UNIVERSITY OF CAPE TOWN
DEPARTMENT OF MECHANICAL ENGINEERING
MEC5000W – MASTER'S DISSERTATION
2012

Dissertation Title:
Converting Activities to Processes for Operational Efficiency Improvement of a South African Agricultural Equipment Manufacturer

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Word count:	*22 500*	*No. of pages*	150

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Acknowledgements

The completion of this dissertation has been both a personal and educational journey; it has provided much enlightenment and an equal (possibly exceeding) amount of personal strain. Therefore. I would first and foremost like thank my family, for their unquestioned support throughout this journey, and Ms. Adele Schoeman for her continual (and ongoing) encouragement.

I would like to express personal gratitude to Professor FJ. Kahlen for continually chucking me into the deep end and believing that I would manage to stay afloat. Additional thanks go to Mr. Charles Rickens for affording me this dissertation opportunity and allowing me to poke my nose in his business, and to Mr. Denys Visser and Mr. Bernie Booisen for always being keen to bounce ideas.

Research Abstract:

Converting Activities to Processes for Operational Efficiency Improvement of a South African Agricultural Equipment Manufacturer

South African agricultural equipment manufacturers face increasing pressures from global competition, in response they have resorted to manufacturing customised machinery in a bid to secure market share. This strategy, while successful, introduces a high degree of product variation and complexity - increasing strain on the manufacturing operation. In response to these strains, manufacturers are placing emphasis on finding new ways to improve manufacturing costs and accelerate product delivery.

The objective of this dissertation is to assemble and sequence a practical framework, using commonly available (and established) tools and improvement methodologies, which will allow its user to effectively direct process oriented improvement through analysis and modification of the operations at the activity level.

The framework seeks to achieve this by formalising the operating structures already present and subsequently modifying it, in a value driven manner, using lean principles and heuristic methods for the purposes of providing practical, easily integrate-able and affordable solutions aimed at promoting operational excellence while eliminating Lean wastages.

Testing conducted showed that regardless of environment lean principles can be successfully adapted to produce significant reductions in lead time and gains in both product flow and overall quality.

KEY WORDS: FRAMEWORK, VALUE, PROCESS, ACTIVITY, LEAN, PRACTICAL

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List of acronyms

BOM – Bill of Material

KPI – Key Performance Indicator

MRP – Materials Resource Planning

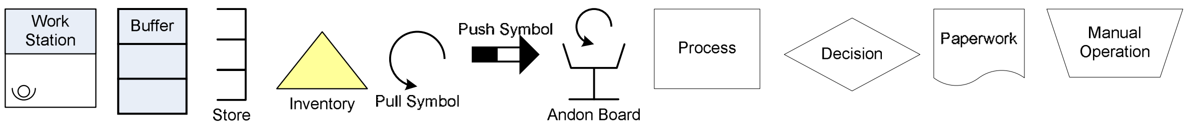
QRM – Quick Response Manufacturing

SOS – Store's Operating System

VSM – Value Stream Map

R&D - Research and Development

Diagram Key:



1. INTRODUCTION

"A process is a specific ordering of work activities across time and space, with a beginning and an end, and clearly defined inputs and outputs: a structure for action" (Davenport, 1993). The objective of an operational process is to facilitate the business' strategic and operational objectives (Davenport, 1993). Ideally, a process should add value to its inputs and create an output that is more useful and effective to its customer (Johansson et al., 1993).

An organisation conducts its operations through the execution of a limited set of high-level overall processes, which align the operation's strategic objective (Rummler & Brache, 1995). These overall processes flow "through" the company, linking functional silos (departments) within an organization through a value chain; the overall processes effectively span the 'white space' between the functional silos of the organisation's organogram (Rummler & Brache, 1995); See Figure 1.

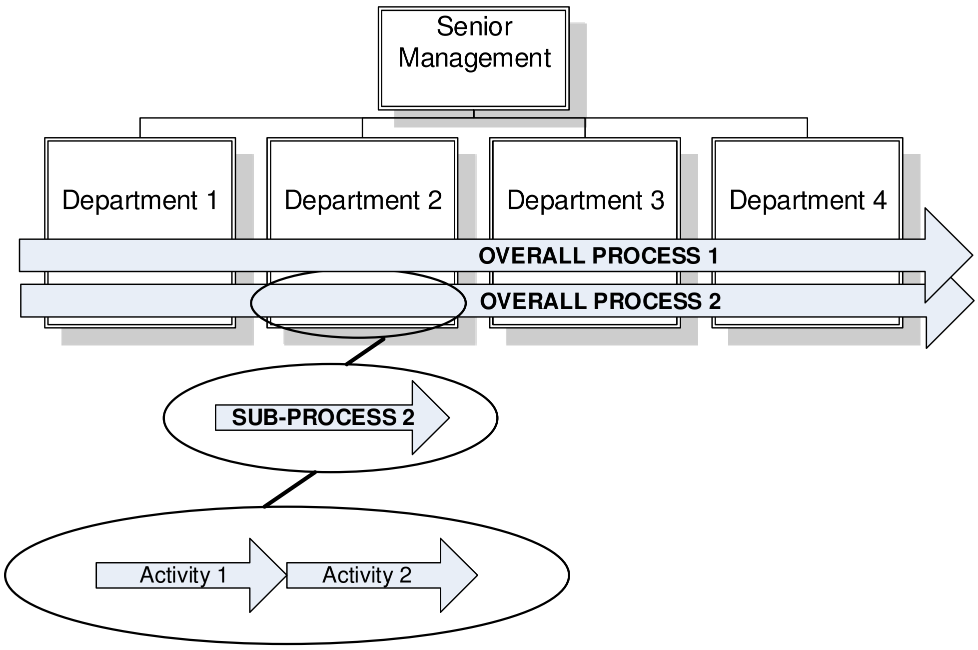


Figure 1 Illustration of the overall process composition

The functional silos execute sub-processes, which allow the flow of the overall processes. Sub-processes can be further decomposed into activities: the activity level is the most detailed level of the process and as such cannot be further broken down without listing the actual activity instructions - See Figure 1.

The activities executed within each functional silo serve to transform the received inputs into the outputs required for the continuation of the overall process flow (Hammer & Champy, 1993). Value creation at an organisational level is generated by the flow of the overall processes, and is hindered if the functioning of activities creates obstructions.

In summary, the overall *process determines "what*" happens in the value chain whereas the related *activities determine "how"* those things happen (Hammer & Champy, 1993).

The outcome of a well-designed business process is increased effectiveness (value to the customer and company) and increased efficiency (less costs to the company) (McDonald, 2009), ensuring that business processes function efficiently, allowing for optimum operation of the organisation as a whole.

1.1. Objective of this dissertation

The objective of this dissertation is to assemble and sequence a framework, using commonly available (and established) tools and methodologies, which will allow its user to effectively direct process oriented improvement through analysis and modification of the operations at the activity level.

The framework aims to allow the user (who does not necessarily possess pre-requisite knowledge of the operations) to *quickly and effectively* determine the root causes of operational issues which obstruct the organisation's ability to deliver value, and to subsequently identify operational modifications required to allow the organisation's overall processes to flow.

The framework seeks to achieve this by, enabling the user to:

1. communicate and affirm the functioning of the organisation's operations in order to target an overall process for improvement
2. employ a value driven approach to determine the operational objective of the overall process selected, as well as its suppliers and customers; and to subsequently define the value add criterion of the overall process selected
3. map the sub-processes which comprise the value chain of the overall process – as well as the inputs, outputs and boundaries of the sub-processes – in order to understand the value add objectives of the sub-processes in terms of the associated overall process and the organisation's elected operating strategy
4. identify and prioritise the resolution of operational root causes local to sub-processes which inhibit the overall process' ability to realise value
5. analyse the affected sub-processes at the activity level to identify value obstructions and subsequently propose solutions – based on analysis observations – intended to resolve value inhibitors
6. test the effectiveness of the proposed solutions prior to implementation where possible

The framework development was hosted by Rovic and Leers, a South African agricultural equipment manufacturer.

1.2. Company introduction

Rovic and Leers are a South African agricultural equipment manufacturer, traditionally involved in the manufacture of a stable but limited range of product. Due to the relatively small size of the company and the manufacture of a limited product range, Rovic has traditionally operated on an ad-hoc basis: i.e. without standardised processes. The repeatability of production and long-time product familiarity made this feasible.

Recently, however, increasing market pressure and an influx of global competition has forced Rovic to diversify its product range. In a bid to gain access to a niche customisation market present in the South African agricultural sector, Rovic responded by acquiring a company which specialised in the design and manufacture of individually customised agricultural implements.

The implements are made to the customer's exact specification (or preference); this adds to the intended value proposition, but also renders Rovic a Make-to-Order jobshop: i.e. a *High-Mix/Low-Volume* environment. In turn increasing the complexity of the design and manufacturing phases, which often run concurrently in order to meet promised manufacturing timeframes.

Design changes (for each unique machine made) ripple throughout the organisation: the effects span all the way from material procurement through to machine assembly. The combined effects of increased product complexity and stressed production periods introduced value obstructions to Rovic's operations. The ad-hoc nature of process execution was unable to effectively host and direct the inter-departmental interaction and collaboration required to make the operation flow in a sustainable manner.

The presence of these value obstructions has prompted Rovic to find innovative ways to increase its manufacturing efficiency through the integration of standardised operating procedures and policies.

Improving the performance of any facet of Rovic firstly requires an understanding of how it achieves its macro objective: building machinery. The value stream map (VSM) in Figure 2 below, illustrates the overall functioning of Rovic and provides an overview of the process involved in the creation of machinery.

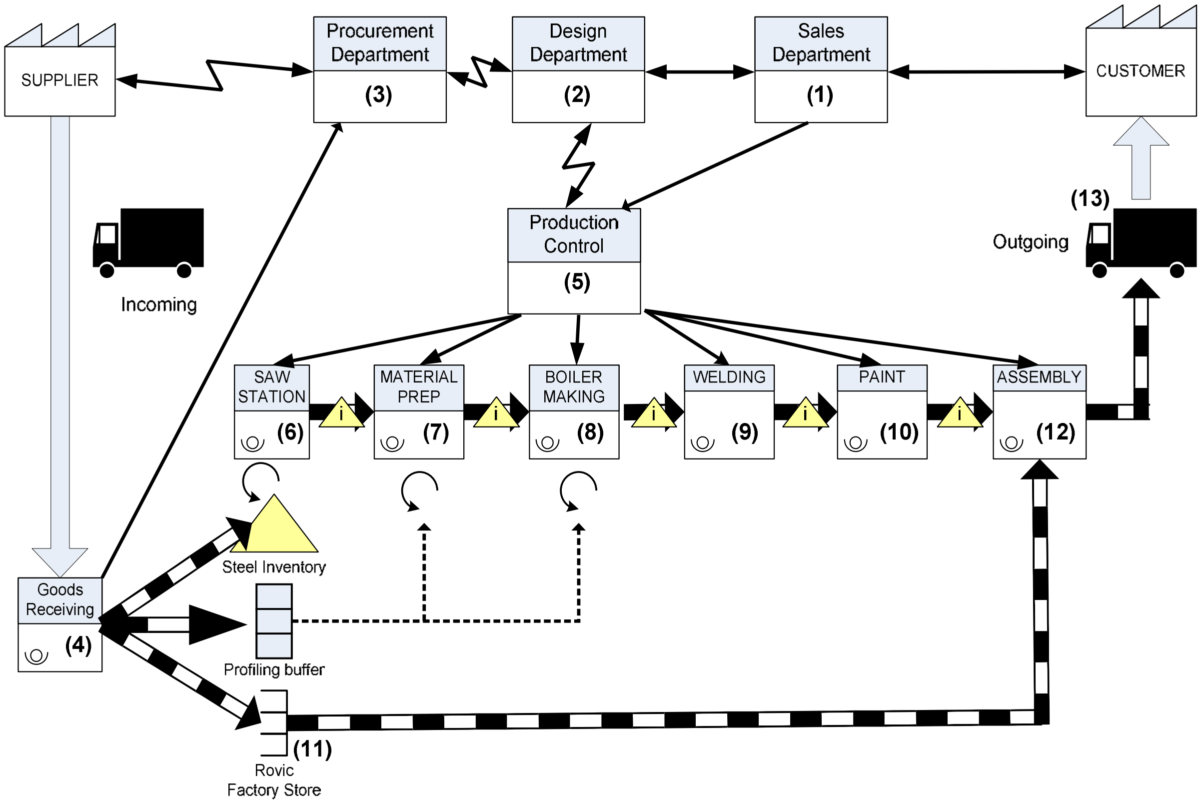


Figure 2 Rovic and Leers' Overall value stream map

It can be seen from the Overall VSM that Rovic build machinery in the following manner:

(Step No.)	Department Responsible	Related Processes
1	Sales	1. Receiving the order from the Customer 2. Relaying the desired machine specification to Design 3. Relaying the machine delivery date to Production
2	Design	1. Designing the machine to the sales specification 2. Creating the Bill of Material (BOM) of the machine

(Step No.)	Department Responsible	Related Activities
3	Procurement	1. Ordering the goods required from external suppliers based on the BOM
4	Factory store	1. Receiving goods procured from Suppliers 2. Placing the goods into storage
5	Production	1. Opening the works orders on the MRP system in-line with the BOM 2. Allocating stock to the works order 3. Generating the work instructions for the production departments in the factory 4. Generating picking lists and delivery schedules for the factory store
6	Saw Station	1. Cutting raw steel to the lengths required for production of the machine.
7	Material Prep	1. Withdrawing the profiling items which require drilling and shaping 2. Performing the drilling and shaping operations on the raw steel and profiling
8	Boiler Making	1. Withdrawing the profiling required to form the machine sub-assemblies 2. Jigging the processed steel and associated profiling together to form the machine's sub-assemblies
9	Welding	1. Welding together the machine's sub-assemblies
10	Paint	1. Painting the sub-assemblies
11	Factory store	1. Supplying the Assembly department with the externally sourced goods required to assemble the machine
12	Assembly	1. Gathering the parts and components supplied by the store and Rovic production departments 2. Assembling the components and parts to form the finished machine
13	Logistics	1. Shipping the finished machine to the Customer

Figure 2 illustrates the connected nature of departments within Rovic and hints at the implications of offering unconstrained customization to the customer at the point of sales.

1.3. Dissertation objective in context

The overall functioning of Rovic's operation as illustrated in Figure 2 was presented to Rovic's management for discussion and selection of a starting point for future operational improvements. The improvements were intended to align the operation with the organisations overall strategy.

Reflecting on the operations from a value delivery perspective, it was realised that value delivery to the customer was only truly created during the assembly phase of production. It was here that WIP was converted to saleable product and enabling this conversion required 3 things: Labour, in-house fabricated parts and externally procured goods.

The availability of externally procured goods at the time of assembly was deemed to be of paramount importance, and reported to be the most common cause of production delays.

For this reason, the objective of the framework in context to Rovic was to improve the effectiveness and efficiency of the overall process related to making externally procured parts available for assembly operation.

This objective was nominated by Rovic's management for the following reasons:

1. Assembly operations were often halted because the parts required could not be found, had not been delivered by the Store or ordered by Procurement
2. The Assembly department was unable to effectively communicate their real time parts needs to the Store
3. The Store was not able to adhere to the delivery schedule for assembly parts as set forward by the Production Manager
4. Store employees were unable to determine whether goods required by assembly had been delivered or were still pending
5. Employees were unable to locate parts within the store
6. Stock was moved often and without record, resulting in parts being lost in the factory

The reasons cited above occurred with varying frequency, but when encountered, incurred production delays – often in the order of weeks. The research sought to identify how the likelihood of these interruptions could be actively minimised from an activities perspective, and in turn modify the process in an attempt to prevent future delays to value realisation.

The solutions generated were constrained by the scope and restrictions defined below.

1.3.1.1.1. Scope:

The process alterations were limited to activities internal to Rovic. Practices between Sales and customers and Procurement and suppliers were to be considered static constraints.

1.3.1.1.2. Constraints

The following constraints were set by Rovic Senior Management:

1. Production instructions were to remain MRP driven and orientated
2. Process alterations were not allowed to incorporate the introduction of electronic order fulfilment systems e.g. barcode scanners, automatic picking systems etc. due to cost restrictions
3. Administrative controls were not to be unduly tedious or time consuming so as to not burden the limited staff compliment
4. Proposed process changes were to require minimal financial investment from Rovic and could not include the appointment of additional staff

The framework's objectives are, in summary: to document the overall process; identify obstructions to value delivery at the level of the sub-process; analyse the sub-processes at the activity level; propose process modifications and, finally, to test the effectiveness of the proposed solutions.

1.4. Literature Review

This intention of this chapter is to outline the key aspects of process structure, continuous improvement philosophies, operational considerations and process tools.

1.4.1. Processes

According to Davenport (1993) a process is, ‘a structured, measured set of activities designed to produce a specific output for a particular customer or market. It implies a strong emphasis on how work is done within an organisation, in contrast to a product focus’s emphasis on what. A process is thus a specific ordering of work activities across time and space, with a beginning and an end, and clearly defined inputs and outputs: a structure for action… Processes are the structure by which an organisation does what is necessary to produce value for its customers.’

From Davenport’s definition, a process:

- has a goal
- provides value to its customer
- has clearly defined inputs and outputs
- is composed of activities
- is structured, and thus repeatable

1.4.1.1. *Advantages of utilising a process view for continuous improvement*

Most organisations are structured into functional departments (e.g. sales, design etc.) that are dedicated to performing specific functions. Business processes cut across these organisational departments and flow “through” the organisation (Rummler & Brache, 1995).

The process view is an alternative view to the traditional departmental (functional) view of an organisation. The process view is a more powerful (and holistic) way of looking at an organisation as it makes an end-to-end assessment of the organisation’s overall objective. The functional view can sometimes straitjacket a process (and limit the potential for improvement) because it is restricted to the predefined inputs and outputs of the process segment being considered. The functional view is focussed on transforming the predefined inputs into the predefined outputs of the process segment rather than catalysing the processes’ overall objective. The process view changes the emphasis from “who does what” to “what needs to be done” (Cousins & Stewart, 2002).

As a practical example consider Figure 3: The functional view would seek to catalyse the transformations within each silo and the process view would seek to eliminate the silos 1 and 2 as they effectively cancel each other and do not contribute value to the end objective: to generate C.

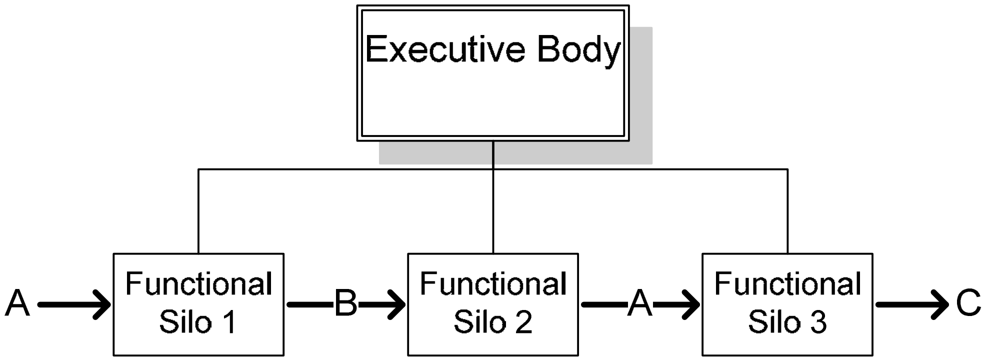


Figure 3 Functional vs. process view for continuous improvement. Arrows indicate the inputs and outputs of each silo.

1.4.1.2. *Process Standardisation*

Jang and Lee (1998) define process standardisation as "The degree to which work rules, policies, and operating procedures are formalised and followed." The objective of process standardisation is to make process activities transparent and achieve uniformity of process activities across the value chain and across firm boundaries (Muenstermann and Weitzel, 2008).

1.4.1.3. *Measuring the performance of a process*

Performance is measured by capturing data. The purpose of capturing data is to provide an objective view of effectiveness and efficiency: without hard data, one is unable to accurately say whether things are becoming better or worse and for what reasons.

Relying on subjective measures of performance provides a blurry picture at best: the picture painted is ultimately still the individual's opinion. When dealing with subjective reviews, there are no concrete definitions and questions like, "How good is good enough? How much faster is faster than before? Exactly how much has it improved?" become increasingly challenging to answer.

In order to provide lucid detail regarding the performance of the process, objective data must be captured. Furthermore, the measurements themselves must be standardised in order to provide data consistency and reliability. i.e. what is measured, and how it is measured, must remain consistent if the data is to be reliable.

The performance of a process has 2 dimensions: effectiveness and efficiency (Oak Ridge Institute for Science and Education, 2001). According to Oak Ridge Institute for Science and Education:

Process Effectiveness refers to the degree to which the process output conforms to requirements. Attaining the desired output more frequently increases effectiveness.

Process Efficiency refers to amount of resources consumed by the process in order to produce the output required. Utilising less resources increase efficiency.

Put simply, effectiveness is a measure of the degree to which the process meets its objective and efficiency is a measure of the effort required for the process to meet its objective.

1.4.1.3.1. Metrics vs. KPIs

Performance is measured by utilising metrics. A metric is any standardised measurement – number of incidents logged, average time to log an incident, number of incidents per month etc. There are an infinite amount of metrics which can be generated and recorded.

A Key Performance Indicator (KPI) is a metric that translates directly to an organisation's end goal, objective or bottom line and can be used as a driver for improvement (Schneiderman, 1996). Improvements in a KPI guarantees an improvement in the organisation's objective, whereas an improvement in a metric has no guaranteed effect on the organisation. All KPIs are metrics, but not all metrics are KPIs. Furthermore, there are substantially fewer KPIs than there are metrics.

1.4.2. Production Factors

There are four factors which determine the nature of the production environment, they are: product mix, product volume, degree of customisation and demand variability.

Product Mix: Refers to the range of the product manufactured: the greater the number of different products, the greater the mix. Product differences do not refer to the appearance or application of the product, but rather to the specific routings, operations and processing times associated with the manufacture of the product. That is to say that two products which appear vastly different but which share routings, operations and processing times are for manufacturing purposes deemed the same.

Product Volume: Refers to the quantity of the product manufactured within a specific time. Whether a product is high or low volume depends on the manufacturing environment: 100 units may be considered high volume in a made-to-order environment, but would be considered low volume in a mass manufacture environment. Broadly speaking, a product is low-volume if it can be easily be over-produced.

Degree of Customisation: Refers to how unique (different from the next) each product is. The two extremes would be the manufacture of a standard product: in this setting every product is identical and the manufacture of an extremely customised product, in which case the product is only ever built once – typical in a made-to-order environment.

Demand Variability: Refers to how stable the demand for the product is over time. If the demand is erratic then the variability is high.

Production environments can generally be classed into two types: *Low-Mix/High-Vol*ume or *High-Mix/Low-Volume*. Examples of these would be an auto manufacturer and a job-shop, respectively. Low-Mix/High-volume environments usually have low degrees of customisation and demand variability, and vice versa for High-Mix/Low-Volume environments.

1.4.3. Material flows in production

There are two types of material flows in production: push and pull (Drew, McCallum, & Roggenhoffer, 2004).

Consider Figure 4, below:

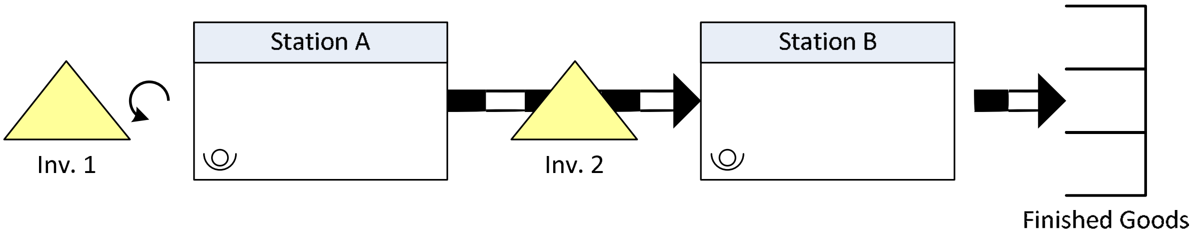


Figure 4 Push vs. Pull

In a push environment, Station A will automatically process inventory whenever it has inputs available. It is not connected to the functioning of Station B and, as such, inventory will build up between stations A and B.

In a pull environment, Station A will only process inventory once it receives a signal from Station B indicating that inputs are required. In this way Stations B and A are synchronised and the amount of WIP allowed to build-up (if at all) is controlled.

1.4.4. Improvement methodologies

This section of the dissertation highlights the fundamental principles of the continuous improvement philosophies leveraged by the framework. Each philosophy has its own way of attempting to improve operational performance.

1.4.4.1. *Lean Manufacturing*

History

Lean Manufacturing is a term popularised by James Womack ,Daniel Jones and Daniel Roos in their book "The Machine That Changed the World" (Womack, Jones, & Roos, 1991). Lean manufacturing has its roots in the Toyota Production System (TPS). TPS was developed by Toyota in response to the business challenges it faced after the Second World War.

Core objective

The core objective is to create product flow, and in turn reduce the total production time, through manufacturing standardisation and waste reduction (Womack & Jones, 2003).

Objective Rationale

Removing waste – any activity that does not add value to the customer – from processes and standardising work improves the overall quality levels and reduces lead times.

The lean wastage as defined by Drew et al (2004) are shown below:

Lean wastages as outlined by Drew (2004):

Lean Wastage	Description
Inflexibility	Inability to response to demand variability
Inventory	Any parts or materials above the minimum required to deliver what customers want when they want it
Motion	Unnecessary movement of people or materials within a process
Over-processing	Effort that isn't required by the customer and adds no value
Over-production	Producing sooner, faster or in greater quantities than is needed by the customer
Rework	Repetition or correction of a process

Transportation	Unnecessary movement of materials
Variability	Any deviation from the standard or nominal condition
Waiting	Idle time (for people or machines) in which no value-adding activities
Working practices	Normal working practices that obstruct flexibility in the operating system

Operation

According to Drew et al (2004) there are seven principles for the lean operating system. They are:

1. Create value streams by grouping similar products or services
2. Flow the value along the stream from beginning to end
3. Pull products to the point where the flow must be broken
4. Flex the operation to match customer demand
5. Introduce information defining customer requirements at a single point, and as late as possible in the process
6. Standardise operations to create to create a foundation for flexibility
7. Detect and fix abnormalities as possible to the point where they occur

Traditional Application:

Lean is traditionally suited to Low-Mix/High-Volume environments.

1.4.4.2. *Quick Response Manufacturing (QRM)*

History

QRM was developed by Professor Rajan Suri (of Wisconsin University) as a materials control strategy to deal with the variability of job-shop environments. QRM was popularised in Suri's 1998 Book "Quick Response Manufacturing: A company wide approach to reducing lead times".

Core objective

To relentlessly reduce the lead time, and thus allocated operational capacity required, for end-to-end process execution, thus increasing the capacity available to create value while eliminating waste (Suri, 2010).

Objective Rationale

Suri (2010) posits that process execution requires operational resource capacity, and that a lack of this capacity prevents the operation from achieving its desired objective. Providing that a consistent level of quality is maintained, reducing the overall lead time will inherently lead to elimination of non-value add activities; in turn liberating operational capacity for further value add (Suri, 2010).

Operation

Suri (2010) outlines the following principles for a QRM environment:

1. Focus on the reduction of overall lead times
2. Employ cellular layouts interlinked with pull controls
3. Macro manage cells, allowing technicians to micro manage
4. Aim to operate at 70-80% capacity utilisation to allow for variability in the system
5. Reduce overall batch sizes to increase manufacturing flexibility

Traditional Application:

QRM was designed for application in High-Mix/Low-Volume environments (Suri, 2010).

1.4.5. Kanban material flow control

Kanban is signal driven pull mechanism employed in lean manufacturing to control WIP flow between successive work stations. It was developed by Taichi Ohno as a mechanism to achieve Just In Time (JIT) flow (Ohno, 1988).

In Kanban-controlled production, work stations only process inventory after receiving signals from downstream stations indicating that there exists a demand for the inventory. There are numerous ways to generate the demand signal: a physical card is traditionally employed.

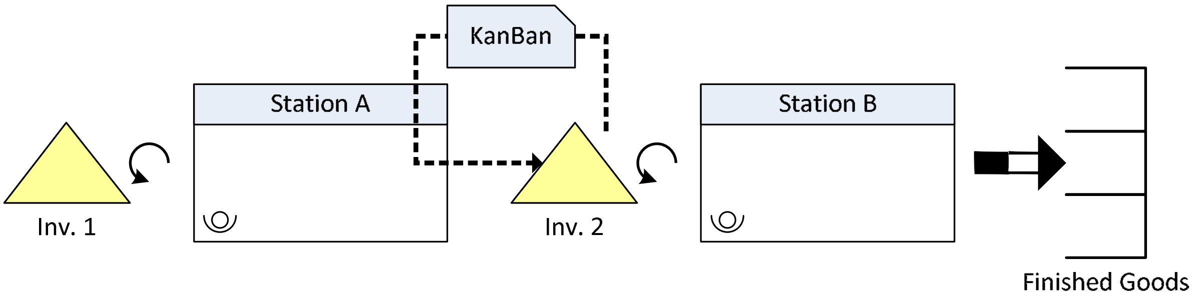


Figure 5 Kanban controlled material flow

The material flow illustrated in Figure 5 is outlined in Figure 6.

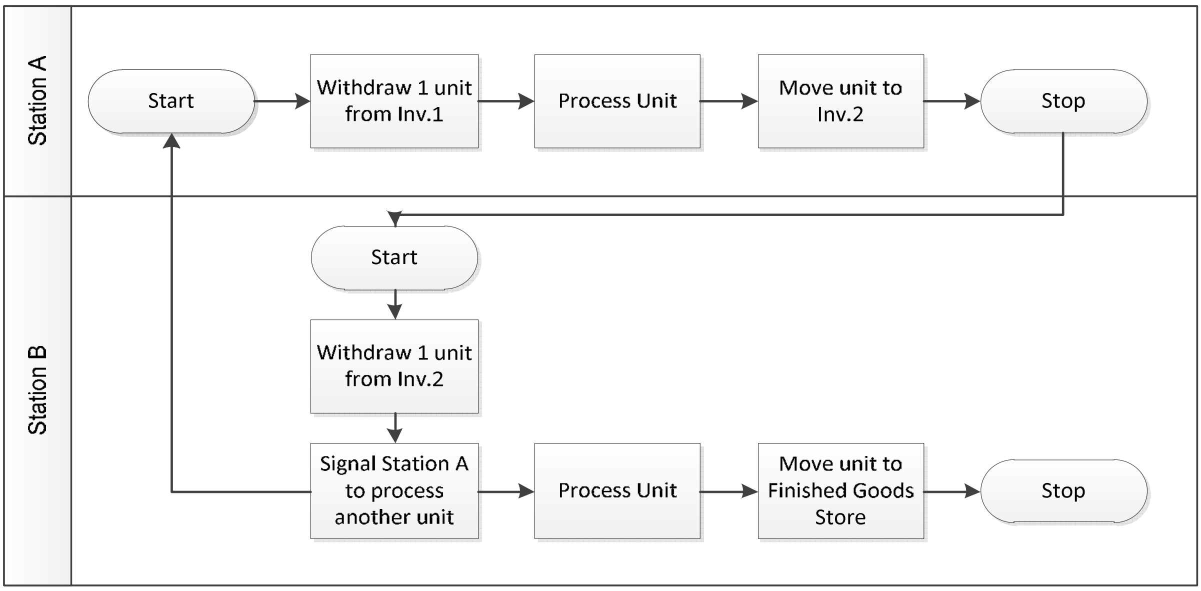
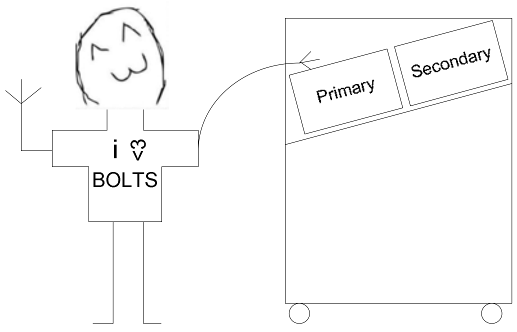


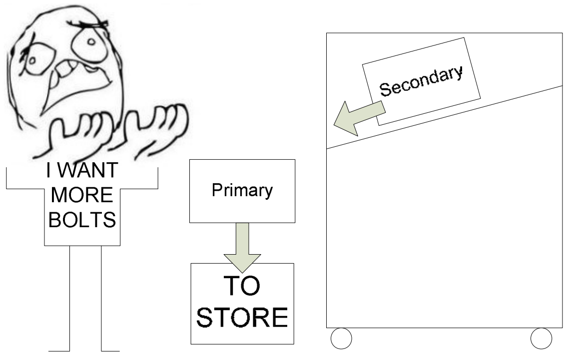
Figure 6 Pull signalled material flow process

1.4.5.1.1. Two-bin Kanban system

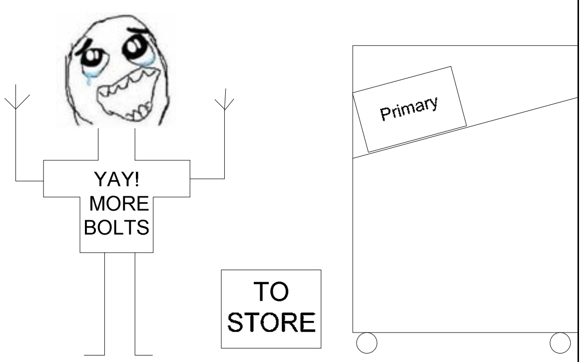
The two-bin Kanban system is a special application of the Kanban principle whereby the parts container itself is used as the signalling mechanism. The functioning of the two-bin Kanban system is illustrated in Figure 7 below:



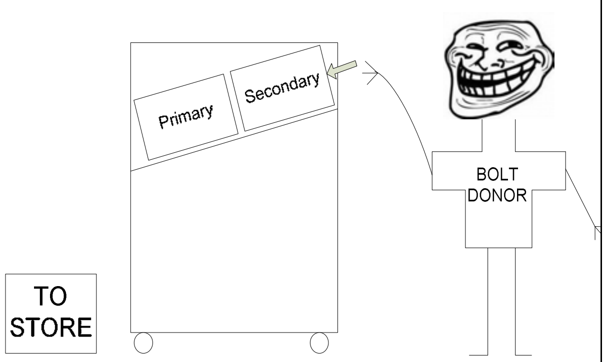
1.) The Assembly Technician uses the primary reservoir until it is depleted.



2.) Once the primary reservoir is depleted, it is placed into a refill bin and collected by the Store. The secondary reservoir is then slid forward – it becomes the new primary reservoir.



3.) The Assembly Technician consumes the new primary reservoir as required.



4.) The Storeman refills the empty reservoir and places it back into the Two-Bin Trolley, it becomes the secondary reservoir. The process repeats.

Figure 7 Illustration of the Two-Bin Bolt refill system functioning.

1.4.5.2. *Enterprise Resource Planning (ERP)*

Enterprise resource planning (ERP) is a software system used to manage manufacturing operations, specifically production planning and inventory control. ERP controlled production is "push" orientated and software scheduled.

The ERP system is driven by the master production schedule. The master production schedule details what the plant is required to produce and by when: the ERP system schedules production activities in order to meet these requirements.

The activities are scheduled by combining the master production schedule requirements with the information detailed in the product BOMs (BOM). See Figure 8. The BOM details for each product: the parts required for production, the manufacturing routings and the time taken for each operation. The ERP system utilises this information to build a detailed production schedule (by arranging activities in reverse chronological order), and to generate buying lists that detail the manufacturing's procurement requirements.

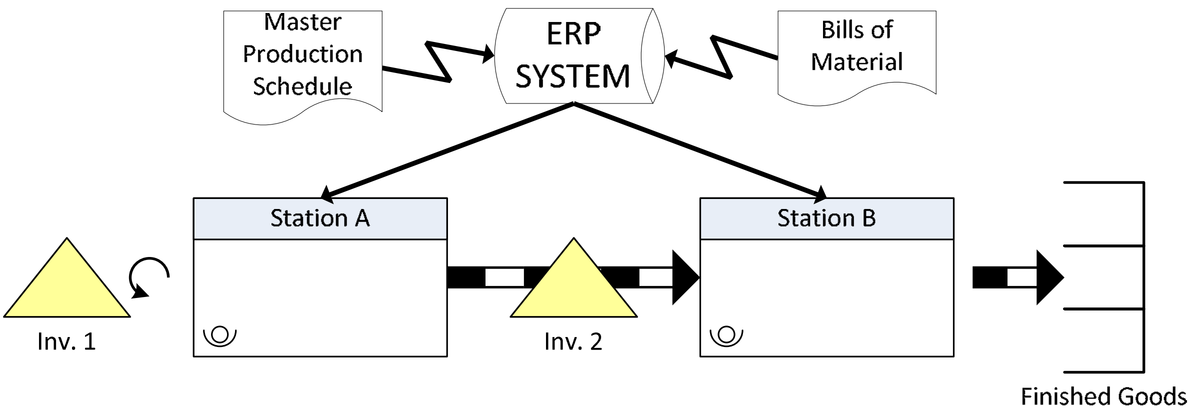


Figure 8 ERP controlled material flow

After calculating the detailed production schedule, the ERP system outputs:

Works Orders – Provide work station with work instructions, these detail: what they are required to produce, the materials required for the tasks, the start and end date of the task.

Buying Lists – Inform procurement staff what to procure by comparing what is required for production to what inventory is available for production.

The documentation produced serves as total control for production, thus the ERP system is unable to cope with any variances between predicted and actual production. Variances in production, like a machine failure or a process taking longer than expected, create a ripple in the ERP system which usually magnifies over time – ERP systems do not cope well with uncertainty.

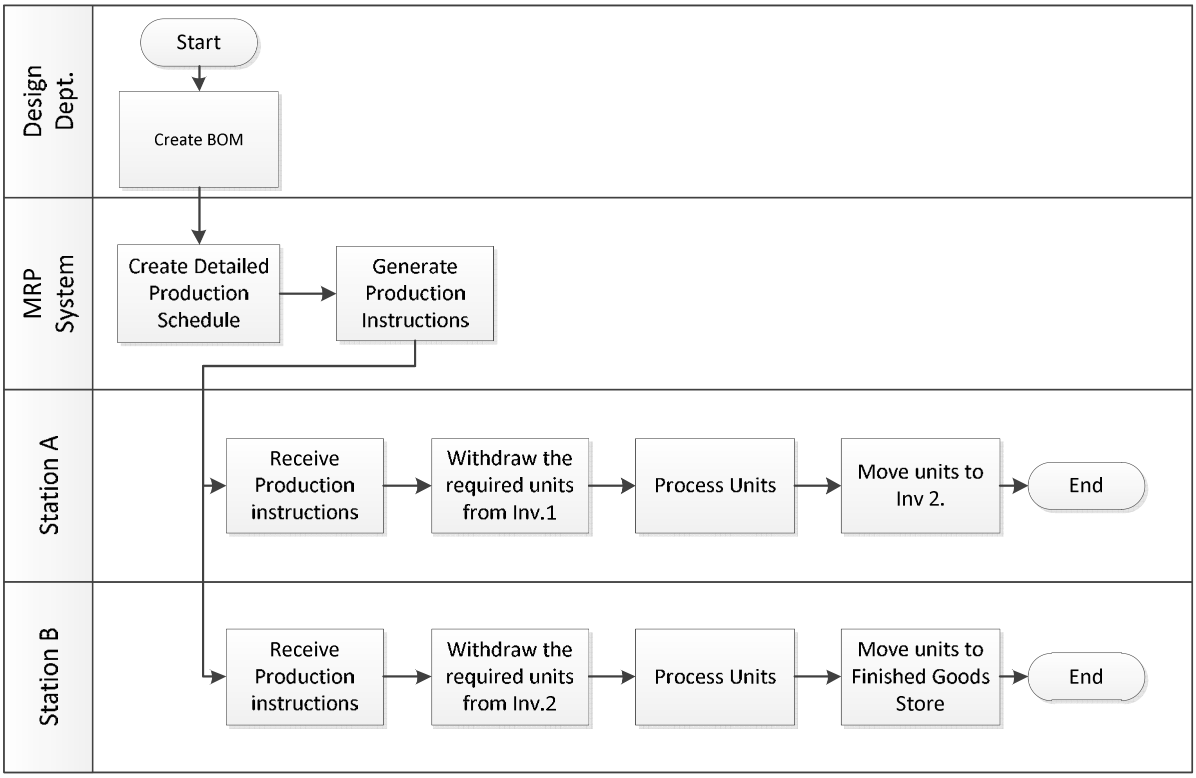


Figure 9 ERP driven material flow process

The process flow for ERP controlled production is detailed in Figure 9. It can be seen that the production at Station A is not synchronised with that of Station B – typical of "push" environments. This disconnect can lead to large amounts of WIP build-up at Inventory buffer 2, and general product flow disruption.

1.4.6. Facility Layout

The objective of an order fulfilment facility is to deliver the right goods at the right time. The ideal physical layout for this environment is structured so as to inherently reduce wastages associated with the order fulfilment process.

The lean wastages which would apply in this environment would be:

Motion – Excessive operator travel during the order fulfilment process increases the time required for order fulfilment.

Transport – Unnecessary movement of inventory during the order fulfilment increases the employee required for order fulfilment.

1.4.6.1. *Physical storage configuration*

Drawing on research conducted by Gray, Karmarkar and Seidmann (1992), and De Koster and Colpaert (n.d) the optimum physical configuration for efficient order fulfilment facility has the following features (Figure 10 is used to demonstrate):

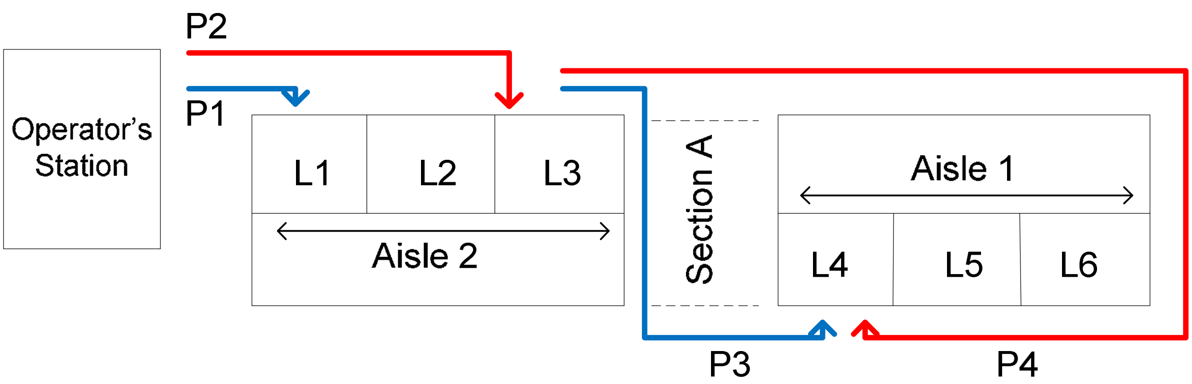


Figure 10 Order fulfilment facility features. Locations (L) and Paths (P).

1. *Inventories which are withdrawn most frequently are placed nearest to the picker*
   - Placing the most frequently withdrawn parts in L1 instead of L2 reduces the cumulative distance travelled by the picker (P1 vs P2).

2. *Aisles allow the operator to travel in "S" shapes*

    - If the picker has to retrieve a part from L4 after L3, keeping Section A clear allows the picker to utilise P3 instead of P4 – reducing the distance travelled.

3. *Inventories are grouped together by functional application*

    - If the parts for Machine A are grouped in Aisle 2, the picker only needs to travel to Aisle 2 to retrieve the parts required. However, if the parts for Machine A are spread across Aisles 1 and 2 the picker has to travel further to retrieve the parts.

1.4.6.2. *Storage Organisation – The 5S system*

5S is a system to reduce waste and optimize productivity through maintaining an orderly workplace and using visual cues to achieve more consistent operational results (United States environmental protection agency, 2012). The guiding principles underlying the 5S system involve organisation, cleanliness and standardisation. The 5S's are: Sort, Set in order, Shine, Standardise and Sustain. The functioning of the 5S cycle is shown in Figure 11 Below:

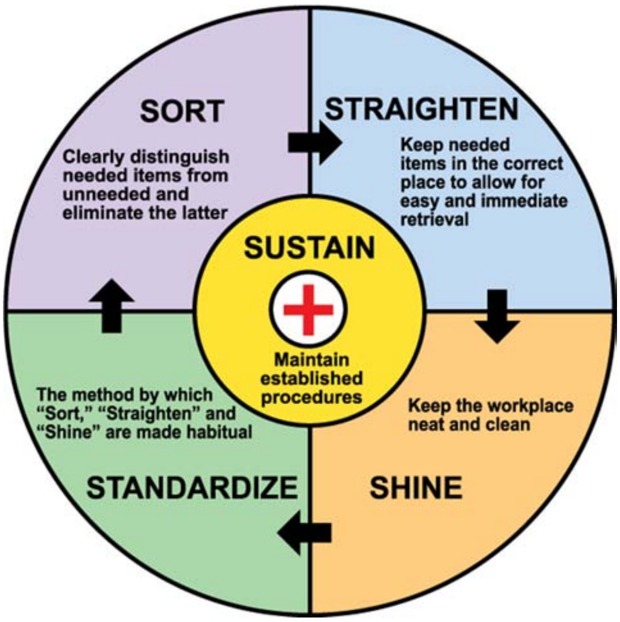


Figure 11 The 5S system continuous improvement cycle

According to Osada (1989), the benefits of implementing 5S are summarised as follows:

- *Cleanliness* – to maximise effectiveness, contribute to a healthier life and reduce deviation (due to enhanced transparency)
- *Orderliness* – to maximise efficiency and effectiveness, reduce people's workload, reduce human errors (due to simplifying processes)
- *Discipline* – to increase the level of morality and ethics and to increase minimum standards through training and education

1.4.7. Tools

This section details process tools commonly employed in the operations environment.

1.4.7.1. *Value Stream Map*

A value stream map is graphical representation of all the actions required to produce a product. It details the following product-specific information:

- material and information flows
- processing and waiting times
- staffing allocations

A typical value stream map is shown in Figure 12, below.

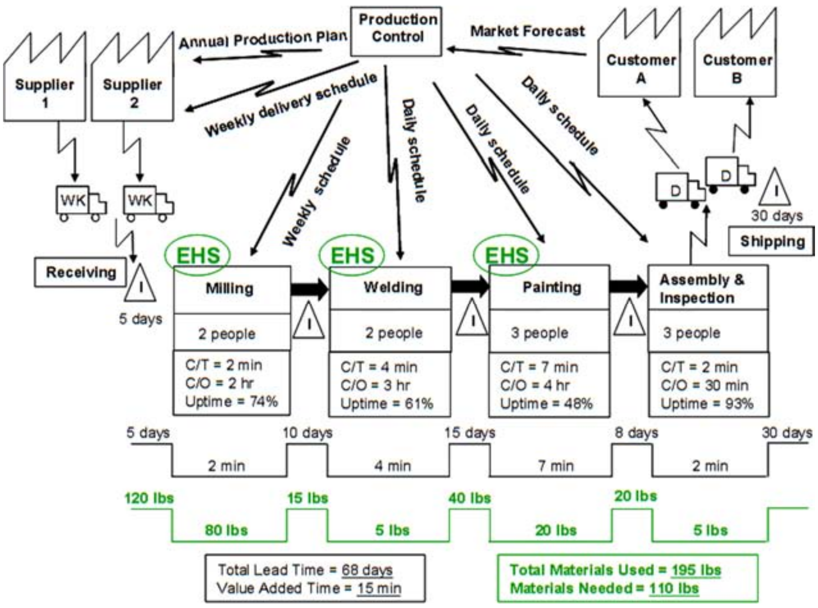


Figure 12 Typical Value Stream Map, Source: US Environmental Protection Agency. (n.d.) [online image].

Value Stream Mapping provides a holistic overview of the operations and activities (both value and non-value adding) associated with the product's manufacture, and as such can be a used to:

- evaluate and communicate the state of operations
- plan business improvements
- manage process change

1.4.7.2. *Process Map*

A process map is a diagrammatic representation of all the steps involved in the execution of a process. The map highlights:

- activities involved in the execution process
- the sequence of activities
- the activity owners

A sample process map is shown in Figure 13, below:

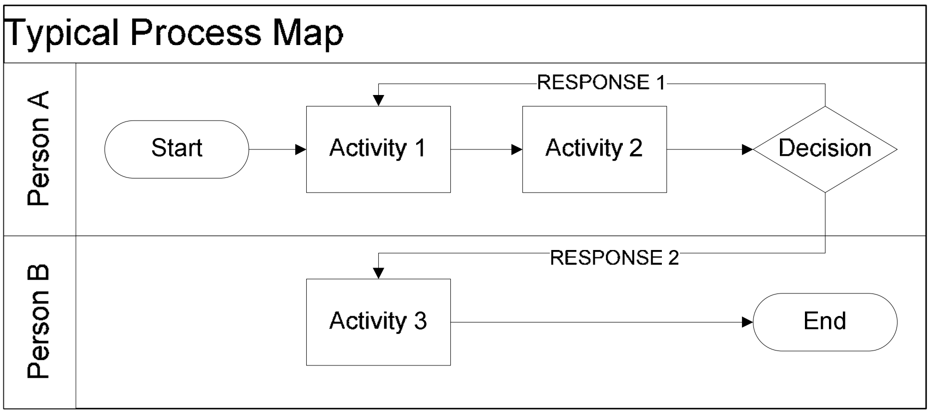


Figure 13 Example of a typical process map

The primary purpose of process mapping is to provide a clear and detailed account of how business processes function. Process maps can subsequently be used to analyse and optimise the functioning of the organisation's operations.

1.4.7.3. *SIPOC Table*

SIPOC is an acronym for Supplier, Input, Process, Output, and Customer. A SIPOC table summarises the inputs, outputs and transformations of a process in tabular form. The objective of the SIPOC table is to provide a high level overview of *what* the process achieves as opposed to the process map's focus on *how* the process is executed.

In a SIPOC table:

- Suppliers and customers may be either internal or external to the organisation
- The inputs and outputs captured may be materials, services, or information

An example of a SIPOC table is shown in Figure 14, below:

Supplier	**I**nput	**P**rocess	**O**utput	**C**ustomer
Student	Dissertation	Dissertation Evaluation	Dissertation Grade	Student

Figure 14 Example of SIPOC table.

1.4.7.4. *Pareto Analysis*

The core of pareto analysis is the 'pareto principle' which states that only a few "key factors" are responsible for producing the majority of the sample observed: typically, 20% of the contributing factors generate 80% of the problems. Correcting these few key causes, promotes an increased probability of successfully resolving the issue at hand. The objective of a pareto analysis is to identify the "key factors" so that the problem may be successfully addressed.

1.4.7.5. ***Fishbone Diagram***

A fishbone diagram is a visual tool that is used to identify (and display) the cause and effect relationships of a particular problem. It achieves this by representing factors which contribute to the problem as nodes stemming from the problem, the completed diagram is visually similar to the bone structure of a fish, see Figure 15. Fishbone diagrams are also commonly referred to as ishikawa and cause and effect diagrams.

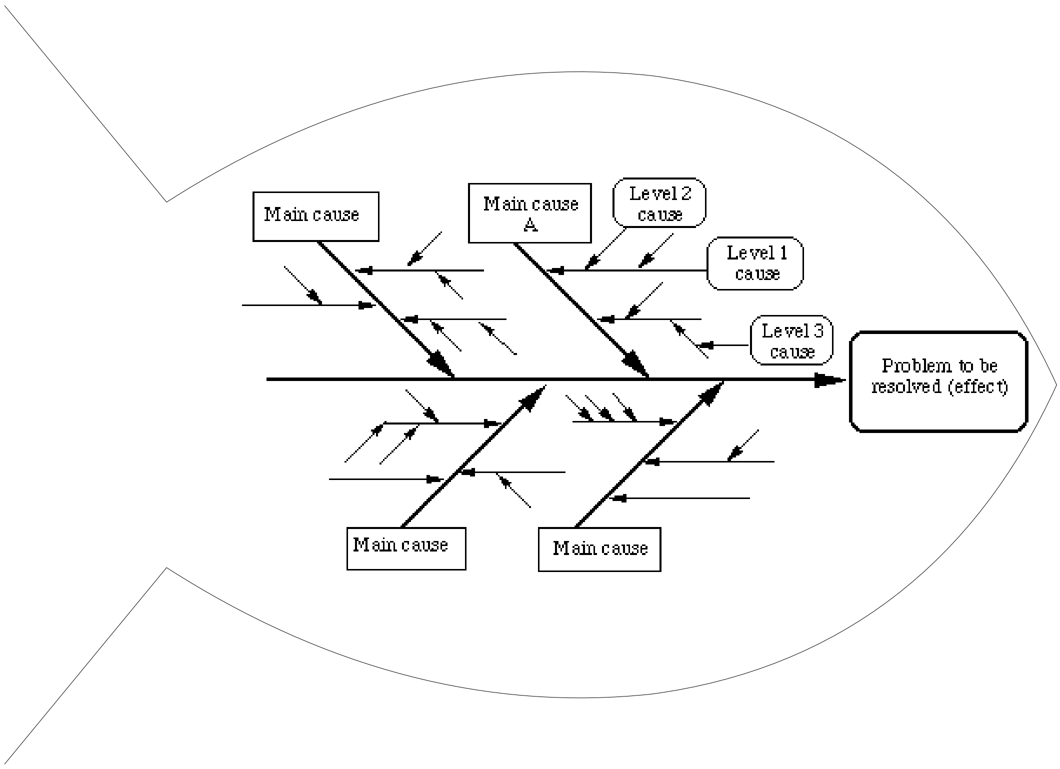


Figure 15 Example of a fishbone diagram. Source: http://www.improhealth.org. (n.d.) [online image].

Fishbone diagrams are particularly useful for continuous improvement applications because they force the improvement team to consider all possible causes of the problem, rather than focus on those that are immediately apparent, thus allowing the problem to be diagnosed thoroughly.

Fishbone diagrams are read by asking "why" the cause has occurred in a "head to bone" direction. For instance, consider Figure 15: "Why" did the problem occur? "Because" main cause 1 occurred. "Why" did main cause 1 occur? "Because" level 1 cause occurred etc.

The root causes of the problem are represented by the bones on the diagram furthest from the head: i.e. the answer to the last "why".

1.4.7.6. *Visual Management*

Visual process management tools act as communication aid and are used to help drive operations and processes in real time (Parry and Turner, 2006). Visual Management promotes a workplace that is self-ordering, self-explaining, self-regulating and self-improving environment where what is supposed to happen does, on time, every time because of visual solutions (Galsworth, 2005) .

The Andon board shown in FIGURE 16igure 16 is a typical example of visual management in practise.

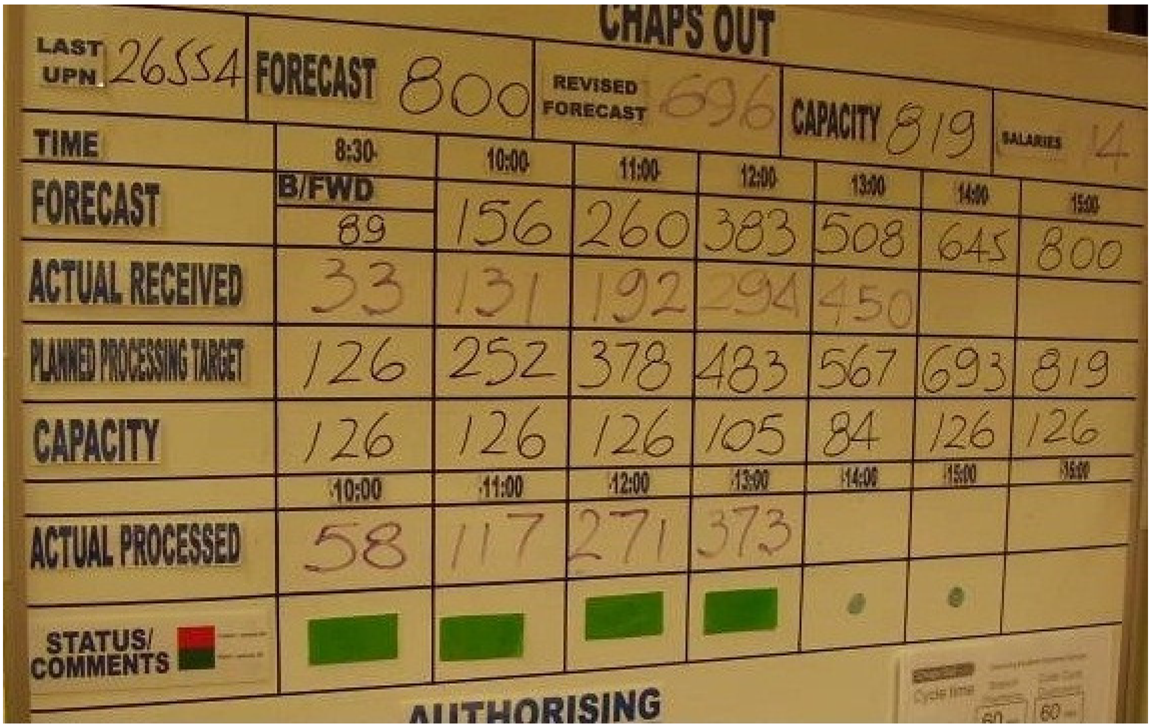


Figure 16: A typical andon board. Source: "Better Business In a Nutshell" by The Small Business Bureau . (n.d.) [online image]

2. DIRECTING THE VALUE INITIATIVE

This chapter commences with an expansion of the framework application methodology, and closes with the high-level application of the framework to Rovic.

2.1. Methodology

A value-driven approach was employed to improve the operations of Rovic. The improvement initiative commenced with the construction of an overall value stream map of Rovic's production facility. This was done to gain insight into the operational functioning of Rovic at a macro level, and to illustrate this to Rovic's management structure. It is worth noting that the value stream map generated (see Figure 2) does not include conventional parameters like cycle times etc. The reason for this omission was that the value stream map was not constructed with the intention of fully quantifying operations parameters, but rather to quickly confirm with the relevant departmental owners the functioning of the operation as a whole and the responsibilities associated with the relevant departments, thus affirming the operation's status quo.

After reviewing the overall value stream map, Rovic's management structure selected an overall process that they felt required urgent improvement in order to enable the organisations operational objective: to design, assemble and deliver customised equipment within the allocated production time frame. The overall process related to the *availability of external sources parts to the Assembly operation* was selected as the improvement focus because of its pivotal role in achieving the operational objective.

A functional analysis of the overall process elected was conducted – again, using a value stream map – to determine its operational objectives, internal suppliers and its customer. The formalised representation of the process functioning was discussed and agreed upon with Rovic management and the relevant department owners.

A criterion for successful value delivery of the overall process was subsequently quantified. This was done with the intention of directing improvement initiatives toward delivering maximum value as defined by the customer and in line with the organisation's operational objectives.

The value chain related to the overall process objective was mapped using a SIPOC table. The SIPOC table highlighted:

1. the functional sub-processes which constituted the overall process, their inputs and outputs
2. the functional boundaries between departments
3. the key activities executed within each functional in line with the overall process objective

Subsequent to gaining a functional understanding of the sub-processes, the root causes of value obstruction were determined by using the Lean “five why’s” method and the previously defined criterion for `successful value delivery` of the overall process. The “five why’s” method has the added benefit of putting the framework user in direct contact with the process stakeholders. This is beneficial because it opens the door for buy-in, and allows the user to directly explore the stakeholder’s operational insights gained through experience.

Value obstructing root causes were then traced back to specific sub-processes using the SIPOC tables previously generated, and prioritised to firstly improve the effectiveness, then efficiency, of the overall process.

The sub-processes linked to the root causes were then analysed at the activity level – through detailed process mapping and observation of lean wastages – to determine why and how they hindered value delivery of the overall process. The resolution of the root causes identified was then prioritised according to the extent to which they obstructed value delivery.

Solutions were subsequently proposed – based on the observations made and the sub-process objective in context to the overall process – to remove the value obstruction while factoring the essential inputs and outputs as originally defined by the SIPOC tables as well as the operational practices local to the functional silo.

The effectiveness of the solutions proposed was determined by using Quick Response capacity philosophy in conjunction with a control experiment. This allowed the effectiveness of the solution to be verified instantaneously, rather than having to stringently monitor production for changes after implementation – a challenging feat in an ad-hoc environment due to operational parameters continually shifting and the work practices actually utilised varying on an impromptu basis, thus making it challenging to pinpoint the exact cause of the effect observed and in turn concretely validating the effectiveness of the solution implemented.

The lean PDCA (Plan, Do, Check, Act) cycle was used to hone the effectiveness of solutions as required. If the solutions proposed were revealed to be ineffective, they were reconfigured and retested until a satisfactory result was obtained, subsequent to which, employee training was provided and followed by full scale implementation where possible.

The methodology employed is summarised in Figure 17, below:

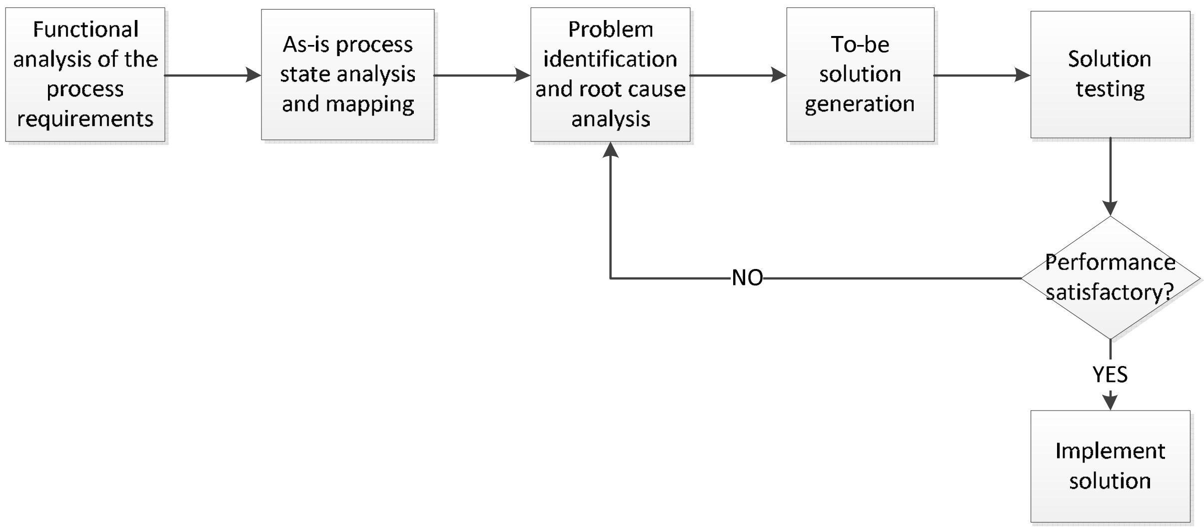


Figure 17 Research methodology summary

The methodology outlined above assists with the conversion and integration (into the overall process) of activities by:

1. Identifying specific aspects of sub-processes which obstruct overall value creation, rather than attempting a silo-focussed approach to operational improvement, enabling improvement efforts to be quickly and explicitly aligned with an overhanging organisational process and objective
2. Investigating how these sub-processes needed to be modified at the activity level in order to enable value delivery
3. Verifying the impact of the proposed activity modification on the overall process in a controllable and consistent manner

Thus allowing for structured and quantifiable performance increases to overall process.

2.2. Overall Analysis

Having confirmed the operations of the company and nominated an overall process for improvement (Chapters **Error! Reference source not found.** & **Error! Reference source not found.**) the next steps in the methodology identify and prioritise value obstructions.

This chapter outlines the application of the methodology to the overall process in order to identify sub-processes which obstruct value delivery. It goes on to formulate discrete value add initiatives intended to enable value delivery.

2.2.1. Identifying the customer and defining value

The ultimate objective of process improvement conducted is to improve value delivery to the customer. For this reason, it is necessary to identify the process customer and the criterion for successful value delivery.

The operations of the Rovic Store is illustrated in the VSM of Figure 18. It can be seen that the customer of the process being investigated is the Assembly department:

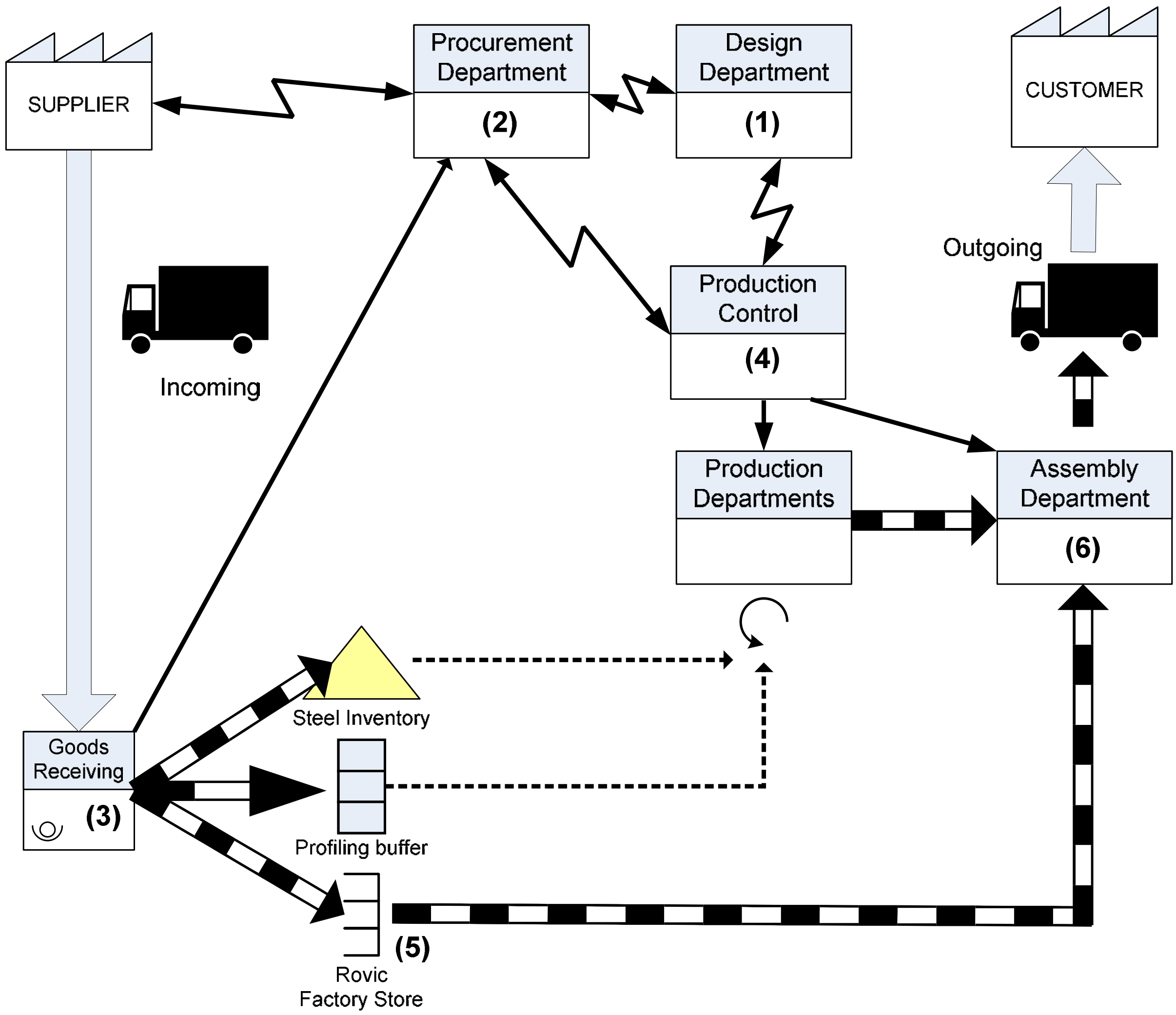


Figure 18 VSM illustrating the operations involved in delivering value to the process customer.

Value to the Assembly Department with regard to the overall process being investigated can be defined as "having the externally sourced parts required to create value, at hand, when required". Thus the overall process objective is "to deliver the parts required by the Assembly Department for value creation, as required".

Furthermore, the following operational objectives are desired whilst providing value to the Assembly Department:

Table 1 Value delivery objectives

Parameter	Objective
Number of correct and valid deliveries	Maximise
Time taken by the Store to deliver the required parts	Minimise
Time taken by the Assembly technician to retrieve the required parts	Minimise
Assembly floor space used to host the delivery	Minimise
Effort and Time required to transport the delivery within the Assembly area	Minimise

2.2.2. Identifying the value chain

The macro process objective of delivering the parts required to create value to the site of value creation is comprised of several contributing sub-processes. These sub-processes are executed through the engagement of activities local to departments within Rovic. Referring to Figure 18, the sub-processes and their related departments are summarised in the SIPOC table (Table 2.) below:

Table 2 SIPOC overview of the value chain

No.	Supplier	Input	Process (Department - Owner)	Output	Customer (Value of output to Customer)
1	Sales	Machine Specification	Designing the machine and creating its BOM (Design –Engineer)	Machine Drawings	a) Production Control i. Used to generate work instructions for value add activities in the factory
				BOM	a) Production Control i. Used to generate work instructions for value add activities in the factory ii. Used to generate Picking lists for the store b) Procurement i. Used to order the parts required from external suppliers
2	Design	BOM	Ordering the externally sourced parts (Procurement - Buyer)	Purchase order	a) External supplier i. Provides the supplier with instructions for what to deliver

No.	Supplier	Input	Process (Department - Owner)	Output	Customer (Value of output to Customer)
3	External supplier	Delivered Goods	Receiving and storing the goods delivered by the external supplier (Factory Store - Storeman)	Delivery Invoice	a) Buyer i. Used as a signal to receive goods into stock on the MRP system
	External supplier	Delivery Invoice			
	Storeman	Storage Location		Stock	a) Factory Store i. Used to make deliveries to the Assembly Dept.
4	Sales	Machine delivery date	Issuing work instructions (Production Control - Planner)	Picking List	a) Store i. Instructs the store which components to deliver to the Assembly Dept.
	Design	Machine Drawings		Delivery Schedule	a) Store i. Instructs the store when to deliver the components to the Assembly Dept.
		BOM		Work Instructions	a) Assembly Dept. i. Provides instructions for what to assemble and which parts to retrieve in order to assemble.
5	Production Control	Picking List	Delivering components to the assembly area (Factory Store - Storeman)	Delivered parts	a) Assembly Dept. i. Ability to complete value add tasks
		Delivery Schedule			
	Factory Store	Components			

No.	Supplier	Input	Process (Department - Owner)	Output	Customer (Value of output to Customer)
6	Production Control	Work instruction	Assembling the machine using parts and components (Assembly Department)	Finished Machine	Rovic Customer
	Store	Delivered Parts			
	Manufacturing Departments	Machine components			

2.2.3. Identifying focal areas for value enhancement

Effective process improvement is focussed. It is directed at the root causes of problems that negatively affect flow, thus producing tangible (and often substantial) results. This guarantees enhancement of the company's baseline. Therefore, the logical forerunner to process improvement is to identify where the process is currently weak and obstructing flow.

The "five why's" technique was used to determine the root causes of failed deliveries to the Assembly department. The results are shown in the fishbone diagram of Figure 19:

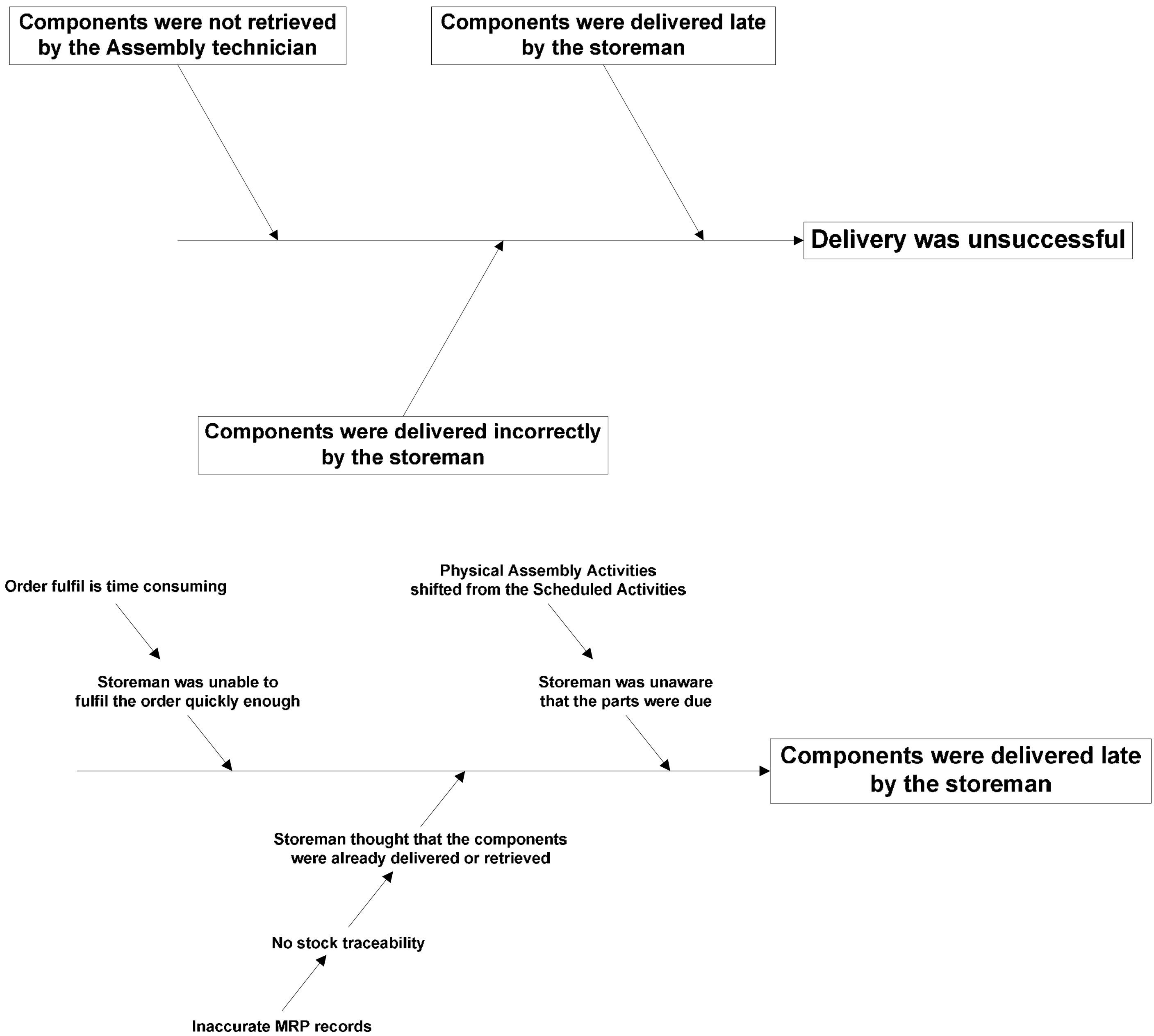
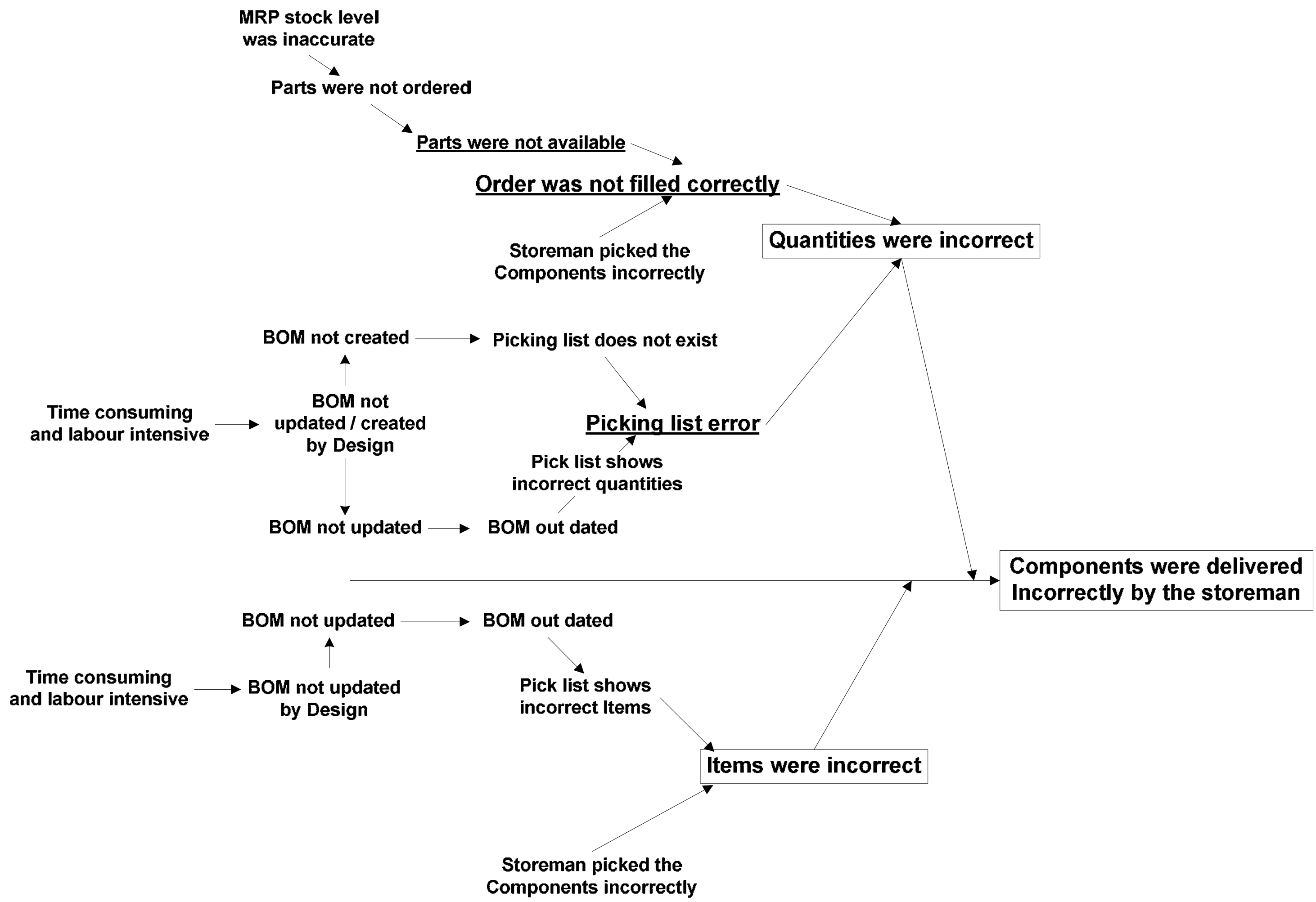


Figure 19 Fishbone diagram for unsuccessful deliveries



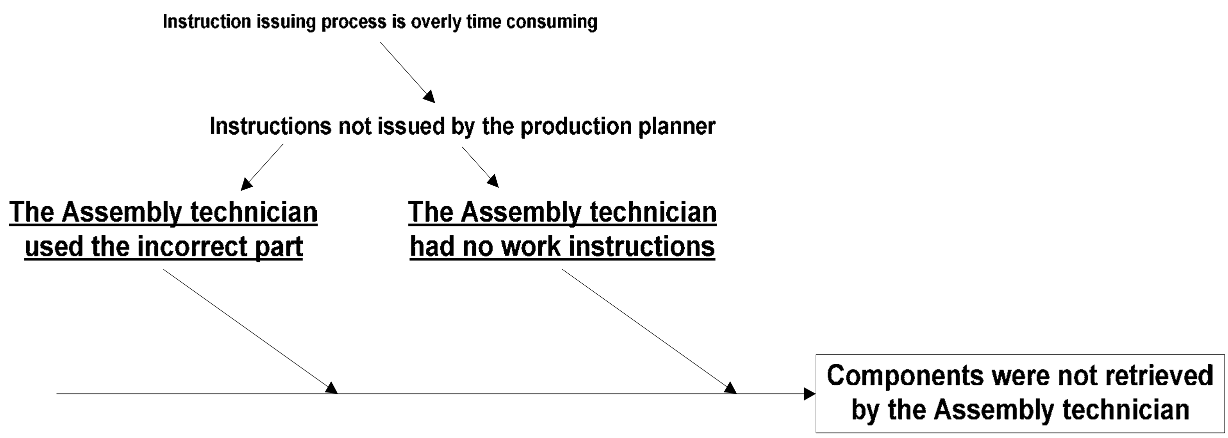


Figure 19 Continued

From the root causes identified in the fishbone diagram of **Figure 19**, it was determined that the activities requiring modification for the overall process to flow were as follows:

Table 3 Root causes of delivery failure

No	Root Cause	Sub-process Ref. from Table 2	Department	Related Activity
1	Ineffective BOM creation/updating	1	Design	Creating / Updating the Machine's BOM
2	MRP stock level inaccuracy	3	Store	Forwarding the delivery invoice to the Buyer
				Physically placing the goods into stock
			Procurement	Receiving goods into stock on the MRP system
		5	Store	Physically issuing the parts to the Assembly Dept.
3	Inefficient order fulfilment	5	Store	Picking the goods required for value add in the assembly area
4	Inefficient order fulfilment scheduling	4	Production	Creating the store's delivery schedule
		5	Store	Picking the goods required for value add in the assembly area
5	Inefficient work instruction issuing process	4	Production	Issuing work instructions to the factory

A review of Table 3 shows that activities related to the operation of the store are associated with failure root causes numbers two, three and four; hinting that the lack of standardised store operations contributes negatively to a number of root causes.

Consolidation of the root causes detailed in reveal four distinct operational objectives required to allow the overall process to flow:

1. Streamlining the BOM creation/update process
2. Increasing MRP stock level accuracy
3. Increasing the efficiency of issuing work instructions to the floor
4. Developing and implementing a standardised system to control store operations

It was elected to prioritise the objectives listed above in a sequence which would, firstly, improve the process effectiveness and subsequently increase its efficiency. The intent is to first increase the number of valid deliveries possible and then increase the ease of making a delivery to the assembly operation.

The initiatives were sequencing as follows:

Gaining Effectiveness:

1. **Streamlining the BOM updating/creation process** – The BOMs are the key drivers of both the procurement and production operations and must be correct if production is to be accurate and timely. The BOMs also define which parts are required for value add.
2. **Increasing the MRP stock level accuracy** – Accurate stock levels are necessary to inform the materials buyer whether parts should be ordered or not. If the parts are not ordered in the correct quantity or are ordered too late, and are not in stock at the time required, the Assembly operation will be unable to deliver value.

Increasing Efficiency:

3. **Increasing the efficiency of the work instruction issuing process** – The assembly technician requires accurate work instructions in order to retrieve the correct parts required for value add, and to assemble them as intended.

   Additionally, increasing the efficiency of this activity has the benefit of liberating time invested by the Production Planner (the sub-process owner). The Production Planner is also responsible for resolving operational conflicts and complications related the store operations and parts availability in general; thus, his availability is a valuable asset to the organisation as whole.

4. **Developing a standardised store's operating system** – Improvements made to the store's operating system contribute to the efficiency (and effectiveness) of the parts delivery process because the store is directly responsible for the on-site handling of parts and making them available to the Assembly operation when required.

Having mapped the value chain, and identified root causes and related inhibiting effects experienced in the value chain's sub-processes, the methodology necessitates the examination of the sub-process at the activity level in order to identify inherent operational aspects, which compromise the organisation's ability to deliver value.

Chapters 3-6 individually address each discrete value add initiative. In accordance with the methodology, each chapter seeks to understand how value delivery is compromised within the sub-process by mapping it in detail, and subsequently identify opportunities – internal to the sub-process – for drastic continuous improvements, which are above all compatible with the sub-processes' suppliers and customers.

The intention of sub-process modifications proposed in Chapters 3-6 was not to second guess the organisation's elected marketing or operational strategy, but rather to accept them as constraints while fundamentally affecting and aligning mechanics at the activity level of the process so as to allow the desired value add ability.

3. ENHANCING THE BOM CREATION AND UPDATE PROCESS

The Bill of Material (BOM) is an essential enabler of parts availability – thus, value add – to the Assembly operation. The operation's procurement requirements are derived from the quantities reflected in the production BOMs, similarly the assembly technicians requirements per operation. Absent or out-dated (by design changes) BOMs negatively affect the overall process' ability to deliver value. Simply: no parts, no production.

The overall analysis conducted (see chapter 2.2) revealed that BOMs were frequently not available when required, due to the reportedly time consuming nature of the BOM creation and updating.

The objective of this chapter is to, firstly, formalise (and verify) an understanding of operations currently involved (The "AS-IS" state) in generating and updating BOMs by mapping the sub-process. Then, to identify aspects which compromise value delivery, propose and test activity modifications intended to enable to value delivery (The "TO-BE" state) and, lastly, to *sustainably* implement in the tested solution, if possible.

3.1. AS-IS State

The activities involved in the creation and updating of BOMs are reflected in Figure 20 and Figure 21 respectively. The current state process maps serve to formalise and verify an understanding of the operations involved.

BOM creation process:

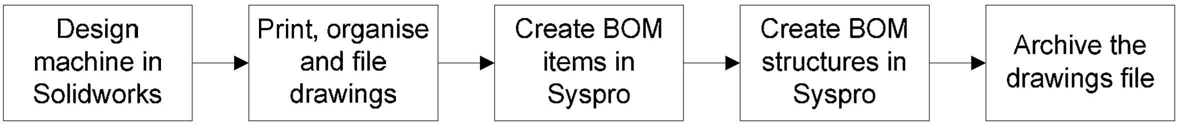


Figure 20 The current state process for creating BOMs

BOM update process:

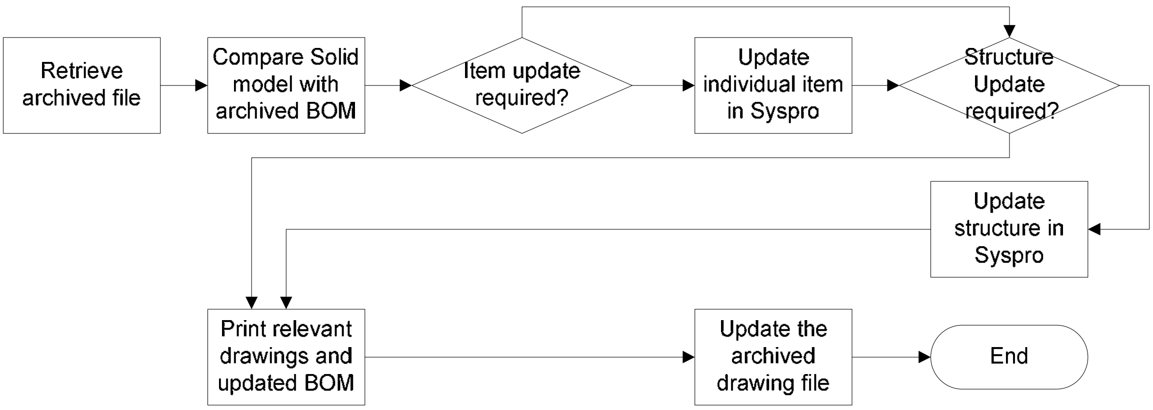


Figure 21 The current state process for updating BOMs

3.1.1. Observations

Having formalised the current state of operations, it is now necessary to examine the activities in detail in order to identify aspects which compromise value delivery. Operational inefficiencies shall be identified in terms of the seven lean wastages (see Chapter 1.4.4.1) and prioritised by their risk to value delivery of the overall process.

The following lean wastage were noted in sub-process activities:

<table>
<tr><td>1)</td><td>Activity :</td><td colspan="2">Creating items and structures in Syspro</td></tr>
<tr><td></td><td>Related Process :</td><td colspan="2">BOM creation process</td></tr>
<tr><td colspan="4">Observation :

1. The majority of the item level information entered during this activity was previously entered during the creation of the solid model in Solidworks. During the creation of the BOM in Syspro, the only “fresh” inputs are:
• The labour hours and manufacturing operations associated with the manufacture of the part
• The raw material stock code and cut length required to fabricate the component
2. The structures created in Syspro already exist in the solid model.</td></tr>
<tr><td colspan="2"></td><td>Significance:</td><td>i. The data recreation consumes design labour and delays production</td></tr>
<tr><td colspan="2"></td><td>Related wastage:</td><td>i. Rework
ii. Over-processing</td></tr>
</table>

<table>
<tr><td>2)</td><td>Activity :</td><td>Printing, organising and filing drawings</td></tr>
<tr><td></td><td>Related Process :</td><td>BOM creation process</td></tr>
<tr><td colspan="3">Observation :

1. This activity consumes a large amount of time and paper. Design engineers report that this process will typically take two to three days and consume roughly 600 sheets of paper.
<table>
<tr><td>Significance:</td><td>i. This activity adds no value – it is only done so that the designer has access to the machine drawings while creating the BOM in Syspro.</td></tr>
<tr><td>Related wastage:</td><td>i. Work Practices</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td>3)</td><td>Activity :</td><td>Comparing the solid model with the archived BOM</td></tr>
<tr><td></td><td>Related Process :</td><td>BOM update process</td></tr>
<tr><td colspan="3">Observation :

1. This activity is time consuming because the designer must sift through the drawings one-by-one while comparing them to the previous BOM - looking for minor changes e.g. the substitution of a bolt in a sub-assembly.
2. Designers report that they often do not capture all the changes/updates due to the scale of the comparison, level of detail involved and time limitations.
<table>
<tr><td>Significance:</td><td>i. Time spent updating BOMs could be used to create value elsewhere
ii. Incorrect BOM’s lead to production delays</td></tr>
<tr><td>Related wastage:</td><td>i. Work Practices</td></tr>
</table>
</td></tr>
</table>

4)	Activity :	Updating the archived drawing file
	Related Process :	BOM update process

Observation :

1. This activity is not performed consistently because it is time consuming
2. The drawing being replaced may exist in multiple files in the archive; some instances of the drawing may be overlooked and will not be updated as a result.

Significance:	i. The archived files are used to drive production. Thus, if the files are not accurate (up to date), the information driving production will not be accurate.
Related wastage:	i. Work Practices

3.1.2. Opportunities to improve value delivery

In order to understand the proportions of time consumed by activities during BOM creation and updating (essentially recreation), a time study of the BOM creation process was conducted. The study was conducted by monitoring the time spent entering information during the BOM creating process in Syspro; time spent creating new information and recreating previously entered (in the solid model) information.

The study followed the creation of BOMs for an entire machine. The average values per activity per machine sub-assembly were then calculated as percentages of the total time invested on the sub-assembly. Percentages were used as indicators because outright durations are specific to the machine being built. The results of the analysis are shown in Figure 22:

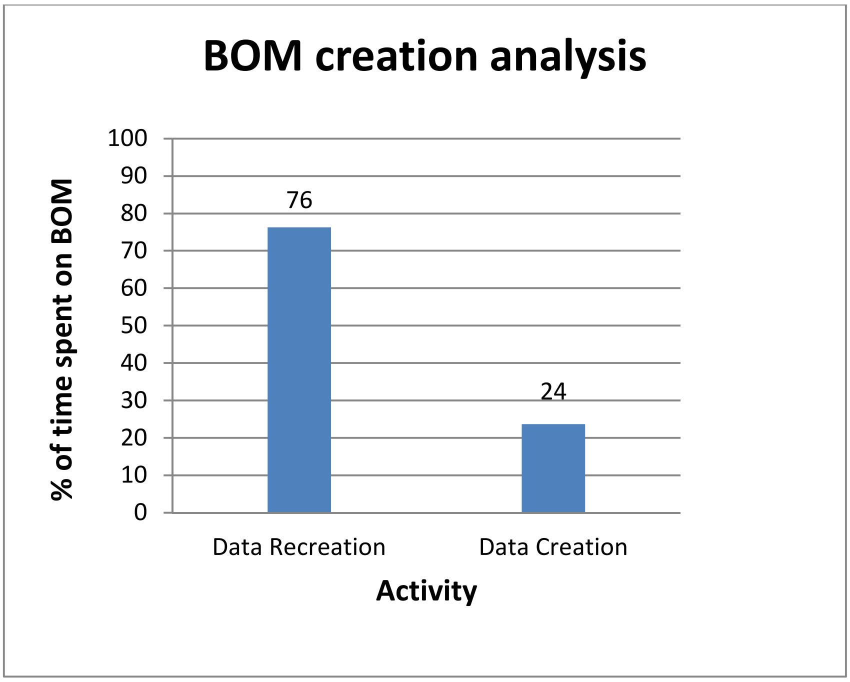


Figure 22 Syspro BOM creation time breakdown

Figure 22 reveals that the majority of the time invested in BOM creation was consumed by data recreation. This observation was confirmed by the design engineers, thus presenting a tangible opportunity to reduce the lead time required to create BOMs, increasing the likelihood of BOMs being available when required.

3.2. TO-BE State

Having identified time consumed by data recreation as the major wastage in the current state process, improvement efforts were focussed on automating data recreation as far as possible.

It was proposed that a software solution be implemented to bridge the design and MRP software (solidworks and Syspro), effectively synchronising the two systems. Based on the data gathered from the BOM creation analysis, this would streamline both the BOM creation and update processes substantially.

3.2.1. Building the bridge

Various software options were considered for the bridging function. Ultimately, the software selected was “Sysproworks”, developed by CAD speed. This software was selected for two primary reasons:

1. The software interface employed visual management and was intuitive. The posting interface can be seen in Figure 23.
2. The software designer was willing to customise the software for Rovic’s application.

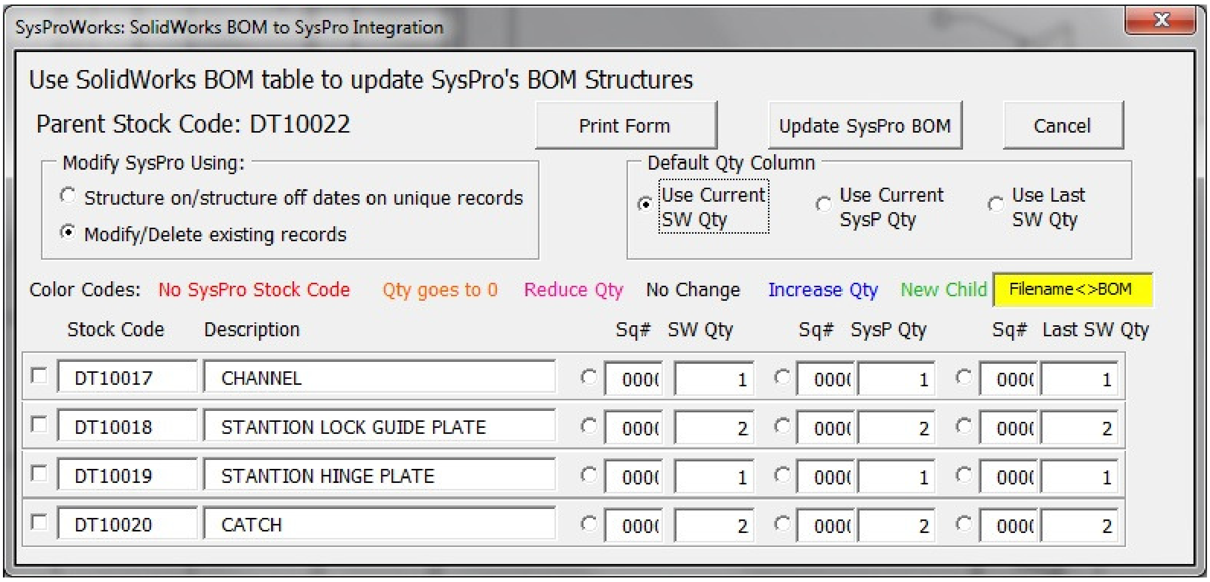


Figure 23 The BOM posting interface

Customisation was required because Rovic used a Linux server instead of a Microsoft server. Also, by default the software only posted across the BOM structures and quantities, where Rovic required the program to post across additional information. The additional information included the labour per operation, operations routings, raw materials stock codes and raw material cut lengths.

Accepting that the success of the software bridge was not guaranteed, it was decided to conduct a feasibility assessment of the proposed solution. It was conducted to reduce the initial financial investment required from Rovic and to localise the implementation to a single design seat – allowing software changes from Rovic's side to be made quickly from a single point. If the pilot proved to be a success, the implementation would be expanded to the remaining design seats.

The feasibility assessment was carried out in the following order:

1. Establishing a working data connection between Solidworks and Syspro
2. Performing the required software modifications
3. Testing the gains achieved
4. Expanding the implementation

3.2.1.1. *Establishing a data connection between Solidworks and Syspro*

The feasibility assessment was conducted on the "Test" portion of the MRP system to protect Rovic's MRP system from any damage. The test portion is an exact copy of Rovic's functional MRP – it shares the same features and configurations and was thus ideal for testing. Damage would be restricted to this portion of the MRP system and in the event of a total failure it could be rolled back to a previous backup version overnight.

CAD speed was given instruction to reconfigure the software's connection file so that it could operate in a Linux environment. After CAD speed's initial reconfiguration of the connection file was completed, a cross-functional team consisting of the researcher, designer, Rovic IT technician and CAD speed developer was established. Meetings were held via web conference on an ad-hoc basis (due to not knowing the scale of each meeting) to iron out the remaining (minor) issues in the connection setup.

The progress made during meetings was iterative and took 3 weeks to get the connection fully functional. The key alteration was the installation of an Open Database Connection (ODBC) driver on the designer's PC. The driver acted as a communication medium between Sysproworks and Syspro. The driver was configured by Rovic's IT technician.

3.2.1.2. *Modifying the software*

In order to accommodate the additional inputs required by Rovic, CAD speed recommended that the interface as seen in Figure 23 be duplicated for each input. This would be the most straightforward approach from a technical perspective.

The researcher and design engineer however, felt that this would not be a feasible option due to the fact that the interface on its own would not offer sufficient information for the designer to accurately input the required information without continually revisiting the drawings. It can be seen in Figure 23 that the only information available to the designer from the default interface is the relevant stock code. It is unlikely that the designer would know off hand which part the stock code it actually corresponded to; much less be able to accurately assign the required inputs without checking the drawing. If this interface was put into service, the process for inputting the required information would be as outlined in Figure 24. This approach requires the designer to continually toggle between Syspro and Solidworks – creating unnecessary movement in the process.

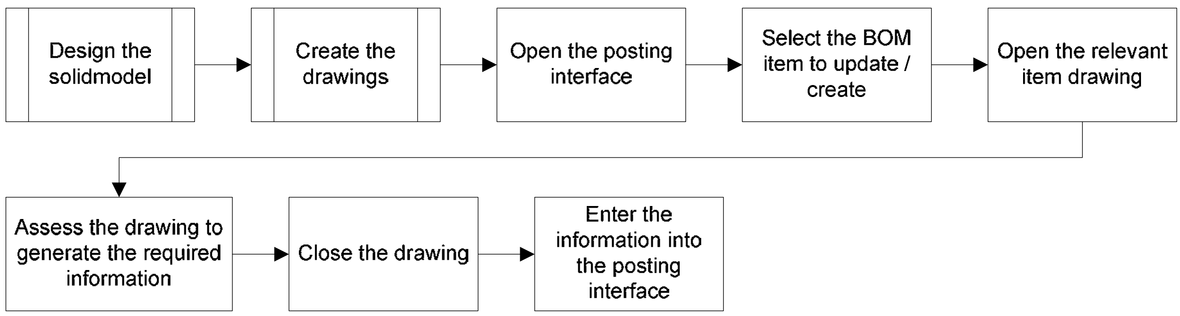


Figure 24 Default process for posting BOM information using the Sysproworks interface

It was proposed by the designer and researcher that Sysproworks pull the required inputs directly from the drawing in Solidworks. This would allow the BOM information capture to be integrated into the drawing creation activity, saving time and removing the need to toggle between applications.

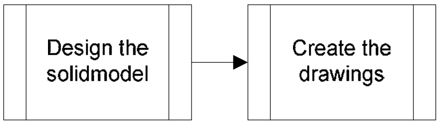


Figure 25 Implemented Process for Posting BOM information

A mock-up of the drawing integrated interface was drawn by hand and forwarded to the developer, who then confirmed the feasibility of this interface. The interface was developed, once again by hosting iterative web meetings. The upgrade was completed and functional after one month.

The finalised interface was integrated into the drawings section of Syspro through the addition of custom buttons, as shown in Figure 26:

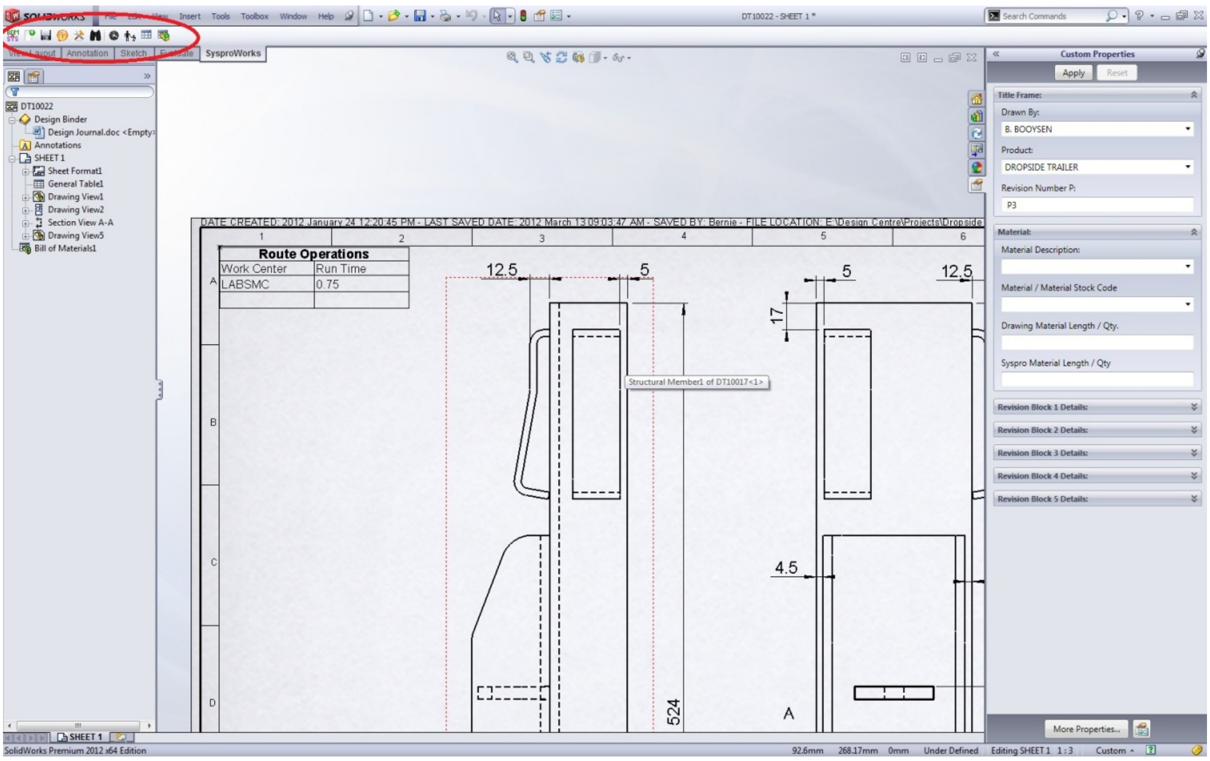


Figure 26 BOM posting integrated into drawing interface

Clicking the buttons opens a posting interface as seen in Figure 27. After the information is posted, it is displayed on the actual drawing – as seen in Figure 28, Figure 29 and Figure 30:

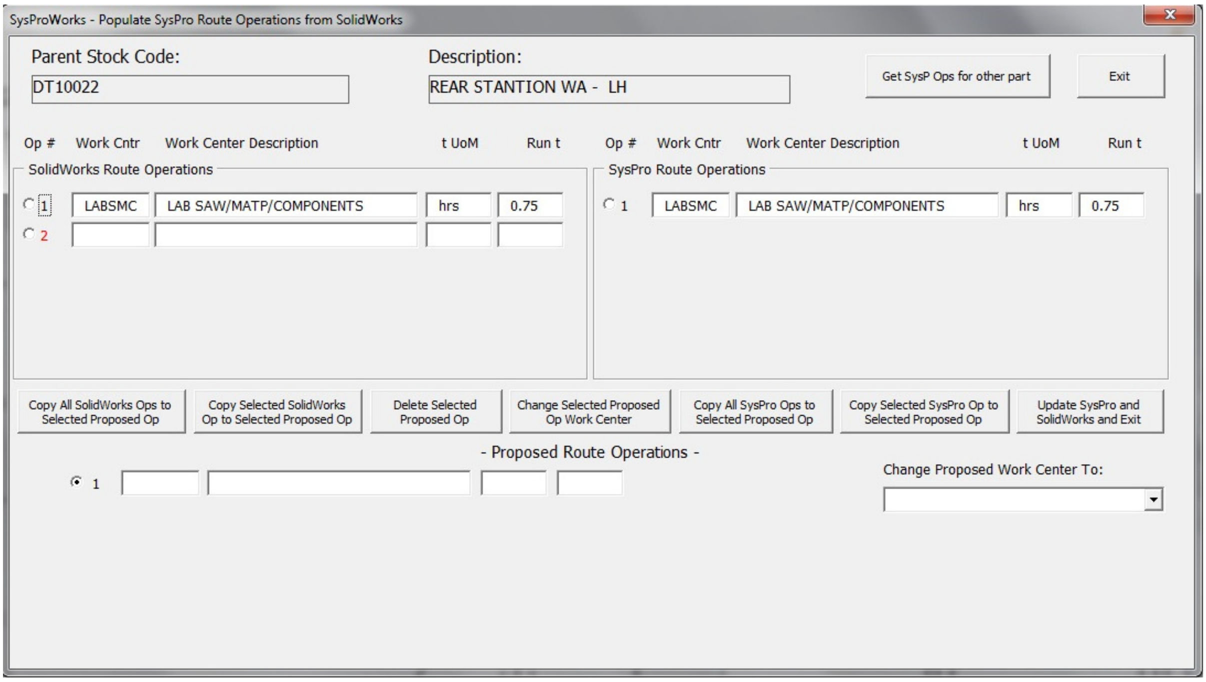


Figure 27 BOM posting interface

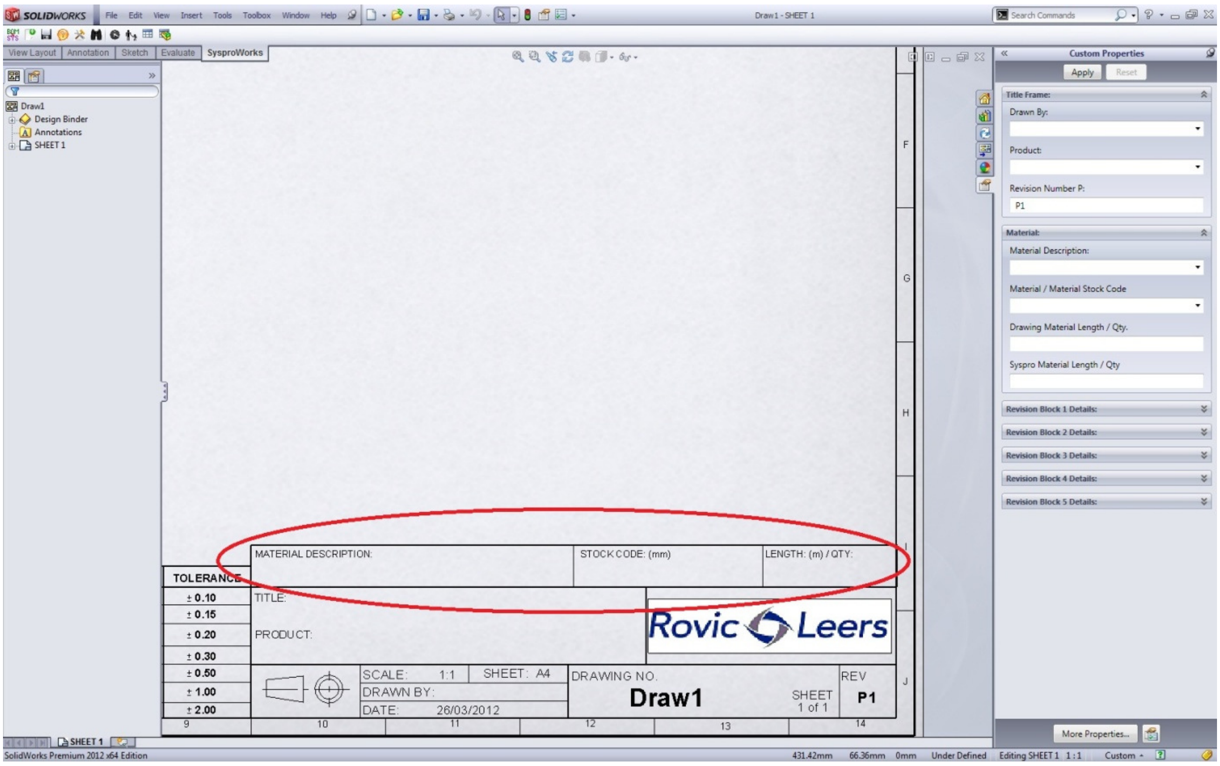


Figure 28 BOM raw material information displayed on the part drawing

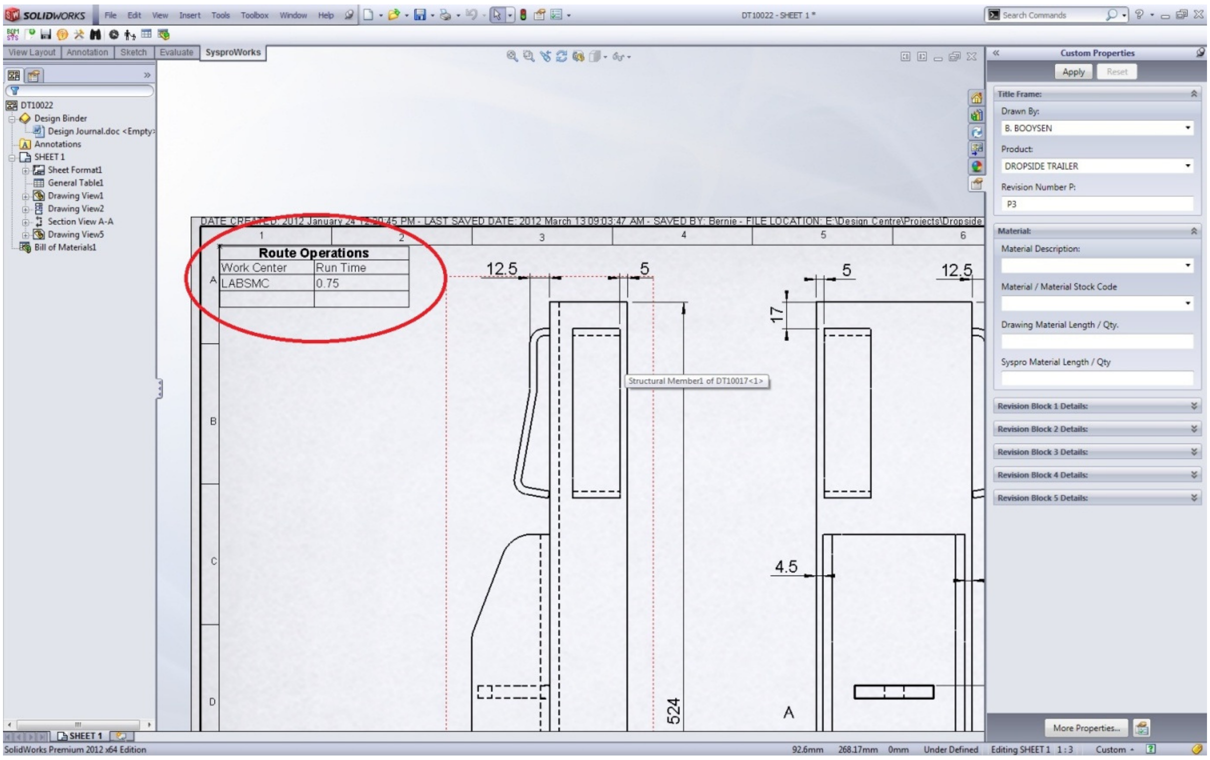


Figure 29 Routing Operations displayed on the part drawing

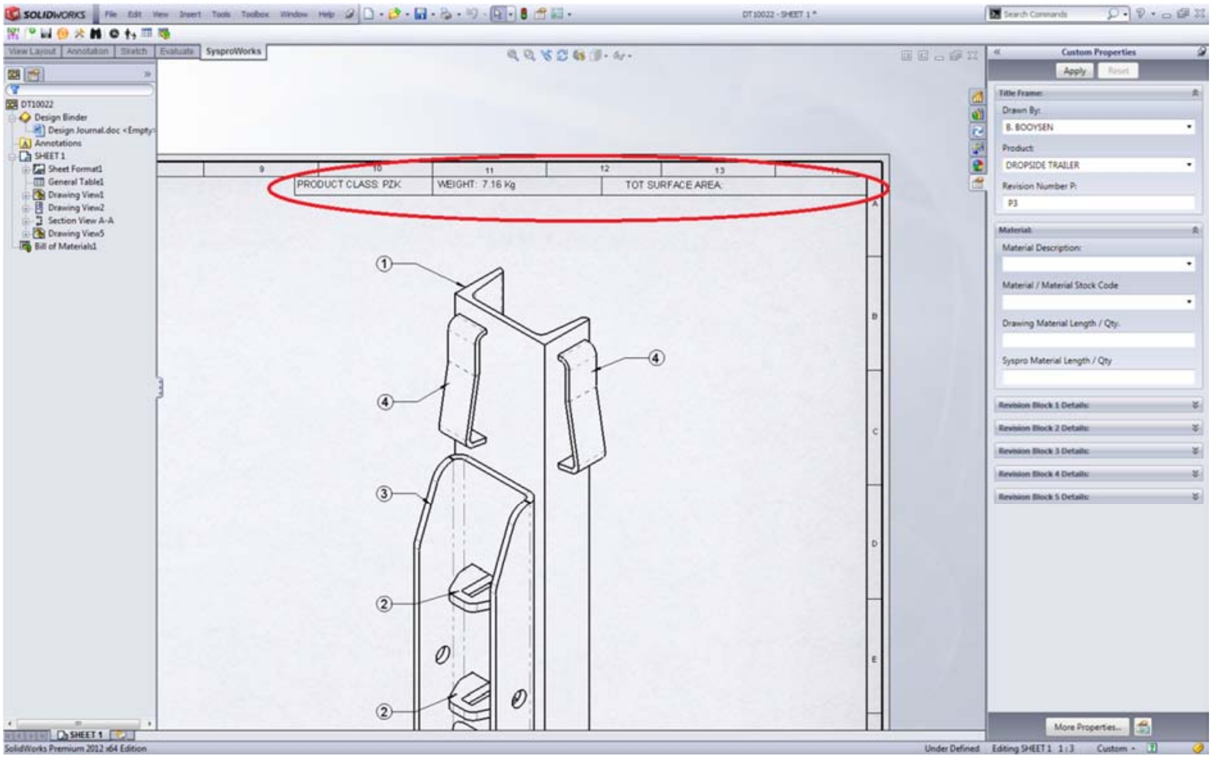


Figure 30 Product class and weight indicated on the part drawing

3.2.2. Testing

A comparison of the previously employed vs the updated BOM creation processes was conducted to assess the impact of the software integration. The objective of the comparison was to determine the total time taken to create the BOM for a single part in Syspro from the point of the drawing completion in Solidworks.

The previous and updated BOM information posting processes are illustrated in Figure 31 and Figure 32 respectively:

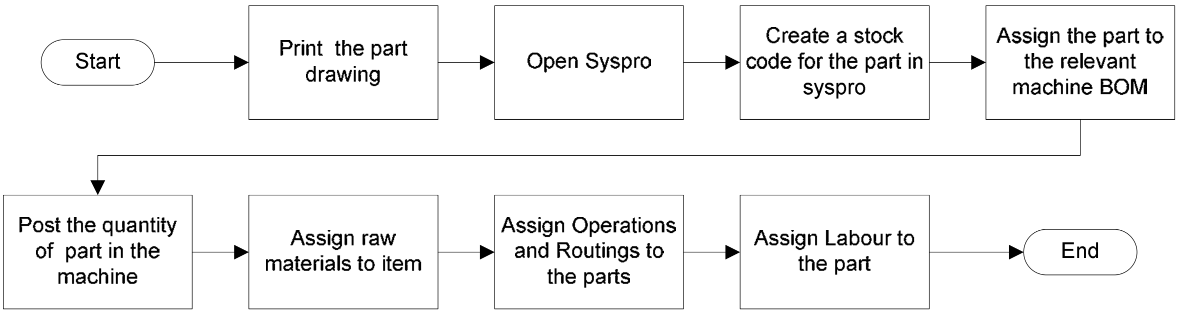


Figure 31 Previously employed BOM creation process

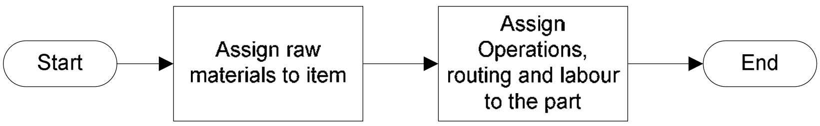


Figure 32 Updated BOM creation process

The results of the comparison are shown in Figure 33:

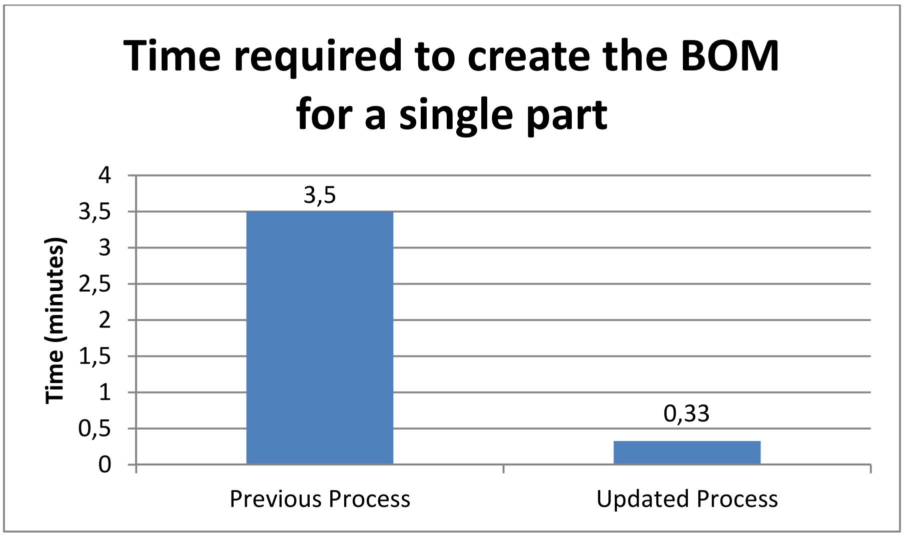


Figure 33 Time comparison of BOM posting processes

It can be seen from Figure 33 that there is a substantial time saving promoted by the updated BOM creation process. The time saving is due to information no longer being recreated in Syspro but rather being extracted directly from Solidworks. Additionally, all the information is captured in a consolidated interface integrated into solidworks' drawing interface, thus eliminating the movement required inside Syspro between each segment of information posting: e.g. post operations, open different menu, post labour etc.

Quantifying the significance of these time savings requires consideration of the total time taken to design a machine and create its BOM: this typically takes 5-6 weeks (depending on the size of the machine and the customisation required).The BOM is created during the last week and the removal of this week equates to a 20% reduction in design time.

Additionally, the software integration has the following benefits:

- The BOM structures are automatically created
- The process does not consume any paper
- The BOM creation process is integrated into the design process
- BOMs are updated on the MRP system at the click of a button (however, the updating of the archived printed design file remains a manual process)

3.3. Implementation

Software licences for the remaining design seats were acquired from CAD Speed after the success of the feasibility assessment was confirmed. The settings from the initial implementation were duplicated on the remaining design PCs within a day. Subsequently, the design engineer involved in the feasibility assessment provided the rest of the design team with Sysproworks training.

The use of Sysproworks was adopted as part of the standard design practice. Given the cost of software upgrade and the labour rate charged by the design department, the investment would be recovered after 100 design hours.

4. IMPROVING MRP STOCK LEVEL ACCURACY

The effectiveness of parts procurement is directly linked to inventory accuracy: the reflected stock on hand quantities decide whether, and in what quantity, parts should be procured. If parts are ill procured, they will not be available when required and will thus disable the operation's ability to deliver value.

The overall analysis conducted (see chapter 2.2) revealed that stock accuracy, and the associated cost implications, were a consistent operational concern. Assembly operations were frequently unable to deliver value because parts were not available; parts which Procurement then had to be expedited logistically, further draining value.

The objective of this chapter is to determine, and alleviate, the cause of excessive stock inaccuracy on Rovic's MRP system. It will attempt to do so by formalising an understanding of the physical operations currently associated with stock handling (The "AS-IS" state), identifying contributing activities which drastically skew inventory accuracy, and lastly proposing activity modifications intended to enable to value delivery (The "TO-BE" state) i.e. improve stock accuracy.

4.1. AS-IS State

Review of previous stock take reports revealed that the physical quantities tallied at stock take seldom matched the quantities reflected on the MRP system: the average stock accuracy was 70%.

The process map of **Figure 34** details all the activities which affect both the physical stock level and the stock level reflected on the MRP system. These activities relate to receiving and issuing stock to and from the store physically:

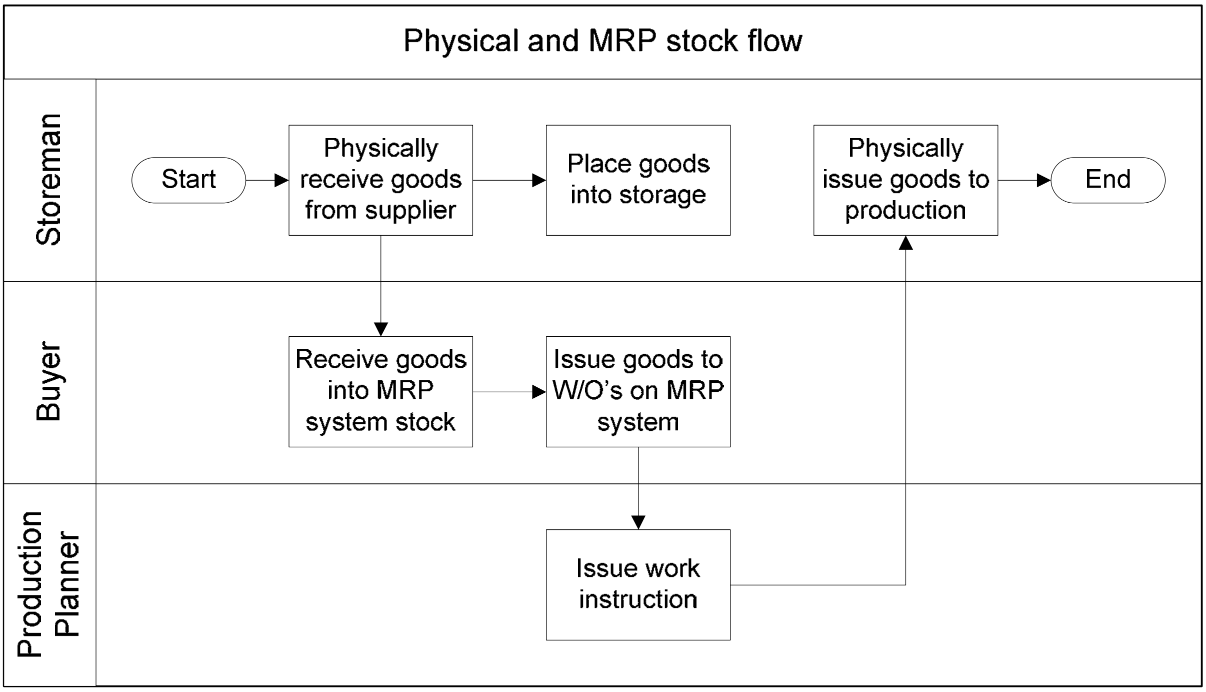


Figure 34 The Current state MRP stock movement procedure

4.1.1. Observations

1)	Activity:	Issuing goods to Works Orders on the MRP system
	Owner:	Buyer

Observation :

1. The buyer issues the goods to the works orders immediately after receiving them into stock. This means that the goods are booked out of stock shortly after they are booked in; more importantly, goods are being booked out of stock before they are physically issued – giving rise to a discrepancies between the indicated MRP stock level and the physical stock level. An inspection of stock movements on the MRP system confirmed that parts were booked in and out of stock within a matter of hours. An examination of previous stock take reports revealed that most stock levels were inaccurate at the time of stock take.

Significance:	i. Inaccurate stock levels lead to goods not being ordered, which in turn incurs production delays because the goods are not available for value add when required.
Related wastage:	i. Work Practices

4.2. TO-BE State

The AS-IS state analysis revealed that the timing of activities related to the MRP stock accuracy fundamentally contributed to stock inaccuracy. The AS-IS activities receive stock into the MRP system upon physical receipt of stock, but then go on to immediately batch issue the stock to a works instruction on the MRP system despite the parts still physically being on the store shelf and the works instruction not been generated.

4.2.1. Proposal

In an effort to synchronise the physical and MRP stock movements, the modified process outlined in Figure 35 was proposed:

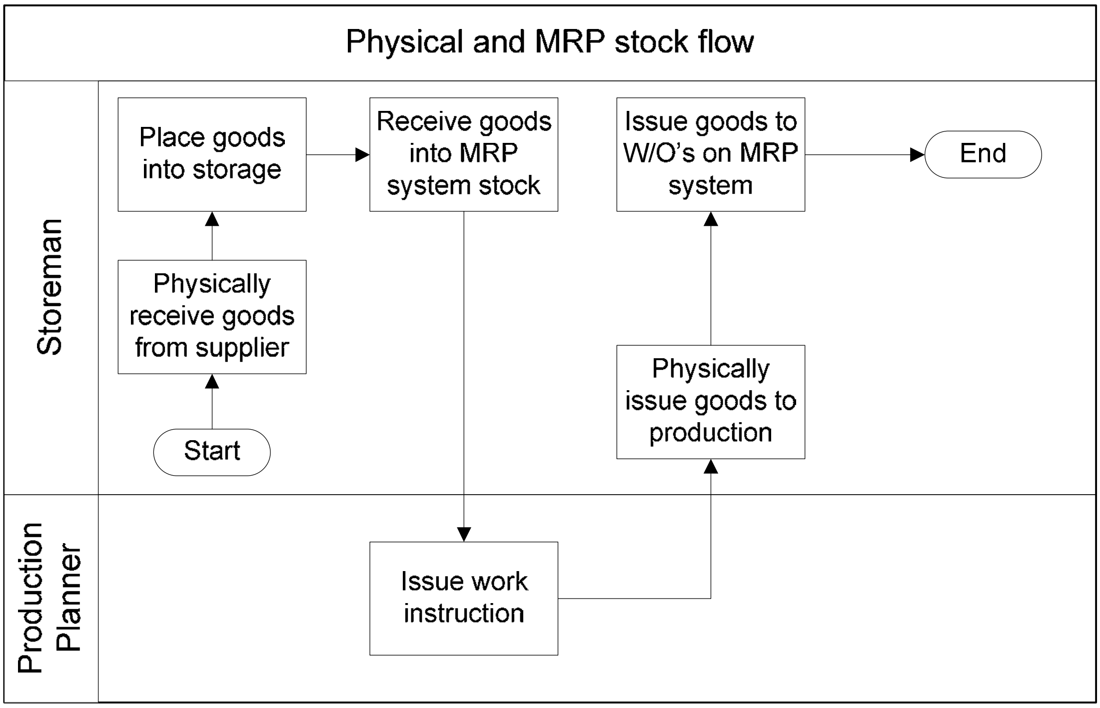


Figure 35 The proposed MRP stock movement procedure

The modified process required the proposed changes, outlined below, to be effected in order to be implementable and sustainable:

1)	Activity :	Receiving and Issuing stock on the MRP system
	Owner :	Storeman

Proposed change :

1. Make the storeman the process owner.

Motivation:	i.	The process is simplified – the buyer is removed from the process
	ii.	Physical and MRP stock movements are synchronised and controlled by a single employee

4.3. Implementation

The proposed modified process was not implemented because the Production Manager was unwilling to grant the storeman rights on the MRP system, while an alternative process was put into service. the process is outlined in Figure 36, below:

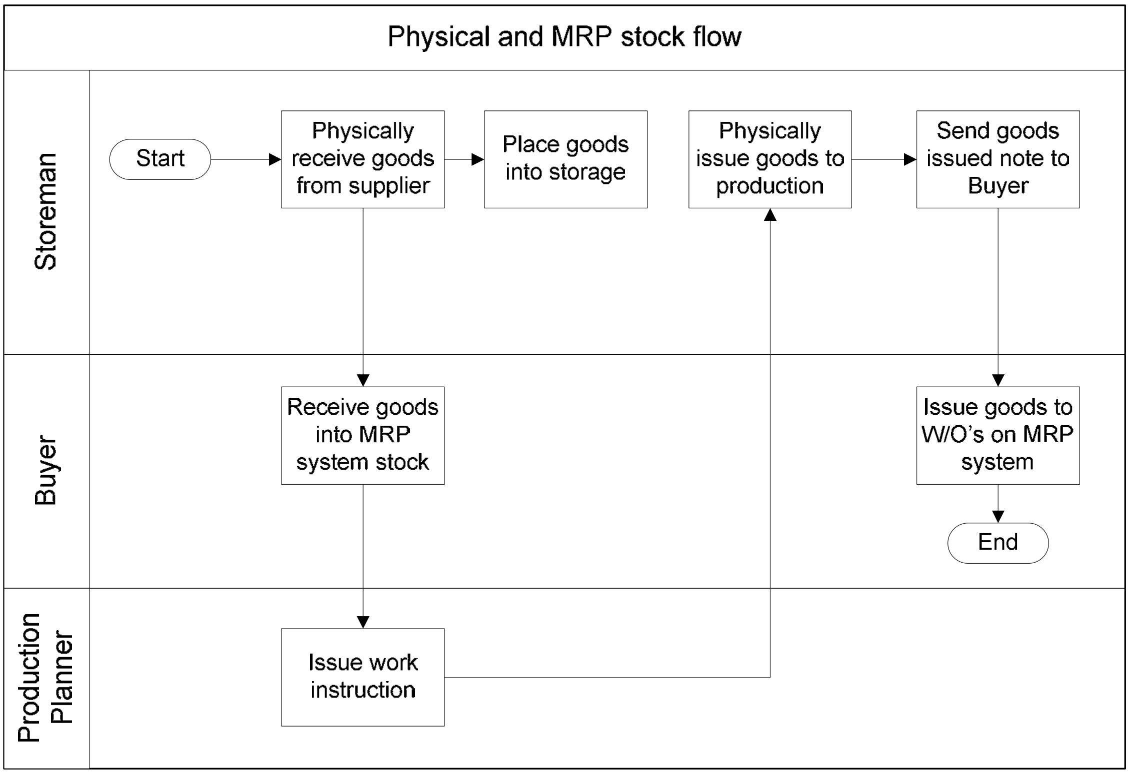


Figure 36 The implemented MRP stock movement procedure

This version of the issuing process does not exclude the buyer, but still aligns the physical and MRP stock issues.

The change was implemented immediately after a mid-year stock take. Stock levels are calibrated at stock take – removing all stock variances. Prior to implementation, the MRP stock accuracy over a 6 month period was 70%. Subsequent to the implementation, the accuracy rose by 30% over the same period. reflects the actual stock take figures attained:

Table 4 Stock take results

	June 2011	December 2011
Stock quantity on MRP System	78212	44865
Stock quantity on hand	54709	44680
Stock accuracy percentage	69.95%	99.59%

5. ISSUING WORK INSTRUCTIONS TO THE FLOOR

The works instruction is a mechanism used to drive and guide production on the factory floor. The works instruction consists of a BOM and a machine assembly drawing. Every production operation executed has a corresponding works instruction. The works instruction relays the designer's vision to the technician's hands. Essentially, the technician requires a works instruction to deliver value. It is thus critical that the works instruction be readily available when required.

The overall analysis conducted (see chapter 2.2) revealed that works instructions could not be generate quickly enough to satisfy production. Due to the criticality of works instructions being available when required, the researcher seeks to investigate the sub-process related to the creation of works instructions with the intention of modifying activities that negatively influence works instruction's readiness.

Increasing the efficiency of this sub-process has the added benefit of liberating time invested by the Production Planner: the sub-process owner. Since the production planner is also responsible for resolving operational conflicts and complications related the store operations and parts availability, his availability is valuable asset to the operations as a whole.

The objective of this chapter is to identify activities in the sub-process that consume large portions of time, and to subsequently propose and test activity modifications intended to enable to value delivery (The "TO-BE" state) through substantially and sustainably reduced lead times.

5.1. AS-IS State

The activities currently involved in the sub-process related to generating works instructions are detailed in Figure 37:

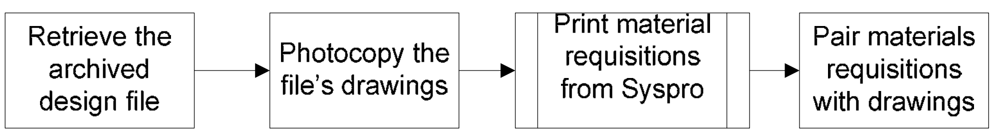


Figure 37 The current state procedure for Issuing working instructions.

5.1.1. Observations

The following observation were made during the documentation of the sub-process.

<table>
<tr><td>1)</td><td>Activity:</td><td>Pairing the material requisitions with the drawings</td></tr>
<tr><td></td><td>Process:</td><td>Issuing work instructions to the floor</td></tr>
<tr><td colspan="3">Observation :

1. The objective of this activity is to pair the materials requisitions to the corresponding machine drawing; in turn, creating the work instruction which guides production.

Each work instruction has:
A unique works order number
A materials requisition list
A unique drawing associated with it. The drawing may span multiple pages.
The pairing criterion is the drawing number indicated on the materials requisition.
<table>
<tr><td>Significance:</td><td>i. The unique nature of the pairing criterion presents an opportunity for process automation

ii. Catalysing the issuing process makes it more likely that the Assembly technician will possess a work instruction. This is necessary for informed production – it provides the Assembly technician with exact knowledge of what is required to complete the job</td></tr>
</table></td></tr>
</table>

2)	Process:	Issuing work instructions to the floor
	Owner :	Production planner

Observation :

1. The process of generating a single work instruction (excluding the retrieval of the file), takes 1 minute on average. Figure 38 shows the scale of the pairing task.

Significance:	i. Given that every task undertaken in the factory requires a work instruction, the amount of time dedicated to this process by the production planner is massive. The production planner estimates that he spends about 30% of his time on this process. ii. The production planner is responsible for resolving any parts related problems in the factory; the more time he has available, the better he is able to do this.
Related wastage:	i. Work Practices

Figure 38 Materials requisitions generated by the MRP system are spool printed, separated, and then paired to their corresponding machine drawings.

3)	Activity:	Retrieving the archived design file.
	Process:	Issuing work instructions to the floor

Observation :

1. The drawings in the files are sometimes out-dated. This occurs when the design department has updated or revised the machine drawings but have not updated the file. Updating of the files is tedious because often a single drawing is used in multiple files; thus, a single design change may require the update of multiple files. The archived files are show in Figure 39.

Significance:	i. Putting out-dated drawings into production inevitably incurs production errors, rework, and delays in product delivery.
Related wastage:	i. Work Practices

Figure 39 Archived machine drawing files

From the observations, it was concluded that the key risk to overall process realising value was the manual and paper based nature of the sub-process activities.

5.2. TO-BE State

This chapter details the functions of the proposed TO-BE state and its associated testing and implementation outcomes.

5.2.1. Proposal

It was proposed that the work instruction issuing process be automated through the implementation of a custom developed software application. The application was intended to bridge the MRP and design software systems, and pair the information required respectively to generate works instructions, effectively automating the sub-process.

Given the simple pairing criterion and the fact that the application would not be required to create information, only manage it, this would be straight forward and easy to implement. The implementation would have high returns in the form of time savings for the production manager; allowing him to better focus on resolving parts related woes in the factory.

The application would require the following information:

	Source	Information
1	MRP system	Data to populate the materials requisition
2	Design	Machine drawings

The application proposed would effectively act as an information pump; performing the function outlined in Figure 40, below:

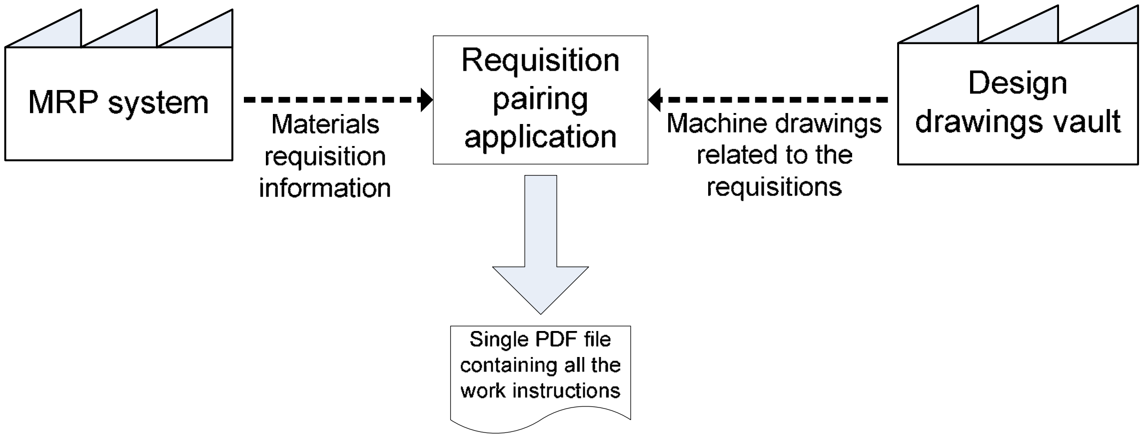


Figure 40 Overview of the work instruction pairing application's functioning

It was acknowledged that in order to achieve a successful implementation, the following pre-requisites would be required:

1. The drawing data had to be available electronically.
2. The MRP system had to output the data required in a format that could be utilised by the application.

5.2.2. The works instruction pump

With the aid of the pairing application, the proposed TO-BE process for issuing work instructions is shown in Figure 41:

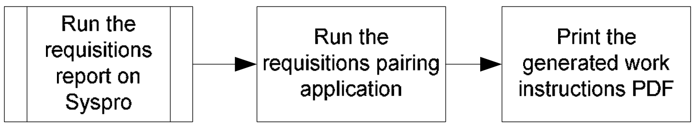


Figure 41 Implement process for issuing work instructions

There were 3 modifications required to enable the pairing application to "pump" works instruction, described below:

5.2.2.1. *Generating the Machine drawings required for pairing*

The drawing data requirements were generated by working in conjunction with the senior design engineer. It was discovered that each drawing had a unique code, and that all the design drawings were backed up weekly in pdf format to an external hard drive kept in the design department. Furthermore, the pdf file name matched the drawing code.

To provide the machine drawings required by the pairing application, a folder specifically for machine drawings was created on the Rovic network share drive. It was agreed that the design engineer would backup and synchronise the folder weekly (at the same time as backing up the external hard drive).

This folder can be accessed by anyone logged onto the Rovic server; meaning that the latest version of each drawing can be accessed remotely by anyone within the company. Thus, discarding the need for archived files and ensuring that the latest drawing version is always put into service.

5.2.2.2. *Generating the materials requisition data required for pairing*

The data required to populate the materials requisitions was generated by working in conjunction with Rovic's internal MRP technician. Data creation was achieved by reconfiguring the report which the production planner used to spool the requisitions. The report was modified to output a tab-delimited data string instead of a print job. The data string contained all the information required to populate the requisition.

5.2.2.3. *Coding the pairing application*

The coding of the actual pairing application was outsourced. The initial contact made with application developer was purely to determine whether the developer could provide the functionality required. This was done by supplying the developer with a sample data string and the associated pdf drawings.

After the feasibility of the application was confirmed, a follow up meeting was conducted to convey the pairing logic, state the required output format and to design the user interface for the application.

It was decided that the output of the pairing application would be a single pdf – which could be double side printed to churn out a paired instruction: one side showing the drawing, the other the materials requisition. The interface was mocked-up on paper, complete with buttons, error reporting etc. The finalised format of the interface can be seen in Appendix A.

The developers set off with the instruction in hand and returned three weeks later with the completed application. The development cost of the application was R20 000.

5.2.3. Testing

After installing the pairing application, the Production Planner tested it by generating various works instructions. The time required by Production Planners to configure and initiate the paring application (regardless of the number of work instructions), is a flat rate of 2.33 minutes. The application then takes a further zero to two minutes to create the pairing pdf, which contained the paired and completed works instructions ready for printing.

The time required to print the instruction would obviously vary depending on the number of instructions, but this would not affect the production planner, as all he is required to do is to collect the instructions from the printer after the printer has completed the print job.

The proposed method of issuing works instructions offers a substantial lead time reduction over the AS-IS process. An added benefit of the revised issuing system is that it ensures that the live version of the drawings and material requisition is always put into production, since it does not rely on the potentially outdated (and now obsolete) design files.

5.3. Implementation

The operational measures required for implementation had to be overcome during the preparation for the testing phase. With the TO-BE gains confirmed, the Production Planner adopted the pairing application as part of standard operations. The design drawing vault was also reconfigured to update daily instead of weekly to ensure that the drawings required by the pairing application are available.

6. DEVELOPING STANDARDISED STORES OPERATIONS

The store operations form a crucial link in enabling value delivery in the assembly operations. The store provides the externally sourced parts required for assembly to take place; it does so through execution of the following sub-processes (see Figure 18):

1. The process for receiving and storing goods
2. The process for issuing goods
3. An administration system, which controls and co-ordinates the above

The structure, as well as underlying activities and operational aspects, of the above sub-processes related to the physical movement of parts (points 1 & 2), should allow the overall process to be executed as efficiently as possible. Similarly, the sub-process related to the administration and instruction of parts movements (point 3) should allow overall process to be executed as effectively as possible, while considering the requirements of points 1&2.

The AS-IS store processes are not formalised, i.e. they are ad-hoc: this promotes a challenge in establishing a baseline for improvement efforts. For this reason, the researcher intends to study the store operations, draft a formalised representation of them and vet it with the operational stakeholders. The final intention is identify activities in the baseline, which can be modified to improve both effectiveness and efficiency of the overhanging overall process and in doing so, establish a formalised status quo to be implemented as a basis for future continuous improvement.

In light of the above, the objectives in the sequence of this improvement initiative in relation to the sub-process concerned are to:

1. Improve the efficiency of the goods receiving and storing sub-process, so that goods received from suppliers are placed into storage effectively and in a manner, which allows it to be speedily picked when required.
2. Improve the efficiency of the goods issuing sub-process, in order to synchronise the store's picking efforts with the real time demand of the Assembly area and to minimise time lost by the assembly technician while retrieving parts.
3. Develop a standardised administration framework for Rovic Store, structured to allow the overall process to realise both effective and efficient operations.

The objectives were sequenced according to the following logic:

The sub-processes related to the physical handling of goods were prioritised because they face operational constraints and should be structured in a manner which is most efficient for the local environment and the administration system would then be structured accordingly. Similarly, the receiving process was prioritised over the issuing process because parts need to initially be stored in a systematic way so that they can be effectively withdrawn later for issuing purposes.

The limitations placed on the proposed operating system were that it had to be:

- Integrated into Rovic's current production infrastructure
- Compatible with Rovic's MRP system
- Straightforward to administer– administrative efforts were to be kept to a minimum
- Cost had to be minimised

Reflecting on Figure 18, it can be seen that the sub-processes concerned each operate on discrete section of the overall process. For this reason, each initiative objective shall be treated individually in the following chapters. The intention is to modify the activities local to the sub-processes so as to maximise the performance of the overall process, while respecting the boundary requirements defined by the SIPOC tables and the operational constraints.

6.1. Receiving and storing goods

The value add objective of this sub-process is to receive goods from external suppliers and place it into storage in such a way that it may be quickly and effectively withdrawn when required by the assembly operation.

6.1.1. AS-IS State

A formalised representation of the sub-process AS-IS state is shown in Figure 42, below.

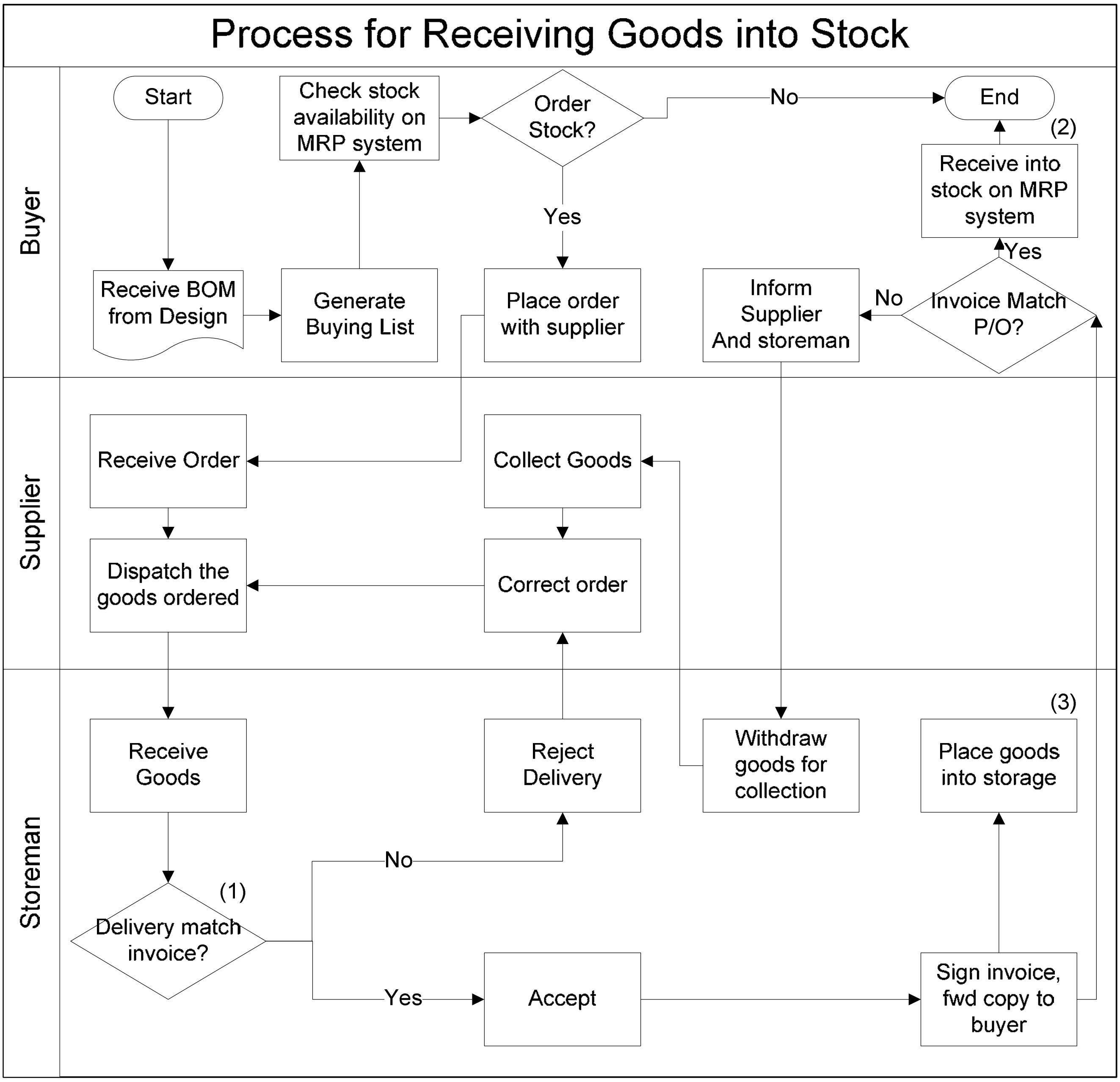


Figure 42 Process map for Receiving and storing goods – Current state

6.1.1.1. *Observations*

The following observations were made while formalising the AS-IS state of the goods receipt and storage sub-process:

<table>
<tr><td>1)</td><td>Activity :</td><td>Checking the goods physically delivered against the delivery invoice</td></tr>
<tr><td></td><td>Owner :</td><td>Storeman</td></tr>
<tr><td colspan="3">Observation :

1. Goods received are always supposed to be confirmed against the delivery invoice. However, this check is not performed consistently. It tends to be done when it is convenient e.g. when a batch of easily identifiable stock items (e.g. profiling) arrives. Large delivery batches are often just signed for and passed into storage; this is especially true for hydraulics (most times the bags are not even opened for a basic inspection).

<table><tr><td>Significance:</td><td>i. A mismatch between the goods physically booked into stock and the goods received into stock on the MRP system gives rise to stock inaccuracy; this tends to incur production delays or flawed procurement at a later point due to the fact that goods which are thought to be on hand and available for production are actually not.</td></tr><tr><td>Related wastage:</td><td>i. Variability</td></tr></table></td></tr>
</table>

2)	Activity :	Checking the delivery invoice against the purchase order
	Owner :	Buyer

Observation :

1. The purchase order reflects what the buyer actually ordered, the delivery invoice reflects what the supplier issued; comparing these after the goods have already been placed into storage creates unnecessary rework.

Significance:	i. If the invoice does not match the purchase order: the storeman has to remove the stock from storage shortly after having placed it there. ii. The check done by the storeman (physical vs. invoice) is irrelevant if the goods being checked were not ordered in the first instance.
Related wastage:	i. Rework ii. Over processing

2. The Storeman has no permissions on the MRP system. Thus, the paperwork must be forwarded to the buyer for processing.

Significance:	i. Forwarding the paperwork creates unnecessary document motion which delays processing ii. The delivery error is only realised once the buyer has time to perform the check. After which, it can only be corrected once the supplier has time to collect the goods. iii. The storeman is unable to execute any of the administrative MRP tasks linked to the store.
Related wastage:	i. Motion ii. Waiting iii. Working practices

3)	Activity :	Placing goods into storage
	Owner :	Storeman

Observation :

1. There are no standardised locations for goods storage; the storeman places the goods wherever he finds space for them.

Significance:	i.	Storing goods in non-standard locations makes locating them difficult
Related wastage:	i.	Working practices

2. The product locations in the store are not indexed on the MRP system

Significance:	i.	The storeman is the only person able to locate goods if their locations are not catalogued on the MRP system.
Related wastage:	i.	Work practices.

3. Goods are not always placed into storage; they are sometimes pushed directly into the assembly area.

Significance:	i.	Holding parts which are not currently required in the assembly area consumes excessive floor space.
Related wastage:	i.	Variability
	ii.	Inventory

4. The store currently utilises a portion of its space to house parts which are inactive, parts bins which are not utilised. The bins are either redundant or duplicate.

   Figure 43 and Figure 44, below, show inactive and redundant parts bins respectively.

Figure 43 Inactive stock bins are not removed from shelf - some have remained empty for multiple stock takes.

Figure 44. Duplicate stock bins consume excessive shelf space in the store

Significance:	i. These items consume space in the store which could otherwise be used to accommodate parts which are actually required by the production.
Related wastage:	i. Inventory

5. Stock in the parts bins are mixed e.g. M8 washers in the M6 washers bin etc.

Significance:	i. It is harder to keep track of when it is not kept in its designated location
Related wastage:	i. Work practices.

Having examined the sub-process, it was observed that there were opportunities to simplify and consolidate the administration related to parts receiving by allocating administrative control to the Storeman, and to improve the ease and accuracy of parts picking by optimising the physical layout of the store.

6.1.2. TO-BE State

In an effort to improve the efficiency of the goods receipting and storing sub-process, the TO-BE process as shown in Figure 45 was proposed.

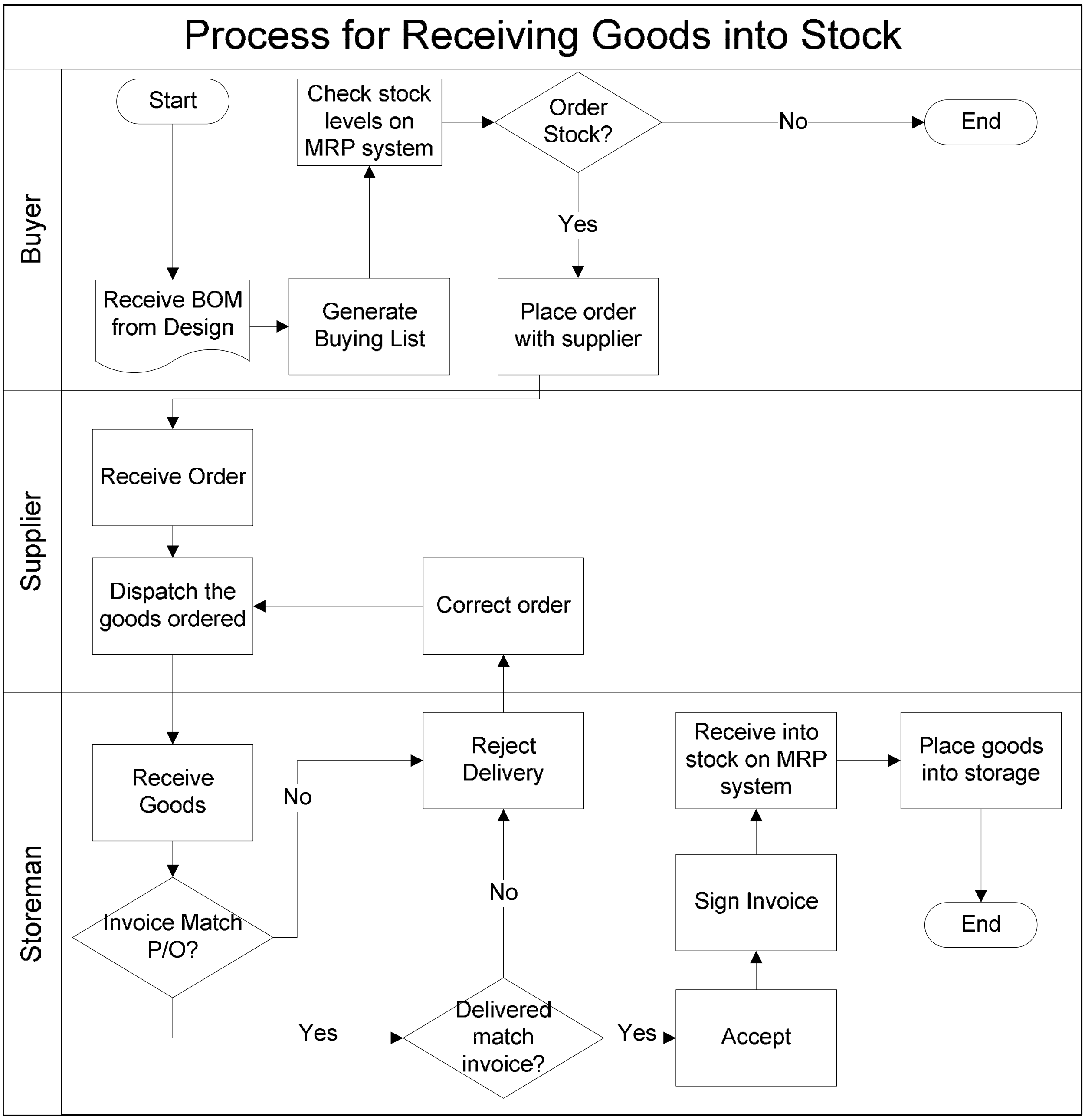


Figure 45 Process map for Receiving and storing goods – Proposed future state

6.1.2.1. *Proposed changes*

The proposed TO-BE process sought to effect the following changes:

1)	Activity :	Checking the delivery invoice against the purchase order.
	Owner :	Storeman

Proposed change :

1. Make the storeman the process owner.

Motivation:	i. Incorrect deliveries are detected immediately. ii. The order correction process is simplified.

2. Perform the Purchase order vs. invoice comparison before the physical vs. invoice comparison.

Motivation:	i. Prevents the storeman placing incorrectly delivered goods into storage.

2)	Activity :	Receiving goods into stock on the MRP system.
	Owner :	Storeman

Proposed change :

1. Make the storeman the process owner.

Motivation:	i. Localises the store's MRP related administration. ii. Provides improved synchronization between physical stock movement and stock movement on the MRP system.

3)	Activity :	Placing goods into storage
	Owner :	Storeman

Proposed change :

1. Remove inactive stock and duplicate bins

Motivation:	i. Liberates space in the store ii. Unused stock can be returned to the supplier for credit

2. Optimise the store layout by moving the fastest moving consumables close to the entrance and by grouping parts by product type.

Motivation:	i. Reduces the time required for order fulfilment

3. Standardise stock locations

Motivation:	i. Ensures that stock can be easily located ii. Provides consistency in goods storage

4. Index stock locations on the MRP system

Motivation:	i. Provides stock location transparency on the MRP system ii. Allows anyone to locate goods in the store by searching for them on the MRP system

6.1.3. Implementation

The proposed changes and motivations were presented to the Production Manager. The production manager was unwilling to allow the Storeman increased administrative control – hence, making proposed changed 1&2 of Chapter 6.1.2.1 unfeasible – but was willing to effect the changes proposed to the physical layout of the store.

6.1.3.1. *Placing goods into storage*

The Store layout was optimised by employing the lean 5S practice (see lit review, chapter 1.4.6.2), as this is a widely proven way to systematically improve the facility.

6.1.3.1.1.i) Sorting

The first step taken toward optimising the store layout was to remove inactive stock and redundant stock bins. This was done to liberate space in the store and to ensure that goods held in stock were useful to production.

Rovic defines inactive stock as any stock which has not been utilised in the past two years. The inactive stock was identified by running the 'Inventory activity exception report' in Syspro; the report scans the stock movement records and identifies stock which has seen no movement since the user defined input date.

The inventory exception report showed that there were inactive stock items on hand, valued at R228 000. Most of these items were returned to their respective suppliers for credit. However, there was a batch of gearboxes which could not be returned; these were bought in a large batch because the supplier offered a bulk buy discount. Bulk buying for discount is common at Rovic, but has limited practicality since production forecasts can't be accurately made. As a result, large amounts of capital are continually tied up in inventory which may never be utilised.

The ‘Inventory activity exception report’ was used to remove inactive stock from shelf. The duplicate stock bins were visually identified and removed by inspecting the store shelves. Figure 46 shows the inactive and redundant stock bins removed:

Figure 46 Stock bins removed from the store

6.1.3.1.1.ii) Setting and Shining

The remaining stock was arranged according to the conventional layout for *low volume/high variation* warehousing centres (see lit review, chapter 1.4.6). More specifically, the fastest moving goods were moved closest to the store entrance, the remaining stock was grouped into universal application (gearboxes, bearings etc.) and product specific (planters, sprayer etc.) silos.

The finalised shelf allocations can be seen in Table 5 on page 82. Appendix B shows a map of the store's layout:

Table 5 Rovic store shelf location data

Shelf No.	Product Description
1	Product manuals and handbooks
2-6	Consumable fasteners
7-16	Product specific silos
17	Stickers
18	Hose Clamps
19	Miscellaneous
20	Technician consumables – welding supplies etc.
21-24	General consumables – standard bearings etc.
25	Gearboxes and wheel stubs
26-27	Hydraulic cylinders and rollers

6.1.3.1.1.iii) Standardising

The shelf locations of all the stock in the store was catalogued and indexed on Syspro (the MRP system). A custom report that listed all the stock locations was created, which was titled "FSBIN". This report was created to serve as a reference document – indicating where received goods should be stored.

Provision was made for when stock was relocated in the store by creating a "bin location change" register. The register can be seen in Appendix C Stock relocations are common at Rovic due to the stock on hand continually changing in both nature and quantity as a result of customised production. In addition, shelved stock often needs to be relocated to accommodate freshly received goods. The register had to be forwarded to the production planner in order to update the MRP system, which was necessary because the storeman had no MRP rights.

6.1.3.1.1.iv) Sustaining

In an attempt to ensure that goods are always placed in a standardised bin location, the procedure outlined in Figure 47, below was implemented as standard practice for placing goods into storage:

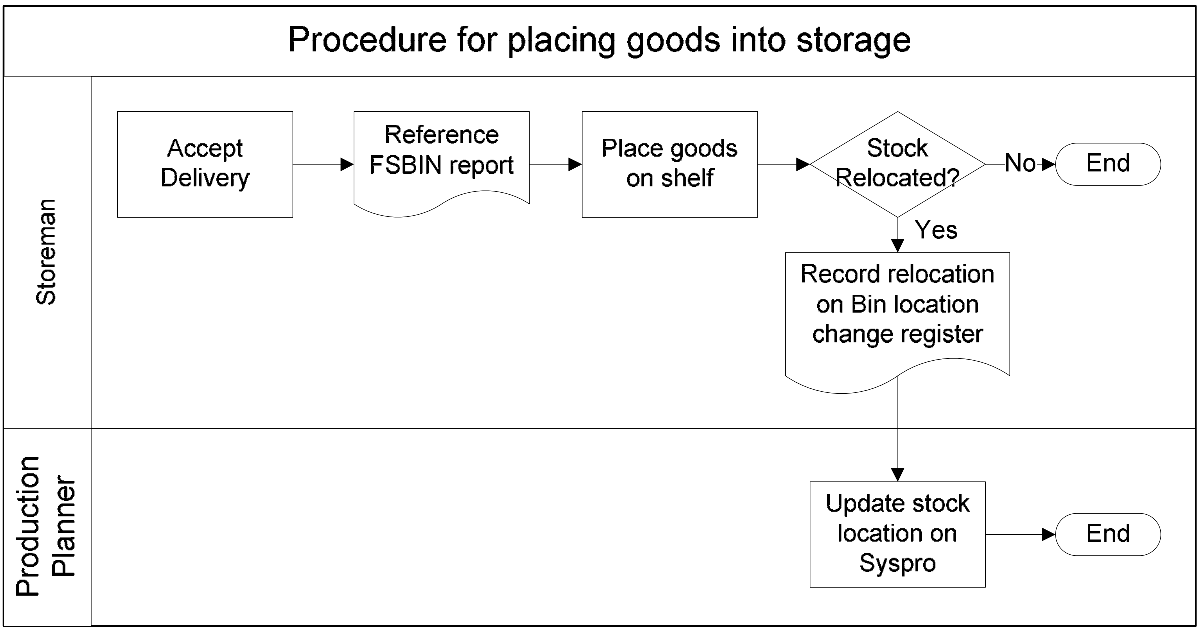


Figure 47 Process for placing goods into storage – Implemented

The change implemented offer benefit to the overall process as standardisation of the goods storage locations will allow parts to be conveniently and accurately retrieved in future, providing that the crucial Sustaining aspect of 5S is upheld. There are, however, still further opportunities for holistic improvement if administrative controls are surrendered to the process owner, i.e the Storeman.

6.2. Issuing parts to the Assembly operation

The value add objective of this sub-process is to issue parts to the Assembly operation when required, in a manner which allows the Assembly technician to withdraw the parts efficiently.

6.2.1. AS-IS State

The method currently used to issue goods to the floor is illustrated by the current state value stream map of Figure 48, below:

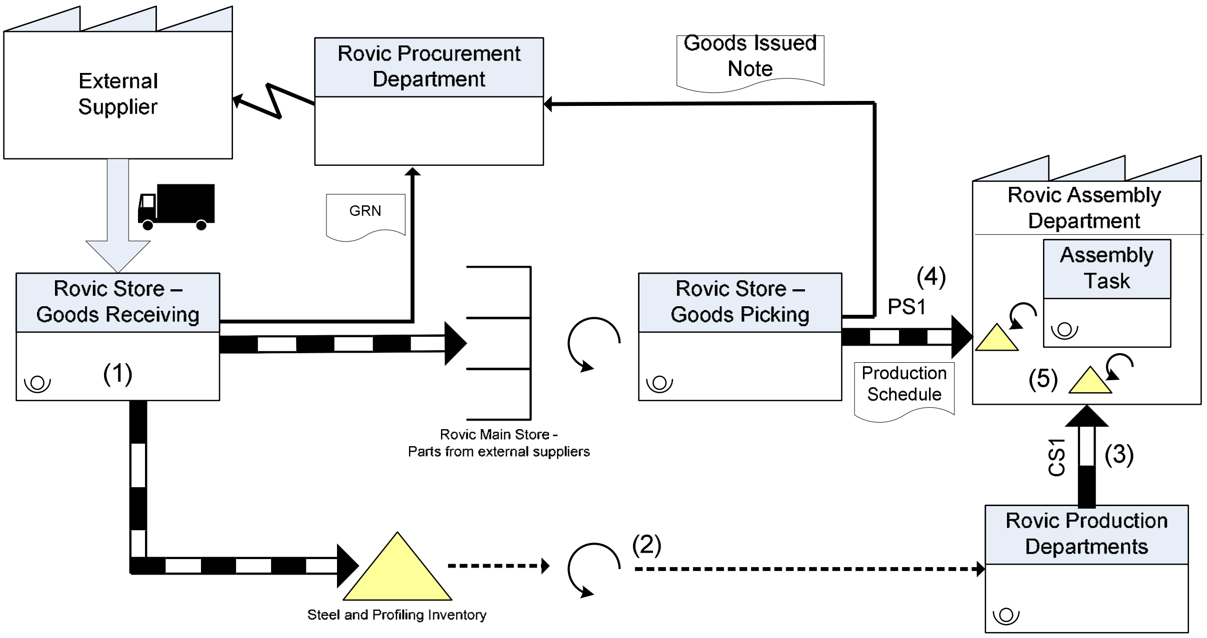


Figure 48 Value stream map of the store's operations – Current State

The current method for issuing goods to the Assembly department can be described as follows:

1. **The goods are received by the store employees and automatically placed in storage.** The goods are then placed into their relevant holding area. There are three holding areas: the main factory store, the profiling store and the steel inventory store.

   At this point the store also relays the Goods Received Note (GRN) to the procurement department to alert them that goods have been received and must be added to stock on the MRP system (goods that are successfully received into stock are subsequently referred to as *"parts"*).

2. **The Rovic Production departments withdraw the profiling and steel required for fabrication from their respective stores.** This is done as required, to complete the necessary fabrication. The internally fabricated items are henceforth referred to as *"components"*.

3. **The Components produced by the production departments are pushed into the Rovic Assembly Area.**

4. **The Store pushes the parts required for the assembly of the components into the Assembly area**. The parts are pushed according to a set production schedule. Parts are pushed as bulk batches containing everything required to complete machine being assembled.

   The Store subsequently forwards a parts issued note to the Procurement Department to indicate that the parts have been physically issued and have to be issued on the MRP system.

5. **The Assembly technician retrieves the parts required for the assembly task (value-add) at hand from the batch of delivered by the store.**

6.2.1.1. ***Scheduling parts deliveries***

The current operation of the Store can be described as being predictive. Meaning that the Store's delivery schedule assumes that everything is always going to plan – in the current state, optimal functioning of the store is very dependent on the activities in the Rovic Assembly area being carried out in a predictable and controlled manner. This, however, is often not the case, mostly due to the custom nature of the work undertaken by Rovic. As such, the store's performance deteriorates accordingly.

To demonstrate consider the scenario presented in Figure 49, below:

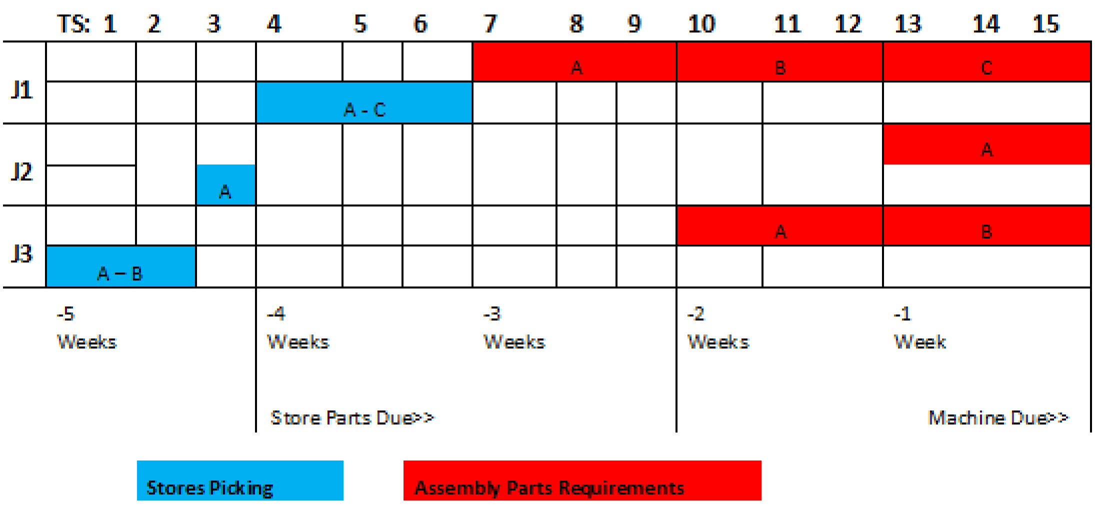


Figure 49 Production Time line - Stable Schedule

Key: Job (J), Time Segment (TS)

For the purposes of this illustration, it may be assumed that the picking duration equals one third of the associated assembly duration. The Time Segments in Figure 49 represent a set unit of time: there are 3 units in a week.

It can be seen from Figure 49 that although Jobs 1 through 3 (J1-J3) have different start dates, the current store delivery policy which states that parts are to be delivered 3 weeks before the machine due date requires the store to deliver all the parts for J1-3 by Time Segment (TS) 7 - despite the fact that only the parts for J1 are required by TS7.

The current delivery policy induces varying delivery safety windows across J1-3. It also forces the storeman to take it upon himself to prioritise the picking order in a sequence he deems fit. The sequence elected is at best a guess since he has no concrete feedback on when the jobs will actually start (the production schedule only indicates the final delivery date) and thus when the parts are actually required.

It is easily seen from Figure 49 that the optimum picking sequence should be J1, J3 and then J2; the storeman however can elect to pick in a sequence of his choice. In this particular instance: J3, J2 and then J1. Ultimately, the picking sequence does not matter providing that all the jobs run as scheduled and the store is able to withdraw the parts within the allocated durations.

It should also be noted that the process of assembling machinery tends to happen in phases – typically per machine sub assembly. For example: the frame is assembled, its wheel sets added, wings added, then its hydraulics and so forth. The assembly phases of each machine (job) are represented in Figure 49 by the letters A, B, C.

It can be seen in Figure 49 that the store does not group its picking batches into units matching the assembly phases, but rather as large job lots i.e. all the parts required for the assembly of the machine. This means that the functional units used for supply and demand between the store and assembly are inconsistent.

Given the above, suppose that for some reason the production schedule was shifted so that J1 was advanced by 1 week. This scenario is reflected in Figure 50 on page 88.

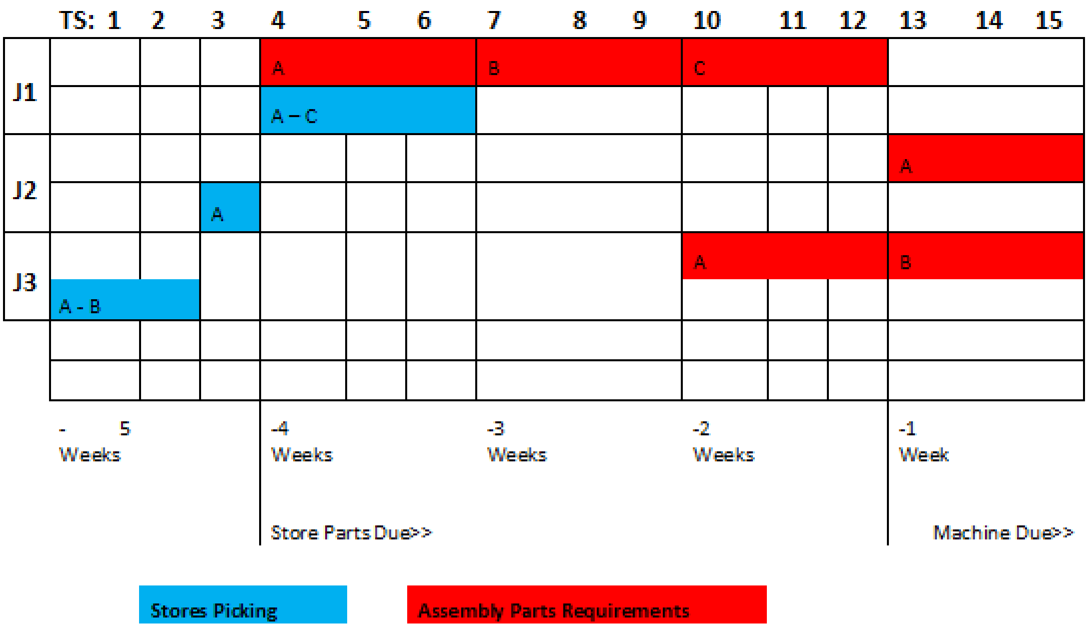


Figure 50 Production Time line - with schedule shift

Key: Job (J), Time Segment (TS)

From Figure 50 it can be seen that:

- The assembly of Sub-assembly A (Sub. A) of J1 will be delayed because the parts required are just being picked.
- This scenario can also arise as a result of J1's parts picking being delayed by a week.
- The picking sequence becomes critical when dealing with a shifting schedule; if the parts for J1 had been picked in TS 1-3, the delay would not have occurred.
- Even though the assembly area only requires the parts for Sub. A of J1, the parts will not be available until the store has picked all the parts for Sub's A-C of J1. At this point the Assembly technicians would usually visit the stores and physically retrieve the parts that are immediately required.

The scenario in Figure 50 is a simplified one as it only reflects one schedule shift, typically however, there are several.

Schedule shifts may be caused by localised variations within the Rovic production departments; for instance, J1 may be held up in production due to a design challenge, as a result of this J2 may be pulled forward to fill the production lull. Or, J1 may take longer than expected in production and as a result may be overtaken J3.

These shift factors cannot be overlooked. The store must be ready at all times to cater to whatever the needs of the assembly area may be.

6.2.1.2. *Quantifying the parts demand*

This section seeks quantitative insights into the operational nature of the parts demand imposed on the Store.

6.2.1.2.1. Nature of the parts demand

An analysis of the parts required for smooth production in the final assembly area was conducted. The purpose of the analysis was to examine the populations of parts consumed by the Assembly area. Gaining insight into the actual demand of the final assembly area allows the insight required to develop an effective parts handling strategy.

The constituents of a machine being developed in the final assembly area can be seen in Figure 51 below:

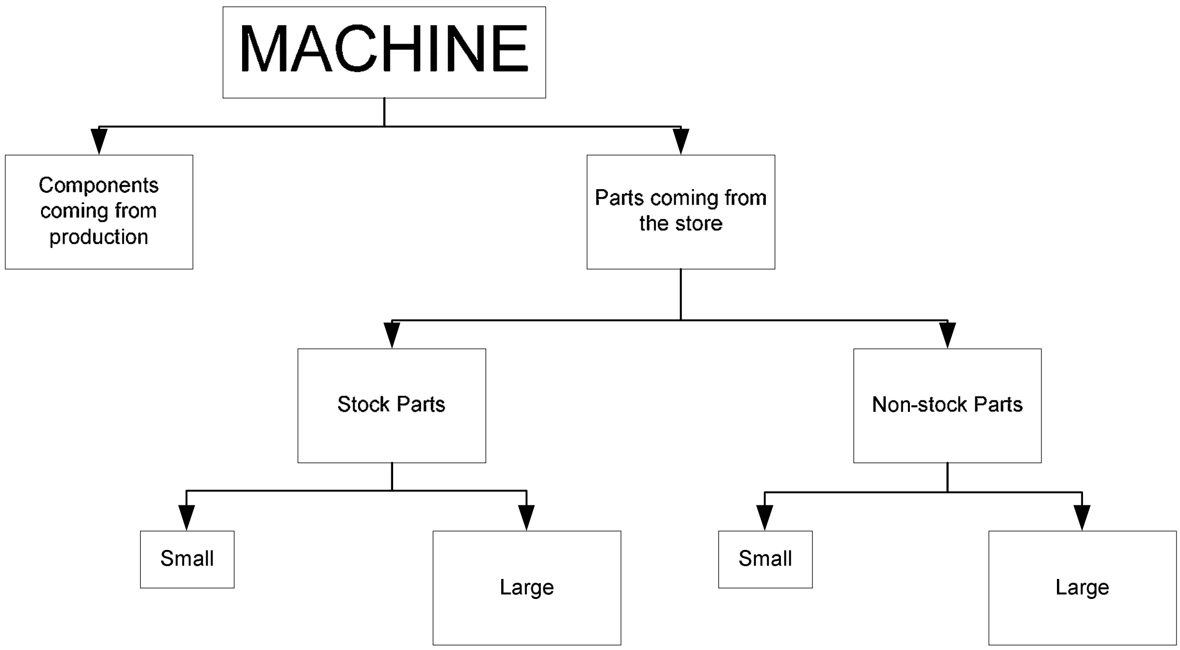


Figure 51 Machine Component Break down

The focal branch of Figure 51 selected for analysis was the ‘parts coming from the store’. These are the only parts actually delivered by the process being investigated. The distinction between small and large parts was made as follows: a small part is any part that can be held in one hand; meaning that it could be easily carried. The components coming from production (steel works) tend to be physically large and are generally well organised by the Production manager.

A Pareto analysis was conducted on the parts coming from the store; this was done to determine the demand distribution for parts across the various product classes at Rovic. See Appendix D for a complete list of Rovic product classes. The goal of the analysis was to determine which part classes made up the bulk of the order required from the store.

The analysis was conducted on the BOMs of a variety of products. This was done to get a general indication of parts consumed by the Assembly area. The products selected for the analysis were: a large sub assembly, a small machine, a medium sized machine and a custom built large machine. The results of analysis were compiled by assessing the contribution of each product class to the total parts population.

The Pareto analysis was performed on the following Rovic products:

No.	Product Name	Description
1	Stackfold Planter Main Section	Main Sub Assembly of a stackfold planter: forms the backbone of the machine – stable design
2	1.5m Mulcher	Small size machine – stable design
3	8 Ton Spreader	Medium size machine – updated design
4	Combination Planter	Large size machine – custom design

The results from the Pareto analysis can be seen in Figure 52 below:

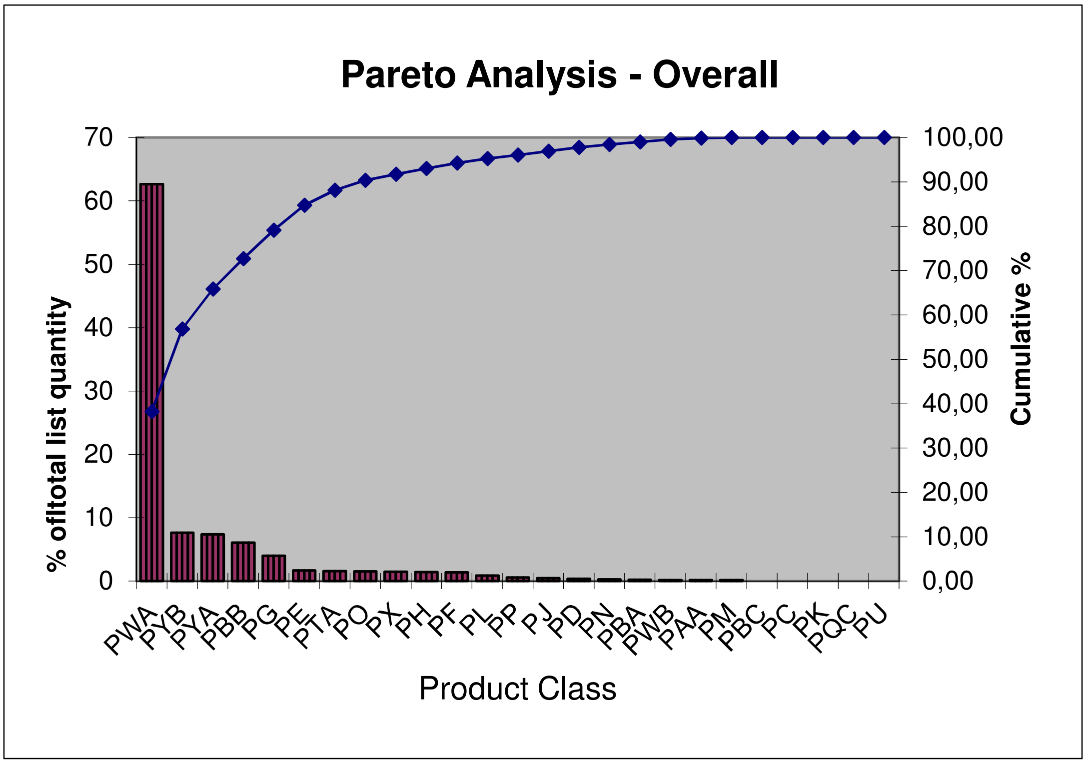


Figure 52 Pareto Chart - Overall product class distribution

It was discovered that the five main BOM contributors were the PWA, PYA, PYB, PBB and PG product classes; accounting for approximately 80% of the parts population and 20% of the product class types.

The PWA, PYA, PYB classes represent nuts and bolts, plating products and outside machining respectively. Particular attention was paid to the PWA class as these represent the stable consumables used during machine assembly; whereas the BOM contribution of the PYA and PYB classes varied depending on machine design and specification.

The contribution of the PWA product class is displayed in Table 6 below:

Table 6 Percentage contribution of consumables to machine parts

Product	PWA class % of BOM product types	PWA class % of BOM parts quantity
Stackfold main sub assembly	29.11	51.63
1.5m Mulchers	42.47	74.20
8 Ton Spreaders	45.79	61.34
Combination planter	35.48	61.87
AVERAGE:	38.21	62.26

It can be seen that while standard consumable fasteners are often overlooked due to their small physical size and low cost, they usually constitute the largest product class being withdrawn from the store. The PWA class generally accounts for approximately 40% of the BOM list entries and 60% of the parts being withdrawn from the store.

6.2.1.2.2. Location of demand

The layout of the Rovic production facility is illustrated in **Figure 53**, below.

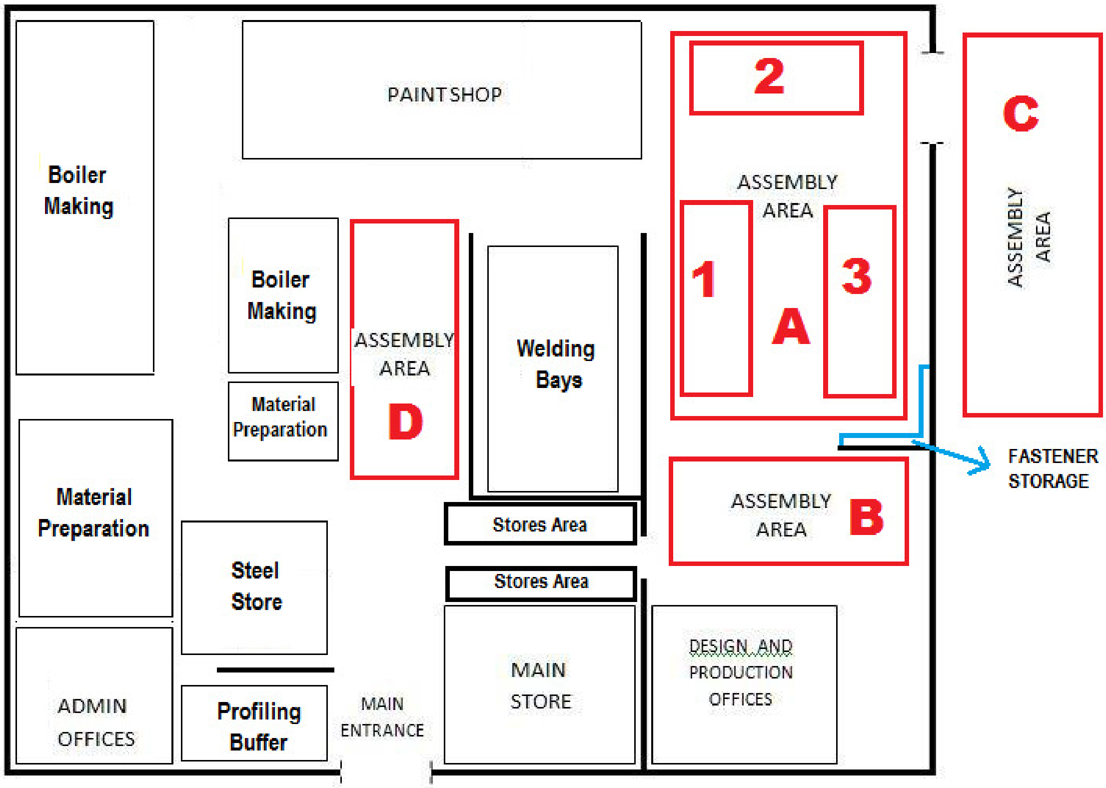


Figure 53 Rovic Factory Layout - The Areas used for machine assembly are marked by letters A to D.

Areas A and B are the only officially designated assembly areas in the factory. Area A is where the large machines like planters are assembled. These machines are often of custom design and a large source of rework as they are designed and built simultaneously. Area B is used to assemble the medium sized machinery like sprayers and spreaders, these machines generally have stable designs and are built with little rework complication. Areas C and D are utilised on an ad-hoc basis.

It must be noted that areas A1 to A3 are general indicators of where assembly tasks are carried out. Assembly work is carried out wherever there is floor space available.

This is done because the machines being built are large relative to the floor space available: standardised work space allocations are difficult to adhere to because of the custom nature of the machinery being built. One machine may consume assembly areas A1, 2 and 3 whereas another may only require A2. Given that machinery builds often overlap each other in the assembly area, it seems reasonable to utilise all the floor space available even though it does not allow the build areas to be standardised

The issue is further complicated by the fact that machine assembly sites are juggled daily to accommodate the work load placed on the assembly area. This makes it particularly difficult for the store to deliver parts exactly where they are needed.

Consider if a machine was being assembled in area A2, if the store delivers parts to this area on a pallet then it is near the work site. However, if the machine is moved to A3 the following day then the parts are no longer in the correct location and must be moved accordingly. This constant shuffling of parts and machinery causes stock mix ups and makes it very hard to track parts, especially considering that the parts are all piled on pallets.

The area indicated as fastener storage is used to store consumable bolts. This area serves as the single delivery point for bolts, when technicians require bolts they withdraw the required bolts by hand and carry them back to the relevant work site.

6.2.1.2.3. Physically picking the parts

This section outlines the key operational aspects related to picking the parts required for the assembly operation.

6.2.1.2.3.i) Picking instructions

The store currently picks parts by using the Buy List Report. This report is generated by the MRP system: it lists all the items which need to be bought in order to complete the machine. Items include raw steel and other items which are not actually picked by the store.

The Buy List arranges the items by product class and then by stock code. It lists the total quantities of each item required. The sequencing and grouping of parts on the buying list is in no way related to the actual demand of the Assembly area. A sample buying list can be seen in Appendix E.

6.2.1.2.3.ii) Picking rate and capacity

Picking rate tests were conducted to benchmark the storeman's ability to effectively provide parts to the assembly area. The storeman's ability was benchmarked against two other testees. In order to determine the stores maximum theoretical picking capacity: the maximum picking rate attained during the test was multiplied by the maximum hours available per day to pick orders.

The test was conducted by having all three testees pick the same number of items from a control picking route. Multiple picking lists were generated to avoid data distortion caused by the learning effect. The lists all share a common walking route and withdraw physically similar items (of an identical quantity) from the same area but with varying shelf location. I.e. when the tester is stood in position to withdraw the first item on List 1, he is also physically able to withdraw the first item from any of the other lists.

The storeman was benchmarked against two research students (who were not familiar with the store and were guided only by the picking list). With all physical factors kept constant across the lists, the picking test benchmarks the testee's ability to identify and withdraw parts. Furthermore, given that the items being withdrawn were light, there was no advantage gained from superior physical strength.

The tests were conducted as follows:

1. Test 1 – The storeman picking Route 1
2. Test 2 – The storeman picking Route 2
3. Test 3 – Researcher 1 picking Route 1
4. Test 4 – Researcher 2 picking Route 2

The Results of the picking tests were:

Table 7 Results of picking rate test in parts per minute

Test No	Route No	Testee	Items	Duration (min)	Number of Errors	Rate (ppm)	Average Rate (ppm)
1	1	Storeman	59	19.2	0	3.1	3.2
2	2	Storeman	59	17.3	0	3.4	
3	1	Researcher 1	59	9.2	1	6.4	6.8
4	2	Researcher 2	59	8.3	1	7.1	

The picking rates from tests 3 and 4 were averaged to provide a reference performance rate and to quantify the effect of adding an additional storeman. The researchers were used as a benchmark based on the assumption that their performance would be similar to that of a trained store man: a safe assumption given the basic nature of the picking task. The test results, as shown in Figure 54, hint that the Storeman's picking performance may be sub-par.

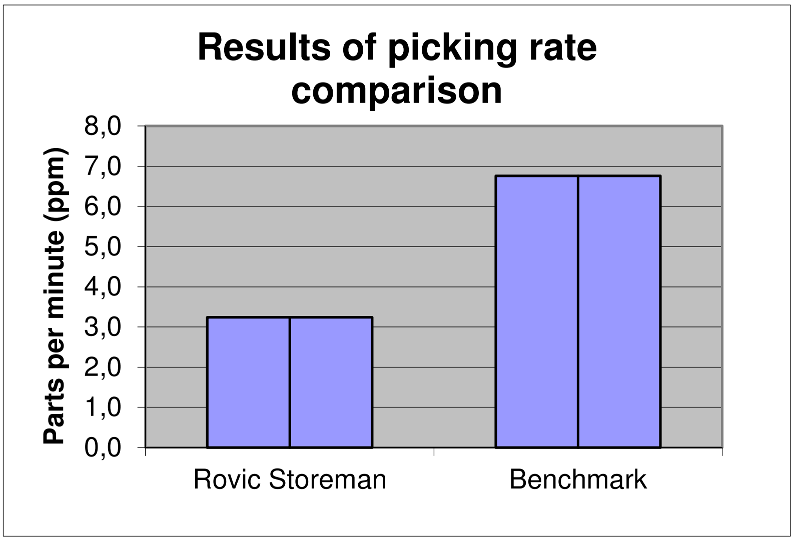


Figure 54 Picking rate test result

6.2.1.2.3.iii) Picking batching

The store currently operates by batch picking multiple parts lists at once. The storeman does this because he feels that is the fastest way to gather parts. This is somewhat true in theory, as the total walking distance required to gather the parts is reduced.

However, picking tests previously conducted show that in actuality this method is much slower. The storeman, instead of simply walking the store and picking the items indicated on the picking list, has to instead cross reference all the lists he is working on, identify the common parts one at a time, tally the total required by the combined lists and then only does he actually pick the parts.

To further compound the problem, batching together picking lists means that machine specific demands cannot be prioritized. The parts are only ready to be released once the parts for all the picking lists in the batch have been picked. The problem is intensified as the list batch size is increased.

Increasing the number of picking lists in the batch also makes is harder for the storeman to keep track of his picking efforts. Figure 55 shows the level of list batching that the storeman currently employs.

Figure 55.Photo taken during a routine Store picking. All the lists in view are being picked concurrently.

In summation, the more picking work the store takes on at once - the longer it takes to deliver parts to the assembly area.

6.2.1.3. *Physical Goods issue*

The parts picked by the Store for the Assembly Department are piled onto a pallet and placed in the assembly area wherever the storeman is able to find floor space. A typical pallet can be seen in Figure 56.

Figure 56 Pallet delivered by the Store

Assembly technicians struggle to identify the parts required for the value add task at hand because all the parts are piled together; as a result, technicians are forced to "unpack" the pallet to sift for the parts required. The sifting consumes time and floor space, and often results in components being misplaced. The result of sifting is shown in Figure 57:

Figure 57 The result of pallet sifting

The key findings discovered during the examination of the current state were that:

- The store operates on a push rather than pull principle
- The nature of the assembly parts demand is complex both in terms of product mix and delivery requirements (location etc), but there are a core set of commonly employed parts across all the machines, these are mostly commonly used fasteners
- The store has limited human capacity available to pick parts
- The Store delivers parts to the Assembly operation in a manner, which makes is time consuming and challenging for the Assembly technician to retrieve the parts required, this consumes time which could be otherwise used to deliver value on the assembly operation at hand.

6.2.2. TO-BE State

The value stream map for the proposed future store operations can be seen in Figure 58 below:

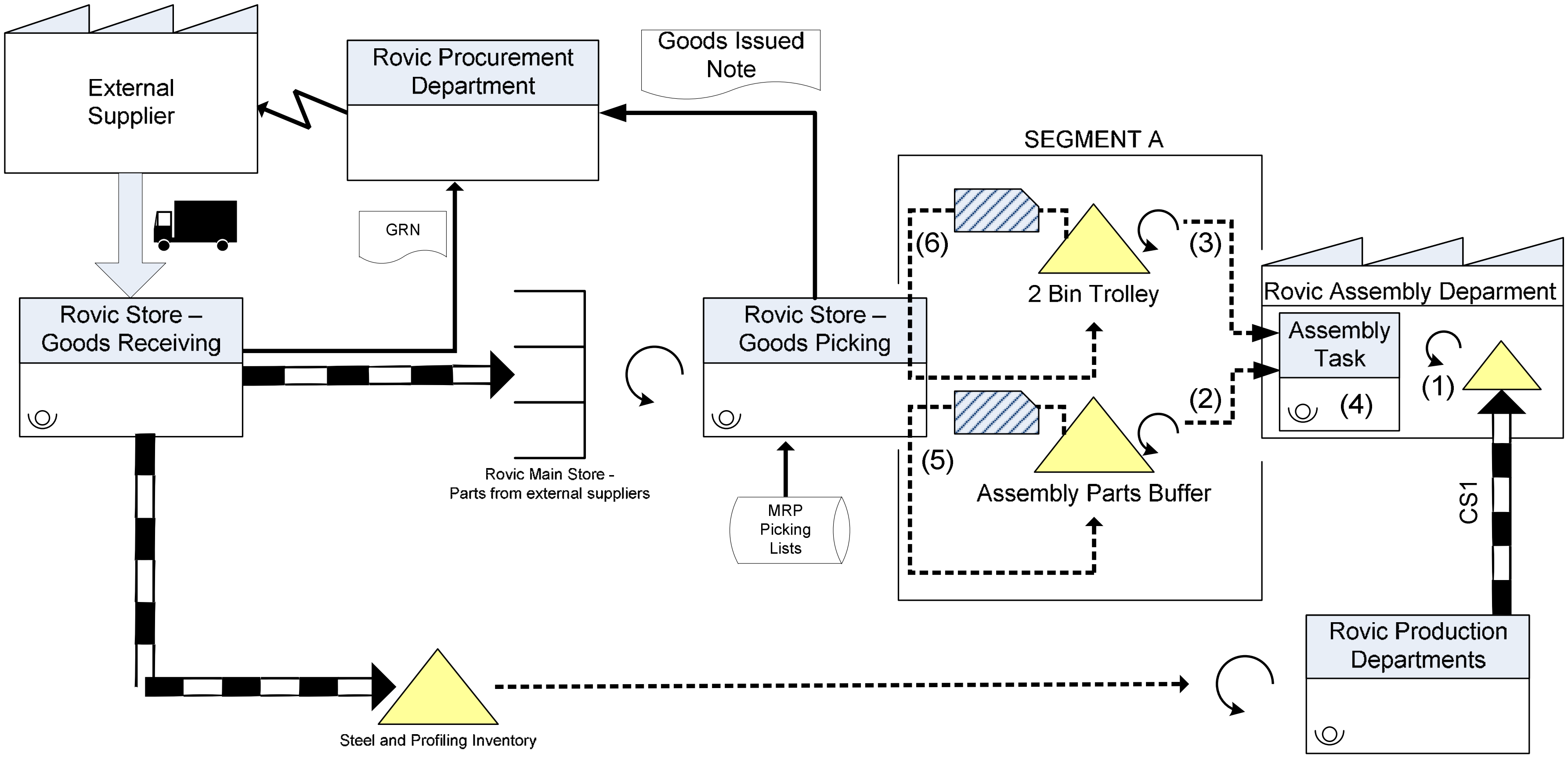


Figure 58 Parts Issuing system - Future state value stream map

The changes proposed to the current operations are highlighted by Segment A of Figure 58. Segment A seeks to convert the store's current delivery schedule driven push mechanism into a Kanban driven pull mechanism.

*It should be noted that a second storeman was added at the conclusion of the current state analysis, the services of the added employee are utilised by the proposed system in the chapters which follow.

Switching from push to pull has the following operational advantages:

- The Store's scheduling for parts delivery is converted from being predictive to reactive.
- The Store's supply and Assembly's demand are synchronised.
- The Store only picks what is required for production as it required by the Assembly area; this allows the stores to focus its efforts toward smoothing production flow in the Assembly area.
- The Store's picking resources are not invested in events which may not occur.

Segment A seeks to realise this conversion through the implementation of a two-bin fastener refill system and a Kanban controlled Assembly WIP Buffer. The functioning of the two-bin system and WIP buffer are outlined in chapters 6.2.2.1 and 6.2.2.2 respectively.

The operation of the pull function in Segment A of Figure 58 is as follows:

1. The Assembly technician selects the components that he wishes to assemble from CS1.
2. The Assembly technician withdraws the additional parts (belts, bearings etc.) required to complete the assembly task from the WIP buffer.
3. The Assembly technician withdraws the fasteners required for the assembly task from the two-bin trolley.
4. The Assembly technician completes the assembly task at hand.
5. A signal is sent to the store to indicate that 1 WIP unit has been consumed and that it needs to be replaced. The store receives the signal and then refills the Assembly WIP Buffer reservoir to the set WIP limit.

6. After the primary reservoir of the two-bin trolley has been consumed by the Assembly area, the primary reservoir is sent to the Store to be refilled. The store receives the refill signal, refills the reservoir, and then returns it to the two-bin trolley.

6.2.2.1. *The two-bin Kanban fastener replenishment system*

The proposed fastener replenishment system is based on the widely proven lean two-bin Kanban mechanism (See lit review, Chapter 0). The objective of the two-bin system is to liberate labour capacity utilised by the store for its current picking efforts. It does this by redistributing the picking load across the combined labour capacity the Store and the Assembly Department.

The two-bin redistributes the picking load by having the Store pick only the specialty items required to complete the machine; Assembly technicians collect the remainder - commonly used fasteners - from a local two-bin fastener reservoir. The refilling of the local reservoir is controlled by the two-bin system and executed by the Store. A process outline of the two-bin system operation can be seen in Figure 59:

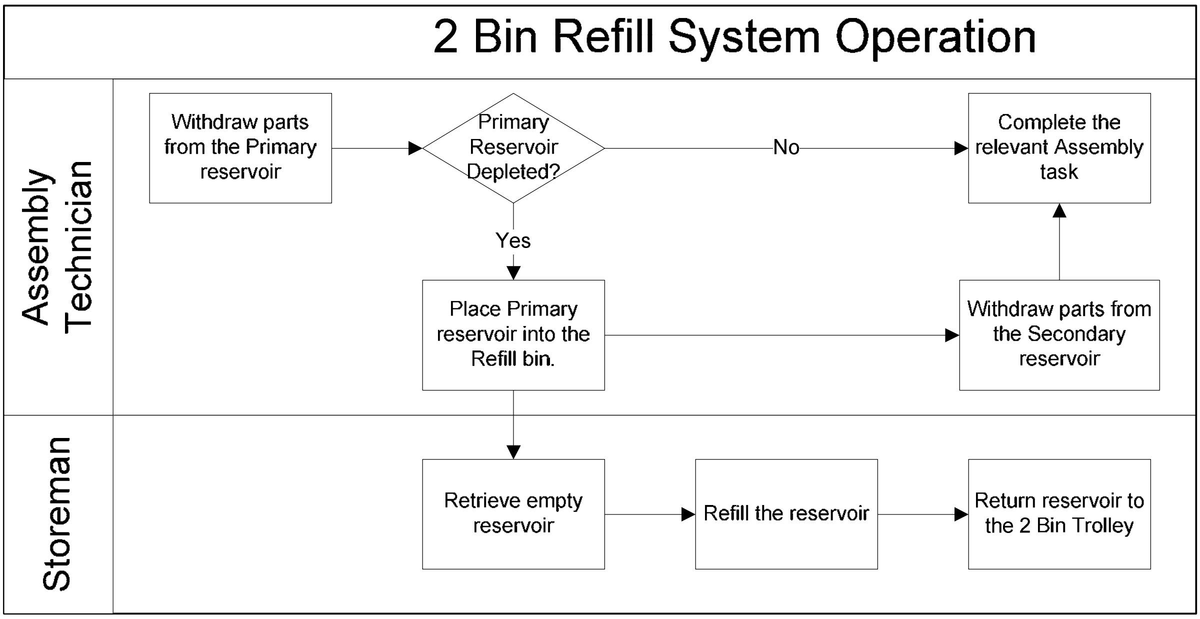


Figure 59 Process outline of the two-Bin refill system operation.

6.2.2.1.1. Selecting the parts to be held in the two-bin system

Based on the outcome of the Pareto analysis in Section 6.2.1.2.1, the PWA class of products was selected to populate the two-bin system.

The PWA class was selected over the other product because:

- They are universal in application; other product classes tend to be machine specific
- They are the most frequently used product class
- They are low cost and as such can be safely issued to the floor in bulk

A BOM analysis was conducted to determine which PWA parts are most prominent within the machinery built at Rovic. The analysis was conducted by cross referencing the BOMs of various machines built at Rovic and then identifying which PWA parts occur most commonly.

The following Rovic products were outlined for analysis by the design department: A standard 43 tine planter, the Morris Meyer planter (custom), the Alfons Visser planter (custom), a 3 ton spreader, a 5 ton spreader, an 8 ton spreader, a No.13 frame, a chisel plough frame, 2 types of Inter-row Cultivators, a 1.5m Mulcher and the 0.9m Rotary Hoe.

The ten most commonly used PWA parts can be seen in Table 8 below:

Table 8 Ten most commonly used PWA parts

No.	Part No.	Description
1	M8GFW	M8 GALVANISED FLAT WASHERS
2	M8NY	M8 NYLOC NUT
3	M16GFW	M16 GALVANISED FLAT WASHERS
4	M16NY	M16 NYLOC NUTS
5	M10NY	M10 NYLOC NUTS
6	M10GFW	M10 GALVANISED FLAT WASHERS
7	M12GFW	M12 GALVANISED FLAT WASHERS
8	M12NY	M12 NYLOC NUTS
9	M24GFW	M24 GALVANISED FLAT WASHERS
10	M24NY	M24 NYLOC NUTS

6.2.2.1.2. Identifying two-bin parts

The parts selected for application in the two-bin system need to be easily identifiable by the Storeman and the Assembly technicians. The storeman needs to know which parts he does not need to withdraw when picking parts for a job (because they are already in the two-bin Trolley). Similarly, the Assembly technician needs to know which parts will not be delivered by the store and have to instead be retrieved from the local two-bin reservoir.

To differentiate the two-bin items from other parts, it was proposed that all two-bin items be placed on “Shelf 1” (01xxxx) of the store. Thus, the storeman and assembly technician can determine whether a part is a two-bin item by looking at the part location listed on the picking list. E.g. a part from shelf 01A05 is a two-bin item and a part from shelf 02A01 is not.

6.2.2.1.3. The two-bin Kanban system Trolley prototype

This section outlines the steps taken to manufacture the two-bin.

6.2.2.1.3.i) Design of the trolley

The following design criteria were set forward for the two-bin trolley:

- The design had to be as simple as possible.
- The finished item had to be easy to manufacture.
- The trolley had to be mobile.
- The trolley was to house and employ standardised reservoir containers which were freely available.
- The floor space consumed by the trolley had to be minimized.

The prototype was modelled in Solidworks. The drawings for its construction are currently stored in the design vault under the folder named, "2Bin_Assembly ". The bills were created with the assistance of the design department and are stored on the MRP system under the stock code " AT0007". Each trolley houses 25 part types. A rendering of the prototype can be seen in Figure 60 below:

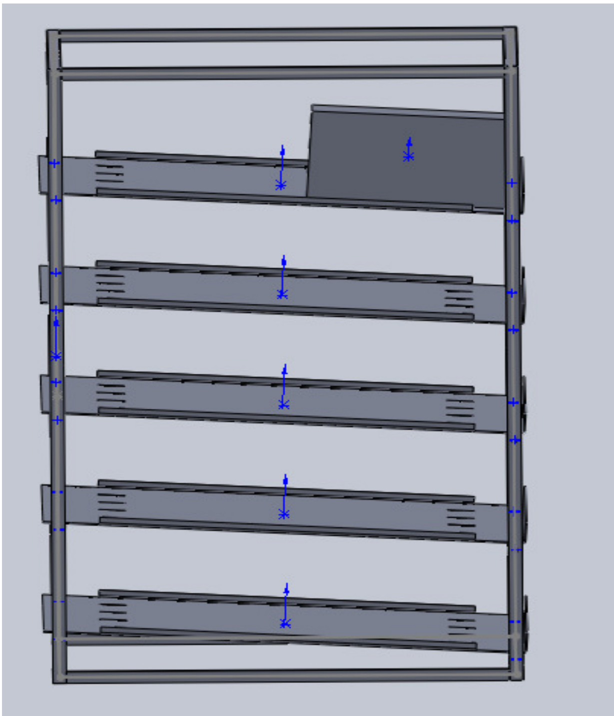


Figure 60 Solidworks mock-up of the two-bin trolley

6.2.2.1.3.ii) Cost of two-bin system Trolley

A cost breakdown of the trolley can be seen in Table 9 below:

Table 9 Two-bin Trolley cost breakdown

two-bin System Trolley Cost Breakdown (Per Trolley)

Item	No of Units Required	Cost / Unit (R)	Total Cost (R)
Steel Tubing	13	24.65	320
Profile Cut Shelves	5	464.33	2322
Profile Cut Shelf Dividers	20	12.44	249
Reservoir Container	50	26	1300
Reservoir Labels	1	32.49	32
Wheels	4	200	800
Labour	4	230	920
		TOTAL	**5943**

6.2.2.1.3.iii) Requirements of the two-bin system

The two-bin system requires the use of appropriately sized refill reservoirs in the Store to function correctly. At present, the fastener reservoirs in the Store are smaller than the ones in the Assembly area; this creates an unavoidable overflow condition in the store - as can be seen in Figure 61:

Figure 61 Stock overflowing onto the Store's working surface

The most convenient way to attain the reservoir capacity required in the Store is to relocate the fastener bins currently in the Assembly area to the store. The Assembly bins will be replaced by the two-bin trolleys. The Assembly bin relocation incurs no extra cost but does require the aisles in the store to be shuffled slightly.

6.2.2.2. *The Assembly WIP Buffer*

The objective of the Assembly parts buffer is to temporarily house a fixed amount of WIP (parts); WIP coming from the Store and destined for use in the Assembly area. Having a set WIP limit ensures that the Store focuses its picking efforts on parts which cater to the real time demand of the Assembly area. The WIP limit also provides a throttling mechanism for the Store. The WIP level is set by the Production manager and maintained through a Kanban loop.

The operation of the Parts buffer can be seen in Figure 62 below:

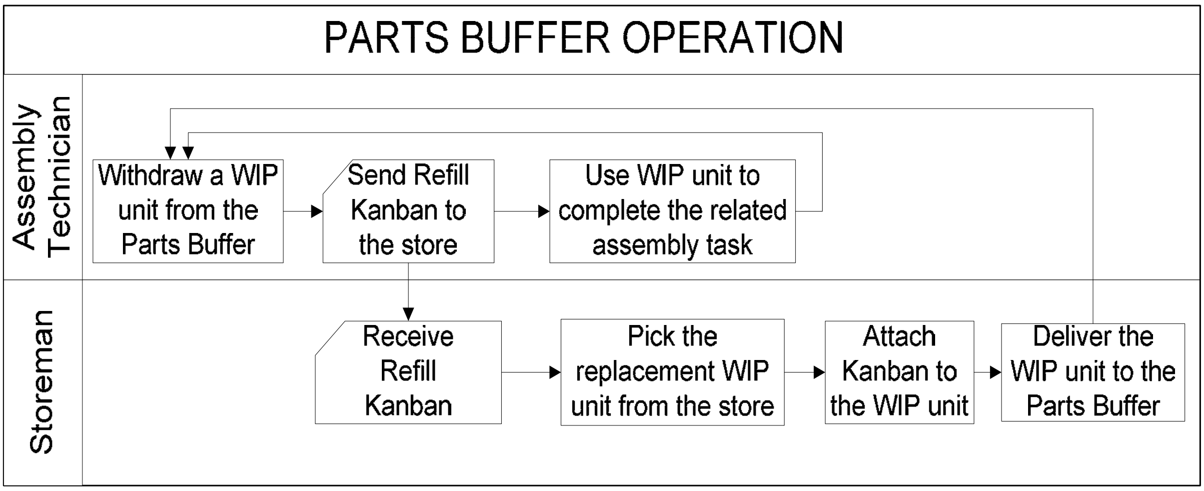


Figure 62 Process Outline of the WIP Buffer operation

6.2.2.2.1. Using Kanban to replenish the Assembly WIP Buffer

This section outlines proposed modification to the conventional Kanban control mechanism in order to leverage the underlying pull principles in Rovic's environment.

6.2.2.2.1.i) Overview

The Kanban system was developed by Toyota. It is a simple yet powerful mechanism for controlling repetitive production. It can be viewed as a real-time production scheduling system. In a repetitive production environment, it prevents starvation of bottlenecks and the formation of large inventory build ups at any work centre by regulating the material flow through the production system; it achieves this by restricting the amount of WIP in the system to a predefined threshold.

The Kanban system absorbs uncertainty, natural variations in production scheduling, and the differences in production rates at work centres; but, it is most effective when the manufacturing demand is uniform and predictable. Kanban systems are typically unable to cope in job shop orientated environments. To understand why this is the case, requires an analysis of how the Kanban control is supposed to function.

In a Kanban-controlled system, there are master and slave processes. The slave processes utilise the outputs generated by the master processes to execute their specific function. When a slave process commences it sends a signal to its master, the purpose of this signal is to inform the master process that its output has been consumed. The master process receives the signal, recognises that its output has been consumed and in turn re-launches itself in order to regenerate its consumed output. It does this so that there is a replacement output available for when the slave process repeats.

Kanban struggles in jobshop environments because the master process output required by the slave process is inconsistent. In repetitive production the input to the slave process is constant e.g. 5 bolts, 2 apples or 3 of that other big thing etc., but in an environment like the Assembly area, the needs of slave process are continually changing: a particular assembly task could require four hydraulic cylinders and 5 bolts and the next assembly task carried out by the same technician could require only 2 washers. The demand placed on the master process, the store's picking in our instance, is too erratic for conventional Kanban control.

Furthermore, the Kanban card itself needs to hold the information required to generate the master process work instruction; simply put, the Kanban card needs to tell the master process what it actually needs to supply the slave process with.

The number of Kanban cards present in the system is dependent on the needs of the slave process. For instance: if 1 cycle of the slave process requires 2 apples, and 1 Kanban supplies the slave process with 2 apples, then we can calculate the demand of the slave process with respect to time and calculate the number of Kanban cards required in the Kanban control system accordingly. However, for our purposes, the number of apples required for each cycle of the slave process is continually changing, thus the ideal number of Kanban cards required for our purposes would also be continually changing.

6.2.2.2.1.ii) Kanban Process Modification

Despite the unsuitability of the assembly input requirements for Kanban control, fortunately the actual pull signal sending aspect of the Kanban system from the slave to the master, remains functional, thus we are able to retain the core principles of Kanban control. i.e. The Kanban pull mechanism for starting and stopping the store's picking operations to refill the Parts Buffer remains functional. All that is required is suitable modification of the Kanban mechanism so that it is able to direct (instruct) the store's picking efforts.

As mentioned previously, the number of Kanban cards in the system is dependent on the real time demands of the slave process. The number of cards in the system is also directly related to the WIP level. Maintaining a constant number of cards in the system requires a constant definition of what 1 WIP unit equates to. To determine this, we need to take a step back and ask, "Why does the assembly technician require these parts?" The assembly technician requires the parts so that he is able to piece together the particular Sub Assembly that he is attempting to assemble.

It seems logical then that 1 Kanban card should represent any and all parts required to put together a particular sub assembly. I.e. 1 Kanban card represents 1 WIP unit consisting of all the parts required to put together 1 sub assembly. This definition allows a hard limit to be set on the Parts buffer, e.g. the Parts buffer should always contain the parts for **5** sub-assemblies.

In order to accurately direct the store's picking efforts, the definition of which parts the Kanban card instructs the store to withdraw must be updated every time the Kanban card is sent back to the store. This definition update would be overly tedious and unfeasible if the Assembly technician had to manually generate the information required on the Kanban card every time. Fortunately, the information already exists on the MRP system and can be conveniently referenced instead.

Every assembly task carried out has a unique Works Order (W/O) number associated with it. The MRP system is able to identify all the parts and components required to complete each W/O. An eight-digit code is used to identify W/O No's.

The proposed production control mechanism utilises laminated Kanban cards with labels placed on them to pull parts from the store. The labels are replaced every time the Kanban is sent back to the store. The operation of this Kanban controlled production pull can be seen in Figure 63, a draft of the Kanban card can be seen in Figure 64:

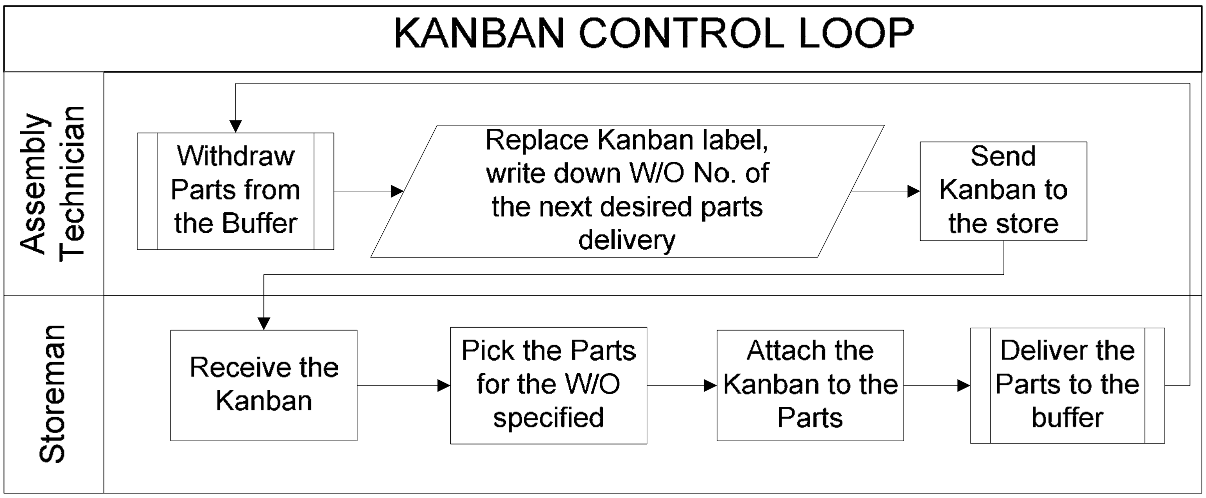


Figure 63 Kanban control loop for refilling the Assembly Parts Buffer

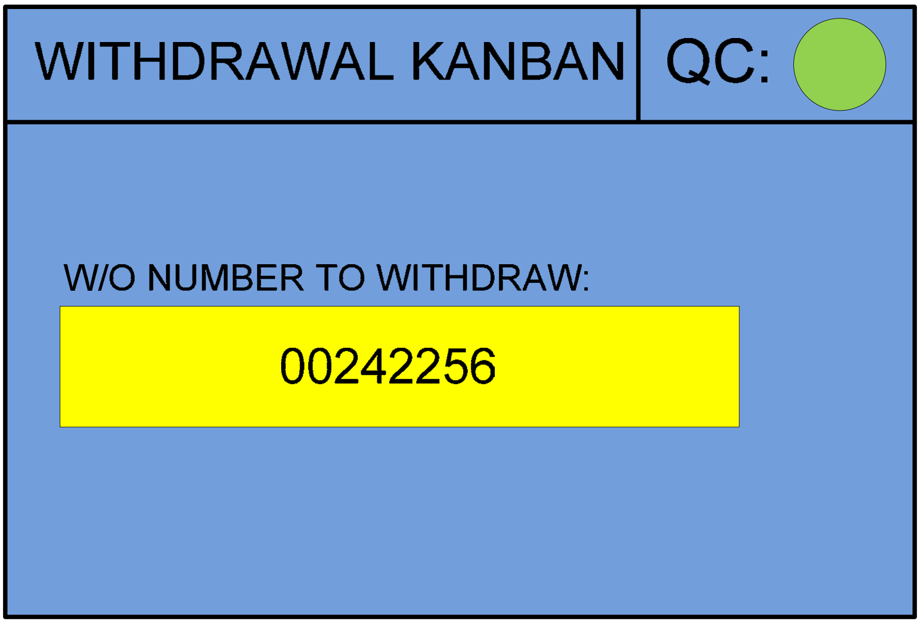


Figure 64 Proposed Kanban card format. Blue section of card is laminated; the green and yellow sections are labels.

6.2.2.2.2. Tuning the Assembly parts buffer size

The size of the WIP buffer can be adjusted by altering the number of Kanban cards in the system. If the Store is unable to pick parts quickly enough, the buffer size should be increased. Conversely, if the store is picking parts faster than they can be used by Assembly, the buffer size should be decreased.

6.2.2.2.3. Physical Configuration of the parts buffer

The physical configuration chosen for the WIP buffer is of no consequence providing that all the constituents of the buffer are kept in the same place. It is proposed that “small” Parts picked by the store are placed into standard plastic hanging containers and stored on a louver panels as shown in Figure 65; larger parts like cylinders will have to be placed into the crates currently used by the Store as seen in Figure 66.

Figure 65 Standardised plastic containers hung on a louver panel

The standard plastic containers are advantageous because they:

- are standardised industry products
- are available in a variety of sizes and colours
- can be easily swapped
- are durable and rugged
- are cheap relative to metal alternatives

Figure 66 Crates used by the store to house "large" parts.

6.2.2.2.4. Parts Picking Lists

A new picking list was formatted on the MRP system in order to synchronise the store's picking efforts with the requests submitted by the Assembly area. The new picking list was added to the MRP system as a report, AGRI07.

The AGRI07 report generates a picking list which is separated according to the works order number of each particular assembly task. The report has also been configured so that it only displays items which are actually required to be picked by the Store – in this way, the storeman is only faced with data relevant to the task at hand when picking orders. Furthermore, because the storeman is now picking and issuing sub-assemblies, Assembly technicians no longer need to sift for parts.

A sample of the AGRI07 picking report can be seen in Appendix F.

In summary, the proposed TO-BE state seeks to convert the Store from a push to a pull operations, prompting the Store to only providing what is needed by the Assembly operation as it is needed. It also attempts to reduce the pick load induced on the store by providing the Assembly operation with reservoirs of the most commonly used fasteners, the refilling of the reservoirs also being controlled by the lean two-bin Kanban mechanism.

6.2.3. Verification of Improvements

This chapter attempts to validate the feasibility and impact of the proposed TO-BE state modifications.

6.2.3.1. *Testing the two-bin system*

The two-bin system was tested by determining the percentage by which it reduced the store's picking load; this was done after the two-bin system population was identified. The two-bin population was compared to the parts listed on three BOMs (created after the finalisation of the two-bin population); if items listed on the BOMs were part of the two-bin system, then the store would no longer be required to pick these – resulting in a decrease of the picking load. The average reduction in the number of items picked by the store was 60%.

6.2.3.2. *Testing the proposed parts issuing strategy*

This experiment focuses on testing the performance differences between two alternative parts picking strategies, and two alternate Work in Progress (WIP) storage strategies.

The picking strategies tested were:

1. **The currently employed batch release strategy** – This is the default production practice. This policy functions by picking and delivering all the components required by the Assembly area for the entire machine build three weeks prior to the commencement of the build.
2. **The proposed sequential release strategy** – This is the policy proposed for improving the overall store delivery performance and enabling faster supply response to the assembly area; it aims to achieve this by employing the lean philosophy of decreasing batch sizes and promoting flow. This policy functions by picking and delivering components per machine subassembly as required by the assembly team throughout the duration of the build.

The WIP storage media tested were:

1. **The currently employed wooden pallet** -parts are loaded onto the pallet and then transported to and deposited in the final assembly area by using either the forklift or a pallet jack.

2. **The proposed purpose-built parts trolley** – the trolley aims to boost floor space flexibility and parts storage mobility in the final assembly area by eliminating the need for the forklift or pallet jack to relocate parts when required. The trolley was also equipped with a flexible storage system, which made use of louver panels and standard plastic bins to boost the floor space efficiency of parts holding: i.e. using less floor space to contain a set amount of WIP related parts.

6.2.3.2.1. Selecting the test's performance measures

The testing procedure sought to quantify the following metrics for both parts issuing strategies:

- **Lead time** – The time taken from the outset of the picking to get the first batch of parts to the assembly area so that value-add may commence.
- **Total delivery time** – The time taken to deliver all the parts required for the machine build to the assembly area.
- **Delivery accuracy** – A measure of whether the goods supplied match the goods required as per the work instruction (picking list).
- **Quality Control duration** – The time taken to ensure that the correct goods are delivered to the assembly area.
- **Withdrawal duration** – The time taken for the technician to retrieve the components required for the execution of the assembly task.

The metrics used to test the WIP storages strategies were:

- **Floor space efficiency** – A measure of how well the factory floor space consumed by the delivery was utilised.
- **Transport time** – The time and effort involved in moving the delivered components from the delivery site to the work site (exact location on the floor where value add activities are being carried out).

6.2.3.2.1.i) Release policy control experiment

External factors were removed in an attempt to promote data consistency and accuracy, allowing for an objective performance test.

In order to provide a consistent baseline for testing, the product selection was held constant for both experiments. It was also noted in previous tests that the Buy List-based picking list, currently in use, had an inherent performance disadvantage due to its lack of location listings for the components detailed: In order to eliminate this disadvantage the Buy List-based picking list was manually generated with the component locations included. The employees involved were also held consistent across the tests.

The experiment procedure employed can be seen in the Figure 67 below:

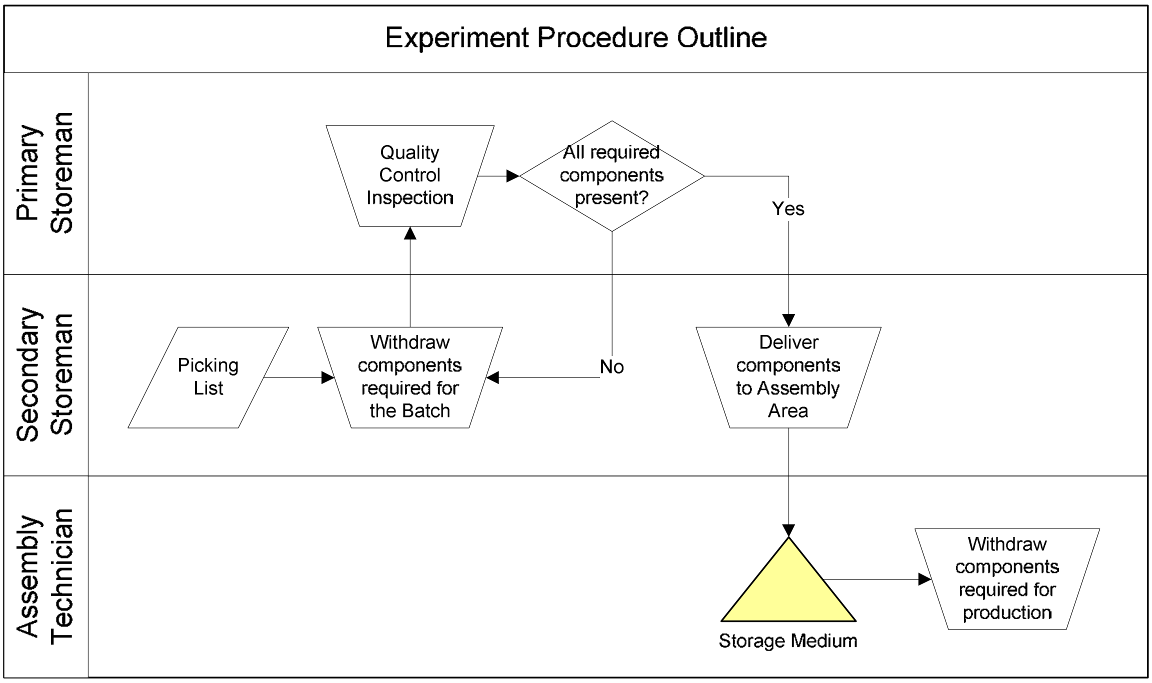


Figure 67 Control Experiment Procedure Outline

Due to the specialised nature machinery built at Rovic, using an actual BOM to perform the testing would lead to complications such as stock outs (components could not be purchased specifically for the purpose of testing) or utilising components required for production at the time of testing; in turn delaying operational progress in the factory.

In order for the tests to continue unhindered (for validity as a control experiment) an equivalent product selection had to be generated. For the purposes of developing component ratios within the selection, items were classed by size: Class 1 items being the largest (drive rollers etc.) and Class 3 being the smallest (grease nipples etc.).

The product selection was generated using the following criterion:

1. The Ratio of class 1 parts to other parts was to be 1:10. This ratio would be indicative of a typical machine subassembly; ratio attained from the design department.
2. Batches were to draw balanced quantities from all sectors of the store: i.e. the storeman would have to withdraw from the downstairs, upstairs and outside areas, as this would be the case if withdrawing for an actual production job.
3. Items in each batch were to be sufficiently far from each other to simulate the excess motion that would be incurred by employing a sequential release over batch release policy.
4. High quantities on the very small class 3 items to test withdrawal count accuracy.

6.2.3.2.1.ii) WIP storage testing

The WIP storage configurations were tested by measuring the amount of floor space consumed and then benchmarking the floor space utilisation. A transport test was also conducted by timing how long it would take a technician to transport the components loaded to the storage medium from the delivery site to the work site 20 meters away.

6.2.3.2.2. Test Results

The results of the TO-BE proposed state are outlined below.

6.2.3.2.2.i) Release policy test results

The results obtained from the policy testing can be seen in below:

Table 10 Release policy test results

	Release Policy	
Test Metric:	**Batch**	**Sequential**
Lead Time (min)	99	6.08
Total Delivery Time (min)	99	61.25
QC duration (min)	24	9.33
No of QC defects	2	0
Assembly Withdrawal Time (min)	35.33	1.33

It can be seen that despite the excess motion induced by reducing the batch size (the distances travelled while picking increases with the number of trips made); releasing components as they are required by assembly encourages a substantial reduction in both lead and total delivery times. It can also be seen in Figure 68 that reducing the batch size also produces shorter bursts of controlled component flow.

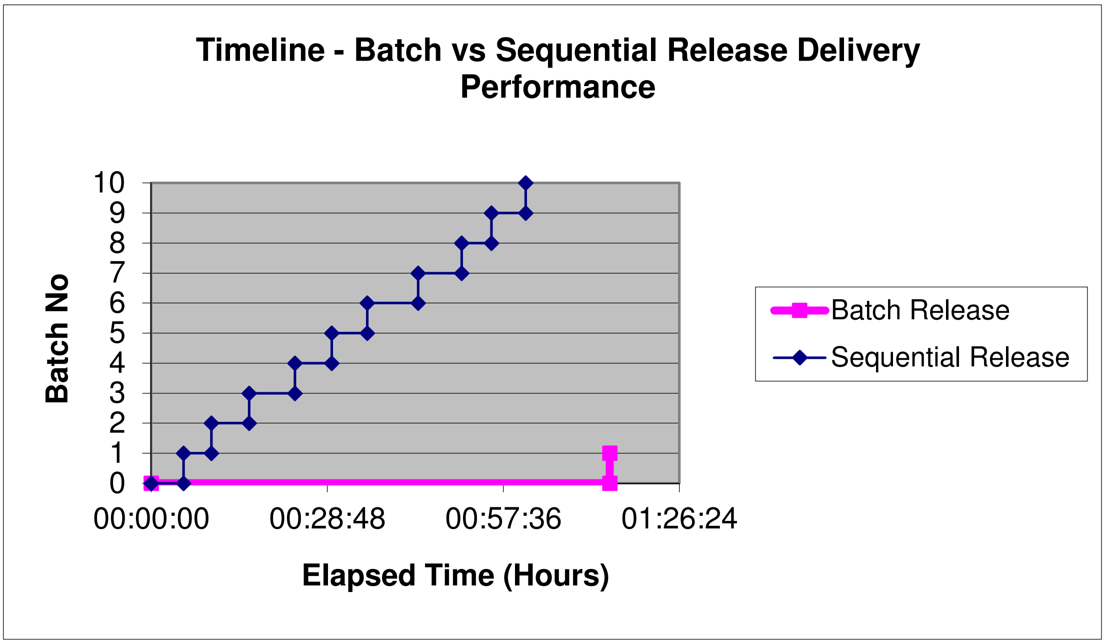


Figure 68 Parts Release Performance Timeline. Horizontal sections represent time spent picking, vertical segments indicate delivery.

In everyday practice, this would allow the storeman to gather the components quickly as required by assembly throughout the progress of the build; rather than requiring large windows of uninterrupted time to gather all the components required for the complete machine assembly at the outset of the build. Smaller batches also allowed for reduced QC times, as products could be quickly visually identified and tallied.

A notable increase in the speed of the withdrawal process was achieved: This was largely due to the parts arriving in preconfigured batches matching the components required for each subassembly, rather than arriving as a job lot which requires the technician to perform a secondary identify and pick exercise (the primary identify and pick is conducted by the storeman). The difference in component arrivals can be seen in Figure 69:

Figure 69 WIP storage comparison: Parts Trolley using sequential release (left) vs. pallet method using batch release

6.2.3.2.2.ii) WIP storage comparison test results

The storage comparison tests returned the test results in Figure 70, below:

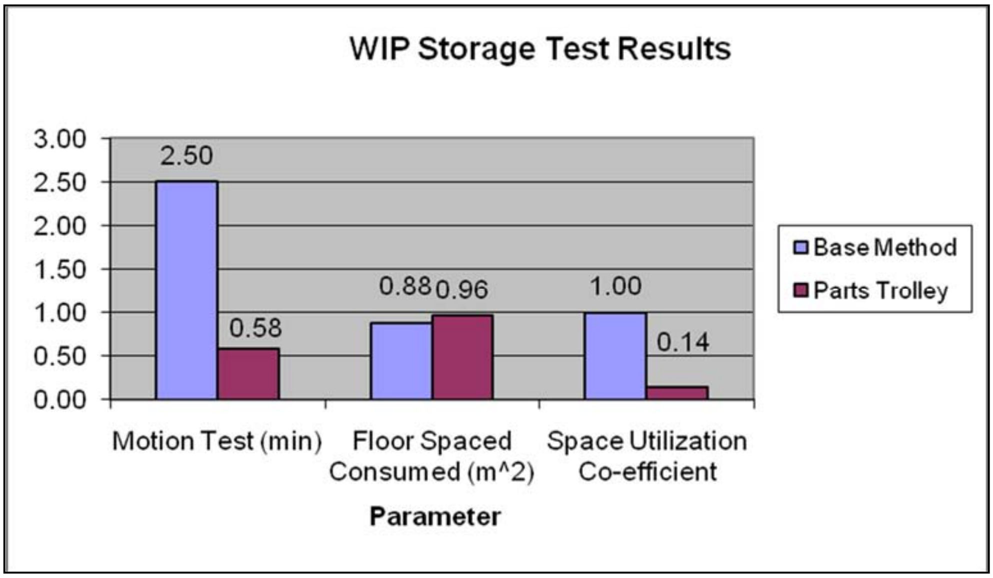


Figure 70 Test Results - WIP storage performance comparison

The gains on the motion test can be attributed to the ability to instantaneously move the trolley without having to first retrieve a pallet jack or the forklift. During the baseline test (pallet test), the pallet carrying the components could not be lifted with a pallet jack and the forklift was unable to manoeuvre through the assembly area to the delivery site where the pallet was located due to WIP blockages. This forced the technicians to carry the components from the delivery site to the work site, making several trips back and forth.

The time indicated for the Pallet test was for two technicians carrying parts back and forth simultaneously. The time taken to move the parts trolley is indicative of a single technician moving all the components in one trip: all that is required to move the trolley is to release the park brakes and push it wherever desired.

It can be seen from Figure 70, that while the parts trolley does consume fractionally more floor space, its utilisation thereof is much more efficient. The utilisation was calculated by dividing the total carrying capacity by the capacity used for the test. The pallet surface area was fully saturated, thus the score of 1 (maximum utilisation). Similarly, the trolley has a storage capacity equal to 208 Linbin Units (LBU) and it employed a total of 30 LBU to house the test components, resulting in a utilisation figure of 0.14.

6.2.3.3. *Conclusions*

It can be seen from the data gathered that there is merit in implementing a sequential component release policy: it performs favourably in all aspects, and has the distinct advantage of reducing the value add time lost by Assembly technicians when retrieving the parts required to execute value add activities. Similarly, the parts trolley promotes enhanced work area organisation and space utilisation. The integration and implementation of these features would lead to improved parts delivery.

6.3. Administrating the Store's activities

It was proposed that the Store switch from push to pull parts issuing. The testing of the proposed pull driven parts issuing mechanism proved favourable. In order to enable the operation of the pull mechanism, we require an administrative control system, which serves to align the real time needs of the Assembly operation with the Store's picking efforts: i.e. provide operational transparency and alignment.

Administration is defined as the universal process of organising people and resources efficiently so as to direct activities toward a common goal (Princeton University Education 2013). From this definition it is apparent that to realise any long term gains from the proposed system, the administration of the proposed system should be executed in a continual and rigorous fashion. The importance of maintaining the status quo cannot be over stressed: If administrative efforts collapse, the stability of the proposed system's driving processes shall likely follow .

In an attempt to foster sustained and low fuss administration, we seek the employ of administrative mechanisms which are themselves specifically fit for purpose.

The store is currently administered in an ad-hoc fashion. The only documentation employed is the final machine delivery schedule and the associated buy lists. The delivery schedule provides the store with instruction for when to deliver parts ALL the parts for the machine (this date is statically recorded); the buy lists outline what the store is needs to pick by the date specified on the delivery schedule.

In the absence of an AS-IS state foundation, the value add objective of this initiative is to attempt the formalisation of an administrative control system which allows the implementation of pull driven parts issuing.

6.3.1. Future State Proposal

The objective of the proposed TO-BE state is to formalise an administrative system which will guide the Store's operations to be executed in an effective and efficient manner.

In considering the activities conducted by the store, the TO-BE administrative system must incorporate:

1. A mechanism to schedule, validate - and correct if required- parts issues to the Assembly operation (Chapter 6.3.1.1)
2. A mechanism to enable transparency of the Store's operations (Chapter 6.3.1.2)
3. A means to apportion labour resources against operational responsibilities
4. A mechanism to measure the store's performance (Chapter 6.3.1.4)
5. A diagnostic logic to interpret failure of the Store's operations and to intervene accordingly control failure (Chapter 6.3.1.5)
6. A training mechanism to impart the functioning of the operation on employees involved with its operation (Chapter 6.3.1.6)

6.3.1.1. *Parts Picking*

This section explores the process activities required to schedule and validate parts deliveries intended for the Assembly operation.

6.3.1.1.1. Scheduling

The implementation of the Kanban controlled parts issuing means that it would no longer be necessary to forecast the picking efforts of the Store: The Kanban control system converts the Store's scheduling from being predictive to reactive. The Store would only pick what is required by the Assembly Department as required. This ensures that the Store's resources invested in picking efforts are efficiently directed toward the real time needs of the Assembly area.

6.3.1.1.2. Quality Control

It is proposed that all picked orders be checked before being delivered to the WIP buffer. Visual management techniques should be employed to differentiate between parts lots which have either failed or passed the QC inspection.

The most straight forward way to achieve this would be through the use of coloured labels placed on the Kanban cards. A green label indicates a QC pass, a red label indicates a QC fail.

Figure 71 below demonstrates the use of coloured labels to differentiate between a pass and a fail.

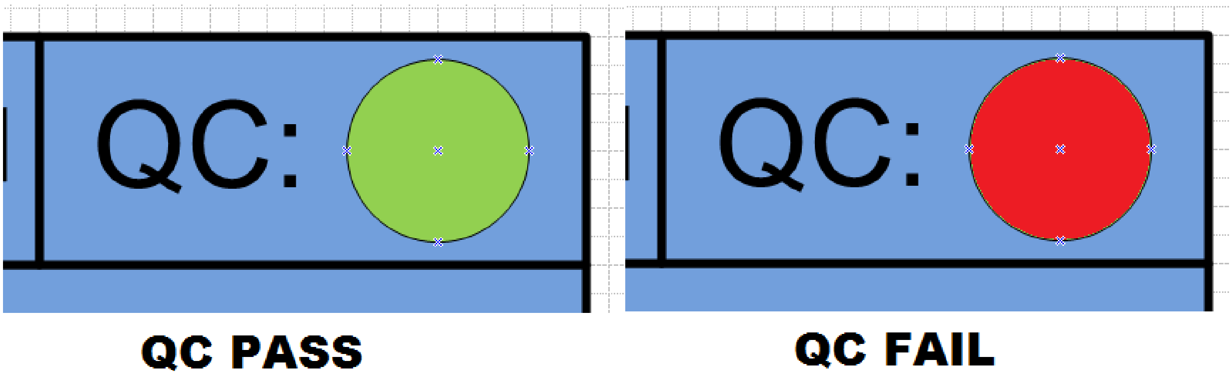


Figure 71 Visual identification of QC status

The logic outlined in below will be used to differentiate between a QC pass and QC fail.

Table 11 QC Pass / Fail conditions

Condition No.	Condition Description	QC Result	Store Action
1	All required parts present and in the correct quantity.	QC Pass	Place green QC sticker on Kanban, forward the order to Assembly.
2	Parts missing or quantity incorrect.	QC Fail	Correct the order if possible, Repeat QC check.
3	Parts missing due to stock not being available.	QC Fail	Place red QC sticker on Kanban, list missing items on Kanban card, notify the Buyer of missing items, forward the order to Assembly.

It is inevitable that at some point the store will not be able to fill an order completely because of a stock-outage. A stock-out condition occurs when the parts have either not arrived from the supplier yet or have not been ordered. In this instance, the particular parts batch will fail the QC check according to Condition No. 3 as indicated in Table 11.

It is proposed that in this instance, the store place a QC failed label on the lot and pass it on to the assembly area regardless. The reason for this is that ultimately only the actual assembly technician (more likely the assembly foreman) can decide whether the parts lot is fit for purpose or not. For instance, a job lot of 500 parts, missing a single unordered bolt, will fail QC condition 3, but will more than likely still be fit for purpose. If that same job lot were missing something more critical like a metering unit, then the parts lot would still fail according to condition 3 and will be unfit for purpose. Ultimately, the relevant technician or foremen is the only person who is qualified to determine whether the parts should be temporarily shelved or put into service regardless.

The procedure for dealing with parts that fail QC because of condition 3 is outlined in Figure 72.

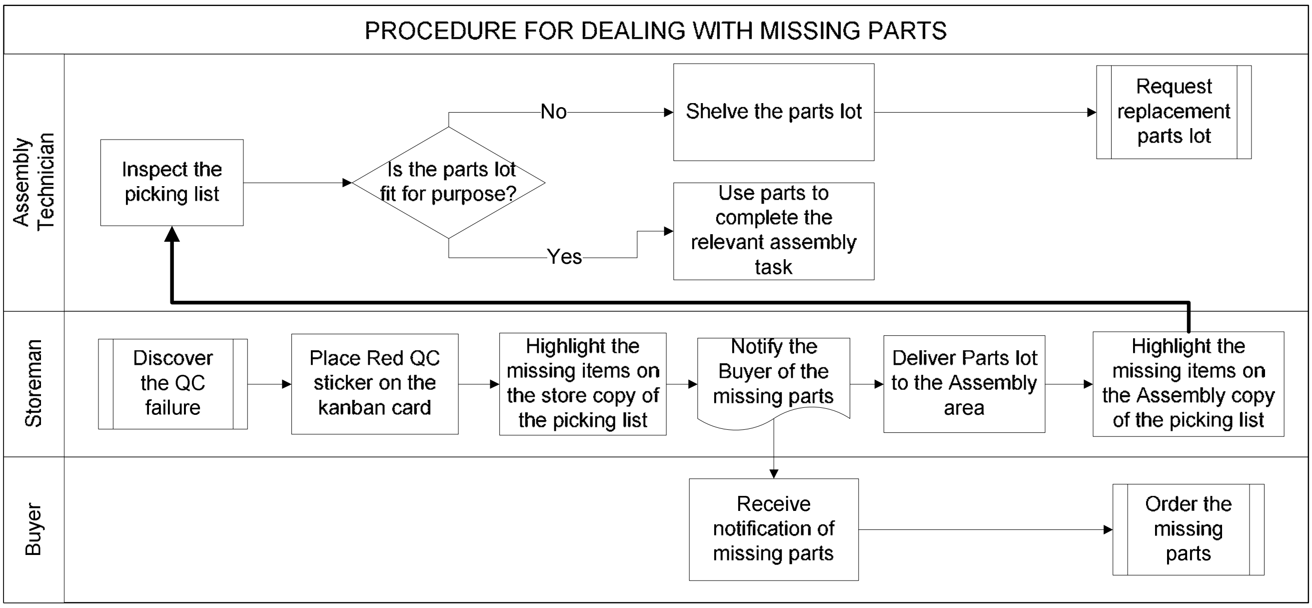


Figure 72 Process outline for dealing with QC failures

6.3.1.2. *The Store Andon Board*

The Andon board serves as a central administrative control point, it utilises the lean principle of ‘visual management’ and can be used to view the current store’s activity, control the stores resources and measure the stores performance. The proposed format of the board can be seen in Figure 73, below.

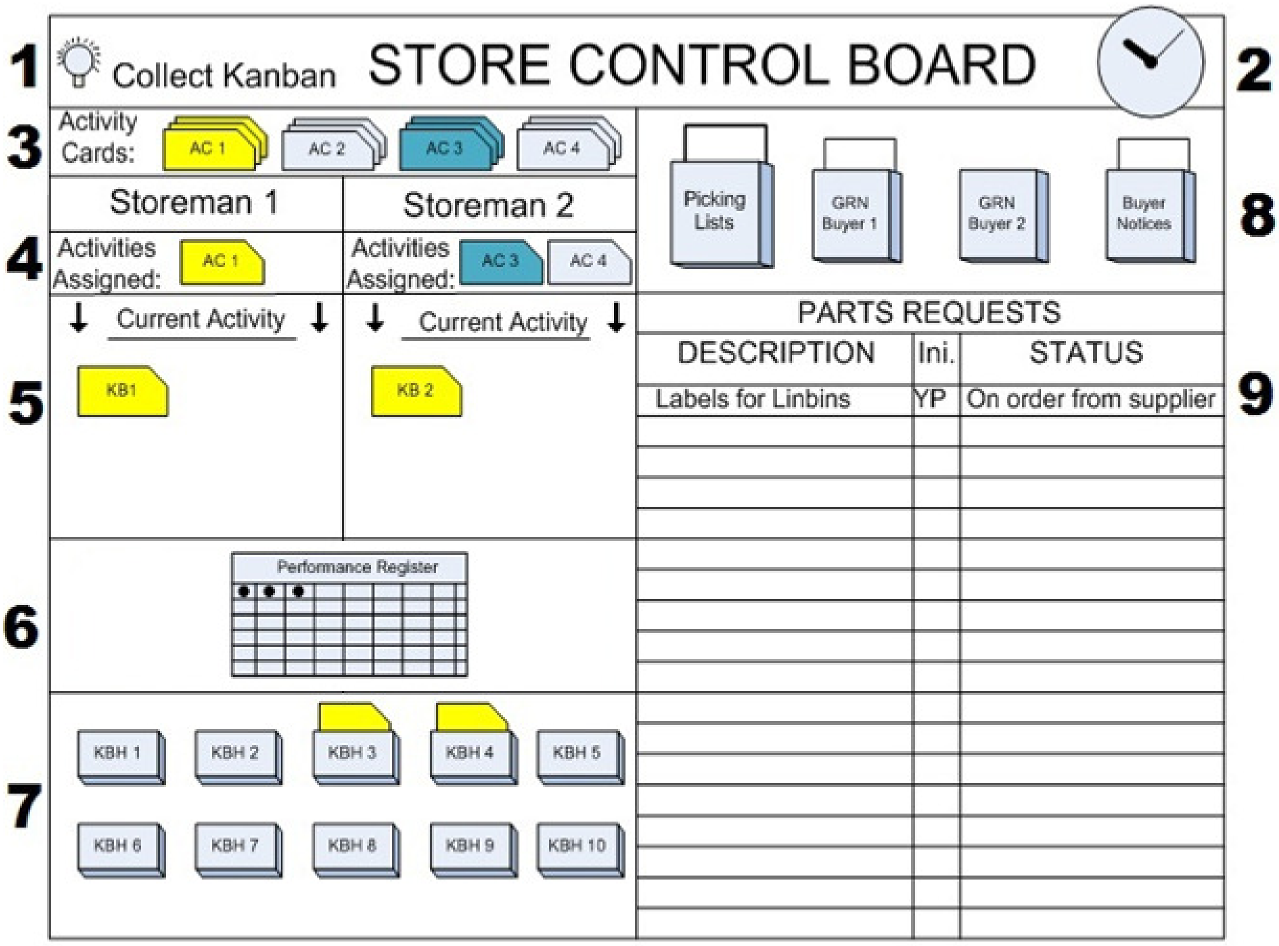


Figure 73 Store's Andon Board

It can be seen from Figure 73 that the Andon board has the following features:

No.	**Description**	**Function**
1	Signal Light	If on: indicates that there are Kanban cards that need to be collected in the assembly area.
2	Clock	Indicates the current time.

3	Activity Cards	Indicate specific types of store activities, used by the production manager to allocate activities to the storeman. Activity cards are colour coded for quick identification.
4	Assigned Activities	Activities currently assigned to each storeman by the production manager.
5	Current Activity	Indicates the activities which the storeman has currently engaged himself in.
6	Daily Performance Register	Logs the performance of the store.
7	Kanban Card Holder	Used to hold Kanban cards retrieved from the assembly area which are waiting to be picked.
8	Documentation Panel	Houses all the administrative documents relevant to the store functions.
9	Parts Requests	Provides a centralised location for employees to request parts and for the storeman (or other relevant person) to indicate the current status of that request.

Taking a quick look at the status of the Andon board in Figure 73, it can be seen that "currently":

1. There are Kanban cards that need to be collected
2. The time is 11:10 am
3. There are 4 types of store activities
4. The production manager has assigned storeman 1 and 2 with activities 1 and 3 & 4 respectively
5. Storeman 1 is currently picking Kanban 1 and Storeman 2 is currently picking Kanban 2 despite not being assigned this activity.
6. The store's daily performance

7. There are 2 requests for parts from the assembly area which are waiting to be picked
8. There are GRNs to be collected by buyer 1 and there are notifications for the buyers
9. YP has requested labels for his linbins; the buyer has informed him that they are on order

The features of the Andon board are described in detail below.

6.3.1.2.1. Signal light

The signal light indicates whether there are Kanban cards which need to be collected from the Assembly area – if it is on there are cards that need to be collected. It is controlled by the Assembly slave board, see chapter 6.3.1.2.6 for details.

6.3.1.2.2. Activity cards

The activity cards represent types of store activities e.g. picking for production, housekeeping, picking kits etc. The Production manager controls how many types of activity cards there are, he utilises these cards to allocate daily activities to each storeman. For instance, if the production manager wanted storeman 1 to conduct activity type 1 for the day, then he would put one of the relevant activity cards in storeman 1's allocated activity block.

The number of each type of activity cards is twice the number of storeman present in the store. This is so that there are sufficient cards for the production manager to allocate activities to the storeman and for the storeman to indicate that he is currently performing that activity.

The types of activities to allocate the storeman are at the discretion of the production manager, but may include:

- Picking Buffer Parts
- Stock take
- Housekeeping
- Picking Kits

6.3.1.2.3. Daily performance register

The purpose of these registers is to log how the store has performed for the day. The reason for capturing this data is so that the production manager is able to monitor how the stores resources are being utilised from day to day. The register is simply be ticked off as each type of activity on the register occurs.

A sample of the register can be seen in Figure 74:

STORE'S DAILY PERFORMANCE REGISTER															
												DATE: 01/01/01			
W/O PICKED	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
KITS PICKED	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
QC FAILURES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
REQUESTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Figure 74 Store's daily performance register

6.3.1.2.4. Documentation Panel

The purpose of the documentation panel is to centralise all the documentation relevant to the administration of the store, which is in accordance with the lean 5S techniques – which seek to standardise the location of things so that they can be quickly and effortlessly found (and replaced) instead of continually being hunted for.

The store has two primary forms of driving documentation: Picking Lists and GRNs. It is also recommended that a document pocket for sundry notices to the buyers be placed on the Andon board. The sundry notices pocket provides a convenient location for passing any information to the store.

6.3.1.2.5. Parts Requests Panel

The purpose of the Parts Requests Panel is to log parts requested from the store by employees. Having a standardised location for these requests allows the storeman quick access to a record of requests that he needs to attend to and provides the person who made the request with information regarding the status of the request.

This process is currently done by word of mouth, which has employees continually questioning the storeman regarding the status of the parts and whether he has ‘remembered to look for them? Have they arrived?’ etc. Word of mouth is also a convenient way for the storeman to forget things. Having a concrete and visible record for requests removes the uncertainty and ambiguity of word of mouth. It also provides everyone with information regarding the status of requests.

The description panel is used by the person lodging the request. The status panel can be used by anyone with information relevant to the request. Revisiting the request in Figure 73: a technician might replace what is currently on the status panel with, “they’re lying under the stairs”, if that information were relevant.

6.3.1.2.6. Assembly Slave Board

The Assembly slave board serves as a remote interface between the Store and Assembly. The board is to be housed in the Assembly Department. The board’s function is to house Kanban cards going to and coming from the Store’s Andon board, and to notify the store that there are Kanban cards which need to be collected and to capture performance data. The board utilises visual management techniques.

A rendering of the proposed board can be seen in Figure 75:

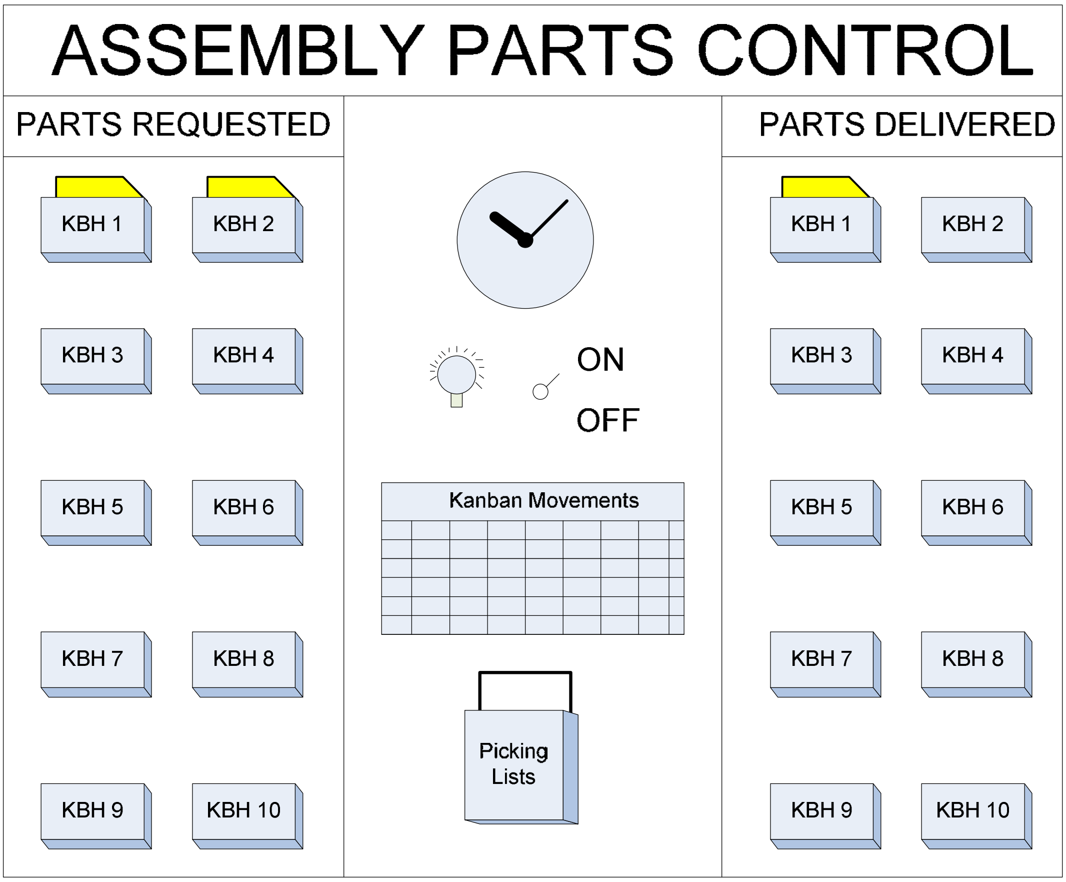


Figure 75 Assembly Kanban board

6.3.1.2.6.i) Visual management

It can be seen from the “current” state of the board in Figure 75 that:

- Assembly has requested 2 parts batches from the Store
- The Store has not as yet recognised the demand for the 2 requested batches
- The Assembly area currently has 1 parts lot available to utilise

6.3.1.2.6.ii) Signal light

The purpose of the signal light is to provide a remote means of communication between the store and the assembly area. If the light is on then there are Kanban cards which need to be collected, i.e. parts that need to be picked.

The supporting electrical system for the signal light can be seen in Figure 76:

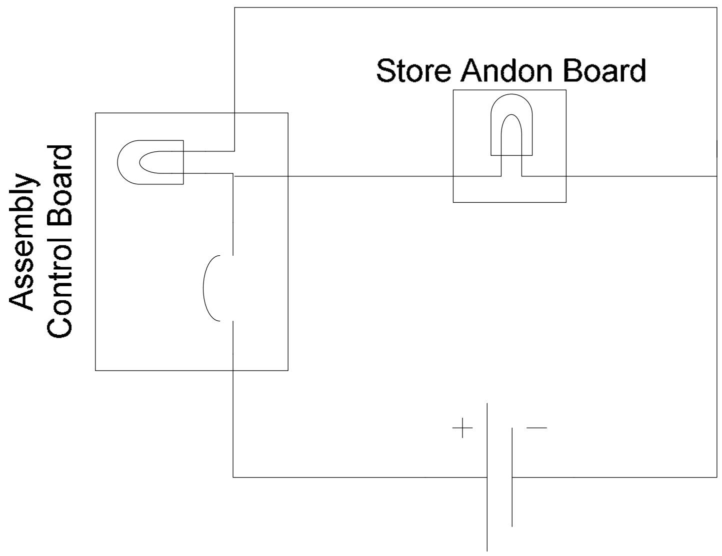


Figure 76 Circuit diagram for signal light.

6.3.1.2.6.iii) Kanban movement Register

The purpose of this register is to log when Kanbans are placed into the parts requested segment of the Assembly control board by the assembly technician, and to log when they are placed back into the parts delivered segment of the Assembly control board by the storeman. The difference between these two time stamps is the store's response time. This forms the Store's driving Key Performance Indicator (KPI), see chapter 6.3.1.4 for KPI details.

The proposed Kanban movement register is displayed in Figure 77:

KANBAN MOVEMENT REGISTER							
	REQUEST DETAILS				DELIVERY DETAILS		
	W/O No.	Time	Initials		W/O No.	Time	Initials
1	00242252	09:00	DV		00242252	09:05	YP
2							
3							
4							
5							

Figure 77 Kanban movement register

6.3.1.2.7. Monitoring store activities

The integration of visual management into the system's control boards allows the real time functioning of the store to be monitored by looking at the control boards.

The following can be determined by inspecting the control boards:

No.	Question	Inspection Method	Comments
1	What activities have been assigned to the storeman?	Check the Assigned activities segment of the Store's control board.	
2	What is the storeman currently working on?	Check the Current activities segment of the Store's control board.	If there is a discrepancy between the storeman's assigned and current activities, he is not adhering to the instructions given.
3	How has the store performed today?	Check the Andon board's performance register.	This is a quick way to gauge the Store's performance throughout the day.

No.	Question	Inspection Method	Comments
4	Are there missing parts? What is the status on missing parts?	Check the parts request segment of the Andon board.	If there is no status indicated, then the storeman has not followed up the request.
5	Is the store supplying the assembly area efficiently?	Check how much backlog there is in the Kanban holders on the Andon board.	If there are no Kanbans in the Store's Andon board but the signal light remains on - then the storeman is not collecting Kanbans from the Assembly area.
6	Is there information that needs to be passed to the buyers?	Check the relevant pockets on the document panel of the Andon board.	
7	Are there subassemblies which are missing parts in the assembly area?	Inspect the Kanban cards on the Assembly control board	Kanbans which have red QC stickers on them indicate parts lots which have missing parts. The relevant picking list will indicate which parts are missing.
8	Which parts have the assembly area been requesting?	Check the Kanban register on the Assembly control board.	
9	How long is the store taking to supply the assembly area with parts?	Check the Kanban register on the assembly control board.	
10	How quickly has the Assembly are been with drawing parts to complete value add tasks?	Check the Kanban register on the Assembly control board.	The more efficient production is in the Assembly area, the more frequently parts will be requested from the Store.

6.3.1.3. *Capacity Scheduling*

Capacity scheduling refers to the practice of pre-allocating time within a schedule to do certain activities. The basic thinking behind capacity scheduling is that, “if you don’t make time for it, it won’t happen” (Suri, 2010).

It is proposed that time should be specifically allocated to the following activities:

No.	Activity Description	Person Responsible	Benefit of activity
1	Housekeeping	Storemen	Keeps the Store organised and tidy.
2	Rolling stock takes	Storemen	Maintains MRP stock level accuracy.
3	Data Processing	Production Manager	Generates store performance data.

6.3.1.4. *Measuring Performance*

The KPIs outlined in below are recommended as performance drivers for the Store:

Table 12 Suggested KPI’s

No.1	**Suggested KPI:**	Average Store order fulfilment time
	Reason for selection:	This is a direct measure of how quickly and efficiently the Store meets the real time demands of the Assembly area. The less time Assembly spends waiting for parts, the more time it is able to spend creating value.
	Objective:	Minimize.
	Calculate by:	Referencing the Kanban movements register and calculating the average duration from when the W/O was requested by Assembly to when it was actually delivered by the Store.

No.2	**Suggested KPI:**	No. of QC failures
	Reason for selection:	Provides a direct measure of how efficient the Store's picking efforts and Procurement department's ordering are functioning. An increasing amount of QC failures results in decreased Assembly efficiency due to parts not being available to create value.
	Objective:	Minimize.
	Calculate by:	Counting the number of failed QC ticks on the Store's daily performance register.
No.3	**Suggested KPI:**	MRP Inventory Accuracy
	Reason for selection:	Having accurate MRP records of the inventory on hand allows the Procurement department to function efficiently – they are always aware of exactly what is on hand and as such are better able to avoid a stock-out condition occurring during the Assembly process.
	Objective:	Maximise
	Calculate by:	Averaging the Inventory accuracy attained during continuous stock takes. Continuous stock taking refers to the practise of doing daily stock takes on predefined segments of the store. E.g. Monday: Check stock on shelves 1&2, Tuesday: Check stock on shelves 3&5 etc. Checking stock frequently allows more insight into actual stock on hand values.

6.3.1.5. *System Failure*

It is expected that, at various points in time, the system will fail due the commonly observed conditions outlined in :

Table 13 Expected system failure causes and remedies

	Failure Condition	Corrective Action
1	Employees to do not adhere to the procedures set out by the system	Discipline / Train employees
2	The Store is unable to pick parts quickly enough	Increase the size of the Parts Buffer
3	The Assembly technicians request the incorrect parts lots	• Stabilize the parts flowing into Assembly from the Rovic production departments to make the incoming parts stream more predictable • Train the Assembly Technicians to work in a systemised fashion
4	Continual parts stock-outs	Improve the performance of the procurement department
5	High levels of MRP stock inaccuracy	Increase stock take frequency

6.3.1.6. *Training*

The objective of training is to familiarise technicians with the system being implemented so that they may utilise it correctly and effectively. Training catalyses learning which would otherwise be gained through direct exposure to the system over time. Therefore, for training to be effective, it must be relevant to the context in which the technician will interact with the system: ensuring successful integration of the system into the technician's work practices.

Developing suitable training requires consideration of when and how the employee will interact with the system. Figure 78 represents a high level timeline segment of an assembly technician (and storemen's) daily activities:

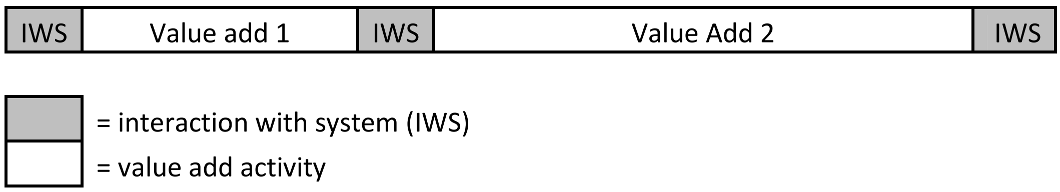


Figure 78. Timeline segment of employees' interaction with the system

The function of the system proposed is to initiate, guide and conclude value add activities carried out by the technician. Familiarisation with the system occurs when the technician interacts with it. It can be seen in Figure 78 that the technician interacts with the system before and after executing value add activities. The duration and nature of the value add activities vary with production; the system, however, is standard and so too is the nature of the employees interaction with it. Regardless of what the actual value add activity is or how long it takes, the technician will always interact with the system in the same manner (as detailed previously) i.e. whether the technician is assembling a planter wing assembly or a cheeseburger, he will always request parts using the same mechanisms and procedures; similarly, regardless of order content the storeman will always receive picking instructions in the same manner and be guided through the process by the same documentation.

It is proposed that technicians be trained through direct exposure to the actual system by substituting the value add activities with activities similar in nature but much shorter in duration. Reducing the duration of the value add activities increases the rate at which the technician interacts with the system, in turn speeding up familiarity with the system and its operation. Offering training in this format allows practical demonstration of the high-level principles of lean, the pros and cons of push and pull etc. in a context which is directly relevant, thus allowing the technician direct exposure to the actual system while being guided through its functioning by the researcher and simultaneously gaining insight into the operating principles (as well as pros and cons) of the lean philosophy integrated into the system.

Training will be conducted by clustering technicians into functional groups (e.g. stores, boilermaking etc.), stringing these groups into a production line, and then having the production line build models as shown in Figure 79.

Figure 79 Toy model utilised for training

The construction of the model makes is suitable for value add activity substitution because:

- Like the machines built at Rovic it is made up of distinct sub-assemblies, as shown in Figure 80.
- The sub-assemblies are modular and can be assembled into different machines. See Appendix G.
- Each sub-assembly is made up of a distinct collection of parts.
- Each sub-assembly has a BOM. See Appendix G.
- The model is low cost (R130)

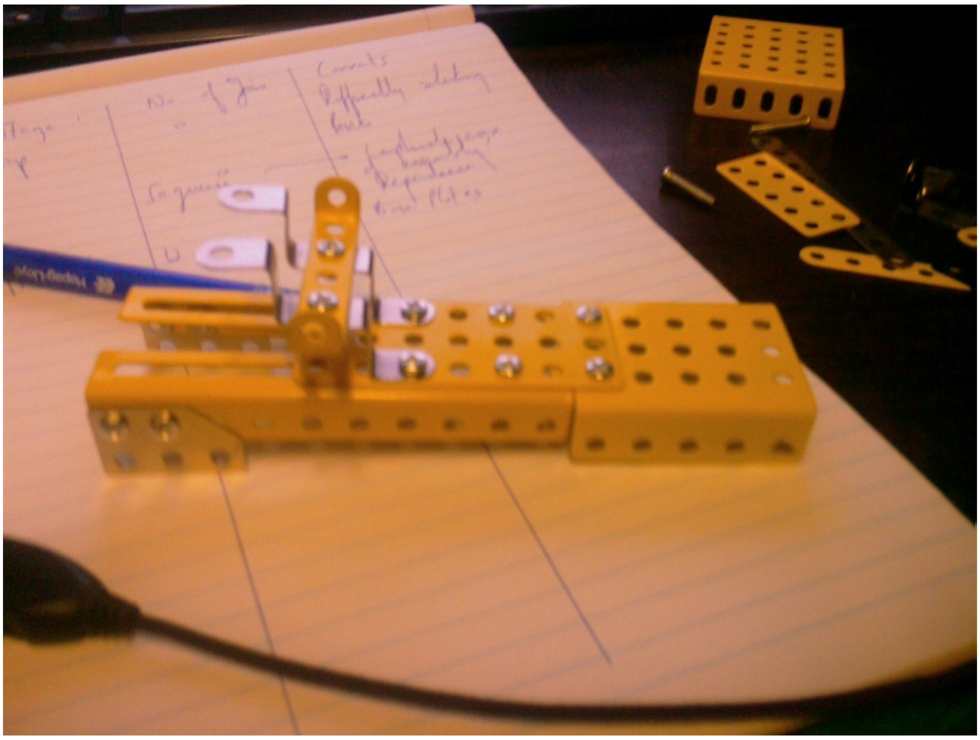


Figure 80 A sub-assembly of the model

The production line will consist of the following functional groups:

Stores – responsible for grouping parts into sub-assemblies.

Boiler Making – responsible for loosely assembling the sub-assemblies e.g. loosely joining two bars together with a screw and nut – but not tightening the nut.

Welding – Tightening and aligning the sub-assemblies received from boiler making.

Assembly – Joining the sub-assemblies to form the completed machine.

The training session will be conducted by running build rounds (a machine will be built during each round) and reflecting after through a question and answer interaction format. Performance will be determined by measuring the time taken to complete the assembly of the model.

The Rounds will be run as follows:

Round 1:

The production team will only be provided the parts and a picture of the fully assembled machine. This will force the team to form an operating structure which they deem most fit.

Focal questions for post round discussion:

- What were the pros and cons of the strategy elected by the team?
- Where do they feel there could have been improvement?

Round 2:

As Round 1, but also providing the team with the sub-assemblies BOMs.

Focal questions for post round discussion:

- Did the team elect to revise the operating strategy? Why?
- Was there benefit in having accurate information to drive production?
- Where do they feel there could have been improvement?
- Would there be merit in improving production co-ordination?

Round 3:

As in round 2, but with the team restructured into functional groups.

Focal questions for post round discussion:

- What were the effects of formally structured functional divisions?
- Were the issues with co-ordination between units?
- Bottlenecks in the production line? Why?
- Where do they feel there could have been improvement?

Round 4:

As in Round 3, but with buffers between production stations and WIP limits introduced

Focal questions for post round discussion:

- What was the effect of introducing the buffers between stations?
- Was their merit in “pulling” sub-assemblies and parts rather “pushing” them?
- Where do they feel there could have been improvement?
- What is the importance of information control and flow?

Round 5:

As Round 4, but using the proposed stores administrative system to co-ordinate information flow. Each functional division will be provided with specific instruction for how they are supposed to utilise the relevant portion of the system. The team members will see how the system functions as a whole and how the functional units are co-ordinated as the round progresses.

Focal questions for post round discussion:

- General feelings about the system?
- Where do they feel there could have been improvement?

Round 5 will be repeated until all technicians have achieved full system operation competency, thus, guaranteeing seamless integration of the system into the “live” production environment.

*The feedback gained here will be used to fine tune the system before live implementation.

6.3.2. Implementation

This chapter outlines the implementation of the proposed activity modifications outlined in Chapter 6.3.1. The primary focusses are the implementation of the two-bin Kanban consumable replenishment system, and the pull driven parts issuing mechanism.

6.3.2.1. *The two-bin Kanban consumable refill system*

The two-bin refill system's simplicity and common sense operation required minimal employee training. Its implementation was green lighted after gauging its financial feasibility; the go ahead was given to build 4 two-bin trolleys.

The implementation was conducted in four phases:

1. Constructing the two-bin reservoir trolleys
2. Migrating the parts present in the Assembly area reservoirs to the trolleys
3. Relocating the previously utilised Assembly area reservoirs to the store – so that they could be utilised to hold the incoming parts required to "fuel" the two-bin refill system
4. Familiarising the storemen and Assembly Dept. Foreman with the refill rules of the system.

The format of the completed reservoir is shown in Figure 81, below.

Figure 81 The two-bin fastener storage trolley

The plastic reservoirs were bought as a wholesale lot from a local supplier; 200 plastic bins were bought in total – 50 per trolley. The labels for each bin were made from laminated card; each bin carried a label indicating the stock code. The volume per bin was 50 items of any parts – the optimum bin volumes per item would be determined over time through iterative adjustments.

The actual frames were constructed through a mix of outsourcing and in-house fabrication. The dividing shelves and wheel mounts were outsourced to Rovic's laser profile cutting vendor. The frame uprights were cut and drilled in-house. The wheels were sourced from a local wholesaler. Painting and assembly was conducted in house.

The total cost of constructing the four two-bin trolleys was R25 000.

6.3.2.2. *The parts issuing system*

The proposed parts issuing system was not implemented. The production manager was unwilling to commit employee time to training, as all the capacity available was required to meet immediate production deadlines. Without employee training the system would be inoperable.

The production manager was, however, willing to have 2 or 3 technicians engage training for an hour or two, and wished to pilot the proposed system after training these individuals. This offer was not acted on. The system (and training) would not be able to function with limited support; piloting the system in the assembly area with 2 or 3 technicians trying to utilise it while the rest operate on an ad-hoc basis on the same machine build is highly unlikely to see positive results as the incoordination would wreak havoc on the WIP buffer and other aspects of parts control. More importantly, trying to operate the system under unsuitable conditions would guarantee its failure, in turn compromising future buy-in and thus sustainability.

Implementation efforts were curbed entirely with the resignation of the production manager at the time of project conclusion.

6.4. Conclusions

The objective of this initiative was to formalise, and subsequently modify for improved value delivery, the sub-processes related to the Store's operation. The intention of the modifications proposed were to maximise the store's performance in line with the overall process objective of delivering parts to the Assembly operation as and when required in full.

The Store's operation is comprised of (and executed through) three sub-processes, each operating on a discrete stages of parts handling. The sub-processes are:

1. The goods receiving and storage process: used to receive and store goods procured from external suppliers
2. The parts issuing process: used to issue parts to the Assembly operation
3. The administrative control process: used to control and direct the Store's operations

The improvement objectives with respect to the stores sub-processes were conducted sequentially (for reasons cited at the outset of this chapter) as follows:

1. Improve the efficiency of the goods receiving and storing sub-process, so that goods received from suppliers are placed into storage effectively and in manner that allows it to be speedily picked when required.
2. Improve the efficiency of the goods issuing sub-process, in order to synchronise the store's picking efforts with the real time demand of the Assembly area and to minimise time lost by the assembly technician while retrieving parts.
3. Develop a standardised administration framework for the Rovic Store, structured to allow the overall process to sustainably realise both effective and efficient operations.

Upon inspection of the sub-processes, it was discovered that there were inherent activities which actively contributed toward the degradation of the overall process' performance. The activities concerned were negatively afflicted by a combination of ill-fitting work practices and or imbalanced physical process aspects.

Sighting opportunities in the AS-IS state, the proposed TO-BE state sought to:

1. Optimise the physical aspects of the sub-processes related to parts handling (objectives 1 & 2, above)
2. Standardise the store's work practices through the integration of an administrative system based on lean pull and visual management principles, to create flow between the Store and the Assembly operation (objective 3, above)

The TO-BE proposals related to the physical parts handling were formally tested and deemed favourable. The solutions were implemented where possible, but only promoted efficiency gains at the level of the sub-process; gains in overall process performance are realised through the coordination, rather than execution, of the physical handling activities.

The key implementations were the reconfiguration of the store's physical layout and the introduction of the two-bin Kanban fastener replenishment system. These implementations enabled, respectively: the Store to place goods into storage in an indexed and repeatable manner; and a reduction on the total parts picking load imposed on the store.

The holistic improvements to the overall process effectiveness sought by the proposed TO-BE Store's administration system was, unfortunately, not realised due to organisational constraints preventing implementation. In the hope of future improvement, the information and physical infrastructure required to enable the administrative aspects were provisioned for, readying the TO-BE state for implementation once the process stakeholders received the required training.

In conclusion, the performance gained through the physical optimisation of the parts handling activities is of benefit to the sub-process efficiency. However, the effectiveness gains desired in the overall process can only be sustainably realised, and monitored, once the store's administration process is embedded into the operation. Embedding the administration process will form a basis for operational control and future continuous improvements.

7. CONCLUSIONS, RECOMMENDATIONS AND NEXT STEPS

This chapter discusses the insights gained through the framework application, the overall dissertation conclusions drawn and the envisioned next steps for further continuous improvement at Rovic.

7.1. Framework Review

The objective of this dissertation was to assemble and sequence a framework, using commonly available (and established) tools and methodologies, which would allow its user to effectively direct process oriented improvement through analysis and modification of the operations at the activity level. The framework development was hosted by Rovic and Leers – an agricultural equipment manufacturer – specialising in the fabrication of made to order implements – and was applied to the overall process related to delivering externally sourced parts to the Assembly operation.

The outcome of a well-designed business process is increased effectiveness (value to the customer and company) and increased efficiency (less costs to the company) (McDonald, 2009); Ensuring that business processes functional efficiently, allows for optimum operation of the organisation as a whole.

The Rovic operations functioned in ad-hoc fashion, absent of standardised processes. The framework was thus required to first and foremost establish a basis and definition for improvement, and subsequently identify areas for value add opportunities. For this reason, the framework assumed that its user would be "starting from scratch" and intended to holistically improve the operation rather focus on a particular department within the organisation.

The framework commenced with the construction of a value stream map of the organisations operations as a whole. The intention of the value steam map was to gain a high-level understanding of the operation and to verify the logic, boundaries and responsibilities of departments in relation to the organisations final objective: in Rovic's case, building machinery. The value stream map omitted traditional parameters like cycle times etc. The map sought only to establish the status quo and the key functions of every department within the operation, in the shortest time possible. The traditional level of detail could be added to the map at a later point, if and when required.

The organisation level value stream map generated was work-shopped with the department owners to ratify its validity. Through the workshop session it became apparent that there was confusion around how the organisation functioned as a whole, and how each department's individual actions impacted the organisation at a macro level. The map helped clarify the significance and benefits of cross-functional alignment.

The ratified organisation level value stream map was then work shopped to define the overall processes required for the operation to deliver value to its customer. The overall processes were then presented to Rovic's senior executive for discussion and selection of an overall process which they felt required the most urgent attention.

The executive elected to focus on the overall process related to making externally procured parts available to the assembly operation. The availability of externally procured goods at the time of assembly was deemed to be of paramount importance, and reported to be the most common cause of production delays (i.e. value realisation).

The functioning of the overall process was then represented using a value stream map, this map was effectively a subset of the organisational level map developed earlier. The map was developed and ratified in the same fashion and for the same reasons as the organisational map.

Subsequent to confirming the overall process value stream map with relevant department owners, a criterion for successful value delivery of the overall process was defined. The criterion was defined as "having the externally sourced parts required to create value, at hand, when required". It was realised while defining the criterion, that it had to relate to a concrete operational objective so as to provide a clear, consistent and tangible measure of whether value was achieved or not. Furthermore, the value criterion had to be defined in terms of the overall process' customer, value was only realised after satisfying the customer.

The next step in the framework was to define and map the discrete sub-processes involved in the execution of the overall process; this was achieved by mapping the sub-processes using SIPOC tables. The SIPOC tables solidified an understanding of sub-processes by highlighting their core functions, required inputs and expected outputs. Mapping the sub-processes allows the framework user to study the boundaries between sub-processes for compatibility; any obvious holes in the overall process would be revealed at this point e.g. a sub-process not receiving an input required for it to execute properly.

The overall process value delivery criterion was then used to “cascade” the value delivery objectives of the constituent sub-processes. Thus directing sub-process improvements toward the betterment of the overall process, rather than the sub-processes itself: i.e. the cascaded criterion provided context for integrated improvement.

On review, it was realised that framework user (in conjunction with internal stakeholders) could loop through the high-level steps of the framework, i.e. organisational value steam mapping to value delivery definition of the sub-process, for all the operation’s overall processes in order to essentially craft integrated process structures intended to support the desired operating strategy. A process is after all a structure for action (Davenport, 1993). Splicing and dicing the overall processes at this level would allow the user to tune the overall characteristics of the operation by detailing the inputs, outputs and objectives of the underlying sub-processes: effectively setting parameters for future detailed process and or organisational design. A structure for development would be particularly beneficial to newly formed operations that may otherwise evolve in ad-hoc fashion.

Having established a holistic understanding of the overall process operation, the root causes preventing value delivery were identified using 5 why’s technique while shadowing the operation. The recurring causes were noted and documented using fishbone diagrams. The 5 why’s exercise had the added benefit of opening a direct communication channel between the framework user and the resources on the ground. This is beneficial because it begins the journey of gaining buy-in, and brings to the fore the tacit knowledge of the resources directly involved in the execution of the process. The value of this tacit knowledge cannot be overstressed, especially when attempting to improvement from ground zero.

The root causes logged were then studied and linked back to the sub-processes previously defined by the SIPOC tables. Root cause resolutions were prioritised to gain effectiveness, then efficiency. In layman’s terms: to first make the process work, then make it work better; the former being crucial to outright value realisation of the overall process.

With the sub-process value delivery criterion defined and the nature of the value obstruction identified, the sub-process was mapped in detail at the activity level – using swim lane process maps - to understand its functioning and inherent inefficiencies. Inefficiencies were observed in terms of lean wastages in an attempt to sight reasons leading to root cause failure generation. Formalising the sub-process status quo allowed the framework user to communicate the operational detail to the stakeholders, similarly the observed lean wastages and how they obstructed value delivery of sub-process. This was beneficial to the improvement initiative execution because it provided the stakeholders with a common vision of where the problem lay, what had to be done where, and who was affected.

Factoring the sub-process value delivery criterion and the observations made, the next step in the framework was to propose solutions to remove the value obstruction inherent to the sub-process. The proposed solutions were formalised – using swim lane process maps – and referenced to observed lean wastages, so that the framework user could communicate to the stakeholders what the intended activity modification was, what wastages it was expected to remove as well as the envisioned future operation. In a general sense, this step can be used to ratify the feasibility of the solutions proposed from an organisational perspective, enabling the framework user to gain buy-in before proceeding with the testing and implementation.

Having proposed TO-BE solutions, the framework next sought to confirm their effectiveness before proceeding to the implementation phase; if testing proved unsuccessful, the solution would be revised and re-tested until it was fit for purpose: in accordance with the Lean PDCA cycle. The effectiveness of the proposed solutions was tested using a control experiment and QRM capacity utilisation philosophy.

The control experiment compared the AS-IS and proposed TO-BE process' execution of a set task – derived from the sub-process value criterion – to determine which exhibited superior performance in terms of their contribution to realising value delivery of the overall process. The final step of the framework was thus to objectively confirm the superiority of the proposed solution prior to commencing the implementation journey; seeking to gain linear continuous improvement momentum by involving the sub-process stakeholder in the testing exercise and only actioning verified improvements.

The limited duration of the experiment, however, blinds the results to the effect of process adherence (a social dimension). In an attempt to factor this lack, the experiment could be run on a broader scale and over an extended duration with the assistance of a formalised metric system. The AS-IS and TO-BE processes could be put into service for alternating periods of time or across different operational cells with the same function, while being monitored using standardised metrics to determine which process is superior and why.

The TO-BE proposals deemed successful through testing were implemented where possible. There was, generally, an immediate acceptance of solutions which enabled effectiveness; Key implementation were: the integration of the design and ERP systems, the automation of works instruction generation, the store layout revision and the two-bin Kanban system for fasteners.

It was, however, noted that the operations owners were hesitant to deploy solutions which aimed to improve process efficiency. The general attitude was, ‘if it works ok, why bother changing it?’ This mind-set poses a threat to the realisation of value gains sought through “fine tuning” the process, and highlights the importance of embedding continuous improvement as an organisational philosophy rather than utilising it as a firefighting tool (Drew 2004; Suri 2010)

7.2. Conclusions

Through the course of this dissertation and framework development, it was discovered that analysing the desired outcomes of the overall process allowed the ability to specifically focus improvement initiatives, fixing only what was necessary to enable and sustain overall process flow. This approach promoted solutions aimed at improving end value delivery holistically rather than solutions which improved the operations of a functional silo purely for the sake of improving that silo in isolation (I.e. improving the function of a silo beyond the requirements of the end customer does not return any additional value). This promotes mutual value add for both business and customer, the customer is satisfied and the business resources are only stretched as far as required.

It was realised that improving the performance of a macro process requires the promotion of cross functional development and integration; and that regardless of the environment, lean principles and tools –specifically around waste reduction – remain an effective catalyst of value creation and delivery in a complex environment. The application of lean principles, however, requires manipulation to blossom in a specific environment; for instance, marrying lean tools with MRP resources to provide operational flexibility. Additionally, adopting a capacity view of process execution – as promoted by QRM – allows a litmus test to determine whether the process is sufficiently resourced to meet its required objective. For example, by comparing the average pick rate and number of pickers against the number of picks required by the operations will provide an indication of whether there are enough pickers.

In the case of Rovic, gains can be had by either utilising technology to automate labour intensive problems or by providing employees with training to increase their relative effectiveness and efficiency. The availability, and involvement, of employee resources to cater for continuous improvement activities (such as brainstorming, training etc.) cannot be overstated.

Therefore, it is recommended that Rovic temporarily reduce their production loading in order to provide the capacity required for continuous improvement developments – a short term sacrifice in exchange for a long term gain. Additionally, continuous improvement initiatives should be actively backed by ALL management levels and emphasis should be placed on involving and empowering employees so that returns can be quickly and sustainably acquired. It is recommended that improvement initiatives, at all times, retain focus on cross functional development and integration. Flow the value along the stream from beginning to end (Drew, 2004).

7.3. Future work

The recommended next steps for Rovic are as follows:

1. Review and roll out the Store's administrative system (and training) as detailed in Chapter 6.3. The formalisation of this area can serve as a platform for future continuous improvement efforts.
2. Develop standardised manufacturing practices which promote operational transparency and control while complimenting the Store's administrative system
3. Investigate the feasibility of introducing modular designs in various sizes instead of offering true once off designs. The expected benefit is reduced total product lead time through a combination of design recyclability, product familiarity and repeatability on the shop floor

The recommended next steps for the development of the framework is the formalisation of a mechanism which allows the user to: Align and weight the value delivery criterion and supporting metric system of the overall processes, used to drive the activity conversion process, with the organisation's discrete operating strategy.

In closing, this research has highlighted that while a jobshop environment like Rovic may face unique challenges, systematic application of improvement philosophies has the potential to formalise and improve the ad-hoc operating processes present. The improvement is achieved through the alignment of people, processes and tools to effectively execute the overall operating processes required to deliver value. The improvements should ideally be conducted in a cross functional manner with the intention of evolving the organisation holistically, and should be prioritised in a manner which promotes effectiveness, then efficiency.

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9. APPENDICES

9.1. Appendix A

Works instruction generator program interface…

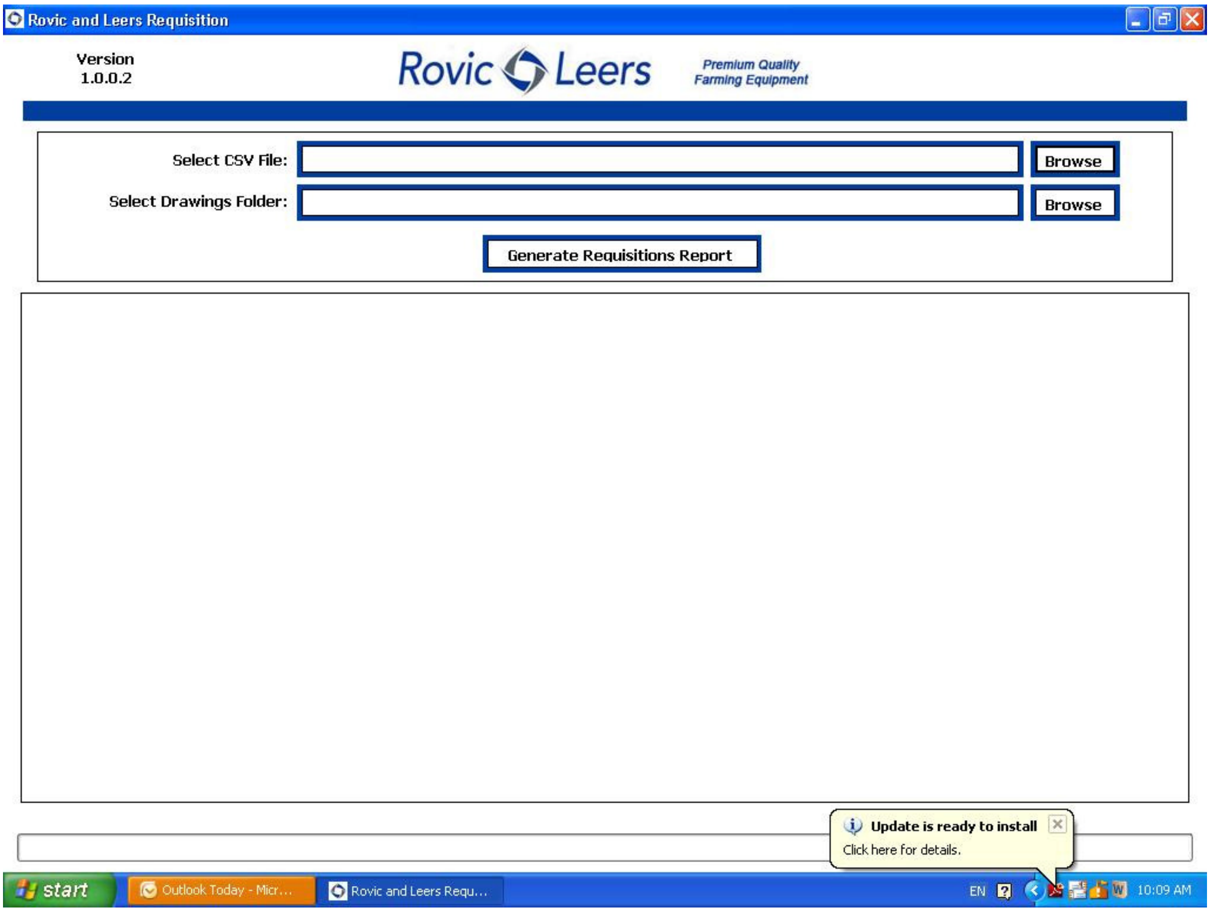

Figure 83. A1 - Works instruction generator program interface

9.2. Appendix B

Store's Layout …

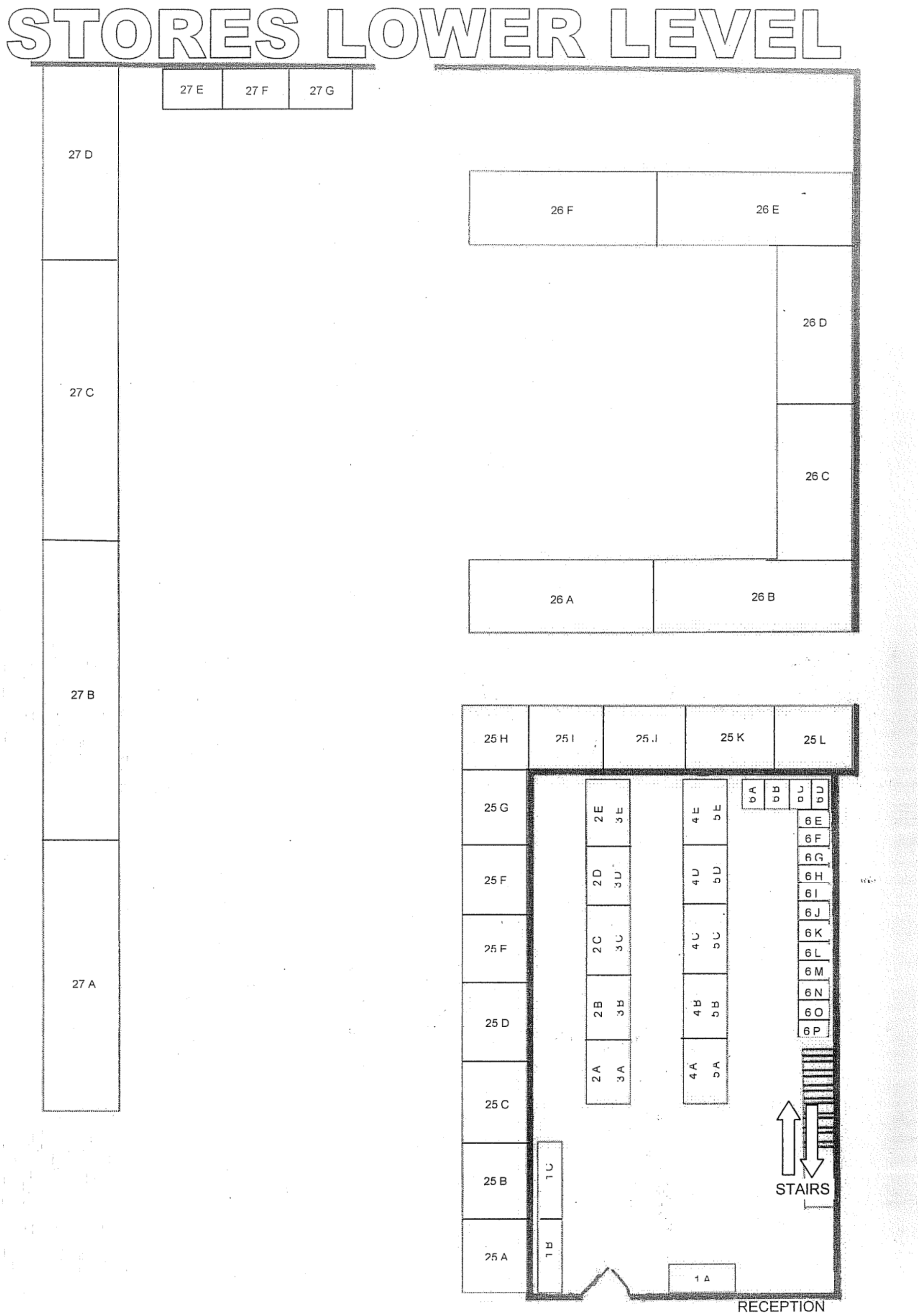

Figure 84. A2 - Store's lower level layout

*(Appendix B. Continued)

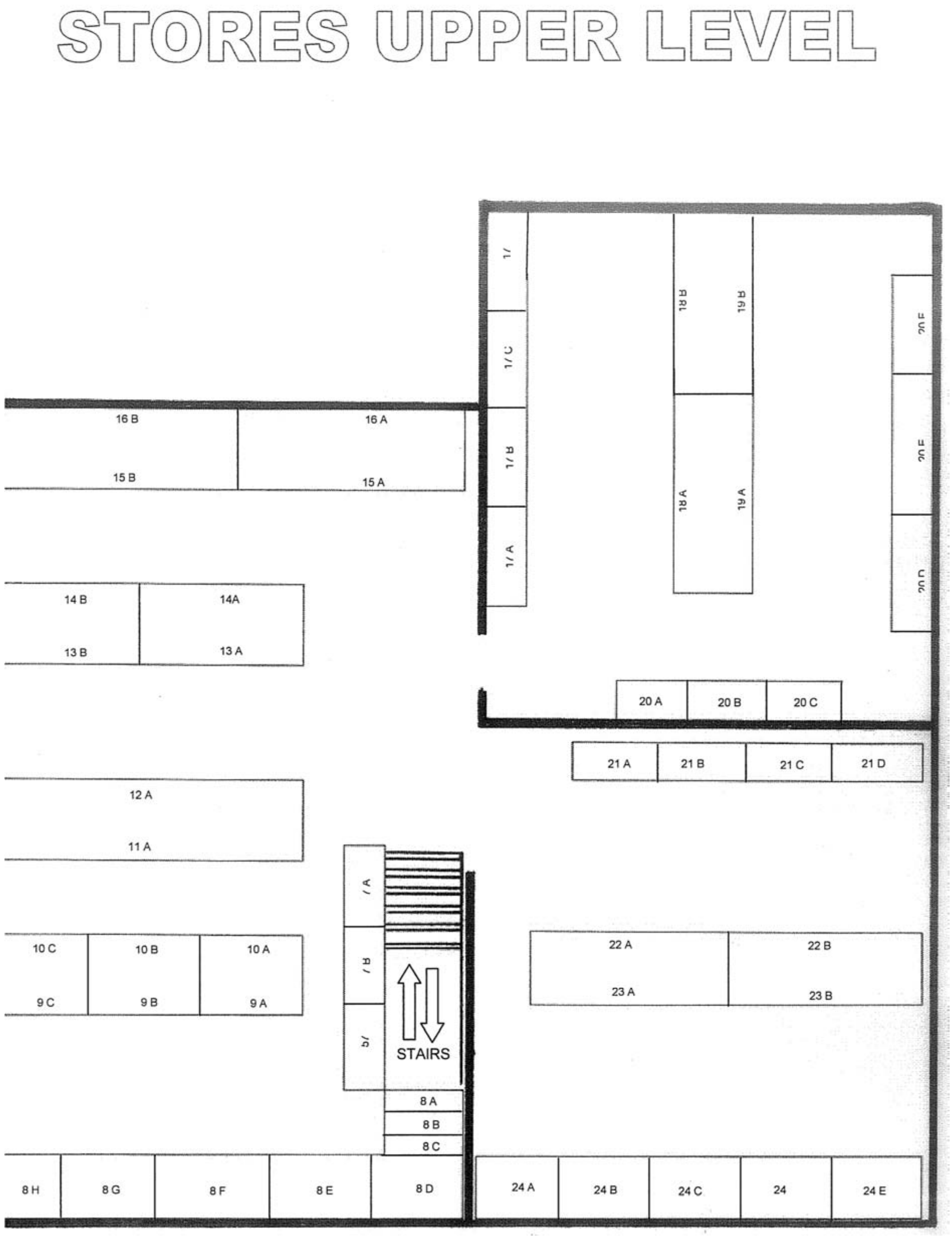

Figure 85. A3 - Store’s upper level layout

*(Appendix B. Continued)

9.3. Appendix C

Bin location change register …

STORE BIN LOCATION CHANGE FORM

Date	Part #	Original Location	New Location	Signature

Figure 86. A4 - Bin location change register

9.4. Appendix D

Rovic Product Classes …

CODES	PRODUCT CLASSES
PAA	GEARBOXES
PBA	HYD. CYLINDERS
PBB	HYD. FITTINGS / PIPES / CLAMPS
PBC	O-SEALS / WEARINGS
PC	CONTROL VALVES
PD	P.T.O SHAFTS
PE	BEARINGS
PF	BELTS & SPROCKETS
PG	NYLON & RUBBER
PH	CASTINGS
PJ	TYNES
PK	SKOTTELS
PL	SPRINGS
PM	AXLES
PN	RIMS / P-JACKS
PP	TYRES / TUBES
PQA	STAAL FLATS
PQB	STAAL SOLIDS
PQC	C50 STAAL
PR	PROFILING
PS	PAINT
PTA	CONSUMABLES
PTB	LUBRICATION
PU	ELECTRICAL COMPONENTS
PWA	NUTS / BOLTS / FASTENERS / U-BOLTS
PWB	CABLES / CHAINS
PX	STICKERS
PYA	PLATING / GALVANISING / HARDENING
PYB	KEYWAYS / BUITE MACHINE
PZK	ALL MANUFACTURING PARTS

CODES	CYCLE COUNT NUMBERS
51	BOUGHT OUT STORE ITEMS ONLY
52	STEEL
53	PROFILING & PLATING & OUTSIDE MACHINING
54	CONSUMABLES
97	MADE IN MANUFACTURING

Figure 87. A5 - Rovic Product Classes

9.5. Appendix E

Sample Buying List …

180 PLATE MULCHER

Prepared : 27/10/2011 16:18
Report : AGRI08

ROVIC & LEERS W/O 245126 -> 170
LLEWELLYN MRP BUY SUMMARY REPORT

STOCK CODE	DESCRIPTION	BIN	TOTAL QTY	PROD CUST	QTY ON HAND	QTY ALLOC	Q
AFTGBG130 1.146	GEARBOX 130KW 21-SPLINE		4.000-	PAA 90	2.000	4.00	
AFTGBG130 1.146HU	HUB 21-SPLINE		4.000-	PAA 90	0.000	4.00	
RFL315	BASE PLATE HRZ2APST.M.BC	22B02	4.000-	PBB 90	10.000	150.00	
RFL316	COMP. DBL.CLAMP HRZ3KP20-		8.000-	PBB 90	2.000	8.00	
RFL317	TOP PLATE HRZ3DPST2NC		4.000-	PBB 90	1.000	4.00	
AFTB612SFF4	PTO 1.2M FRIC. CLUTCH 21S	27B02	4.000-	PD 90	1.000	4.00	
LT57621	INPUT CONNECTION SHIELD		4.000-	PD 90	0.000	34.00	
MU0180	RED FIRECHECK HOSE 50M RO		10.800-	PG 90	0.000	10.80	
J116	BLADE GENERAL		16.000-	PJ 90	5.000	16.00	
J116F	BLADE FLAT		16.000-	PJ 90	4.000	16.00	
J116T	BLADE TWISTED	BULK	8.000-	PJ 90	2.000	8.00	
J1520	BLADE PRUNING		8.000-	PJ 90	2.000	8.00	
100X100X10A	ANGLE IRON		3.040-	PQA 90 1L ✓	1.460	3.04	
10RB	ROUND BAR		1.440-	PQA 90 2L ✓	0.000	9.07	
10SB	SQUARE BAR		1.120-	PQA 90 5L ✓	0.000	38.36	
16RBEN8BR	ROUND BAR		0.168-	PQA 90 —	19.956	38.77	
25RBEN8BR	ROUND BAR		0.568-	PQA 90 —	29.457	912.63	
28RBEN8BR	ROUND BAR		1.136-	PQA 90 —	3.208	1.13	
40X20HB	HOLLOW BAR		0.616-	PQA 90 3L ✓	14.301	27.58	
40X40X6A	ANGLE IRON		1.440-	PQA 90 1L ✓	0.000	2.16	
50RBEN8BR	ROUND BAR		0.992-	PQA 90 3L ✓	0.928	15.93	
2450X1225X2	SHEET		0.004-	PQB 90 —	1.735	0.00	
50X12	FLAT BAR		3.600-	PQB 90 —	68.372	99.34	
80X12	FLAT BAR		5.440-	PQB 90 8L ✓	5.176	50.26	
JD35233	BOTTOM LINK GUSSET		[illegible]				

Figure 88. A6 - Sample Buying List

9.6. Appendix F

AGRI07 Picking List …

Prepared : 25/11/2011 07:53 ROVIC & LEERS Page : 1
Report : AGRI07 KIT LIST STORES - FROM JOB NO: 00242252 TO JOB NO: 00242425

Stock code	Stock description	Qty required	Job Number	Stock description	Customer	Alt key 2	Bin Location
LS80012	5TON ONDERDEELBOEK	10.000	00242253	5 ton RF3000 TRAILED SPREADER	49	PX	01B03
LS1087	HYDR. HOSE COMPL. 5T	10.000	00242254	5T SPREADER W/0 SIEV	49	PBB	27F01
LS1155	DRIVE CHAIN STD 5T	10.000	00242254	5T SPREADER W/0 SIEV	49	PWB	11G05
M12GFW	GALV FLAT WASHERS	120.000	00242254	5T SPREADER W/0 SIEV	49	PWA	02A04
M12NY	12MM NYLOC NUTS	120.000	00242254	5T SPREADER W/0 SIEV	49	PWA	02A05
M12X35GSS	GALV SET SCREWS	120.000	00242254	5T SPREADER W/0 SIEV	49	PWA	03A02
S12RC	R-CLIPS	10.000	00242254	5T SPREADER W/0 SIEV	49	PWA	01D03
LS3488	SPACER FOR CHASSIS	10.000	00242255	DRAWBAR &CHASSIS ASS	49	PR	
LT58376	RF4500 CHASSIS LUBRICATION SYS	10.000	00242255	DRAWBAR &CHASSIS ASS	49		
M12GFW	GALV FLAT WASHERS	40.000	00242255	DRAWBAR &CHASSIS ASS	49	PWA	02A04
M12NY	12MM NYLOC NUTS	40.000	00242255	DRAWBAR &CHASSIS ASS	49	PWA	02A05
M12X30X3GFENW	GALV FEND/WASH	40.000	00242255	DRAWBAR &CHASSIS ASS	49	PWA	03A02
M12X45G	GALV BOLTS	40.000	00242255	DRAWBAR &CHASSIS ASS	49	PWA	03A04
M24GFW	GALV FLAT WASHERS	20.000	00242255	DRAWBAR &CHASSIS ASS	49	PWA	04C01
M24NY	24MM NYLOC NUTS	20.000	00242255	DRAWBAR &CHASSIS ASS	49	PWA	04D05
M24X160G	GALV BOLTS	20.000	00242255	DRAWBAR &CHASSIS ASS	49	PWA	04C03
LS1016	DRIVE ROLLER ASSY	10.000	00242256	SPR BELT CASSETTE 5T	49	PO	27C03
LS1022	BEAUTY PANEL	10.000	00242256	SPR BELT CASSETTE 5T	49	PR	11G03
LS1061	IDLER ROLLER SCRAPER	10.000	00242256	SPR BELT CASSETTE 5T	49	PR	11G06
LS1092	BELT SUPPORT 1	20.000	00242256	SPR BELT CASSETTE 5T	49	PR	11G06
LS2036	TENSIONER ROLLER	10.000	00242256	SPR BELT CASSETTE 5T	49	PO	27C03
LS2213	BEARING 3&5&MINI UCFL208	10.000	00242256	SPR BELT CASSETTE 5T	49	PE	21A03
LS2216	BEARING 35MM 3&5&MINI UCT207	20.000	00242256	SPR BELT CASSETTE 5T	49	PE	21B03
LS2218	BRG 35MM FYTB35 UCFL207	30.000	00242256	SPR BELT CASSETTE 5T	49	PE	
LS3009R	IDLER ROLLER ASSY CHINA	130.000	00242256	SPR BELT CASSETTE 5T	49	PO	27A03
LS459	5TON CONVEYOR BELT	10.000	00242256	SPR BELT CASSETTE 5T	49	PF	
LS80030	WOOD BEARER SUPPORT - LH	10.000	00242256	SPR BELT CASSETTE 5T	49	PR	
LS80031	WOOD BEARER SUPPORT - RH	10.000	00242256	SPR BELT CASSETTE 5T	49	PR	
M10GFW	GALV FLAT WASHERS	80.000	00242256	SPR BELT CASSETTE 5T	49	PWA	02B01
M10NY	10MM NYLOC NUTS	90.000	00242256	SPR BELT CASSETTE 5T	49	PWA	02B01
M10NY	10MM NYLOC NUTS	30.000	00242256	SPR BELT CASSETTE 5T	49	PWA	02B01
M10X25GSS	GALV SET SCREWS	80.000	00242256	SPR BELT CASSETTE 5T	49	PWA	02B03
M12GFW	GALV FLAT WASHERS	60.000	00242256	SPR BELT CASSETTE 5T	49	PWA	02A04
M12NY	12MM NYLOC NUTS	60.000	00242256	SPR BELT CASSETTE 5T	49	PWA	02A05
M12X30GSS	GALV SET SCREWS	40.000	00242256	SPR BELT CASSETTE 5T	49	PWA	03A01
M12X45G	GALV BOLTS	20.000	00242256	SPR BELT CASSETTE 5T	49	PWA	03A04
M14GFW	GALV FLAT WASHERS	80.000	00242256	SPR BELT CASSETTE 5T	49	PWA	03B04
M14NY	14MM NYLOC NUTS	80.000	00242256	SPR BELT CASSETTE 5T	49	PWA	03B05
M14X40GSS	GALV SET SCREWS	20.000	00242256	SPR BELT CASSETTE 5T	49	PWA	03B06
M14X45GSS	GALV SET SCREWS	60.000	00242256	SPR BELT CASSETTE 5T	49	PWA	03B07
M201/2NG	GALV HALF NUT	20.000	00242256	SPR BELT CASSETTE 5T	49	PWA	03E04
M20GFW	GALV FLAT WASHERS	20.000	00242256	SPR BELT CASSETTE 5T	49	PWA	03E04
M20GN	GALV NUTS	60.000	00242256	SPR BELT CASSETTE 5T	49	PWA	03E04
M20NY	20MM NYLOC NUTS	20.000	00242256	SPR BELT CASSETTE 5T	49	PWA	03E07
M6X45GN	GREASE NIPPLE	50.000	00242256	SPR BELT CASSETTE 5T	49	PWA	04A06
M8GFW	GALV FLAT WASHERS	40.000	00242256	SPR BELT CASSETTE 5T	49	PWA	02D03
M8GFW	GALV FLAT WASHERS	280.000	00242256	SPR BELT CASSETTE 5T	49	PWA	02D03
M8NY	NYLOC NUT	240.000	00242256	SPR BELT CASSETTE 5T	49	PWA	02D03
M8X20GSS	GALV SET SCREWS	120.000	00242256	SPR BELT CASSETTE 5T	49	PWA	02D06
M8X25GSS	GALV SET SCREWS	120.000	00242256	SPR BELT CASSETTE 5T	49	PWA	02D07
M8X50GSS	GALV SET SCREWS	40.000	00242256	SPR BELT CASSETTE 5T	49	PWA	02C04

Figure 89. A7 - AGRI07 Picking List

9.7. Appendix G

Model used for Employee Training …

Figure 90. A8 - Model used for Employee Training

EBE Faculty: Assessment of Ethics in Research Projects

Any person planning to undertake research in the Faculty of Engineering and the Built Environment at the University of Cape Town is required to complete this form before collecting or analysing data. When completed it should be submitted to the supervisor (where applicable) and from there to the Head of Department. If any of the questions below have been answered YES, and the applicant is NOT a fourth year student, the Head should forward this form for approval by the Faculty EIR committee: submit to Ms Zulpha Geyer (Zulpha.Geyer@uct.ac.za; Chem Eng Building, Ph 021 650 4791). Students must include a copy of the completed form with the thesis when it is submitted for examination.

Name of Principal Researcher/Student: Department: Mechanical Engineering

If a Student: Degree: MSc Mechanical Engineering Supervisor: Prof. FJ Kahlen

If a Research Contract indicate source of funding/sponsorship:

Research Project Title: Continuous Business Improvement through Process Optimization

Overview of ethics issues in your research project:

Question 1: Is there a possibility that your research could cause harm to a third party (i.e. a person not involved in your project)?		NO
Question 2: Is your research making use of human subjects as sources of data? If your answer is YES, please complete Addendum 2.	YES	
Question 3: Does your research involve the participation of or provision of services to communities? If your answer is YES, please complete Addendum 3.		NO
Question 4: If your research is sponsored, is there any potential for conflicts of interest? If your answer is YES, please complete Addendum 4.		NO

If you have answered YES to any of the above questions, please append a copy of your research proposal, as well as any interview schedules or questionnaires (Addendum 1) and please complete further addenda as appropriate.

I hereby undertake to carry out my research in such a way that

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

Signed by:

	Full name and signature	Date
Principal Researcher/Student:	Yusuf Mohamed Patel	30/5/2011

This application is approved by:

Supervisor (if applicable):	Franz-Josef Kahlen	30/May/11
HOD (or delegated nominee): Final authority for all assessments with NO to all questions and for all undergraduate research.		30
Chair : Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the above questions.		28/06/2011

ADDENDUM 2: To be completed if you answered YES to Question 2:

It is assumed that you have read the UCT Code for Research involving Human Subjects (available at http://web.uct.ac.za/depts/educate/download/uctcodeforresearchinvolvinghumansubjects.pdf) in order to be able to answer the questions in this addendum.

2.1 Does the research discriminate against participation by individuals, or differentiate between participants, on the grounds of gender, race or ethnic group, age range, religion, income, handicap, illness or any similar classification?		NO
2.2 Does the research require the participation of socially or physically vulnerable people (children, aged, disabled, etc) or legally restricted groups?		NO
2.3 Will you not be able to secure the informed consent of all participants in the research? (In the case of children, will you not be able to obtain the consent of their guardians or parents?)		NO
2.4 Will any confidential data be collected or will identifiable records of individuals be kept?	YES	
2.5 In reporting on this research is there any possibility that you will not be able to keep the identities of the individuals involved anonymous?		No
2.6 Are there any foreseeable risks of physical, psychological or social harm to participants that might occur in the course of the research?		NO
2.7 Does the research include making payments or giving gifts to any participants?		NO

If you have answered YES to any of these questions, please describe below how you plan to address these issues:

In response to Question 2.4:

The nature and purpose of the research was explained to the employees and their participation is voluntary, they reserve the right to withdraw should they wish to do so.

Records will be confidentially kept by the researcher. These metrics must be recorded due to the large influence of the human factor in the manufacturing environment.

Where possible broad observations will be made i.e. reporting that there is a general problem in the welding department, as opposed to highlighting that there is a definite problem with employees X and Y.

If the metrics objectively reflect that there is cause for concern regarding a specific employee then action will be taken to directly assist the employee where possible (discuss the concern, provide possible solutions, offer training etc.).

However, if the problem cannot be resolved confidentially (i.e. between the researcher and employee concerned) then the relevant data would be presented to a senior power within the company structure. The senior power would be informed of possible courses of action and would solely make a final decision based on the company's best interest.

In publishing external (outside the company) reports all participant identities will remain anonymous.

Brandon Collier-Reed - RE: Assessment of Ethics in Research

From: Brandon Collier-Reed
To: Yusuf Patel
Subject: RE: Assessment of Ethics in Research

Dear Yusuf
With these amendments, your applications meets the minimum required for approval. I will forward the signed version to Zulpha today. Good luck with your project.
Sincerely
Brandon

>>> "Yusuf Patel" <yusufp@rovicleers.co.za> 27/06/2011 15:57 >>>

Dear Doctor Reed,

I'm glad that you have found the proposal satisfactory thus far ☺

In response to your queries: the technicians have the option to withdraw from the research phase (i.e. testing) if they so wish. However if the tests are successful and the company adopts the work procedure as standard policy then all technicians must follow this procedure. The operational procedures will be enforced by the line managers (or other relevant senior power).

It must be noted though that the research is focused on the macro management of the factory and not on the micro behavior directly related to the employee's actual job.

E.g. IF we look at the process : [Boiler maker performs actual boilermaking operation i.e. drilling, jigging, tacking etc] >>> Transitional process to welder >>> [Welder performs welding segment of production].

The research focuses on the transitional processes; i.e. where goods are moved to once the boilermaker has completed his task, how they are moved, coordinating the next step of production, Quality procedures etc. The workers themselves are still free to conduct the actual task in whichever manner they feel is most productive.

Simply put: The research's goal is to streamline product flow between the end of the first technician's job and the start of the second technician's job.

Regards

Yusuf