



**Creating a priority based pull system within pre-packing area for Cosira
Group, Vulcania**

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Executive Summary

This document provides the reader with insight into the project at *Cosira Group*, Vulcania, Springs. The document includes the path of the student, as well as the proposed solutions that will potentially be followed in order to successfully complete the project. The aim of the project is for the student to showcase his competency in the relevant areas. This is done so that the University may award the student a BEng Industrial degree.

Included in this paper is research that was done by the student regarding similar cases and problems in industry. The methods, tools, techniques, successes and failures from different projects were investigated. This was done to increase the understanding and insight into the problems that the student will face. Relevant techniques that will be used as well as methodologies that will be followed are discussed.

Research was done at Cosira and the data was analysed in such a way as to complement the aim of the project. After the solutions or proposed systems are potentially implemented, there will be estimated cost savings as well as improved customer satisfaction. The work in progress (WIP) will be less and the time an order spends in the entire facility should be less.

This project will showcase the ability of the student to analyze a problem as well as prove the legitimacy and motivation for the completion of a project using industrial engineering tools and thinking.

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List of Abbreviations

- WIP: Work in Progress
- JIT: Just in Time
- DMAIC: Define, Measure, Analyze, Implement, Control.
- CTQs Customers and Requirements
- DFSS Design for *Six Sigma*
- MRP Materials Requirement Planning
- TOC Theory of Constraints
- SPC Statistical Process Control

1. Introduction & Background

Cosira Group is one of South Africa's largest privately-owned structural steel companies. The company has grown exponentially over the last 8 years. This tremendous growth has caused gaps to form within the company. *Cosira* has come to the point where they would like to close those gaps to ensure that the company is operated at the necessary level of excellence to stay competitive.

Cosira's operations are divided into the fabrication facility (where this project will be completed), the painting and/or the galvanizing facility as well as the site where the structure will be erected. All of the work is mainly done in-house, but some of the operations are expedited to other companies whenever it is cheaper or the capacity is reached. This is done especially whenever smaller assemblies are needed as part of a bigger job, but are not financially feasible to fabricate in-house.

The fabrication facility is simple to understand. Plates, Rods and beams are procured. These are then cut to size, drilled or both to form a part. These parts are then used to fabricate assemblies which may be used in larger assemblies or just as it is. A job consists of various assemblies. When all of the assemblies from a specific job are completed, the job is complete and gets dispatched to the next facility.

2. Problem Definition

After observations and conversations with management personnel at Cosira, some problems have been identified that can be traced back up until the start of the business. Certain principles and procedures have not improved in the past 30 years. Some of these principles are fundamental to the business and should be addressed; however this project will focus on the improvement of the flow and the reduction of waste within the pre-packing area of the facility.

Assemblies within the pre-packing area are not pulled according to the priority of the job it belongs to on a consistent basis. This is concluded from the data collected and the time a job spends in the pre-packing area. The effect of this problem is unhappy clients and unnecessary WIP that inhibits cash flow and increases financing costs.



Figure 1: Pre-packing area full of WIP

3. Research and Data Gathering

3.1 Data Analysis

All of the available data from *Cosira* was analysed to determine what is currently being achieved with regards to time to complete a job. This data was found by looking at each job separately. The starting date was taken as the earliest day that raw material was ready for an entire assembly within a job. The ending date was taken as the day when the last assembly from that job was completed; hence the whole job is completed and dispatched. Each job was also divided into the number of assemblies that it contained. These assemblies contain different parts.

The charts that have been drawn up are not statistical process control (SPC) charts. This is because all of the data was not complete i.e. there were instances where incomplete entries were made. Also, the sampling procedure was not done according to the requirements of a SPC system. Therefore normal charts were used to get an idea of the severity of the variation within the pre-packing area.

The data was analysed with the aim of finding a metric that can be used as benchmark for the time it takes a job to be processed within the pre-packing area. As can be seen on Figure 2, each job takes a random amount of time to complete. This is expected seeing that each job contains different amounts of assemblies.

Figure 3 shows the amount of time it takes to complete an assembly per job. This was calculated by dividing the days it took to complete the job by the number of assemblies within the job. When looking at this between all the different jobs there should be less variation than depicted in figure 2. This is clearly not the case. Variation is expected seeing that each assembly within a job does not have the same weight or complexity. The time it takes to complete an assembly will vary depending on the above 2 factors. Therefore days/assembly is also not a relevant enough metric. Less variation is expected though between figure 2 and 3.

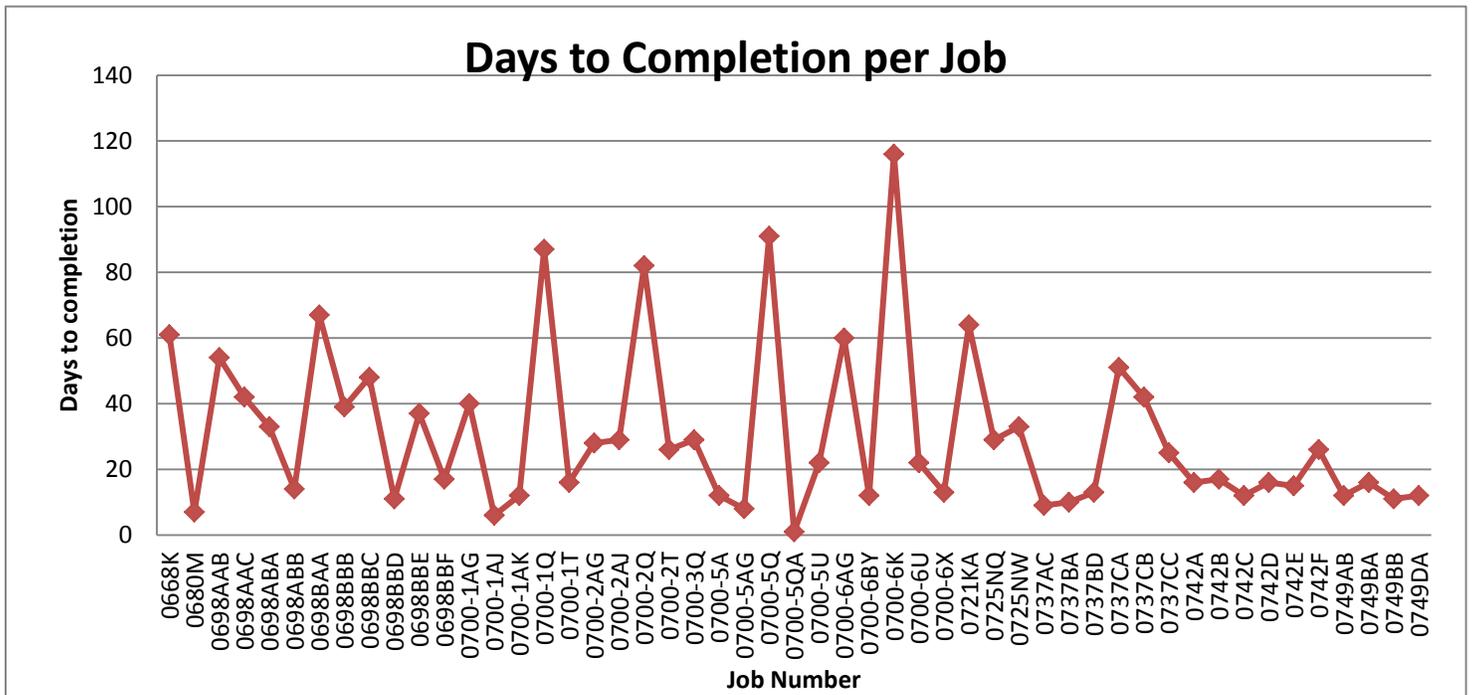


Figure 2 Days to completion per job

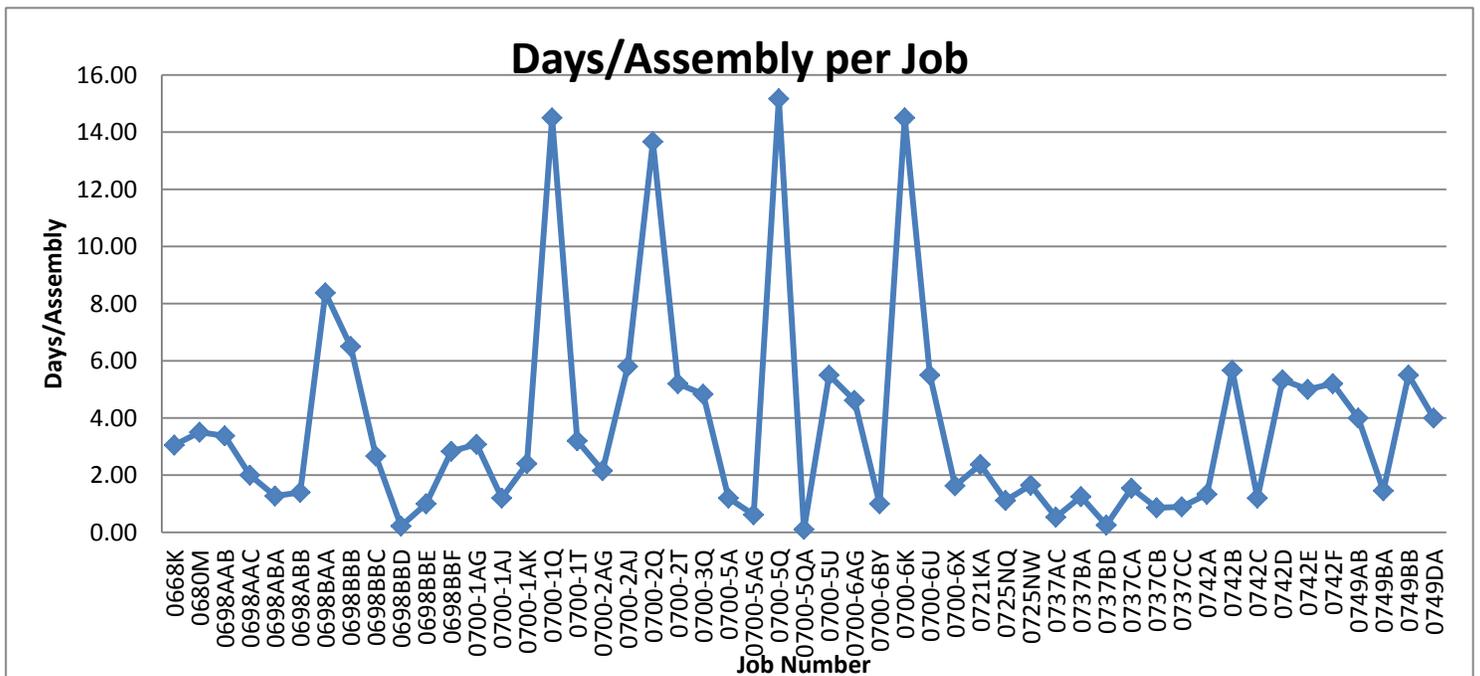


Figure 3 Days to complete each assembly per job

Figure 4 and 5 below shows the tons per day that a job takes to complete. The disconnection between the weight of a job and the tons that is completed each day on average for the duration of the job is evident of no priority system for a job. The spike for job nr 0700-5QA shows that a job needed to be completed immediately and therefore it was done within a day. The variation must be minimized.

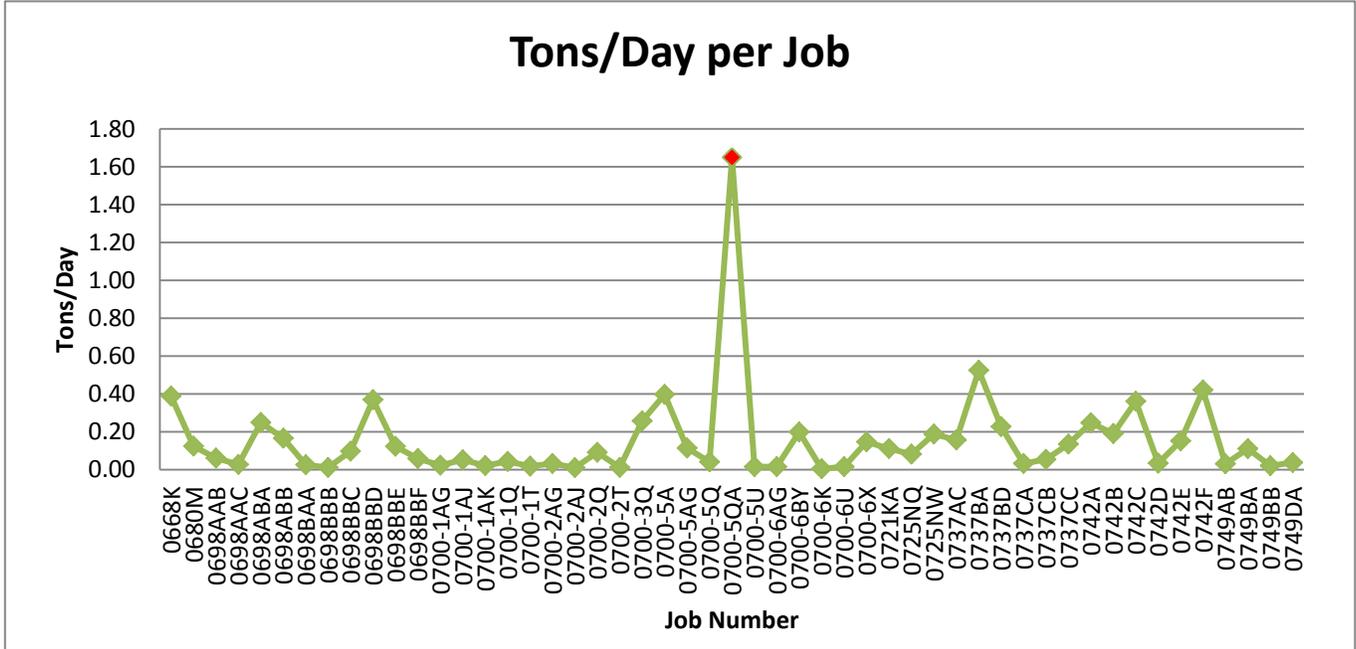


Figure 4: Tons completed per day per job

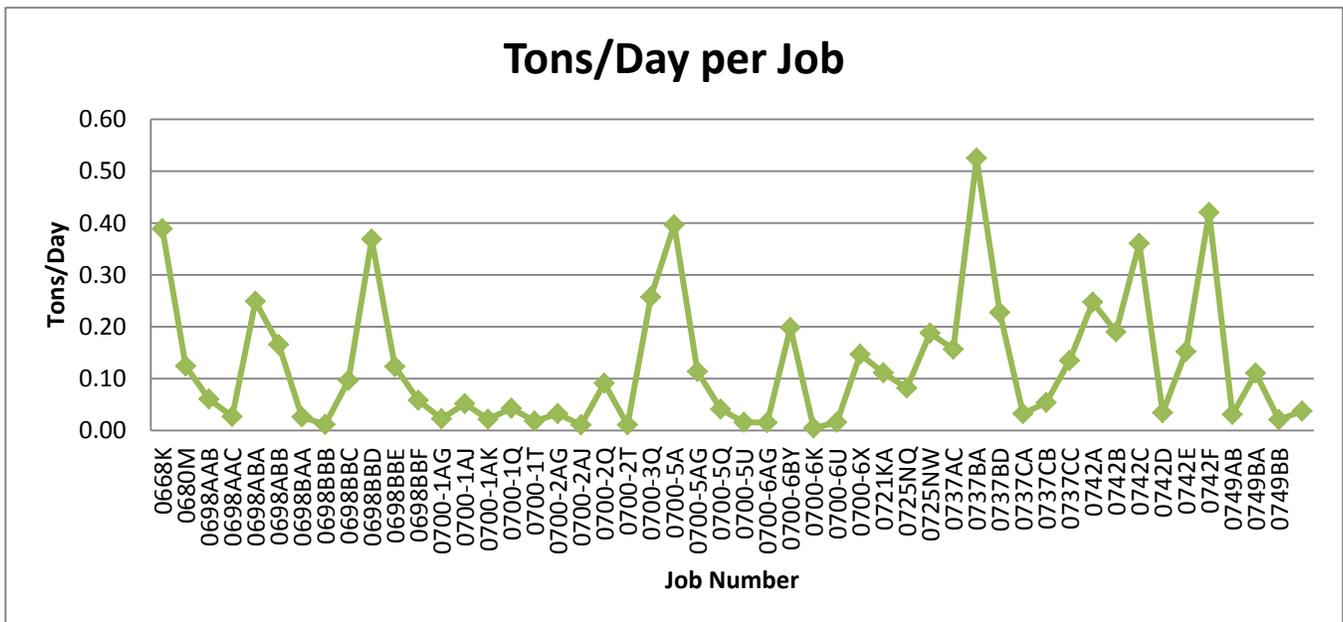


Figure 5: Revised figure 5

The job that is clearly an exception is removed from figure 4 to see the variation between the remaining jobs. This can be seen in figure 5 above.

From figure 5 it is clear that the weight of the assemblies cannot be used a metric to trace the rate at which assemblies are processed within the pre-packing area. There is still a very large variation between the different jobs. There should also be clear connection between figure 6 and figure 2 relating the time it takes for a job to be completed and the weight of the job. This connection is not here which will be discussed in the conclusion below.

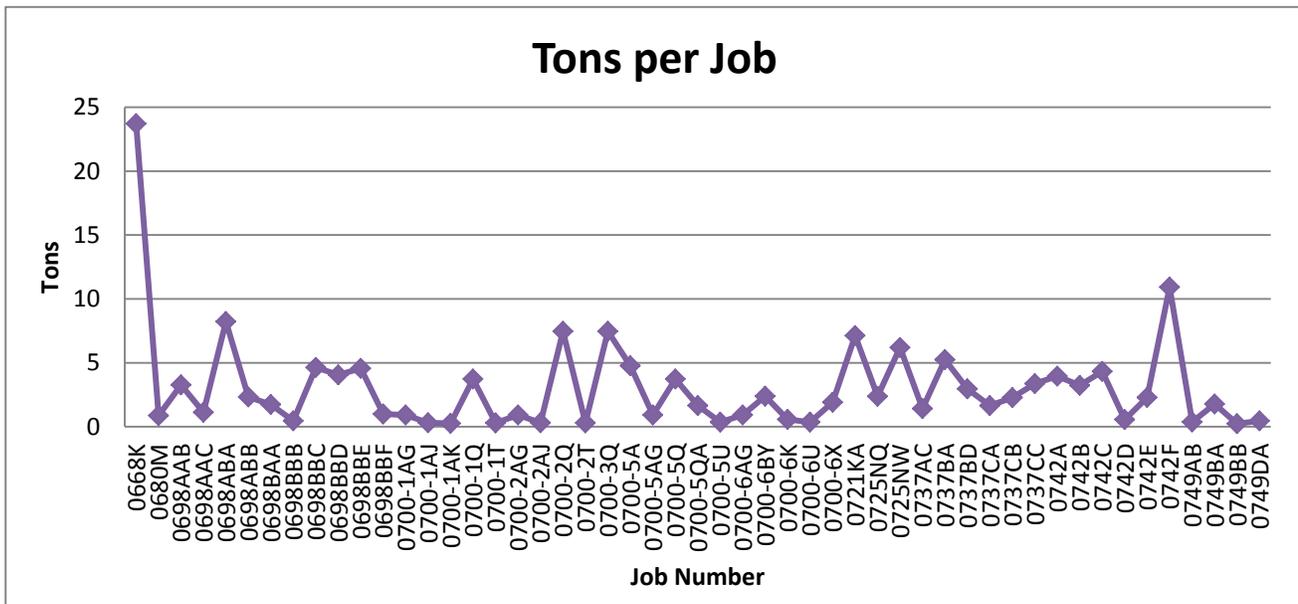


Figure 6: Total Tons per job

3.2 Conclusion

It is evident from the above data analysis that there are two main concerns within the pre-packing area. Firstly there is no feasible metric being used currently to track the different jobs and its assemblies’ movement through the area. On its own the number of assemblies or weight of an assembly is not enough to stipulate a standard time or benchmark of the flow of the assemblies. This will not be covered in the project but is noted.

Secondly, disregarding the lack of the above metric, the jobs and its subsequent assemblies are not processed efficiently. Certain jobs, of the approximate same weight and number of assemblies, take months to complete, while others only take a few days. This variation is causing scheduling issues within the planning department as well as issues at the downstream external and internal customers. The flow of assemblies and jobs, in particular in the pre-packing area, will be the main problem that this project will address.

4. Project Aim

The aim of the project is to optimize the downstream flow of the pre-packing area. This will constitute of everything that happens from parts that arrive from the various machining areas, up until the parts are packed to make up assemblies. The assemblies then wait to be pulled into the fabrication area.

The aim is to reduce the time it takes for a job (order) to be completed. Therefore the time in system of a job need to be reduced. This will improve the relationship with the clients. Currently the clients are not satisfied with the order fulfilment time. Improving this will be the ultimate goal of the project.

The secondary objective that will be pursued will be to reduce the amount of WIP in the pre-packing area. The extra parts created as well as parts in assemblies on the shop floor that are not yet fabricated are costing Cosira money each day it is not used. The amount of inventory on the floor at any given time is worth millions of Rands. It is not being used to improve flow and reduce idle time. It is unnecessary waste and should be reduced to create a more lean system.



5. Project Scope

This project will be limited to the physical boundaries of the workshop. More specifically it will be narrowed down to the pre-packing area where all of the assemblies are stacked awaiting a boilermaker to pull the assembly into further production. This area, as indicated in the floor plan diagram, as well as the machines directly responsible to produce parts for this area will be the main focus of the project.

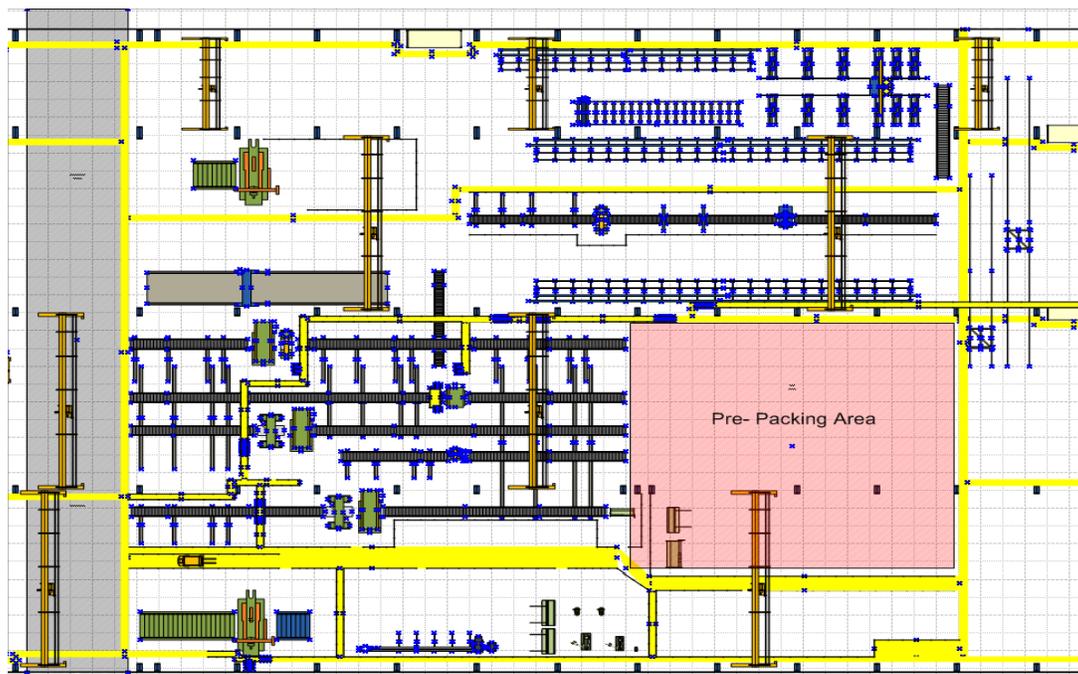


Figure 7 Floor Plan Diagram. Cosira Group 2012.

The scope will explicitly include:

- ✚ Any part that flows into the pre-packing area. This will include parts that were pre-fabricated from the different up-stream machining areas, as well as parts arriving from any other area of the workshop that have not been used for any reason.
- ✚ Everything that happens to the part before an assembly is pulled by a boilermaker.

The following are explicitly excluded from the scope:

- ✦ Suppliers as well as external customers.
- ✦ Variable orders that enter the system. These are orders that are placed because of certain assemblies that got lost in transit, stolen or are not within the specifications of the customer. They are then given top priority and may intervene with normal production.
- ✦ Other assignable causes that may change normal production and are completely unpredictable.
- ✦ All of the operations that precedes the pre-packing area.
- ✦ All of the downstream stations following the pre-packing area.

6. Literature Review

6.1 Key Principles

6.1.1 *Lean*

The term *Lean Manufacturing* was first made popular in the book by James Womack in 1990, *The Machine That changed the World: The Story of Lean Production*. This Machine referred to the TPS (Toyota Production System), while comparing it to previous approaches to automotive manufacturing. Lean has lately become synonymous with a pull system as well as methods and tools that support it.

Lean Manufacturing is a name given to the overall operational system that is characterized by extensive use of standardized methods to remove waste. The body of knowledge, leadership behaviors and the social / organizational reality that create an environment in which every employee at every level is provided with the focus, structure, discipline, and ownership required to generate continuous improvement, commitment, pride, and enthusiasm to help the organization excel. Processes require less human effort, capital investment, floor space, materials and time in all aspects of the operation. Simply, the fervent elimination of waste. (Kaufman Global, 2003)

Removing waste is the main objective of lean. There are either seven (Womack and Jones, 1996; Machines, 2002; George, 2002; Ohno, 1998) or eight forms of waste (McAdam, 2003). These forms of waste as showed in Table 1 are identified by investigating customer values.

Lean installs a philosophy and practice of waste reduction that attacks all of the wastes listed in Figure 1 with the intent to create a self-regulating, pull system that has minimal inventory.

Principles and goals of lean are all centered on improving processes. Another *Lean* pioneer, James P. Womack, describes a process as “A series of actions that must be conducted properly in the proper sequence at the proper time to create value for a customer” (Womack, 2004).

Waste	Definition
Over Processing	The addition of value to a product that the customer will not necessarily pay for.
Transportation	The moving around of products or parts thereof unnecessarily.
Motion	People moving around for no apparent reason.
Inventory	Stock or WIP which are not being sold or worked on at the moment.
Wait Time	Any time WIP is not being worked for a specific customer.
Defects	Any flaws in the product that do not conform to requirements of the company or customers.
Overproduction	Any product that is not needed in current customer orders.
Unused Human Resources	Man power that are not being used on the process.

Figure 8 Forms of Waste

An example of *Lean* principles by McAdam, 2003 states:

1. Specify what does and does not create value from the customer's perspective and not from the perspective of individual firms, functions and departments
2. Identify all the steps necessary to design order and produce the product across the whole value stream to highlight non value adding waste.
3. Make those actions that create value, flow without interruption, detours, backflows, waiting or scrap.
4. Only make what is pulled by the customer.
5. Strive for perfection by continually removing successive layers of waste, as they are uncovered.

In conclusion, *Lean* focuses on increasing process speed. To increase speed, *Lean* focuses on removing wasteful or non-value added process steps. *Lean* assumes that once waste is removed the process not only gets faster, it becomes focused on what the customer values and the quality of the product is improved.

Relevance to project

Lean principles will be applied specifically to the layout of the pre-packing area and how parts are sorted, packed and moved at any given time. There are numerous areas where waste has been identified.

The following types of waste will typically be addressed in the pre-packing area as well as some areas leading up to the pre-packing area:

- ✚ *Inventory* is the biggest waste element that needs to be eliminated as much as possible.
- ✚ *Transportation* is also identified particularly where the parts are leading up to the pre-packing area. This is a grey area where the machining personnel expect the pre-packing personnel to come and collect the parts upon completion and vice versa.
- ✚ *Wait Time* is also waste and is directly proportionate, but not limited to the *inventory*-waste mentioned above.

6.1.2 Six Sigma

Six Sigma was born within Motorola in 1979 out of frustration with quality problems. It merely refers to six standard deviations wherein a product must lie to conform to specifications. *Six Sigma* (6σ) (Kaufman Global, 2003) is a statistically based problem-solving methodology for reducing variation within processes. This is based on the premise that variations in measurement, fit and timing are common causes of defects, which, in turn, create waste. It uses martial arts terms to describe various levels of expertise of its practitioners, i.e., yellow belt, green belt, black belt, master black belt.

Six Sigma attacks specific problems with statistical thinking and techniques. The emphasis is on eliminating a problem through rigorous process definition, metric development and measurement, process capability studies, root cause analysis and installation of process improvements. *Six Sigma* attacks problems with a range of statistically based, problem solving tools. *Six Sigma* has no inherent pull-versus-push philosophy, or inventory reduction foundation built into it.

Six Sigma is a continuous improvement methodology that focuses on the reduction of variation. *Six Sigma* assumes that once the variation is minimized the process is improved. *Six Sigma* is defined as a statistic, a philosophy, and a methodology. As a statistic in the quality paradigm, it is 3.4 defects per 1 million opportunities and is related to the cost of quality.

The philosophy of *Six Sigma* is the use of data and statistical analysis tools for systematic processes improvement. Process data are gathered and analyzed to determine average process performance and the output quality variation. The *Six Sigma* methodology is a five-phase, disciplined approach to continuous improvement. The five-phases are Define, Measure, Analyze, Improve, and Control. These phases are referred to as DMAIC.

Relevance to project

Six Sigma thinking and background will be used but seeing that the problem is more lean-based the solutions will not be sustainable. After the lean implementation Cosira can start to look at a more *Six Sigma* based (minimum variation) system.

6.2 Project Specific Principles from Literature Study

6.2.1 Successful Instances of Lean and Six Sigma Implementation (Case Studies)

6.2.1.1 Memorial Hermann Southwest Hospital in Houston, Texas

This hospital, like many others, had a problem with the delays it experienced with admitting new patients. The project was scoped from the time the physician wrote the discharge order to the time the bed was clean and available for the next patient. (Rushing and Pexton, 2010) followed the DMAIC *Six Sigma* procedure and from the case study the following became evident:

- ✚ The whole system was very similar to a production plant like *Cosira* where new orders cannot be accepted while orders or “jobs” are still pending within the warehouse. In this case the same problem is being solved. Variation within the process of admittance must be reduced just like the time an order spends within the packing area in *Cosira* must be reduced.
- ✚ After measurements were done and the mean time it takes before another patient can be admitted was determined, the process was broken down into four phases:

1. Order written to “noted” in chart.
2. “Noted” in chart to patient leaving.
3. Patient leaving to entered in computer
4. Entered in computer to bed clean

Each step was closely examined and assigned upper specification limits. Initial capability analysis revealed 90 % defects, or 909,000 DPMO (defects per million opportunities). The sigma level was essentially zero, but the team gave themselves credit of .2 sigma to start. The performance objective was to reduce defects by 80%, reaching 2.41 sigma or 18% defects.

- ✚ After addressing the staffing problems that included the time of day the most patients are discharged, as well as the improvement of the post-discharge lobby, a huge improvement was noted. After implementation of plans and improvement in 6 areas the defects in the process was lowered to 55% (down from 90%). The median turnover time decreased from 329 minutes to 179 minutes. Productivity has increased in housekeeping, and feedback collected during the Improve phase helped to verify that satisfaction for physicians and patients has risen as a result of changes that have been implemented.
- ✚ A few months later the control measures indicated that the process has slipped back into the previous inefficient routine. This was due to new staffing and a lack of management to implement the changes that caused the improvement. The Black Belt immediately called a meeting with the Green Belts, project sponsor and executive Champion to address the issue. After some automation and alerts being set in place when a patient is discharged the process was back on track.

Relevance to project

Clearly the *control* aspect of DMAIC is critically important to achieve sustainable improvement and will be a crucial challenge at *Cosira* where process owners play an important role in the implementation of any plan. Although the lean approach will be dominant within the project, the sustainability issue is critical and any solution/improvement needs to be monitored to ensure maintained improvement.

6.2.1.2 Process Cycle Efficiency Improvement through Lean (Paint Line)

This case study dealt with the workings of a construction equipment manufacturing company. The assembly line paint shop was the main focus for improvement.

- ✦ Major tasks were identified within the paint shop
- ✦ After intense brainstorming and study of the shop activities were identified that do not add value.
- ✦ *Lean* implementation was used in conjunction with *Six Sigma*.
- ✦ Value stream mapping was done for the current state.
- ✦ Total cycle time and cycle efficiency was improved through various initiatives.
- ✦ The time to complete the masking process was improved
- ✦ The drying process was improved through the use of ovens instead of the sun.
- ✦ Overall safety was improved.
- ✦ Future state value stream mapping was done.

Improvements after the *Lean* approach included:

- ✦ 29% reduction in **Work In Progress**
- ✦ 29% reduction in the **Total Cycle Time**
- ✦ 88.56% improvement in **Value Added Time**
- ✦ 153.13% improvement in **Cycle Time** efficiency
- ✦ 45% improvement in **Process Lead Time**

Relevance to project

The team involved used value stream mapping as well as intensive brainstorming to determine the best action to take and improve the most critical areas. In the same way it is extremely important to find the most critical areas in *Cosira*, apply *Lean* and certain *Six Sigma* methodologies and have a clear scope with quantifiable objectives.

6.3 Tools and Techniques within Case Studies

6.3.1 Value-Stream Mapping

Value stream mapping is a tool that is used to identify 1) which areas of a process or processes are responsible for adding value (as perceived by a customer) to a product. Also, 2) which areas do not add value to the product, but are nevertheless required by the creation of the product. Then most importantly 3) those areas that do not add value to the product as perceived by the customer. Last mentioned should be eliminated immediately.

The “value-stream” or “value-chain” mapping is a visual representation of all the steps, tasks, or activities in a process and documents their sequence from start to finish (George, 2002). This is done primarily to identify the system’s current state with the aim to remove non-value adding areas as well as improve and support areas that add the most value.

To determine which questions to ask to determine which steps/tasks are value-adding and which do not George (2002) lists the following questions:

✚ Customer Value-Added Questions:

- Does the task add a form or feature to the product or service?
- Does the task enable a competitive advantage?
- Would the customer be willing to pay extra or prefer us over the competition if he or she knew we were doing this task?

✚ Business Value-Added Questions:

- Is this task required by law or regulation?
- Does this task reduce the financial risk of the owner?
- Does this task support financial reporting requirements?
- Would the process break down if this task were removed?

✚ Non-Value-Added Questions:

- Does the task include any of the following activities: transporting, inspecting, moving, storing, delaying, counting expediting, handling and multiple signatures?
- Taking a global view of the supply chain, having made these improvements, to how many factories do we really need to deliver projected volume? Will the faster lead time and lower costs fill up existing facilities?
- With faster lead times, how many distribution centers can be eliminated?

Relevance to project

Value stream mapping is very insightful, but other processes are needed to implement the knowledge that is gained from the value stream. The main issue in the warehouse at Cosira is still waste reduction. Therefore the use of a value stream map will indicate the most appropriate areas where waste should be eliminated or reduced.

7. Preliminary Solutions

7.1 Solution Requirements

When thinking of the possible solutions to the root cause of the problem, there are certain effects that should at least be addressed within the solution. These include:

- ✦ The solution should address the primary metric, *time of job in system*, reducing it to improve the flow in the pre-packing area. This will reduce the time it takes an assembly to move through the area consequentially.
- ✦ The WIP within the pre-packing area cannot increase and should at least stay the same or decrease within the pre-packing area.
- ✦ There must be a clear direct or indirect financial benefit which accompanies the solution.
- ✦ The complexity of the solution should be of such a case that the workers can implement it with minimal to no extra training

7.2 Improving process flow and reduce WIP

Seeing that the pre-packing area is the major bottleneck in the plant it is crucial to manage the flow of parts and assemblies accordingly. Parts arrive in the pre-packing area in set intervals from the various upstream manufacturing machines. When all of the parts for a specific assembly have arrived, this assembly can be pulled out of the pre-packing area into fabrication.

A simulation model, illustrating the flow of parts into the pre-packing area, and the allocation to the different active jobs was created. This model was done on simulation software package called *Simio*. One can construct a model that illustrates real life circumstances. This model is representative of the process and can therefore be used to test any possible improvements made to the system. This model is not an exact version of what happens in the pre-packing area but is downscaled for practical reasons. Therefore if the model is simulated for a day on the software, it is not an exact day according to manufacturing at Cosira. The model is still representative of the process. The purpose of the model is to compare the as-is (current) state of the process to the to-be (proposed) state of the process.

The model assumes the following:

- ✚ Ideal system. There are no unplanned breakages or shortages in parts or staff. Also there is no planned maintenance on the machines upstream from the pre-packing area.
- ✚ The parts arrive in batches with a normal distribution, representing the normal operation of each machine on the workshop.

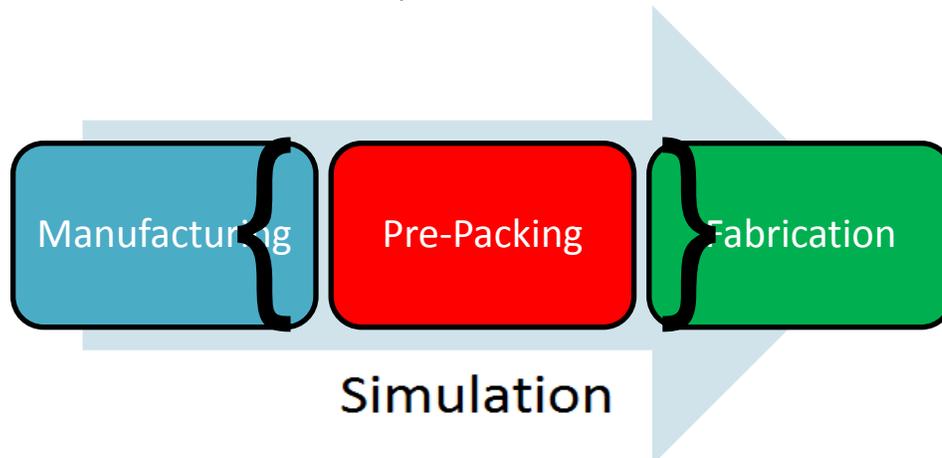


Figure 9: Area being simulated

The simulation will encompass the output of the manufacturing area as the input to the pre-packing area. The simulation will not take into account the fabrication area. The flow through the pre-packing area is the most critical element in this simulation. Two different scenarios will now be discussed and results of the simulation will be analyzed and compared.

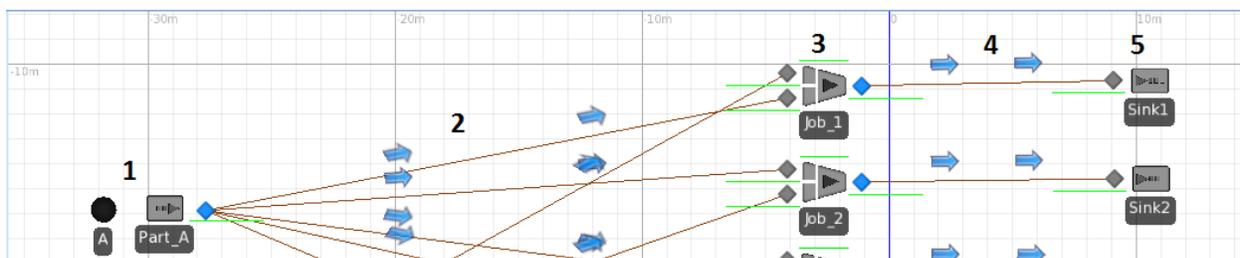


Figure 10: Model Entity Descriptions

1. → Parts arrive from the manufacturing area in predetermined batch sizes.
2. → Parts are pulled into different jobs as required.
3. → Each job consists of various assemblies which in turn consist of different parts.
4. → When all of the assemblies within a job is completed and sent (pulled) into fabrication, a new job can be issued from the planning office.
5. → This is the fabrication department where the assemblies are completed.

7.2.1 Current as-is system

At any given moment Cosira is working on 10 jobs. This means that on average 10 clients are waiting for their orders. Each job consists of numerous assemblies. All of these assemblies need to be completed before the job can be completed and a next job can be started on.

Currently the rates at which jobs are completed are not meeting the requirements of the customer. The promised/planned date is not being met. Customer satisfaction is low.

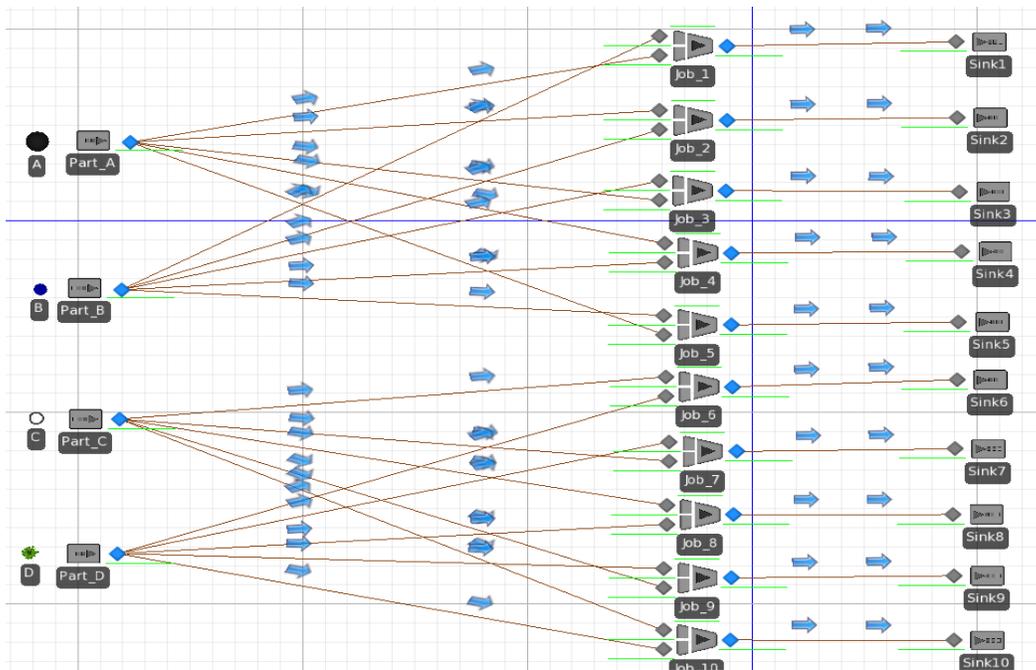


Figure 11: Simio as-is system

After running the simulation for a day the following results were obtained:

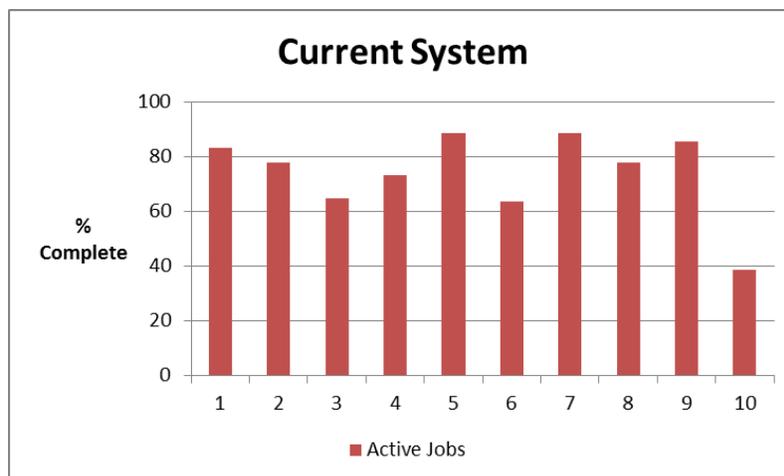


Figure 12: Average Completion Rate: Current Process

From the graph it is clear that not all of the assemblies are being completed at the same rate. The average completeness of an assembly is 74%.

7.2.2 Proposed System

To improve the flow within the pre-packing area and create continuity with regards to the completing of jobs the following system is proposed where the active jobs are reduced to 5:

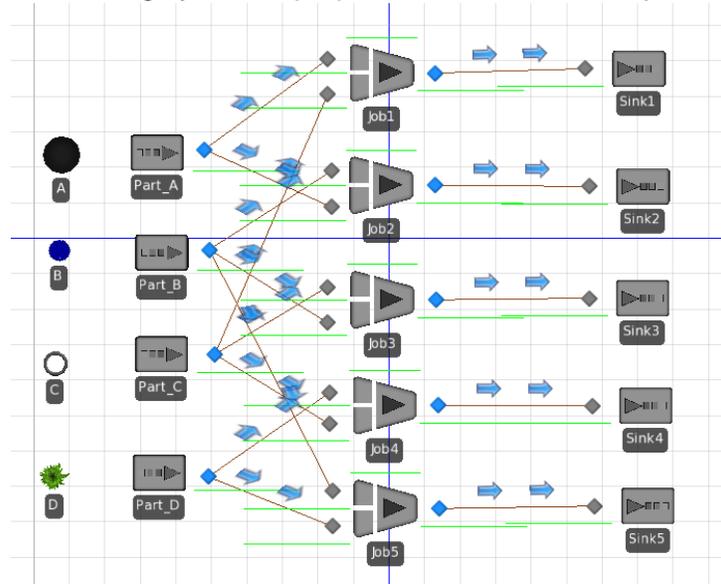


Figure 13: Proposed System

Reducing the active jobs within the pre-packing area will improve the flow of the process. If the amounts of steel that enters and exits the pre-packing area remain the same, the assemblies that are being worked on should take less time to be completed. This system will reduce the complexity of prioritizing the assemblies that need to be pulled. There should also be less WIP in the system. After running the simulation for the same amount of time the following was seen:

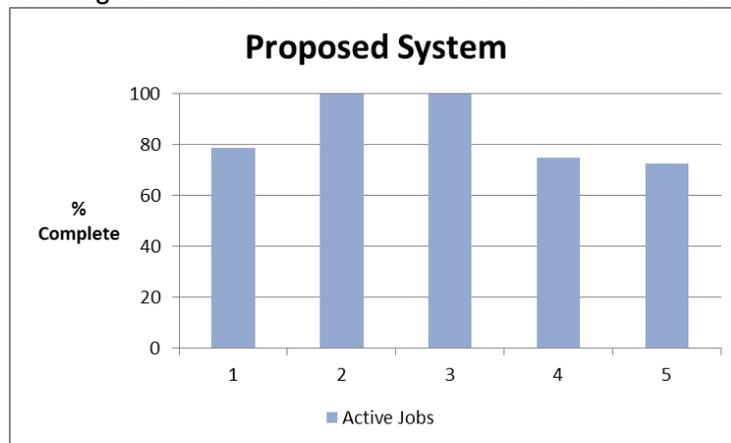


Figure 14: Average Completion Rate: Proposed Process

The average completeness of an assembly is now 85%. This is a 10% increase from the current system. By doing this more time can be spent on each job that is active and therefore increase the throughput rate.

7.2.3 Validation of solution

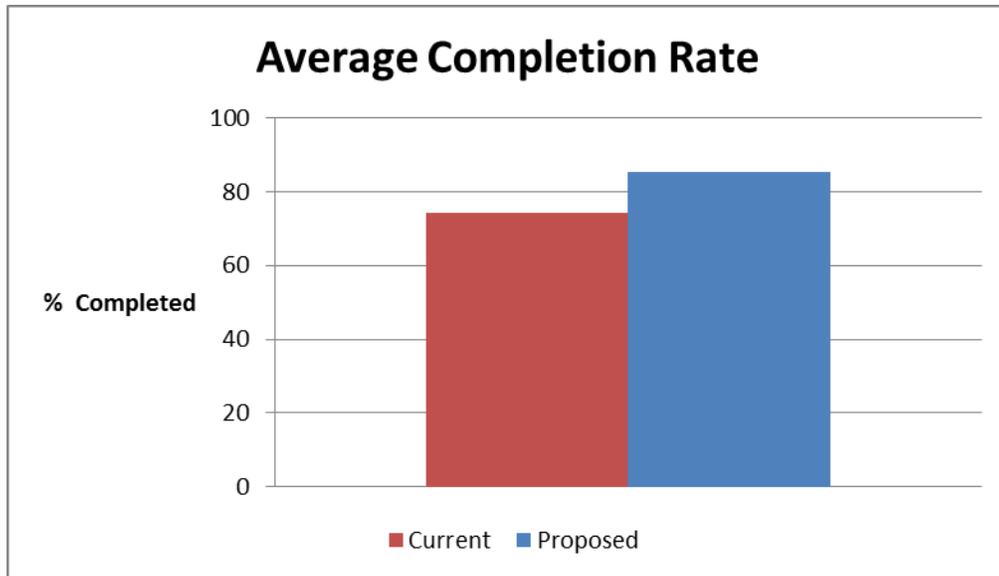


Figure 15: Average Completion Rate Comparison

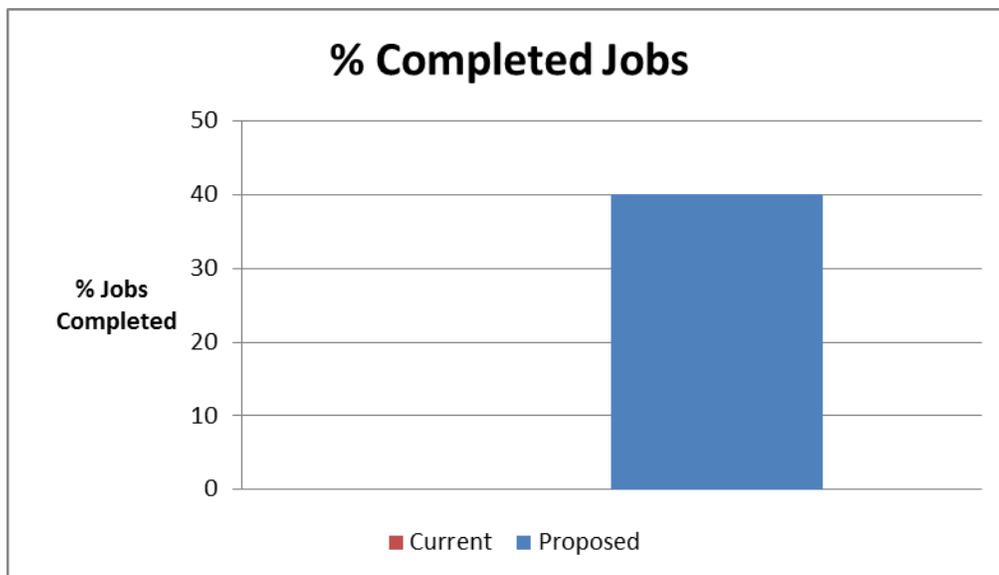


Figure 16: Percentage of jobs completed

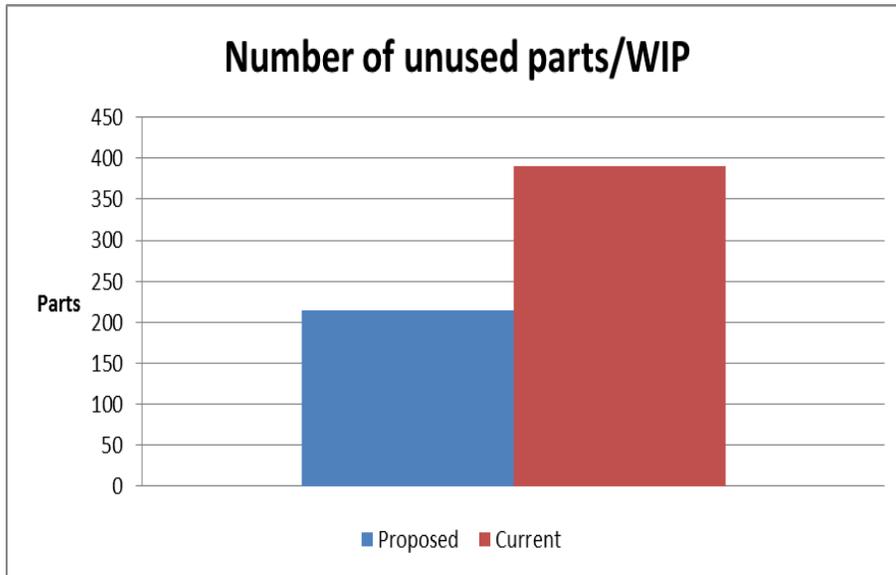


Figure 17: Excess Parts or WIP

7.2.4 Conclusion

From the above graphs and comparisons the following can be said about the proposed system:

- ✚ The average completion per day of a job is 10% higher with the proposed system.
- ✚ 40% of the jobs started are completed within the planned time for the proposed system, while none of the jobs are completed in time for the current system. This is a true representation of the current system that is documented and observed.
- ✚ The amount of excess parts or WIP during one day of simulation is 45% higher for the current system than for the proposed system. After running the model for 30 days, the amount of excess parts/WIP was calculated as 47% higher for the current system.

The potential monetary saving per month:

Average WIP at any given time in the pre-packing area: **160 tons**

Reduction of WIP with new system: **75 tons**

Cost of steel at pre-packing area: **R12 000 per ton**

Potential saving 75 tons x R12 000 per ton = **R900 000***

*This does not include the amount saved with regards to interest on overdraft account.

7.3 Facility Design Optimization

Parts arrive into the pre-packing area from various different locations by means of:

- ✚ Forklifts
- ✚ People carrying the parts
- ✚ Overhead cranes
- ✚ Automated roller conveyor system

7.3.1 Current movement of parts

This spaghetti diagram illustrates the current movement into the pre-packing area from the upstream manufacturing machines:

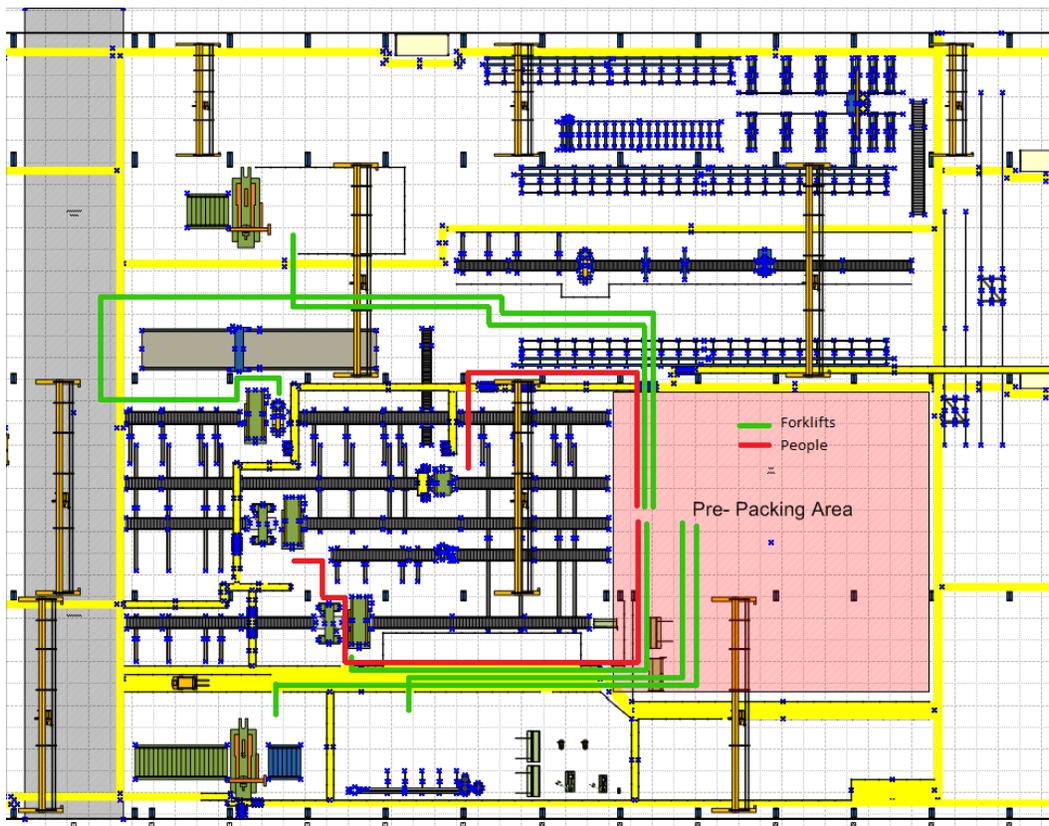


Figure 18: Current Spaghetti diagram of movement into pre-packing area

The green flow lines indicate forklift movement. The red lines are workers who have to carry the parts by hand seeing that the forklifts cannot reach the machines. Problems with the current flow:

- ✚ There is a lot of unnecessary movement that creates waste.
- ✚ Parts get lost while transported.
- ✚ Parts do not get moved to the same place constantly.
- ✚ Parts do not arrive on time. Only 1 forklift driver is available and parts may wait for hours to be transported.

7.3.2 Proposed movement of parts

The automated roller system that runs from each machining area up unto the pre-packing area is not currently being used. The parts are too small and will fall through the rollers. This can be solved by placing the parts on a pallet on the roller. They can be moved directly to the pre-packing area from where they will be unpacked and the empty pallet returned to the necessary machine.



Figure 19: Automated roller conveyor system

The flow diagram that indicates the movement for this proposed system will look as follows:

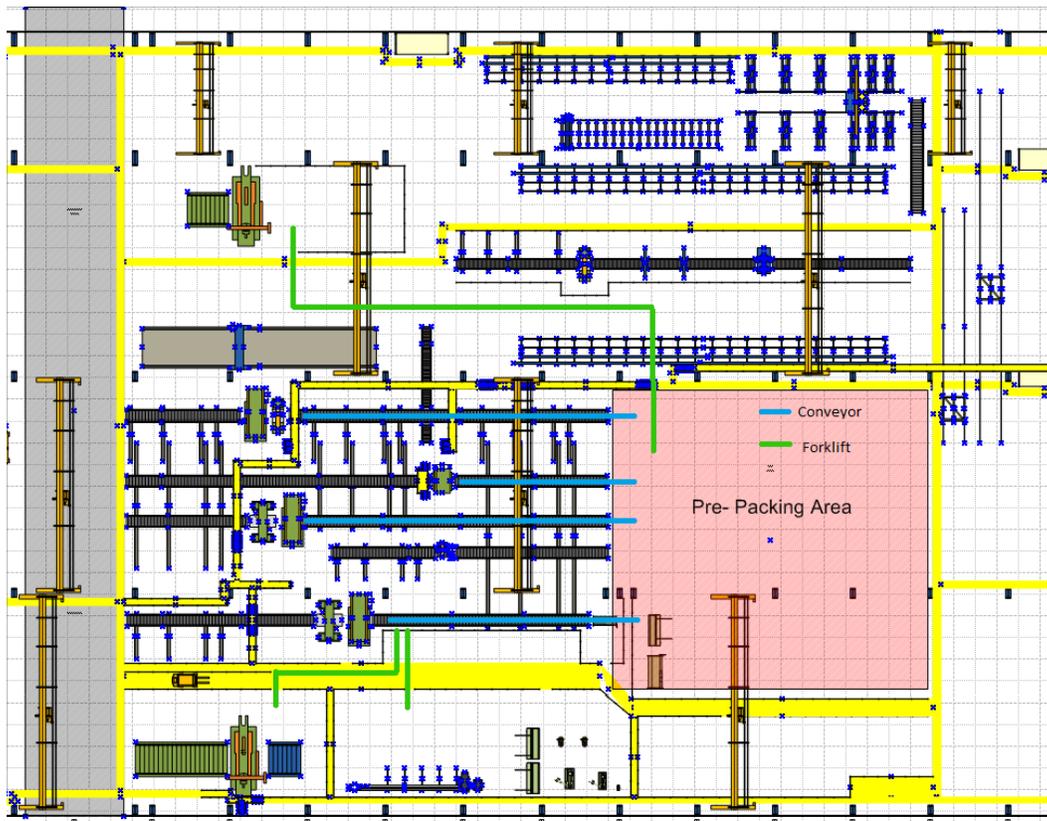


Figure 20: Proposed spaghetti diagram of movement into pre-packing area

7.3.3 Improvement in distance travelled

Manufacturing Machine #	Current Movement (Meters)	Proposed Movement (Meters)	Percentage Improvement
1	118	38	210%
2	72	72	-
3	56	41	27%
4	53	31	42%
5	73	59	19%
6	68	38	44%
7	45	20	56%

Figure 21: Quantified Reduction in Movement

- ✚ Overall reduction in movement: **186m or 38% improvement.**
- ✚ Reduction in movement of people: **100% improvement.**
- ✚ Reduction in movement of forklifts: **262m or 70% improvement.**

The forklift will still play a role but the conveyors will be the main transporter of parts.

Advantages of this proposed system changes:

- ✦ Encourage continuous flow of parts through the system. As soon as a pallet is packed it can be moved on the conveyor. It does not have to wait for a forklift or a worker to transport the parts.
- ✦ Decrease the opportunity for parts to get lost in transit.
- ✦ No new infrastructure is required.
- ✦ Parts arrive at the same place within the pre-packing area each time. The pre-packing area can also be better utilized with regards to new, predetermined space allocations.
- ✦ The forklift will be used less which will also be a cost saving.
- ✦ The overall time it takes to get the parts to the pre-packing area is less.

7.4 Priority System

7.4.1 Current system

After assemblies are completed they are currently being pulled at random into fabrication. The larger assemblies are normally pulled first seeing that more tons are moving through the facility. This is very ineffective. Assemblies should be pulled according to the most critical job that is active in the pre-packing area. Each assembly gets a flag to indicate that all the parts are present. It can then be pulled into fabrication.



Figure 22: Flags being used to indicate completeness



Figure 23: An assembly awaiting fabrication

Currently there is no discernment between the different flags. There is no assembly awaiting fabrication that is seen as more important or critical to be completed.

7.4.2 Proposed System

The following priority system should be considered:

Each assembly gets a flag corresponding to the urgency of the job it belongs to. The flags will typically be used as follows:

- ✚ Red flags: These flags will be placed on the assemblies that are completed and late. This will be a sign for the fabrication department that these assemblies are behind schedule and should have been pulled already. The red flags are the highest priority and should be completed as soon as possible.
- ✚ White Flags: These will be used to put on assemblies that are not yet completed (filled with all the necessary parts). These assemblies will be a sign for the personnel in the pre-packing area that they have the highest priority to be filled next. Whenever parts arrive in the pre-packing area, these assemblies should be filled first.
- ✚ Green flags: Green flags are placed on assemblies that are completed and await fabrication but are still on time. If there are no red-flag assemblies in the pre-packing area, the fabrication department will pull the green-flag assemblies into fabrication.

Typically there should never be any red flags on the floor, only green and white flags. This will indicate that the process is running on time. Whenever there are red flags in the area, it should be closely monitored and communicated to the planning office so that the rate at which new jobs and material are pushed into the facility can be adjusted. The pre-packing area is the bottleneck and should always determine the flow of the workshop.

8. Implementation Plan

The plan with regards to the improvements described in section 7.2 to 7.4 will be implemented as needed or possible for the company. As Cosira is in the process of changing management, there are no specific dates or schedules with regards to the changes.

8.1 Improving process flow and reducing WIP

As the simulations have shown in section 7.2, it will be advantageous to reduce the amount of active jobs in the pre-packing area from 10 jobs to 5 jobs. To implement this there are a number of changes that should be made:

- ✚ The planning office should change their scheduling and only allow new jobs into the process once there are less than 5 jobs in the pre-packing area. This must be communicated to the planning office by the pre-packing area. A pull system from the pre-packing area must be implemented.
- ✚ Planning must adjust the scheduled procurement of raw material so that it fits into the new system. If contracts need to be changed or adapted with suppliers to accomplish this, it should be set in place beforehand.
- ✚ The workers in the pre-packing area must ensure that they do not receive any parts that are not allocated to a job that is not active in the pre-packing area. If they receive parts that are meant for the next active job it should be communicated to planning.
- ✚ Most importantly, everyone that is part of the system up until the pre-packing area should understand the reasons for the changes made. Each process owner must communicate this to every worker so that they can be held accountable at all times. Every worker need to be part of the solution for this project to be a success.

8.2 Facility design Optimization

The reduction in movement described in section 7.3 will require minimum changes to the current process:

- ✚ The conveyor system must be tested and the operators must practise using it. A number of test runs can be done to ensure reliability.
- ✚ The maximum weight should also be determined to ensure the conveyor is used within its design specification.
- ✚ Each station in manufacturing must be taught the new procedure. No more manual movement of parts are allowed, only the conveyor or at selected stations a forklift will still be used.
- ✚ Fewer workers are now needed to carry parts to pre-packing area, therefore they must be reassigned to another station or their job description must be adapted accordingly.
- ✚ The forklift(s) previously assigned to moving of parts between the pre-packing area and the manufacturing stations must be rescheduled or reallocated.

8.3 Priority System Implementation

The proposed system that will address the movement of parts within the pre-packing area and out of the pre-packing area into fabrication will be addressed:

- ✚ The boilermakers, pre-packing staff and floor managers must be trained on the new priority system. They must understand why the changes were made. It is important to let them buy into the idea to ensure success. Also, a visual indication of priority on the floor will be easier to manage by the employees.
- ✚ A white board must be installed in the pre-packing area to constantly indicate the active jobs and the priority of each. Only one person like the floor manager should be allowed to update and change the priorities on the board.
- ✚ How regularly the white board must be updated should also be determined beforehand i.e. each shift, daily or weekly.

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