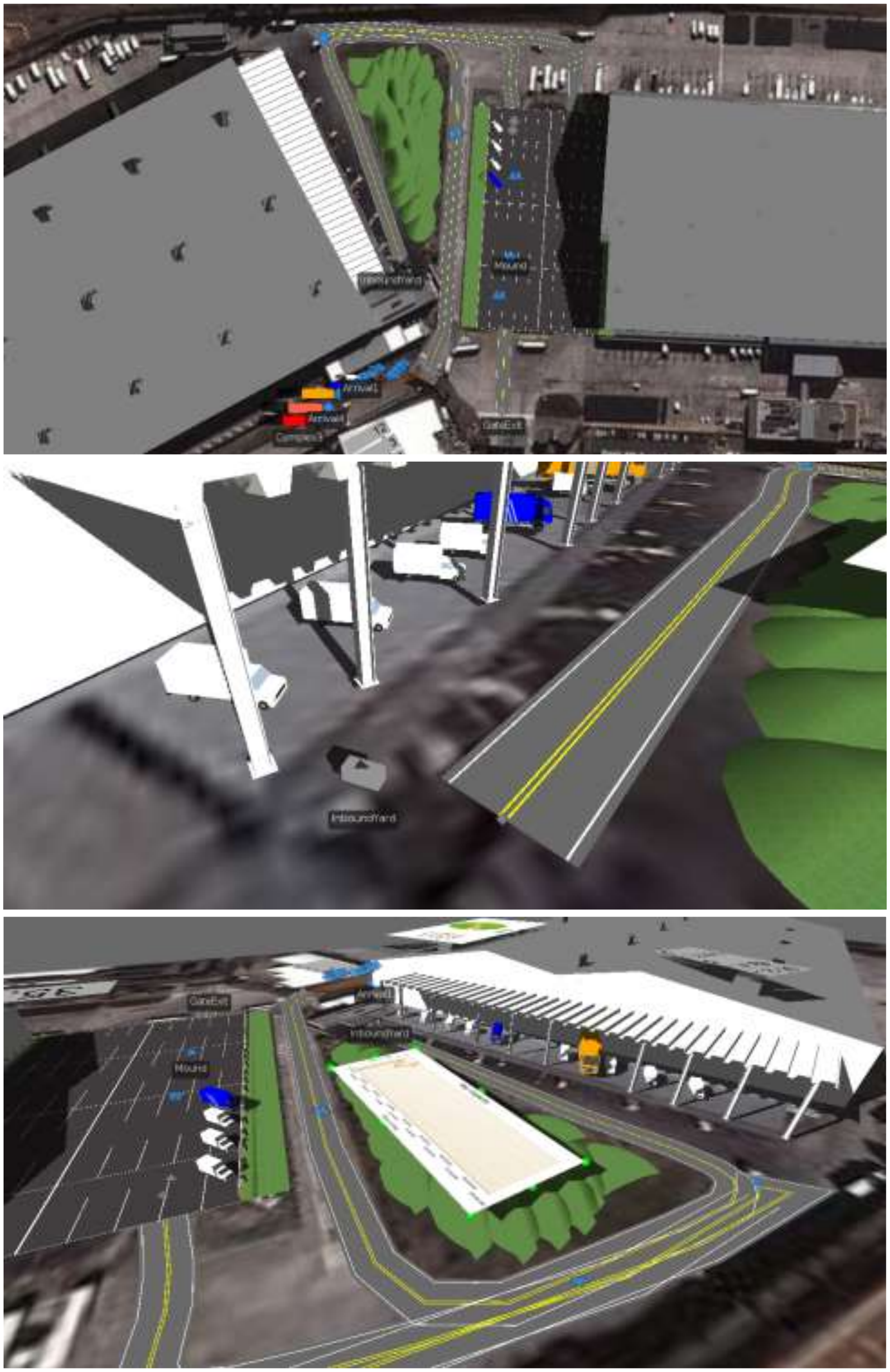


Figure 3.5 Various views of the 3D simulation model displaying the inbound yard

3.4.2 Vendor Scheduling Outputs

Once the outputs for the Grocery Inbound Yard have been calculated, the outputs for vendor scheduling can be calculated and modified accordingly.

3.5 SUMMARY OF THE METHODOLOGY

A complete conceptual design required for this paper will be created from two methods, one for the vendor scheduling process and one for the Grocery Inbound yard. After enough data has been compiled, a simulation model using Simio™ can be created for the optimisation of the Grocery Inbound yard. This optimised process will see a decrease in truck TAT and in turn a decrease in operational costs. An optimal process model from this simulation can then be used to determine base rules (such as when a truck will be required to arrive at the DC) and these base rules can then be used to determine a vendor schedule. This schedule will help create a smooth flow for the DC, and thus help improve the internal operations as stated above.

CHAPTER 4. FINAL DATA OUTPUTS

4.1 FINAL DATA OVERVIEW

In the previous chapter, the methods that were used in order to find a solution were described. In this chapter, an analysis of what those methods produced will be discussed. This will include all of the simulation model outputs.

4.2 SIMULATION OUTPUTS

4.2.1 New Optimised Schedule

As intended, the simulation experiment produced an optimised schedule for vendor trucks. This is the same schedule that was shown earlier (see page 9), however after the simulation has run the optimisation experiment (using OptQuest™), and the schedule now looks like this:

	Express	Normal	Complex 1	Complex 2	Complex 3	
06h00	-	7	-	-	1	
07h00	4	6	-	-	-	
08h00	3	1	2	-	-	
09h00	3	3	1	1	-	
10h00	6	-	-	1	-	
11h00 Lunch						
12h00	1	7	-	-	-	
13h00	2	7	-	-	-	
14h00	-	7	-	-	-	
15h00	3	7	1	-	-	
16h00	-	3	1	-	-	

17h00 Handover						
18h15	3	4	1	-	-	
19h15	1	2	2	-	-	
20h00	2	1	-	1	-	
Total	**28**	**55**	**8**	**3**	**1**	**95**

Table 4.1 Optimised Vendor Arrival Schedule

What this schedule now shows is how many trucks (per type) should arrive during a given time slot throughout day. For example, 4 Express truck types are allowed to arrive between 7h00 and 8h00 in the morning, while no Normal truck types are allowed to arrive between 10h00 and 11h00. Lunch Time (11h00 to 12h00) and Handover Time (17h00 to 18h15) are when staff are on break, therefore no activities will take place and trucks aren't allowed to arrive during those times. The total at the bottom states the number of trucks per type that are allowed to arrive per day.

The result of this new schedule provided a new, shorter turnaround time, shown in the table below.

Old Turnaround Time	**5.2 hours**
New Turnaround Time	**4.3 Hours**
Total TAT Saving	**0.9 hours**

Table 4.2 Turnaround Time Comparison Table

What this table shows is that 0.9 hours (or 54 minutes) can be saved per day just by rearranging the arrival schedule. Therefore on average, a truck in the system will take almost a whole hour less to complete the grocery inbound process.

4.2.2 Cost Savings

This reduced TAT and improved vendor schedule were also linked to a cost saving outcome. All the idle times at each process were recorded (as a percentage). Shown below is the output from this experiment.

Old Turnaround Time	5.2 hours
New Turnaround Time	4.3 hours
Total Time Saved	**0.9 hours**
Extra Vehicles per day	**22 Trucks**
Potential Profit	**22 Trucks/day x 0.5 million (est.) x 10% profit margin x 250 days = R 275 million/year**

Table 4.3 Comparison of Total Process Busy Time Percentage and Potential Savings

The table above shows that 0.9 hours will be saved everyday due to the successful schedule, which means that more trucks will be able to be received into the DC therefore increasing the throughput. The potential saving was calculated to being R 275 million for the grocery inbound process per year (supplied by IML).

4.3 Simulation Outputs Conclusion

The outputs for the simulation model have now been illustrated. An optimised schedule was shown, as well as the reduced turnaround time linked to it. The cost savings for the model were also shown. The next and final chapter will conclude the project and report.

CHAPTER 5. CONCLUSION

5.1 OVERVIEW OF THE CONCLUSION

Through reading this report, the reader is been made aware of a problem that a large retailer faced, namely to create an optimised vendor schedule for the grocery inbound process, and to suggest ways on improving the efficiency of the grocery inbound process within the large retailer's distribution centre. Background information of the company involved helping the retailer as well as why it was necessary to address the issue was explained. From here the report then included literature helping to further the reader's understanding of simulations. Next the methodology of addressing the problem was described, and from there the final outputs were shown. This chapter will now describe the conclusions and recommendations made about the project.

5.2 THE OPTIMISED VENDOR SCHEDULE AND POTENTIAL COST SAVINGS

As shown in Chapter 4, an optimised vendor schedule was created using a simulation model. The reason this was created was to reduce the TAT within the grocery inbound process as well as to reduce the costs involved.

If the large retailer were to follow this new schedule, the new TAT would be an average of 4.3 hours, a reduction of 54 minutes. This is because the trucks are following an improved method, which determines when a truck should arrive in order to provide the most minimal delay within the system. This in turn could result in the large retailer deciding to expand the number of trucks that can arrive during the day, therefore increasing throughput and eventually sales, as now more goods can be sent to the retailer's shops. Also, this will be the minimum TAT saved, as it does not include the recommendations for the general process improvement (shown in 5.3) that will still need to be implemented to see a result.

From the output shown a saving of R 275 million per year can be saved based only on the new vendor schedule. This is due to the fact that the running a more efficient grocery inbound yard means that there will be more unallocated free time. The retailer can either decide that not as many staff will be needed, or the staff can be allocated to other duties, and improving the efficiency of those new duties. This saving might seem small, but future potential costs by using the recommendations below will allow for this amount to increase. In the end, following the optimised schedule will always see a reduction in costs.

5.3 Overall Grocery Inbound Process Improvement Decisions

This section will highlight the recommendations needed to fully optimise the inbound process. In Chapter 1, the complete grocery inbound process was mapped and detailed. The observations made at each one of the sub-processes enabled the student to deduce certain recommendations that will also help address the large TAT that the retailer currently deals with. Discussed below are each one of the sub-processes, and the recommendations for each.

5.3.1 Conclusions and Recommendations for the Arrival Process

This sub-process was quite stable, however, the only concern is determining when it is acceptable for a truck to enter the DC. From what was observed at the Inbound Grocery bay, a truck will occasionally wait a while in the Inbound Grocery yard as even though it will be ready as soon as a bay is free, this can end up taking half an hour. In conclusion the arrival sub-process is very effective, it is only when the truck enters the DC that major delays occur. There are no recommendations here as with the improved process, a maximum truck waiting time will only be a few minutes.

5.3.2 Conclusions and Recommendations for the Inspection Process

In conclusion for the inspection process, if a truck is in the queue (inside the yard), that truck will wait on average of 10 minutes, which is included in the TAT. Therefore it doesn’t play a large role in affecting the total TAT but it can still be reduced. A recommendation can be made that only when a truck is certain to leave a bay, can the next truck arrive into the yard and into that recently vacated bay.

5.3.3 Conclusions and Recommendations for the Offloading Process (External)

To summarise the observations of this process, the main problem was found to be that the goods were counted/scanned more than once. First alongside the truck, second in the staging area and lastly if there are errors. A recommendation would be somehow integrating the first two. For example, the receiver and the inspector can simultaneously count/scan the goods when they are alongside the vehicle. This would result in the goods only having to be put away once they have been transported into the staging area.

Another recommendation would be to assign forklifts with the sole duty of putting away inbound goods, as well as more forklifts assigned during peak times. This is because only when a general (put-away, replenishment, picking, etc.) forklift is assigned to store these goods (which isn't a high priority, as determined by their SAP system) will these goods be put away; and if forklifts were always assigned to this position, the problem would be alleviated. Another recommendation would be altering the current arrival schedule so that there aren't busy hours where the staging areas can become heavily congested.

Therefore a few recommendations are suggested in order to eliminate these problems:

- Institute an SMS/Email feature for the mound supervisor that sends a notification to the mound supervisor that an AOD is ready as soon as it's printed
- Better communication between all employees, so that all employees associated with the receiving process are aware of what their duties are and who they should be in contact with
- Clearer instructions for drivers so that they know exactly what the procedures are and where they should go. This will eliminate drivers getting lost or confused.

A recommendation to penalise (either monetary or vendor selection) should be considered.

5.3.4 Conclusions and Recommendations for the Departure Process

There are no recommendations as the process is quite straightforward and there are no bottlenecks present. In conclusion this sub-process is fully optimised and nothing should change.

5.4 FINAL THOUGHTS

To end this report, the project has now been fully discussed and detailed, and the solution has been found. The aim of the project was to optimise the grocery inbound process within the large retailers distribution centre by creating an improved scheduling system and minimising TAT within the DC.

The main problem that the large retailer deals with was identified to optimise its inefficient vendor schedule for the grocery inbound process, and to suggest ways on improving the efficiency of the grocery inbound process within the large retailer's distribution centre. Research was then required to create a better understanding of the simulation process, the method used to solve the problem. This research was done with the aid of a literature review.

The appropriate simulation software was chosen using the AHP Process, whereby Simio™ was then used to create a simulation model to determine what schedule was the most beneficial to the retailer.

The outputs of the model provided both an optimised vendor schedule that will decrease the overall turnaround time within the system, as well as increase the potential profit to be made each year by the retailer.

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APPENDICES

APPENDIX A: SIGNED INDUSTRY SPONSORSHIP FORM

Industry Sponsorship Form.pdf https://clickup.up.ac.za/bbcswebdav/pid-210756-dt-content...

Department of Industrial & Systems Engineering
Final Year Projects
Identification and Responsibility of Project Sponsors

All Final Year Projects are published by the University of Pretoria on *UPSpace* and thus freely available on the Internet. These publications portray the quality of education at the University and have the potential of exposing sensitive company information. It is important that both students and company representatives or sponsors are aware of such implications.

Key responsibilities of Project Sponsors:

A project sponsor is the key contact person within the company. This person should thus be able to provide the best guidance to the student on the project. The sponsor is also very likely to gain from the success of the project. The project sponsor has the following important responsibilities:

1. Confirm his/her role as project sponsor, duly authorised by the company. Multiple sponsors can be appointed, but this is not advised. The duly completed form will considered as acceptance of sponsor role.
2. Review and approve the Project Proposal, ensuring that it clearly defines the problem to be investigated by the student and that the project aim, scope, deliverables and approach is acceptable from the company's perspective.
3. Review the Final Project Report (delivered during the second semester), ensuring that information is accurate and that the solution addresses the problems and/or design requirements of the defined project.
4. Acknowledges the intended publication of the Project Report on UP Space.
5. Ensures that any sensitive, confidential information or intellectual property of the company is not disclosed in the Final Project Report.

Project Sponsor Details:

Company:	BROCO LOGISTICS MANAGEMENT SOLUTIONS
Project Description:	Large Retailer Longmeadow - Grocery DC inbound Function Optimisation
Student Name:	Marco Edward Agas
Student number:	28220286
Student Signature:	[signature]
Sponsor Name:	ANDREW STEPHENS
Designation:	CONTINUOUS IMPROVEMENT MANAGER
E-mail:	andrew@broco.co.za
Tel No:	011 574 4548
Cell No:	083 456 7678
Fax No:	
Sponsor Signature:	ANStephens

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Figure A Signed Industry Sponsorship Form

APPENDIX B: GLOSSARY OF TERMS

The following are descriptions given for terms used in this paper.

Term	Definition
Backhaul Loads	This is a truck owned by the large retailer that picks up goods from vendor that is along its route. This saves both companies time and cost.
Complex Loads	A truck that contains more than one simple load. This truck requires much more resources to offload.
Distribution Centre	A distribution center for a set of products is a warehouse or other specialized building, often with refrigeration or air conditioning, which is stocked with products (goods) to be redistributed to retailers, to wholesalers, or directly to consumers.
High Risk Loads	Trucks that offload goods that require special care. These loads can contain items such as razor blades or knives.
Higher level agent-based emulation framework	A class of computational models for simulating the actions and interactions of autonomous agents (either individual or collective entities such as organizations or groups) with a view to assessing their effects on the system as a whole.
Loads per Slot Total	Amount of loads over the sum of a week that are required per time slot.

Mound	Demarcated parking area for all trucks that are waiting or sent there due to lack of space.
Programmable Logic Controller	A digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures.
Sin Bin	Demarcated area within the Grocery DC where all damaged/incorrect goods are kept till the following morning
Slot Quantity	How many pallets over the sum of a week that are offloaded per time slot (i.e. between 06:00 and 07:30)
	Trucks that offload goods that are common and don't require any special care.
Turnaround Time	The time from which a truck enters the DC till the time the truck departs from the DC.

Table B Table of Terms

APPENDIX C: DETAILED TAT FOR GROCERY INBOUND PROCESS

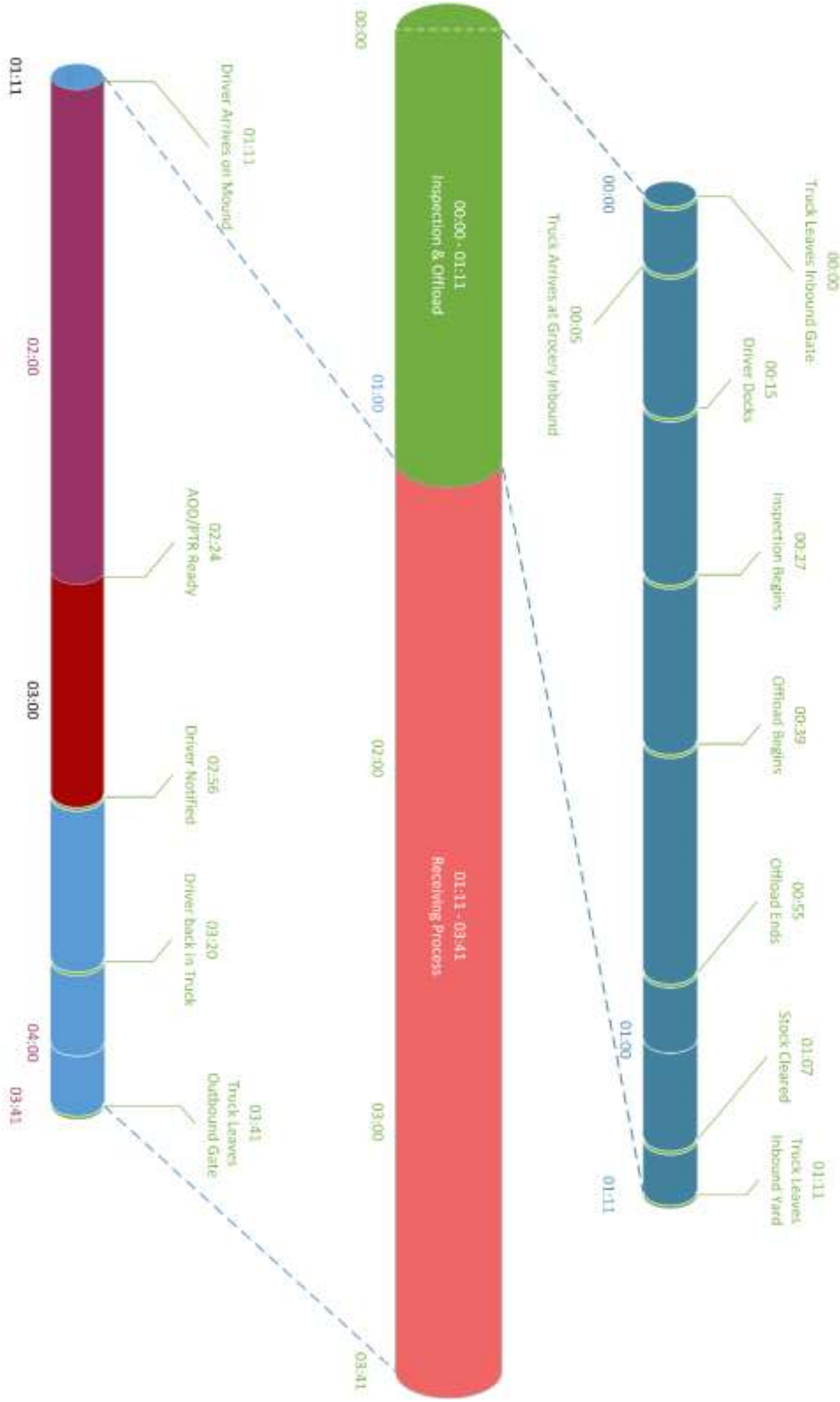

Figure C Detailed TAT for Grocery Inbound Process