Facilities design and Process Modeling for ECO Technology

by

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EXECUTIVE SUMMARY

The computer industry is a fast growing, lucrative and competitive field, where the companies who provide the best service, get the most contracts and customers. It can no longer be acceptable for any company in this industry to perform at a mediocre service level.

ECO Technology is one of the leading computer orientated companies in the Gauteng area. In an attempt to increase their service rate and customer satisfaction and integrate the newly acquired supplementary space, they have asked for a re-layout and facility layout plan for the space.

The main focus of the project will be to design a more efficient, objective orientated distribution facility layout, through the use of simulation modeling, economic analysis and space requirement planning.

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ACRONYMS

Term	Meaning
PDP	Probabilistic Dynamic Programming
CSD	Client Service Desk (Department)
CSR	Component Space Requirement
TTS	Time Through System

CHAPTER 1: INTRODUCTION

RESEARCH QUESTION

The computer hardware industry has been growing steadily over the last four decades, starting in garages with soldering kits and growing into the multibillion Rand industry that it is today.

The distribution of computer hardware in South Africa falls to a few companies, who have direct contracts with the manufacturers and importers of hardware. Only companies and businesses can buy from these suppliers, the general public has to buy from the second tier suppliers.

Eco Technology is a leading supplier of computer hard-and software in the Gauteng area. They have been part of the growing industry for almost a decade; this makes them one of the most established suppliers in the area.

To cope with the increasing demand of systems as more businesses start to realize that staying on the edge as far as technology goes is invaluable, seeing as programs become more advanced and need more processing power, ECO Technology need to refine and re-evaluate their current work environment, to keep up with customer expectations and demands.

Recently ECO Technology has purchased the building adjacent to their current premises. They intend to expand their place of business into these premises in order to help cope with the growing demand from the technologically driven market. The move will enable them to have more storage space, better and bigger working areas for the employees and improve the effectiveness of the flow of goods through the premises.

PROJECT AIM

The main objective of this project is to supply ECO Technology with a facility plan that is not only feasible, but also uses the expanded premises effectively and creates an efficient environment for workers and customers alike.

Through taking these actions ECO Technology hopes to improve business relations by means of a better customer experience as well as by improving the quality of the work environment for the employees.

RESEARCH DESIGN

The project will cover the following activities:

- Analysis of the stock arriving at the reception (Inbound Deliveries)
- Analysis of how the stock flows through the facility to the three main end processes:
    - Deliveries
    - Technical Department
    - Sales Counter
- Data gathering on these processes and flows
- Analysis of the equally important flow of customers through the facility to improve the efficiency of the customers interface with the business
- Determining the inter departmental relationships
- Analysis of the current space requirements to ensure future capacity compatibility of the end facility design
- The generation of three alternative layouts for the facility
- Simulation of these alternatives as well as the current situation
- Analysis of the simulation results
- Generation of a facilities design around the best layout (from simulation)
- A Validation of the design chosen, including a cost analysis
- An implementable facilities plan

In short simulation modeling will be used as a tool to analyze different alternative layout and work flow designs to give the most beneficial facilities plan for the company, using the current facility plan and flow as a benchmark for comparison.

DELIVERABLES

The main deliverables of the project will be to provide ECO Technology with an implementable facilities plan that improves the efficiency of the current work environment. The use of simulation modeling through Arena will be called upon to help in achieving and justifying the aforementioned deliverable.

The successful completion of the project depends on the following outcomes:

- Three alternatives layouts
- Analysis and comparison of Alternate Layouts through:
    - Simulation
    - Economic Analysis
    - Space Requirements
- Choosing of best Alternative
- Departmental Layout for Best Performer
- Equipment Layout for Best Performer
- Implementation Schedule

CHAPTER 2: LITERATURE REVIEW

The main engineering principles that will be used to enable the successful conclusion of the project to give ECO Technology an efficient and effective facilities design are facilities planning and simulation modeling. The last will be used along with financial analysis to choose the best possible layout to be implemented.

RESEARCH ON POTENTIAL METHODS TO BE USED

In order to gain the most effective and efficient facilities design for ECO technology the different aspects of the tools to be used were studied in order to gain the most use from them and produce a high quality final implementable facilities design.

MODELING

A model can be defined as a representation of an actual situation that may be used to make better decisions or simply understand the actual situation better. (Winston, Venkataramanan, 2003)

In the case of ECO Technology the model in question will aid in determining the most effective and efficient layout of departments for their distribution facility.

There are basically three classifications of simulation models, namely: (Kelton, Sadowski & Sturrock, 2007)

1. **Static v Dynamic**: The main difference is that time is a consideration factor in dynamic models whereas it is not in static models
2. **Continuous v Discrete**: In a continuous model changes to the state can happen at any point in time continuously, whereas in discrete models the state can only change at certain times.
3. **Deterministic v Stochastic**: Deterministic models have no elements that are based on variability or probability, whereas stochastic models have at least one probabilistic element.

MATHEMATICAL MODELING

A mathematical model uses mathematical language to describe a system. (Wikipedia, 2009)

The two main paths of modeling that can be used to model the flow of stock and customers through the facility are mathematical and simulation models.

The main types of mathematical models that were considered were: Probabilistic Dynamic Programming and Linear Programming.

LINEAR PROGRAMMING

A linear programming problem (LP) is am optimization problem for which we do the following: (Winston, Venkataramanan, 2003)

1. We attempt to maximize or minimize a linear function of decision variables
2. The value of the decision variables must satisfy a set of constraints
3. A sign restriction is associated with each variable

Linear programming can be seen as a brute force method of modeling, in some instances, seeing as it mainly focuses on the definition of constraints that the model must try to solve for while still trying to keep the objective function as optimal as possible. It is computationally inefficient when there are a large number of constraints.

The proposed model to be constructed will have quite a few stochastic elements and the number of constraints will prove to make this the less efficient way of analyzing the different alternative layouts.

PROBABILISTIC DYNAMIC PROGRAMMING (PDP)

Dynamic programming (DP) is a general approach to making a sequence of interrelated decisions in an optimum way (Chinneck, 2006). From the same source we find that the following can be seen as some of the most important characteristics of DP:

1. The problem can be divided into stages
2. Each stage has a number of states
3. The decision of a stage updates the state at the stage into the state of the next stage
4. Given the current state, the optimal decision for the remaining stages is independent of decisions made in previous states
5. There is a recursive relationship between the value of decision at a stage and the value of the optimum decision at previous stages

A Probabilistic Dynamic Program (PDP) differs only in the sense that there are probabilities involved for solution to take a specific state in a specific stage.

The basic solution path stays the same for both DP and PDP's. These are: (Chinneck, 2006)

1. Determine the states of the solution
2. Divine the state at a stage
3. Determine what kind of decision to make at a stage
4. Determine how the decision updates the state of the next stage
5. Determine the recursive value relationship between the optimum decision at a stage and a previous optimum decision

One of the major advantages of DP and thus PDP is that, though it can be quite tedious to formulate, the solution of these types of models are usually efficient. (Chinneck, 2006)

Although as far as modeling the different layouts and their respective flow of customers and stock, the model will no longer be a simple PDP. It is a queuing model with the different departments have certain processing times and capacities and stock arriving at intervals and with a probabilistic distribution for different sizes.

This will render quite a complex and inelegant model to solve and model the situations.

SIMULATION MODELING

Simulation refers to a broad collection of methods and applications to mimic the behavior of real systems (Kelton, Sadowski & Sturrock, 2007).

Using this as a definition to work from it becomes clear that through the use of simulation software the behavior of the facility as stock and customers flows through it could be effectively modeled and these models could be used to do "what-if" analysis to determine how different changes to the facility will influence the flow through the facility.

As with any type of model, a simulation model has certain clear advantages and disadvantages. A short list of some of these is: (Chase,Jacobs & Aquilano, 2007)

Advantages

1. Development of the systems often leads to a better understanding of how the real system functions
2. Time can be compressed in simulation; years of experience in the real system can be compressed into seconds or minutes
3. Simulation does not disrupt ongoing activities of the real system
4. Simulation is far more general than mathematical models and can be used where conditions are not suitable for standard mathematical analysis
5. Simulation can be used as a game for training experience
6. Simulation provides a more realistic replication of a system than mathematical analysis
7. Simulation can be used to analyze transient conditions, whereas mathematical techniques usually can not
8. Simulation answers what-if questions

Disadvantages

Although a great deal of time and effort may be spent to develop a model for simulation, there is no guarantee that the model will, in fact, provide good answers

1. There is no way to prove that a simulation model's performance is completely reliable
2. Simulation may take a longer than would be productive
3. Simulation may be less accurate because it is randomly based
4. A significant amount of computer time may be needed to run complex models
5. The technique of simulation still lacks a standardized approach

The techniques to be used and reasons for their implementation will be discussed in the following main section.

FACILITIES PLANNING

Facilities planning is one of the more overlooked of principles when it comes to the successful interface between the employees and the environment in which they work, yet when analyzed, it becomes clear that improper facilities planning leads to a unpleasant working environment, bad flow between departments and more.

Layout decisions entail determining the placement of departments, work groups within the departments, work stations, machines and stock holding points within a production facility. (Chase,Jacobs & Aquilano, 2007)

This gives an idea of the many facets of any business wishing to have a competitive advantage in the modern business environment that facilities design directly influences.

FACILITIES PLANNING METHODOLOGY

There are different ways techniques that could be used in the planning of a facility. One of these is through the use of computer technology; an example would be The Intelligent Floor Space Allocation Advisor (IFSAA) which was developed as part of a larger effort to provide the industrial maintenance complex at Ogden Air Logistics Centre with a comprehensive tool to advice floor space management (Fink, P, 1992). The IFSAA uses standard facilities planning methodology to analyze data that is imported by facilities planners to create a conceptual facility layout.

Another tool to use in the process of facilities planning is systematic layout planning (SLP). This technique encompasses the entire process of facilities design and breaks it up into different stages with sub-steps. This creates a roadmap and logical plan to follow for any facility to be designed or re-designed.

The basic systematic approach to facilities design is given in the following steps (Thompkins, White, Bozer & Tanchoco, 2003):

1. Define the problem
    - Define or redefine the Objective of the facility
    - Specify the primary and support activities to be performed in accomplishing the activities
2. Analyze the Problem
    - Determine the interrelationships between activities
3. Determine Space requirements for all activities
4. Generate alternative facilities Plans
5. Evaluate Alternatives
6. Select the Preferred Design
7. Implement the design

An alternative methodology of the same type as above was given in (Bodi Engineering LLC, 2003).

The basic methodology is:

1. Document Current Activities
   - Define activities
     - Present and future operations
     - Specific Pieces of Equipment
     - Work Spaces
     - Areas
   - Flow Chart
     - Operations
     - Materials
     - Information
   - Document current activities
   - Present equipment layout
2. Develop improved flows
   - Look for redundant or unnecessary steps
   - Add steps that will improve the operations
3. Develop space requirements
   - Determine a planning horizon
   - Determine what to include in each activity
     - Space
     - Equipment
     - Operational improvements
   - Look at each activity's planning horizon requirements
4. Develop activity relationships
   - Rate activities to all others in terms of a closeness rating
   - Give reasons why rating was given
5. Develop square meter requirements spreadsheet
   - An area based on estimates is assigned to each activity
   - Areas may take any improvements in to consideration
6. Develop block plan layouts
   - Area requirements spreadsheet and Relationship chart
   - Blocks of space are developed and positioned according to their relationship
   - Always develop a few alternatives to assist in the final layout
7. Develop the equipment layout

The two techniques given above have similarities, but the methodology given in (Bodi Engineering LLC, 2003) incorporates the use of flow though the facility in a more direct manner, whereas the steps given by (Thompkins, White, Bozer & Tanchoco, 2003) is a more general model.

CHAPTER 3: SOLUTION METHODOLOGY

After thorough and lengthy analysis of pertaining literature on the subjects of facilities design and modeling, the following techniques were chosen to be used in the solving of the Facilities design problem for ECO Technology.

MODELING

The use of simulation modeling through Arena lends itself the most to the testing and analysis of the flow of customers and stock through the facility. Seeing as it allows the most flexibility in the creation and modification of models to suit different situations.

The modeling to be used in the project will be as a validation medium for selecting the appropriate facilities layout after a few alternatives were generated. Each alternative will be simulated in turn in order to get comparative results on each to ensure that the best of the feasible solutions will be taken into the final departmental layout design and implementation of the design.

Arena was selected for the ease of operation and great versatility it has shown in the use of modeling different complex processes.

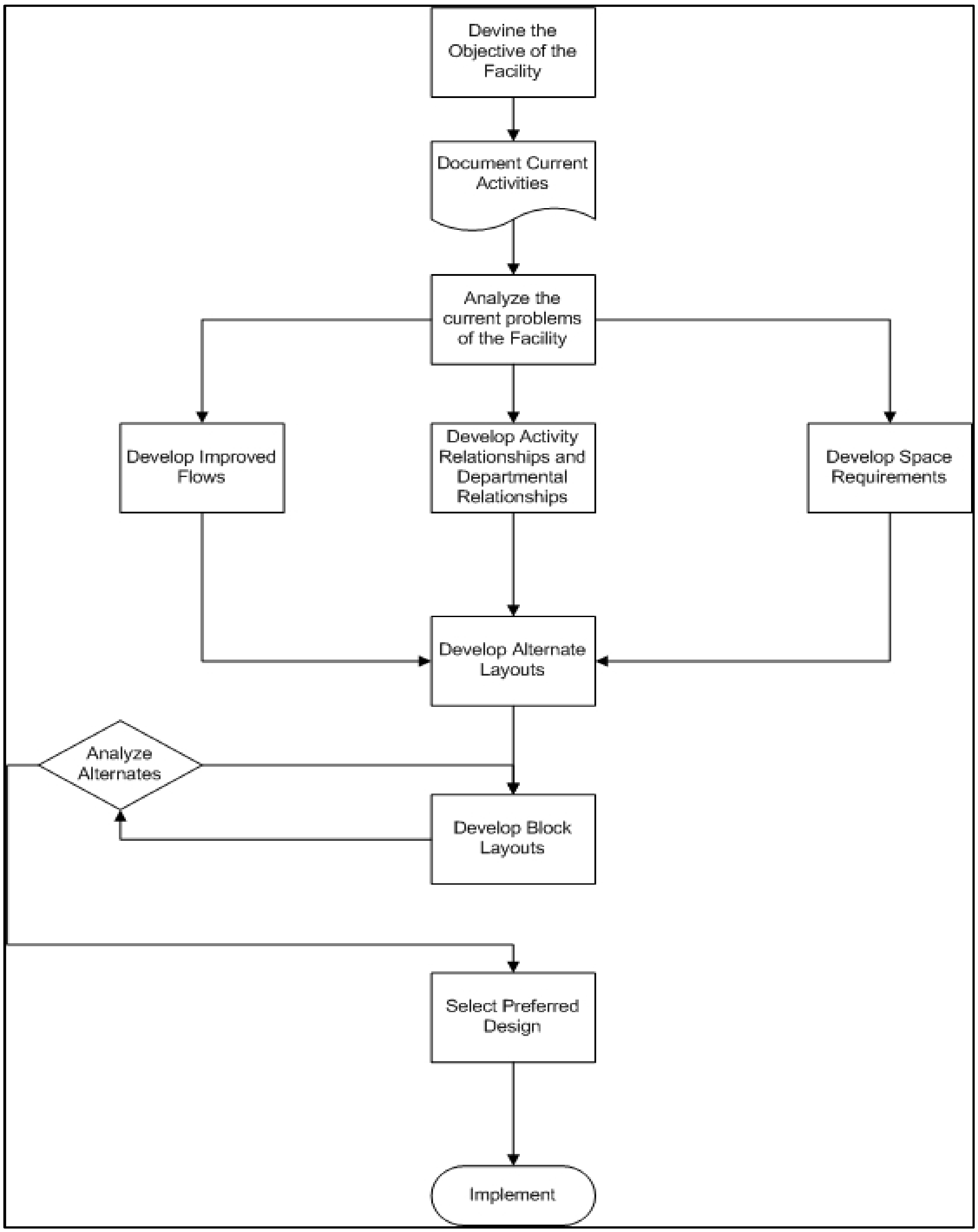
The advantage of using simulation software over other modeling techniques such as Probabilistic Dynamic Programming is the adaptability to changes that simulation modeling allows.

FACILITIES DESIGN

A combination of the Facilities Planning steps given by (Thompkins, White, Bozer & Tanchoco, 2003) and that of (Bodi Engineering LLC, 2003) will be used to ultimately provide a feasible facilities plan

The basic total methodology to be used in the facilities design will be as follows:

Figure 1: Methodology to be used



SUPPLEMENTARY TOOLS AND TECHNIQUES TO BE USED

ECONOMIC ANALYSIS

In addition to simulation modeling, breakeven and cost analysis will be done on the different layouts proposed to help give an estimate of the cost as well as give comparative cost measures to justify the choice of layout.

Economic analysis of the cost of implementing the facilities plan will have to be done in order to justify the costs generated. The economic analysis will be done for the short and-long term economic repercussions of the project

SUPPLEMENTARY SIMULATION TOOLS

Monte Carlo simulation involves feeding a large number of random inputs into a model while recording the range of outputs. (Savage, 2003). This form of simulation will be used in order to generate and evaluate some of the data that will be required for the simulation models to be executed successfully.

PREDICTIONS

Forecasting is another tool to be used in order to successfully predict the amount of flow through the facility in terms of stock and customers; the amount of storage space that will be required and the number of personnel that the facility will have to be able to support. The current planning horizon for the project is 5 years.

The Facility's space requirements will be analyzed on their ability to manage and cope with an increase in demand and stock levels.

CONCEPTUAL DESIGN

ANALYSIS OF THE CURRENT SITUATION

Currently ECO Technology's distribution facility is still on the premises that they first purchased when they started 8 years ago. Their corporate divisions are on multiple premises on a few sites throughout Gauteng.

The current premise is in a rebuilt and modified garage from where their distribution is run. They have in the last few years added space to the premises as well as a second floor. Figure 2, bellow shows a schematic of the current premises' first floor as well as the new space that they recently purchased. Figure 3 shows the added second floor.

Figure 2: Schematic showing basic layout of ECO Technology's first floor

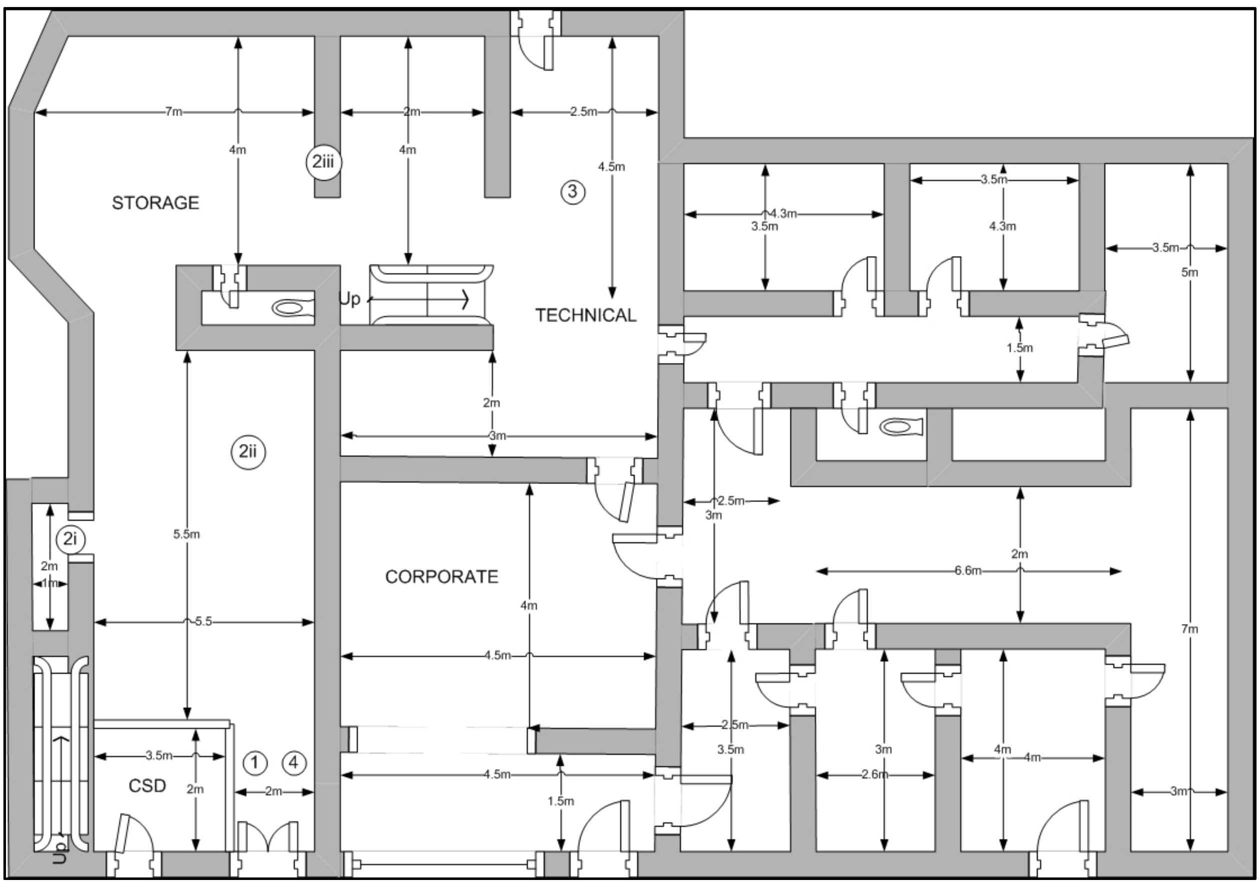
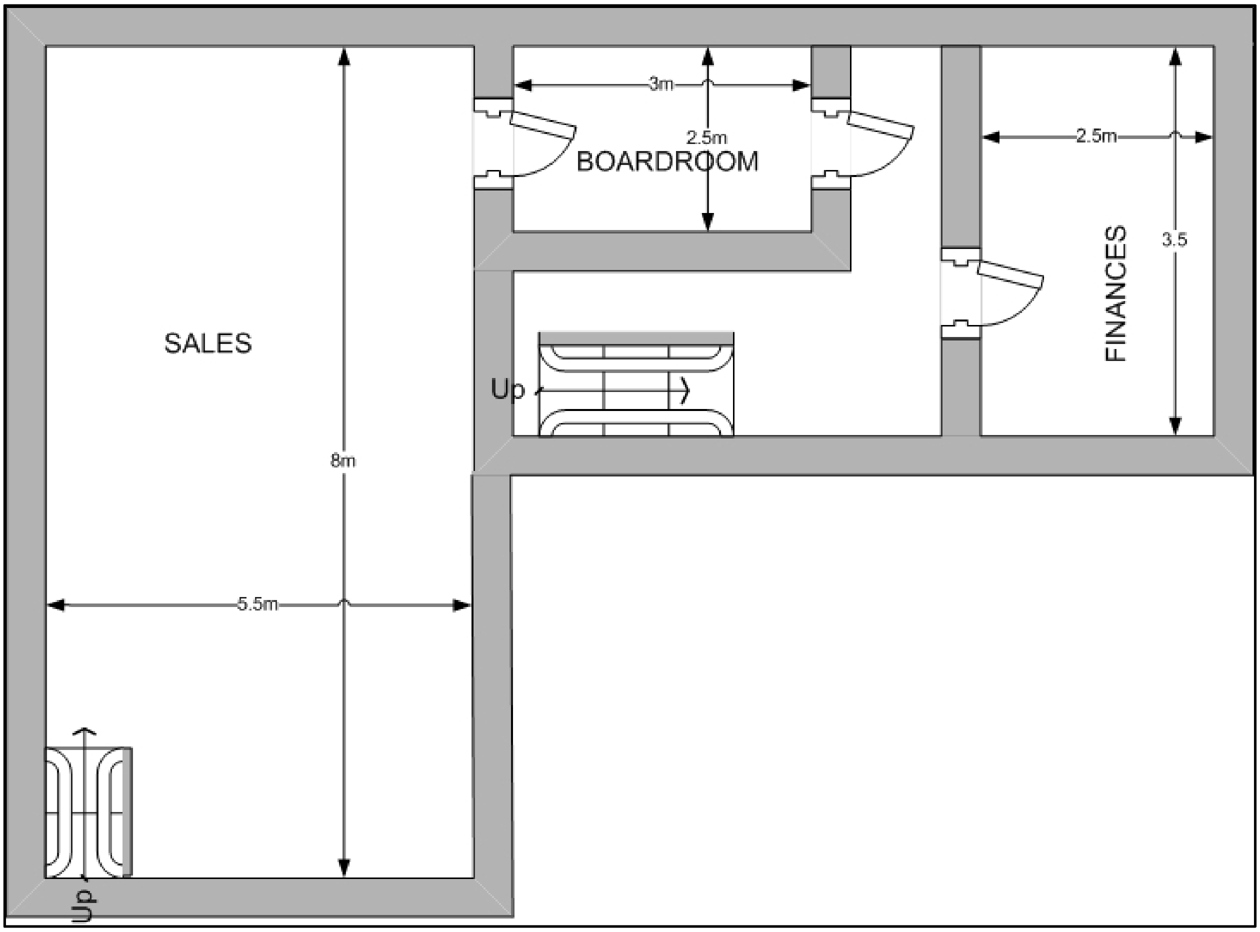


Figure 3: Schematic showing ECO Technology's top floor



STOCK FLOW THROUGH THE FACILITY

As ECO Technology is one of the biggest distributers of computer hard and software in Gauteng, their current operations facility has to cope with a large amount of stock flowing through the different departments at any given time. The arrival of stock is at the inbound deliveries area is when the drivers arrive from ECO Technology's suppliers. The arrival time is usually late morning and late afternoon.

The outbound deliveries area is currently the same area as the inbound deliveries, often leading to a stressful work environment, as employees scramble to sort out the inbound and outbound deliveries. It also leads to mix-ups with orders and customers being dissatisfied. This area in particular will be addressed in the project as it further develops, to try and eliminate it completely.

The basic sequence in which stock flows through the facility is as follows:

When a stock delivery is made, it is unloaded off the truck and in to the delivery area of the distribution counter (Figure 1 Area 1). From there it is sorted and put in the storage areas, of which there are:

1. Small commodities (Area 2i)
2. Small high value (Area 2ii)
3. Larger and lower value products (Area 2iii)

When a customer orders a product or a certain number of products, the products are removed and send to the different areas of sale, namely:

1. The outbound deliveries area (Area 4); where products to be directly delivered to customers are kept before being sorted and taken by the drivers
2. The sales counter where customers pick up orders (Area 5)

Another "point of sale" is an internal one. The technical department may need certain products from the store rooms for maintenance, repairs or a specific build order. The department then places an order for the required products and it is sold to them at cost price. This sale is all controlled internally through auditing.

CUSTOMER FLOW THROUGH THE FACILITY

When a customer who has either ordered products that have arrived or wish to place an order, arrives at ECO Technology's distribution facility, they enter through a security gate that is there to ensure not only the safety of the personnel but also that of the high value products kept there.

When customers arrive, they can:

1. Give the order information at the distribution counter and wait for the order to be filled
2. Go upstairs to the sales department to place additional orders. If this is the case they have to go back to the distribution counter to pick up the products.
3. The customer can go to the finances department
4. They can go to the technical department

See figure2 and figure 3

for schematics showing above mentioned areas

A customer could also on any trip do all of the above mentioned

The basic rules of operation at ECO Technology as far as fulfilling customer's requirements when they arrive are:

1. All payments and new goods are picked up and paid for at the distribution counter
2. All orders are placed at the sales department
3. All technical services are done at the technical department.

As long as these rules are kept, any of the above activities can be done by a registered customer in any order they so wish.

DEPARTMENTAL ANALYSIS

The first step that needs to be undertaken in order to better understand the functioning of the distribution facility is to understand how the different departments interact and the importance of the ease of flow between them.

By understanding how different areas of operation interact with one another in the facility at large a more effective solution can be generated, seeing as important links will be remembered and taken into account as the new facility design progresses.

The analysis of the current departmental as well as sub-facility relationships was done using a relationship diagram (Figure 4 in the Appendix). This diagram shows the important links between the different departments and sub-facilities, by looking at the link between a department and each of the other departments then giving a score based on importance of the link between them, and giving a reason for the importance. The results of this analysis can be seen in the appendix. The most important links are shown in blue and the most unwanted links in red. The key to understanding the notation of the relationship diagram are given bellow the diagram itself in Table 1 and Table 2

As can be seen from the relationship diagram the most important departmental links are those between:

1. The Distribution Counter and Shipping
2. Distribution Counter and Sales
3. Distribution Counter and The Technical Department
4. Distribution Counter and Storage
5. Inbound Deliveries (Receiving) and Outbound storage
6. Shipping and Storage
7. Technical and Storage
8. Sales and the Boardroom

The most unwanted inter departmental links are:

1. Between receiving and Shipping
2. Receiving and the Boardroom
3. Sales and Storage
4. Storage and Boardroom
5. Storage and the Lunch Garden

By constantly referring back to the relationship diagram alternative layouts can be generated that in themselves eliminate most of the problems, seeing as many of the biggest problems and areas where flow is bad are highlighted through the use of the relationship diagram

SPACE ANALYSIS

The analysis of the amount of space that a certain function of a facility takes is one of the most important steps in successful facilities design. Without it, a new facility may end up with insufficient space for a function or process.

The main focus of the space analysis is to look at the amount of space that stock takes up in the facility and then at their current storage capabilities. Because the actual, physical space available is limited to the existing rooms, with a few opportunities to break out walls to expand spaces, it is very important to plan and estimate future requirements very carefully.

CURRENT STORAGE CAPABILITIES

The analysis of the area that is currently being used will be done in terms of three functions: The Total Shelving space being used; the total floor area available and the amount of space that the stock currently requires.

CURRENT SHELVING AVAILABLE

Table 1, bellow depicts the amount of shelf area available in the different storage areas. This table, along with the one depicting the floor area can be used in comparison with the amount of storage space that is currently necessary.

Table 1: Amount of Shelving Space Available

Current Shelving Available								
Area	**Sub Area**	**No. of Stacks**	**L(mm)**	**D(mm)**	**H(mm)**	**Area (m^2)**		**Cubic Space (m^3)**
STOCK 1	a	6	1840	460	400	5.0784		9.344256
STOCK 2	a	6	1840	460	400	5.0784		9.344256
STOCK 3	a	6	1840	460	400	5.0784		9.344256
SMALL	a	5	1120	600	243	3.36		3.7632
	b	3	210	210	100	0.1323		0.027783
CSD	a	1	940	480	200	0.4512		0.424128
	b	5	880	480	400	2.112		1.85856
	c	5	880	480	400	2.112		1.85856
	d	1	270	480	560	0.1296		0.034992
					Total	23.5323		35.999991

FLOOR AREA AVAILABLE

The total amount of floor space available in the different storage areas in the current facility are as follows:

Table 2: Amount of Floor Space Available

Area	Area Description	Length		Width		Area		Cubic	
		m	mm	m	mm	m^2	mm		m^3
1	**CSD**	3.5	3500	2	2000	7	7000000		49
2	**Incoming/Outgoing**	2	2000	2	2000	4	4000000		16
3	**Small Storage**	2	2000	1.5	1500	3	3000000		12
4	**Storage 1**	5.5	5500	5.5	5500	30.25	30250000		332.75
5	**Storage 2**	7	7000	4	4000	28	28000000		392
6	**Storage 3**	4	4000	2	2000	8	8000000		64
7	**Technical**	4.5	4500	2.5	2500	11.25	11250000		101.25
					Total	91.5			967

This data will aid in determining the total amount of storage space needed to hold the current amount of stock.

STOCK SPACE REQUIREMENTS

The current total amount of space needed by the stock can be summed up as follows:

Table 3: Total amount of space needed for Component Stock

	Area (m^2)	Cubic (m^3)
Total	176.6262597	84.23119534

As can be seen from the above, the use of floor area and stacking is essential to meeting the space requirements of the stock in the facility. Otherwise there will be a deficit on the amount of space of 62 m^2.

By using these space requirement parameters, a strategy can be created to ensure that any new layout will be able to cope with the space requirements of the stock for both the present and future requirements.

STORAGE AREA ORGANIZATION

Without knowing where a certain component goes in the storage areas of the facility, currently, it will be hard to effectively determine the best way to set-up alternate layouts in terms of the stock.

The basic breakdown of the different parts of the storage areas; in terms of what components are stored there, are as follows (Please refer to Figure 2):

Table 4: Storage Area Breakdown in terms of components

Storage 2i (Small Storage)	Storage 2ii	Storage 2iii	CSD (Display Case)
RAM	Motherboards	Printers	Flash Drives
Hard Drives	CPU	Keyboards	Memory Cards
Software	Graphics Cards	Speakers	Headsets
	Software	Headsets	Game Controllers
	Cables	Boxes CPU’s	Graphics Cards
	Screens	Boxes Motherboards	Mouse
	Multimedia Devices	Routers	
		Switches	
		DVD-RW	
		LCD	
		Cases	
		CD/DVD’s	
		Mouse Pads	
		Cartridges and Toner	
		Add-on Cards	
		PSU	
		Laptop Bags	
		UPS	

By using this current storage strategy as a base, an improved strategy can be determined, once an alternative, new layout has been chosen.

CHAPTER 4: DEVELOPMENT OF SOLUTION TOOLS

ALTERNATIVE LAYOUTS

After the space requirement study is done, the next step in the systematic layout planning methodology is to develop block or alternate layouts. From these layouts the most suitable layout will be chosen to be implemented.

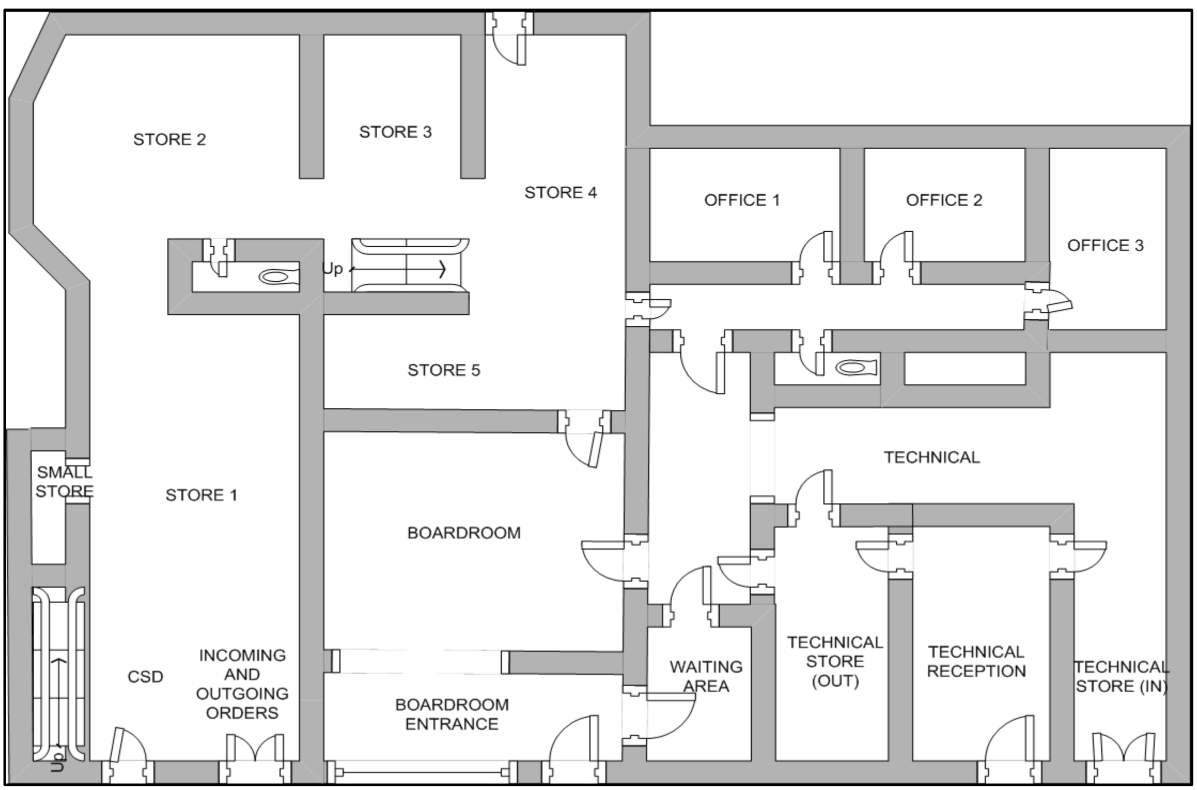
The alternate layouts will be judged by means of simulation modeling of the flow of customers and stock through the facility; how much expansion each layout gives in terms of stock carrying capabilities; economic analysis and by means of looking at the positive and negative features of each of the layouts.

ALTERNATE LAYOUT ONE

The first layout as can be seen in the figure below, is one that changes very little in the way that the day to day operations of the CSD and storage systems works. It simply moves the technical department and gives it more space.

Another feature of this layout is the large corporate dedicated areas. The boardroom now has its own entrance and waiting area, as well as a more private link to the offices of the managers and corporate liaison. The storage areas have also been increased significantly.

Figure 4: Alternate Layout One



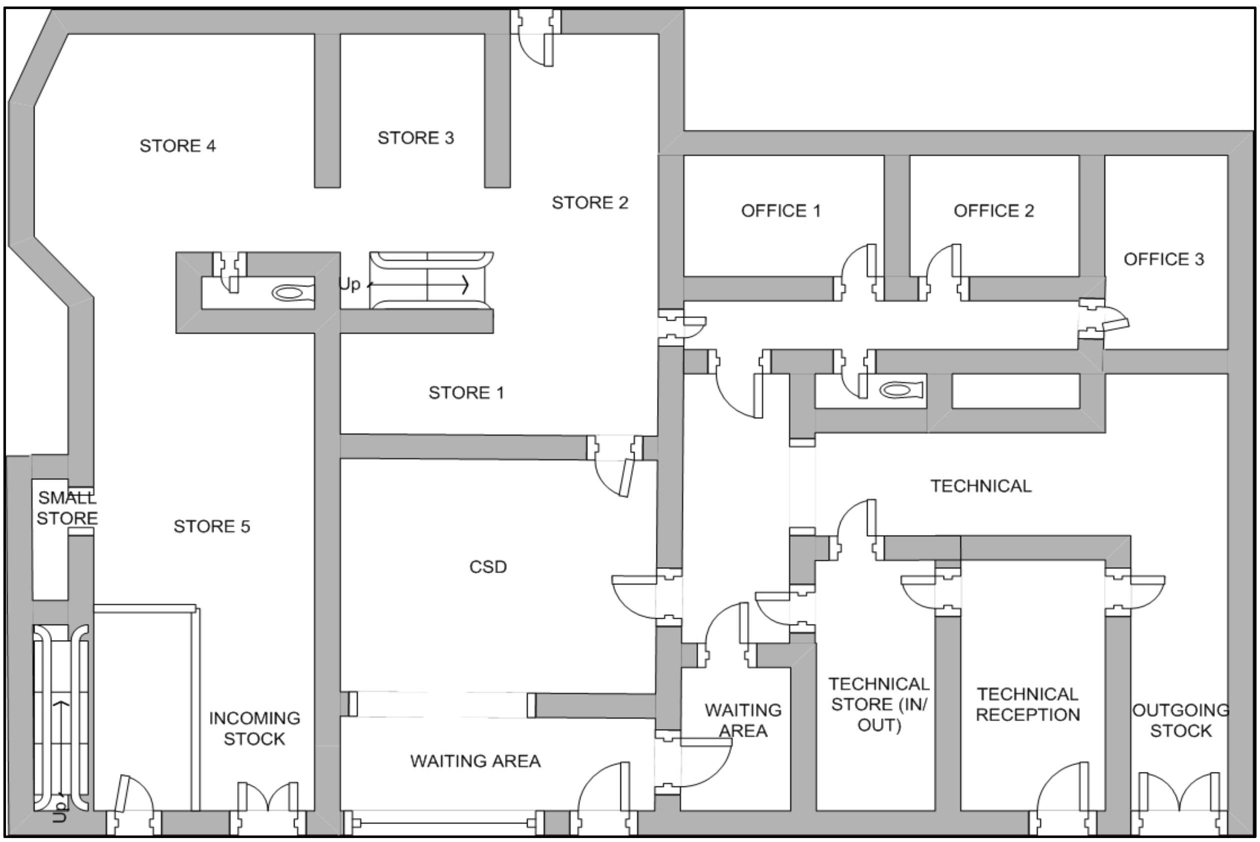
ALTERNATE LAYOUT TWO

The second Layout is much more orientated towards the internal flow of stock through the facility.

The Incoming and Outbound Deliveries have been split, eliminating confusion of orders coming in and going out. Another Key feature is that as the stock comes in; it is sorted, sent to the correct storage area. When it is needed, either at the CSD or by the technical department, everything is easily interlinked and the flow of stock will be improved.

However, seeing as the customers have to walk by the inbound stock area from the sales department to the CSD, it can be seen as not a very customer friendly layout.

Figure 5: Alternate Layout Two

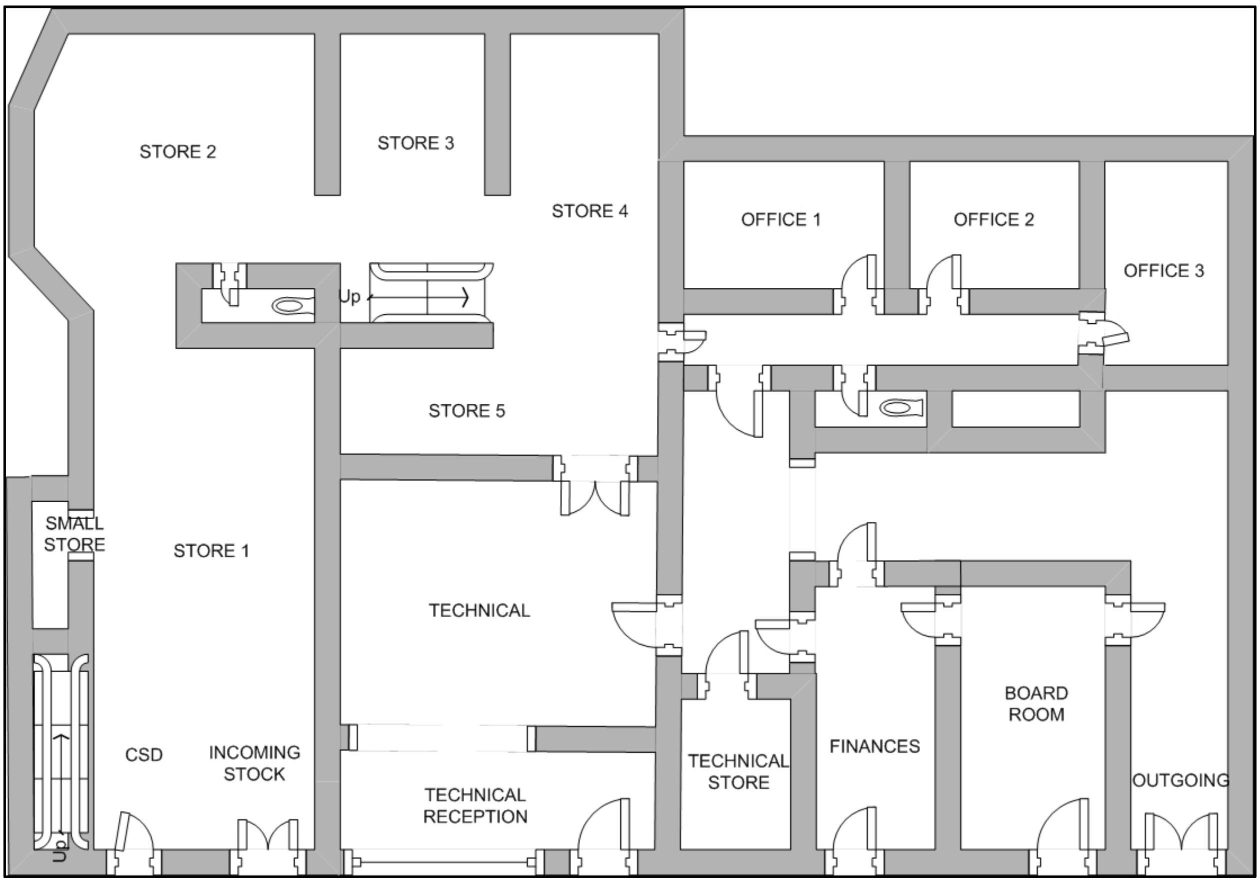


ALTERNATE LAYOUT THREE

The biggest trademark of this alternative is that the technical department is located directly next to the stores, this will increase the flow through them significantly. It is also the only layout where the outbound orders can be assembled and stored in their own area before pickup.

A problem with this layout is that the use of space may not be as effective as would otherwise be with the other two layouts. However, the fact that finances moves down means that customers can now go to any of the areas that they may wish to visit more easily. Thus this can be seen as a customer friendlier layout.

Figure 6: Alternate Layout Three



The top floor of the facility mostly stays the same for all three alternatives, except that the small board room becomes a coffee room for the staff and on Alternate Layout Two Finances is replaced with corporate offices. Please refer to the Appendix; Figure 18 and 19 for the schematic on each of the alternatives' top floor layout.

ALTERNATE LAYOUT ANALYSIS

The main purpose of this section will be to look at any flaws as well as good features of the alternate layouts in order to help in the final decision making processes. This analysis should be confirmed by the simulation models as well as the other decision making tools that will be used

The alternatives will be evaluated according to the following criteria:

- Whether the alternative meets the space requirements
  - Utilization assuming current stock levels
  - How much headroom for expansion is available?
- The general flow of the layout (General, not simulation)
  - Customer flow
  - Stock flow
  - Identification of bottle necks
  - Inefficiencies
- Critically looking at obvious advantages and disadvantages of a layout
- Amount of area assigned to functional areas

SPACE REQUIREMENT STUDY OF ALTERNATIVE LAYOUTS

The space requirements for each alternative will be discussed by means of looking at the total amount of floor space available, the amount of shelving space that can be put in and then looking at the ratio between the space that the components require and the space that is available for storage. Please take note that the only workstation space requirement that has an influence on the storage area is the workstation at the CSD and in terms of the departmental planning is negligible for this analysis.

In the tables below the complete space analysis is shown for each alternative

Table 5: Floor and shelf space for Alternate One

Alternate Layout 1 Floor Space Available					Shelving Area		
Area Description	**Length**	**Width**	**Area**	**Cubic**	**Shelves**	**Area of Shelf**	**Shelving Area**
	m	m	m^2	m^3		m^2	m^2
CSD	3.5	2	7	49	0	4.8	4.8
IN/OUT	2	2	4	16	0	0	0
Small Storage	2	1.5	3	12	0	3.492	3.492
Storage 1	5.5	5.5	30.25	332.75	8	0.8464	6.7712
Storage 2	7	4	28	392	8	0.8464	6.7712
Storage 3	4	2	8	64	6	0.8464	5.0784
Storage 4	4.5	2.5	11.25	101.25	6	0.8464	5.0784
Storage 5	3	2	6	36	3	0.8464	2.5392
Technical IN	7	3	21	294	6	0.8464	5.0784
		Total Floor	118.5	1297		**Total**	39.6088
		CSR	176.63	84.23		**Floor and Shelf**	158.1088
	Utilization		1.490549	0.06494		**Total Utilization**	1.11714212

Table 6: Floor and shelf space for Alternate Two

Alternate Layout 2 Floor Space Available					Shelving Area			
Area Description	**Length**	**Width**	**Area**	**Cubic**		**No of Shelves**	**Area of Shelf**	**Shelving Area**
	m	m	m2	m3			m2	m2
CSD	4.5	4	18	162		6	0.8464	9.8784
IN	2	2	4	16		0	0	0
Small Storage	2	1.5	3	12		0	3.492	3.492
Storage 5	5.5	5.5	30.25	332.75		8	0.8464	6.7712
Storage 4	7	4	28	392		8	0.8464	6.7712
Storage 3	4	2	8	64		6	0.8464	5.0784
Storage 2	4.5	2.5	11.25	101.25		6	0.8464	5.0784
Storage 1	3	2	6	36		3	0.8464	2.5392
Technical IN/OUT	3	2	6	36		4	0.8464	3.3856
Outbound	7	3	21	294		0	0.8464	0
		Total	135.5	1446			**Total**	42.9944
		CSR	176.63	84.23			**Total Floor and Shelf**	178.4944
		Utilization	1.303542	0.05825			**Total Utilization**	0.989554854

Table 7: Floor and shelf space for Alternate Three

Alternate Layout 3 Floor Space Available					Shelving Area		
Area Description	**Length**	**Width**	**Area**	**Cubic**	**No of Shelves**	**Area of Shelf**	**Shelving Area**
	m	m	m2	m3		m2	m2
CSD	3.5	2	7	49	0	4.8	4.8
Incoming	2	2	4	16	0	0	0
Small Storage	2	1.5	3	12	0	3.492	3.492
Storage 1	5.5	5.5	30.25	332.75	8	0.8464	6.7712
Storage 2	7	4	28	392	8	0.8464	6.7712
Storage 3	4	2	8	64	6	0.8464	5.0784
Storage 4	4.5	2.5	11.25	101.25	6	0.8464	5.0784
Storage 5	3	2	6	36	3	0.8464	2.5392
Technical IN/OUT	3.5	2.5	8.75	61.25	4	0.8464	3.3856
Technical	2.5	2	5	25	4	0.8464	3.3856
OUT	7	3	21	294	0	0.8464	0
		Total	132.25	1383.25		**Total**	41.3016
		CSR	176.63	84.23		**Total Floor and Shelf**	173.5516
	Utilization		1.335577	0.060893		**Total Utilization**	1.017737664

As can be seen from the space availability studies above, the minimum total (Floor and Shelving) utilization is for Alternate 2, this being 0.98. The utilization figure is for the area only, thus it ignores stacking and thus the use of cubic space. In the storage areas stacking is used throughout

The use of stacking decreases the total amount of space being used significantly and thus increases the amount of goods that can be stored in the facility. Through the use of stacking, all three alternatives can accommodate a large increase in the volume of goods stored for the timeframe of the project.

If at any time the cubic space utilization rises above a certain level, the stacking and packing procedures and methodologies can simply be reviewed and optimized to make better use of the space available

Thus all three alternatives are viable in terms of space requirements for component stock levels as well as workstations.

For the full breakdown of the workstation space requirements, that is to be used during the departmental planning phase of the project, please see the Appendix, Table 29

FLOW ANALYSIS FOR THE ALTERNATIVE LAYOUTS

Through the analysis of the flow of customers and stock through the facility, we can gain an understanding of how the different functional areas in the facility interact.

CUSTOMER FLOW

Alternative 1:

The customers arrive at ECO Technology and as previously stated and true for all Layouts have the option of going to any one of the following functional areas:

- CSD
- Sales
- Technical
- Finances
- And in some cases the boardroom.

The CSD, Sales and Technical departments are the three that get the most traffic between them though. In this light, this layout is not perfect, seeing as they are quite far removed from one another.

Alternative 2:

In this layout the CSD and Technical departments are close together, but far away from the sales department. Another negative factor is that customers will have to walk by the incoming deliveries on their way from the sales department to the CSD, this is undesirable.

Alternative 3:

In this layout all the departments and areas that customers may wish to go to are close together. The sales department and CSD are where customers are use to them being, the technical department and finances are also quite close.

The only negative factor is that the customers will have to walk by the inbound deliveries on the way to the technical department.

STOCK FLOW

The stock flows between the following functional areas of the facility for all of the alternate layouts, the only deferens is the constraints that stock flow can encounter on the path between:

- Inbound Deliveries
- Storage Areas
- CSD
- Technical
- Outbound deliveries

The flow of stock through each alternative will now be analyzed.

Alternative 1:

The first thing to note is that the inbound and outbound deliveries are at the same place. This could lead to confusion and mistakes being made with orders and cost the company some money in the long run.

From the inbound side the stock is sorted and sent to the different storage areas; from here it is taken either to the technical department, the CSD or the outbound deliveries.

In this layout the flow from the storage areas to the technical department is constrained and may form bottle necks in the flow, however the ease of access from the store rooms to the CSD, inbound and outbound delivery areas are very high.

Alternative 2:

In this alternative it can be seen that the same constriction lies between the store rooms and the technical department.

The advantage to flow of this layout is in the fact that the inbound and outbound delivery areas are split and may lead to less confusion between what is coming in or going out. The CSD has ample access to the storage areas in this layout, as well.

Alternative 3:

Like the previous layout this layout features the splitting of the In and Outbound delivery areas, the CSD has easy access to any of the store rooms as does the technical department.

The only feature that may not be as effective as could be possible is the fact that a large room in the middle is not being used, as this leads to the outbound delivery area, thus helping in the flow to that area. This open area could easily accommodate a few shelves for supplementary storage space though.

SIMULATION MODELING

The same basic simulation strategies will be used in the simulation of the customer and stock flow models respectively; for the current, base situation, as well as for the alternates.

CUSTOMER FLOW SIMULATION

The analysis of the customer flow will be done as follows: analysis of the input data needed to construct the models; analysis of the basic simulation logic for the models and by analyzing the output data necessary in the final decision making process.

CUSTOMER FLOW INPUT DATA ANALYSIS

The base simulation as well as the three alternate layout simulations will all need the same basic sets of data to construct the models:

- Probability of a customer going to a specific area when they first arrive
- Probability of a customer going to another area after already having been to one
- Time it takes a customer to go to a area when they arrive (Arrival to Area Times)
- Time it takes a customer to move between areas (Inter area Times)

ARRIVAL PROBABILITIES

The analysis of the probabilities of customers to go to a specific area first after their arrival was done by means of personal experience as well as on site statistics available and a short study of the trends over a time. Where the probability to go to a specific area first can be determined as follows

$$P(x_n) = \frac{n}{m}$$

Where $P(x_n)$ is the Probability of a customer going to area n when arriving

M is the total number of arrivals over a time span

Through the use of this analysis the following results were obtained for the current layout as well as the alternatives, seeing as the alternative layouts do not change the need for customers to go to a specific area. This is also true for the probability of going to a specific area after having been to another.

Table 8: Probability of Going to area after Arrival

Area	Probability
Customer Service Desk (CSD)	0.385
Sales	0.373
Technical	0.192
Finances	0.05

INTER AREA PROBABILITIES

Another probability to be considered is that of a customer to go to an area after already having been to a different area. The same strategy of experience and study was followed to obtain this data set.

$$P(x_{ij}) = \frac{n_{ij}}{M}$$

With:

$P(x_{ij})$ is the probability of going to area i after having been to area j.

n_{ij} is the number of customers going from area i to j.

M is the total number of customers moving between areas in a time.

The results of this analysis are as follows:

Table 9: Probability of going to Area i after having been to Area j

	CSD	Sales	Technical	Finances	Leave
CSD	0	0.3	0.25	0.05	0.4
Sales	0.6	0	0.2	0.05	0.15
Technical	0.25	0.2	0	0.1	0.45
Finances	0.45	0.35	0.1	0	0.1

The analysis of the times it takes customers to move between areas is one of the most important seeing as this is what will eventually determine the flow time of customers in the system.

The data was collected through the use of time study and previous experience. The times will be given in two data sets: The time it takes a customer arriving to go to an area and the time it takes between areas.

ARRIVAL TO AREA TIMES

The basic Arrival to Area time's data was gathered and then put through arena's input analyzer to determine the correct process times for customers arriving, traveling to an area.

The results obtained after doing this will be given in the format of Arena's input language.

Table 10: Arrival to Area Distribution Times for each Simulation (In Minutes)

To Area	Current Facility	Alternative 1	Alternative 2	Alternative 3
CSD	BETA(2.52,4.15589)	BETA(1.8,2.40871)	0.06 + ERLA(0.0277,10)	-0.04 + ERLA(0.0274,8)
Sales	NORM(0.409,0.143)	0.09 + 0.53*BETA(5.49,3.45)	0.16 + GAMM(0.035,7.03)	0.19 + ERLA(0.0252,9)
Technical	0.29 + 1.08*BETA(3.03,5.24)	NORM(0.413,0.0836)	NORM(0.501,0.0789)	NORM(0.32,0.0703)
Finances	0.17 + 1.18*BETA(3.47,4.51)	0.41 + 0.49*BETA(3.82,3.64)	NORM(0.66,0.091)	0.2 + GAMM(0.0257,15.3)

These distributions will be used directly in the model to ensure that the arrivals to area times are as close to a real life situation as possible, yet it is important to remember that these times are only an estimate.

INTER AREA TIMES

The analysis of the inter area times for each simulation is a very important time, seeing as it is the time that will differ the most from simulation to simulation and thus add the most to the validation of the simulations and the usefulness of it as a decision making tool.

The data gathered on each data set was once again put through Arena's Input Analyzer and the following output sets were gathered to be used. Only the current facility's simulation data is shown, the alternate layouts' can be seen in the Appendix, Table 30 to 32.

Table 11: Current Layout inter area distribution times

Current Layout Simulation				
	CSD	**Sales**	**Technical**	**Finances**
CSD		0.11 + 0.45*BETA(3.77,3.71)	NORM(0.582,0.13)	0.06 + 0.94*BETA(4.84,3.56)
Sales	0.11 + 0.45*BETA(3.77,3.71)		0.3 + 0.82*BETA(5.19,4.28)	0.09 + 0.3*BETA(4.97,4.26)
Technical	NORM(0.582,0.13)	0.3 + 0.82*BETA(5.19,4.28)		0.29 + 1.11*BETA(8.22,6.83)
Finances	0.06 + 0.94*BETA(4.84,3.56)	0.09 + 0.3*BETA(4.97,4.26)	0.29 + 1.11*BETA(8.22,6.83)	

All the data given will be used in the setup of the simulations in order to ensure that the simulations are as true to the real life situation as possible.

OTHER DATA

The main focus of the simulation of the customers through the system is to determine the flow times of the customers in the system, something that is not important is the time the customer spends in service as the determination of optimal service times and levels falls outside the scope of the project.

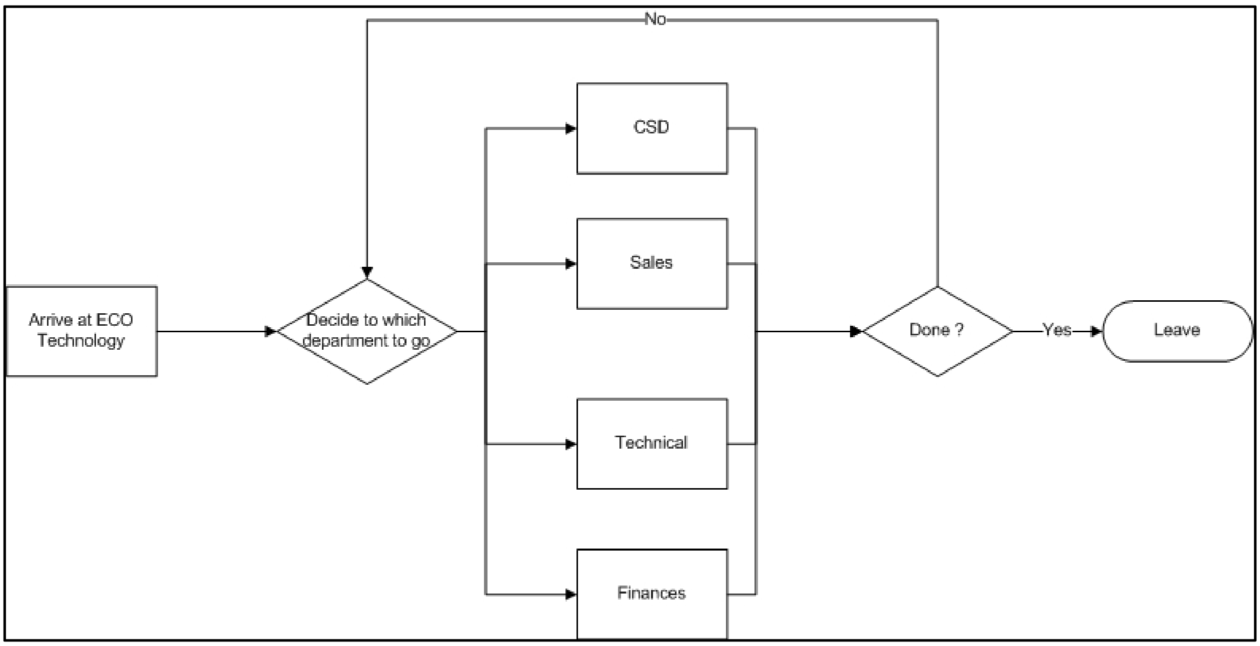
Another thing considered in the time studies was the obstruction of flow by deliveries etc by means of time penalties added to the allotted time if a customer has to walk by, for example the inbound deliveries area on the way to another area, as this influences the efficacy of the layout in terms of customer flow.

The arrival rate was also determined through the use of historical data and analyzed through the Input Analyzer and the basic arrival rate was found to be: Pois(6), which is according to a basic estimated Poison Distribution with a mean and standard deviation of 6 customers per hour.

CUSTOMER FLOW SIMULATION LOGIC

The basic logic can be seen in the following flow chart that demonstrates the flow of customers through the system. This basic schematic is what the models will be built from.

Figure 7: Customer Flow



As can be seen from the schematic the simulation model has to include not only the ability for a customer to go to one area but to go to multiple areas in one trip to ECO Technologies.

The final basic simulation model as well as the alternative layout simulations can be seen in the Appendix, Figure 20.

The time that the customers spend waiting to be served as well as in service at each area is not taken into account as this does not influence the actual traveling time between areas, which is the focus and aim of this simulation model.

The exclusion of the service time is done to ensure that the simulation model is as simple as possible without over cluttering and still useful to the final purpose; being the determination of the customer flow time, not the total service time or the utilization of employees in the different areas.

CUSTOMER FLOW SIMULATION RESULTS

The data that will be useful to the decision making and comparative purpose will be: the average time a customer spends in the system and the number of customers that are serviced.

AVERAGE TIME IN SYSTEM

The average time that a customer spends in the system is the main focus of the simulation as it represents the flow of the customers through the system. This will be the main representative statistic of the simulation and used to compare the alternative layouts to one another and to the base simulation of the current layout.

Table 12: Customer Flow Simulation Time in System

	Customer Flow	
Layout	**Hours**	**Seconds**
Current Layout	0.02628794	94.63
Alternative 1	0.0231075	83.187
Alternative 2	0.02534497	91.24189
Alternative 3	0.01912371	68.84536

These times represent the total average time of an entity through the simulated system. As can be seen, the current facility's time through system (TTS) is 94.63 seconds and the best alternative layout is Alternative 3 with a TTS of 68.85 seconds. This result is in line with what was predicted when Alternative Layout 3 was developed.

This result will be used along with the other decision making aids in determining the best layout to be implemented.

NUMBER OF CUSTOMERS THAT ARE SERVICED

The analysis of this statistic is only in aid of determining the comparability of the simulations to each other, as the arrival rate of the customers stays the same. Thus the output of the system should stay roughly similar.

Table 13: No of Customers Services

Layout	**No of Customers Serviced**
Current Layout	57
Alternate 1	58
Alternate 2	59
Alternate 3	59

Thus it is clear that none of the Alternate Layouts negatively affect the number of customers that can be serviced, although the recourses available to help customers at each station and the service time will have a larger effect. But it is clear that the difference in flow times does not have a significant influence on customer service capacity.

VERIFICATION AND VALIDATION OF CUSTOMER FLOW SIMULATIONS

Considering that all the Alternative simulations are built from the same basic simulation, the current facility's benchmark simulation. The validity of this simulation; should, given no important logic or principals changes, ensure that the other simulations stay valid.

Seeing as the only data that differs in each of the simulations is the travel times, it can be stated that these simulations will give accurate relative descriptions of the travel times of customers in the facility and thus be a good measure of the flow.

STOCK FLOW SIMULATION

The simulation of the flow of stock through the facility is in order to compare the time that stock takes on average to reach its destination in a particular layout. This is only in order to consider the amount of time that the stock spends in flow and not the time it is being sorted or in storage.

The simulation of the stock flow is a comparative aid, as the customer flow, in order to help in the final decision making of which layout to implement.

STOCK FLOW INPUT DATA ANALYSIS

The Data needed to create a valid simulation for the flow of stock through the facility is significantly more as that of the customer flow, seeing as there is a lot more processes and decisions to make.

The Data sets needed are as follows:

- The number of a particular size item in a delivery
- The probabilities of a size item to go to storage in a particular storage area
- The time it takes to move a size item to that area
- Probability of a size item to be assembled into an order for a particular output area
  - CSD
  - Technical
  - Outbound Deliveries
- The time it takes an item to be moved from a storage area to the aforementioned output area

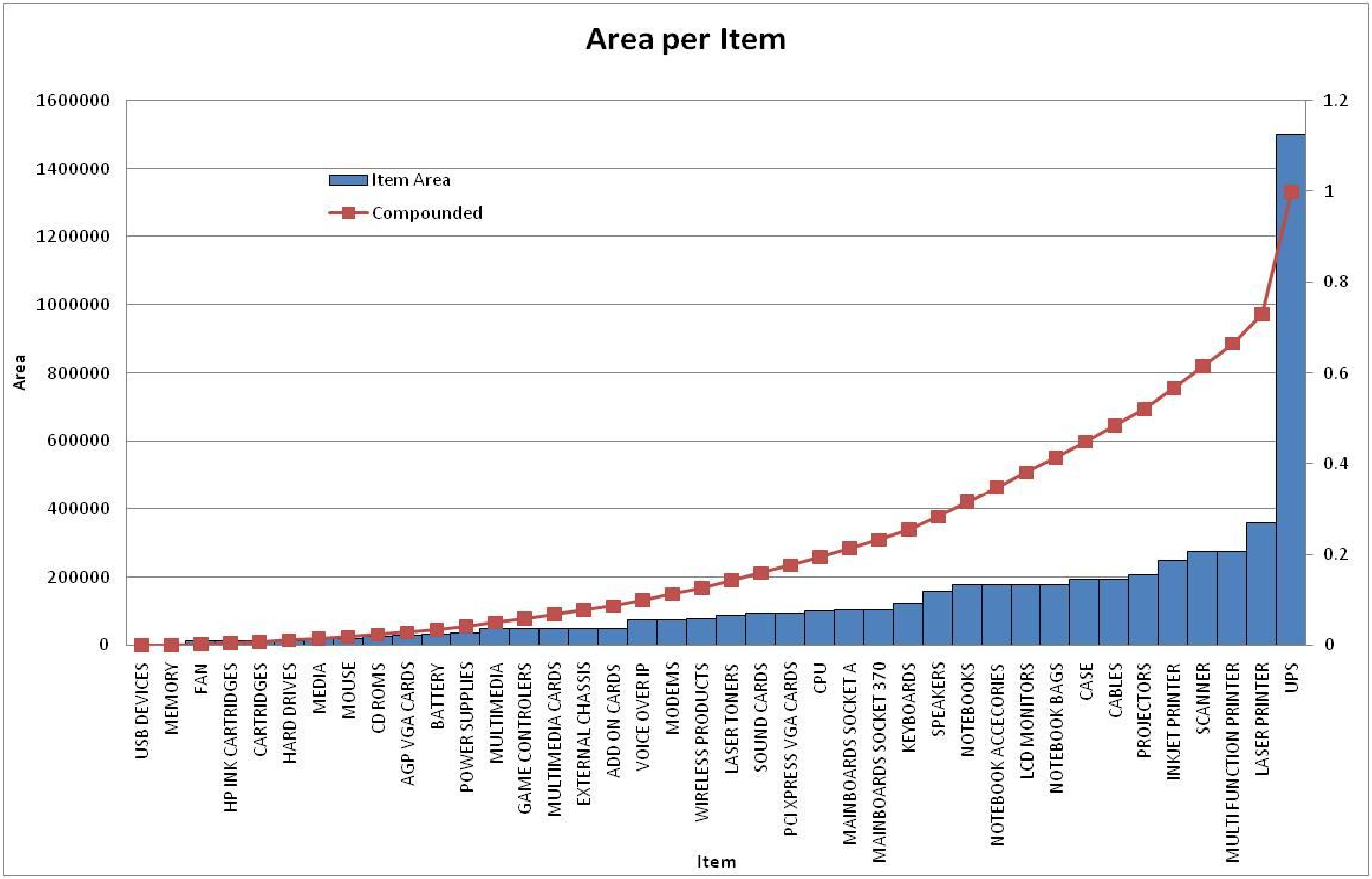
In the next sections, each of these input data sets will be discussed.

DELIVERY DISTRIBUTION

Deliveries from ECO Technology's suppliers are done twice a day, the first round 08:00 and the second approximately 16:00. The makeup of these order deliveries is what is important, seeing as this will determine the amount of a particular sized item to be moved through the system.

The decision to consider the stock arriving was done because an items size, rather than the quantity's that it is delivered in, determines its movement time in the facility. The 80:20 rule was applied to the gathering of the statistics in terms of that 20% of the types of stock make up 80% of the stock levels. The results can be seen on the graph on the next page.

Figure 8: Area per Item:



Considering this graph the items to be considered in the deliveries are as follows.

Table 14: Delivery Item Figures

		Quantity	Area	Area (m)
1	Scanner	5	275000	2.75
2	Laser Printer	9	360000	3.6
3	Multifunction Printer	11	275000	2.75
4	UPS	27	1500000	15
5	CPU	87	100000	1
6	CD ROMS	95	25600	0.256
7	MEMORY	99	1800	0.018
8	CASE	111	195000	1.95
9	KEYBOARDS	116	125000	1.25
10	HARD DRIVES	119	15000	0.15
11	NETWORK PRODUCTS	128	25600	0.256
12	CARTRIDGES	134	60000	0.6
13	MOUSE	136	21600	0.216
14	USB DEVICES	171	1050	0.0105

From these sets of data it was found that the arrival rate of each type of item is constant, with 8 hour intervals between each delivery and the entities per arrival for each of the different size of items are all triangularly distributed with the following details.

Table 15: Entities per Arrival Analysis

Size	Min	Expected	Max
Large	0	5	10
Medium	15	20	30
Small	35	50	60
Misc	6	12	20

PROBABILITY FOR SIZES TO GO TO AREAS

The analysis of where certain size items are stored is created using logic as well as knowledge of their current storage strategies and the obvious future storage strategies.

Table 16: Probability for an Item to go to a Storage Area

Probability of an item going to a particular Store (Current Simulation)				
Size	**Store 1**	**Store 2**	**Store 3**	**Small Storage**
Small	0.25	0	0.25	0.5
Medium	0.4	0.4	0.2	0
Large	0.1	0.6	0.3	0
Misc	0.15	0.45	0.35	0.05

The logic behind the links with 0.0 probabilities is that the particular size item is just not stored in that particular area.

TIME TO AREA

As each size item will have a different time it takes to get it to an area for each different facility layout, it is important to take note of these movement times in order to have a successful model.

The times and the necessary distributions were determined through the analysis of the traveling times of each size item to the area and then putting these data sets through Arena's Input Analyzer. The following outputs were gathered from this process for the current facility layout.

Table 17: Time to Area for Current Facility

Time to Area Distributions (Minutes)				
Size	**Store 1**	**Store 2**	**Store 3**	**Small Storage**
Small	-0.32 + 1.15*BETA(5.79,4.63)	NORM(0.665,0.166)	TRIA(0.56,0.787,1.16)	0.04 + 0.75*BETA(2.77,2.79)
Medium	NORM(0.406,0.105)	NORM(0.758,0.0953)	0.72 + WEIB(0.292,3.13)	0.19 + 0.6*BETA(4.16,3.69)
Large	0.45 + 0.8*BETA(4.14,4.43)	NORM(1.5,0.134)	NORM(1.67,0.122)	NORM(0.906,0.139)
Misc	NORM(0.628,0.198)	NORM(0.733,0.252)	NORM(1.33,0.239)	0.45 + LOGN(0.684,0.26)

The same data for each of the three alternatives can be seen in the Appendix, Tables 33 to35

FROM STORAGE TO AREA PROBABILITIES

The probability for an item to go to an output is taken to be the same for each of the storage areas, and each of the alternative layouts. This is to ensure that the only differentiating factors in the simulations are those of the travel times between areas and increase the comparability of the simulations

Table 18: Probability to go to Output Areas

Store	**CSD**	**Technical**	**Outbound Deliveries**
All	0.5	0.3	0.2

TIME TO OUTPUT AREAS

The time it takes from a particular store to an output area is a factor of the item size as well as the distance and constraints between the storage areas and the output area. A general time is taken as orders are made up from different size items and it then becomes hard to determine actual times for a particular size item from a area to a output. The times are setup relatively to each other.

The data needed for the simulations was once again gathered by studying the actual time it takes and inputting the data into Arena's Input analyzer. The output received for the current facility's simulation can be seen in the table to follow. The other alternate layout's data can be seen in the Appendix, Tables 36 to 38

Table 19: From Storage Times for Current Facility

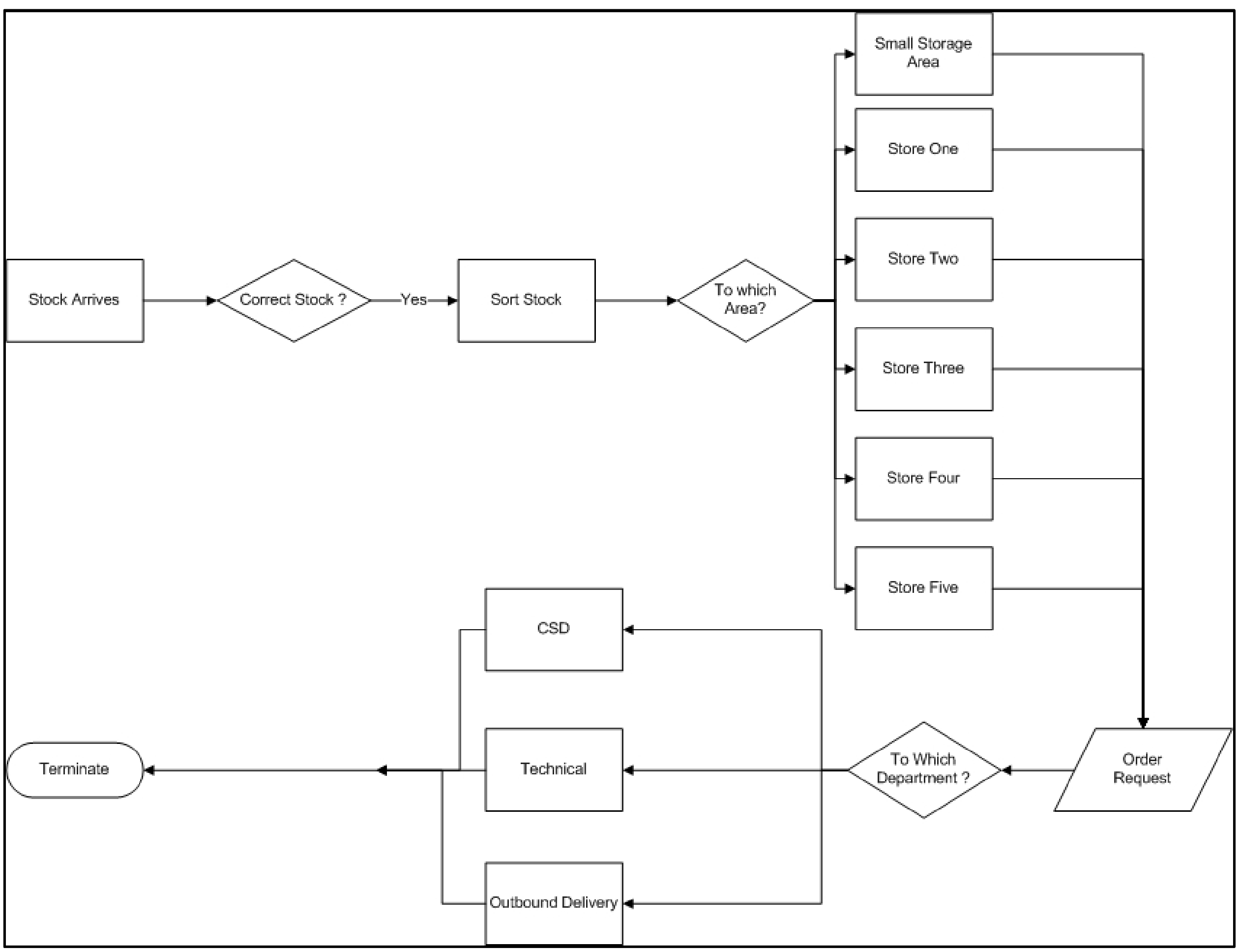
From Storage times distributions for Current Facility (Minutes)			
Store	**CSD**	**Technical**	**Outbound Deliveries**
Store 1	NORM(0.599,0.182)	0.65 + WEIB(0.962,3.42)	NORM(0.513,0.182)
Store 2	NORM(1.01,0.193)	NORM(1.33,0.19)	0.18 + 1.09*BETA(3.99,4.52)
Store 3	NORM(2.16,0.239)	NORM(1.54,0.246)	NORM(0.882,0.255)
Small Store	NORM(0.841,0.159)	1.24 + 1.17*BETA(6.11,5.2)	NORM(0.85,0.154)

SIMULATION LOGIC

The modeling of stock flow though the facility will help in analyzing each alternative's efficiency of operation between the internal departments.

The stock flow will be modeled as follows:

Figure 9: Stock Flow Logic



The actual model can be seen in the Appendix, Figure 21

The time that an item spends in storage will not be considered as it has no influence on the flow time of an item through the facility. The time in storage will be taken as a constant value, seeing as:

$$Time_{Total} = Time_{Flow} + Time_{Storage}$$

$$and\ if: Time_{Storage} = C$$

$$Then: Time_{Total} = Time_{Flow} + C$$

STOCK FLOW SIMULATION RESULTS

The results that will be used comparatively to determine the best facilities layout will be the average time in system. As this is a verifiable result to be compared to the real world situation and to each alternative's own result.

The average time in system is the time on average that an entity, in this case an item in stock spends in the system. This output will give us the best indication of how each layout compares to the next.

Figure 10: Stock Flow Simulation Results

Stock Flow Simulation Results	
Layout	**Average Time in System (Seconds)**
Current	69.48
Alternative 1	43.92
Alternative 2	53.64
Alternative 3	48.24

It is clear that for this simulation that Alternative Layout 1 is the best option as far as flow time is concerned. This will be taken into account when the final decision is made

VALIDATION AND VERIFICATION OF RESULTS

The easiest way to compare and validate a simulation like this is to compare it to the real life situation; to do this the results from the current facility's simulation will be compared to that of the current situation at ECO Technology.

When doing this it is clear that the base simulation at least conforms to the real world within a tolerance. As the alternative simulations were built from the base simulation and seeing as the results obtained from these simulations are as were expected in terms of stock flow and make logic sense, they can also be considered valid.

ECONOMIC ANALYSIS

The purpose of the economic analysis is to determine the estimated costs that will be incurred in the execution of the project. The analysis results will have a direct influence on the decision of which layout is to be implemented. In order to fully understand the cash flow, the analysis will be divided up into two parts:

- Short Term: The initial costs that will be incurred
- Long Term: The costs that may influence the cash flow over time (5 Year Horizon)

SHORT TERM COST ANALYSIS

The short term costs are those that will have to be incurred in order to implement a new facilities plan.

Table 20: Short Term Costs

Costs						
Alternative	**Shelving**		**Changes / Construction**	**Conference Facility**	**Office Equipment**	**Total**
	No Required	Costs				
1	37	R 60,310.00	R 30,000.00	R 31,000.00	R 30,600.00	R 151,910.00
2	41	R 66,830.00	R 20,000.00	R 22,200.00	R 30,600.00	R 139,630.00
3	39	R 63,570.00	R 20,000.00	R 22,200.00	R 30,600.00	R 136,370.00

As can be seen the most important costs that will be incurred during the execution of the facilities layout plan is: the cost of construction needed to transform current areas to suit their new purpose; cost of creating a conference facility; shelving costs that will be incurred to meet the shelving requirements of the new layout and the cost of any office equipment that may be necessary.

The best layout according to the short term analysis is Alternative 3, mostly because of the combination of low construction and shelving costs.

LONG TERM COST ANALYSIS

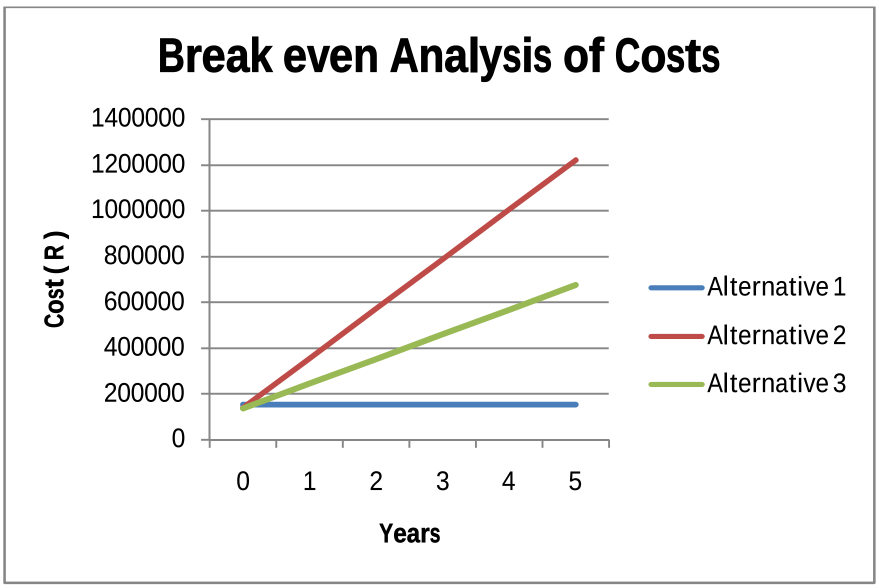
All the costs incurred in the short term are still applicable, but a factor that comes in with the 5 year planning horizon is that of the supplementary employees that may be needed in certain areas of the facility to ensure that the changes are worthwhile.

The following graph shows the long term implications of the implementation of each of the alternatives.

Table 21: Long Term Costs

Costs								
Alternative	Shelving		Changes / Constructio n	Conference Facility	Office Equipment	Employees		Total
		Costs					Cost (p.a)	
1	37	R 60,310.00	R 30,000.00	R 31,000.00	R 30,600.00	0	R 108,000.00	R 151,910.00
2	41	R 66,830.00	R 20,000.00	R 22,200.00	R 30,600.00	2	R 108,000.00	R 139,630.00
3	39	R 63,570.00	R 20,000.00	R 22,200.00	R 30,600.00	1	R 108,000.00	R 136,370.00

Figure 11: Long term Cost Analysis



Thus from the long term analysis here it becomes apparent that because Alternative 1 needs no new employees, it becomes the best option for implementation, economically.

The reason for the new employees for Alternate Layout 2 and 3 is because of the increase in space for CSD and Technical, respectively in each of the layouts.

DETERMINATION OF PREFERRED LAYOUT

This section will deal with the steps followed to ensure that the layout picked to be implemented is the best all-round alternative to ensure the best trade-off between the different analysis method's results.

The method of choosing between different alternatives and considering different decision making tools that makes the most sense is; the weighted average method, which is implemented through the use of the weighted Factor Comparison Form. This forms scores each alternative against the importance of the decision criteria and its performance.

The following table shows how each alternative places on each of the criteria. This will be important in the final decision.

Table 22: Alternative Layout Placements

Criteria	**1st**	**2nd**	**3d**
Stock Flow Simulation	Alternative 1	Alternative 2	Alternative 3
Customer Flow Simulation	Alternative 3	Alternative 1	Alternative 2
Short Term Economic Analysis	Alternative 2	Alternative 3	Alternative 1
Long Term Economic Analysis	Alternative 1	Alternative 3	Alternative 2
Space Requirements	Alternative 2	Alternative 3	Alternative 1

From this we can determine that the final scores of each of the alternatives with the Weighted Factor Comparison Form.

Table 23: Weighted Factor Comparison Form

Weighted Factor Comparison Form							
		Alternative 1		**Alternative 2**		**Alternative 3**	
Factor	Weight	Rate	Score	Rate	Score	Rate	Score
Stock Flow	30	10	300	8	240	6	180
Customer Flow	20	8	160	6	120	10	200
Short Term Economic Analysis	10	6	60	10	100	8	80
Long Term Economic Analysis	20	10	200	6	120	8	160
Space Availability	20	6	120	10	200	8	160
	100		840		780		780

CHAPTER 5: SOLUTION

The methodology that will be followed to represent the solution will consist of the following basic elements

- Facility Layout Schematics
    - Departmental Layout
    - Equipment Layout
- A list of amounts of equipment to be purchased
- A list representing what and how much equipment must go to each area (Both purchased and already owned)
- A basic implementation Strategy

FACILITY LAYOUT SCHEMATICS

The following Layout schematics are included in this section to ensure that the departmental and equipment layout schematics of the ground floor as well as the top floor receive accurate and clear representation.

Figure 12: Departmental Facility Layout to be Implemented (Ground Floor)

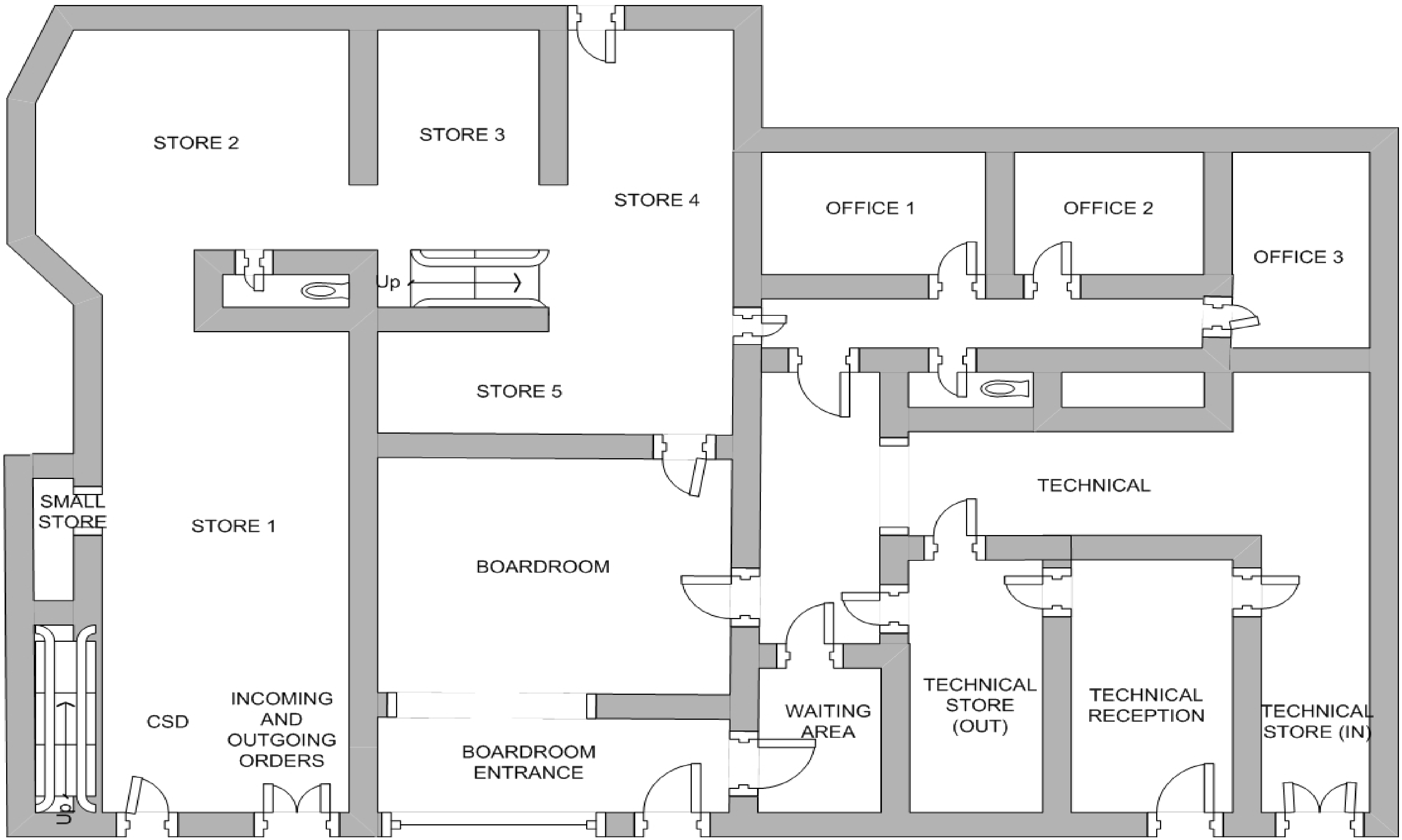


Figure 13: Departmental Facility Layout to be Implemented (Top Floor)

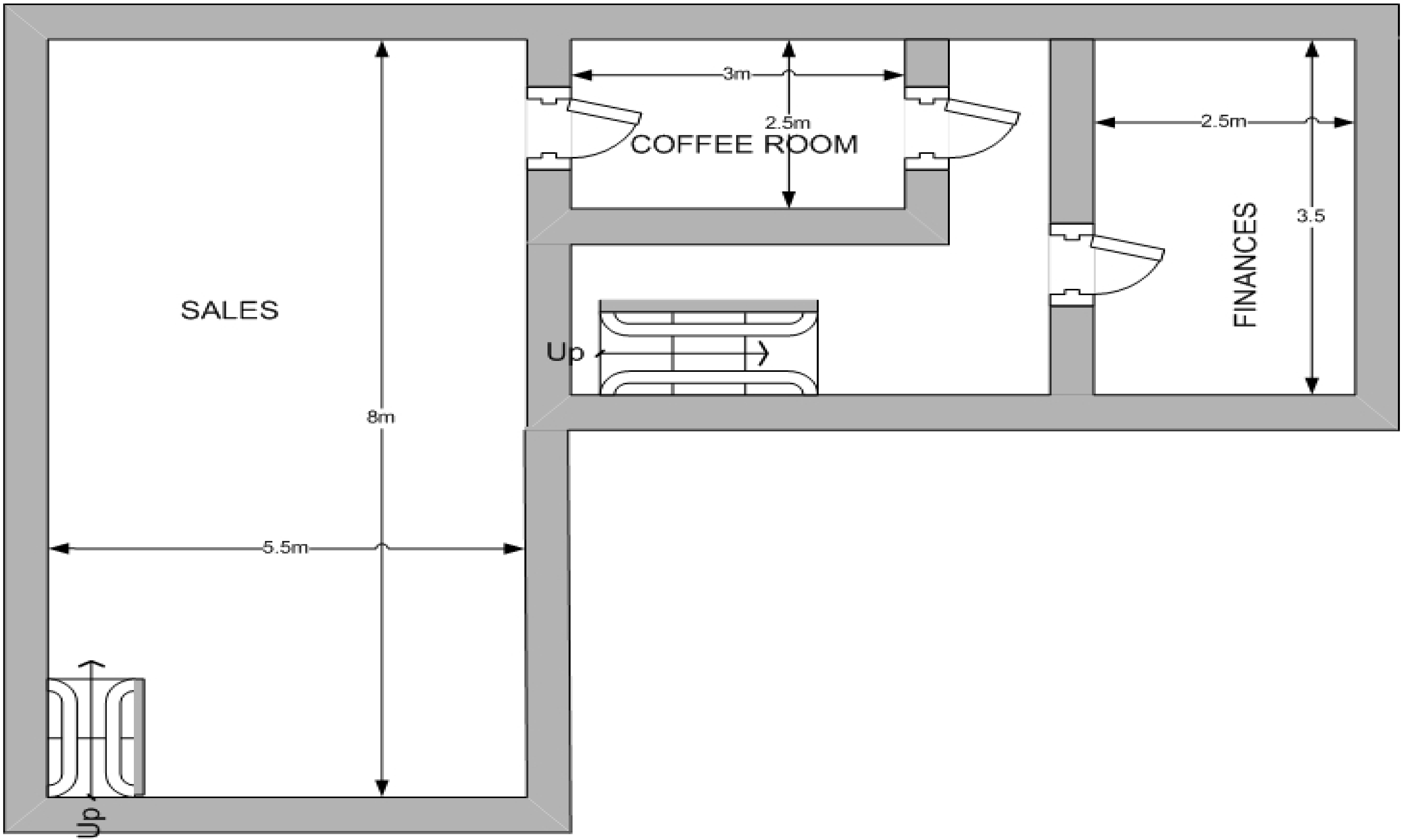


Figure 14: Equipment Layout Schematic (Ground Floor)

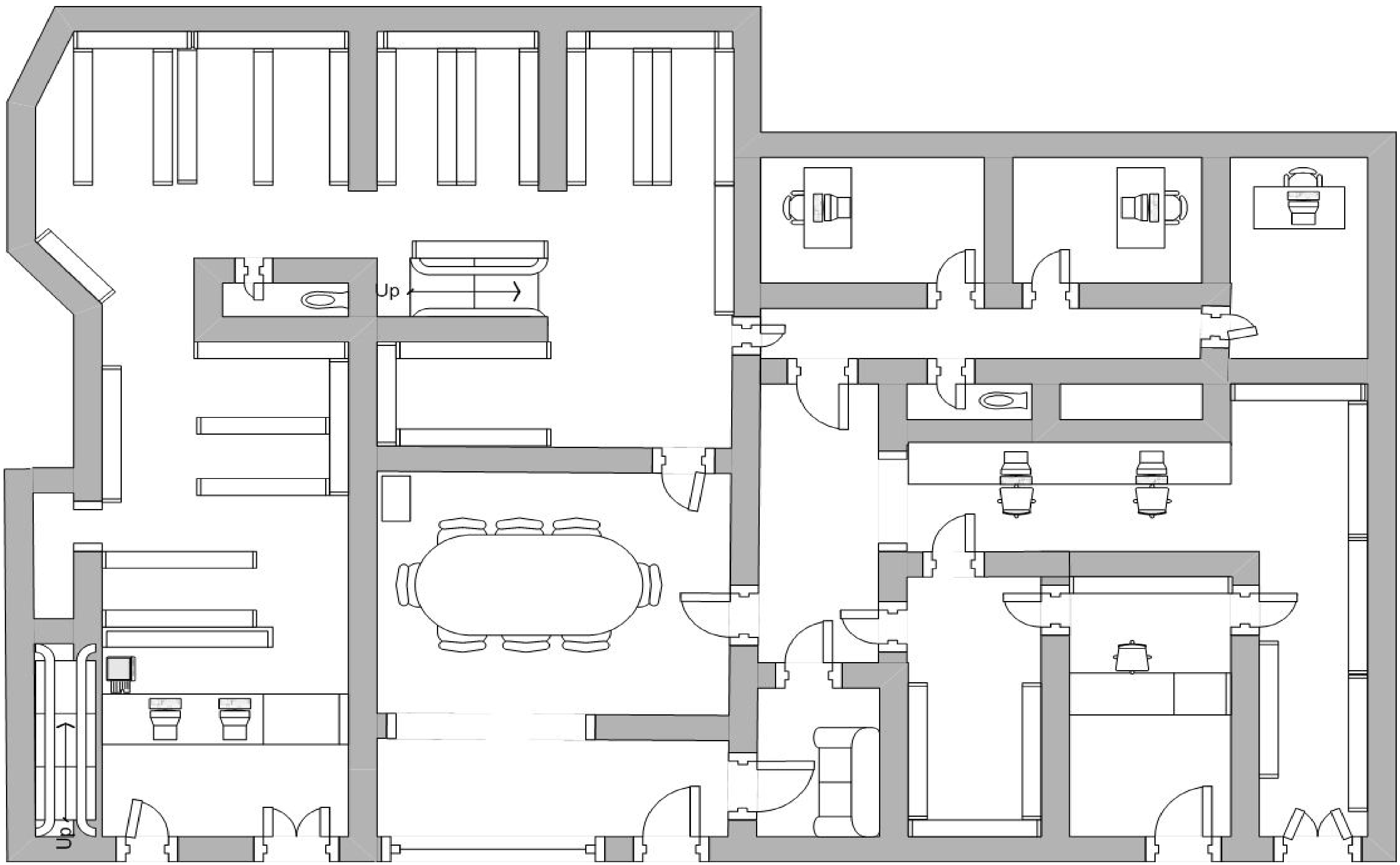
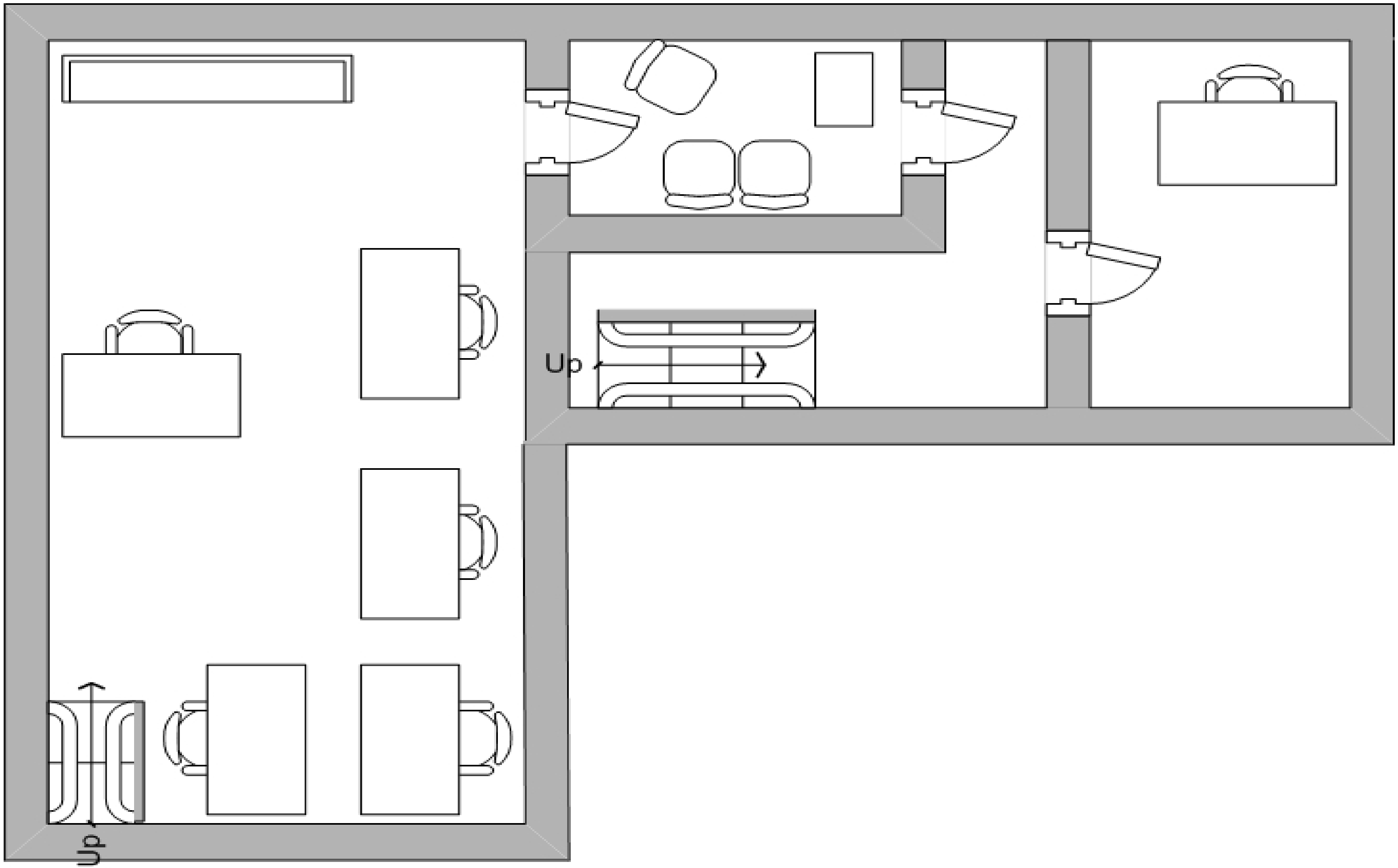


Figure 15:Equipment Layout Schematic (Top Floor)



EQUIPMENT NEEDED

This section deals with the details of what equipment needs to be purchased and how much, it also deals with the type and amount of equipment that every functional area of the facility needs.

These lists can be used to, not only determine what needs to be purchased, but also to determine where things need to be put or moved to.

LIST OF EQUIPMENT

Table 24: Equipment Requirement Details

	Need	Currently	Buy
Shelves	37	18	19
Conference Tables	1	0	1
Desks	9	6	3
Conference Chairs	8	0	8
Coffee Machines	2	1	1
Desk Chairs	9	6	3
Printers	2	2	0
Desktop Computers	14	14	0
Filing Cabinets	2	2	0
Chairs	3	0	3
Display Cases	2	2	0
Work Benches	3	2	1
Stools	3	2	1
Couch	1	0	1

The table above can be used as a quick reference if there is doubt on the amounts of equipment needed in terms of what is currently needed and what needs to be bought.

EQUIPMENT PLACEMENT

This section shows two tables: the first shows how much and where a particular piece of equipment needs to be placed and the second shows the shelving requirements for an area.

This is to aid the layout implementation process and ensure that all the departments are adequately equipped.

Table 25: Departmental Equipment Requirements

Departmental Equipment Requirements							
	CSD	Technical	Sales	Finances	Conference	Management	Coffee
Conference Tables					1		
Desks			5	1		3	
Conference Chairs					8		
Coffee Machines					1		1
Desk Chairs			5	1		3	
Printers	1		1				
Desktop Computers	2	3	5	1		3	
Filing Cabinets				2			
Chairs				0			3
Display Cases	1		1				
Work Benches	1	2					
Stools		3					
Couch					1		

Table 26: Departmental Shelving Requirements

Departmental Shelving Requirements	
	No Of Shelves Needed
Store 1	8
Store 2	8
Store 3	6
Store 4	6
Store 5	3
Small Store	0
Technical	6
Total	37

IMPLEMENTATION STRATEGY

Any form of change is commonly met with resistance as the employees are comfortable with the way that things operate and because of fear of more things changing. The change to a facility can be especially troublesome as there is not just a change in how things are done, but in where they are done.

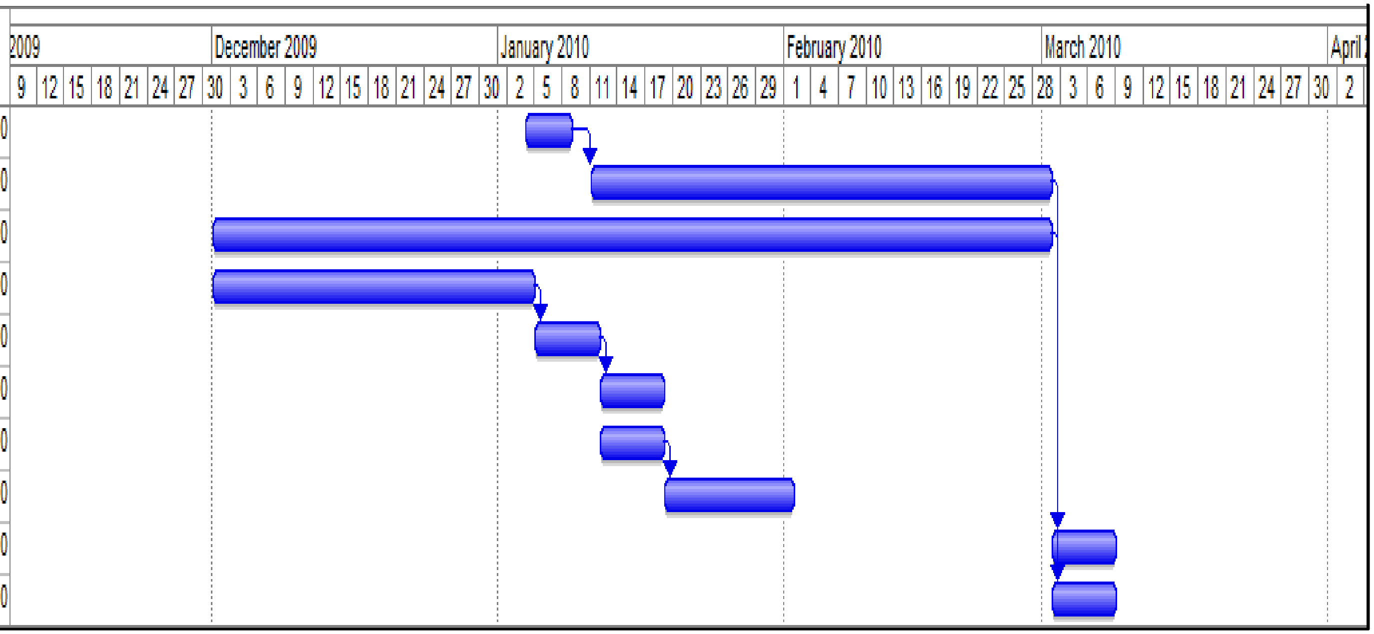
By following a simple schedule or strategy employees can feel much more secure, as they can anticipate what is to change and when. This allows them adjustment time.

A Gantt chart will depict an approximate schedule of the tasks to be completed during the implementation. Some of the activity lengths are estimates, for example the construction, as it tends to take longer than scheduled.

The Implementation Schedule can be seen on the next page. It shows all the most important activities to be completed and their start and end dates, as well as the activities that precede them. This schedule will be an invaluable tool to the implementation phase of the facility plan.

Figure 16: Implementation Schedule

ID	Task Name	Duration	Start	Finish
1	Get a Contractor to Do the Work	5 days?	Mon 1/4/10	Fri 1/8/10
2	Start Construction	36 days?	Mon 1/11/10	Mon 3/1/10
3	Get Needed equipment	65 days?	Tue 12/1/09	Mon 3/1/10
4	Get Shelving	25 days?	Tue 12/1/09	Mon 1/4/10
5	Move Technical	5 days	Tue 1/5/10	Mon 1/11/10
6	Move Management	5 days	Tue 1/12/10	Mon 1/18/10
7	Move Corporate	5 days	Tue 1/12/10	Mon 1/18/10
8	Expand Stores	10 days	Tue 1/19/10	Mon 2/1/10
9	Move in Board Room	5 days	Tue 3/2/10	Mon 3/8/10
10	Outfit Coffee Room	5 days	Tue 3/2/10	Mon 3/8/10



CHAPTER 6: CONCLUSION

For the execution of the facility re-layout to be successful, the company will have to ensure that they remember the following, not just during the implementation, but also during the day to day long term operation:

- Maintaining the Facility. This includes constant evaluation of the facility and identifying any shortcomings in the design so they can be addressed
- Re-evaluate the design. This continuous process is to ensure that the facility can stay up to date with the changing requirements. Too often facilities stay unchanged, even though they are no-longer appropriate for their function.
- Parkinson's Law. This law, in general states that no matter how much headroom for expansion is available, an area will be filled up quicker than was estimated. Thus a space should not be assumed to be sufficient for the duration of the life span and evaluations should be done regularly.

If the basic strategy is followed as stated during the solution methodology, the company should be able to get efficient work flow and capacity related service from the facility.

The contents in the solution chapter should provide Eco Technology with sufficient information to start implementing the re-layout project.

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APPENDIX

RELATIONSHIP DIAGRAM

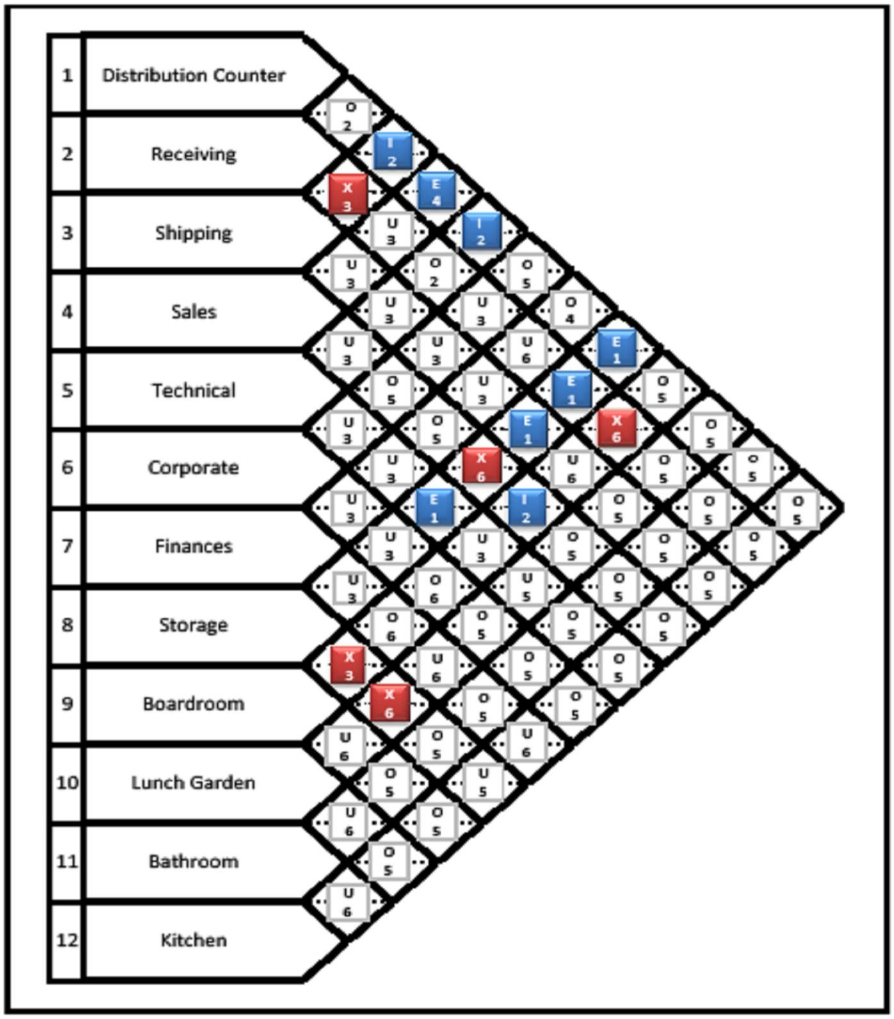


Figure 17: Relationship Diagram for Departments

KEY FOR RELATIONSHIP DIAGRAM

The Key required for examination of the relationship diagram is shown bellow in Tables 1 and 2.

CLOSENESS INDEX

Table 27: Closeness Index for the Relationship Diagram

Value	Closeness
A	Absolutely Necessary
E	Especially Important
I	Important
O	Ordinary Closeness Okay
U	Unimportant
X	Undesirable

REASONS FOR CLOSENESS

Table 28: Reasons for Closeness index in Relationship Diagram

Code	Reason
1	High Stock Flow
2	Medium Stock Flow
3	Low Stock Flow
4	High Foot Traffic
5	Medium Foot Traffic
6	Low Foot Traffic

WORKSTATION SPACE REQUIREMENTS

Table 29: Workstation Space Requirement

	Work Area's Space Requirement							
Description	ech Adm	ech Mana	Technical	CSD	Corporate	Sales	Finances	Total Area (mm2)
Table	1	1	1	1	1	1	1	1500000
Computer	1	1	1	1	1	1	1	250000
Laptop	0	1	0	0	0	1	1	122449
Printer	1	0	0	1	1	0	1	300000
Storage	1	1	1	1	1	1	1	200000
Cashier	0	0	0	1	0	0	0	225000
Work Area	0	0	1	0	0	0	0	120000
Stock Area	0	0	1	0	0	0	0	80000
Person	1	1	1	1	1	1	1	1000000
Allowances	1	1	1	1	1	1	1	0.1
Total 2D Space	3250000	3072449	3150000	3475000	3250000	3072449	3372449	
Total 2D Space	3575000	3379694	3465000	3822500	3575000	3379694	3709694	
No of workstations	1	1	1	1	2	5	1	Total
Total Area	3.575	3.379694	3.465	3.8225	7.15	16.89847	3.709694	42.0003573

TOP FLOOR LAYOUTS

Figure 18: Top Floor Layout for Alternative One and Two

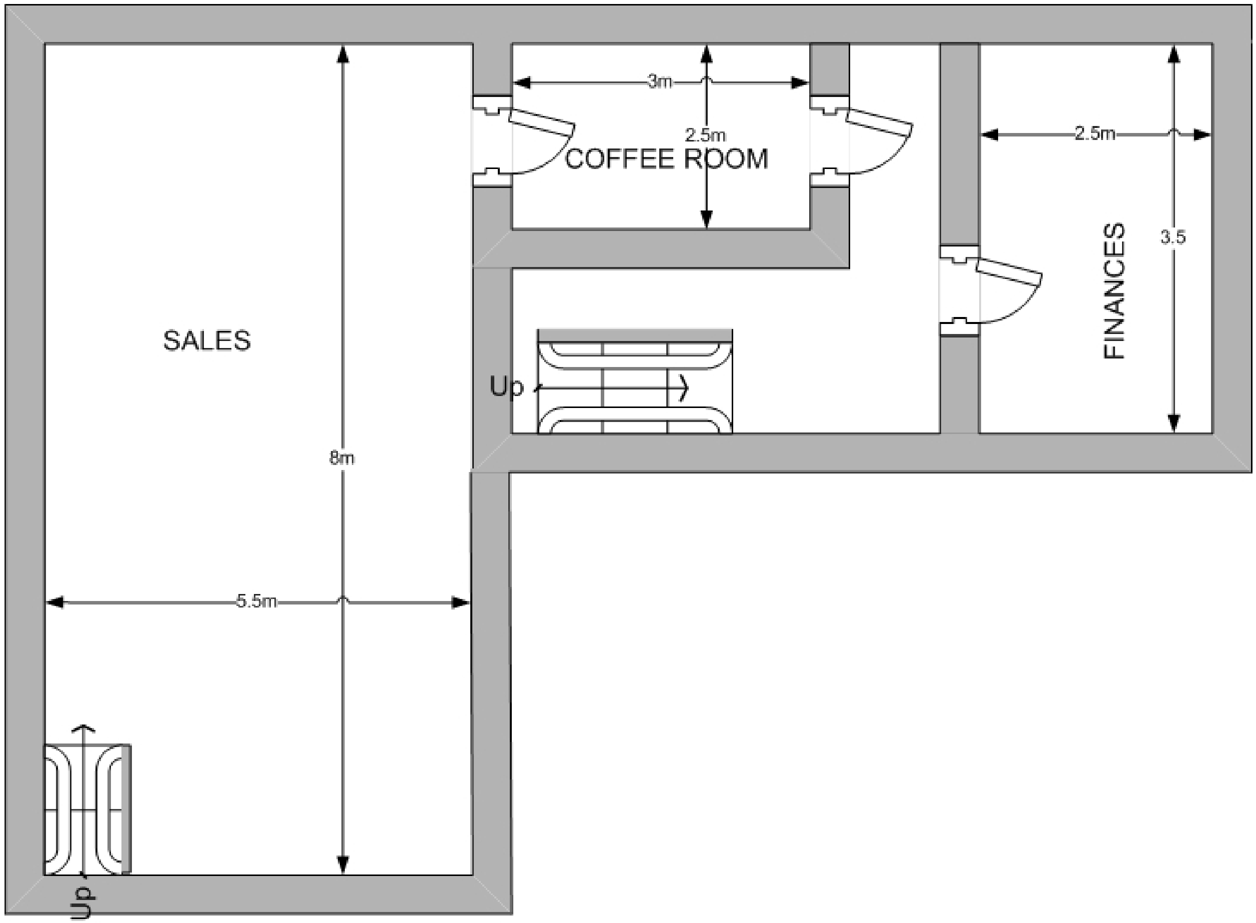
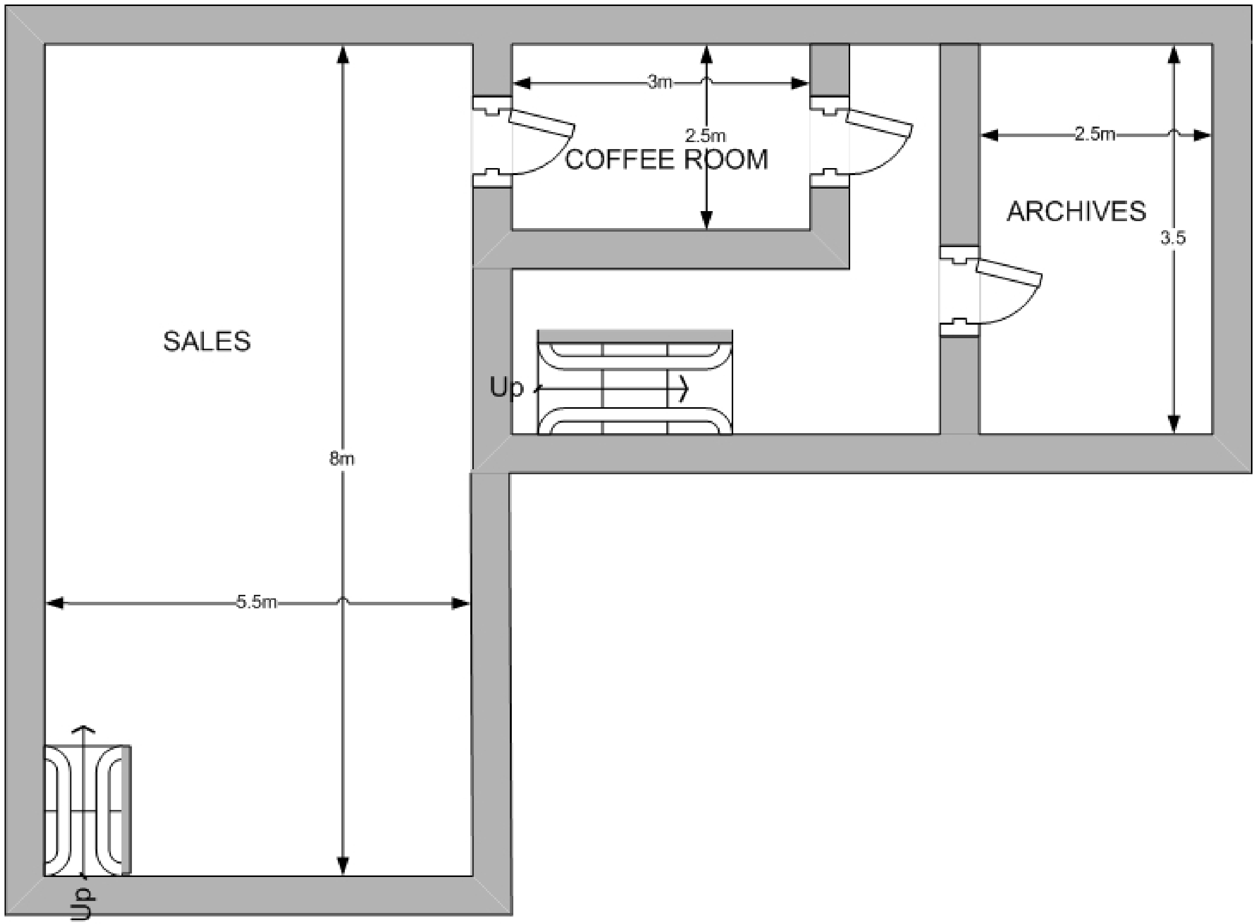


Figure 19: Top Floor Layout for Alternative 3



CUSTOMER FLOW SIMULATION DATA

Table 30: Alternate Layout 1 inter area distribution times

Alternate Layout 1 Simulation				
	CSD	**Sales**	**Technical**	**Finances**
CSD		NORM(0.261,0.127)	0.24 + 0.65*BETA(3.88,5.15)	0.28 + ERLA(0.0379,8)
Sales	NORM(0.261,0.127)		NORM(0.752,0.097)	-0.18 + WEIB(0.471,3.62)
Technical	0.24 + 0.65*BETA(3.88,5.15)	NORM(0.752,0.097)		NORM(0.911,0.106)
Finances	0.28 + ERLA(0.0379,8)	-0.18 + WEIB(0.471,3.62)	NORM(0.911,0.106)	

Table 31: Alternate Layout 2 inter area distribution times

Alternate Layout 2 Simulation				
	CSD	**Sales**	**Technical**	**Finances**
CSD		NORM(0.479,0.12)	0.12 + 0.73*BETA(2.5,3.78)	0.49 + WEIB(0.294,2.65)
Sales	NORM(0.479,0.12)		0.46 + WEIB(0.313,3.3)	-0.17 + WEIB(0.465,4.03)
Technical	0.12 + 0.73*BETA(2.5,3.78)	0.46 + WEIB(0.313,3.3)		TRIA(0.67,0.881,1.14)
Finances	0.49 + WEIB(0.294,2.65)	-0.17 + WEIB(0.465,4.03)	TRIA(0.67,0.881,1.14)	

Table 32: Alternate Layout 3 inter area distribution times

Alternate Layout 3 Simulation				
	CSD	**Sales**	**Technical**	**Finances**
CSD		NORM(0.23,0.116)	-0.14 + 0.84*BETA(6.97,7.96)	NORM(0.4,0.123)
Sales	NORM(0.23,0.116)		0.21 + 0.64*BETA(3.26,4.06)	0.31 + GAMM(0.0429,10.4)
Technical	-0.14 + 0.84*BETA(6.97,7.96)	0.21 + 0.64*BETA(3.26,4.06)		NORM(0.255,0.102)
Finances	NORM(0.4,0.123)	0.31 + GAMM(0.0429,10.4)	NORM(0.255,0.102)	

STOCK FLOW SIMULATION DATA

TO AREA TIMES

Table 33: Time to Area for Alternate Layout 1

Time to Area Distributions for Alternative Layout 1(Minutes)						
Size	**Store 1**	**Store 2**	**Store 3**	**Store 4**	**Store 5**	**Small Store**
Small	-0.13 + WEIB(0.508,3.01)	NORM(0.65, 0.143)	0.28 + WEIB(0.599,4.31)	0.52 + WEIB(0452,2.72)	0.42 + WEIB(0.648, 4)	TRIA(0,0.467,0.85)
Medium	-0.25 + 1.23*BETA (4.86,4.03)	0.09 + ERLA(0.0825,8)	0.33 + 1.18*BETA(7.66,6.32)	NORM(1.15,0.209)	0.71 + WEIB(0.583, 2.74)	TRIA(0,0.552,1)
Large	NORM(0.857,0.256)	NORM(1.52, 0.24)	NORM(1.66,0.255)	0.52 + 1.46*BETA(3.49,3.3)	NORM(1.41, 0.247)	1.76*BETA(7.38,6.29)
Misc	0.1 + WEIB(0.566,3.27)	0.58 + WEIB(0.578, 3.97)	0.91 + WEIB(0.468,3.250	0.75 + ERLA(0.0546, 9)	NORM(1.33, 0.178)	NORM(0.69,0.177)

Table 34: Time to Area for Alternate Layout 2

Time to Area Distributions for Alternative Layout 2(Minutes)						
Size	**Store 1**	**Store 2**	**Store 3**	**Store 4**	**Store 5**	**Small Store**
Small	0.56 + 1.03*BETA(5.37,6.840	0.42 + WEIB(0.553,3.21)	0.32 + 0.94*BETA(3.85,3.16)	0.17 + WEIB(0.544,3.2)	-0.23 + WEIB(0.613,3.7)	TRIA(0,0.434, 0.87)
Medium	0.65 + WEIB(0.697,3.37)	0.5 + GAMM(0.0585,11)	NORM(1.03,0.182)	0.15 + WEIB(0.66,3.33)	-0.38 + WEIB(0.901,4.2)	NORM(0.493, 0.214)
Large	NORM(1.43,0.247)	0.62 + WEIB(0.758,3.77)	NORM(1.66,0.263)	0.65 + 1.54*BETA(4.11,3.11)	0.23 + 1.33*BETA(2.73,3.18)	NORM(0.962, 0.274)
Misc	0.91 + WEIB(0.492,3)	0.79 + 0.82*BETA(3.28,2.74)	0.81 + WEIB(0.598,3.37)	NORM(1.12,0.157)	TRIA(0.24,0.688,1)	0.23 + 1.01*BETA(3.84,4.29)

Table 35: Time to Area for Alternate Layout 3

Time to Area Distributions for Alternative Layout 3(Minutes)						
Size	**Store 1**	**Store 2**	**Store 3**	**Store 4**	**Store 5**	**Small Store**
Small	-0. 19 + ERLA(0.0535, 10)	NORM(0.681, 0.17)	0.43 + 0.86*BETA(2. 69,3.21)	0.41 + 0.99*BETA(3. 44,3.3)	TRIA(0.59,1.0 7,1.37)	NORM(0.426 ,0.176)
Medium	-0.15 + WEIB(0.666, 3.04)	NORM(0.733, 0.1890	0.52 + 1.01*BETA(3. 14,3.21)	NORM(1.16,0. 197)	NORM(1.25,0. 195)	BETA(2.5,2.5 5171)
Large	0.05 + ERLA(0.082,9)	0.8 + GAMM(0.11,6 .7)	NORM(1.67,0. 275)	NORM(1.33,0. 232)	TRIA(0.6,1.51, 2)	0.05 + 1.6*BETA(4.6 9,4.25)
Misc	NORM(0.646 ,0.148)	0.62 + 0.89*BETA(4. 52,3.74)	NORM(1.33,0. 18)	0.86 + 0.77*BETA(2. 78,3.42)	0.74 + 1.09*BETA(4. 11,3.29)	NORM(0.721 ,0.153)

FROM AREA TIMES

Table 36: From Storage Times for Alternate Layout 1

From Storage times distributions for Alternate Layout 1 (Minutes)			
Store	**CSD**	**Technical**	**Outbound Deliveries**
Store 1	-0.23 + 0.88*BETA(4.89,4.51)	0.19 + 1.08*BETA(10.1,7.08)	1.16 + 0.84*BETA(2.83,2.76)
Store 2	TRIA(0,0.488,0.92)	0.11 + 1.01*BETA(3.32,2.96)	0.73 + 1.23*BETA(4.03,4.39)
Store 3	GAMM(0.0898,5.47)	NORM(0.6,0.177)	0.63 + 1.08*BETA(4.1,4.45)
Store 4	NORM(0.705,0.238)	-0.33 + GAMM(0.0826,9.73)	NORM(1.25,0.264)
Store 5	0.2 + ERLA(0.0665,10)	NORM(0.444,0.212)	0.26 + 1.62*BETA(8.9,7.41)
Small Store	NORM(0.362,0.250	0.38 + 1.27*BETA(3.99,4.56)	TRIA(0.88,1.43,1.95)

Table 37: From Storage Times for Alternate Layout 2

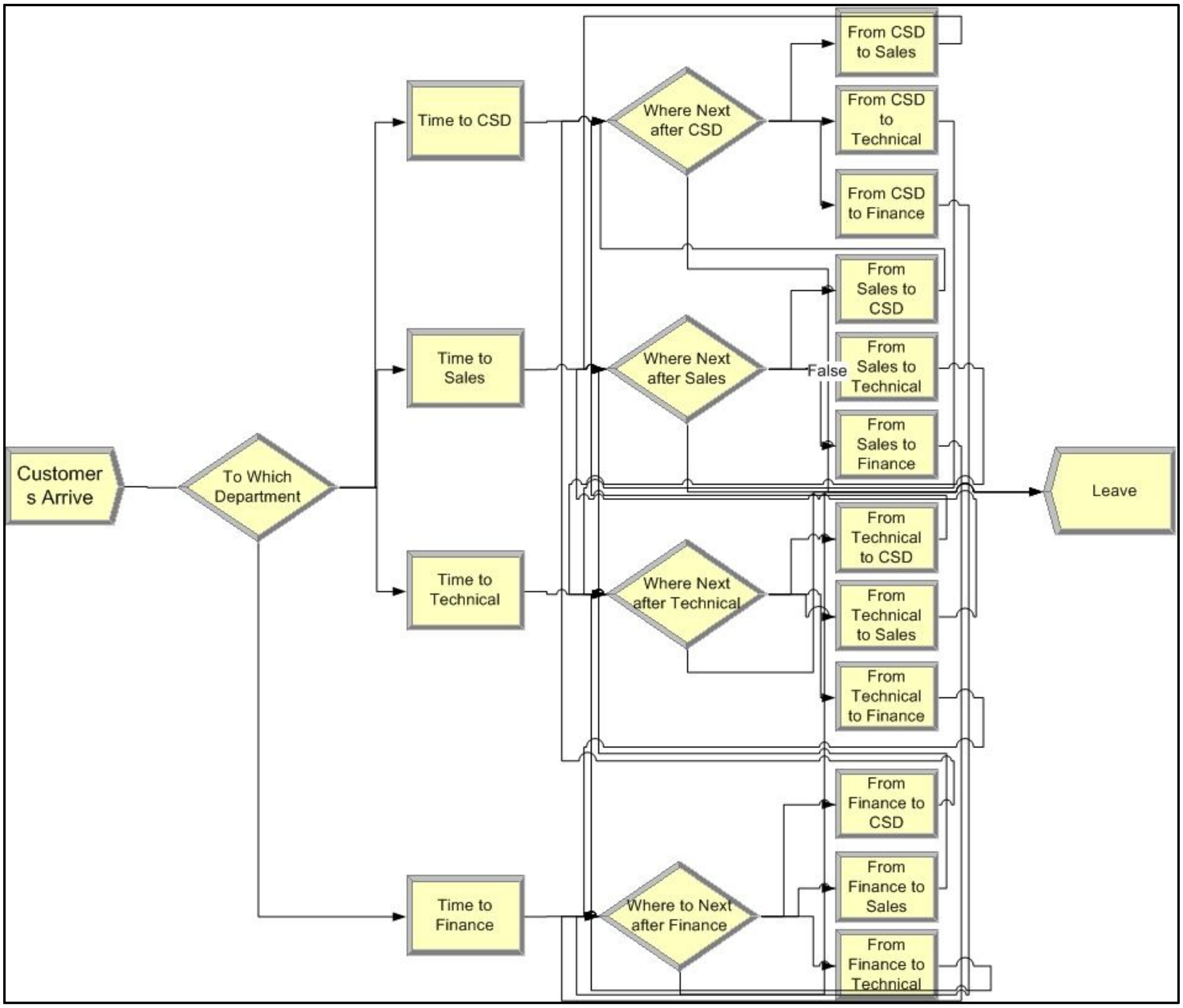
From Storage times distributions for Alternate Layout 2 (Minutes)			
Store	**CSD**	**Technical**	**Outbound Deliveries**
Store 1	NORM(0.246,0.132)	BETA(5.02,4.40626)	0.1 + 1.02*BETA(5.13,4.21)
Store 2	-0.27 + 1.11*BETA(3.72,3.26)	1.14*BETA(7.3,7.56)	0.39 + 1.09*BETA(3.79,3.99)
Store 3	NORM(0.494,0.108)	0.45 + 0.74*BETA(3.5,4.27)	0.86 + WEIB(0.281,2.43)
Store 4	0.18 + WEIB(0.528,3.89)	0.42 + 0.77*BETA(3.43,3.090	NORM(1.16,0.141)
Store 5	0.56 + WEIB(0.487,2.75)	NORM(1.21,0.177)	NORM(1.59,0.154)
Small Store	0.51 + 1.04*BETA(3.62,3.89)	0.69 + 0.92*BETA(4.85,3.07)	NORM(1.6,0.181)

Table 38: From Storage Times for Alternate Layout 3

From Storage times distributions for Alternate Layout 3 (Minutes)			
Store	**CSD**	**Technical**	**Outbound Deliveries**
Store 1	BETA(4.02,3.65079)	NORM(1.33,0.0807)	0.21 + WEIB(0.414,5.08)
Store 2	NORM(0.418,0.163)	0.71 + 0.9*BETA(3.84,3.78)	0.14 + WEIB(0.673,4.29)
Store 3	NORM(0.515,0.215)	0.29 + WEIB(0.743,3.62)	0.36 +0.96*BETA(3.25,3.23)
Store 4	0.1 + ERLA(0.07,8)	0.18 + GAMM(0.0655,9.88)	0.35 + ERLA(0.0698,9)
Store 5	NORM(0.834,0.231)	1.29*BETA(3.89,4.33)	NORM(1.16,0.238)
Small Store	NORM(1.35,0.224)	NORM(0.343,0.232)	NORM(0.641,0.221)

CUSTOMER FLOW SIMULATION MODEL

Figure 20: Arena Customer Flow Model



STOCK FLOW SIMULATION MODEL

Figure 21: Arena Stock Flow Model