BPJ 420 Final Report

Determining the optimal departmental resource allocation at Wispeco Aluminium

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Executive Summary

Wispeco Aluminium's Profiling department is used for the production of the aluminium profiles that Wispeco sells to its' customers nationwide. The production at this department is achieved through the usage of five extrusion machines (EP1-EP5) that run continuously throughout a working shift. The continuous running of these machines is what Wispeco would like to maintain as any stoppage of the machines results in financial losses for the company, an estimated loss of R25248 per hour per machine was highlighted. This figure was calculated using the average production quantity per machine (789kg/hr.) multiplied by the price per kilogram (R32/kg) of aluminium. The only reason that causes the machines to be stopped from running is when there is a shortage of skips within this department. A skip is a material handling component that needs to be readily available next to the extrusion machines after the production of the aluminium profiles by the machines.

The problem for this project was to ensure that there is always an availability of skips next to each extrusion machine and therefore the continuous running of the machines can be maintained, of which a total number of 2720 skips is available within the company and is shared by four departments including the Profiling department. The other three departments are Powder coating, Anodizing and Gauteng Stockists (warehouse). To get a clear understanding of the problem, a time study for a single shift (6am-6pm) was performed with the results thereof used as input data to a simulation model using Simio software. The results of the simulation model gave an indication of the instantaneous production quantities for every machine and hence gave an indication of the number of skips needed per machine per production batch. The remaining number of skips was allocated to the remaining three departments based on the average number of skips needed per department, this number was achieved using the daily skip counts performed at each department.

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Chapter 1 Introduction

1.1 Introduction and Background

Wispeco Aluminium is the largest and has become one of the leading manufacturers and suppliers of aluminium extrusions to the architectural market within South Africa's geographical scale. The quality and service of Wispeco's products has always stood out hence the quality standards of the company have being held highly while both trusted and renowned by loyal customers. Wispeco's mission is to have short turnaround times with reference to production and delivery, hereby enabling the successful operation of the businesses of fellow customers, without having to hold onto many weeks of stock. With reference to product development, Wispeco has expanded their production capacity and capabilities in an effort to meet the requirements of new markets.

With all the above mentioned facts, it becomes imperative for Wispeco to make its internal operations more efficient in order to be able to adapt to the ever-changing needs of the market they serve. For Wispeco to achieve this, it must look into its departmental operations which are where the produced material flows from one department to another until the eventual delivery thereof to customers. These internal departments consist of the profiles, powder coating, anodising and the distribution departments. The produced product, the aluminium extrusions, move to and from these departments depending on the needs of the customers, an example would be of that where the customer wants their aluminium extrusion to be powder coated before the receival thereof. In this case the product would go from the production department to powder coating then to the distribution department from where it will ultimately be delivered to the customer. The produced material is moved between these departments using **Skips** where material is packed on to prevent the damage thereof. The shortage of these skips however results in quite a considerable delay in the movement of material, resulting in a lot of labour hours being lost due to idling of the workforce which ultimately affects the company's output due to the extrusion machines having to be temporarily stopped from producing because of the shortage of these skips. The machine stoppage is done so to prevent material pile up on the extrusion machine tables.

1.2 Problem Statement

There is currently no management system that seeks to bring about the efficient usage of these above-mentioned skips within the Profiling department which is Wispeco's main area of concern. The lack of this management system results in a frequent shortage of these particular skips at certain departments while there exists an excess at other departments. The shortage of these skips halts work at the affected departments as material cannot be loaded anywhere else as it would be damaged.

1.3 Project Aim

This project should prioritize and ensure that no shortage of skips is experienced near the extrusion machines at the Profiling department as this result in a stoppage in production that directly translates into financial losses to the company.

The results achieved should help to create a skip management system that seeks to ensure that the Profiles departments' experiences no skip shortages while the other departments may have minimum shortages. The shortage of skips in this area forces management to temporarily halt the machines from operation and therefore temporarily stop production, this is an undesirable consequence that Wispeco aims to eliminate.

1.4 Project Scope and deliverables

The scope is as follows:

- In the first phase of the project, all aspects of the internal supply chain with regards to skip movement will be investigated. This revealed the active role players, while at the same time revealed who the internal customer and supplier are within the operational framework.
- Following the above task was the analysis of the material flow from production to ultimate distribution between departments, emphasis was on the Profiles department for the purpose of this study
- An analysis regarding the utilization of the current resources was also performed with the aim of meeting the internal supply chain requirements regarding the shortage or excess thereof.
- A time and motion study of the operations performed by each extrusion machine

- Development of a simulation model for the current series of operation by each machine
- Analysis of processes triggering the need for skips for the Profiling department

Chapter 2 Research

2.1 Literature Review

In an organization, resource management is the efficient and effective deployment of an organization's resources when and where they are needed. Resource management is a key element to activity resource estimating and project human resource management. The real challenge within most companies is allocating their resources efficiently to meet expected performance outcomes. This includes ensuring that no shortage (resource under allocation) of resources occurs at certain departments while there is an excess (resource over allocation) of the same resources at other departments. This ultimately drives, if not force, companies to perform studies within their internal operations in an effort to eliminate the over allocation or under allocation of resources. Efficient resource allocation is a complex and dynamic task in business process management. According to Huang and Van der Aalst **(**2011:127-145**)**, a wide variety of mechanisms are emerging to support resource allocation in business process execution, these approaches however do not consider performance optimization.

Resource over allocation **(**Ronda, 2008) happens when assignments of more tasks than your resources can handle or reasonably complete within a standard eight hour workday are assigned. When this happens, because project health and resource allocation affect how teams work, both in-house and outsourced, your projects may stall, come to a complete stop or fail, especially if they are over-allocated **(**Ronda, 2008). The above can be remedied by applying various resource managerial techniques which can range from setting priorities for resource allocation for various departments to linking tasks between the same departments and therefore sharing resources between those departments. It also becomes of utmost importance for companies to scrutinize the cost-effectiveness that is linked to decisions pertaining resource allocation for various departments as costs form an integral part of any business operation (Cost effectiveness and Resource allocation, 2010). A cost minimization approach in resource allocation can be achieved through Resource Smoothing according to Edem Akpan (2000:775-780)**.** He deliberates the aim of resource smoothing as an exercise to achieve optimal resource usage by avoiding high peaks and deep valleys in the project resource profile, in this method, the cost of the activity in question is determined.

As mentioned by Kumar and Aalst (2002:157-193), proper resource allocation is a key issue in providing efficient usage of resources in business process execution. It ensures that each work item is performed by the correct resource at the correct time, so as to balance the demand for process execution facilities against the availability of these resources. This ideology however does not take into account the sequential preferences that have to take place within company departments as most departments do not contribute equally to the company's profit margin. In a more general perspective, resource allocation, as a common topic in operations management, has been widely studied in the area of operations management, e.g., the job-shop scheduling problem where ideal jobs are assigned to resources at particular times (Zhang & Dietterich, 1995)**.**

The optimal resource allocation problem according to Huang and Van der Aalst in a business process execution can be seen as a sequential decision making problem. Considering this problem, the cost of a resource performing a task cannot be seen as an isolated decision, but is only one element in a sequence of decisions (Huang & Aalst, 2011:127-145)**.** Markov Decision Processes (MDPs) have been widely used to model sequential decision making problems (Puterman, 1994)(Filar & Vrieze, 1997). The most important property of MDPs is that an optimal decision in a given state is independent of earlier states the decision maker encountered. For MDPs, there exist a number of algorithms that are guaranteed to find optimal policies. For example, dynamic programming methods can be used to define such optimal policies

Resource management is important for the performance of an organization. In a BPM context, a resource is defined as an actor or an agent that carries out business process activities. Typically, resources are humans. However, depending on the application domain, resources can be machines, manpower, money, software (vanHee et al, 2007:59-75)**.** Business Process Management (BPM) provides a broad range of tools and techniques to enact and manage operational business processes. Increasingly, more and more organizations use BPM techniques and tools to promote business effectiveness and efficiency. These BPM techniques and tools focus on control-flow in combination with mature support for data in the form of XML and database technology (Huang et al, 2011:127-145)**.**

Given the above information pertaining the problem at hand, solutions through the application of the various industrial engineering techniques can be identified. These techniques, amongst others, include simulation modelling, value stream mapping, operations management, operations research and information system design.

2.1.1 Simulation modelling methods

The aim of using the above method would be provide a pictorial view of the series of events taking place during resource utilization. This particular modelling approach has become one of the most popular techniques in deciphering intricate systems. Using this approach, the behaviour of a complex system can be tracked with time. According to Ghomi and Ashjari (2002:127-130) however, simulation is not without drawbacks, it is an expensive and time-consuming process that requires verification to ensure that the model behaves as intended and also validation that it represents the real system, and sophisticated input and output analysis techniques to interpret the data. It shall also be noted that a simulation model is just as good as the data input it received. Discussed below are the types of manufacturing simulation software widely used in industry for process improvement.

2.1.1.1 Simio

Simio simulation software provides manufacturing solutions that encompass a broad set of industries including discrete part manufacturing, automotive, consumer packaged goods, and metals & plastics. Typical application areas are:

- Design of green field production plants.
- Process improvement using Six Sigma and Lean Manufacturing.
- Combining production facilities to adjust reduce costs.
- Production planning /scheduling

Simio's modelling solutions provide answers to key questions such as:

- What the best layout for a production facility might be with respect to service, quality and cost
- What the impact of implementing a new production process might be on overall output
- What the impact of different product mixes and volumes on overall output

Simio achieves the above by employing an object approach to modelling, whereby models are built by combining objects that represent physical components of the systems (Simio, 2011).

2.1.1.2 Arena

Arena Professional simulation software is most effective when analysing complex, medium to large-scale projects involving highly sensitive changes related to supply chain, manufacturing, processes, logistics, distribution, warehousing, and service systems (Rockwell Automation, 2011).

In addition, Arena PE is used to create customized simulation modelling products; that is, templates focused on specific applications or industries. With Arena Professional, customers develop custom templates that consist of "libraries" of modelling objects that make it significantly easier and faster to develop models that require repeat logic (Rockwell Automation, 2011).

Examples of applications include:

- Detailed analysis of complex manufacturing processes that include material-handling intensive operations (fork trucks, AGV systems, and labour)
- Analysis of Six Sigma implementations, KanBan/Pull or Push systems
- Modelling complex customer-handling activities such as passenger movement and baggage handling in airports, customer service in entertainment parks and other service systems
- Improving local and global supply chain processes
- Detailed analysis of warehousing, logistics, or transportation, military and mining applications
- Creating a custom Arena-based template for modelling logistics network of a global travel agency
- Creating a custom Arena-based template for modelling manufacturing flow of a major automotive manufacturer

Arena Professional is targeted toward industrial or manufacturing systems engineers, business analysts, consulting firms providing services to a specific industry/application, or corporations with a dedicated simulation team (Rockwell Automation, 2011).

2.1.1.3 Simul8

SIMUL8 is a computer package for Discrete Event Simulation. It allows you to create visual model of the system under investigation by drawing objects directly on the screen (Haige et al., 2001). SIMUL8 simulation software can simulate entire production processes, from warehouse capacities, to staff shift patterns, to equipment utilization, allowing you to easily identify and eliminate inefficiencies (Simul8, 2011). Simul8 can improve a company's production processes through the following ways:

- Visually identify and eliminate bottlenecks
- Improve resource utilization
- Plan for future growth and capacity
- Increase quality and efficiency

2.1.1.4 Pro Model

The ProModel Optimization Suite is a discrete-event simulation technology that helps you to make better decisions faster. It is used to plan, design and improve new or existing manufacturing, logistics and other tactical and operational systems. It empowers you to accurately replicate complex real-world processes with their inherent variability and interdependencies, to conduct predictive performance analysis on potential changes, and then to optimize the system based on your key performance indicators (ProModel, 2011).

To understand how ProModel can help you, you need to think of your facility as a collection of resources that are intended to function together cost-effectively. Each person and piece of equipment is related to every other component (by coincidence or convenience). Together, they define how your facility works. ProModel lets you dissemble all or part of the factory and reconfigure the pieces to find ways to run the entire system more efficiently. ProModel also lets you see which new configurations work best and which ones fail, by watching them for a week, month or year on a trial basis. Forget risk, disruption and expense—test multiple alternatives in an amazingly short time (ProModel, 2011).

With ProModel, you can create a dynamic, animated computer model of your business environment from CAD files, process or value stream maps, or Process Simulator models. From this you can clearly see and understand current processes and policies in action (ProModel, 2011). You can brainstorm using the model to identify potential changes and develop scenarios to test improvements which will achieve business objectives. Run scenarios independently of each other and compare their results in the Output Viewer integrated within the software package.

ProModel lets you immediately test the impact of changes on current and future operations, risk free, with predictive scenario comparisons. You can determine optimal business performance with a high probability of meeting your business goal with ProModel (ProModel, 2011)

ProModel software allows you to:

- Quickly realize Lean project goals
- Effectively predict resource requirements
- Visually demonstrate improvement scenarios
- Enhance the Analyse and Improve steps in DMAIC.

2.1.2 Operations management

Operations management is a technique that will seek to control the process of production so as to balance the supply and demand of the resources at hand (MRP systems). MRP systems (http://www.awaresystems.com.au/mrp.html) encompass quoting and estimating, sales orders, product costing, production planning, shop floor documents, recording of production, advanced stock control, purchasing of materials used in manufacturing, purchasing of all other product including spares. It may offer forecasting of demand, inventory planning, and a production planning board. All this is integrated with financials. A major disadvantage of this method is the unfortunate circumstance that results from unexpected delivery problems and shortages of material, this eventually will cause a ‘go-slow’ in the production department. Based on existing customer orders and a medium-term aggregate production plan, a Master Production Schedule (MPS) prepares a short-term production plan for end or rather main products. The planning result is the Master Production Schedule, which is commonly referred to as the MPS. The next step, Material Requirements Planning (MRP), uses the MPS as a starting point and computes derived demands for all components required for the production of the end products. The planning data used are the bill-of-materials structure, the current inventory status and planned lead times. Within this planning step lot sizes are computed under the assumption that infinite capacity is available. Results of these computations are planned production quantities per item and period (advanced-planning, 2010). Shown below is a diagram that shows the hierarchy of activities when applying production planning systems.

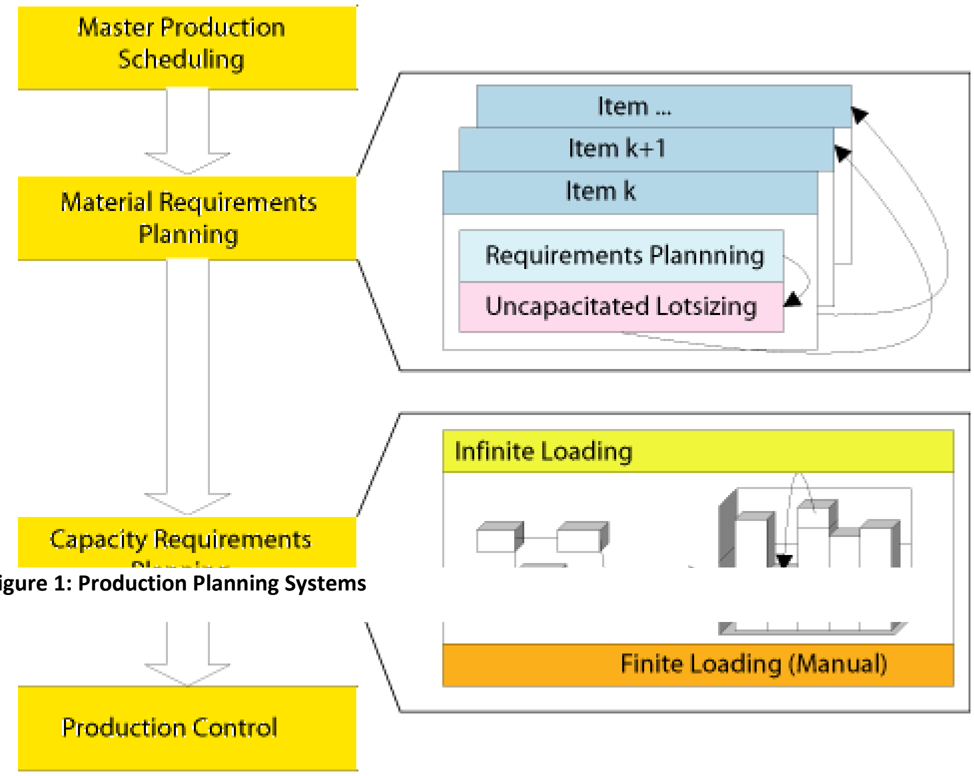

Figure 1: Production Planning Systems

2.1.3.1 Theory of constraints

The above operations management technique can be used to determine where the constraint that tends to limit the level of production within the manufacturing system is. Theory of constraints gets its name from the central role it plays in constraining overall production. TOC is about how to improve and manage how the system constraint performs in the context of the total system. It is about managing the total system, which is comprised of interdependencies, variability and constraints, to ensure maximum bottom line results for the organization (Goldratt, 2012). The TOC systems approach requires that you first understand the system, its goal and measurements, then you can apply the five focusing steps:

1. Identify the constraint(s).
2. Decide how to exploit the constraint(s).
3. Subordinate/synchronize everything else to the constraint(s).
4. If needed elevate the system's constraint.
5. If the constraint has been broken go back to step one. Don't let inertia become the constraint.

The second focusing step is the basis of this project as management at Wispeco has already identified what limits their current output in terms of production. This limiting factor is that of the shortage of skips when needed by any department within those mentioned in the introductory sections of this report. This project will seek to use this fact in the design of a skip management system that will ensure that the constraint, which is the resource (skips) under study, is utilized to its fullest extent. In an attempt to exploit the resource which constrains the production system, Simio Simulation Software will be used.

Chapter 3 Data Analysis and Preparation

3.1 Data Analysis

3.1.1 Process overview

Before choosing the appropriate method to attempt solving the problem, data regarding the resource at hand had to be initially collected. Before the collection of such data, an understanding of the processes that trigger the need for the resource needed to be understood. This calls for the need to understand the Wispeco aluminium production process that leads to the eventual request of skips to load the produced aluminium profiles. A schematic representation of the series of activities involved in the production of aluminium is shown in **Figure 2**.

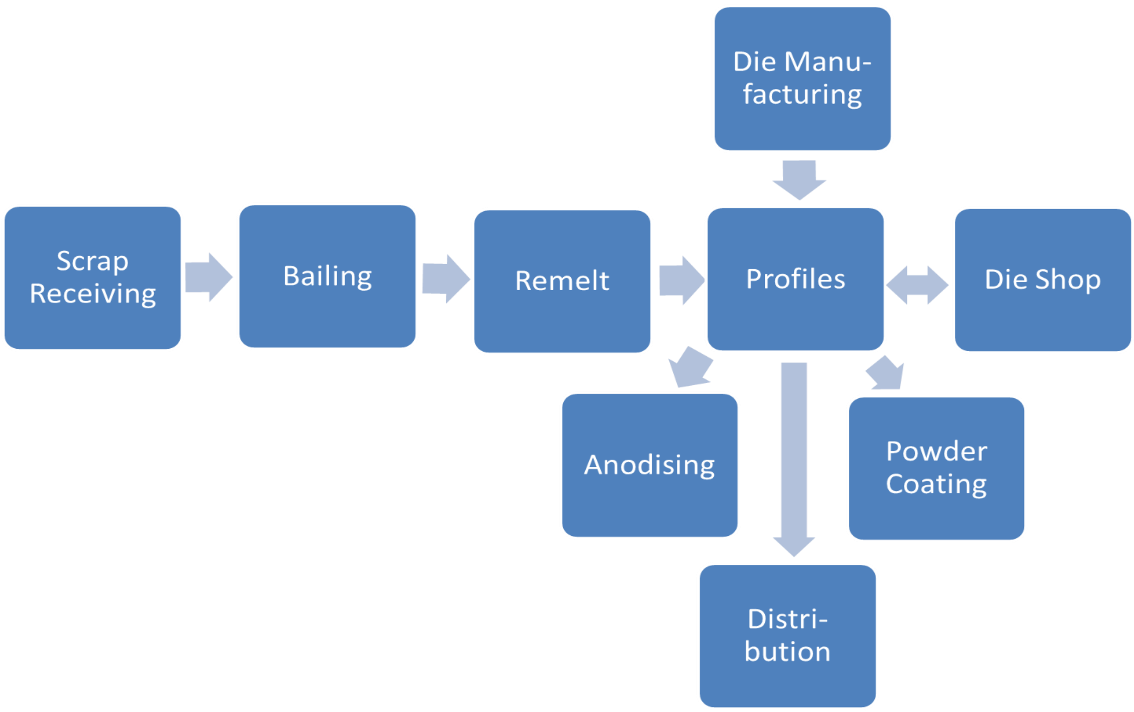

Figure 2: Production process flow

The process of aluminium production at Wispeco is begun by scrap receiving and sorting (**figure 3**), this is where scrap aluminium is bought from scrap vendors so it can be reused in production. The metal received is sorted to remove unwanted metals like steel after which the sorted material is stored in scrap bins ready to be bailed. The bailing machine forces the scrap aluminium into a square shape as seen on **figure 4.** It is then weighed and stored until orders from the Remelt department arise.

Figure 3: Scrap receiving and sorting

Figure 4: Square shaped scrap

In remelting, aluminium scrap is melted in furnaces to form molten aluminium. It is then cast into logs of approximately 7m long and then cut in half. **Figure 5** shows the produced logs from Remelt. **Figure 6** shows the inputs and outputs associated with the Remelt department.

Figure 5: Produced logs

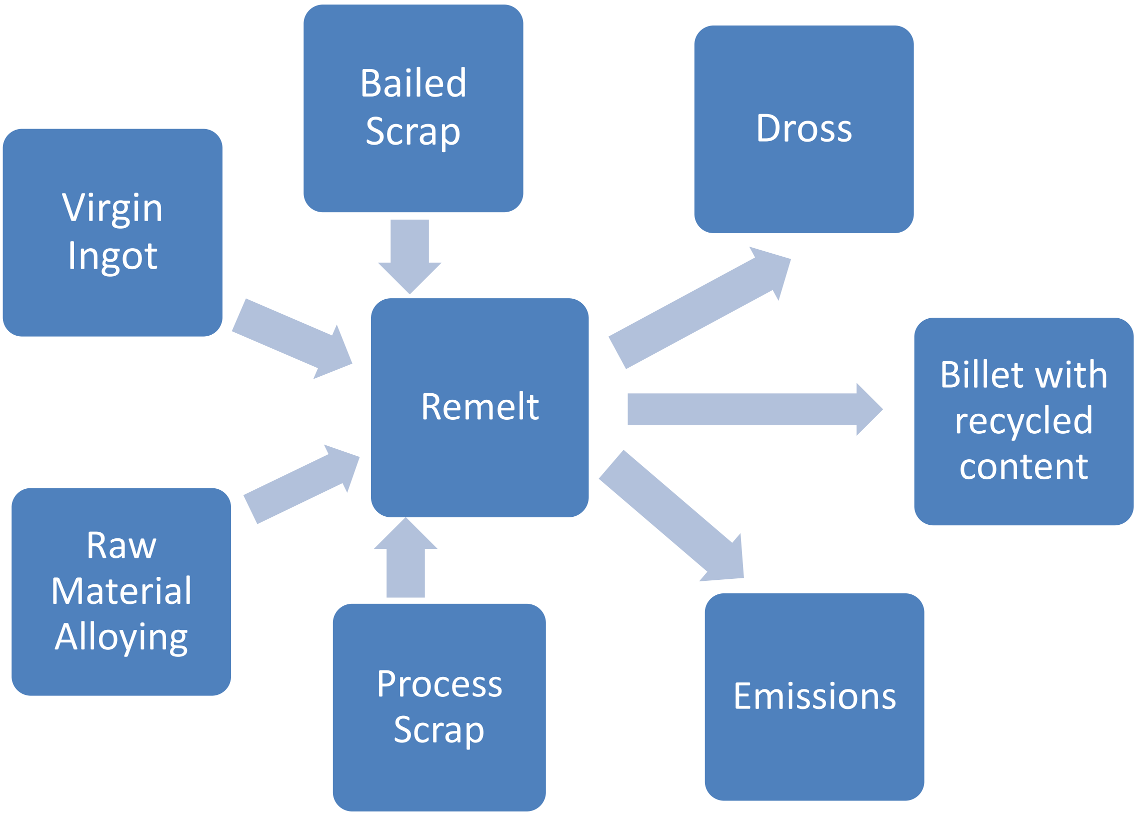

Figure 6: Inputs/Outputs to Remelt

As seen on **figure 2** (aluminium production process), it can be seen that the Profiles department becomes the immediate customer of the Remelt department. The Profiles department is where the extrusion (**figure** 7) process of producing the required aluminium profiles takes place. Within the Profiles department are five extrusion machines that are used for the daily production of aluminium profiles. There should always be skips available next to these machines as material (produced aluminium profiles) needs to be immediately packed on these skips ready for transportation to the dispatch area for customer receival, the machines have to be stopped if there are no skips available which is an undesirable action as it halts production temporarily. Ensuring that there is never a shortage of these skips near the machine will be the purpose of this study. In this department, billets of different sizes are received from the Remelt department. These billets are heated and then extruded in presses through various dies. **Figure** (aluminium production process) shows the Die manufacturing department and the Die shop as providing input to the Profiles department. The reason behind this is that of the various aluminium extrusions that are being produced having various design patterns according to customer requirements, these die patterns are provided by the die shop or sometimes have to be manufactured if the die shop does not have them. At the manufacturing department, dies are machined according to drawings from the drawing department which was made according to customer specification.

Figure 7: Extrusion machine

The Profiles department eventually provides profiles to the Anodizing, Powder coating and Distribution departments. At Anodizing, the surface of the aluminum profiles is prepared by dipping the profiles into rinsing tanks. Then the metal is dipped into tanks with a current running through it, changing the colour of the aluminium, this is achieved through using the principle of electrolyses. At Powder coating, a chemical preparation for the powder to stick to the metal is done. Powder is applied using a spray booth, after which it is dried in an oven, producing an evenly painted surface. The customer can choose amongst a large variety of colours. Not all aluminium profiles from the Profiling department need to go through Anodizing and Powder coating, the necessity for profiles to go through these departments depends on customer requirements.

This means that profiles can go from the Profiling straight to the customer. The third internal customer of the Profiles department is the Distribution department, here extrusions are distributed by means of trucks to appointed stockists and customers countrywide.

3.1.2 Time studies

Following the understanding of the process flow as detailed in the section above, data needed to be collected in order to identify objectives that the simulation model should attempt to execute. The data gathered and subsequent analysis will serve as input to the simulation model, with the simulation model serving to provide output in terms of descriptive statistics inherent in the software package. After studying the production process flow, detailed in the process overview, data that needed to be an essential part of the simulation model was identified. The first segment of data to be identified was that of the frequency of shortages of skips at each of the five extrusion machines (**EP1 to EP5**) within the Profiles department. **Figure 9 and 10** shows these shortages identified at the various extrusion machines through time studies from the times shown. Note that the situation the 'Situation at press' refers to the state of skip availability/shortage near extrusion machines. The objective in this case is to eliminate the waiting time at the presses (extrusion machines) caused by the shortage of skips.

Following the data gathering above, it was seen fit to gather data regarding the time it takes for each extrusion machine to complete producing one batch of aluminium profiles ready to be packed on skips. The series of activities involved in achieving this is shown on **Figure 8** below. **Figure 11** shows the results of the time studies performed.

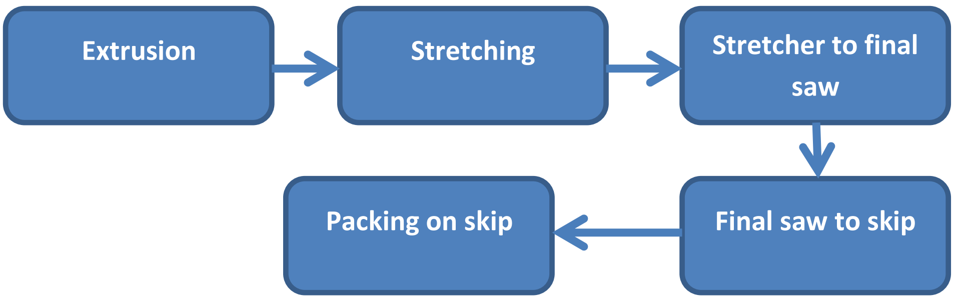

Figure 8: series of activities in extrusion

06:00 - 13:45				
Time	**Element**	**Location**	**Duration(min)**	**Situation at press**
06:00	MBA	**Press**	10	Nothing
06:10	Log sheet+ageing sheets	**Ep3**	15	No pressure
06:15	Fetch Skip	**Powder Coating**	5	No Pressure
06:20	Recycle Skip	**Ep3 and 4**	10	No pressure
06:30	Prepare ageing material	**Ageing ovens**	15	No Pressure
06:45	fetch and Load Billets	**Ep4**	15	10 min waiting for skip
07:00	Fetch and Recycle Skip	**Powder Coating and Ep3**	15	skip available
07:15	load billet and Recycle Skip	**Ep4**	5	skip available
07:20	Scrap Bins	**Ep3**	10	3 min waiting for skip
07:30	Scrap Bins, fetch recycle	**Ep4 and 3**	30	skip available
08:00	Recycle Skip	**Ep3, 4 and 5**	15	skip available
08:15	Move Skips to oven	**Ageing ovens**	15	5 min waiting for skip
08:30	Recycle Skip,load billets	**Ep3, 4 and 5**	15	skip available
08:32	Load Billets	**Ep 4**	2	skip available
08:34	Fetch Skips	**Powder coating**	10	skip available
08:44	Move Skips to oven, and record	**Ageing ovens**	15	skip available
09:00	Tea Break	**MBA**	15	FLM to take over
09:15	Fetch Skips	**Powder Coating**	5	No pressure
09:20	Skips arrive	**Ep3**	2	skip available
09:30	Recycle skip and move to oven	**Ep3 and 4**	15	skip available
09:45	Record ageing material	**Ageing ovens**	15	skip available
10:00	Recycle skips,fetch and load billets	**Ep3 and 4**	15	skip available
10:15	Prepare ageing material	**Ageing ovens**	15	10 min waiting for skip
10:30	Fetch Skips and stock	**Powder coating and store**	10	5 min waiting for skips
10:40	Recycle Skip	**Ep 4**	3	skip available
10:43	Load billets	**Ep 4**	2	4 minutes waiting for skips
10:45	Fetch and load logs	**Ep3**	15	Skip available
10:50	Fetch and load Billets	**Ep4**	5	skip available
10:55	Skip recycle	**Ep3 and 4**	2	skip available
10:57	Scrap bin to remelt	**Ep 4**	16	10 minutes waiting for skip
11:15	Skip recycle	**Ep 3 and 4**	5	skip available
11:20	Fetch abd load logs	**Ep5 and 3**	5	skip available
11:25	Break	**Bathroom**	10	skip available
11:35	Skip recycle	**Ep 3 and 4**	5	skip available
11:40	Scrap to remelt	**Ep 3 and 4**	15	skip available
12:00	**Lunch**			
12:35	Scrap bin to remelt	**Ep 3**	5	Skip available
12:40	Skip recycle	**Ep 3 and 4**	5	skip available
12:45	Fetch, load billets and logs	**Ep 3, 4 and 5**	15	skip available
13:00	Record and count ageing material	**Ageing ovens**	20	5 minutes waiting for skips (Ep 4)
13:20	Brought and loaded billets, and recycled skips	**Ep 4**	10	Skip available
13:30	Skip recycle and move material to ageing oven	**Ep 3**	15	skip available
13:45	Skip recycle	**Ep 4 and 5**	10	

Figure 9: shortages identified

09:00 - 10:00				
Time	**Element**	**Location**	**Duration (min)**	**Situation at press**
09:00	Tea Break	**MBA**	10	Skip available
09:10	Recycle skip	**Ep 3 and 4**	3	Skip available
09:13	Fetch Skips	**Powder coating**	15	3 minutes waiting fro skips
09:30	Fetch and load billets, logs	**Ep 3 and 4**	10	Skip available
09:40	Assist at packing site	**Packing**	10	Skip available
09:50	Recycle skip	**Ep 3**	25	Skip available
10:15	Prepare and load ageing material	**Ep 3**	35	15 minutes waiting for skips
10:50	Recycle skip	**Ep 3 and 4**	5	Skip available
10:55	Load billets and logs	**Ep 3 and 4**	5	Skip available
11:00	Fetch Skips	**Powder coating**	5	Skip available
11:05	recycle Skip	**Ep 3 and 4**	7	Skip available
11:12	Prepare ageing material	**Ep 4**	4	Skip available
11:16	load billets	**Ep 4**	2	Skip available
11:18	recycle skip	**Ep 3 and 4**	3	Skip available
11:21	scrap bin	**Ep 3 and 4**	30	10 minutes waiting for skips
11:50	Recycle skip	**Ep 4**	2	Skip available
11:52	Fetch skips	**Powder coating**	5	Skip available
11:20	Prepare ageing material	**Ageing ovens**	10	Skip available
11:30	Fetch Skips	**Powder coating**	10	Skip available
11:55	Load Ageing oven	**Ageing ovens**	5	5 minutes waiting for skip

Figure 10: shortages

	10/07/2012			17/07/2012		
EP	**Extrusion**	**Stretching table**	**Final Saw table**	**Extrusion**	**Stretching table**	**Final Saw table**
1	15	10	10	15	10	7
2	20	16	20	10	36	26
3	14	19	15	19	15	9
4	18	19	14	18	26	28
5	16	9	17	14	10	20

	24/07/2012			31/07/2012		
EP	**Extrusion**	**Stretching table**	**Final Saw table**	**Extrusion**	**Stretching table**	**Final Saw table**
1	20	16	20	15	8	10
2	19	10	7	22	9	20
3	12	12	11	18	18	22
4	16	23	25	14	18	15
5	15	19	25	20	15	16

Figure 11: Time study results

The above data will serve as input to the simulation model that will be built using Simio.

Shown below (**Figure 12**) is a daily count, extending from 12 April to 03 May, of the Skips available at the various departments at Wispeco Alberton premises. It shall be noted that Wispeco has four major departments, these are the Anodizing, Powder Coating, Gauteng Stockists and Profiling (production department), the other departments viewed on the table below can be seen as 'mini departments' that were created for ease of counting. Under the department column, it shall also be noted that 'Widney' is not within Wispeco's premises, Widney is Wispeco's major client that requires and insists on material being ordered by them arrive at their premises on skips as material being ordered is always of high value. This causes an average of 390 skips (for the days counted) that are not available when needed on Wispeco's premises.

A subtotal of 2720 Skips were counted during data collection, this represents the highest number ever counted during a skip count. The reason why this number varies over time is the fact that no specific number of skips is allocated for each department, departments have to share the same resource. This is what eventually leads to the problem at hand, the problem of having unused skips at one department while there's a shortage at the other department. Shortage of the skips at these departments results in adverse consequences for the business at large, this results in Wispeco losing a lot of labour hours as time is lost due to employees having to wait for the skips before any work can commence. The effect of this drawback is more severe when its experienced by the Profiling department, this department is the major money-generator of the company. An hour of skip shortage at this department results in an estimate of R25248 per hour per machine. It therefore becomes imperative to ensure that no shortage of the skips occurs at this department. It is also the largest department at Wispeco. This department can be viewed as a 'stand-alone' department which produces product and sells it without any intervention from the other departments, its independent of the other departments. On the contrary, the other three departments depend on each other somehow in order to conduct their business, an example would be that of Powder Coating depending on Gauteng Stockists (GS) for items that need special design patterns as requested by various clients.

A pattern of the skip distribution (**Figure 13**) shows a trend of how the skips were distributed during the days as indicated on the x-axis of the graph. This pattern shows a random probability distribution, meaning that its behaviour may be analysed statistically but not predicted precisely. A good solution to the problem would provide a smoother trend line for the Despatch department, given its importance to the company. This trend line should also provide sufficient skips at this department with no shortages.

DATE COUNTED	12-Apr-12	13-Apr-12	16-Apr-12	17-Apr-12	18-Apr-12	19-Apr-12	20-Apr-12	23-Apr-12	24-Apr-12	25-Apr-12	03-May-12
DEPARTMENT	NO OF SKIPS	NO OF SKIPS	NO OF SKIPS	Total	NO OF SKIPS	NO OF SKIPS	NO OF SKIPS	NO OF SKIPS	NO OF SKIPS	NO OF SKIPS	NO OF SKIPS
ANODISING	234	192	194	193	218	206	214	219	269	247	217
DESPATCH (AE + AS)	575	562	536	535	584	498	529	433	561	719	605
EP 3 & 4	520	470	426	517	529	596	591	532	523	476	434
GAUTENG STOCKIST	56	66	0	116	127	135	100	20	87	101	56
MAINTENANCE	0	0	9	8	9	7	4	5	5	6	0
POWDERCOATING	645	668	578	629	579	584	570	719	589	514	722
REMELT	6	18	3	5	0	24	0	0	3	22	3
WIDNEY	426	426	426	426	363	363	363	363	363	406	406
COUNTED	2462	2402	2172	2429	2409	2413	2371	2291	2400	2491	2443
TOTAL STOCK	2720	2720	2720	2720	2720	2720	2720	2720	2720	2720	2720
MISSING	258	318	548	291	311	307	349	429	320	229	277

Figure 12: Daily departmental Skip count

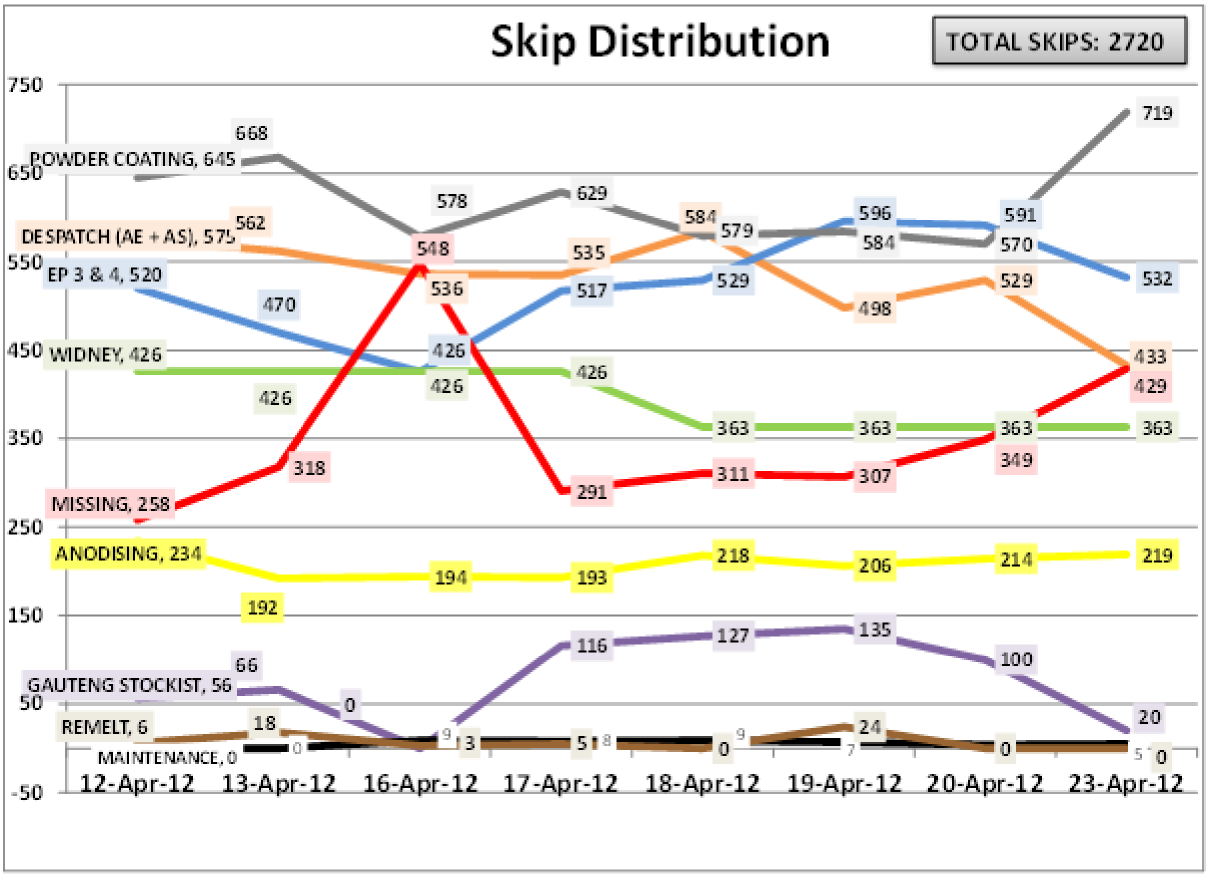

Figure 13: Skip distribution (12-23 April)

Shown in **Figure 14** is a Pie Chart showing the daily averaged skip distribution within the respective departments. From this chart we can see the under-allocation of the resource at the department that needs it the most, a percentage of 18% is allocated to Profiles which is the largest department by size and largest income generating department at Wispeco.

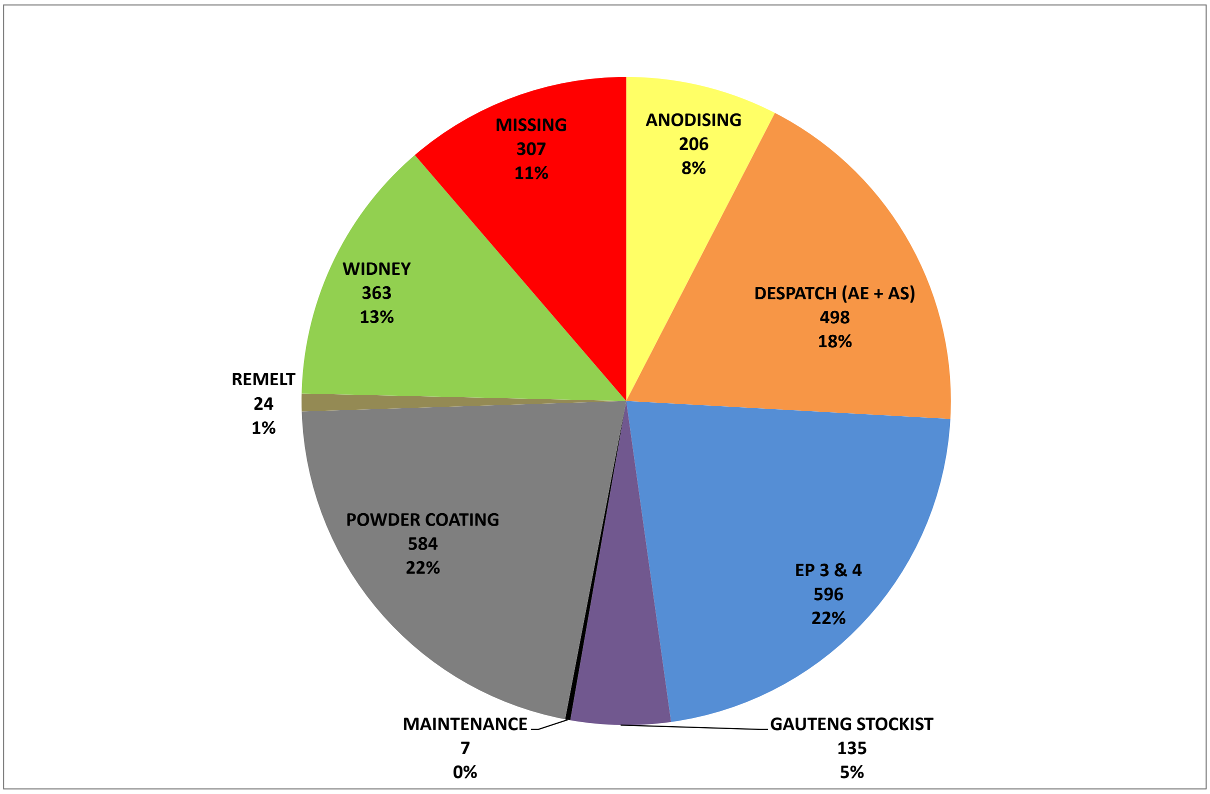

Figure 14: Pie chart on skip utilization per department

The latest figures (6 Aug – 20 Aug) regarding the skip count are shown on **Figure 15**. This shows a total number of 2675 skips that are currently available for use on premises for the date shown, a slight difference from the number initially counted (2720). The distribution of skips within the various departments has changed by a negligible difference according to management, making skip shortage within the production (profiles) department an issue that still needs to be addressed. The skip count also shows the unavailability of skips at EP1, EP2, and EP3, these are the additional extrusion machines that together with EP3 and EP4 make up the five machines that are used for the production of aluminium profiles.

The absence of skips on these extrusion machines results in the machines having to be temporarily shut down until the skips are available, this is to avoid material pileup on the machines tables. This temporary shutdown results in a temporary halt in production which eventually results in the company not realising their planned production of 700-1000kg/hr, this translates into estimated financial losses of R25248 as mentioned. This financial loss does not include the loss in labour hours incurred due to employees being idle during skip shortage.

DATE COUNTED	06-Aug-12	13-Aug-12	20-Aug-12
DEPARTMENT	NO OF SKIPS	NO OF SKIPS	NO OF SKIPS
ANODISING	170 + 437	243 + 391	266 + 52
DESPATCH (AE + AS)	395 + 209	425 + 192	379 + 239
EP 1 &2			
EP 3 & 4	275	396	491
EP 5			
GAUTENG STOCKIST	120	174	180
MAINTENANCE	0	0	0
POWDER COATING	165 + 104	191 + 71	286 + 42
REMELT	0	0	0
WIDNEY	453	363 + 41	374
TOTAL COUNTED	2328	2487	2289
TOTAL STOCK	2675	2675	2675
TOTAL MISSING	347	188	386

Figure 15: Latest skip count

Chapter 4 Simulation Model

4.1 Simio Simulation Software background

The literature covered in this report provided meaningful suggestions to consider when attempting finding a solution for this particular problem. A thorough examination of the methods suggested by literature, given the data that was available during solution formulation, led to most of the methods being inapplicable to the problem at hand. The method that was chosen to attempt a solution at this particular problem was Simulation Modelling using Simio Simulation Software package. The reason for choosing this particular simulation was due to its free availability to students as well as its abilities that sets it apart from other simulation modelling software. With this software, the user can test how various machine processing times can affect the time an entity spends on the system, a feature one can exploit when defining model properties through experiments. The Simio modelling software lets you build and run dynamic 3D animated models of a wide range of systems – e.g. factories, supply chains, emergency departments, airports, and service systems. Simio employs an object approach to modelling, whereby models are built by combining objects that represent the physical components of the systems.

4.1.1 Modelling Approach

The following modelling method was followed for the simulation:

- Defining a functional specification for the model. This will describe the problem completely, provide vision of the task at hand as well as outline how simulation will be used for this problem. Within the functional specification, there will also exist assumptions that the simulation run will take into account. Data requirements will also be identified and stated clearly on this specification. Finally, the output statistics required will be identified for future analysis.
- Following the above, a formulation of the simulation model will be constructed. The only constraint that'll occur in this phase is the quality of data that will be used as input.

- Verification and Validation of input data will be performed. Verification will ensure that the model behaves in a way that it was intended while validation will ensure that the model behaves the same as the real system would.
- Analysis of the output. This will be made possible by the statistical output that will be given by the model following the simulation run. Different scenarios will be used during this phase to track the system's behaviour for varying inputs.
- Solution recommendation with alternatives observed through the model.

Thorough understanding of the in-house operations at Wispeco will assist in identifying object classes that will be included in the model. These objects include the physical components inherent to the system (machines, workers, customers etc). All object definitions are derived from an underlying class that defines its core functionality as can be seen in the figure below (Figure 4)

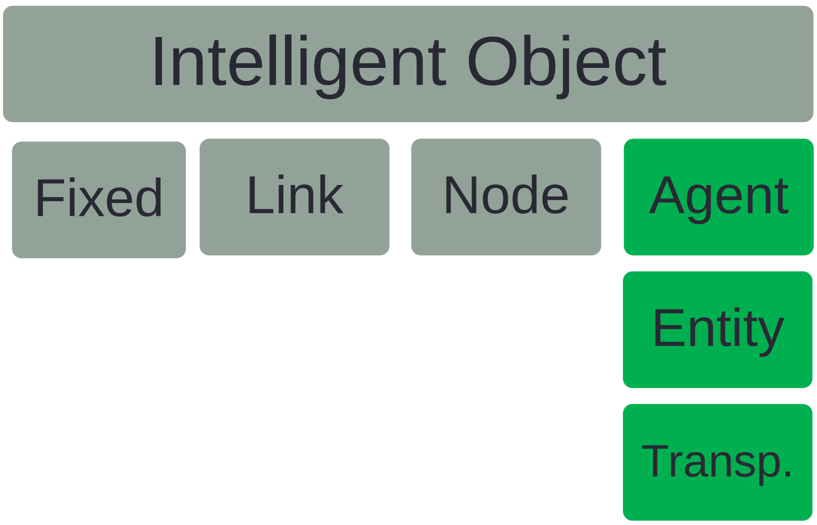

Figure 14 : Object Classes

The above simulation model will serve to provide information on how the skip allocation for the various departments will affect the system as a whole, this will eventually give an indication of an optimal number of skips that need to be at a department at any point in time to avoid shortages or excess with respect to the resource. For the purpose of this current study however, only operations at the Profiles department will be modelled at this point in time, this is due to the data quality received at the other departments (powder coating, anodising, and distribution) as well as the complexity and magnitude of operations at the Profiles department.

4.2 Model design

The first step towards designing the model was to create a layout of the facility that the model will attempt to mimic the operations inherent to it, the layout of the Profiles department will in this case be the layout that needs to be created. Management at Wispeco had this layout readily handy, the remaining duty in this case was to verify whether it was a true reflection of what was currently in the facility and if anything has changed from the time the layout was constructed to the current. Following the construction of the facility layout was the difficult task of defining the model logic, which in this case would be a particular way of model execution, one that will be reasonable in driving the model in a way that mimics the current process with an insignificant difference. This led to the identification of the model entities that need to be created and destroyed throughout the simulation run. Since the simulation model attempts to simulate the aluminium profiles production process at the extrusion machines until the eventual loading/packing of these aluminium profiles on the skips, it was found fit to make the aluminium profiles the entities of the model. The *Source and Sink* were used to dynamically create and destroy these entities within the simulation model. The *Source* is comprised of the main Source object plus the associated output node, type Transfer node, named *Output*. The Source object serves to hold entities that are waiting to exit the source through the associated output node. The Source object in this case will model the arrival of entities to the system. This source object was used to create a specific number of entities (cannot be specified due to confidentiality) at the beginning of every run. Five *Source* objects were created to model the arrivals for the five extrusion machine operations, these operations are independent hence each had to have its own source object.

The following activity to be modelled was the process of extrusion done by the extrusion machines. This was done through the inclusion of a *Server* object, this will model the service operation as done by the extrusion machine for each workstation (EP1 to EP5). A *Random triangular* time distribution was used to model the *Processing Times* for the server, the time distribution was inferred from the time studies performed. The same applied for the other servers linked to the various source objects through the usage of *Paths*. Three *Servers* were used to model the processes of Extrusion, Stretching and Final saw. Random triangular processing times were used for these servers. A Seize, Delay and Release process was modelled within the first server to model the process of operation.

Following these server objects was a Combiner object that would serve to combine multiple member entities together with a parent entity. This models the process of the produced aluminium profiles having to be loaded onto skips before the eventual transportation thereof to the despatch area. The *Combiner* will match the produced entities, group them into a batch and attach the batched member to the parent entity which is the skip in this case. A batch quantity was included in the combiner to model the output of each machine.

Finally a vehicle was attached to the output node of the combiner to model the transportation that takes place after the aluminium profiles have been loaded on the skips, the transportation is to the despatch area. The combiner object is linked to the *Sink* object through a bidirectional path to model the back and forth movement of the forklift in transporting the skips. This destroys the arriving entities and removes them from the system.

The model was made to run for 12 hours, from 6am to 6pm. This represents a single shift within the Profiles department, the second shift was not included as this represents the night shift of which data may vary extensively when it comes to skip availability. For the purpose of this study however, the output of each extrusion machine was monitored on an hourly basis to see the quantity produced per hour so suggestions could be made regarding the number of skips that will be needed next to each machine per hour. Skips on average has a capacity of 200kg to 250kg depending on the type of aluminium profiles loaded. Simio will take the set run time as a standard working day. After the simulation run, a report was developed where meaningful information can be extracted.

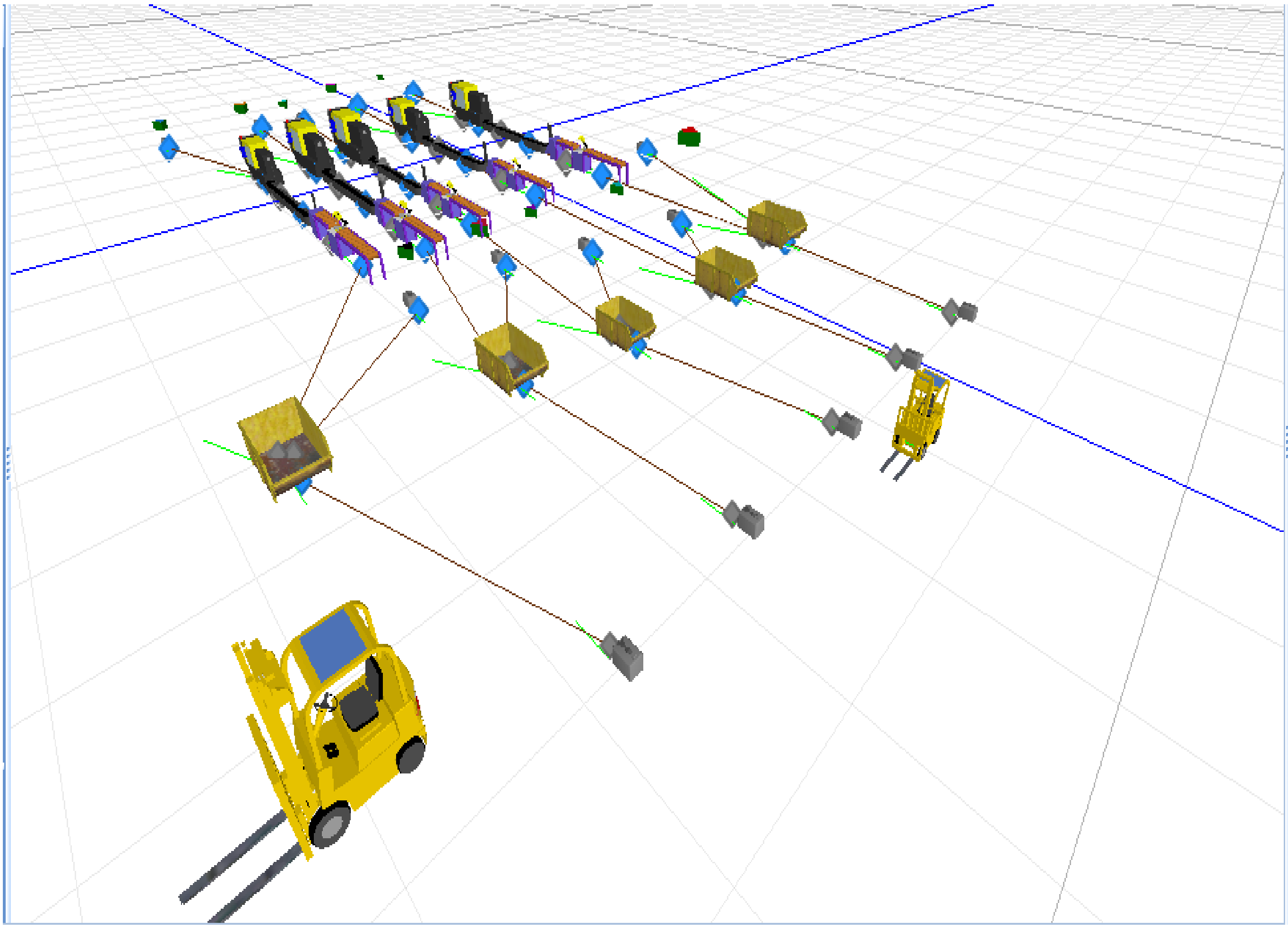

Figure 15: Facility view of simulation

Chapter 5 Findings

5.1 Current process

5.1.1 Simulation Parameters

The figure below shows the input data that used to model the process within the Profiles department. The input data is that for the five work stations (EP1-EP5), it should be noted that these workstations are identical and hence have the same data inputs.

Parameter	**Simio expression**	**Units**	**Object**
Processing time	Random. Triangular (30,38,40)	Minutes	Server (extrusion)
Processing time	Random. Triangular (12,15,18)	minutes	Server (stretching)
Processing time	Random.normal (2, 5,7)	minutes	Server (final saw)
Batch quantity	4		Combiner(skip)
Matching rule	Match members and parent		Combiner (skip)
Ride on transporter	True		output@combiner
Entity destination	input@sink		Output@server (final saw)

Figure 16: Input data

5.1.2 Simulation output

The simulation run yielded the following output:

Object type	**Object name**	**Data source**	**Average total**
Combiner	Combiner 1	Parent input buffer	Average: 70
			Max: 140
Combiner	Combiner 2	Parent input buffer	Average : 1430
			Max : 2882
Combiner	Combiner 3	Parent input buffer	Average : 1396
			Max: 2795
Combiner	Combiner 4	Parent input buffer	Average: 1440
			Max: 2878
Combiner	Combiner 5	Parent input buffer	Average: 1377
			Max: 2764
Model entities	Model entity 1-5	Throughput	Created: 11674

Figure 17: Simulation Output data

This output provides a baseline from which meaningful decision can be made regarding the number of skips that need to be available near each extrusion machine.

5.1.3 Interpretation of findings

The main aim behind modelling the series of activities within the current framework of operations was to create a form of understanding of the system's behaviour in order to be able to develop a feasible 'To-be' scenario that will attempt to remedy the shortage of skips at the press/extrusion machines. The combiner output data details the production quantity relating to aluminium profiles generated by each extrusion machine. The figures can be seen on **Figure 20.** The data on **Figure 20** is the output per hour on each extrusion machine. The model entity refers to the quantity of aluminium profiles produced during the simulation run, where a single entity represents a kilogram of material that moves through the system. This assumption was verified using production data that was provided by Wispeco which cannot be included on this report due to confidentiality reasons. From the output data, only the average output data will be used for solution design, this was deemed appropriate after observing production quantity data. This means the five extrusion machines combined produces 5713 kg of material per hour, the usual output per hour for each machine according to manage is 700kg to 1000kg for soft loading conditions (less busy times). The 5713kg figure thus represents the highest production quantity the machines could produce an hour.

Chapter 6 Conclusion and Recommendations

Efficiency and effectiveness are two key elements within most business entities as they can be seen as a support structure on which the business at large can gain a competitive edge and ultimately have a higher market share. Although most companies are striving and working towards achieving these two elements, most are trailing behind, with Wispeco Aluminium unfortunately falling victim to the consequences of a lack of efficiency and effectiveness within their internal operations. This ultimately creates adverse and undesirable forthcomings within designated departments.

The problem for this project was to ensure that there is always an availability of skips next to each extrusion machine and therefore the continuous running of the machines can be maintained, of which a total number of 2720 skips is available within the company and is shared by four departments including the Profiling department. The main area of concern however was the availability of the skips near the extrusion machines. The reason behind this concern is justified through the financial loss that Wispeco incurs due to the shortage of skips in the production area, this is essentially the area next to the extrusion machines. This financial loss is an estimate of R25248. . This figure was calculated using the average production quantity per machine (789kg/hr.) multiplied by the price per kilogram (R32/kg) of aluminium.

In attempting to solve the problem within the profiling department, a simulation model was designed so that production quantities could be tracked on an hourly basis. The reason behind this ‘per hour’ observation was to determine the number of skips that will be needed per hour next to each extrusion machine. Each skip has a capacity to accommodate 200kg to 250kg of material (aluminium profiles). The simulation run per hour yielded an overall output of 5713kg of material. This output represents heavy loading conditions for production, it represents the amount Wispeco produces when the demand is higher than normal. Given the capacity of the skips, it was calculated that there needs to be at least 30 skips between the extrusion machines with each machine being allocated at least 6 skips per hour. This brings the number of skips needed per shift to at least 360. It should be noted that this number only applies to the area near the extrusion machines and hence should not be confused with the number seen on the daily skip count figures discussed earlier in this report. It is recommended that this figure of 360 be inflated to 400 to account for the volatile and ever changing unpredictable dynamics regarding the movement of skips. For the Despatch area, which is where the produced aluminium profiles are plastic-wrapped and transported for final delivery to the customer, an estimate number of 600 skips will be needed per shift. The Despatch area does not have a formal process detailing the series of activities that takes place, hence the figure recommended above was achieved through a daily skip count. This figure represents a smooth series of operations within the Despatch area with minimum shortages if any. The above recommended figure brings the number of skips needed in the Profiling department as a whole to at least 1000 skips. This figure represents an experimental solution that will solve the shortage of skips within the Profiling department.

The allocation of 1000 skips to the Profiling department leaves 1720 skips that still need to be allocated to the remaining three departments. The allocation of skips within these three departments is not within the scope of this project but it is suggested that time studies be performed at the Anodizing and Powder coating departments since these two departments have processes which includes a standard series of activities that eventually trigger the need for skips. These time studies can be used as input data to a simulation model that will be designed for each department, the simulation study should indicate the output quantities achieved per specified time frame, and this will eventually give an indication of the number of skips needed in the individual departments. For Gauteng Stockists, this is the third of the remaining departments, it is suggested that the same procedure be followed as that followed for the allocation of skips to the Despatch area of the Profiling department, the procedure is of allocating skips that ensure a minimum shortage. The reason why the same procedure can be followed is because of the similarity between the Despatch area and Gauteng Stockists, these areas are where material is temporarily placed before being picked up by customers.

The above recommendations can be used as a baseline on which a skip management system that seeks to eliminate or ensure a minimum shortage can be designed for the four departments.

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