Resource Optimisation of a Warehouse Process through Simulation Modeling - Agrinet

by

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Executive Summary

In the distribution industry warehousing plays one of the most important roles in the distribution of products. It is therefore of utmost importance that a warehouse performs at optimum levels to ensure cost efficiency, in time delivery and productivity.

All warehouses have opportunities for improvement; the opportunities just need to be identified. There are a significant number of methods and techniques to identify and solve problems within a warehouse. Some of these methods and/or techniques involve the elimination of bottle necks, which can increase the throughput volume of a warehouse and ultimately lead to an increase in profit.

This project primarily consists of building a simulation model in order to determine the optimum number of resources required in the current bottleneck of the warehouse; the audit area.

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1 Introduction

1.1 Introduction and Background

"Agrinet is a wholesale distributor of industrial and agricultural products to retailers and end-users in Sub-Saharan Africa." (Agrinet, n.d.) The core of Agrinet's customers is Agricultural companies (previously co-operatives). The company used to be a central co-op, which was formed by the grain co-operatives to procure Agricultural inputs and products on their behalf to utilize economies of scale. At that stage it was known as VETSAK (Vrystaatse en Transvaalse Aankope Koöperasie). The co-operative was later changed to a company known as Agrinet. The shareholders of Agrinet are still mainly agricultural companies. The Agricultural business is very cyclical which create additional pressure on warehousing in certain months and underutilisation in other. In order to curb this problem the company decided to diversify its offering into the non-agricultural market (industrial products).

Agrinet currently has two warehouses from which they operate, one in Samrand (Centurion), and the other in Bellville. The warehouse in Samrand (Centurion) currently processes an average of around seven thousand orders per day, and has an order delivery time that can vary between one to seven days. The warehouse currently uses an Embrace Warehouse Management system.

The warehouse consists of four sections namely: The Warehouse Reception, Storage Area, Audit area, and Dispatch.

When products are delivered from suppliers, they are received at the warehouse reception. Upon arrival, product information such as the product name and type are entered on the system, and the system will respond with a bin number in which the product must be stored. If the storage bin for the attained type of product is full or unavailable, an empty bin will be allocated for that product type. Certain product types have fixed bins to which they will be allocated. After bins are allocated to products, they are transported to those bins in the storage area.

When the warehouse receives an order from a customer, the products for that order must be picked from the bins in the storage area by personnel called pickers. Every picker receives pick transactions on a scanning device, which indicates the products that must be picked for a client. The picker then moves to the bin where the products must be picked and scans the barcode on the bin. This will indicate to the system that the pick will now be made. The picker then picks the product and places it in a box. The picker then attaches a barcode (sticker) on the box which was printed by the scanner after the Picker scanned the bin barcode. The picker then transports the picks he/she made to the next section of the warehouse, the audit area.

In the audit area all the boxes are stacked on a conveyor. Their stickers will then be scanned where an address label (delivery sticker) will be printed which will then be attached to the box next to the barcode. A packing slip that indicates the product type and quantity that should be in the box is then printed and placed on the box. Boxes then move onto a rotating conveyor. The boxes are then placed on a large counter next to a worker. Each box is checked to assure it contains the correct type and quantity of products. When a box is approved it will be sealed and prepared for distribution. It will then be placed on another rotating conveyor that will transport the boxes to dispatch.

As boxes arrive via the conveyor belt at dispatch, they are scanned and placed on pallets according to their route of distribution. When a pallet is full, it is taken to shelves where the boxes are scanned again to ensure they are on the correct route, and then sorted according to their town of destination on the shelves. They will be held here to be loaded for transportation to their destinations. The following figure shows a flow chart of the products in the warehouse:

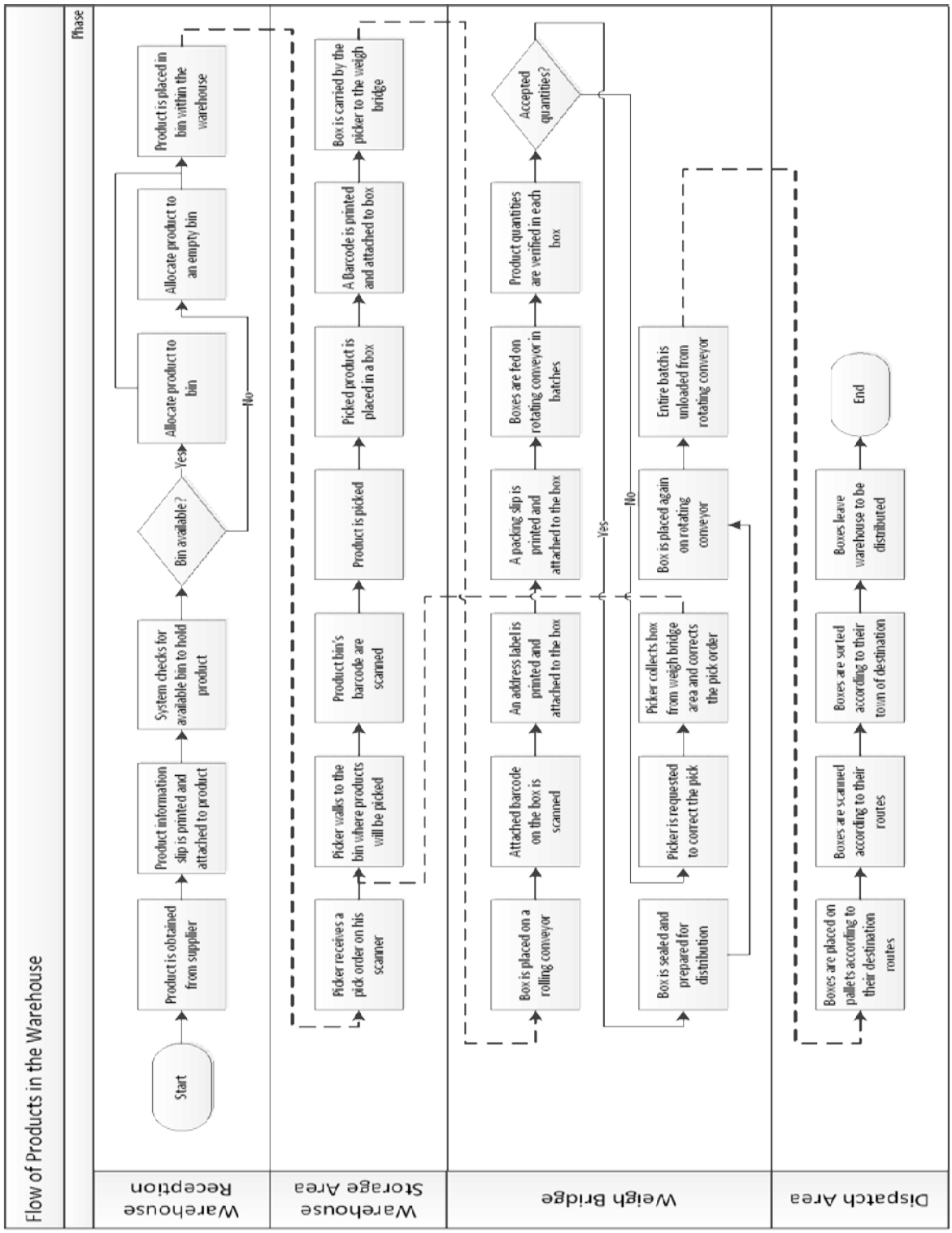

Figure 1: Flow of products in the warehouse

1.2Problem Statement

From personal experience gained through visiting and critically examining Agrinet's warehouse there are definitely room for improvement.

The main problem experienced by Agrinet is in the audit area. This section is currently identified as the bottleneck in the system, and limits the throughput volume of the warehouse. Each order has to be checked to contain the correct type of product as well as the correct amount of products. After the order is approved to contain the correct type and amount of products, it needs to be sealed and the correct stickers (ex. "This way up" or "Fragile content") must be attached to the applicable boxes.

It takes a considerable amount of time for orders to be audited here and prepared for distribution. It often occurs that pickers put their picks on hold, due to insufficient space available at the audit area.

Due to the large queues of boxes in front of the audit area, workers are often required to work overtime. All the picks for a day needs to be cleared and loaded on vehicles for distribution before the warehouse can close. This problem leads to additional and unnecessary overtime pay.

1.3 An Overview of the Audit area

The audit area currently consists of three sections for auditing different sizes of products. Products are classified into three sizes, namely; small, medium, and large products. Small products includes products with sizes such as screws and bolts and are currently audited by two auditors at a table as shown in figure 2, no.2. Medium sized products include products such as screw drivers and power drills, and are the most common sized products in the warehouse. These orders are currently audited by five auditors at a table as shown in figure 2, no.1. Large products include products such as wheel barrows and shovels, and are audited by three auditors. Due to the product sizes, they are handled and audited next to the audit area as shown in figure 2, no.3. Auditors are indicated with an "A" and the packers with an "P" in figure 2 below.

Boxes are scanned and prepared for the audit on the rolling conveyor by four workers, indicated with an "F" in figure 2 below. They are then fed onto the rotating conveyor when requested. Only batches of about fifty boxes will be fed on the rotating conveyor at a time. After auditing and sealing around ninety percent of the previous batch, the next batch will be fed onto the conveyor. There are two lanes of rolling conveyors, to allow that the nextbatch of boxes can be prepared for the audit while the other batch waits to be fed onto the rotating conveyor.

No. 4 in the figure below indicates the space where boxes are stacked by the pickers to be audited at the audit area.

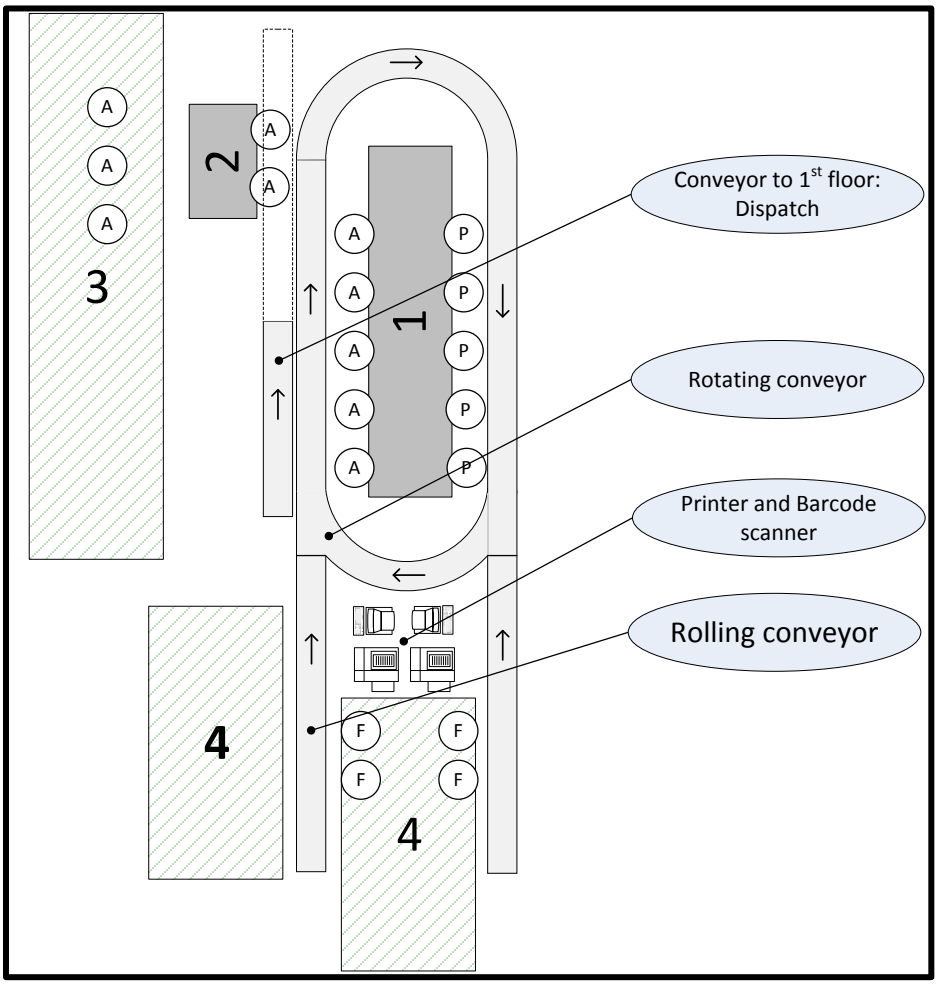

Figure 2: Floor plan of the Audit area

1.4 Project Aim

One of Agrinet's core focus areas is to be able to receive and process thousands of orders per day with maximum speed and efficiency. Therefore opportunities for improvement must be identified and implemented in order to make the warehouse as efficient and effective as possible.

As mentioned above in the problem statement, the auditing of orders and preparation of boxes for distribution at the audit area poses the biggest problem in the warehouse.

The aim of this project is to optimize the warehouse and increase its efficiency by developing a simulation model of the audit area in order to find the optimum number of resources required to achieve the desired throughput rate as well as to minimize the overtime costs incurred.

The following objectives will be used:

- To firstly analyze all the processes of the audit area in detail.
- To develop a simulation model that can be used to observe alterations made to the audit area and to examine different concepts, techniques and /or alternate processes that could improve the efficiency and effectiveness of this area.

1.5 Project Scope

After having a clear understanding of the way the warehouse operates and how orders are processed through the entire warehouse, the first phase of this project will be to analyze the audit area and obtain a better understanding of its processes.

The next phase of the project involves doing an in-depth literature study. This comprises of projects done on the optimization of processes in warehouses, methods used in practice to identify and eliminate bottlenecks, the workings and methods of analyzing warehouse operations and methods for developing a simulation model. This will be studied to ensure the appropriate methods are used and considered in the optimization of the warehouse processes.

The third part of the project will consist of data collection and designing a simulation model that will assist in finding the optimal number of resources required for optimum throughput and efficiency of the audit area. This will require working closely with Hennie Snyman, Agrinet's warehouse manager, and Javo Mudau, the audit area supervisor, to ensure all the appropriate aspects are covered.

1.6 Research Design

After examining the audit area in detail it was concluded that if the processes for auditing and/or sealing boxes can be accelerated, it would result in an increase of the throughput of the audit area.

To accelerate these processes, either an alternate process needs to be implemented or there has to be an increase in the workforce. The impact these solutions would have on the audit area is undefined, therefore it would be appropriate to design a simulation model of the audit area and its processes that will reflect the outcome of every alteration that would be made to it.

“By means of a simulation program it is possible to replicate in a controlled environment the behavior of a real system in different conditions. In general, a simulation is an auxiliary tool that allows both analysis and synthesis of dynamic systems, which allows to measure the performances of existing systems for different structural features as well as to assess at design-time the behaviors of the system for different operative conditions.” (Rey&Muneta, 2010:472)

2 Literature Study

2.1Problem Classification

“A bottleneck (or constraint) in a supply chain means the resource that requires the longest time in operations of the supply chain for certain demand. Usually, phenomena such as increase of inventory before a bottleneck and insufficiency of parts after a bottleneck are often seen. Statistically, since fluctuations are inconsistent, the phenomena (excess inventory and insufficient materials) do not always occur. In the case of hiking, a bottleneck means the slowest member in walking. An interval between the bottleneck member and the one before spreads, and narrows with the one after.” (Imaoka n.d.)

“Bottlenecks determine the throughput of a supply chain. Recognizing this fact and making improvements will increase cash flow.” (Imaoka n.d.)

The audit area is identified as the bottleneck in Agrinet’s warehouse therefore it is important that it is improved.

2.2 Solution Options

It was established that the best method to optimize the audit area would be to primarily create a simulation model that will reflect any changes to the audit area and provide information on its throughput. Alternate processes and techniques for the audit area can then be tested on the simulation to identify the optimum solution for improving the throughput.

“Among the different kinds of plants that can be simulated, warehouses are surely one of the most common, because of the need of an easy and fast retrieve of the different items to dispatch, independently on the system adopted for their storage.” (Rey&Muneta, 2010:471)

Alternate engineering techniques such as facilities planning and operational research methods can be used to assist in producing the optimum solution.

2.3 Simulation Modeling

“Modeling and Simulation is a discipline for developing a level of understanding of the interaction of the parts of a system, and of the system as a whole. The level of understanding which may be developed via this discipline is seldom achievable via any other discipline.” (Bellinger 2004) With the capability of the simulation programs available at present, it is possible to simulate a process such as the audit area in great detail.

“Many of the significant advances in the theory and practice of simulation over the past one hundred years have been driven by problems central to industrial engineering and the systems analysis techniques developed to solve them.” (Goldsman, Nance & Wilson 2009)

(Rey&Muneta 2010:471) “Warehouse design or re-design often require the use of a simulator for different reasons:

- “ provide a proof of concept;”
- “ test warehouses performances with different throughput;”
- “optimize the layout;”
- “optimize storage strategies;”
- “answer "what if" questions.”

2.3.1 Advantages and Disadvantages of Simulation

Simulation has its advantages as well as disadvantages. The following advantages and disadvantages of simulation modeling are indicated as discussed by Craig (1996), Maria (1997), and Ncetianz (n.d.).

❖ **Advantages of simulation**:

- “Simulators are able to provide users with practical feedback when designing real world systems. This allows the designer to determine the correctness and efficiency of a design before the system is actually constructed.” (Craig 1996)
- Simulators also permit designers to study a problem at a number of different levels of abstraction. At higher levels of abstraction the designer would be better able to

understand the behaviors and interactions of all high level components within the system. Said by Craig (1996)

- With intelligent use of computer graphics and animations, the user can be provided with a meaningful understanding of a system's nature. Said by Craig (1996)
- According to Ncetianz (n.d.) "time can be compressed or expanded allowing for a speedup or slowdown of the process under investigation." System operations can be observed in detail over a long period of time.
- "Bottleneck analysis can be performed indication where work-in-process, information materials and so on are being excessively delayed." Said by Ncetianz (n.d.:4)

❖ **Disadvantages of simulation:**

- Events occurring instantaneously in the real world may take several hours to model in simulation. Simulation modeling requires a large amount of time in order to create a realistic environment.
- A Large amount of training is required for someone to understand the program and its concepts, as well as to design a simulation of a system.
- Results reflected by a simulation may be difficult to interpret.
- Simulation programs are expensive.
- Simulation model can be too complex, or too simple. Said by Maria (1997:12)

2.3.2 Components of a System

"A system is defined as an aggregation or assemblage of objects joined in some regular interaction or interdependence toward the accomplishment of some purpose." Ncetianz (n.d.:7). There are several components in a system that needs to be understood in order to build a simulation model. Important terms follow as defined by Ncetianz (n.d.).

- **Entity** – "Object of interest in a system."
- **Attribute** – "denotes the property of an entity."
- **Activity** – "Any process causing changes in a system"

- **State of the System** – "The collection of variables necessary to describe a system at any time, relative to the objective of study."
- **Event** – "an instaneous occurrence that may change the state of the system."

2.3.3 Approach in Simulation Modeling

According to Maria (1997). The steps involved in developing, designing, and analyzing a simulation model includes the following:

- **"Identify the problem"**

  Problems in the current system must be identified and enumerated. Then requirements for a proposed system must be produced.

- **"Formulate the problem"**

  "Select the bounds of the system, the problem or a part thereof, to be studied. Define overall objective of the study and a few specific issues to be addressed. Define performance measures - quantitative criteria on the basis of which different system configurations will be compared and ranked. Identify, briefly at this stage, the configurations of interest and formulate hypotheses about system performance. Decide the time frame of the study, i.e., will the model be used for a one-time decision (e.g., capital expenditure) or over a period of time on a regular basis (e.g., air traffic scheduling). Identify the end user of the simulation model, e.g., corporate management versus a production supervisor. Problems must be formulated as precisely as possible." (Maria 1997:8)

- **"Collect and process real system data"**

  Collect data on the current system such as; system specifications, input variables and system performance. Identify sources of randomness in the system, i.e. the stochastic input variables. An appropriate input probability distribution must be selected for each input variable, and an estimation of the corresponding parameter(s) must be made. As

explained by Maria (1997:8). Time studies have to be done on the audit area, in order to collect data on the system performance and as part of the system specifications.

- **"Formulate and develop a model"**

  "Develop schematics and flow diagrams of the system (How do entities flow through the system?). Translate these conceptual models to simulation software acceptable form. Verify that the simulation model executes as intended. Verification techniques include traces, varying input parameters over their acceptable range and checking the output, substituting constants for random variables and manually checking results, and animation" said by Maria (1997:9).

- **"Validate the model"**

  "Compare the model's performance under known conditions with the performance of the real system. Perform statistical inference tests and get the model examined by system experts. Assess the confidence that the end user places on the model and address problems if any." (Maria 1997:9). It is very important that the model provide results which are realistic and acceptable, as it will be used to decide on a system that will be implemented on the audit area.

- **"Select appropriate experimental design"**

  Maria (1997:9) said, "Select a performance measure, a few input variables that are likely to influence it, and the levels of each input variable." The factors that will have the biggest influence on the audit area will include the auditing and packaging of boxes, thus alternate processes for them will also be modeled in this step.

- **"Establish experimental conditions for runs"**

  "Address the question of obtaining accurate information and the most information from each run. Determine if the system is stationary (performance measure does not change over time) or non-stationary (performance measure changes over time)" (Maria 1997:9).

- **“Perform simulation runs”**

  Perform the simulation runs according to the two previous steps. Perform runs for all the proposed systems.

- **“Interpret and present results”**

  “Compute numerical estimates (e.g., mean, confidence intervals) of the desired performance measure for each configuration of interest.” (Maria 1997:10). The aim in this step is to confirm an increase in the throughput of the weighbridge.

- **“Recommend further course of action”**

  “This may include further experiments to increase the precision and reduce the bias of estimators, to perform sensitivity analyses, etc.” (Maria 1997:10). This is important to ensure maximum accuracy for the simulation and tests.

“Although this is a logical ordering of steps in a simulation study, much iteration at various sub-stages may be required before the objectives of a simulation study are achieved. Not all the steps may be possible and/or required. On the other hand, additional steps may have to be performed.” (Maria 1997:8)

2.3.4 Software

The program “Simio®” will be used for designing a simulation model for this problem as it is made available for use by the University of Pretoria and is appropriate for modeling a simulation of the audit area, as it provides all the necessary tools for reflecting a very realistic imitation of the processes that will occur.“Simio is designed from the ground up to support the object modeling paradigm; however it also supports the seamless use of multiple modeling paradigms including a process orientation and event orientation. It also fully supports both discrete and continuous systems, along with large scale applications based on agent-based modeling. These modeling paradigms can be freely mixed within a single model.” (Simio LLC n.d.)

2.3.5 Definition of Simio® Objects

It is important to understand the definition of the objects used in Simio®. The main objects that will be used in this model follow as defined by Simio Documentation (2006):

- **Source –** "A Source is an object that allows the creation of entities at a specified rate, by a specified arrival pattern, on the firing of an event. The Source has an Output Buffer where entities can wait before leaving the Source via a Node. From this node the entities leave on the outgoing link(s) to wherever the designed logic is going to send them."
- **Sink** – "The Sink destroys entities. It also has the capability to collect automatic statistics."
- **Basic Node –** "A basic node is a simple node to support connection between links.
- **Transfer Node –** "A transfer node is a more comprehensive node that supports connection to paths as well as the ability to select destination, path, and transfer device. Most objects that support outgoing connections have an associated (embedded) transfer node."
- **Server** – "A Server represents a capacitated resource with optional constrained input and output buffers." Entities enter a server, get processed, and then leave the server. Servers will mainly be used in the model as the processes.
- **Worker** – "A Worker object may be used to define a dynamic population of moveable unit resources in the modeled system." Workers can seize servers, as well as transport entities from one node to another.
- **Conveyor** – "A Conveyor is a link that can represent both accumulating and non-accumulating devices."

2.4 Throughput

An objective of this project is to increase the throughput of the audit area at minimum cost. Throughput can be defined as “the measure of the number of items that enter or exit during a time unit (hour, shift, day)” (Rey & Muneta 2010:477)

$$T_{in}=I_{in} / \Delta t \quad (1)$$

$$T_{out}=I_{out} / \Delta t \quad (2)$$

Where; T is the throughput and I is the number of inbound (in) or outbound (out) items as explained by Rey&Muneta (2010:477).

2.5 Time Studies

A detailed time study would have to be done on every process of the audit area in order to provide accurate data to the simulation model. This is necessary to enhance the realism of the model. “A time study attempts to find out the amount of work that a qualified operator, properly trained, can do in a given time. The operator must do the work according to a certain method, under certain conditions, and at a certain pace which will produce a certain physical reaction. Certain allowances for personal and other delays are provided.” Pigage and Tucker (1954:23). This is done by measuring random observations of a process with the following calculation:

$$ST = NT + Allowance \quad (3)$$

Where ST is the Standard time duration for a process to complete and NT is the normal time duration for a process to complete. NT = Observed time + Good pace rating (observed time, but taking into consideration rate of effort). “The fundamental purpose of all allowances is to add enough time to normal production time to enable the average worker to meet the standard when performing at standard performance.” (Niebel & Freivalds 2008)

2.6 Sample Size

In order to ensure the data collected from the audit area is adequate for a realistic prediction, the correct sample size must be used. According to Krejcie & Morgan (1970) there are several factors to consider when determining a sample size.

- Confidence Interval – Also known as margin of error. This is the margin to which the sample results can be incorrect. For example. If a confidence interval of four is used, the sample may be accurate within plus or minus four percent.
- Confidence Level – The confidence level is the amount of uncertainty that can be accepted. This represents how often a result will fall within the confidence interval.
- Range – This includes all the units in the group which is represented by the sample.

When the confidence interval, confidence level and population size is known, the needed sample size for accurate data can be calculated with the following formula:

$$Sample\ Size = \frac{(\frac{Range}{2})\text{^}2}{(\frac{Accuracy\ Level}{Confidence\ Level})\text{^}2}$$

Where Accuracy level = Range x Confidence interval (Expressed as a proportion).

3 System Data; Collection and Processing

The first two steps in the approach of building a simulation have already been addressed in the problem statement, project aim, and project scope. The next step will be to collect and process system data. This is a fundamental part of the project as the data will have an enormous influence on the reliability of the simulation. Thus it is critical that accurate data will be collected and used as inputs to the simulation to resemble the actual system as much as possible.

3.1 Calculation of Sample Sizes

The throughput of the audit area is around five thousand boxes per day. Thus five thousand will be used as the range in the calculation. A confidence level of 95% and a confidence interval of 5% would be sufficient to provide data accurate enough to be used in the simulation. With a confidence level of 95% an alpha level of 1.64 will be used as shown in table 19 in appendix A. Accuracy level = Range x Confidence interval (Expressed as a proportion):

Acccuracy level = 5 000 x 0.05. Thus:

$$Min\ Sample\ Size = \frac{(\frac{Range}{2})\text{^}2}{(\frac{Accuracy\ Level}{Confidence\ Level})\text{^}2}$$

$$\therefore Min\ Sample\ Size = \frac{(\frac{5000}{2})\text{^}2}{(\frac{5000\ \text{x}\ 0.05}{1.64})\text{^}2}$$

$$\therefore Min\ Sample\ Size = 268.96$$

$$\therefore Min\ Sample\ Size \approx 269 \text{ boxes}$$

3.2 Data Collection and Processing

Before collecting the data, four main stages in the auditing department were firstly identified. These stages include; arrival of boxes at the audit area, preparing the boxes for the audit process,

audit process of a box, and the process of preparing a box for distribution. Each of these stages was carefully examined to ensure every process is observed in the detail necessary to ensure that realistic data will be generated.

The required sample size calculated in 3.1 will only apply to processes that process only one box per cycle (A cycle is the time taken to complete a process). Thus it will apply to; the audit process of a box and the process of preparing a box for distribution. The sample sizes for the arrival of boxes at the audit area and the process of preparing the boxes for the audit process will have larger sample sizes as multiple boxes are handled and processed in these processes.

3.2.1 Fitting Distributions

EasyFit©, probability distribution software by Mathwave are used to fit different probability distribution graphs to a data set in order to determine the most suitable distribution for each process.

Most of the distribution type's fall in three basic categories: bounded, unbounded, and non-negative. A large number of distributions were overlooked as the data collected are all regarded to have a non-negative distribution. Approximately twenty four different distributions were fitted to each process.

Three tests are used to test for distributional adequacy, namely: Kolmogorov Smirnov-, Anderson Darling-, and the Chi-Squared-test. These techniques measure the "goodness of fit" of numerous different probability distributions to the data set in order to select the distribution that will be most accurate.

The "goodness of fit" describes how well a probability distribution fits a set of data. A lower "goodness of fit" score is better as it refer to the distance between the distribution graph and the data set.

3.2.2 Arrival of Boxes at the Audit area

This process will be the input of the simulation as the simulation will only focus on the audit area. Boxes arrive via pickers unloading their picks at the audit area which they collected with forklifts and trolleys.

Two possible types of boxes arrive at the audit area namely, boxes containing correct picks, and boxes containing incorrect picks. The arrival rate for these entities will be calculated separately as they will be generated from two sources in the simulation. Agrinet provided data for the picks made for June and a portion of August.

Picks are made according to routes. A route can be defined as orders from a number of cities or towns that are close to one another, or in the same direction from the deliverable's starting point. Agrinet knows in advance the number of routes that will be picked on a specific day.

The number of picks made for a day depends on the number of routes that will be picked for that day. Agrinet regularly pick five or six routes per day. The more routes picked per day, the larger the number of boxes will be to be processed by the audit area for that day. The first input will be the average boxes processed on days where five routes are picked, and the second input will be the average boxes processed on days were six routes are picked.

The following were obtained with the data provided from Agrinet: (Attached in Appendix B: Operation totals)

Arrival of Boxes at the Audit Area	5 Routes	6 Routes
Average No. of Correct Boxes per Day	4760	6056
Average No. of Incorrect Boxes per Day	119	152

Table 1: Model Input Data

3.2.3 Preparing Boxes for the Audit

The stage was broken down into four sub-processes before data were collected. These sub-processes are in the following order:

- Preparation – Each box are loaded onto a conveyor and arranged to ensure the barcode applied by the picker faces the side from which it will be scanned.
- Scanning – After the boxes are prepared, their barcodes are scanned. Distribution stickers, as well as paper invoices are printed as soon as a box is scanned.
- Attach stickers – A distribution sticker is attached to each box corresponding to the barcode applied earlier by the picker.
- Apply papers – A paper invoice is applied to each box corresponding to the barcode applied earlier by the picker.

The time of each of the sub-processes were measured per cycle, as well as the time to complete the entire process. (Shown in Appendix B – figure 33) Boxes are prepared in batches before they are fed onto the rolling conveyor to be audited.

For this process fixed allowances are included for personal needs and basic fatigue. Contingency allowances are included for the printer or scanner that could be slow or when replenishing printer paper.

Data Summary:

Preparation per box:

Distribution: Gamma
Expression: Random.Gamma(7.3818, 0.39828)

Number of batches Observed:	30
Min Data Value:	1.05
Max Data Value:	5.25
Sample Mean:	2.94
Sample Std. Deviation:	1.0821
α Value:	7.3818
β Value:	0.39828
Total allowance:	0.05

Data Summary:

Scanning (per box): Distribution: Weibull
Expression: Random.Weibull(3.2847, 2.376)

Number of batches Observed:	30
Min Data Value:	1.08
Max Data Value:	3.24
Sample Mean:	2.124
Sample Std. Deviation:	0.52934
α Value:	3.2847
β Value:	2.376
Total allowance:	0.08

Data Summary:

Attach Sticker (per box): Distribution: Weibull
Expression: Random.Weibull(3.3796, 2.4531)

Number of batches Observed:	30
Min Data Value:	1.08
Max Data Value:	4.32
Sample Mean:	2.2345
Sample Std. Deviation:	0.64069
α Value:	3.3796
β Value:	2.4531
Total allowance:	0.08

Data Summary:

Apply paper (per box): Distribution: Weibull
Expression: Random.Weibull(3.8457, 3.0513)

Number of batches Observed:	30
Min Data Value:	2.14
Max Data Value:	4.28
Sample Mean:	2.782
Sample Std. Deviation:	0.72189
α Value:	3.8457
β Value:	3.0513
Total allowance:	0.07

3.2.4 Audit Process

The time taken to audit one box for each cycle is included. As calculated in 3.1, two hundred and sixty nine cycles are needed in order to achieve the desired accuracy. Two hundred and eighty cycles were observed. (Shown in Appendix B – figure 31) Four auditors were studied in order to ensure the data is more realistic as not all auditors audit a box in the same period. Seventy cycles were observed for each auditor. Fixed allowances are included for personal needs and basic fatigue.

As identified in Table 20 (Appendix B) the Pearson VI distribution fit this process best, and will be used in the model.

Data Summary:

Audit box:

Distribution: Pearson VI
Expression: Random.PearsonVI(1083.7, 2.8496, 0.05286)

Number of Observations:	280
Min Data Value:	7.35
Max Data Value:	126
Sample Mean:	30.345
Sample Std. Deviation:	23.491
α_1 Value:	1083.7
α_2 Value:	2.8496
β Value:	0.05286
Total allowance:	0.05

3.2.5 Prepare for Dispatch

Once more, the time taken to prepare one box for distribution to a customer is included for each cycle. Two hundred and eighty cycles were also observed for this process (Shown in Appendix B – figure 32), and seventy cycles for four workers were studied for the same reason as with the audit process. Fixed allowances are included for personal needs and basic fatigue, also contingency allowances for replenishment of wrapping tape and stickers.

As identified in Table 21 (Appendix B) the Gamma distribution fit this process best, and will be used in the model. The following data were obtained:

Data Summary:

Prepare box for dispatch: Distribution: Gamma
Expression: Random.Gamma(5.2939, 5.8276)

Number of Observations:	280
Min Data Value:	6.42
Max Data Value:	92.02
Sample Mean:	30.85
Sample Std. Deviation:	13.408
α Value:	5.2939
β Value:	5.8276
Total allowance:	0.07

3.2.6 Other Factors influencing the Model

Other factors and conditions in the audit area need to be mentioned in order to model an accurate representation of the real system.

- **Picking hours –** Pickers start picking an hour before the official opening time of the audit area in order to ensure boxes are available to be processed. Pickers operate from 7:00 to 16:00 in the actual system. Entities will stop to generate at 16:00h and will only generate for seven hours. Thus it will generate twice the number of entities it should generate per hour for the first hour.

- **Lunch- and tea-breaks** – Working hours of the audit area are from 8:00 to 17:00 with one hour of lunch- and tea-breaks included. The model will therefore only generate entities from 9:00 to 16:00.
- **Breakdowns –** This refers to scanner and printer problems. Scanners will be modeled to breakdown on a processing count basis with a uniform distribution of 1000 to 2000 boxes. They will have a repair time with triangular distribution with a mean of 6 minutes and a minimum and maximum of 3 and nine minutes respectively. Printer breakdowns include paper jams and paper replenishment, and will also occur on a processing count basis with a uniform distribution of 200 to 300 pages. Repair time with a triangular distribution with a mean of 60 seconds and a minimum and maximum of 30 and 90 seconds will be modeled respectively.

4 Preliminary Design

After the conceptual model is designed, it must be translated into a computer model that could represent the system. The current system will first be modeled with the previous mentioned amount of resources at each stage.

4.1 Model Formulation

In order to formulate the model, a process flow diagram of the audit area is developed. This flow diagram will be used as guidance when designing the model to ensure all processes are included.

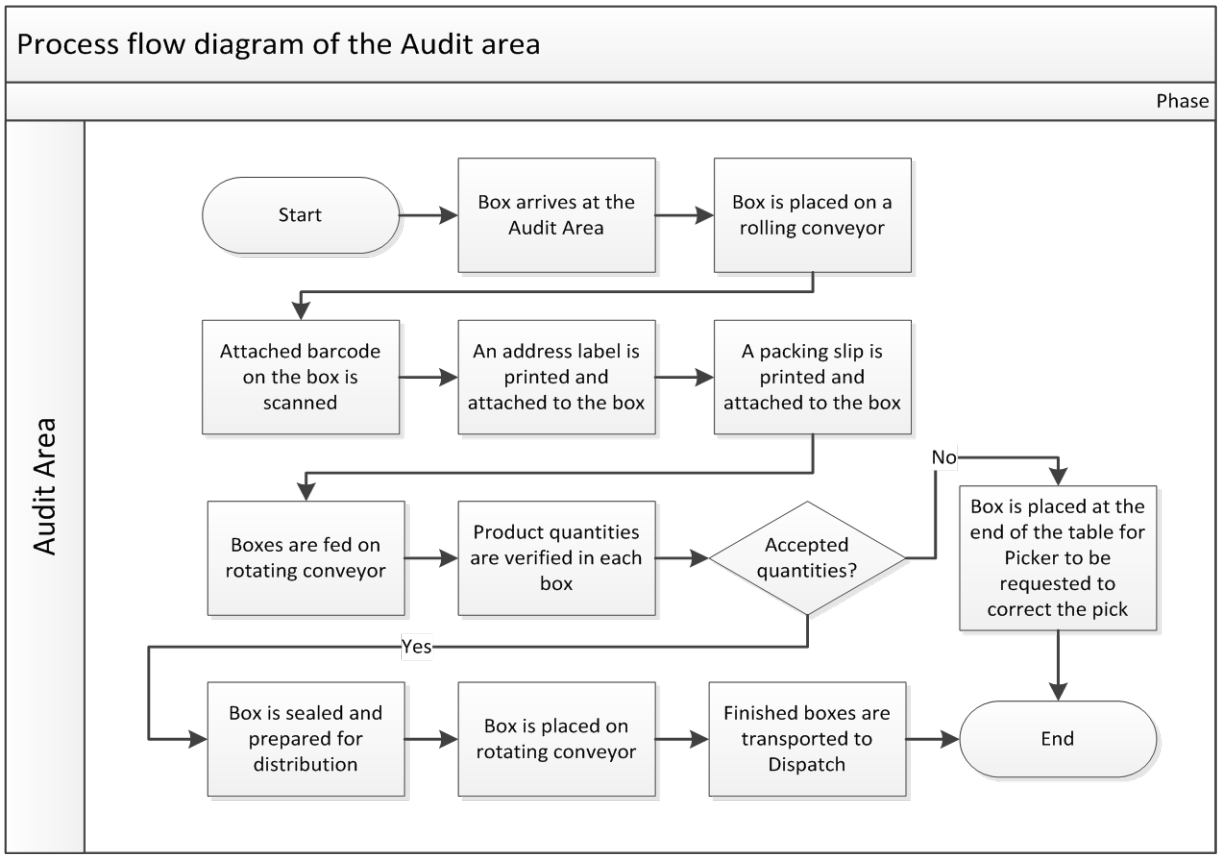

Figure 3: Process flow diagram of the audit area

4.2 Model Construction

The construction of the model can be time consuming, depending on the level of detail and complexity. By using the process flow diagram stated in figure 5, the basic model was first constructed in Simio® simulation software. More detail and complexity was added to the model as system knowledge advanced.

Each stage of the model was developed individually, and their components and properties will be discussed separately. The different stages were discussed in section 3.2.

4.2.1 Stage 1: Arrival of Boxes

This stage includes the creation of entities that will travel through the system. A Source is used in Simio® to create the entities. Two Sources are used, one to generate boxes containing correct picks, and another for boxes containing incorrect picks as shown in the figure below. On average, 2.5 percent of all picks made are incorrect, thus the Source creating the incorrect arrivals will generate 0.025 times the entities of the source creating the correct arrivals. The Output Buffer for each source is set to infinity to allow for queuing of the boxes prior to being processed.

Rate tables are used in Simio to model a steady flow of boxes into the system according to the rates and constraints specified in section 3.2.2 and 3.2.6.

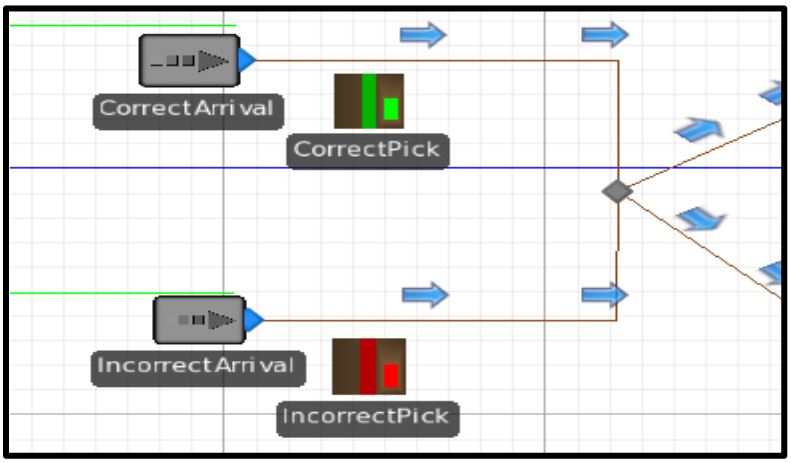

Figure 4: Generation of Entities

4.2.2 Stage 2: Preparing boxes for the audit

This stage contains four processes as discussed in section 3.2.3. In the actual system, two workers prepare the boxes for the audit, thus only two of the four processes can occur at the same time. These processes always occur in the following order for entities:

i. Worker A places a batch of boxes on the roller conveyor in a line. He/she arranges the boxes (starting at the front end of the roller conveyor) to ensure each sticker (attached by the picker) faces the direction from which the workers work.
ii. While worker A arranges the boxes, Worker B start by scanning the boxes already arranged at the front end of the conveyor, after which a delivery sticker and packing slip is printed.
iii. When Worker A is finished arranging the batch, he/she attaches the printed stickers to each box that was scanned. Also starting at the front end of the conveyor.
iv. When Worker B is finished scanning the batch, he/she will apply the papers (packing slips) to each box.

In the model, each process is represented by a server which process entities according to a rate specified in section 3.2.3. Two worker objects are assigned to the servers, Worker A

(PrepareAndSticker) seizes the processes PrepareForAudit and AttachSticker individually, and Worker B (ScanningAndPaper) which seizes the processes Scanning and AddPaper individually.

There are two lanes in the audit area that performs this task as shown in the figure below.

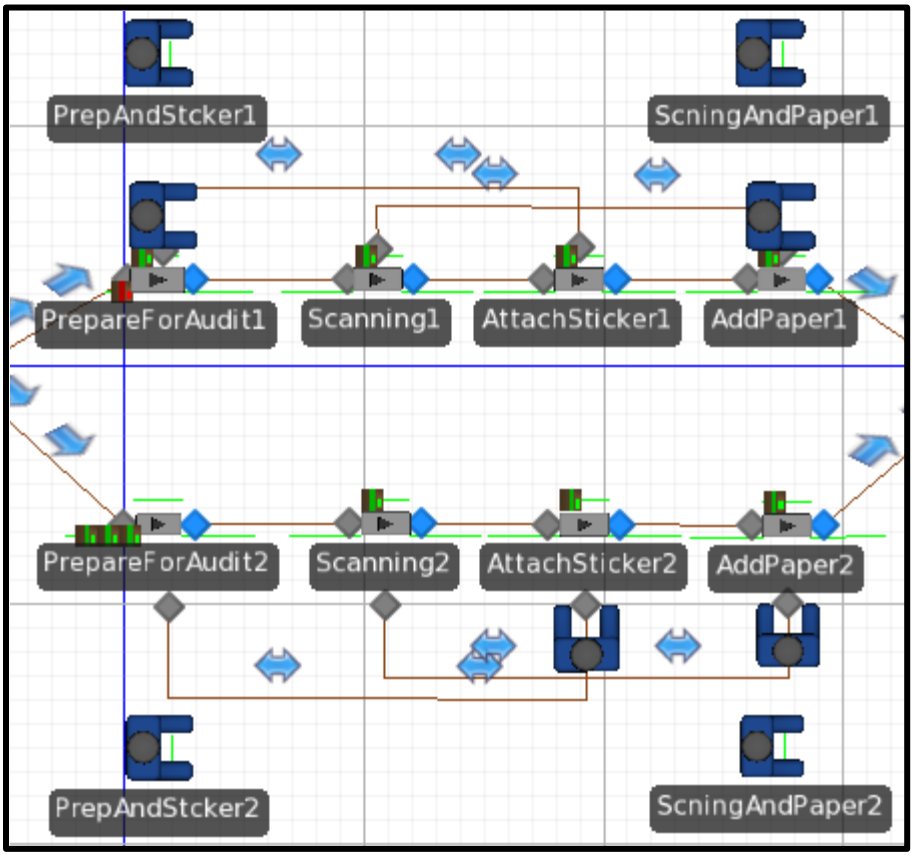

Figure 5: Preparing Boxes for the Audit

4.2.3 Stage 3: The audit Process

After entities are processed in stage 2, they are transported onto a conveyor. The conveyor then transports the entities to stage 3 where it will be processed in the auditing process. The property for the conveyor in the model is set to ensure stage 2 will be blocked if stage 3 does not process boxes fast enough. The conveyor properties are also set to accumulate to ensure boxes stack at the end of the conveyor while the first box waits to be transported by the provider.

When boxes arrive via the conveyor at stage 3 in the actual system, a worker (named Provider) unloads the boxes from the conveyor onto the large table ensuring a continuous supply of boxes to the auditors. In the model, a worker object (called Provider1) is used to model the task of the provider. Paths are inserted as guidelines for the worker object to transport boxes from the transport node at the end of the conveyor to each auditor. The paths are not drawn to scale and all of them have the same logical length. The conveyor is parallel with the table in the actual system, and the provider can unload boxes from any point on the conveyor, thus all auditors are the same distance from the conveyor. The logical manner of distribution in the model would be for the provider to transport boxes to the auditor with the least amount of boxes available in its input buffer to minimize the shortages of boxes at the auditors. This would not be realistic as the provider would rather provide boxes to auditors as he/she goes "down the line". Thus the selection goal property for the transport node (the transport node controls the worker object) is set to cyclic, which will require Provider1 to transport boxes in a cyclic sequence.

Server objects are used to represent the auditors in the model. The processing rate for each server is set according to the specified values in section 3.2.4.

The table on which the auditors audit can accommodate up to sixty boxes on the auditing side. Therefore the input buffer capacities for each auditor will be set as:

$$\text{Rounded down } \left(\frac{60}{number\ of\ auditors\ in\ the\ system}\right)$$

The output buffer capacity for each auditor will be set to zero.

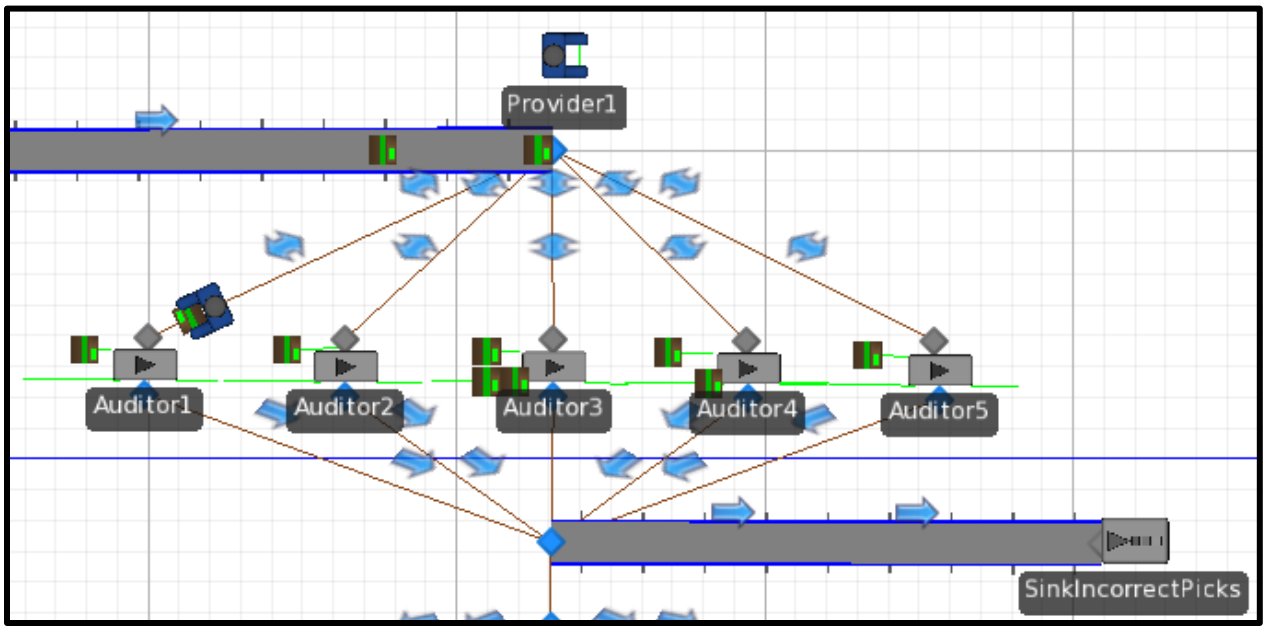

Figure 6: Auditing of Boxes

4.2.4 Stage 4: Prepare box for dispatch

After entities leave the auditing process, they are transported via a connector to a transport node. This transport node will send the entities containing incorrect picks to the sink object where it will be destroyed. Boxes containing incorrect picks do not have to be packed, as they will not be distributed.

The transport node will also allocate the entities containing correct picks to the packers. Each entity will be allocated to the packer containing the least amount of entities in its input buffer. This will ensure that the packers have more or less the same amount of entities to process at the end of the day. The input buffers for each packer will be set to a maximum of 5 for the same reason stated above.

Server objects are used to represent the packers. The processing rate for each server is set according to the specified values in section 3.2.5.

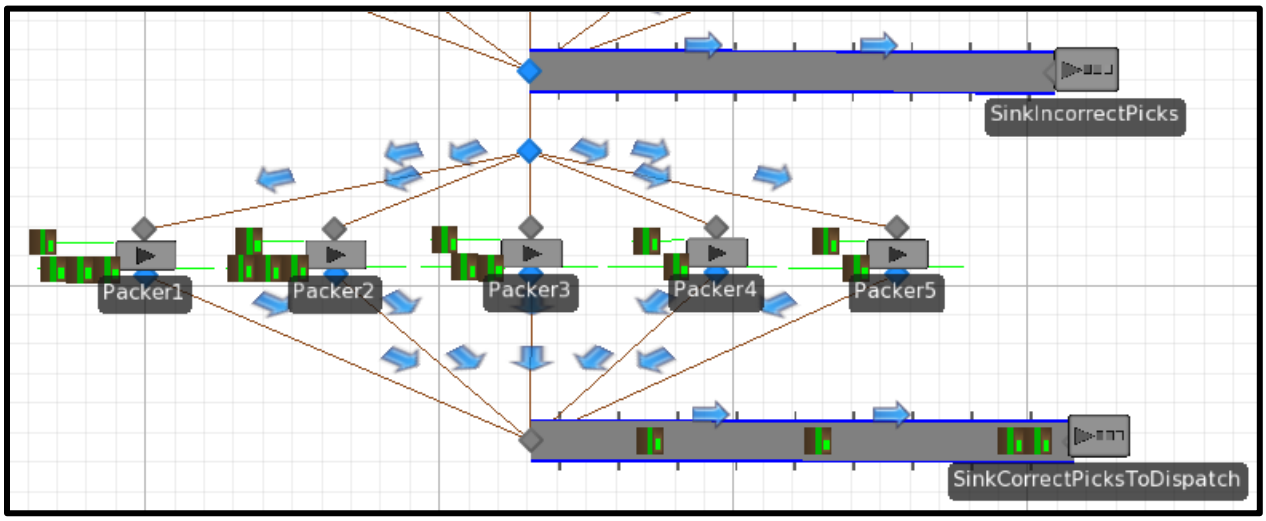

Figure 7: Packing process and sinking of entities

4.3 Model Verification and Validation

4.3.1 Verification

Verification of the model is the process of ensuring the model executes as intended. A detailed investigation on all input parameters and processes is necessary. Debugging is an important process involved in the process of verifying a model.

A technique used in the verification process is to generate a single entity at the source, and track it through the system. This identifies any execution logic related problems in the model.

4.3.2 Validation

The validation process is to confirm if the model is a good representation of the actual system. It does not necessarily mean the simulation model should be exactly the same as the actual system, but it should be sufficient to be used as a simulator for testing any decisions concerning the actual system.

The results for the simulation model must be compared to the results from the actual system. If the results are the same, it means the model is valid to be used as a simulation of the actual system. The audit area closing time is used as a measurement to compare the actual system with the simulation model. The average number of boxes processed by the warehouse for a day is used as input to the simulation.

Six experimental runs were done on the model and the average of the end of day times is used for the validation process.

Validation	5 Routes	6 Routes
Average No. of Correct Boxes per day	4760	6056
Average No. of Incorrect Boxes per day	119	152
Average end of day time after processing all Boxes by Actual System	17:47:33	19:55:25
Average end of day time after processing all Boxes by Simulation Model	17:39:54	19:48:45
Repetition details:		
Repetition 1	17:57:13	19:56:06
Repetition 2	17:32:06	19:50:11
Repetition 3	17:45:25	20:00:51
Repetition 4	17:29:32	19:37:58
Repetition 5	17:42:07	19:39:36
Repetition 6	17:33:04	19:47:47

Table 2: Validation of the model

In both cases the simulation is around seven minutes thirty seconds faster on average than the actual system, this is an error of one percent. Hence the model is acceptable to be used.

4.4 Experimental Development

The main objective is to determine the optimum number of staff required in the audit area to minimize the overall costs. Different alternatives will be developed that will make small alterations to the system. Each alternative model will be tested and compared to find the optimal system.

4.4.1 Current System

The first model to test is the current system. Models are run for days where five routes are picked as well as for days where six routes are picked. This was done in order to validate the model as well as to get information on the utilisation of each resource. By focusing on the utilisation of each resource it will be possible to identify the resources that cause bottlenecks in the system. After running each model, three reports will be extracted and processed in excel as shown below. Each report will be used to determine the impact a system would have in terms of cost and throughput capacity. For this validation each of the reports will also be explained below.

4.4.1.1 Current System – 5 Routes

Current system details		Normal rate cost per day	Overtime cost per day	Total cost per day
Length of run (hours) (17:57:13)	8.954			
Number of workers at stage 2	4	R 642.56	R 114.94	R 757.50
Number of Auditors	5	R 803.20	R 143.67	R 946.87
Number of Packers	5	R 803.20	R 143.67	R 946.87
Number of Providers	1	R 160.64	R 28.73	R 189.37
Audit Area supervisor	1	R 480.96	R 86.03	R 566.99
Dispatch Staff	3	R 481.92	R 86.20	R 568.12
		R 3,372.48	**R 603.25**	**R 3,975.73**

Table 3: Current System Resource Cost

The above table will be used to determine the resource cost that will be incurred by the audit area for a day where it was operational for a duration specified as the "Length of run". In this case, the audit area finished processing all the boxes at 17:57:13, and was operational for a total length of 8.954 hours. The second column indicates the number of staff that is required to keep the audit area operational. Not all of them have the same cost per hour, thus the normal and overtime cost is calculated for each type of staff individually. For this system the total normal and overtime costs incurred by the audit area per day are R3 372.48 and R 603.25 respectively. These costs will fluctuate as resources are added or removed.

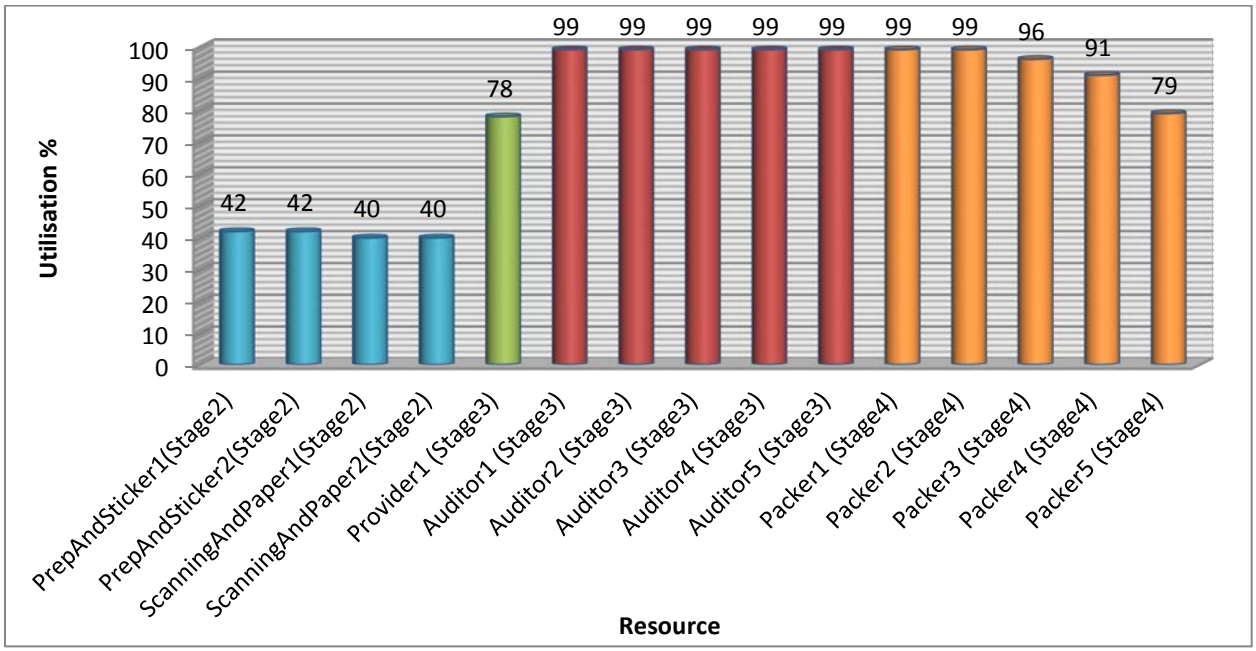

Figure 8: Resource Utilisation of the Current System

The above report indicates the utilization of each resource throughout the run. The report shown below indicates the percentage each resource is blocked due to insufficient processing of boxes in the subsequent stages.

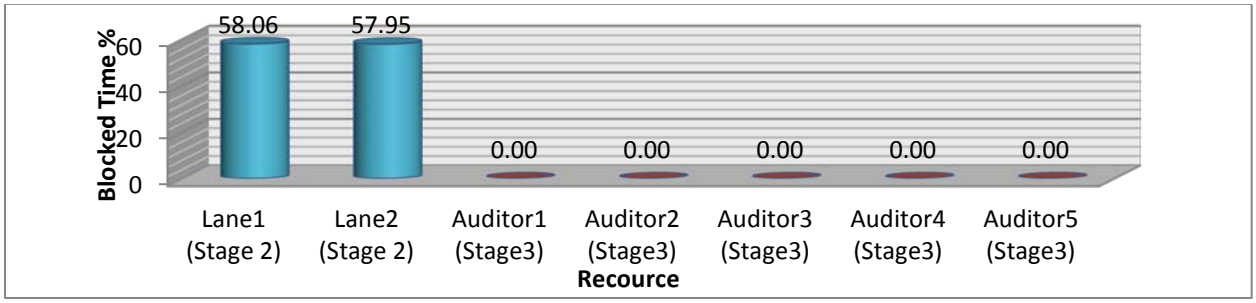

Figure 9: Resources Average Time Blocked for Current System

The above reports clearly indicate the low utilisation of the processes of stage two and the bottlenecks forming in front of the audit process. Due to the fact that stage two are blocked more than fifty five percent throughout the run, and its utilisation of less than forty two percent, it is possible to reallocate a proportion of the resources used in stage two to support stages three and four. Scenarios will be performed on the model to identify the outcome these impact would have on the system.

4.4.1.2 Current System – 6 Routes

Current System details		Normal rate cost per day	Overtime cost per day	Total cost per day
Length of run (hours) (19:47:44)	10.7955			
Number of workers at stage 2	4	R 642.56	R 336.80	R 979.36
Number of Auditors	5	R 803.20	R 421.00	R 1,224.20
Number of Packers	5	R 803.20	R 421.00	R 1,224.20
Number of Providers	1	R 160.64	R 84.20	R 244.84
Audit Area supervisor	1	R 480.96	R 252.10	R 733.06
Dispatch Staff	3	R 481.92	R 252.60	R 734.52
		R 3,372.48	**R 1,767.71**	**R 5,140.19**

Table 4: Current System Resource Cost

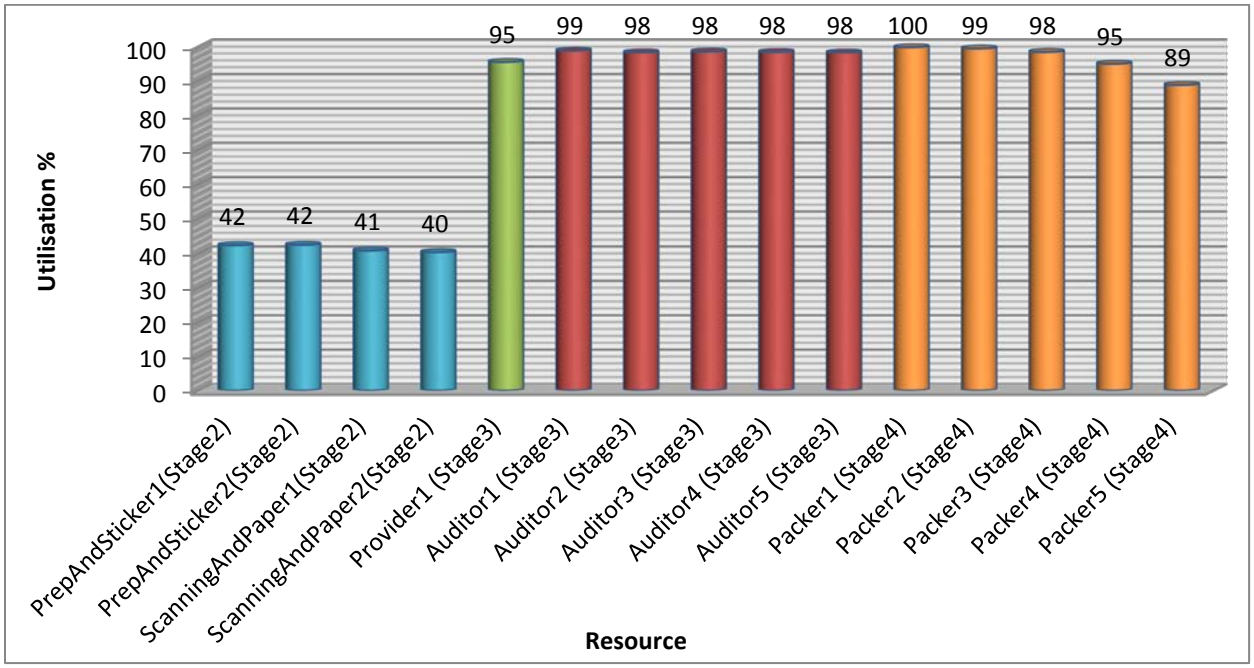

Figure 10: Resource Utilisation of the Current System

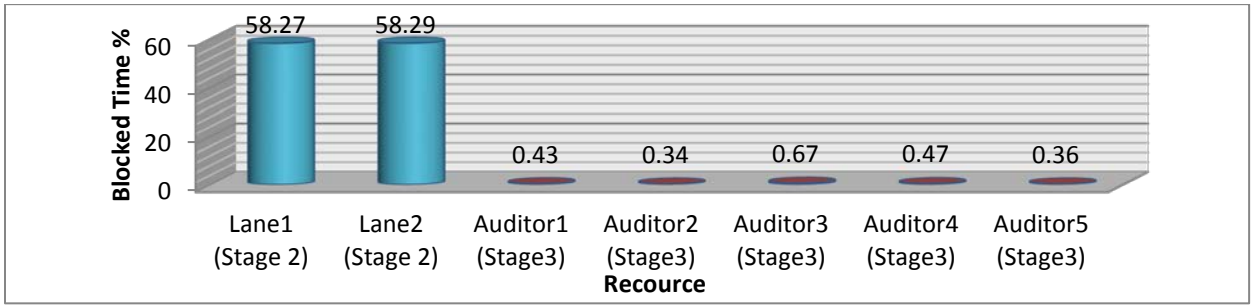

Figure 11: Resources Average Time Blocked for Current System

The same as with the current situation where five routes are picked, the utilisation of stages three and four are considerably high. Due to the volume of boxes needed to be processed, the utilisation for stage two will rise as resources for stages three and four are increased. Scenarios will be developed accordingly.

4.4.2 Alternative Systems

Alternative systems will represent different scenarios were changes will be made to the resources of the current system. After an alternate system is tested, its results will be analysed to determine the changes that will be made in the following alternative.

Agrinet is growing rapidly, and so does their demands. They had a twenty one percent increase in the number of picks made for the first six months of the year from 2011 to 2012. Therefore an additional system will be developed that can be implemented when their demands increases in 2013.

4.4.2.1 Alternative 1: Current Demand – 5 Routes

Two alternative systems were identified for the input capacity of the audit area on days where five routes need to be picked. The model is adjusted from the current system according to each alternative and tested.

- **Alternative 1-A:** Remove both resources from one of the lanes in stage two. Increase the resources for the audit and packing processes by one.
- **Alternative 1-B:** Remove both resources from one of the lanes in stage two. Increase the resources for the audit process by one.
- **Alternative 1-C:** Increase auditing and packing resources by two, and add an additional provider. Conveyor speed is increased by sixty percent.

4.4.2.2 Alternative 2: Current Demand – 6 Routes

Four alternative systems were identified for the input capacity of the audit area on days were six routes need to be picked. The model is adjusted from the current system according to each Alternative and tested.

- **Alternative 2-A:** Increase auditing and packing resources by one.
- **Alternative 2-B:** Increase auditing and packing resources by one, and add an additional provider. Conveyor speed is increased by sixty percent.
- **Alternative 2-C:** Increase auditing and packing resource by two, and add an additional provider. Conveyor speed is increased by sixty percent.
- **Alternative 2-D:** Remove both resources from one of the lanes in stage two. Increase the resources for the audit and packing processes by one.

4.4.2.2 Alternative 3: Future Demand

The current input capacity of the model will be increased by twenty percent for these scenarios. Three alternative systems were identified to be tested. The model is adjusted from the current system according to each Alternative and tested.

- **Alternative 3-A:** Increase auditing and packing resource by two, and add an additional provider. Conveyor speed is increased by sixty percent.
- **Alternative 3-B:** Increase auditing and packing resource by three, and add an additional provider. Conveyor speed is increased by sixty percent.

4.4.3 Conveyor Speed

The conveyor speed for the current system is considerably slow to ensure the provider can cope with the amount of boxes arriving in stage three and not having to interrupt the flow of boxes by stopping the conveyor. With the aid of an additional provider, this speed could be increased. The speed will be increased from 0.7 meters per second to 1.12 meters per second. Agrinet provided that the current conveyor system's speed can be increased as required.

5 Evaluation

Each of the alternatives specified in section 4.4.2 was run and consisted of one replication of the duration to process all boxes for a day. A report is generated for each Alternative and exported to Microsoft Excel. Data is then processed with Microsoft Excel for the purpose of this evaluation. Data extracted from Simio for each Alternative can be viewed in Appendix C.

5.1 Alternative 1: Current Demand – 5 Routes

The input parameters are set as specified in section 3.2.2. The following alterations were made on the current system specified in section 4.4.1.1.

5.1.1 Alternative 1-A

Remove both resources from one of the lanes in stage two. Increase the resources for the audit and packing processes by one. The following data are generated:

Current system details		Normal rate cost per day	Overtime cost per day	Total cost per day
Length of run (hours) (17:03:22)	8.056			
Number of workers at stage 2	2	R 321.28	R 3.37	R 324.65
Number of Auditors	6	R 963.84	R 10.12	R 973.96
Number of Packers	6	R 963.84	R 10.12	R 973.96
Number of Providers	1	R 160.64	R 1.69	R 162.33
Audit Area supervisor	1	R 480.96	R 5.05	R 486.01
Dispatch Staff	3	R 481.92	R 5.06	R 486.98
		R 3,372.48	**R 35.41**	**R 3,407.89**

Table 5: Alternative 1-A Resource Cost

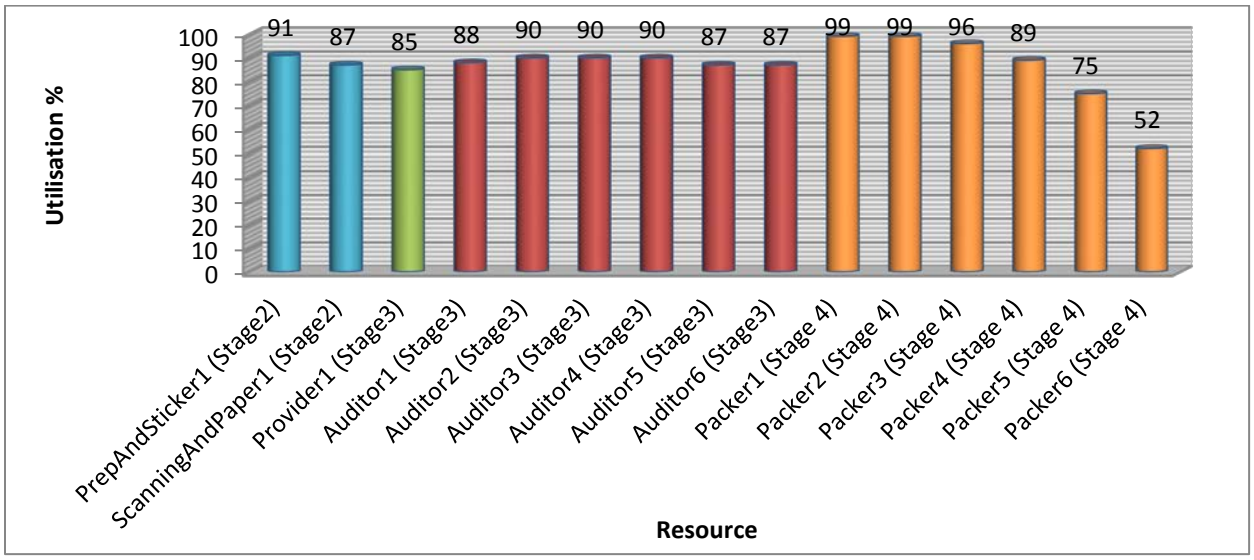

Figure 12: Resource Utilisation for Alternative 1-A

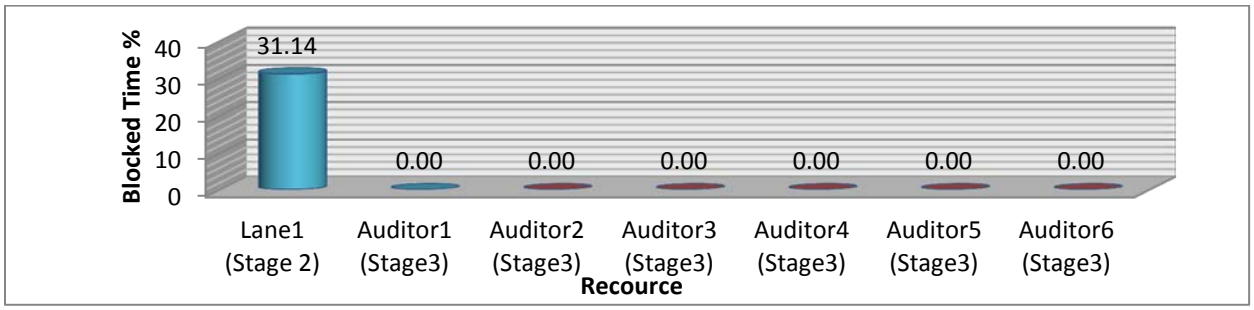

Figure 13: Resources Average Time Blocked for Alternative 1-A

This change increased the utilisation of stage two significantly and reduced strain on stages three and four. It can be considered to remove one resource from stage four due to the lower utilisation of resources in stage four in this scenario.

5.1.2 Alternative 1-B

Remove both resources from one of the lanes in stage two. Increase the resources for the audit process by one. The following data are generated:

Current system details		Normal rate cost per day	Overtime cost per day	Total cost per day
Length of run (hours) (17:18:53)	8.31			
Number of workers at stage 2	2	R 321.28	R 18.67	R 339.95
Number of Auditors	6	R 963.84	R 56.02	R 1,019.86
Number of Packers	5	R 803.20	R 46.69	R 849.89
Number of Providers	1	R 160.64	R 9.34	R 169.98
Audit Area supervisor	1	R 480.96	R 27.96	R 508.92
Dispatch Staff	3	R 481.92	R 28.01	R 509.93
		R 3,211.84	**R 186.69**	**R 3,398.53**

Table 6: Alternative 1-B Resource Cost

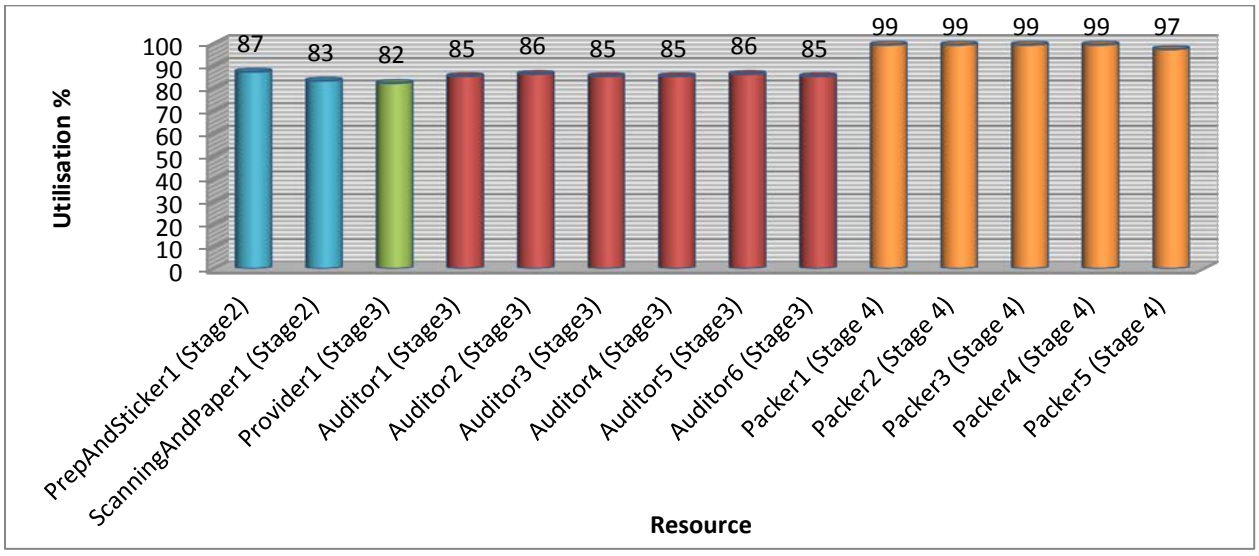

Figure 14: Resource Utilisation for Alternative 1-B

The lower utilisation in stage three is due to blockages occurring from not enough resources at stage four.

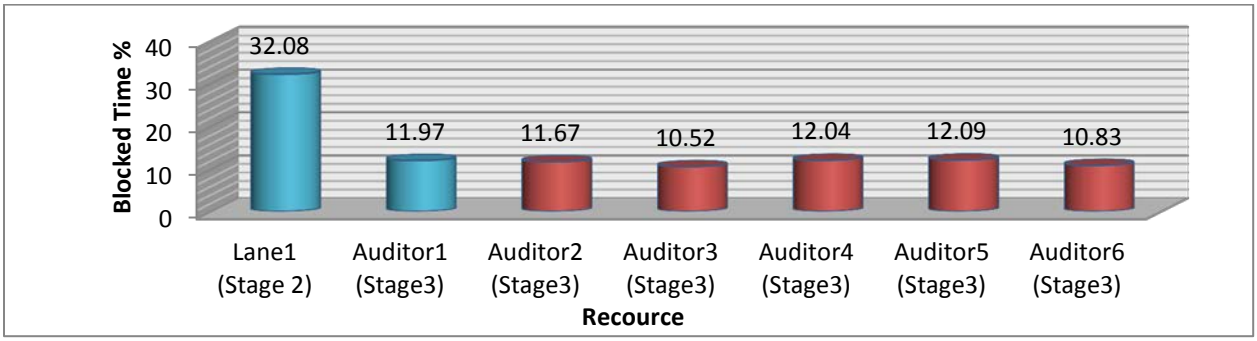

Figure 15: Resources Average Time Blocked for Alternative 1-B

As stated in figure 17, the reduction of resources in stage four resulted in blockages that occurred at the auditors. Regardless of these blockages, this alternative is still more cost efficient than the previous specified alternative, although it is only by a small fraction.

To reduce the time of processing all boxes for a day will require added resources in stage two and increased travel time between stages two and three. The increased travel time will require an additional provider, which will decrease strain on Provider1, and increase the conveyor speed by sixty percent.

5.1.3 Alternative 1-C

Increase auditing and packing resources by two, and add an additional provider. Conveyor speed is increased by sixty percent. The following data are generated:

Current system details		Normal rate cost per day	Overtime cost per day	Total cost per day
Length of run (hours) (16:21:11)	7.35			
Number of workers at stage 2	4	R 590.35	R 0.00	R 590.35
Number of Auditors	6	R 885.53	R 0.00	R 885.53
Number of Packers	6	R 885.53	R 0.00	R 885.53
Number of Providers	2	R 295.18	R 0.00	R 295.18
Audit Area supervisor	1	R 441.88	R 0.00	R 441.88
Dispatch Staff	3	R 442.76	R 0.00	R 442.76
		R 3,541.23	**R 0.00**	**R 3,541.23**

Table 7: Alternative 1-C Resource Cost

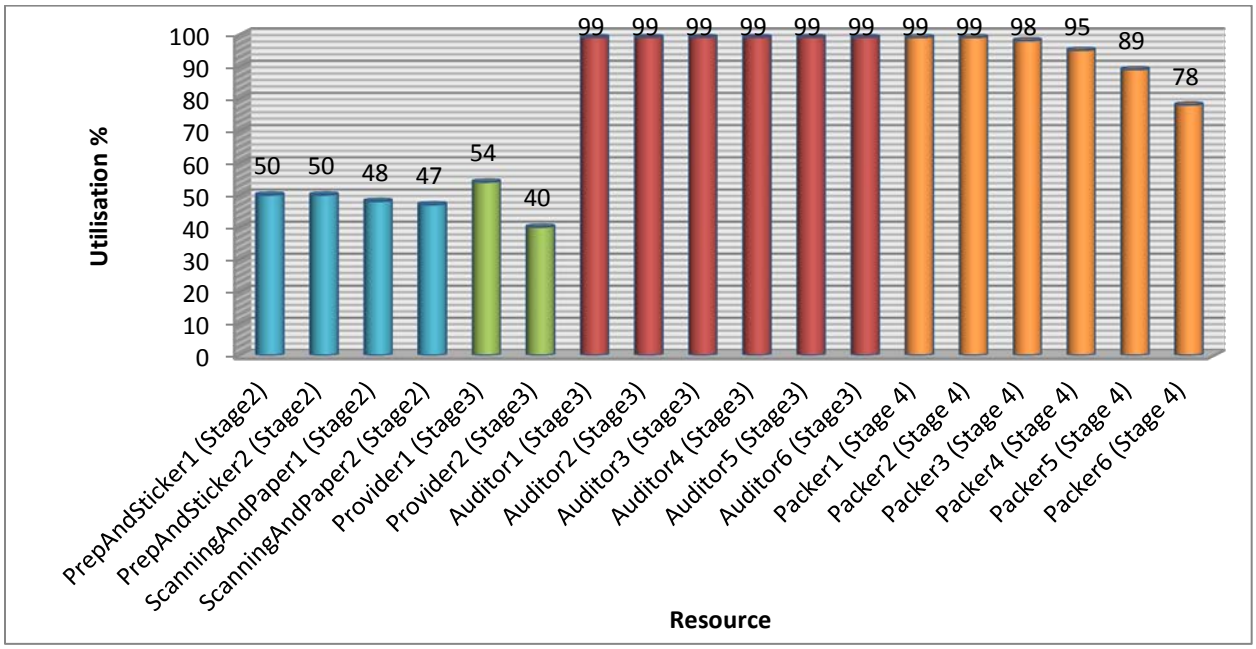

Figure 16: Resource Utilisation for Alternative 1-C

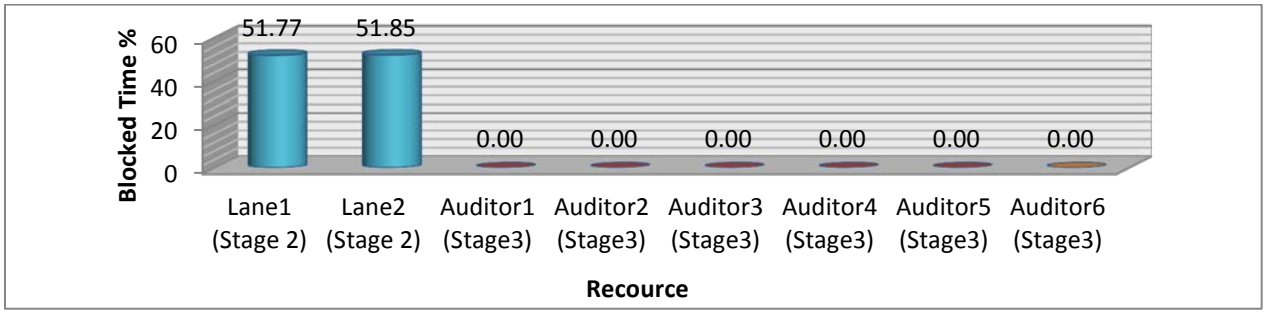

Figure 17: Resources Average Time Blocked for Alternative 1-C

Regardless of the reduced time of completing the processing of all boxes, this alternative still costs more than the previous ones specified in 5.1.1 and 5.1.2.

Although the resources in stages three and four are fully utilised, it will not improve the cost efficiency by adding additional resources, as the run length can only be reduced by about fifteen more minutes.

5.2 Alternative 2

The input parameters are set as specified is section 3.2.2. The following alterations were made on the current system specified in section 4.4.1.2.

5.2.1 Alternative 2-A

Increase auditing and packing resources by one. The following data are generated:

System details		Normal rate cost per day	Overtime cost per day	Total cost per day
Length of run (hours) (18:05:28)	9.09			
Number Of workers at stage 2	4	R 642.56	R 131.32	R 773.88
Number of Auditors	6	R 963.84	R 196.98	R 1,160.82
Number of Packers	6	R 963.84	R 196.98	R 1,160.82
Number of Providers	1	R 160.64	R 32.83	R 193.47
Audit Area supervisor	1	R 480.96	R 98.30	R 579.26
Dispatch Staff	3	R 481.92	R 98.49	R 580.41
		R 3,693.76	**R 754.91**	**R 4,448.67**

Table 8: Alternative 2-A Resource Cost

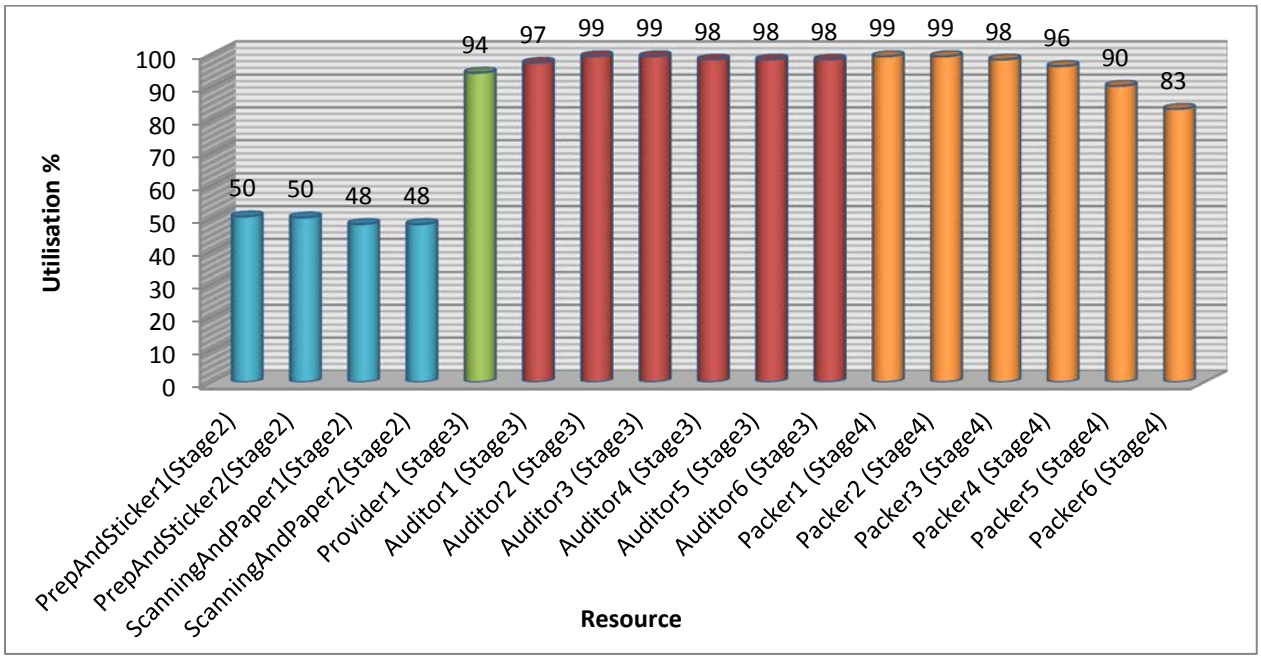

Figure 18: Resource Utilisation for Alternative 2-A

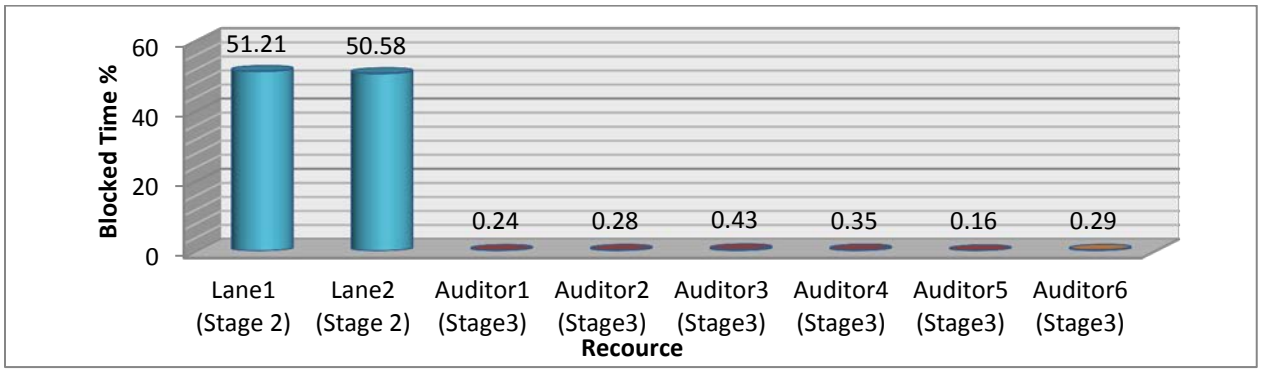

Figure 19: Resources Average Time Blocked for Alternative 2-A

By adding the two additional resources the time to process all the boxes for a day were significantly reduced. Figure 21 clearly indicates that further auditors can be added as the processes in stage two are blocked more than fifty percent of the time. It also indicates the auditing process being blocked. This only occurred around 0.3 percent of the time, but this will increase and lead to delays if an additional packer is not also added.

5.2.2 Alternative 2-B

Increase auditing and packing resources by two. The following data are generated:

Current system details		Normal rate cost per day	Overtime cost per day	Total cost per day
Length of run (hours) (17:44:51)	8.75			
Number of workers at stage 2	4	R 642.56	R 90.36	R 732.92
Number of Auditors	7	R 1,124.48	R 158.13	R 1,282.61
Number of Packers	7	R 1,124.48	R 158.13	R 1,282.61
Number of Providers	1	R 160.64	R 22.59	R 183.23
Audit Area supervisor	1	R 480.96	R 67.64	R 548.60
Dispatch Staff	3	R 481.92	R 67.77	R 549.69
		R 4,015.04	**R 564.62**	**R 4,579.66**

Table 9: Resource Cost for Alternative 2-B

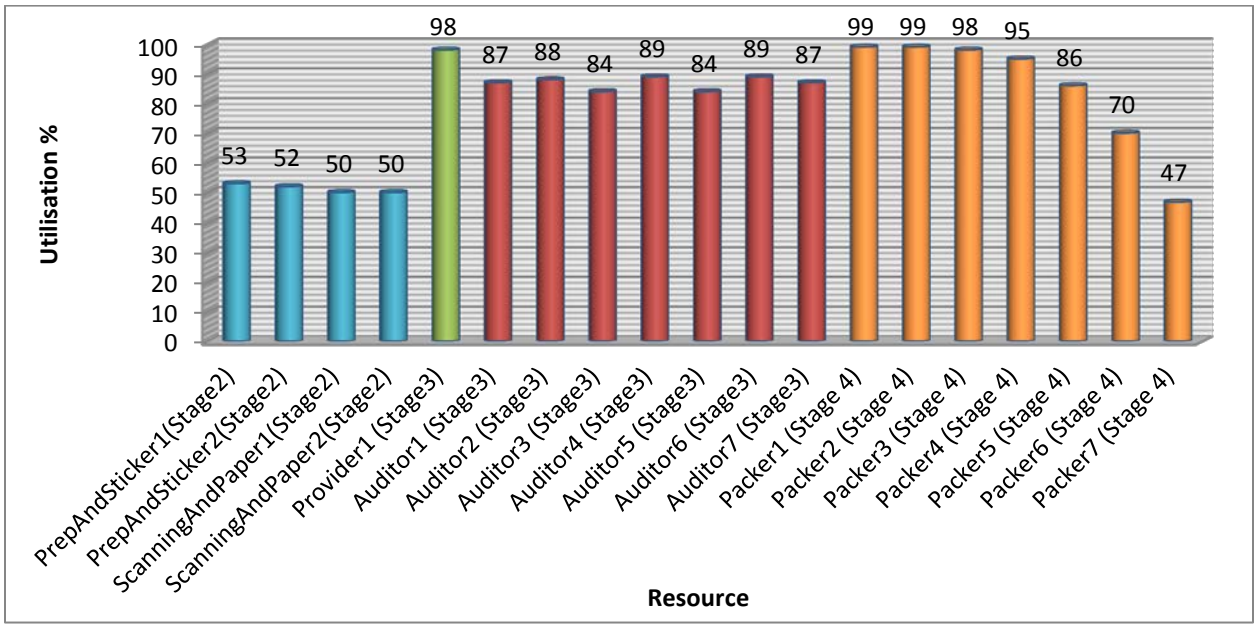

Figure 20: Resource Utilisation for Alternative 2-B

With the low utilisation of the auditors, it is clear that the transportation of boxes between stage two and three needs to be accelerated. With provider1 fully utilised, an additional provider will accelerate the process of providing boxes to auditors as well as to increase the speed of the conveyor.

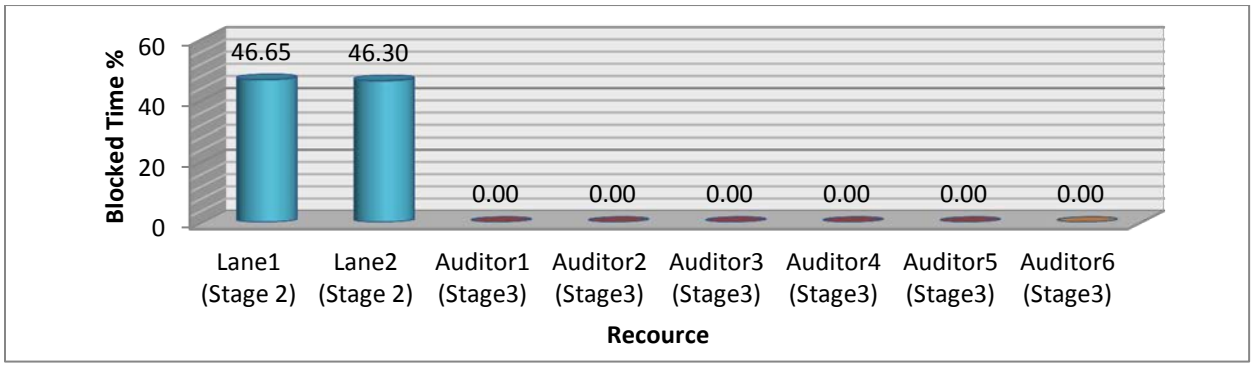

Figure 21: Resources Average Time Blocked for Alternative 2-B

5.2.3 Alternative 2-C

Increase auditing and packing resources by two, and add an additional provider. Conveyor speed is increased by sixty percent. The following data are generated:

Current system details		Normal rate cost per day	Overtime cost per day	Total cost per day
Length of run (hours) (16:41:00)	7.6833			
Number of workers at stage 2	4	R 642.56	R 0.00	R 642.56
Number of Auditors	7	R 1,124.48	R 0.00	R 1,124.48
Number of Packers	7	R 1,124.48	R 0.00	R 1,124.48
Number of Providers	2	R 321.28	R 0.00	R 321.28
Audit Area supervisor	1	R 480.96	R 0.00	R 480.96
Dispatch Staff	3	R 481.92	R 0.00	R 481.92
		R 4,175.68	**R 0.00**	**R 4,175.68**

Table 10: Resource Cost for Alternative 2-C

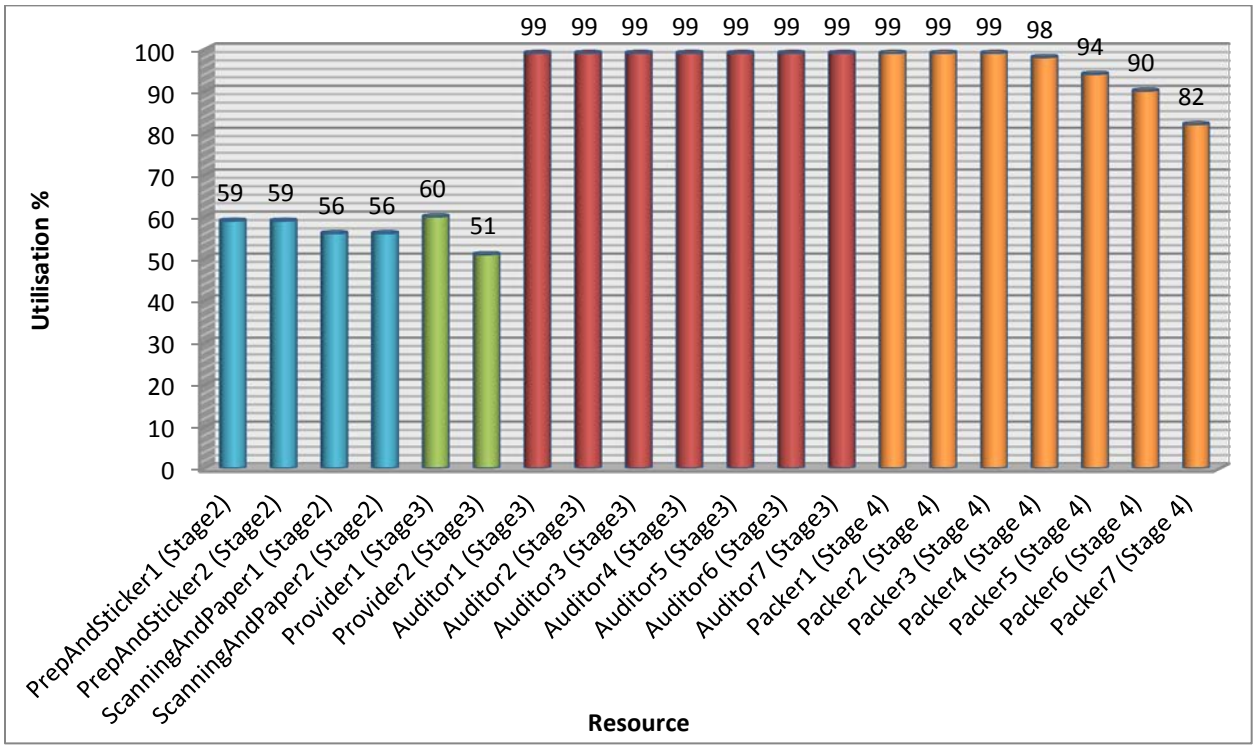

Figure 22: Resource Utilisation for Alternative 2-C

The resources in stage three are now fully utilised. Additional resources can be added as stage two are utilised less than sixty percent of the time.

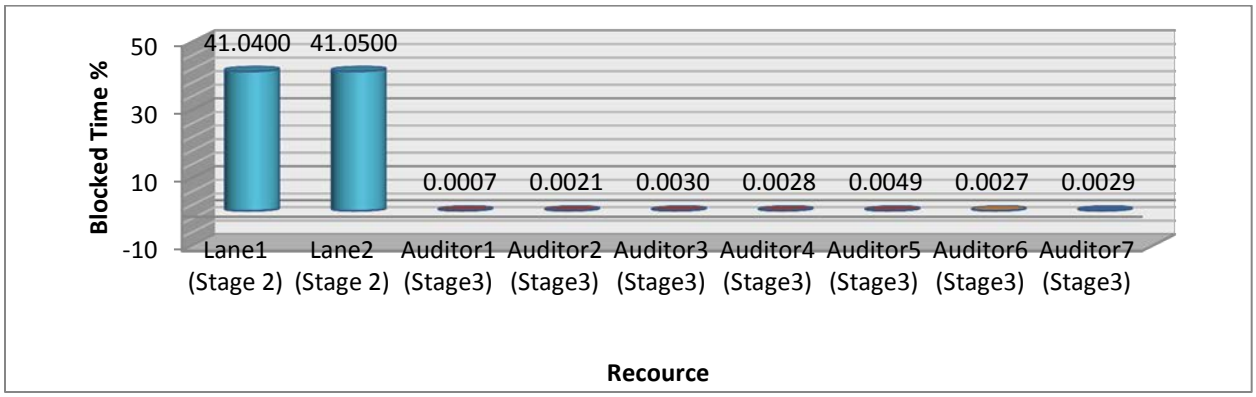

Figure 23: Resources Average Time Blocked for Alternative 2-C

The blockages occurring in stage two also suggests additional resources should be added in stages three and four.

5.2.4 Alternative 2-D

Increase auditing and packing resources by three, and add an additional provider. Conveyor speed is increased by sixty percent. The following data are generated:

Current system details		Normal rate cost per day	Overtime cost per day	Total cost per day
Length of run (hours) (16:05:14)	7.087			
Number of workers at stage 2	4	R 642.56	R 0.00	R 642.56
Number of Auditors	8	R 1,285.12	R 0.00	R 1,285.12
Number of Packers	8	R 1,285.12	R 0.00	R 1,285.12
Number of Providers	2	R 321.28	R 0.00	R 321.28
Audit Area supervisor	1	R 480.96	R 0.00	R 480.96
Dispatch Staff	3	R 481.92	R 0.00	R 481.92
		R 4,496.96	**R 0.00**	**R 4,496.96**

Table 11: Resource Cost for Alternative 2-D

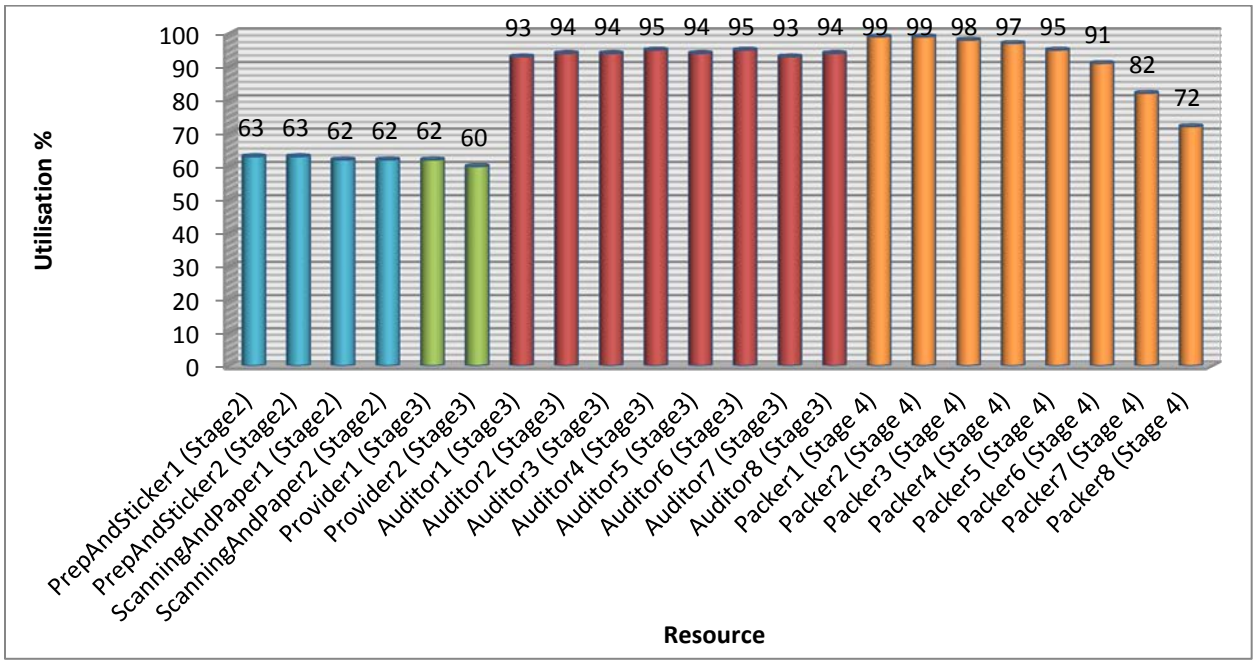

Figure 24: Resource Utilisation for Alternative 2-D

With the additional resources added, the auditors could not be fully utilised as there are insufficient boxes to be processed. The additional resources led to an increase in the total cost for the day, regardless of the reduced time to process all boxes.

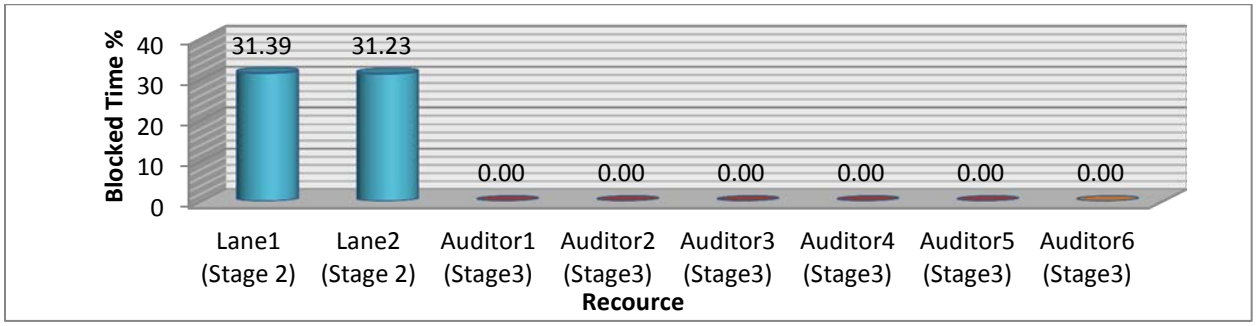

Figure 25: Resources Average Time Blocked for Alternative 2-D

5.3 Alternative 3

The aim of these alternate developments is to find the optimal number of resources required, should the demand increase by twenty percent.

5.3.1 Alternative 3-A

Increase auditing and packing resource by three, and add an additional provider. Conveyor speed is increased by sixty percent. The following data are generated:

System details		Normal rate cost per day	Overtime cost per day	Total cost per day
Length of run (hours) (17:12:19)	8.21			
Number of workers at stage 2	4	R 642.56	R 25.30	R 667.86
Number of Auditors	8	R 1,285.12	R 50.60	R 1,335.72
Number of Packers	8	R 1,285.12	R 50.60	R 1,335.72
Number of Providers	2	R 321.28	R 12.65	R 333.93
Audit Area supervisor	1	R 480.96	R 18.94	R 499.90
Dispatch Staff	3	R 481.92	R 18.98	R 500.90
		R 4,496.96	**R 177.07**	**R 4,674.03**

Table 12: Resource Cost for Alternative 3-A

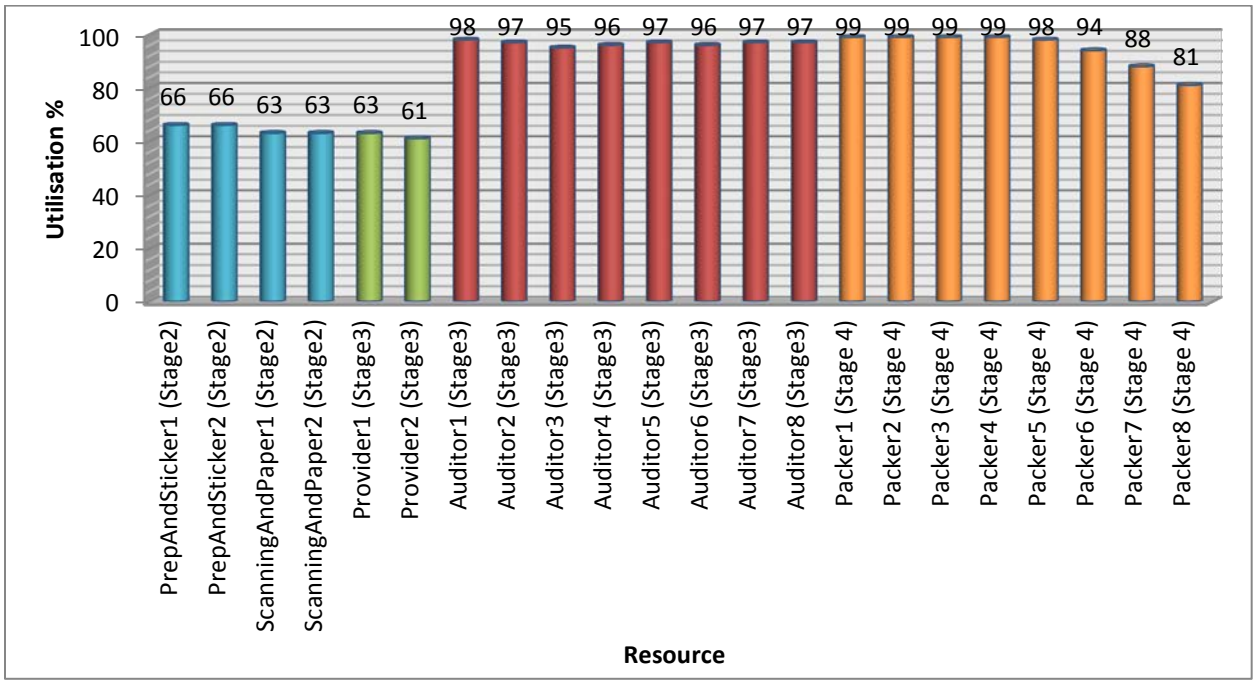

Figure 26: Resource Utilisation for Alternative 3-A

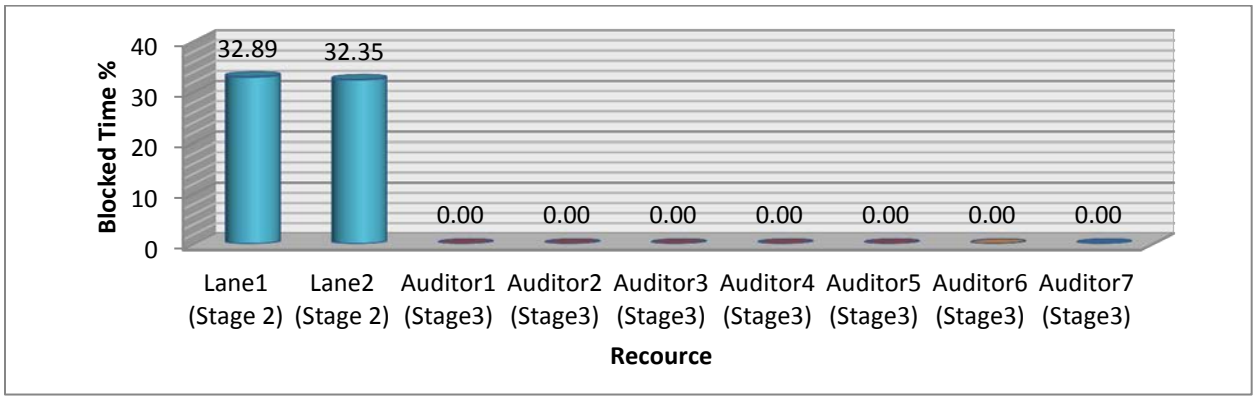

Figure 27: Resources Average Time Blocked for Alternative 3-A

Blockage of stage two occur more than thirty percent and the utilisation for stages three and four are on its maximum, thus additional auditors and packers should be added.

5.3.2 Alternative 3-B

Increase auditing and packing resource by four, and add an additional provider. Conveyor speed is increased by sixty percent. The following data are generated:

System details		Normal rate cost per day	Overtime cost per day	Total cost per day
Length of run (hours) (16:13:59)	7.23			
Number of workers at stage 2	4	R 580.71	R 0.00	R 580.71
Number of Auditors	9	R 1,306.61	R 0.00	R 1,306.61
Number of Packers	9	R 1,306.61	R 0.00	R 1,306.61
Number of Providers	2	R 290.36	R 0.00	R 290.36
Audit Area supervisor	1	R 434.67	R 0.00	R 434.67
Dispatch Staff	3	R 435.54	R 0.00	R 435.54
		R 4,354.48	**R 0.00**	**R 4,354.48**

Table 13: Resource Cost for Alternative 3-B

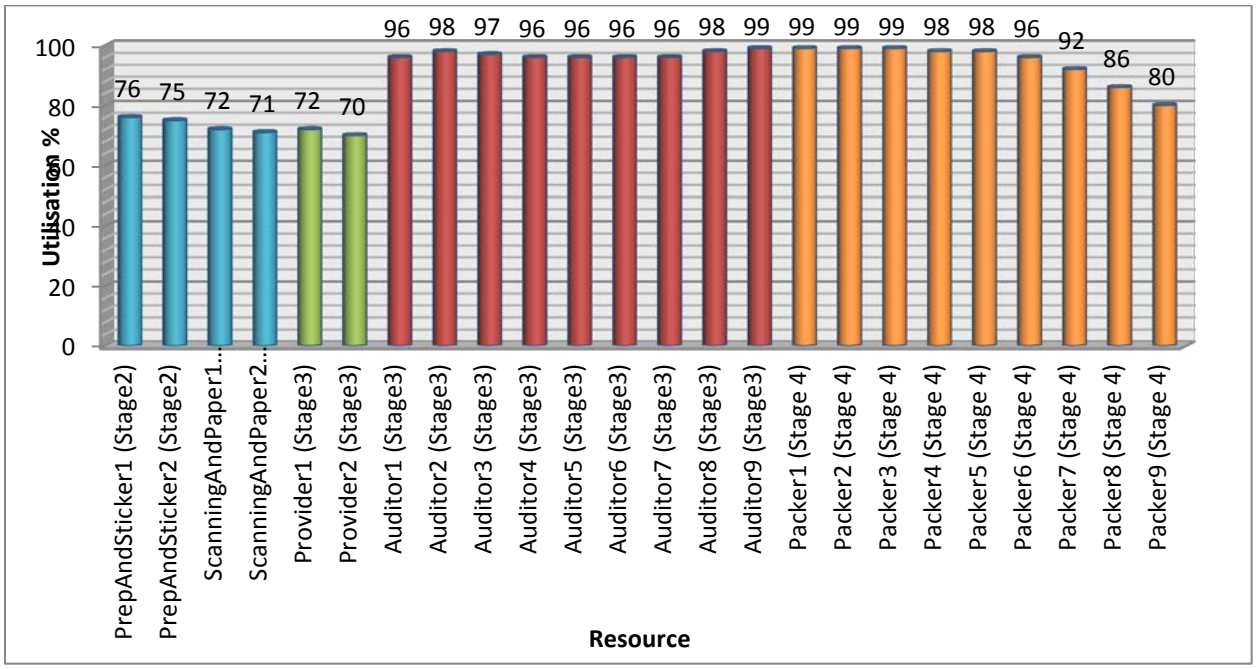

Figure 28: Resource Utilisation for Alternative 3-B

Resources in stage three are not fully utilised, the reason for this is due to the conveyor speed not being fast enough. Thus adding additional resources will not improve the system.

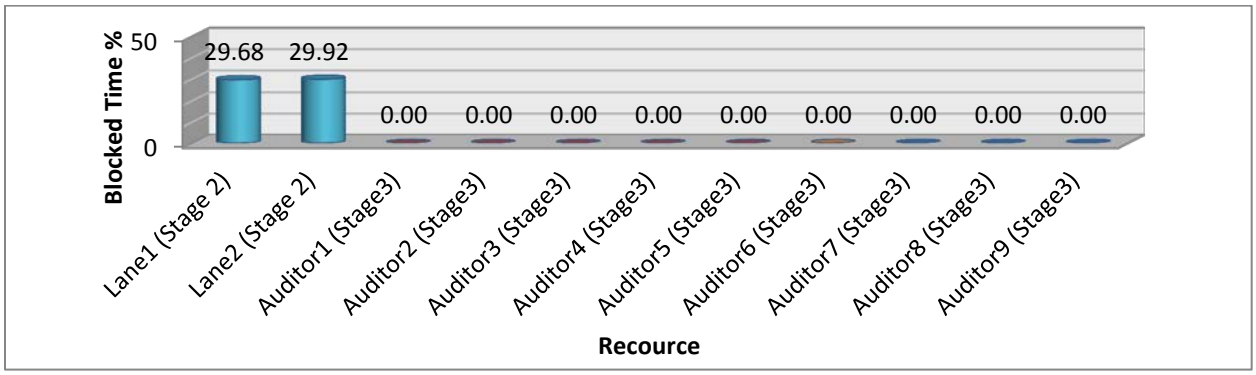

Figure 29: Resources Average Time Blocked for Alternative 3-B

The blockages that occur are also due to the conveyor speed. This will be the maximum throughput of the system in a time space of seven hours and twenty three minutes, as the bottle neck is formed at the conveyor.

5.4 Summary and Evaluation of Alternatives

The factors to consider in choosing an alternative that would be most beneficial to Agrinet are provided in each table.

5.4.1 Current Demand: 5-Routes

The following table provides a summary of the alternative systems developed for days where five routes are picked:

Model	Duration of Simulation Run (hours)	Number of Staff Required	Average % Utilisation of Auditors	Average % Utilisation of Packers	Total Cost per Day
Current	8.68	19	99	93	R 3,802.47
Alternative 1-A	8.06	19	89	85	R 3,407.89
Alternative 1-B	8.31	18	85	99	R 3,398.53
Alternative 1-C	7.35	22	99	93	R 3,541.23

Table 14: Summary of Alternative 1

Considering the total cost per day, alternative 1-B would be the best solution to minimize the total resource cost. The downside of this is that the average utilisation for packers is very high which could lead to larger delays in the actual system and higher costs than Alternative 1-A as there will be very little room for unsuspected interruptions at the packers. Taking all these factors into consideration it is therefore suggested that Alternative 1-A is implemented. The following table shows the financial implication Alternative 1-A would have on days where five routes are picked:

Resource cost savings after implementation	Amount
Current resource cost per day	R 3,802.47
Resource cost per day of proposed Alternative	R 3,407.89
Expected savings per Day	R 394.58
Expected savings per Year (249 working days)	R 98,250.42

Table 15: Total savings by implementing Alternative 1-A

5.4.2 Current Demand: 6-Routes

Model	Duration of Simulation Run (hours)	Number of Staff Required	Average % Utilisation of Auditors	Average % Utilisation of Packers	Total Cost per Day
Current	10.80	19	98	96	R 5,140.19
Alternative 2-A	9.09	21	98	94	R 4,448.67
Alternative 2-B	9.05	23	87	85	R 4,805.50
Alternative 2-C	7.68	24	99	94	R 4,010.38
Alternative 2-D	7.09	26	94	92	R 4,685.80

Table 16: Summary of Alternative 2

The above table clearly shows that Alternative 2-C would be the best solution to minimize the total resource cost. Although the utilisation of auditors is high, there is still substantial room for unsuspected interruptions before the system will incur higher costs than Alternative 2-A. It is therefore suggested that Alternative 2-C is implemented. The following table shows the financial implication Alternative 2-C would have on days where six routes are picked:

Resource cost savings after implementation	Amount
Current resource cost per day	R 5,140.19
Resource cost per day of proposed Alternative	R 4,010.38
Expected savings per Day	R 1,129.81
Expected savings per Year (249 working days)	R 281,322.69

Table 17: Total savings by implementing Alternative 2-C

5.4.3 Future Demand

With an increased demand of twenty percent the following Alternatives where developed:

Model	Duration of Simulation Run (hours)	Number of Staff Required	Average % Utilisation of Auditors	Average % Utilisation of Packers	Total Cost per Day
Alternative 3-A	8.21	26	97	95	R 4,674.03
Alternative 3-B	7.23	28	97	94	R 4,354.48

Table 18: Summary of Alternative 3

Currently Agrinet has no proposed system for future demands, thus no comparison can be made to show the effectiveness of the Alternative systems. They both have relatively the same utilisations, therefore it is suggested that Alternative 3-B would be used in the future as it has the lowest resource cost.

6 Conclusion

The aim of this project was to optimize the audit area and increase its efficiency and effectiveness by developing a simulation model that will be capable of finding the optimum number of resources required to achieve the desired throughput rate as well as to minimize the overall costs incurred.

Several industrial engineering techniques were initially considered to be used. With regards to the literature review, it was confirmed that simulation modeling would be the best technique to solve the problem in the audit area. Simulation modeling made it possible to replicate the audit area in a controlled environment to be studied and evaluated in order to find the optimal resources required for maximum effectiveness and efficiency.

Process analysis and time-studies was a critical requirement in the development of the simulation model. It ensured that a realistic model was developed and that it could be used as a simulator in finding the best solution for the problem.

The model was successful and several alternative systems could have been developed witch had a large impact on the system.

If the proposed resource configurations according to the specifications in section 5.4 are implemented, Agrinet would be able to save around R153 000 per year on resource costs if days where six routes are picked occur thirty percent of the time, and days where five routes are picked occur seventy percent of the time. (Averages calculated from operation totals) Days where six routes are picked are expected to increase in the future.

By implementing alternative 2-C on days where six routes are picked, the average time the audit area operates per day could be reduced by three hours. This will boost the morale of workers and could lead to an increase in work effectiveness. Other costs such as electricity will also be reduced.

For future demands with an increase of twenty percent, the resource configurations as proposed in section 5.4.3 should be implemented to ensure the audit area can cope with the increased capacity, and still keep the resource costs to a minimum.

Agrinet should monitor the number of routes picked per day as well as the demands, and implement the suggested resource configurations accordingly.

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Appendices

Appendix A: Combined Model

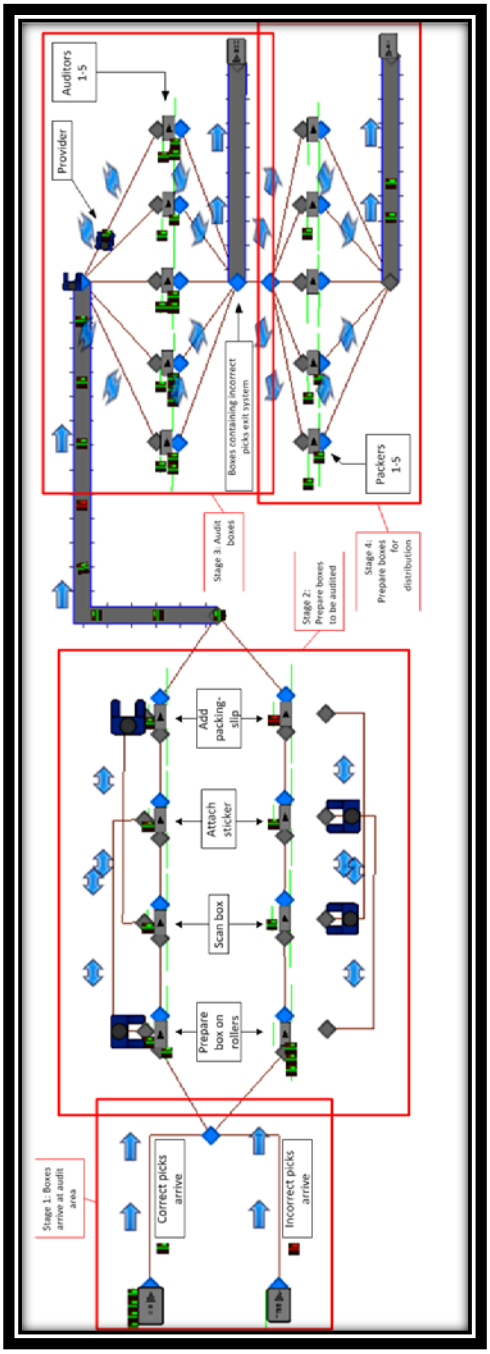
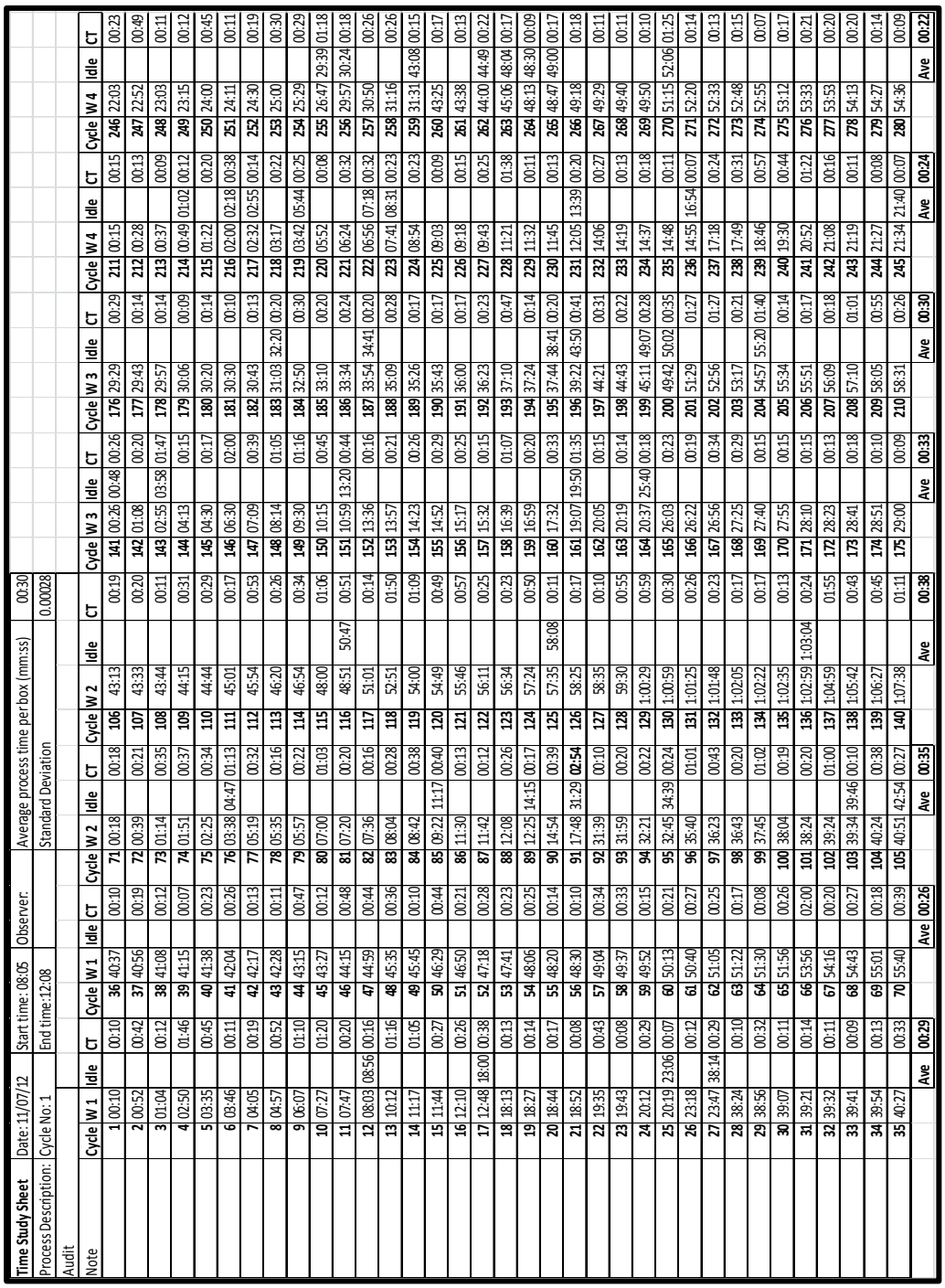


Figure 30: Computer Model

Appendix B: Probability Distribution Calculation

Time Studies:



Time Study Sheet	Date: 11/07/12	Start time: 08:05	Observer:	Average process time per box (mm:ss)	00:30
Process Description: Cycle No: 1		End time:12:08		Standard Deviation	0.00028
Audit					

Note	Cycle	W 1	Idle	CT	Cycle	W 1	Idle	CT	Cycle	W 2	Idle	CT	Cycle	W 2	Idle	CT	Cycle	W 3	Idle	CT	Cycle	W 3	Idle	CT	Cycle	W 4	Idle	CT	Cycle	W 4	Idle	CT
	1	00:10		00:10	36	40:37		00:10	71	00:18		00:18	106	43:13		00:19	141	00:26	00:48	00:26	176	29:29		00:29	211	00:15		00:15	246	22:03		00:23
	2	00:52		00:42	37	40:56		00:19	72	00:39		00:21	107	43:33		00:20	142	01:08		00:20	177	29:43		00:14	212	00:28		00:13	247	22:52		00:49
	3	01:04		00:12	38	41:08		00:12	73	01:14		00:35	108	43:44		00:11	143	02:55	03:58	01:47	178	29:57		00:14	213	00:37		00:09	248	23:03		00:11
	4	02:50		01:46	39	41:15		00:07	74	01:51		00:37	109	44:15		00:31	144	04:13		00:15	179	30:06		00:09	214	00:49	01:02	00:12	249	23:15		00:12
	5	03:35		00:45	40	41:38		00:23	75	02:25		00:34	110	44:44		00:29	145	04:30		00:17	180	30:20		00:14	215	01:22		00:20	250	24:00		00:45
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	7	04:05		00:19	42	42:17		00:13	77	05:19		00:32	112	45:54		00:53	147	07:09		00:39	182	30:43		00:13	217	02:32	02:55	00:14	252	24:30		00:19
	8	04:57		00:52	43	42:28		00:11	78	05:35		00:16	113	46:20		00:26	148	08:14		01:05	183	31:03	32:20	00:20	218	03:17		00:22	253	25:00		00:30
	9	06:07		01:10	44	43:15		00:47	79	05:57		00:22	114	46:54		00:34	149	09:30		01:16	184	32:50		00:30	219	03:42	05:44	00:25	254	25:29		00:29
	10	07:27		01:20	45	43:27		00:12	80	07:00		01:03	115	48:00		01:06	150	10:15		00:45	185	33:10		00:20	220	05:52		00:08	255	26:47	29:39	01:18
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	13	10:12		01:16	48	45:35		00:36	83	08:04		00:28	118	52:51		01:50	153	13:57		00:21	188	35:09		00:28	223	07:41	08:31	00:23	258	31:16		00:26
	14	11:17		01:05	49	45:45		00:10	84	08:42		00:38	119	54:00		01:09	154	14:23		00:26	189	35:26		00:17	224	08:54		00:23	259	31:31	43:08	00:15
	15	11:44		00:27	50	46:29		00:44	85	09:22	11:17	00:40	120	54:49		00:49	155	14:52		00:29	190	35:43		00:17	225	09:03		00:09	260	43:25		00:17
	16	12:10		00:26	51	46:50		00:21	86	11:30		00:13	121	55:46		00:57	156	15:17		00:25	191	36:00		00:17	226	09:18		00:15	261	43:38		00:13
	17	12:48	18:00	00:38	52	47:18		00:28	87	11:42		00:12	122	56:11		00:25	157	15:32		00:15	192	36:23		00:23	227	09:43		00:25	262	44:00	44:49	00:22
	18	18:13		00:13	53	47:41		00:23	88	12:08		00:26	123	56:34		00:23	158	16:39		01:07	193	37:10		00:47	228	11:21		01:38	263	45:06	48:04	00:17
	19	18:27		00:14	54	48:06		00:25	89	12:25	14:15	00:17	124	57:24		00:50	159	16:59		00:20	194	37:24		00:14	229	11:32		00:11	264	48:13	48:30	00:09
	20	18:44		00:17	55	48:20		00:14	90	14:54		00:39	125	57:35	58:08	00:11	160	17:32		00:33	195	37:44	38:41	00:20	230	11:45		00:13	265	48:47	49:00	00:17
	21	18:52		00:08	56	48:30		00:10	91	17:48	31:29	**02:54**	126	58:25		00:17	161	19:07	19:50	01:35	196	39:22	43:50	00:41	231	12:05	13:39	00:20	266	49:18		00:18
	22	19:35		00:43	57	49:04		00:34	92	31:39		00:10	127	58:35		00:10	162	20:05		00:15	197	44:21		00:31	232	14:06		00:27	267	49:29		00:11
	23	19:43		00:08	58	49:37		00:33	93	31:59		00:20	128	59:30		00:55	163	20:19		00:14	198	44:43		00:22	233	14:19		00:13	268	49:40		00:11
	24	20:12		00:29	59	49:52		00:15	94	32:21		00:22	129	1:00:29		00:59	164	20:37	25:40	00:18	199	45:11	49:07	00:28	234	14:37		00:18	269	49:50		00:10
	25	20:19	23:06	00:07	60	50:13		00:21	95	32:45	34:39	00:24	130	1:00:59		00:30	165	26:03		00:23	200	49:42	50:02	00:35	235	14:48		00:11	270	51:15	52:06	01:25
	26	23:18		00:12	61	50:40		00:27	96	35:40		01:01	131	1:01:25		00:26	166	26:22		00:19	201	51:29		01:27	236	14:55	16:54	00:07	271	52:20		00:14
	27	23:47	38:14	00:29	62	51:05		00:25	97	36:23		00:43	132	1:01:48		00:23	167	26:56		00:34	202	52:56		01:27	237	17:18		00:24	272	52:33		00:13
	28	38:24		00:10	63	51:22		00:17	98	36:43		00:20	133	1:02:05		00:17	168	27:25		00:29	203	53:17		00:21	238	17:49		00:31	273	52:48		00:15
	29	38:56		00:32	64	51:30		00:08	99	37:45		01:02	134	1:02:22		00:17	169	27:40		00:15	204	54:57	55:20	01:40	239	18:46		00:57	274	52:55		00:07
	30	39:07		00:11	65	51:56		00:26	100	38:04		00:19	135	1:02:35		00:13	170	27:55		00:15	205	55:34		00:14	240	19:30		00:44	275	53:12		00:17
	31	39:21		00:14	66	53:56		02:00	101	38:24		00:20	136	1:02:59	1:03:04	00:24	171	28:10		00:15	206	55:51		00:17	241	20:52		01:22	276	53:33		00:21
	32	39:32		00:11	67	54:16		00:20	102	39:24		01:00	137	1:04:59		01:55	172	28:23		00:13	207	56:09		00:18	242	21:08		00:16	277	53:53		00:20
	33	39:41		00:09	68	54:43		00:27	103	39:34	39:46	00:10	138	1:05:42		00:43	173	28:41		00:18	208	57:10		01:01	243	21:19		00:11	278	54:13		00:20
	34	39:54		00:13	69	55:01		00:18	104	40:24		00:38	139	1:06:27		00:45	174	28:51		00:10	209	58:05		00:55	244	21:27		00:08	279	54:27		00:14
	35	40:27		00:33	70	55:40		00:39	105	40:51	42:54	00:27	140	1:07:38		01:11	175	29:00		00:09	210	58:31		00:26	245	21:34	21:40	00:07	280	54:36		00:09
			Ave	**00:29**			Ave	**00:26**			Ave	**00:35**			Ave	**00:38**			Ave	**00:33**			Ave	**00:30**			Ave	**00:24**			Ave	**00:22**

Figure 31: Time Study – Audit Process

Time Study Sheet	Date: 06/07/12	Start time: 08:00	Observer:	Average process time per box (mm:ss)	00:29	29
Process Description:	Cycle No: 1	End time:11:50		Standard Deviation	0.00015	0.00015
Prepare box for distribution						

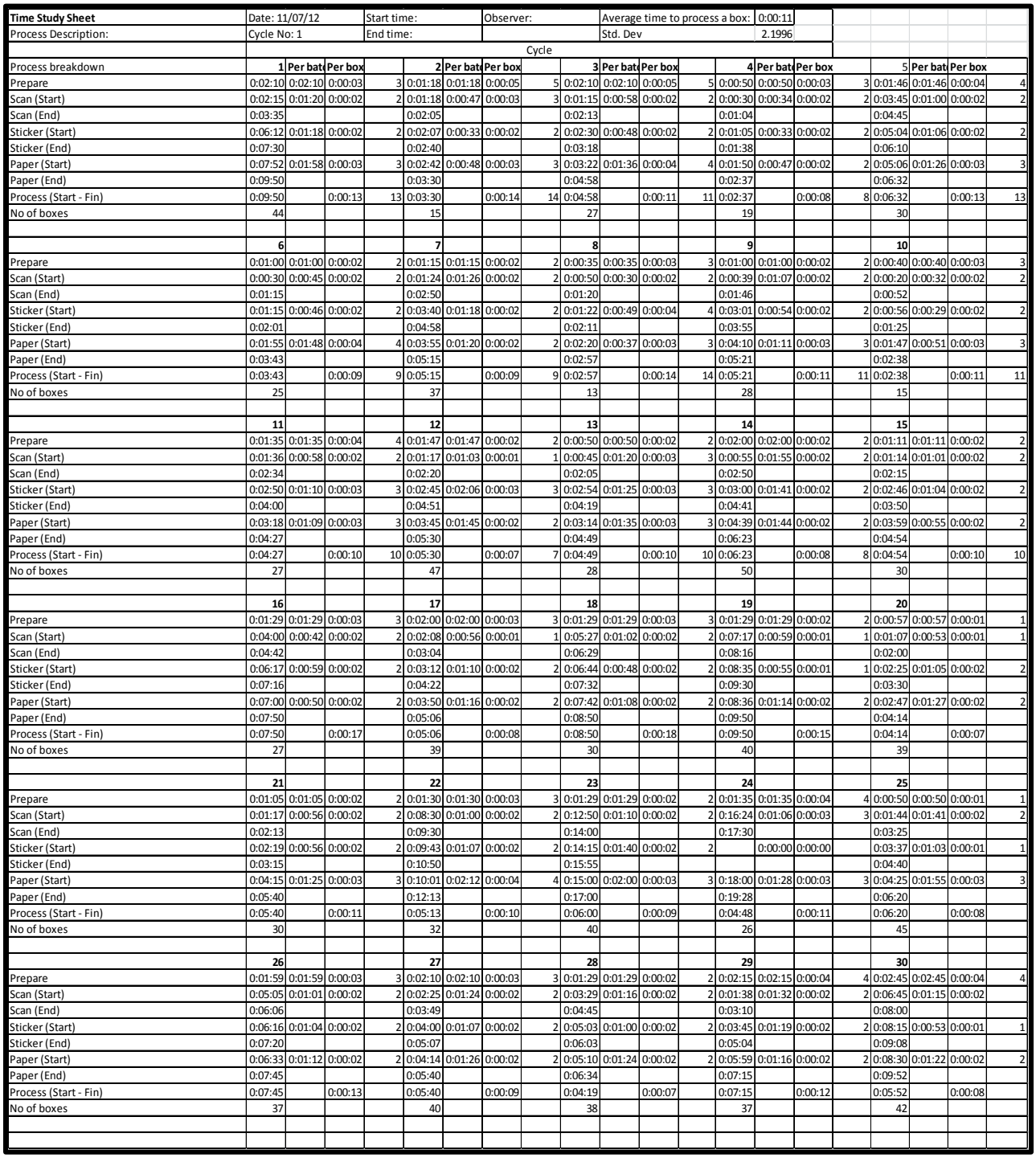
Note	Cycle	W 1	Idle	CT		Cycle	W 1	Idle	CT	
	1	00:22		00:22	22	36	19:34		00:34	34
	2	00:52		00:30	30	37	20:06		00:32	32
	3	01:19		00:27	27	38	20:42		00:36	36
	4	01:56		00:37	37	39	20:56		00:14	14
	5	02:40		00:44	44	40	21:27		00:31	31
	6	03:34		00:54	54	41	22:04		00:37	37
	7	03:55		00:21	21	42	22:54	23:15	00:50	50
	8	04:31		00:36	36	43	23:30	25:00	00:15	15
	9	04:57		00:26	26	44	25:20	26:46	00:20	20
	10	05:17		00:20	20	45	27:32	27:34	00:46	46
	11	05:41		00:24	24	46	28:00	28:19	00:26	26
	12	06:07		00:26	26	47	28:48	29:25	00:29	29
	13	07:19		01:12	72	48	30:26		01:01	61
	14	08:04		00:45	45	49	30:57		00:31	31
	15	08:38		00:34	35	50	31:28		00:31	31
	16	09:07		00:29	29	51	32:03		00:35	35
	17	09:18		00:11	11	52	32:23		00:20	20
	18	09:43		00:25	25	53	32:57		00:34	34
	19	10:08		00:25	25	54	33:25	33:52	00:28	28
	20	10:29		00:21	21	55	34:18	35:40	00:26	26
	21	10:47		00:18	18	56	35:59	36:44	00:19	19
	22	11:15		00:28	28	57	37:06		00:22	22
	23	11:46		00:31	31	58	37:37		00:31	31
	24	12:24		00:38	38	59	38:03	38:05	00:26	26
	25	12:39		00:15	15	60	38:26	39:33	00:21	21
	26	12:55		00:16	16	61	40:12	41:15	00:39	39
	27	13:26		00:31	31	62	41:55	41:57	00:40	40
	28	14:00		00:34	34	63	42:29	42:55	00:32	32
	29	14:30	15:00	00:30	30	64	43:34		00:39	39
	30	15:22		00:22	22	65	44:15		00:41	41
	31	15:50		00:28	28	66	44:30		00:15	15
	32	16:28		00:38	38	67	45:04		00:34	34
	33	17:12		00:44	44	68	45:40		00:36	36
	34	17:50	18:15	00:38	38	69	46:21		00:41	41
	35	18:43	19:00	00:28	28	70	46:52		00:31	31
			Ave	00:31				Ave	00:32	

Cycle	W 2	Idle	CT		Cycle	W 2	Idle	CT	
71	00:18		00:18	18	106	23:35		00:14	14
72	00:41		00:23	23	107	24:07	24:18	00:32	32
73	00:57		00:16	16	108	24:28		00:10	10
74	01:17		00:20	20	109	25:00		00:32	32
75	01:40	01:50	00:23	23	110	25:28	25:40	00:28	28
76	02:18		00:28	28	111	26:39		00:59	59
77	02:49		00:31	31	112	26:59	27:54	00:20	20
78	03:04		00:15	15	113	28:05		00:11	11
79	03:40		00:36	36	114	28:29	28:32	00:24	24
80	03:57		00:17	17	115	29:04		00:32	32
81	04:19		00:22	22	116	29:25		00:21	21
82	04:45	05:20	00:26	26	117	29:51		00:26	26
83	06:46	07:32	01:26	86	118	30:02		00:11	11
84	07:56		00:24	24	119	30:23		00:21	21
85	08:09	08:36	00:13	13	120	31:03		00:40	40
86	09:20	10:13	00:44	44	121	31:17		00:14	14
87	10:41	10:58	00:28	28	122	31:43	31:45	00:26	26
88	11:23		00:25	25	123	32:09		00:24	24
89	11:51		00:28	28	124	32:33	33:17	00:24	24
90	13:07		01:16	76	125	33:29		00:12	12
91	13:45		00:38	38	126	33:52		00:23	23
92	14:20	14:35	00:35	35	127	34:07		00:15	15
93	15:10		00:35	35	128	34:38		00:31	31
94	16:11		01:01	61	129	35:19		00:41	41
95	16:50		00:39	39	130	35:35		00:16	16
96	17:07		00:17	17	131	35:58		00:23	23
97	17:46		00:39	39	132	36:23		00:25	25
98	18:22		00:36	36	133	36:48		00:25	25
99	18:50	19:47	00:28	28	134	37:10		00:22	22
100	20:14	20:26	00:27	27	135	37:35	37:47	00:25	25
101	21:19		00:53	53	136	38:14		00:27	27
102	22:23		01:04	64	137	38:36		00:22	22
103	22:44		00:21	21	138	39:08		00:32	32
104	22:59		00:15	15	139	39:38		00:30	30
105	23:21		00:22	22	140	40:10		00:32	32
		Ave	00:32				Ave	00:25	

Cycle	W 3	Idle	CT		Cycle	W 3	Idle	CT	
141	00:32		00:32	32	176	14:28		00:25	25
142	00:57		00:25	25	177	14:51		00:23	23
143	01:08		00:11	11	178	15:12	15:52	00:21	21
144	01:20		00:12	12	179	16:26	16:52	00:34	34
145	01:30		00:10	10	180	17:12		00:20	20
146	02:02		00:32	32	181	17:23		00:11	11
147	02:11		00:09	9	182	17:55		00:32	32
148	02:27		00:16	16	183	18:25		00:30	30
149	02:46		00:19	19	184	18:55		00:30	30
150	03:04		00:18	18	185	19:30		00:35	35
151	03:43		00:39	39	186	20:14		00:44	44
152	04:06		00:23	23	187	20:52		00:38	38
153	04:34		00:28	28	188	21:06		00:14	14
154	04:54		00:20	20	189	21:23		00:17	17
155	05:30		00:36	36	190	21:53		00:30	30
156	05:46		00:16	16	191	22:02		00:09	9
157	06:16		00:30	30	192	22:10		00:08	8
158	06:37	06:50	00:21	21	193	22:38		00:28	28
159	07:18		00:28	28	194	23:02		00:24	24
160	07:38		00:20	20	195	23:36		00:34	24
161	07:55		00:17	17	196	24:04		00:28	28
162	08:22	08:49	00:27	27	197	24:25		00:21	21
163	09:05		00:16	16	198	24:41		00:16	16
164	09:38		00:33	33	199	25:05		00:24	24
165	10:01		00:23	23	200	25:23		00:18	18
166	10:36		00:35	35	201	25:45	26:09	00:22	22
167	11:33		00:57	57	202	27:00		00:51	51
168	12:04		00:31	31	203	27:37		00:37	37
169	12:12		00:08	8	204	28:04		00:27	27
170	12:26		00:14	14	205	28:11		00:07	7
171	12:32		00:06	6	206	28:34		00:23	23
172	12:59		00:27	27	207	28:49		00:15	15
173	13:23		00:24	24	208	29:00		00:11	11
174	13:44		00:21	21	209	29:16		00:16	16
175	14:03		00:19	19	210	29:34		00:18	18
		Ave	00:23				Ave	00:24	

Cycle	W 4	Idle	CT		Cycle	W 4	Idle	CT	
211	00:28		00:28	28	246	23:05		00:33	33
212	01:10	01:25	00:42	42	247	23:45		00:40	40
213	02:10		00:45	45	248	24:17		00:32	32
214	02:31	03:27	00:21	21	249	24:53		00:36	36
215	04:00	04:18	00:33	33	250	25:50		00:57	57
216	04:53		00:35	35	251	26:16		00:26	26
217	05:26	05:53	00:33	33	252	26:42		00:26	26
218	06:21		00:28	28	253	27:04		00:22	22
219	06:52		00:31	31	254	27:16		00:12	12
220	07:30		00:38	38	255	27:45	27:50	00:29	29
221	08:03	08:05	00:33	33	256	28:27	28:44	00:37	37
222	08:37		00:32	32	257	29:04		00:20	20
223	09:08		00:31	31	258	29:28		00:24	24
224	09:41	09:52	00:33	33	259	30:06		00:38	38
225	10:08		00:16	16	260	30:30	30:47	00:24	24
226	10:36	10:54	00:28	28	261	31:33		00:46	46
227	11:23		00:29	29	262	32:17		00:44	44
228	12:02		00:39	39	263	32:42	32:59	00:25	25
229	12:46		00:44	44	264	33:35		00:36	36
230	13:26		00:40	40	265	34:34		00:59	59
231	14:52		01:26	86	266	35:03	35:10	00:29	29
232	15:23		00:31	31	267	35:50		00:40	40
233	15:50		00:27	27	268	36:26		00:36	36
234	16:38	17:00	00:48	48	269	36:58		00:32	32
235	17:33	17:40	00:33	33	270	37:29		00:31	31
236	18:20		00:40	40	271	37:45		00:16	16
237	18:44		00:24	24	272	38:17		00:32	32
238	19:28		00:44	44	273	38:50		00:33	33
239	19:45		00:17	17	274	39:24		00:34	34
240	19:59		00:14	14	275	39:55	40:24	00:31	31
241	20:57		00:58	58	276	40:52		00:28	28
242	21:08		00:11	11	277	41:26		00:34	34
243	21:18		00:10	10	278	41:58		00:32	32
244	21:53	21:58	00:35	35	279	42:04		00:06	6
245	22:15	22:32	00:17	17	280	42:38		00:34	34
		Ave	00:33				Ave	00:32	

Figure 32: Time Study - Prepare for distribution process



Time Study Sheet	Date: 11/07/12			Start time:			Observer:			Average time to process a box:			0:00:11					
Process Description:	Cycle No: 1			End time:						Std. Dev			2.1996					
	Cycle																	
Process breakdown	1	Per batc	Per box		2	Per batc	Per box		3	Per batc	Per box		4	Per batc	Per box		5	Per batc	Per box	
Prepare	0:02:10	0:02:10	0:00:03	3	0:01:18	0:01:18	0:00:05	5	0:02:10	0:02:10	0:00:05	5	0:00:50	0:00:50	0:00:03	3	0:01:46	0:01:46	0:00:04	4
Scan (Start)	0:02:15	0:01:20	0:00:02	2	0:01:18	0:00:47	0:00:03	3	0:01:15	0:00:58	0:00:02	2	0:00:30	0:00:34	0:00:02	2	0:03:45	0:01:00	0:00:02	2
Scan (End)	0:03:35				0:02:05				0:02:13				0:01:04				0:04:45			
Sticker (Start)	0:06:12	0:01:18	0:00:02	2	0:02:07	0:00:33	0:00:02	2	0:02:30	0:00:48	0:00:02	2	0:01:05	0:00:33	0:00:02	2	0:05:04	0:01:06	0:00:02	2
Sticker (End)	0:07:30				0:02:40				0:03:18				0:01:38				0:06:10			
Paper (Start)	0:07:52	0:01:58	0:00:03	3	0:02:42	0:00:48	0:00:03	3	0:03:22	0:01:36	0:00:04	4	0:01:50	0:00:47	0:00:02	2	0:05:06	0:01:26	0:00:03	3
Paper (End)	0:09:50				0:03:30				0:04:58				0:02:37				0:06:32			
Process (Start - Fin)	0:09:50		0:00:13	13	0:03:30		0:00:14	14	0:04:58		0:00:11	11	0:02:37		0:00:08	8	0:06:32		0:00:13	13
No of boxes	44				15				27				19				30			
	6				7				8				9				10			
Prepare	0:01:00	0:01:00	0:00:02	2	0:01:15	0:01:15	0:00:02	2	0:00:35	0:00:35	0:00:03	3	0:01:00	0:01:00	0:00:02	2	0:00:40	0:00:40	0:00:03	3
Scan (Start)	0:00:30	0:00:45	0:00:02	2	0:01:24	0:01:26	0:00:02	2	0:00:50	0:00:30	0:00:02	2	0:00:39	0:01:07	0:00:02	2	0:00:20	0:00:32	0:00:02	2
Scan (End)	0:01:15				0:02:50				0:01:20				0:01:46				0:00:52			
Sticker (Start)	0:01:15	0:00:46	0:00:02	2	0:03:40	0:01:18	0:00:02	2	0:01:22	0:00:49	0:00:04	4	0:03:01	0:00:54	0:00:02	2	0:00:56	0:00:29	0:00:02	2
Sticker (End)	0:02:01				0:04:58				0:02:11				0:03:55				0:01:25			
Paper (Start)	0:01:55	0:01:48	0:00:04	4	0:03:55	0:01:20	0:00:02	2	0:02:20	0:00:37	0:00:03	3	0:04:10	0:01:11	0:00:03	3	0:01:47	0:00:51	0:00:03	3
Paper (End)	0:03:43				0:05:15				0:02:57				0:05:21				0:02:38			
Process (Start - Fin)	0:03:43		0:00:09	9	0:05:15		0:00:09	9	0:02:57		0:00:14	14	0:05:21		0:00:11	11	0:02:38		0:00:11	11
No of boxes	25				37				13				28				15			
	11				12				13				14				15			
Prepare	0:01:35	0:01:35	0:00:04	4	0:01:47	0:01:47	0:00:02	2	0:00:50	0:00:50	0:00:02	2	0:02:00	0:02:00	0:00:02	2	0:01:11	0:01:11	0:00:02	2
Scan (Start)	0:01:36	0:00:58	0:00:02	2	0:01:17	0:01:03	0:00:01	1	0:00:45	0:01:20	0:00:03	3	0:00:55	0:01:55	0:00:02	2	0:01:14	0:01:01	0:00:02	2
Scan (End)	0:02:34				0:02:20				0:02:05				0:02:50				0:02:15			
Sticker (Start)	0:02:50	0:01:10	0:00:03	3	0:02:45	0:02:06	0:00:03	3	0:02:54	0:01:25	0:00:03	3	0:03:00	0:01:41	0:00:02	2	0:02:46	0:01:04	0:00:02	2
Sticker (End)	0:04:00				0:04:51				0:04:19				0:04:41				0:03:50			
Paper (Start)	0:03:18	0:01:09	0:00:03	3	0:03:45	0:01:45	0:00:02	2	0:03:14	0:01:35	0:00:03	3	0:04:39	0:01:44	0:00:02	2	0:03:59	0:00:55	0:00:02	2
Paper (End)	0:04:27				0:05:30				0:04:49				0:06:23				0:04:54			
Process (Start - Fin)	0:04:27		0:00:10	10	0:05:30		0:00:07	7	0:04:49		0:00:10	10	0:06:23		0:00:08	8	0:04:54		0:00:10	10
No of boxes	27				47				28				50				30			
	16				17				18				19				20			
Prepare	0:01:29	0:01:29	0:00:03	3	0:02:00	0:02:00	0:00:03	3	0:01:29	0:01:29	0:00:03	3	0:01:29	0:01:29	0:00:02	2	0:00:57	0:00:57	0:00:01	1
Scan (Start)	0:04:00	0:00:42	0:00:02	2	0:02:08	0:00:56	0:00:01	1	0:05:27	0:01:02	0:00:02	2	0:07:17	0:00:59	0:00:01	1	0:01:07	0:00:53	0:00:01	1
Scan (End)	0:04:42				0:03:04				0:06:29				0:08:16				0:02:00			
Sticker (Start)	0:06:17	0:00:59	0:00:02	2	0:03:12	0:01:10	0:00:02	2	0:06:44	0:00:48	0:00:02	2	0:08:35	0:00:55	0:00:01	1	0:02:25	0:01:05	0:00:02	2
Sticker (End)	0:07:16				0:04:22				0:07:32				0:09:30				0:03:30			
Paper (Start)	0:07:00	0:00:50	0:00:02	2	0:03:50	0:01:16	0:00:02	2	0:07:42	0:01:08	0:00:02	2	0:08:36	0:01:14	0:00:02	2	0:02:47	0:01:27	0:00:02	2
Paper (End)	0:07:50				0:05:06				0:08:50				0:09:50				0:04:14			
Process (Start - Fin)	0:07:50		0:00:17		0:05:06		0:00:08		0:08:50		0:00:18		0:09:50		0:00:15		0:04:14		0:00:07	
No of boxes	27				39				30				40				39			
	21				22				23				24				25			
Prepare	0:01:05	0:01:05	0:00:02	2	0:01:30	0:01:30	0:00:03	3	0:01:29	0:01:29	0:00:02	2	0:01:35	0:01:35	0:00:04	4	0:00:50	0:00:50	0:00:01	1
Scan (Start)	0:01:17	0:00:56	0:00:02	2	0:08:30	0:01:00	0:00:02	2	0:12:50	0:01:10	0:00:02	2	0:16:24	0:01:06	0:00:03	3	0:01:44	0:01:41	0:00:02	2
Scan (End)	0:02:13				0:09:30				0:14:00				0:17:30				0:03:25			
Sticker (Start)	0:02:19	0:00:56	0:00:02	2	0:09:43	0:01:07	0:00:02	2	0:14:15	0:01:40	0:00:02	2		0:00:00	0:00:00		0:03:37	0:01:03	0:00:01	1
Sticker (End)	0:03:15				0:10:50				0:15:55								0:04:40			
Paper (Start)	0:04:15	0:01:25	0:00:03	3	0:10:01	0:02:12	0:00:04	4	0:15:00	0:02:00	0:00:03	3	0:18:00	0:01:28	0:00:03	3	0:04:25	0:01:55	0:00:03	3
Paper (End)	0:05:40				0:12:13				0:17:00				0:19:28				0:06:20			
Process (Start - Fin)	0:05:40		0:00:11		0:05:13		0:00:10		0:06:00		0:00:09		0:04:48		0:00:11		0:06:20		0:00:08	
No of boxes	30				32				40				26				45			
	26				27				28				29				30			
Prepare	0:01:59	0:01:59	0:00:03	3	0:02:10	0:02:10	0:00:03	3	0:01:29	0:01:29	0:00:02	2	0:02:15	0:02:15	0:00:04	4	0:02:45	0:02:45	0:00:04	4
Scan (Start)	0:05:05	0:01:01	0:00:02	2	0:02:25	0:01:24	0:00:02	2	0:03:29	0:01:16	0:00:02	2	0:01:38	0:01:32	0:00:02	2	0:06:45	0:01:15	0:00:02	
Scan (End)	0:06:06				0:03:49				0:04:45				0:03:10				0:08:00			
Sticker (Start)	0:06:16	0:01:04	0:00:02	2	0:04:00	0:01:07	0:00:02	2	0:05:03	0:01:00	0:00:02	2	0:03:45	0:01:19	0:00:02	2	0:08:15	0:00:53	0:00:01	1
Sticker (End)	0:07:20				0:05:07				0:06:03				0:05:04				0:09:08			
Paper (Start)	0:06:33	0:01:12	0:00:02	2	0:04:14	0:01:26	0:00:02	2	0:05:10	0:01:24	0:00:02	2	0:05:59	0:01:16	0:00:02	2	0:08:30	0:01:22	0:00:02	2
Paper (End)	0:07:45				0:05:40				0:06:34				0:07:15				0:09:52			
Process (Start - Fin)	0:07:45		0:00:13		0:05:40		0:00:09		0:04:19		0:00:07		0:07:15		0:00:12		0:05:52		0:00:08	
No of boxes	37				40				38				37				42			

Figure 33: Time Study - Prepare for audit

Resources for calculating probability distributions:

Confidence Level	
Level:	**α**
0.10	1.28
0.05	1.64
0.01	2.33
0.001	3.09

Table 19: Alpha Level for sample size calculation

Audit process:

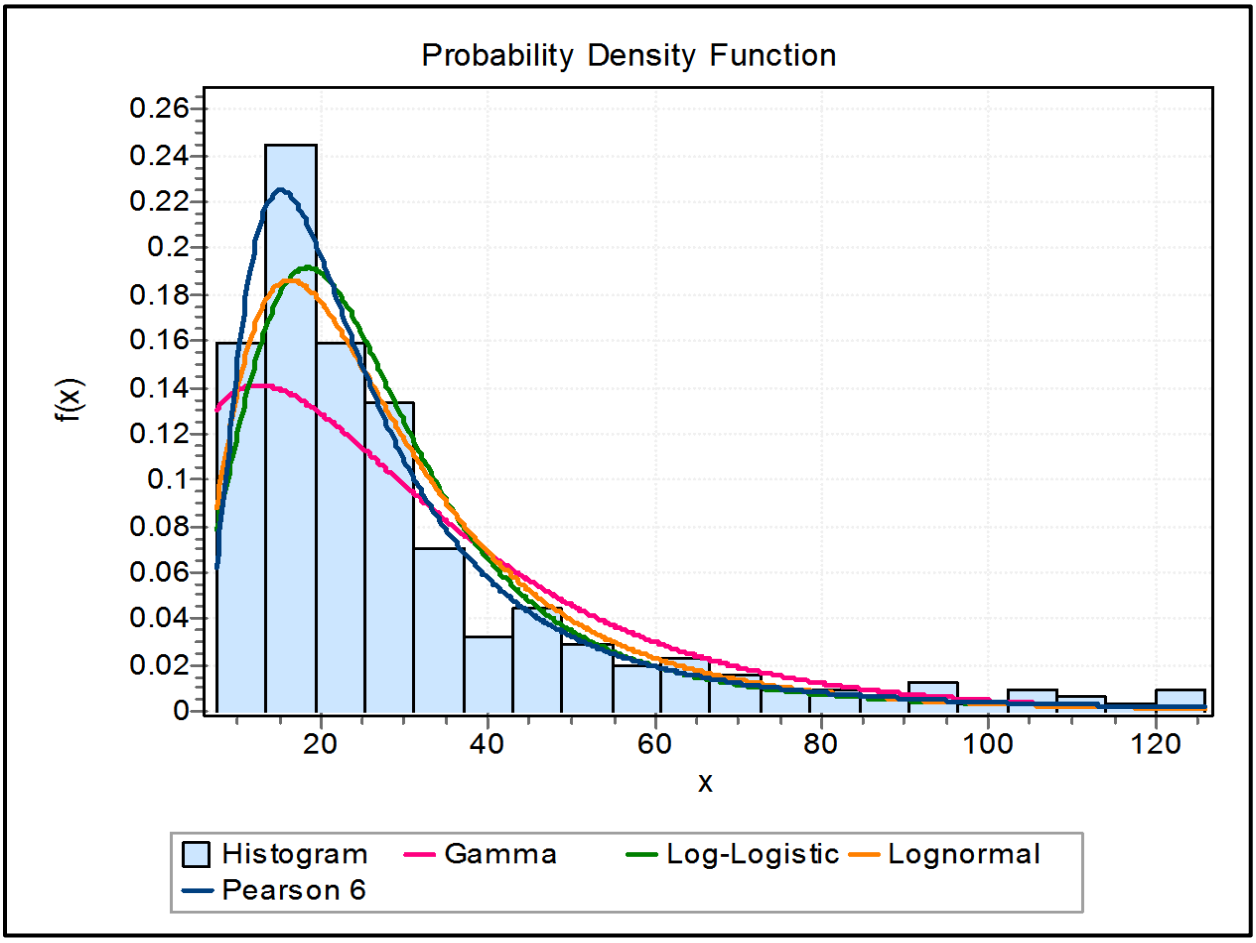


Figure 34: Histogram of the audit process

Test: Statistic value (Squared error)	Pearson VI	Lognormal	Log-Logistic	Gamma
Kolmogorov-Smirnov	0.0411	0.07787	0.08188	0.12643
Anderson-Darling	0.48098	1.9259	2.0546	6.9277
Chi-Square	10.949	10.267	12.873	30.834
Fraction Kolmogorov-Smirnov	0.1255805	0.2379308	0.25018333	0.386305
Fraction Anderson-Darling	0.0422313	0.1690991	0.18039929	0.60827
Fraction Chi-Square	0.1686459	0.1581412	0.19828104	0.474932
Average of fractions	**0.1121526**	0.1883904	0.20962122	0.489836

Table 20: Audit process distribution statistics

Preparing boxes for distribution:

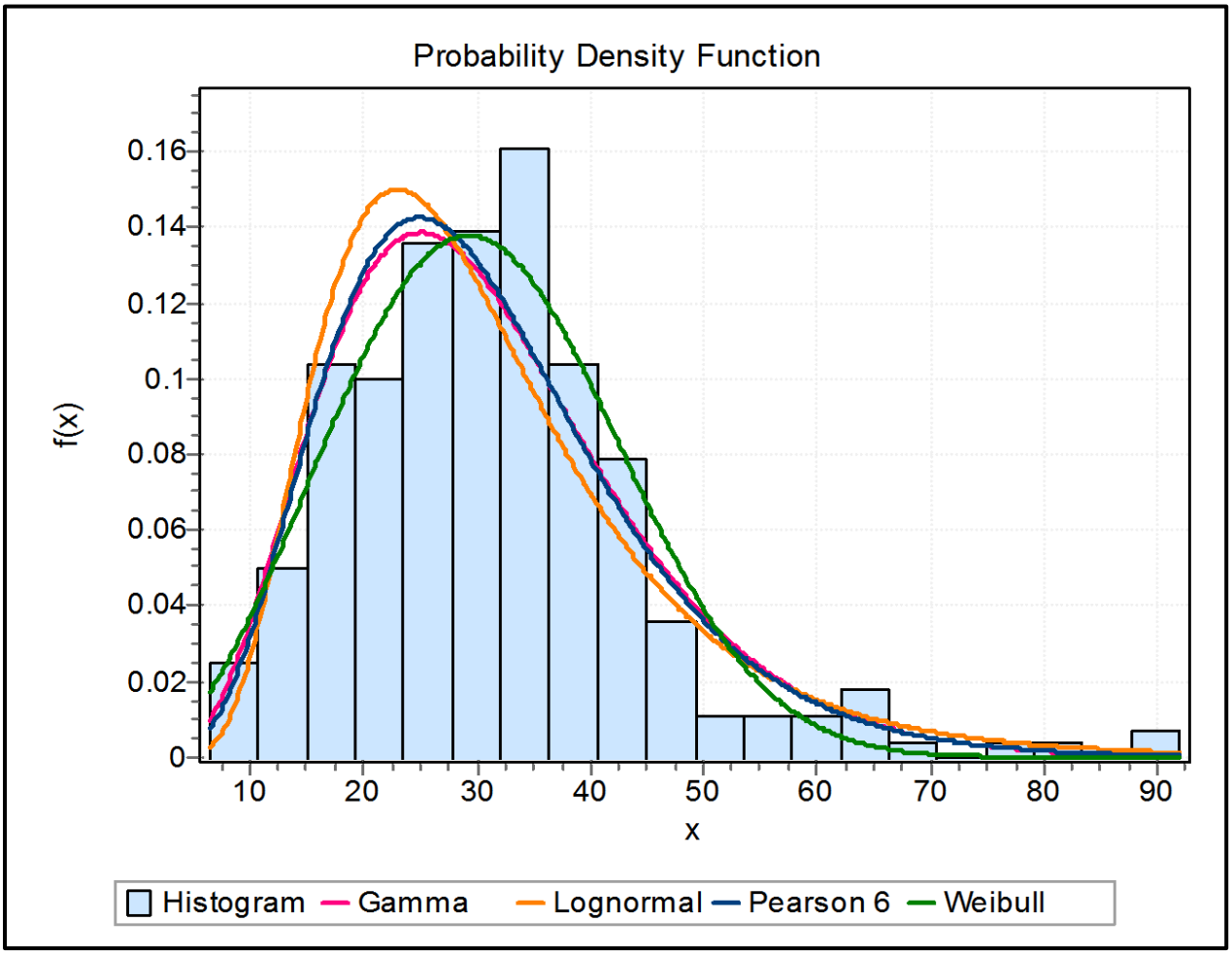


Figure 35: Histogram of preparing boxes for distribution

Test: Statistic value (Squared error)	Weighbull	Gamma	Pearson VI	Lognormal
Kolmogorov-Smirnov	0.05543	0.05982	0.05956	0.08238
Anderson-Darling	1.6499	1.4071	1.3283	2.5265
Chi-Square	11.03	9.9376	10.756	25.435
Fraction Kolmogorov-Smirnov	0.2155216	0.23259	0.2315798	0.320307944
Fraction Anderson-Darling	0.2387077	0.20358	0.1921786	0.365534304
Fraction Chi-Square	0.1929718	0.17386	0.1881782	0.444989905
Average	0.2157337	**0.20334**	0.2039788	0.376944051

Table 21: Preparing boxes for dispatch distribution statistics

Preparing boxes to be audited:

Test: Statistic value (Distance)	Weibull	Gamma	Log-Logistic	Lognormal
Kolmogorov-Smirnov	0.19198	0.20351	0.21871	0.20666
Anderson-Darling	1.2592	1.353	1.4497	1.4178
Chi-Square	5.4963	0.3197	0.25955	0.34159
Fraction Kolmogorov-Smirnov	0.233876666	0.24792291	0.26644008	0.2517603
Fraction Anderson-Darling	0.229793602	0.24691133	0.26455828	0.2587368
Fraction Chi-Square	0.856503053	0.0498197	0.04044637	0.0532309
Average	0.440057774	**0.18155131**	0.19048157	0.1879093

Table 22: Preparation process distribution statistics

Test: Statistic value (Distance)	Weibull	Gamma	Pearson VI	Lognormal
Kolmogorov-Smirnov	0.38534	0.42656	0.42772	0.44043
Anderson-Darling	5.0208	5.8277	5.6798	5.8521
Fraction Kolmogorov-Smirnov	0.229362221	0.25389721	0.25458766	0.2621529
Fraction Anderson-Darling	0.224339154	0.26039302	0.25378456	0.2614833
Average	**0.226850688**	0.25714511	0.25418611	0.2618181

Table 23: Time to scan box barcode distribution statistics

Test: Statistic value (Distance)	Weibull	Pearson VI	Gamma	Lognormal
Kolmogorov-Smirnov	0.38388	0.38771	0.38799	0.40465
Anderson-Darling	4.7008	4.8855	4.8357	5.0023
Fraction Kolmogorov-Smirnov	0.24541148	0.24785997	0.24803897	0.2586896
Fraction Anderson-Darling	0.242006147	0.25151486	0.24895106	0.2575279
Average	**0.243708814**	0.24968741	0.24849501	0.2581088

Table 24: Time to add sticker distribution statistics

Test: Statistic value (Distance)	Weibull	Log-Logistic	Gamma	Lognormal
Kolmogorov-Smirnov	0.27449	0.27489	0.31066	0.32727
Anderson-Darling	2.8304	2.9224	3.197	3.5547
Chi-Square	1.9886	2.2499	3.1738	3.808
Fraction Kolmogorov-Smirnov	0.231186464	0.23152336	0.26165029	0.2756399
Fraction Anderson-Darling	0.226350514	0.23370787	0.25566796	0.2842737
Fraction Chi-Square	0.177232338	0.20052049	0.28286231	0.3393849
Average	**0.211589772**	0.22191724	0.26672685	0.2997661

Table 25: Time to add paper distribution statistics

Resource Cost:

Labour Cost Rates	Audit Area Staff	Audit Area Supervisor
Normal Rate (per hour)	R20.08	R60.12
Overtime (per hour)	R30.12	R90.18

Table 26: Resource Cost Rates

Sample of Operation Totals as provided by Agrinet:

Number of picks - June 2012	01 June 2012	02 June 2012	03 June 2012	04 June 2012	05 June 2012	06 June 2012	07 June 2012	08 June 2012
Number of Routes Picked	5	Saturday	Sunday	5	6	6	5	6
Number of staff - Front	4	Saturday	Sunday	4	4	4	4	4
Number of staff - Middle	19	Saturday	Sunday	18	20	19	19	19
Number of staff - Up	6	Saturday	Sunday	6	7	6	6	6
Number of staff - On leave	1	Saturday	Sunday	3	2	1	1	1
Number of staff - Sick leave	0	Saturday	Sunday	0	0	0	1	1
Number of staff - AWOL	0	Saturday	Sunday	0	0	0	0	0
Number of staff - Total	29	Saturday	Sunday	28	31	29	29	29
Time finished	17:20	Saturday	Sunday	17:45	20:30	20:30	18:30	20:00
Number of end-day picks	4213	Saturday	Sunday	4351	6473	6396	5423	6084
Incorrect picks	27	Saturday	Sunday	20	24	25	17	19
Short picks	26	Saturday	Sunday	17	23	20	13	15
Over picked	7	Saturday	Sunday	15	10	11	3	1
Number of picks - non 1st time	53	Saturday	Sunday	37	47	45	30	34

09 June 2012	10 June 2012	11 June 2012	12 June 2012	13 June 2012	14 June 2012	15 June 2012	16 June 2012	17 June 2012	18 June 2012
Saturday	Sunday	6	6	6	5	5	Saturday	Sunday	5
Saturday	Sunday	4	4	4	4	4	Saturday	Sunday	4
Saturday	Sunday	20	20	20	20	20	Saturday	Sunday	20
Saturday	Sunday	7	7	7	7	7	Saturday	Sunday	7
Saturday	Sunday	0	0	0	0	0	Saturday	Sunday	0
Saturday	Sunday	0	0	0	0	0	Saturday	Sunday	0
Saturday	Sunday	0	0	0	0	0	Saturday	Sunday	0
Saturday	Sunday	31	31	31	31	31	Saturday	Sunday	31
Saturday	Sunday	19:30	19:20	20:45	17:55	17:45	Saturday	Sunday	17:40
Saturday	Sunday	5957	5880	6435	4868	4726	Saturday	Sunday	4554
Saturday	Sunday	23	20	28	31	25	Saturday	Sunday	23
Saturday	Sunday	12	16	27	13	15	Saturday	Sunday	18
Saturday	Sunday	3	11	15	11	7	Saturday	Sunday	6
Saturday	Sunday	35	36	55	55	40	Saturday	Sunday	41

19 June 2012	20 June 2012	21 June 2012	22 June 2012	23 June 2012	24 June 2012	25 June 2012	26 June 2012	27 June 2012	28 June 2012	29 June 2012
5	6	5	5	Saturday	Sunday	5	5	5	5	5
3	4	3	4	Saturday	Sunday	4	4	4	4	4
20	19	18	19	Saturday	Sunday	20	20	19	17	20
7	6	6	6	Saturday	Sunday	7	7	7	7	7
1	2	4	2	Saturday	Sunday	0	1	0	1	0
0	0	0	0	Saturday	Sunday	0	1	1	1	0
0	0	0	0	Saturday	Sunday	0	0	0	0	0
30	29	27	29	Saturday	Sunday	31	31	30	28	31
17:40	19:30	18:40	15:45/11:20	Saturday	Sunday	18:15	17:40	17:40	17:00	16:00
4386	5998	5336	4982	Saturday	Sunday	5124	5009	4966	4723	4117
22	17	13	14	Saturday	Sunday	24	15	18	18	14
27	26	15	15	Saturday	Sunday	12	21	28	12	24
9	10	5	6	Saturday	Sunday	7	11	13	14	4
49	43	28	29	Saturday	Sunday	36	36	46	30	38

Appendix C: Extracted Simulation Reports

Scenario: Current System - 5 Routes

BlockedTime - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	ResourceState	58.05879166	58.05879166	58.05879166
AddPaper2	[Resource]	ResourceState	57.95019308	57.95019308	57.95019308
AttachSticker1	[Resource]	ResourceState	76.88168608	76.88168608	76.88168608
AttachSticker2	[Resource]	ResourceState	76.80969664	76.80969664	76.80969664
PrepareForAudit1	[Resource]	ResourceState	53.68019475	53.68019475	53.68019475
PrepareForAudit2	[Resource]	ResourceState	53.63594654	53.63594654	53.63594654
Scanning1	[Resource]	ResourceState	76.85052504	76.85052504	76.85052504
Scanning2	[Resource]	ResourceState	76.91803209	76.91803209	76.91803209

ScheduledUtilization - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	Capacity	38.48864838	38.48864838	38.48864838
AddPaper2	[Resource]	Capacity	38.5224741	38.5224741	38.5224741
AttachSticker1	[Resource]	Capacity	18.11083138	18.11083138	18.11083138
AttachSticker2	[Resource]	Capacity	18.25223103	18.25223103	18.25223103
Auditor1	[Resource]	Capacity	99.30825532	99.30825532	99.30825532
Auditor2	[Resource]	Capacity	99.3952266	99.3952266	99.3952266
Auditor3	[Resource]	Capacity	98.80814752	98.80814752	98.80814752
Auditor4	[Resource]	Capacity	99.10663323	99.10663323	99.10663323
Auditor5	[Resource]	Capacity	99.0784859	99.0784859	99.0784859
Packer1	[Resource]	Capacity	99.70329863	99.70329863	99.70329863
Packer2	[Resource]	Capacity	99.05171747	99.05171747	99.05171747
Packer3	[Resource]	Capacity	96.15743376	96.15743376	96.15743376
Packer4	[Resource]	Capacity	91.28772879	91.28772879	91.28772879
Packer5	[Resource]	Capacity	78.97565718	78.97565718	78.97565718
PrepareForAudit1	[Resource]	Capacity	40.49590018	40.49590018	40.49590018
PrepareForAudit2	[Resource]	Capacity	40.85505028	40.85505028	40.85505028
Scanning1	[Resource]	Capacity	17.38039573	17.38039573	17.38039573
Scanning2	[Resource]	Capacity	17.37503822	17.37503822	17.37503822
PrepareAndStcker1	[Population]	Capacity	41.51187073	41.51187073	41.51187073
PrepareAndStcker2	[Population]	Capacity	41.78768554	41.78768554	41.78768554
Provider1	[Population]	Capacity	77.72220173	77.72220173	77.72220173
ScningAndPaper1	[Population]	Capacity	39.51893386	39.51893386	39.51893386
ScningAndPaper2	[Population]	Capacity	39.56375414	39.56375414	39.56375414

Scenario: Current System - 6 Routes

BlockedTime - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	ResourceState	58.27114373	58.27114373	58.27114373
AddPaper2	[Resource]	ResourceState	58.29144898	58.29144898	58.29144898
AttachSticker1	[Resource]	ResourceState	80.56663846	80.56663846	80.56663846
AttachSticker2	[Resource]	ResourceState	80.27358805	80.27358805	80.27358805
Auditor1	[Resource]	ResourceState	0.433924736	0.433924736	0.433924736
Auditor2	[Resource]	ResourceState	0.335660155	0.335660155	0.335660155
Auditor3	[Resource]	ResourceState	0.366507283	0.366507283	0.366507283
Auditor4	[Resource]	ResourceState	0.47425288	0.47425288	0.47425288
Auditor5	[Resource]	ResourceState	0.35860535	0.35860535	0.35860535
PrepareForAudit1	[Resource]	ResourceState	56.58979669	56.58979669	56.58979669
PrepareForAudit2	[Resource]	ResourceState	56.02503005	56.02503005	56.02503005
Scanning1	[Resource]	ResourceState	80.93545347	80.93545347	80.93545347
Scanning2	[Resource]	ResourceState	80.64859023	80.64859023	80.64859023

ScheduledUtilization - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	Capacity	40.69881494	40.69881494	40.69881494
AddPaper2	[Resource]	Capacity	40.24588169	40.24588169	40.24588169
AttachSticker1	[Resource]	Capacity	18.36944912	18.36944912	18.36944912
AttachSticker2	[Resource]	Capacity	18.21406732	18.21406732	18.21406732
Auditor1	[Resource]	Capacity	98.73954027	98.73954027	98.73954027
Auditor2	[Resource]	Capacity	98.23422473	98.23422473	98.23422473
Auditor3	[Resource]	Capacity	98.49296785	98.49296785	98.49296785
Auditor4	[Resource]	Capacity	98.34519271	98.34519271	98.34519271
Auditor5	[Resource]	Capacity	98.20039382	98.20039382	98.20039382
Packer1	[Resource]	Capacity	99.73715848	99.73715848	99.73715848
Packer2	[Resource]	Capacity	99.37893696	99.37893696	99.37893696
Packer3	[Resource]	Capacity	98.36570755	98.36570755	98.36570755
Packer4	[Resource]	Capacity	94.92640949	94.92640949	94.92640949
Packer5	[Resource]	Capacity	88.7614201	88.7614201	88.7614201
PrepareForAudit1	[Resource]	Capacity	42.25919474	42.25919474	42.25919474
PrepareForAudit2	[Resource]	Capacity	42.38418122	42.38418122	42.38418122
Scanning1	[Resource]	Capacity	17.94276004	17.94276004	17.94276004
Scanning2	[Resource]	Capacity	17.79706197	17.79706197	17.79706197
PrepAndStcker1	[Population]	Capacity	42.30212971	42.30212971	42.30212971
PrepAndStcker2	[Population]	Capacity	42.40824683	42.40824683	42.40824683
Provider1	[Population]	Capacity	95.46358074	95.46358074	95.46358074
Provider2	[Population]	Capacity	0	0	0
ScningAndPaper1	[Population]	Capacity	40.7505958	40.7505958	40.7505958

Scenario: 1- A

BlockedTime - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	ResourceState	31.17930246	31.17930246	31.17930246
AttachSticker1	[Resource]	ResourceState	29.38121373	29.38121373	29.38121373
PrepareForAudit1	[Resource]	ResourceState	8.190067676	8.190067676	8.190067676
Scanning1	[Resource]	ResourceState	16.58983307	16.58983307	16.58983307

ScheduledUtilization - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	Capacity	61.91200868	61.91200868	61.91200868
AttachSticker1	[Resource]	Capacity	62.93325958	62.93325958	62.93325958
Auditor1	[Resource]	Capacity	88.48521792	88.48521792	88.48521792
Auditor2	[Resource]	Capacity	89.75129152	89.75129152	89.75129152
Auditor3	[Resource]	Capacity	90.58114487	90.58114487	90.58114487
Auditor4	[Resource]	Capacity	90.17971137	90.17971137	90.17971137
Auditor5	[Resource]	Capacity	86.8302768	86.8302768	86.8302768
Auditor6	[Resource]	Capacity	87.13796637	87.13796637	87.13796637
Packer1	[Resource]	Capacity	99.51838997	99.51838997	99.51838997
Packer2	[Resource]	Capacity	98.93354219	98.93354219	98.93354219
Packer3	[Resource]	Capacity	96.33676604	96.33676604	96.33676604
Packer4	[Resource]	Capacity	88.97745339	88.97745339	88.97745339
Packer5	[Resource]	Capacity	74.70866873	74.70866873	74.70866873
Packer6	[Resource]	Capacity	52.03392809	52.03392809	52.03392809
PrepareForAudit1	[Resource]	Capacity	90.7822991	90.7822991	90.7822991
Scanning1	[Resource]	Capacity	58.57087886	58.57087886	**58.57087886**
PrepareAndStcker1	[Population]	Capacity	90.79785846	90.79785846	90.79785846
Provider1	[Population]	Capacity	84.96693331	84.96693331	84.96693331
ScningAndPaper1	[Population]	Capacity	87.02819438	87.02819438	87.02819438
ScningAndPaper1[1]	[Resource]	Capacity	87.02819438	87.02819438	87.02819438

Scenario: 1-B

BlockedTime - Percent

Object Name	Data Source	Category	Average	Half Width	Minimum	Maximum
AddPaper1	[Resource]	ResourceState	32.08271833	#DIV/0!	32.08271833	32.08271833
AttachSticker1	[Resource]	ResourceState	33.75136666	#DIV/0!	33.75136666	33.75136666
Auditor1	[Resource]	ResourceState	11.96970564	#DIV/0!	11.96970564	11.96970564
Auditor2	[Resource]	ResourceState	11.6740595	#DIV/0!	11.6740595	11.6740595
Auditor3	[Resource]	ResourceState	10.51899627	#DIV/0!	10.51899627	10.51899627
Auditor4	[Resource]	ResourceState	12.04408277	#DIV/0!	12.04408277	12.04408277
Auditor5	[Resource]	ResourceState	12.09338265	#DIV/0!	12.09338265	12.09338265
Auditor6	[Resource]	ResourceState	10.83338363	#DIV/0!	10.83338363	10.83338363
PrepareForAudit1	[Resource]	ResourceState	10.43400915	#DIV/0!	10.43400915	10.43400915
Scanning1	[Resource]	ResourceState	22.3754776	#DIV/0!	22.3754776	22.3754776

ScheduledUtilization - Percent

Object Name	Data Source	Category	Average	Half Width	Minimum	Maximum
AddPaper1	[Resource]	Capacity	60.72615651	#DIV/0!	60.72615651	60.72615651
AttachSticker1	[Resource]	Capacity	58.60597233	#DIV/0!	58.60597233	58.60597233
Auditor1	[Resource]	Capacity	84.50051963	#DIV/0!	84.50051963	84.50051963
Auditor2	[Resource]	Capacity	86.29620887	#DIV/0!	86.29620887	86.29620887
Auditor3	[Resource]	Capacity	85.34166692	#DIV/0!	85.34166692	85.34166692
Auditor4	[Resource]	Capacity	84.88159502	#DIV/0!	84.88159502	84.88159502
Auditor5	[Resource]	Capacity	85.87389935	#DIV/0!	85.87389935	85.87389935
Auditor6	[Resource]	Capacity	84.83648785	#DIV/0!	84.83648785	84.83648785
Packer1	[Resource]	Capacity	99.79751137	#DIV/0!	99.79751137	99.79751137
Packer2	[Resource]	Capacity	99.50742303	#DIV/0!	99.50742303	99.50742303
Packer3	[Resource]	Capacity	99.3073741	#DIV/0!	99.3073741	99.3073741
Packer4	[Resource]	Capacity	98.67142329	#DIV/0!	98.67142329	98.67142329
Packer5	[Resource]	Capacity	97.31503654	#DIV/0!	97.31503654	97.31503654
PrepareForAudit1	[Resource]	Capacity	87.53040106	#DIV/0!	87.53040106	87.53040106
Scanning1	[Resource]	Capacity	54.70814991	#DIV/0!	54.70814991	54.70814991
PrepareAndStcker1	[Population]	Capacity	87.54122832	#DIV/0!	87.54122832	87.54122832
PrepareAndStcker1[1]	[Resource]	Capacity	87.54122832	#DIV/0!	87.54122832	87.54122832
PrepareAndStcker2	[Population]	Capacity	0	#DIV/0!	0	0
Provider1	[Population]	Capacity	82.05717778	#DIV/0!	82.05717778	82.05717778
Provider1[1]	[Resource]	Capacity	82.05717778	#DIV/0!	82.05717778	82.05717778
Provider2	[Population]	Capacity	0	#DIV/0!	0	0
ScningAndPaper1	[Population]	Capacity	83.34813033	#DIV/0!	83.34813033	83.34813033
ScningAndPaper1[1]	[Resource]	Capacity	83.34813033	#DIV/0!	83.34813033	83.34813033
ScningAndPaper2	[Population]	Capacity	0	#DIV/0!	0	0

Scenario: 1-C

BlockedTime - Percent

Object Name	Data Source	Category	Average	Half Width	Minimum	Maximum
AddPaper1	[Resource]	ResourceState	51.76584741	#DIV/0!	51.76584741	51.76584741
AddPaper2	[Resource]	ResourceState	51.85110144	#DIV/0!	51.85110144	51.85110144
AttachSticker1	[Resource]	ResourceState	76.46125833	#DIV/0!	76.46125833	76.46125833
AttachSticker2	[Resource]	ResourceState	76.75526815	#DIV/0!	76.75526815	76.75526815
PrepareForAudit1	[Resource]	ResourceState	48.33617504	#DIV/0!	48.33617504	48.33617504
PrepareForAudit2	[Resource]	ResourceState	48.49141723	#DIV/0!	48.49141723	48.49141723
Scanning1	[Resource]	ResourceState	76.60611184	#DIV/0!	76.60611184	76.60611184
Scanning2	[Resource]	ResourceState	76.73740259	#DIV/0!	76.73740259	76.73740259

ScheduledUtilization - Percent

Object Name	Data Source	Category	Average	Half Width	Minimum	Maximum
AddPaper1	[Resource]	Capacity	46.81773021	#DIV/0!	46.81773021	46.81773021
AddPaper2	[Resource]	Capacity	46.70900349	#DIV/0!	46.70900349	46.70900349
AttachSticker1	[Resource]	Capacity	22.04663239	#DIV/0!	22.04663239	22.04663239
AttachSticker2	[Resource]	Capacity	21.74766713	#DIV/0!	21.74766713	21.74766713
Auditor1	[Resource]	Capacity	99.56984002	#DIV/0!	99.56984002	99.56984002
Auditor2	[Resource]	Capacity	99.18971521	#DIV/0!	99.18971521	99.18971521
Auditor3	[Resource]	Capacity	99.34588527	#DIV/0!	99.34588527	99.34588527
Auditor4	[Resource]	Capacity	99.33509704	#DIV/0!	99.33509704	99.33509704
Auditor5	[Resource]	Capacity	99.23815716	#DIV/0!	99.23815716	99.23815716
Auditor6	[Resource]	Capacity	99.13577756	#DIV/0!	99.13577756	99.13577756
Packer1	[Resource]	Capacity	99.68173906	#DIV/0!	99.68173906	99.68173906
Packer2	[Resource]	Capacity	99.24180973	#DIV/0!	99.24180973	99.24180973
Packer3	[Resource]	Capacity	98.11044685	#DIV/0!	98.11044685	98.11044685
Packer4	[Resource]	Capacity	95.12333452	#DIV/0!	95.12333452	95.12333452
Packer5	[Resource]	Capacity	88.96583701	#DIV/0!	88.96583701	88.96583701
Packer6	[Resource]	Capacity	77.84380661	#DIV/0!	77.84380661	77.84380661
PrepareForAudit1	[Resource]	Capacity	50.14074309	#DIV/0!	50.14074309	50.14074309
PrepareForAudit2	[Resource]	Capacity	50.00833222	#DIV/0!	50.00833222	50.00833222
Scanning1	[Resource]	Capacity	21.62224581	#DIV/0!	21.62224581	21.62224581
Scanning2	[Resource]	Capacity	21.53388661	#DIV/0!	21.53388661	21.53388661
PrepareAndStcker1	[Population]	Capacity	50.19449057	#DIV/0!	50.19449057	50.19449057
PrepareAndStcker1[1]	[Resource]	Capacity	50.19449057	#DIV/0!	50.19449057	50.19449057
PrepareAndStcker2	[Population]	Capacity	50.04527076	#DIV/0!	50.04527076	50.04527076
PrepareAndStcker2[1]	[Resource]	Capacity	50.04527076	#DIV/0!	50.04527076	50.04527076
Provider1	[Population]	Capacity	53.62377533	#DIV/0!	53.62377533	53.62377533
Provider1[1]	[Resource]	Capacity	53.62377533	#DIV/0!	53.62377533	53.62377533
Provider2	[Population]	Capacity	40.46730531	#DIV/0!	40.46730531	40.46730531
Provider2[1]	[Resource]	Capacity	40.46730531	#DIV/0!	40.46730531	40.46730531
ScningAndPaper1	[Population]	Capacity	47.63475317	#DIV/0!	47.63475317	47.63475317
ScningAndPaper1[1]	[Resource]	Capacity	47.63475317	#DIV/0!	47.63475317	47.63475317
ScningAndPaper2	[Population]	Capacity	47.36706609	#DIV/0!	47.36706609	47.36706609
ScningAndPaper2[1]	[Resource]	Capacity	47.36706609	#DIV/0!	47.36706609	47.36706609

Scenario: 2-A

BlockedTime - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	ResourceState	51.21030569	51.21030569	51.21030569
AddPaper2	[Resource]	ResourceState	50.58323682	50.58323682	50.58323682
AttachSticker1	[Resource]	ResourceState	76.30541371	76.30541371	76.30541371
AttachSticker2	[Resource]	ResourceState	76.35192017	76.35192017	76.35192017
Auditor1	[Resource]	ResourceState	0.236436736	0.236436736	0.236436736
Auditor2	[Resource]	ResourceState	0.279373918	0.279373918	0.279373918
Auditor3	[Resource]	ResourceState	0.430580223	0.430580223	0.430580223
Auditor4	[Resource]	ResourceState	0.353812165	0.353812165	0.353812165
Auditor5	[Resource]	ResourceState	0.158306569	0.158306569	0.158306569
Auditor6	[Resource]	ResourceState	0.290632439	0.290632439	0.290632439
PrepareForAudit1	[Resource]	ResourceState	47.39378145	47.39378145	47.39378145
PrepareForAudit2	[Resource]	ResourceState	47.51932012	47.51932012	47.51932012
Scanning1	[Resource]	ResourceState	76.47666623	76.47666623	76.47666623
Scanning2	[Resource]	ResourceState	76.13235335	76.13235335	76.13235335

ScheduledUtilization - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	Capacity	47.15299763	47.15299763	47.15299763
AddPaper2	[Resource]	Capacity	47.81036337	47.81036337	47.81036337
AttachSticker1	[Resource]	Capacity	21.77317259	21.77317259	21.77317259
AttachSticker2	[Resource]	Capacity	21.69005778	21.69005778	21.69005778
Auditor1	[Resource]	Capacity	97.45573608	97.45573608	97.45573608
Auditor2	[Resource]	Capacity	98.61267129	98.61267129	98.61267129
Auditor3	[Resource]	Capacity	98.54853119	98.54853119	98.54853119
Auditor4	[Resource]	Capacity	98.21247134	98.21247134	98.21247134
Auditor5	[Resource]	Capacity	97.99908319	97.99908319	97.99908319
Auditor6	[Resource]	Capacity	98.43729375	98.43729375	98.43729375
Packer1	[Resource]	Capacity	99.45864365	99.45864365	99.45864365
Packer2	[Resource]	Capacity	98.86763391	98.86763391	98.86763391
Packer3	[Resource]	Capacity	98.23321566	98.23321566	98.23321566
Packer4	[Resource]	Capacity	96.48558695	96.48558695	96.48558695
Packer5	[Resource]	Capacity	90.24172089	90.24172089	90.24172089
Packer6	[Resource]	Capacity	83.4647709	83.4647709	83.4647709
PrepareForAudit1	[Resource]	Capacity	49.96891621	49.96891621	49.96891621
PrepareForAudit2	[Resource]	Capacity	49.78547682	49.78547682	49.78547682
Scanning1	[Resource]	Capacity	21.04339043	21.04339043	21.04339043
Scanning2	[Resource]	Capacity	21.36838385	21.36838385	21.36838385
PrepAndStcker1	[Population]	Capacity	50.33334216	50.33334216	50.33334216

PrepAndStcker1[1]	[Resource]	Capacity	50.33334216	50.33334216	50.33334216
PrepAndStcker2	[Population]	Capacity	50.17460259	50.17460259	50.17460259
PrepAndStcker2[1]	[Resource]	Capacity	50.17460259	50.17460259	50.17460259
Provider1	[Population]	Capacity	94.14595517	94.14595517	94.14595517
Provider1[1]	[Resource]	Capacity	94.14595517	94.14595517	94.14595517
Provider2	[Population]	Capacity	0	0	0
ScningAndPaper1	[Population]	Capacity	47.56499741	47.56499741	47.56499741
ScningAndPaper1[1]	[Resource]	Capacity	47.56499741	47.56499741	47.56499741
ScningAndPaper2	[Population]	Capacity	48.23293176	48.23293176	48.23293176
ScningAndPaper2[1]	[Resource]	Capacity	48.23293176	48.23293176	48.23293176

Scenario: 2-B

BlockedTime - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	ResourceState	46.65163813	46.65163813	46.65163813
AddPaper2	[Resource]	ResourceState	46.29834901	46.29834901	46.29834901
AttachSticker1	[Resource]	ResourceState	73.46481076	73.46481076	73.46481076
AttachSticker2	[Resource]	ResourceState	73.22688277	73.22688277	73.22688277
PrepareForAudit1	[Resource]	ResourceState	45.54018654	45.54018654	45.54018654
PrepareForAudit2	[Resource]	ResourceState	46.22677251	46.22677251	46.22677251
Scanning1	[Resource]	ResourceState	73.70465052	73.70465052	73.70465052
Scanning2	[Resource]	ResourceState	73.64583895	73.64583895	73.64583895

ScheduledUtilization - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	Capacity	49.22158381	49.22158381	49.22158381
AddPaper2	[Resource]	Capacity	49.08204139	49.08204139	49.08204139
AttachSticker1	[Resource]	Capacity	23.41348755	23.41348755	23.41348755
AttachSticker2	[Resource]	Capacity	23.09104961	23.09104961	23.09104961
Auditor1	[Resource]	Capacity	87.17376289	87.17376289	87.17376289
Auditor2	[Resource]	Capacity	87.76414974	87.76414974	87.76414974
Auditor3	[Resource]	Capacity	84.04736494	84.04736494	84.04736494
Auditor4	[Resource]	Capacity	89.05043024	89.05043024	89.05043024
Auditor5	[Resource]	Capacity	83.62517968	83.62517968	83.62517968
Auditor6	[Resource]	Capacity	88.57942653	88.57942653	88.57942653
Auditor7	[Resource]	Capacity	86.62331565	86.62331565	86.62331565
Packer1	[Resource]	Capacity	99.43156127	99.43156127	99.43156127
Packer2	[Resource]	Capacity	98.58841509	98.58841509	98.58841509
Packer3	[Resource]	Capacity	97.88353349	97.88353349	97.88353349
Packer4	[Resource]	Capacity	94.75673832	94.75673832	94.75673832
Packer5	[Resource]	Capacity	85.56743844	85.56743844	85.56743844
Packer6	[Resource]	Capacity	69.7485737	69.7485737	69.7485737

Packer7	[Resource]	Capacity	47.35538413	47.35538413	47.35538413
PrepareForAudit1	[Resource]	Capacity	52.27283295	52.27283295	52.27283295
PrepareForAudit2	[Resource]	Capacity	51.91646705	51.91646705	51.91646705
Scanning1	[Resource]	Capacity	22.56697768	22.56697768	22.56697768
Scanning2	[Resource]	Capacity	22.30272612	22.30272612	22.30272612
PrepAndStcker1	[Population]	Capacity	52.57073191	52.57073191	52.57073191
PrepAndStcker1[1]	[Resource]	Capacity	52.57073191	52.57073191	52.57073191
PrepAndStcker2	[Population]	Capacity	52.19304186	52.19304186	52.19304186
PrepAndStcker2[1]	[Resource]	Capacity	52.19304186	52.19304186	52.19304186
Provider1	[Population]	Capacity	98.25669671	98.25669671	98.25669671
Provider1[1]	[Resource]	Capacity	98.25669671	98.25669671	98.25669671
Provider2	[Population]	Capacity	0	0	0
ScningAndPaper1	[Population]	Capacity	50.32530191	50.32530191	50.32530191
ScningAndPaper1[1]	[Resource]	Capacity	50.32530191	50.32530191	50.32530191
ScningAndPaper2	[Population]	Capacity	49.89500503	49.89500503	49.89500503
ScningAndPaper2[1]	[Resource]	Capacity	49.89500503	49.89500503	49.89500503

Scenario: 2-C

BlockedTime - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	ResourceState	41.04004057	41.04004057	41.04004057
AddPaper2	[Resource]	ResourceState	41.04861705	41.04861705	41.04861705
AttachSticker1	[Resource]	ResourceState	68.78454257	68.78454257	68.78454257
AttachSticker2	[Resource]	ResourceState	68.92510939	68.92510939	68.92510939
Auditor1	[Resource]	ResourceState	0.018594878	0.018594878	0.018594878
Auditor2	[Resource]	ResourceState	0.268821899	0.268821899	0.268821899
Auditor3	[Resource]	ResourceState	0.193481115	0.193481115	0.193481115
Auditor4	[Resource]	ResourceState	0.290066776	0.290066776	0.290066776
Auditor5	[Resource]	ResourceState	0.256598295	0.256598295	0.256598295
Auditor6	[Resource]	ResourceState	0.241035447	0.241035447	0.241035447
Auditor7	[Resource]	ResourceState	0.075509606	0.075509606	0.075509606
PrepareForAudit1	[Resource]	ResourceState	39.91083231	39.91083231	39.91083231
PrepareForAudit2	[Resource]	ResourceState	40.21790989	40.21790989	40.21790989
Scanning1	[Resource]	ResourceState	67.76960801	67.76960801	67.76960801
Scanning2	[Resource]	ResourceState	68.15802964	68.15802964	68.15802964

ScheduledUtilization - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	Capacity	53.19370314	53.19370314	53.19370314
AddPaper2	[Resource]	Capacity	53.64040168	53.64040168	53.64040168
AttachSticker1	[Resource]	Capacity	26.78652261	26.78652261	26.78652261

AttachSticker2	[Resource]	Capacity	27.31395637	27.31395637	27.31395637
Auditor1	[Resource]	Capacity	99.37964246	99.37964246	99.37964246
Auditor2	[Resource]	Capacity	98.79983613	98.79983613	98.79983613
Auditor3	[Resource]	Capacity	99.29009812	99.29009812	99.29009812
Auditor4	[Resource]	Capacity	99.30939613	99.30939613	99.30939613
Auditor5	[Resource]	Capacity	98.63405702	98.63405702	98.63405702
Auditor6	[Resource]	Capacity	98.75625646	98.75625646	98.75625646
Auditor7	[Resource]	Capacity	99.23592806	99.23592806	99.23592806
Packer1	[Resource]	Capacity	99.76671105	99.76671105	99.76671105
Packer2	[Resource]	Capacity	99.58056585	99.58056585	99.58056585
Packer3	[Resource]	Capacity	99.43212429	99.43212429	99.43212429
Packer4	[Resource]	Capacity	97.58556831	97.58556831	97.58556831
Packer5	[Resource]	Capacity	94.49356549	94.49356549	94.49356549
Packer6	[Resource]	Capacity	89.54526486	89.54526486	89.54526486
Packer7	[Resource]	Capacity	81.95109865	81.95109865	81.95109865
PrepareForAudit1	[Resource]	Capacity	58.66000356	58.66000356	58.66000356
PrepareForAudit2	[Resource]	Capacity	58.9184886	58.9184886	58.9184886
Scanning1	[Resource]	Capacity	26.6596901	26.6596901	26.6596901
Scanning2	[Resource]	Capacity	26.54560474	26.54560474	26.54560474
PrepAndStcker1	[Population]	Capacity	58.6911164	58.6911164	58.6911164
PrepAndStcker2	[Population]	Capacity	58.9457265	58.9457265	58.9457265
Provider1	[Population]	Capacity	59.87833928	59.87833928	59.87833928
Provider2	[Population]	Capacity	50.74128573	50.74128573	50.74128573
ScningAndPaper1	[Population]	Capacity	55.75321088	55.75321088	55.75321088
ScningAndPaper2	[Population]	Capacity	56.21567568	56.21567568	56.21567568

Scenario: 2-D

BlockedTime - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	ResourceState	31.39230673	31.39230673	31.39230673
AddPaper2	[Resource]	ResourceState	31.23149378	31.23149378	31.23149378
AttachSticker1	[Resource]	ResourceState	57.49903016	57.49903016	57.49903016
AttachSticker2	[Resource]	ResourceState	56.99919927	56.99919927	56.99919927
PrepareForAudit1	[Resource]	ResourceState	27.49087312	27.49087312	27.49087312
PrepareForAudit2	[Resource]	ResourceState	28.75188992	28.75188992	28.75188992
Scanning1	[Resource]	ResourceState	55.59679992	55.59679992	55.59679992
Scanning2	[Resource]	ResourceState	55.36394116	55.36394116	55.36394116

ScheduledUtilization - Percent

Object Name	Data Source	Category	Average	Minimum	Maximum
AddPaper1	[Resource]	Capacity	56.80330677	56.80330677	56.80330677
AddPaper2	[Resource]	Capacity	56.16993617	56.16993617	56.16993617
AttachSticker1	[Resource]	Capacity	31.10194215	31.10194215	31.10194215

AttachSticker2	[Resource]	Capacity	31.0142632	31.0142632	31.0142632
Auditor1	[Resource]	Capacity	93.25287117	93.25287117	93.25287117
Auditor2	[Resource]	Capacity	93.94215805	93.94215805	93.94215805
Auditor3	[Resource]	Capacity	93.65173998	93.65173998	93.65173998
Auditor4	[Resource]	Capacity	95.3211378	95.3211378	95.3211378
Auditor5	[Resource]	Capacity	93.8253261	93.8253261	93.8253261
Auditor6	[Resource]	Capacity	95.20667416	95.20667416	95.20667416
Auditor7	[Resource]	Capacity	93.01685373	93.01685373	93.01685373
Auditor8	[Resource]	Capacity	94.01301495	94.01301495	94.01301495
Packer1	[Resource]	Capacity	99.083493	99.083493	99.083493
Packer2	[Resource]	Capacity	98.72481698	98.72481698	98.72481698
Packer3	[Resource]	Capacity	97.84989237	97.84989237	97.84989237
Packer4	[Resource]	Capacity	96.75927922	96.75927922	96.75927922
Packer5	[Resource]	Capacity	94.86998153	94.86998153	94.86998153
Packer6	[Resource]	Capacity	90.63106132	90.63106132	90.63106132
Packer7	[Resource]	Capacity	82.02903703	82.02903703	82.02903703
Packer8	[Resource]	Capacity	71.84321904	71.84321904	71.84321904
PrepareForAudit1	[Resource]	Capacity	63.03604258	63.03604258	63.03604258
PrepareForAudit2	[Resource]	Capacity	62.9777159	62.9777159	62.9777159
Scanning1	[Resource]	Capacity	30.14915032	30.14915032	30.14915032
Scanning2	[Resource]	Capacity	30.06679458	30.06679458	30.06679458
PrepAndStcker1	[Population]	Capacity	65.51388984	65.51388984	65.51388984
PrepAndStcker1[1]	[Resource]	Capacity	65.51388984	65.51388984	65.51388984
PrepAndStcker2	[Population]	Capacity	65.05611727	65.05611727	65.05611727
PrepAndStcker2[1]	[Resource]	Capacity	65.05611727	65.05611727	65.05611727
Provider1	[Population]	Capacity	62.33274577	62.33274577	62.33274577
Provider1[1]	[Resource]	Capacity	62.33274577	62.33274577	62.33274577
Provider2	[Population]	Capacity	60.14629044	60.14629044	60.14629044
Provider2[1]	[Resource]	Capacity	60.14629044	60.14629044	60.14629044
ScningAndPaper1	[Population]	Capacity	62.37169525	62.37169525	62.37169525
ScningAndPaper1[1]	[Resource]	Capacity	62.37169525	62.37169525	62.37169525
ScningAndPaper2	[Population]	Capacity	61.74945022	61.74945022	61.74945022
ScningAndPaper2[1]	[Resource]	Capacity	61.74945022	61.74945022	61.74945022