2022

Improved Warehouse for SMT Material Management Using Modern Technology Retrieval System and Better Traceability

Ferdinand Mabeya
Minnesota State University, Mankato

Improved warehouse for SMT material management using modern technology retrieval system and better traceability.

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN MANUFACTURING ENGINEERING TECHNOLOGY

MINNESOTA STATE UNIVERSITY, MANKATO

MANKATO, MINNESOTA

May 2022

11/11/2021

Mr. Ferdinand Mabeya

This Thesis has been examined and approved by the following members of the student's committee.

_____
Advisor

_____
Committee Member

_____
Committee Member

Table of Contents

List of Figures

List of Tables & Graphs

ABSTRACT

Warehouse play a vital role in the manufacturing and distributing of goods from raw material to finished product and finally ship/sell to the end-user. Optimizing warehouse material management will make an impact on productivity, quality, and on-time delivery. My thesis focuses on material management of surface mount (SMT) industry and focus from suppliers, receiving and inspection, and warehouse to maximize efficiency. Surface mount is the process of building printed circuit using pick and place machines. The complete SMT line and ready for production, costs over 2 million. This expensive line needs warehouse material management to be improved for better yields or able to meet the line demand. Things like cycle count and picking material are much slower and it makes the overall equipment efficiency (OEE) very low. To make this material management process faster and possible, manufacturers must embrace Six Sigma and Lean methodology and improve the processes. The old way of managing SMT material has been outdated for many years. Since the evolution of intelligent storage in the 21st century is taking shape, it can handle material better and provide maximum utilization of the machines for better OEE. The improved technology can also provide better resources in enabling the process to be more accurate than the current methodology hence gives a better feasibility for continuous improvement.

Chapter 1

Introduction

A warehouse is a place where goods are stored, and commonly used in supply chain logistics. Manufactures, exporters, imports, wholesales, customs, etc. use this warehouse service to store raw materials, sorting and packaging, spare parts, components, and finished goods. In manufacturing, the competitive market is pushing businesses to do time on delivery. The warehouse plays a key role in this Just-In-Time philosophy which states that you get the parts/goods when you need them, and this is from Toyota Production Systems (TPS). The focus of the research will be on the improvement by automating some processes in the warehouse to replace the current manual warehouse.

The variety of different warehouse applications will make the determinations of which direction my research is going to take. We have production warehouses and distribution centers of which, a large quantity (pallet storage), high racking/shelving for small quantities are utilized.

The Typical Function of a Warehouse

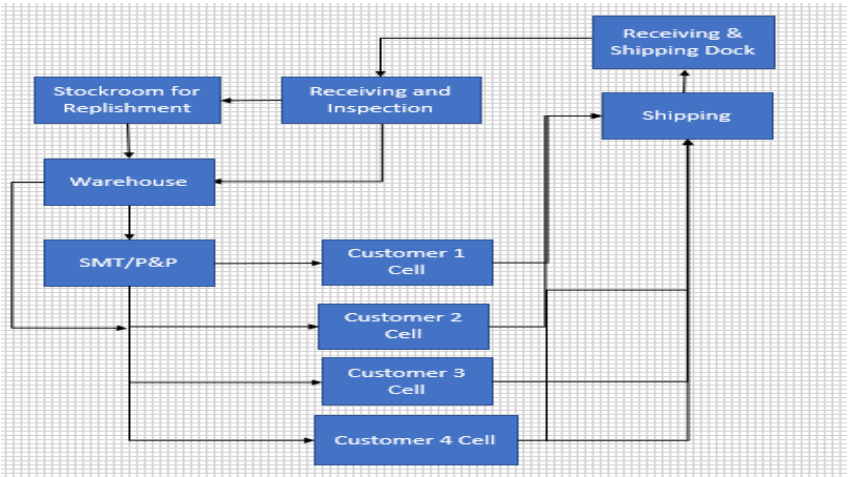


Fig 1

We have different systems being used such as the Warehouse management system (WMS) which is a mechanism used to control the movement of material and the storage material as an inventory. Bill of Material (BOM) which is used for product build and many other mechanisms which I will talk about more as an exploration of this research.

I Have developed an interest in this specific warehouse improvement project because from experience, I have witnessed how the process is labor-intensive and time-consuming. Key areas that have not been discussed a lot are cycle count, accuracy inventory, time spent to store and retrieve parts, and better mechanism to address traceability. Also, the cost of implementation can be an issue even if we may find better options to tackle these processes again. The key elements are to bridge this gap of cutting-edge technologies and give a return on investment (ROI) on warehouse improvement as I will provide a better solution/alternative. I Have done cycle counts numerous times and witnessed how time-consuming they are, and it can sometimes give inaccurate data. This cycle count can depend on different warehouse settings and can be a challenge in many ways.

Normally we must count twice for double-checking the inventory and is better if done by two different individuals to confirm the accuracy of the count. My goal is to prove that this can be controlled through a simple smart storages mechanism which will be discussed further in the next chapters. I will also give the benefits of this type of system on how it transforms production in the WIP and change machine set-ups norms. The system will monitor inventory in the real-life setting and communicate when it drops

a certain level to maintain continuity in production and even ordering of the low parts in stocks.

The second reason to automate/improve the warehouse is because of lower back injuries that result from manual warehouse work. The needs to be possessive as well: Warehouses personnel who do repetitive work by lifting heavy loads are going to develop some type of disability or even die if warehouses and material handling are not going to be addressed.

Anticipations

Upon completion, the research would provide guidelines and an improved warehouse on material management capability with a better optimization on the following key deliverables.

- Components/parts traceability
- Deliver on time
- Accuracy on current inventory
- Automatic updates on inventory
- Significant improvement on order to pick.
- Reduce human resources in a warehouse
- ROI
- Eliminate manual cycle count.
- **Safety-related Manual Handling**.
    - Reduce/eliminate lower back pain (LBP)
    - Avoid pre-mature deaths

  - Savings on disability benefit
  - Reduction on healthcare costs
  - Significantly reduces missing workdays from workers

Tools to be used for better results.

- Six Sigma
- Lean manufacturing
- Value stream mapping
  - Current state
  - Future state
- Time study

Chapter 2

Literature Review

Technologies

Different applications are being explored to manage warehouse supply chain and logistics to improve from old warehouse systems for better warehouse management. RFID is one of the technologies gaining popularity in modern warehouse design.

The case study warehouse management with a lean and RFID application by Chen et.al. states that, RFID is a critical technology for efficiency and effectiveness improvement in manufacturing, supply chain, and logistics. The RFID system can locate, identify, and manage the flow of materials and data throughout the supply chain with minimal human intervention and minimal human errors or zero errors if entered correctly

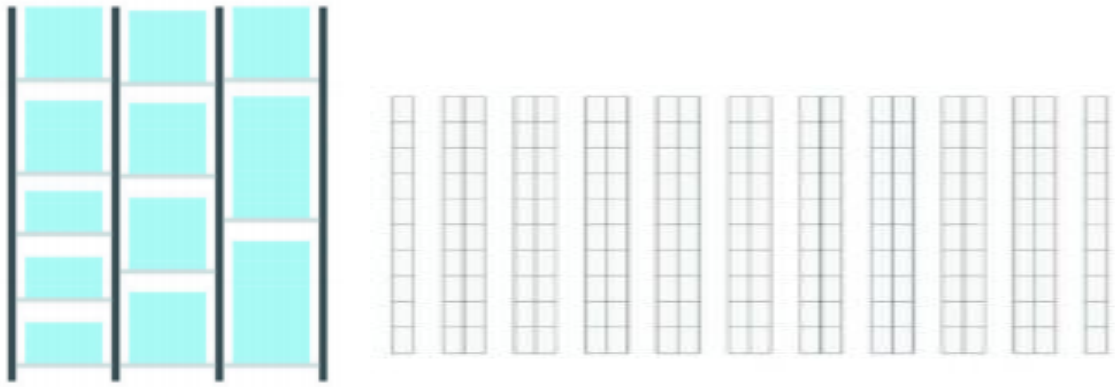
from the material entry time. Components/parts data's current location, status, and history can be stored and retracted on a real-time basis by providing better traceability/visibility for decision making. This can also put alerts when inventory goes low and order promptly for continuous production.

The RFID uses two types of identification with chips installed in them: passive without power and active with power. The antenna is used to send the signal whenever the reader is within the frequency. Chen et al., found that, Saygin compared stocking models which use RFID data on basis of services level, inventory and waste minimization, and decision-making complexity. Then simulated and demonstrated better benefits such as low cost of production solutions, minimal waste, and reduced inventory. All this can boost better customer service delivery, increased accuracy of inventory, reduce lead time, and hence provides better warehouse visibility.

Differences in Warehouse Operations

We have a pallet storage mechanism in high bay racking where you retrieve the pallet as a unit and order-picking warehouse parts/components by using high/low shelving/racking in which operators walk around with a picklist as they pick the orders per job. Depending on the industry, the unit load varies, and/or parts picking vary and is labor-intensive. For example, from the electronics industry where my experience is based, the operator takes a lot of time to pick parts per each job and it can be labor-intensive. Also, we have high/low mix and low/high in our surface mount printed circuit boards (PCB) runs.

Pallet Racking for Unit Load and Layout



Layout 1

Durability

Warehouse or distribution center (DC) stores a range of products, perishable, and non-perishable goods. To ensure that the warehouse system works as intended, first-in-first-out and first-expired-first-out are implemented correctly (FIFO and FEFO). For FIFO, products are shipped depending on their time of arrival and do not consider the shelf life of the product, but the time received dictates the shipping time, but FEFO looks at the expired date and sends those expires coming soon even if they were received later in the warehouse/DC. The mathematical modeling has evolved to different algorithms which are used in different applications to improve warehouse efficiency. For example, as science and technologies are advancing over time, many application possibilities opened to track the temperature of perishable food through storage and freight in the cold chain (Hertog at el.) Wireless sensors such as active or semi-active RFID systems enable real-life monitoring and the current conditions of those products even if when they are in transit. This is the technology also used in the medical industries as Pfizer vaccine needed

cold temperatures, sensors were used in the shipping tracks to monitor the movement of those products and maintain the safety of those Covid-19 medications.

Safety

Low back pain is a public health problem in all the industrialized nations, and it causes disability hence high costs in healthcare and disability benefits. It affects 60% to 85% of all people in their lifetime and between 15% to 30% on any given day (Hincapie et al.,). Every workplace should be cautious about back safety and ergonomics on how to handle heavyweight goods. Chris PTA magazine mentioned that healthcare workers are among the most injured in workplace-related incidents and is the second-leading cause of lost workdays. The US Health and Human Services Department predicates that eight out of 10 workers suffer a back injury at some given time during their careers. Physical therapy teaches good body mechanics of lifting and good body posture, but these movement skills are very complex and therefore difficult to assess subjectively (Kernozek et al., 2006). Kernozek also found that this body mechanics has been unreliable even trained observers doing simple forward lifting tasks cannot be accurately determined unless using some type of sensors.

Handling of material in the warehouse is going nowhere but still workers are affected with back injuries and stay away from work. Some warehouse workers end up in long-term care as well as results in premature deaths. The study, which was done in Denmark 2018, shows that 36% of workers reported musculoskeletal pain several times per week and 7% reported limited work capacity due to pain hence those workers are exposed to occupational lifting which risks lower back pain (LBP) (Blafoss et al., 2018).

From the literature review, I found out that back injury or lower back pain is related to workers' occupational lifting and poor body mechanics while at work and the cost is expensive in terms of healthcare and disability work compensation. If we get a well-designed and automated mechanical lift, will reduce these injuries in warehouse working environment.

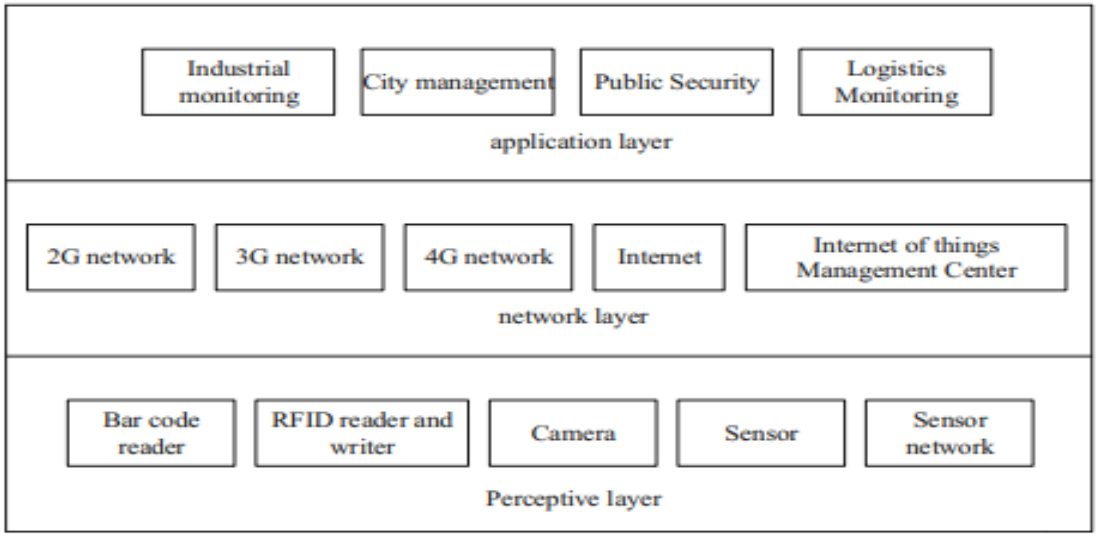
Types of Equipment and Application.

Forklift, Order Picker and AGV

Forklift, order-picker, and Automated guided vehicle (AGV) are used in common warehouses, but AGVs has not been ventured yet in the market as the forklift and order-picker. Multi-objective Automated guided vehicle is a high logistics transport vehicle with great performance and enhanced safety and can achieve an enormous work unmonitored after a computerized schedule is issued. The use of AGV in intelligence warehouses or unmanned warehouses for sorting can improve not only the efficiency of warehouses, (Liu at el,). Therefore, edging the competitive market on quick delivery of parts whenever the destination needed. For those who provide supply and logistics services will quickly seize more competitive market share and with the great help of this emerging of an intelligent and unmonitored warehouse will contribute a lot to it. It uses computer systems, sensors, automatic control navigators, mechanical, communication, and other technologies. Many industries such as agriculture, military, and among others are using this application of robotic intelligence. Its algorithm uses the shortest path possible, (Zhou et al.). With different ideas keep emerging, the rapid development of the Internet of Things (IoT) is also coming into play in warehouse material management

control systems based on ARM micro-controller, emphasizing the high performance, low cost, and easy expansion of the system (Nandyal *et al*., 2017). It is used in combination with RFID with three layers; perceptual layer which captures the first information, network layer where the wireless Apps are deployed to achieve good Wi-Fi coverage in the storage area and application layer for system users (Mao *et al*., 2019)

Internet of Things Layers are Shown Below.



Questionnaire for daily operation

		Questionnaire							
		Material Management Summary							
Customer Name		**Customer's Project Leader:**		**Customer' s Project Leader**		**Other Contact Information:**			

and Location:				**Contact Information**					
Plant #		**Project #**		**Start date**		**Date completed**		**Revision**	
Customer's manufacturing operation information						**Shift 1**	**Shift 2**	**Shift 3**	**Avg OT hours per week**
Number of operators in the stockroom						N/A	N/A	N/A	N/A
Number of operators kitting and returning SMT parts								N/A	5/OPERATOR
Number of operators loading feeders						8	7	N/A	5/OPERATOR
Number of operators running the lines						4	2	N/A	5/OPERATOR
Number of lines running						3	2	N/A	
Average number of kits per shift						4	4	N/A	
Average Kit set up time						2	2	N/A	
Average labor cost for ROI calculation								N/A	

Average number of SMT components per kit	95	95	N/A	
SMT pick and place equipment manufacturer				
Do you use Kanban or supermarket next to the lines?	If yes, please provide the information needed in chart below			
Which Smart Platform are you planning to implement?		**Remarks - Comments**		
Smart Stockroom and Kitting Platform		Please provide the information needed in the Stockroom summary tab		
Complete Smart Storage Platform				
Smart Storage Kitting and Line set-up				
Additional Questions:				
Are you space constraint? Yes		**Stockroom size**		
Do you use in plant store?				**Yes**
Do you have consigned inventory that you need to manage?				**Yes**
Average monthly machine down time due to material issues, such as shortages or waiting for kits, long set up time etc.				**32Hrs**

Approximate annual scrap cost due to wrong build because of material inaccuracy	
How much time does it take to find a part in WIP? (Replenishment)	**36 seconds**
Has your line been down due to inventory inaccuracies? Yes	**Yes**
How many times has a wrong part been set-up on your machine?	

Reels	**Width**								
	8mm	**12mm**	**16mm**	**24mm**	**32mm**	**44mm**	**56mm**	**Other**	
7" Reels	**6400**	**424**	**300**	**30**		**10**			
10" Reels		**15**							
						16			
13" Reels			**400**	**300**		**16**			
15" Reels						**216**			
Other									

Table 1

Chapter 3

Methods of Improvement, Reports, and Discussion

From literature review and experience, material management and handling play a critical role in the manufacturing and supplying quality products, on-time delivery, and product traceability. In connection to that, I will apply continuous improvement tools and methodology for better processes. I will utilize lean all the time to make sure the process is monitored for any changes for improvement or if it remains in control.

For the project to be successful, I will also, explore more Six Sigma tools (DMAIC) to analyze every step for improvement. Key areas to be studied are receiving and inspection, warehouse, and surface mount technology (pick and placement machines). The current problems surface mount lines are experiencing are PTS, change over time, and quality (rate DPMO). I will consider human labor and automating some of the processes during this study.

Receiving and Inspections Analysis

The current process in receiving and inspection is affected by issues from the supplier/manufacturer, creating a tracking excel log to record those issues. The backlog of material stretches up about two months of a timeline to be solved.

Production Flow Chart.

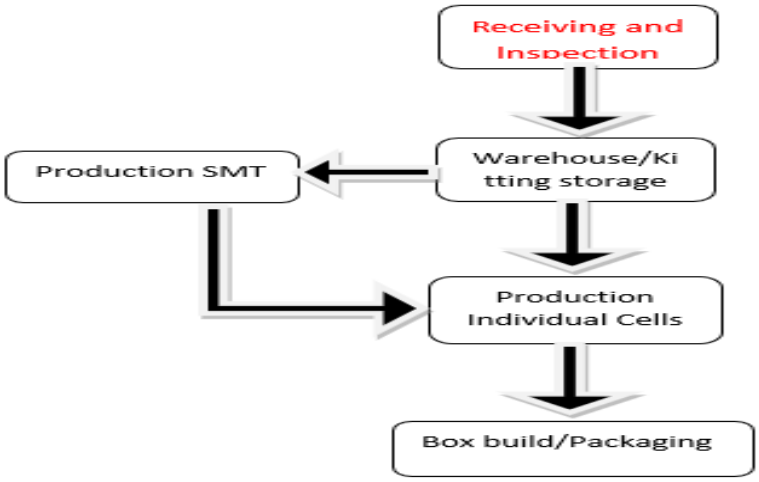


Fig 2

The flow chart above shows the material flow from receiving through packaging and ready for shipping.

Receiving Flow Chart

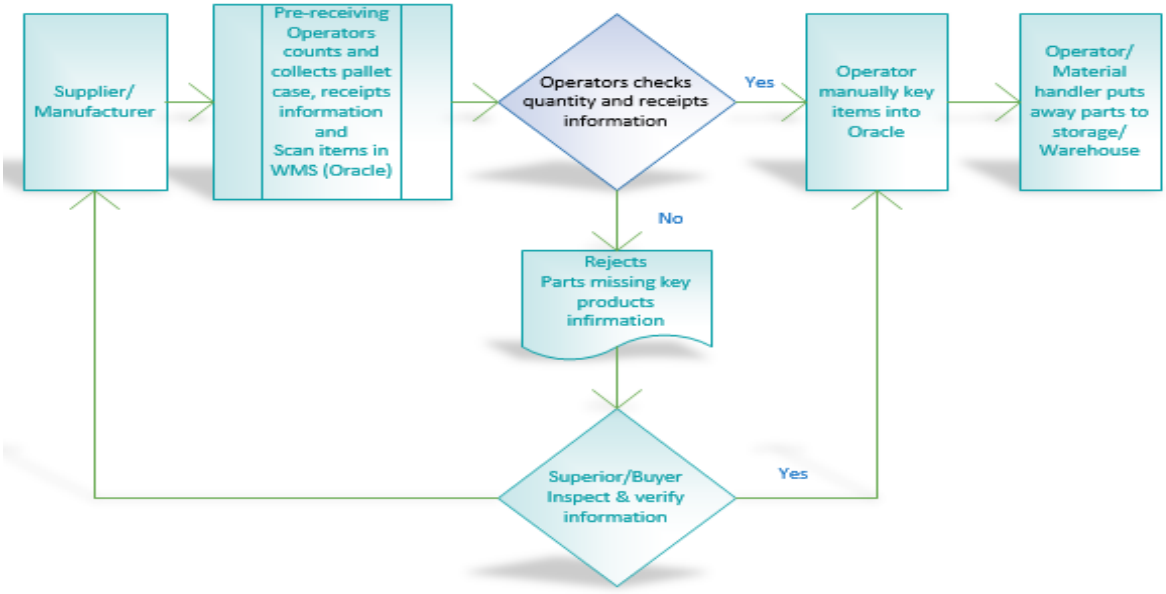


Fig 3

All these systems must communicate with each other for the process to be effective. Optimize material handling and management; will improve product efficiency, reduce product cost, and improve the quality of products. The material handling is estimated to costs between 20 and 50 percent of total product cost even if it does not add value to finished goods (Robert at el), and typically the value for finished goods is about 5 percent. Improvement in receiving and inspection can have an impact on the process downstream.

Current Receiving and Inspection Value Stream Map Analysis.

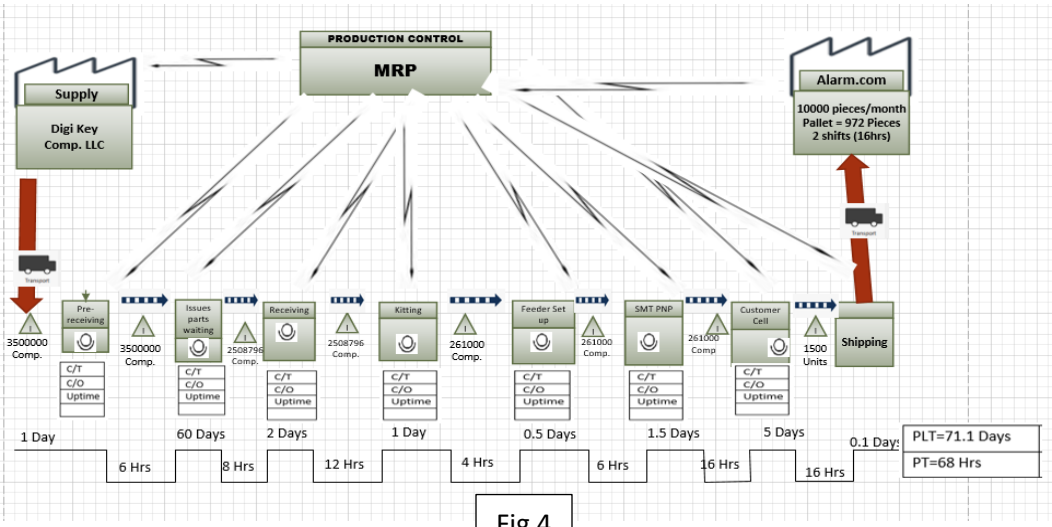


Fig 4

Problems Experienced Daily at Receiving and Inspection

Item	Code	Criticality
❖ No PO/Closed/Cancelled/Incomplete	1	Major
❖ Requires Reapproval	2	Minor

❖ Need Certs	3	Major
❖ No Inspection Folder	4	Major
❖ First Article	5	Minor
❖ Manufacture P/N does not match	6	Major
❖ No Packing slip	7	Major
❖ Quantity Issues	8	Critical
❖ No locators	9	Minor
❖ Expense Items with no owner attached to PO	10	Minor
❖ Misc. - tubes instead of reels; damaged parts	11	Critical
❖ Early Receipt date	12	Minor

Most of the time, small things not done correctly can cause other tasks' defects. Once the material arrives at the dock, the material/forklift handler receives and signs off to confirm receipts. Then they are pre-received by quick scan to oracle and sorted according to size/quantity for inspection. The parking slip always in the packaging boxes and it carries all the information required to complete verification to oracle. If the inspector finds information matches with the items and no damages, it can be entered and confirmed as received into warehouse management system. Still if not, the information is logged into issue list excel sheet with identified codes. The parts that don’t match the descriptions, can be rejected by the receiving clerk, and forwarded to superior personnel

for further inspection and verification on what is missing. Below are some of categorized issues in receiving.

Cause-and-Effect Table for Further Investigation.

Materials	• Shortages • Lack of traceability • Lack of control • MPN doesn't match Oracle • Missing parking slip • Overstocking/understocking • Mixed parts • Wrong packaging
Methods/Process	• Lack of procedures • Long and unnecessary procedures • No notifications
Manpower/labor	• Lack of labor • Unskilled labor • On the job training
Machines/Equipment	• Lack of modern tools • Broken hardware

	• Not enough computer • Software
Mother nature/Environment	• Bad weather related to storms, snow, tornedo etc
Measurement	• Lack of KPI metrics • Lack of methods to collect data • Lack of right tools to collect data

Table 2

Fishbone Diagram.

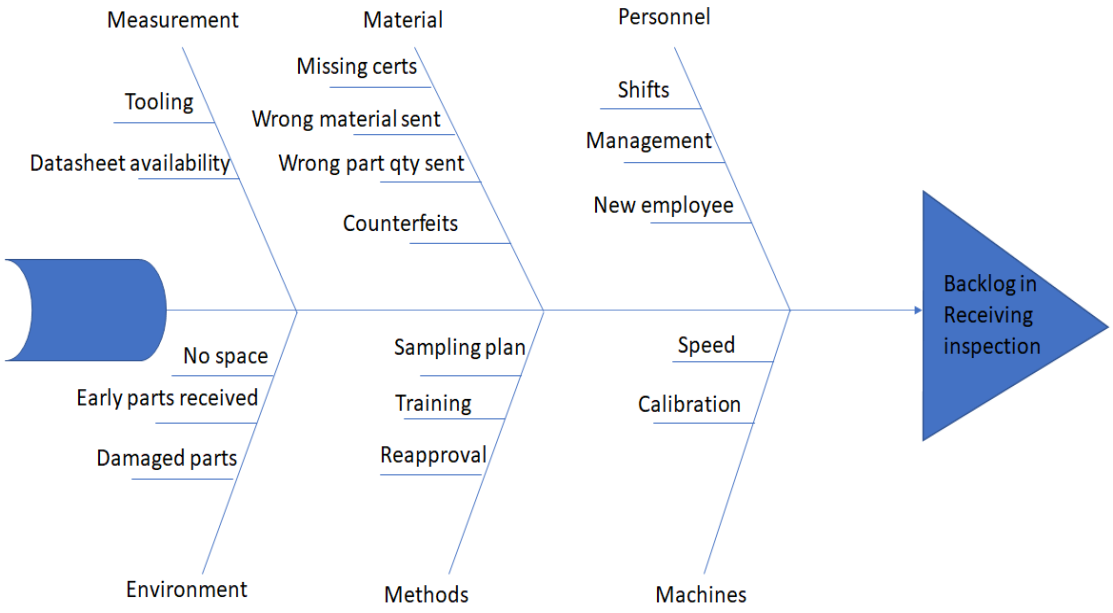
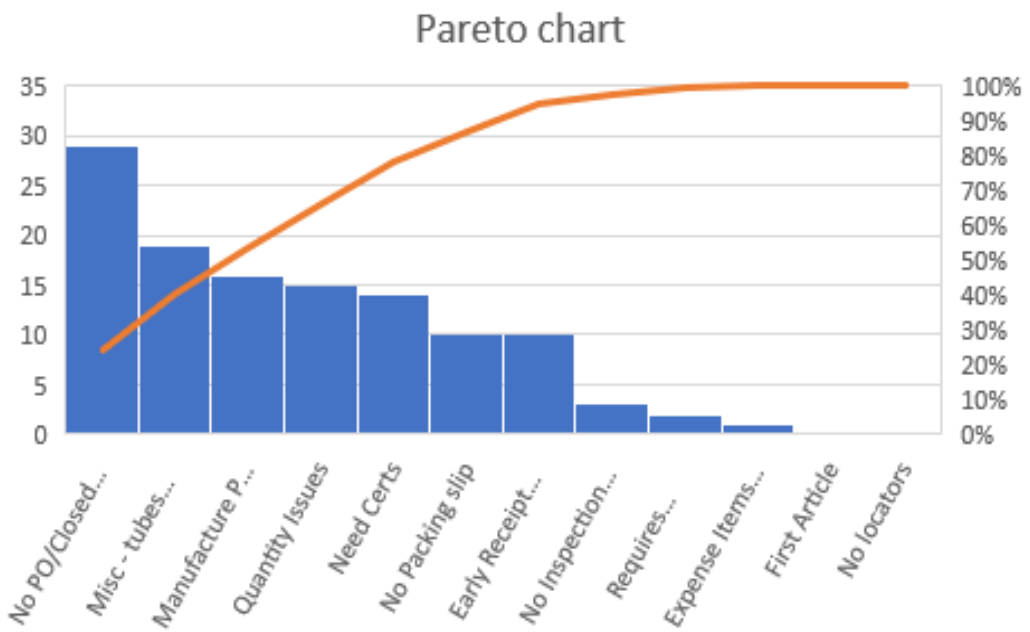


Fig 5

The Occurrence of Issues in Receiving and their Codes

Code	Item	Origin/responsible	Issues
1	No PO/Closed/Cancelled/Incomplete	Internal	29
2	Requires Reapproval	Internal	2
3	Need Certs	Internal/extenal	14
4	No Inspection Folder	Internal	3
5	First Article	Internal	0
6	Manufacture P/N does not match	External	16
7	No Packing slip	External	10
8	Quantity Issues	External	15
9	No locators	Internal	0
10	Expense Items with no owner attached to PO	Internal	1
11	Misc - tubes instead of reels; damaged parts	External	19
12	Early Receipt date	Internal/extenal	10

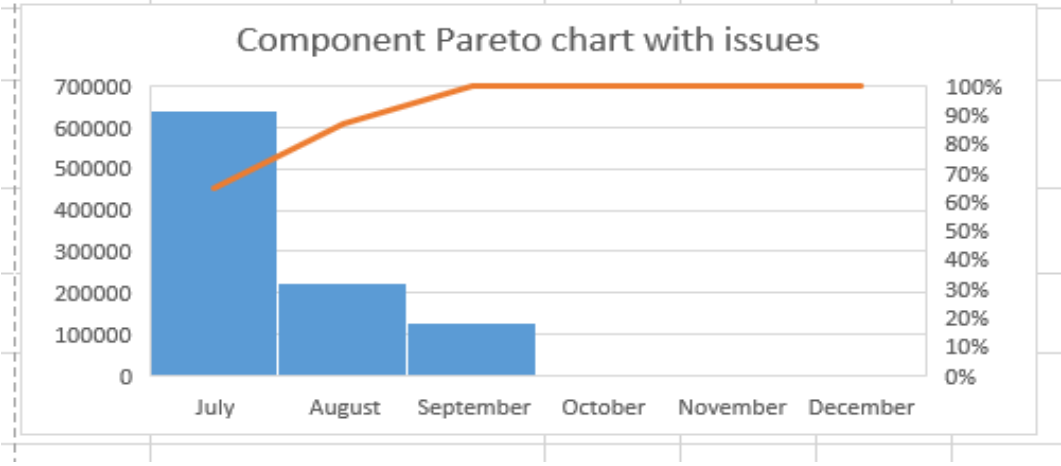
Table 3



Graph 1

Three months Pareto Chart issues

Month	Total componets with issues
July	642556
August	222725
September	125923
October	
November	
December	

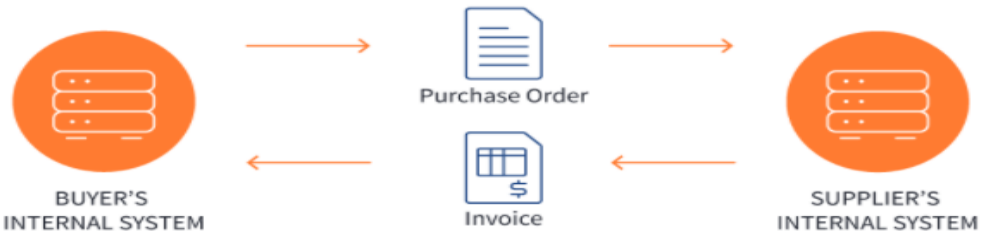


Graph 2

Receiving Improvement

From value stream map**,** the identified issues can be addressed in the following suggested means

- Using electronic data interchange (EDI) will eliminate things such missing parking slip, purchase orders and no certifications. Manual entry will be eliminated as well as shown below from their website image.



The EDI documents use a standard format to enable computer read and understand it. We have several options of EDI in use today and they include ANSI, EDIFACT, TRADACOMS and ebXML and they have different versions. There must be an agreement on specific EDI standard and version to use among business partners (EDI Solutions, North America 2021).

Easy Steps on EDI

The data segments in EDI transactions are the individual items of information within the document. It can contain purchase orders and invoices that contain city, state, country, item number, quantity, and price. This can make receiving easy by tailoring the needs to include the format which satisfy whatever applicable to individual businesses and can eliminate the loss of information.

The example below shows the related data group which you can expect the EDI transmitted document contains. They are four sections, each providing a different set of

information. The image below is obtained from EDI website.

If this information is included in the EDI, pre-receiving can easily be done and the missing of necessary documentation will be no longer the issue and delays will be absolutely minimized to zero defects. This format of EDI is an example on how to improve receiving and communication between buyer, supplier, receiving and storage of the products.

Chapter 4

Warehouse Management

Success on any supply chain depends on well managed warehouse system management. Dr. Edward wrote world-Class warehousing in 1995 and people were worried why he did the study and wrote about warehouses system as it was to be faced out by lean manufacturing. The question then depended on why we kept the inventory? Let us think about the end user (customer)'s needs. For example, if you go to the grocery store and miss an item you needed urgently, what will happen? Of course, you would not

be happy but think of the time you have wasted. Mostly, the customer would need their orders filled whenever they needed. Continuous flow of products alone can keep the existence of the warehouse (customer satisfaction).

The focus should make warehouse management efficient and cost effective. There are different application depending on bulk, quantity, sizes, and types of parts ranging from small to large and with different weights.

What Happens at the Warehouse?

- Incoming goods
- Receiving goods and labeling
- Check and affirm the quantity and quality
- Sort and put away to respective storage location
- Order picking - material Retrieval
- Fill in orders to different customer cells
- Shipping destination
- Load and check the outgoing orders
- Replenishment

Internal Warehouse Process Flow Chart

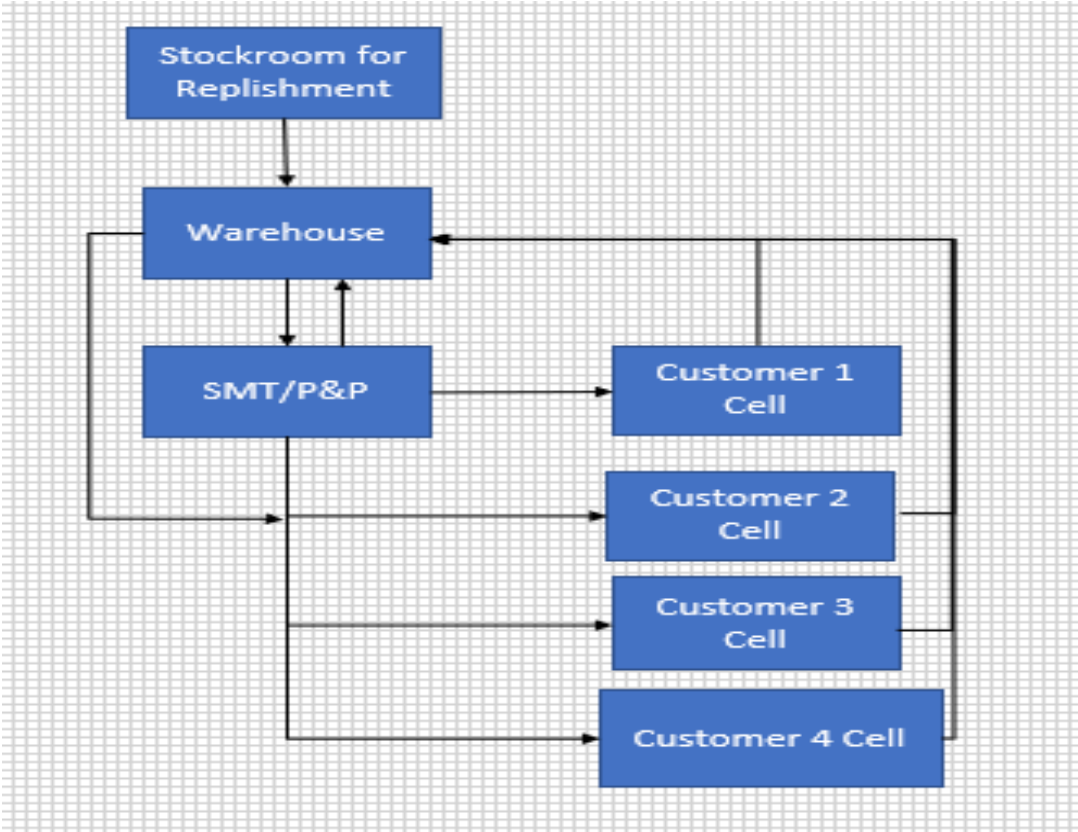


Fig 6

The flow chart above shows how material flows and kitted to different customers within the manufacturing processes following specific orders. Rack and bin material arrangement for SMT kitting by Identification part number (IPN) from small to biggest and in sequential manner and grouped to a specific customer or using locater-based system. It is easy to approximate the place to be picked from, but there is more challenge in picking at a faster rate. Locator based picking, is a system used to assign each part to a position using the aisle number, self-number and how high in the racking. This method is

much faster than using IPN since it directs to shelve number but still the operator tends to count the shelves to locate it.

To better improve warehouse performance, I must do kitting by reducing non-value activities within the process such as delays in receiving, putting away parts, picking, packing, and loading. Also, I consider picking path, ergonomics, congestion and functioning condition of equipment and availability. From chapter one on receiving, I have identified things which causes delays in receiving and can be easily eliminated by following some simple procedures and control measures. I will provide later in the discussion.

By attaining a good process flow, is to provide current value stream map from which I can be able to create the anticipated future value stream map that can provide a better improvement. Therefore, is essential having a point of reference as you correct some of the identified non-value steps. Involving key stakeholders by accommodating all their suggestions to be evaluated by the team members. Questioning every step if it makes sense, develop some justification before improvements and run the process to check the errors. Consider 5S +1 during the process. Some of the challenges experienced in the warehouse are evaluated below to give more insights and help design a better process.

Challenges of Material Optimization

1. Available parts go missing – most cases parts in stock are misplaced and/or go missing as it can cause major challenge for SMT operations or shutdown. Parts

can be readily available in the system, but traceability and locating them is a big challenge.

2. Poor record inventory management – the material flow and restocking can provide false information such as missing parts, and parts put back in the wrong bins. Material picking, putting back, and receiving in, needs to be synchronized
3. Poor floor layout – unorganized floor layout causes material labor intensive. Material stored in a right condition like moisture sensitive devices (MSD) needs to be controlled and comply with its use. Large area or distance warehouse causes unnecessary movement and consumes a lot of time
4. Parts shortages – dropping components during set up and running are not accounted for and can give false information about the inventory.
5. Cycle count – although regular material count help in adjusting the inventory and benefit from quick responding to manufacturing but, it's a non-value-added process that increases cost to production. Some other parts like SMT takes longer time when you use mechanical counting devices and is slow.
6. Right label on a wrong part or wrong label on a right part- this happens all the time and makes information false to the user.

The value and non - value process map below, is assigned tasks in each stage and some of the issues related to the next step.

Warehouse Value and Non-value-added flow Analysis Map

Fig 7

The value-added analysis is useful in identifying what needs to be studied for improvement. From the above process flow, I will add another layer for what happens daily on each step and analyze them for better results. This outside layer is very essential because it provides everything which happens and why they happen. If there is data, it will be analyzed to find the root cause of any problem or if it's the benefit, can be documented to control the process.

Value and non-value-added Analysis and the Related Issues

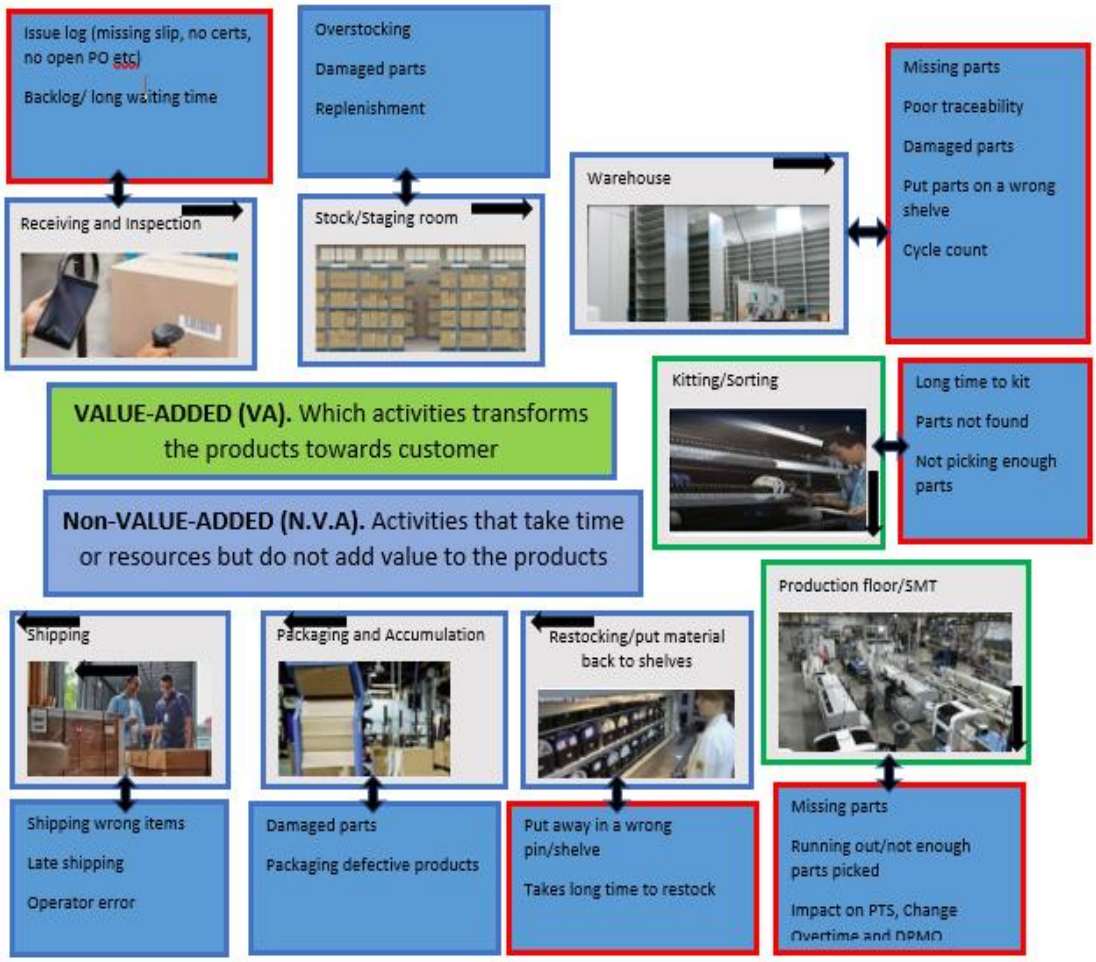


Fig 8

Issues to be Addressed in Warehouse are:

- Parts missing
- Kitting time
- Not picking enough parts

- Lack of traceability
- Cycle count
- Restocking parts on wrong bins/shelve
- Right label on a wrong part

Chapter 5

Surface Mount Inventory Management

Material handling and management is one of the biggest bottlenecks most SMT companies are experiencing. For many years, companies have sat down and relaxed and work on other improvement to improve processes, but the struggle persists, and this now needs a closer look and find the best solution. I have never known that $.26 part can stop the entire pick and place line because we cannot find the parts in shelves. The price tag of running the line is about $300 an hour excluding labor. Also, the total cost of full surface mount line is about 2 to 3 million and it has a depreciation value on it. By looking at the values of the equipment, something needs to be done to better maximize the output efficiency of the line.

Current Storage System

Rack and bin are the most used method of component storage, and it has been there for many years and companies assume without cost analysis that it will be expensive for other alternate methods currently emerging. Its manually intensive where materials are arranged in racking/shelving, unit pallets and carts. Then the operator uses order picking list to pick the materials. Forklift, pushcart, ladder, pallet jack, and

order picker for high bay is applicable in this process, and they are labor intensive. The process has a lot of movements and time consuming.

High Bay Racking

Fig 8

From receiving, warehouse kitting and put away components, it has shown to be a challenge in how efficient the SMT line can run and account for Overall Equipment Efficiency (OEE).

Identified common critical problems in SMT processes which need some serious consideration done for better control and productivity. Problem such as missing parts,

wrong label from receiving, wrong part placement, cycle count, long time kitting/waiting, not enough parts picked, kit verification and traceability can cause animal like food chain problem. Remember everything depends on one another for continuous existence of its prey otherwise extinction can be the results. If these issues are addressed from warehouse and receiving, the SMT efficiency will improve by big margin.

Types of Better Solutions and Application for Improved Process

Carousel Systems

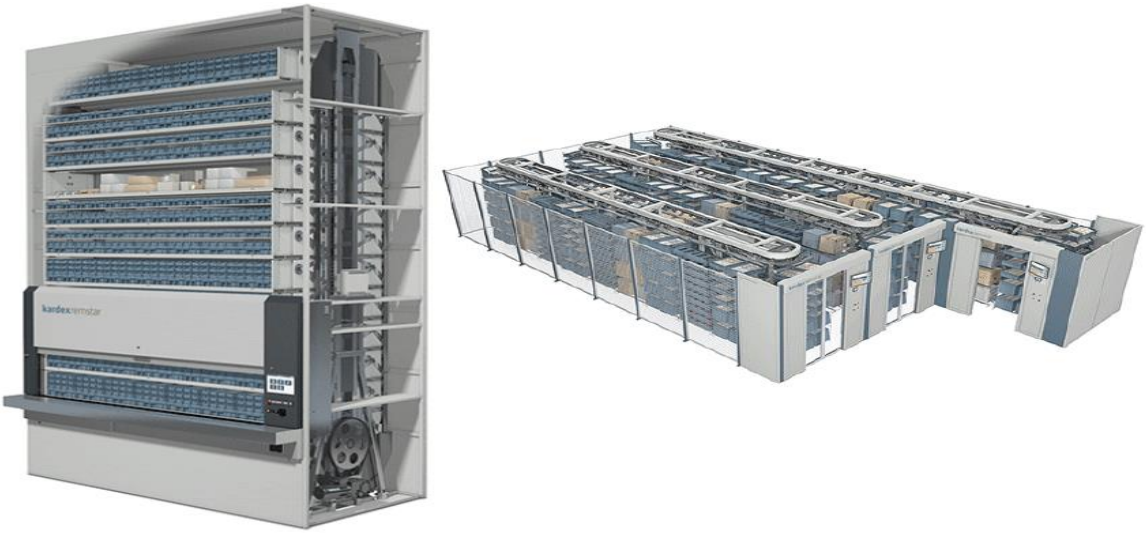


Fig 10

There are two types of carousel systems: Vertical that utilizes the maximum ceiling space and takes less footprint in squire footages, and the horizontal which rotates the shelves around same axis which brings part to the operator to pick by light. The horizontal has similar application except going around horizontally with increased footages. Maintenance cost is expensive and can cause potential bottleneck during break

down. Other similar storages of this kind are Modula. Cost estimation depends on the number of materials stored.

Fig11

SMD Storage Towers

SMD Storage Towers automatically retrieves and store using robotic system. The operator puts in the request on the kiosk window for kitting parts and walks away to do other things as the equipment kit the 45 components in 3 minutes with zero operator error. This can be linked to ERP system for material management. It's very expensive both to buy and installation plus ongoing maintenance. Potential bottlenecks in case it fails.

Scienscope Smart Storage Rack

Fig 12

Receiving machine

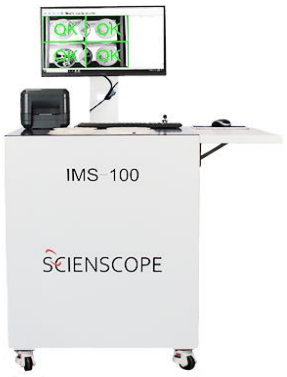


Fig 13

The Scienscope smart storage rack is most precise and accurate to store SMT components. It integrates best with a Sceincscope component counter and incoming Reel labeling machine that provides unique ID and inventory traceability or can provide the exact location by lighting the LED light. They Provide benefits of easy to move, easy-to-use software, small footprint, multi-kitting, and auto slot assignment by LED light. IMS-100 Sceincscope system will automate the incoming goods and has high-resolution barcode camera system with image-based algorithm reads any barcode, even those with defects. It comes with free MES and ERP integration, faster receiving cycle time, automatic data entry in ERP, new label double-checks mode and simple point click with advanced inspection routines. The information and images are provided in Scienscope website.

Innovax Smart Storage Solution

This system provides solutions by using LED light to call out the kitting of components. It can detect when components added or removed. It uses control units to operate multiple carts or racks which allows for expansion and increase capacity overtime. It is flexible and easy to integrate with MES system or ERP system. It provides pick time of less than 4 seconds a reel and 8 seconds to put away. There is a maintenance and an annual support fee, and if the tray breaks, the whole tray must be replaced.

Figs14

XRHCounter X-ray

XRHCounter X-ray, is a plug and play x-ray component counter which does not need any programming and the new software version has a very intuitive user interface that developed with touch screen. Can optimize cycle time through improved software and hardware.

- The new generation is up to 20% faster and counts within 8.5 secs per reel
- System ready for robotics
- Easy to integrate with customer's existing systems (ERP)
- No maintenance
- $70000

Fig 15

Current Process Flow Vs Future State Process Flow

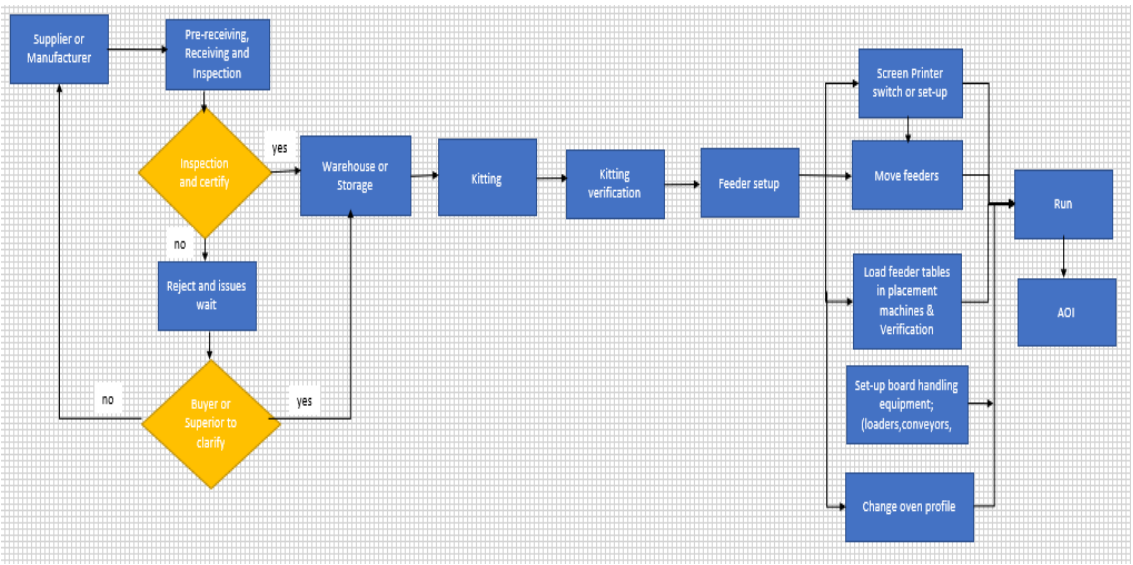


Fig 16

Detailed Value Added and Non-Value-Added Flow Map

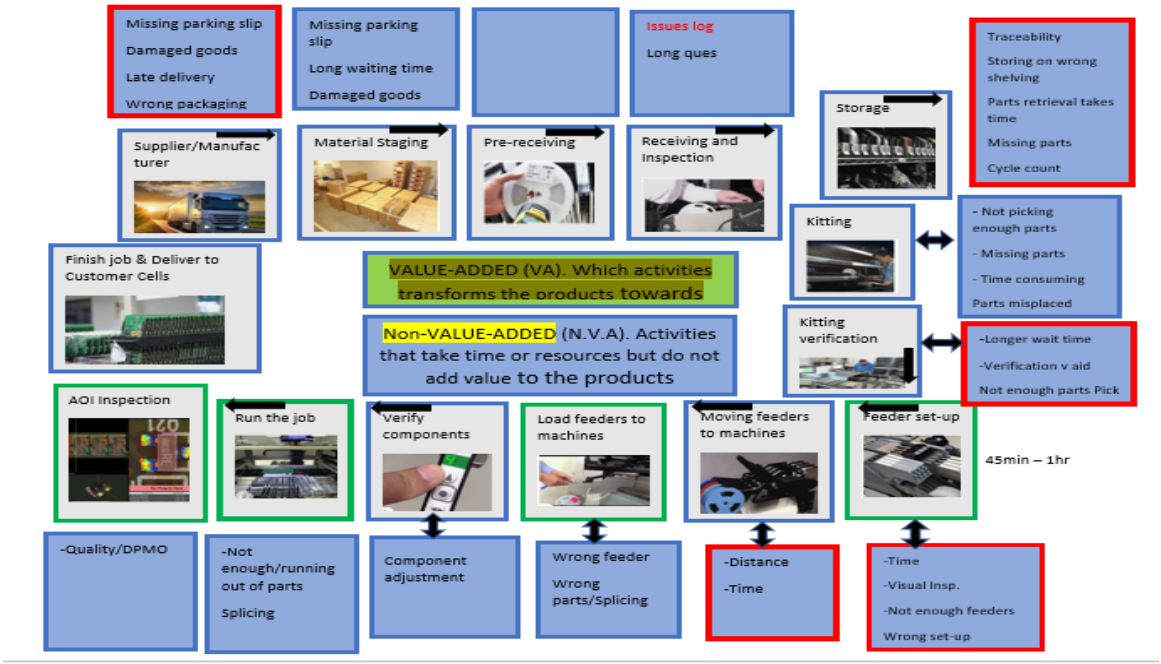


Fig 17

The value-added and non-value-added flow map helps identify each activity in each process and can help improve the process by eliminating waste. The red box is the area of interest in making this process efficient if better designed and implemented. Showing the entire process can help support evidence of how issues transfer down the process and, if prevented at the source, can stop defects from happening.

Future State Process Flow with Identified Issues

I can improve the identified and highlighted boxes with different colors below and create the new process flow.

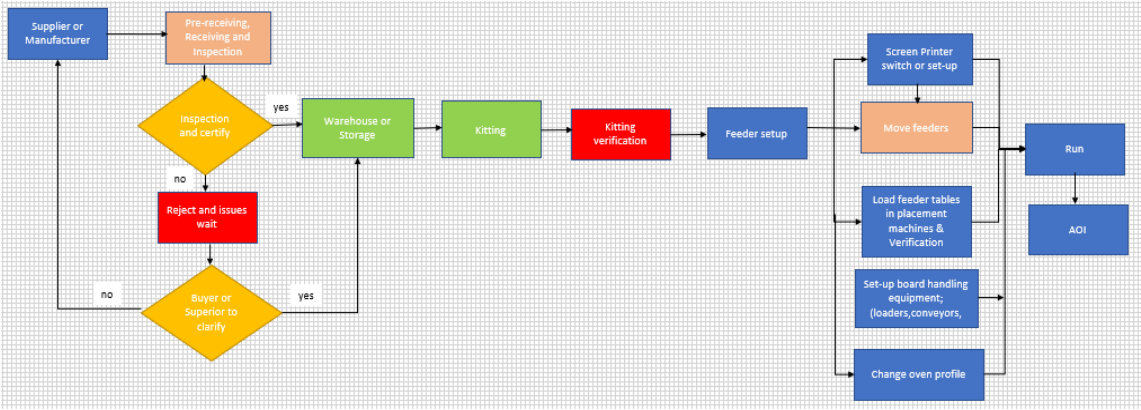


Fig 18

Improved Future State

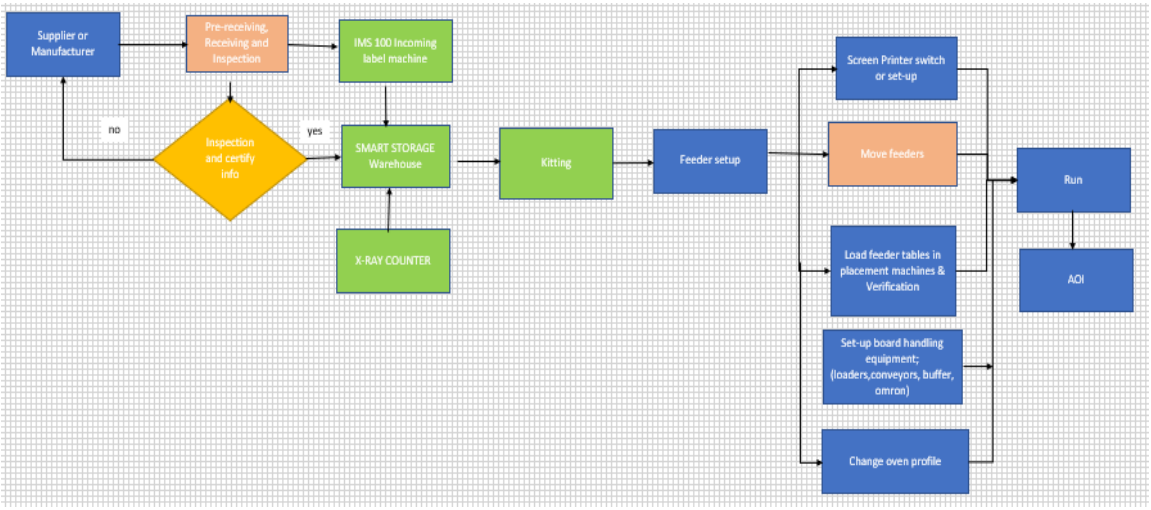


Fig 19

Material and Cost Analysis

The capital for smart storage depends on how many reels, tubes, trays, and PCBs are to be stored. To account for the need, we must get all the inventory at hand and set the buffer to the stock. The table below shows different size tapes ranging from 8mm, 12mm,

16mm, 24mm, 32mm, 44mm, and 56mm. I should take the diameter of the reels into considerations. I have picked some of the intelligent storages vendors to analyze the cost of the project. Have factored in other issues encountered to help pay the project. The table below shows the quantity stored in the new inventory systems and the cost associated with intelligent storage. They come in different designs; semi-automatic, assisted by scan, and automatic, which use sensors to send a notification after placement or removal. SMD is fully automated because it does the kitting for you to pick them at the window of the machine.

Quantity of Material to be Managed

Creation Technologies Q#2509	Quantity of	Quantity of	Quantity of	Quantity of	Quantity of	Quantity of	Quantity of	Quantity of	Quantity of	Quantity of	Total Locations Requested	Total Excess Storage Locations	Total Locations to be Provided
Reels/Packages	8mm	12mm	16mm	24mm	32mm	44mm	56mm	72mm	Tubes	Trays			
7" Reels Requested	6400	424	300	30	0	10	0	0	0	0	7164		
7" Reels to be Provided	6640	480	300	36	0	20	0	0	0	0			7476
7" Excess Reel Locations	240	56	0	6	0	10	0	0	0	0		312	
13" Reels Requested	0	15	400	300	0	16	0	0	0	0	731		
13" Reels to be Provided	0	30	400	306	0	20	0	0	0	0			756
13" Excess Reel Locations	0	15	0	6	0	4	0	0	0	0		25	
15" Reels Requested	0	0	0	0	0	216	0	0	0	0	216		
15" Reels to be Provided	0	0	0	0	0	220	0	0	0	0			220
15" Excess Reel Locations	0	0	0	0	0	0	0	0	0	0		0	
Tubes Requested	0	0	0	0	0	0	0	0	30	0	30		
Tubes to be Provided	0	0	0	0	0	0	0	0	48	0			48
Tube Excess Locations	0	0	0	0	0	0	0	0	18	0		18	
Trays Requested	0	0	0	0	0	0	0	0	0	60	60		
Trays to be Provided	0	0	0	0	0	0	0	0	0	72			72
Tray Excess Locations	0	0	0	0	0	0	0	0	0	12		12	
Total Locations to be provided with this proposal:	6640	510	700	342	0	260	0	0	48	72	8201	367	8572

Table 4

Cost Estimate of Different Systems and Vendors

No		Total quantity stored	Vendor equipment Name	Cost
1		8600	Innovax smart storage	$307 200
2		8600	Cluso	$ 193 585
3		8600	Scienscope Smart Storage Rack	$150 000
4		8600	SMD storage towers	$350 000
5		8600	Carousel Systems	$192 000
6		8600	Kardex	$232 000

Table 5

Time Saving Tables

Planned kit per shift is 4 jobs and which makes 8 kits for our 2 shifts. Average kitting is about 90 reels/tubes/trays.

No. of Kit/Day	Quantity/kitt	Using locator pi	Total time	Smart pick	Total time	Time Sa	Year lost hours
1	90	36	54	4	6.0	48.0	
2	65	36	39	4	4.3	34.7	
3	53	36	31.8	4	3.5	28.3	
4	89	36	53.4	4	5.9	47.5	
5	65	36	39	4	4.3	34.7	
6	106	36	63.6	4	7.1	56.5	
7	44	36	26.4	4	2.9	23.5	
8	94	36	56.4	4	6.3	50.1	
						323.2	
Total time						5.386667	
Total time						6 hours	1564.2
Kitted components verification				**Put away time parts**			
No. of Kit/Day	**Quantity/kitt**	Time		Locator	Smart store		
1	90	67.5		36	8	42.0	
2	65	48.75		36	8	30.3	
3	53	39.75		36	8	24.7	
4	89	66.75		36	8	41.5	
5	65	48.75		36	8	30.3	
6	106	79.5		36	8	49.5	
7	44	33		36	8	20.5	
8	94	70.5		36	8	43.9	
Total time		454.5	7.575			4.7	1228.766
Total time		8 hours					2085.6
Other time saving							
		Time in minutes	Time in hours				
Parts Missing		3294	54.9	Eliminated			54.9
Part Exhaust		144051	2400.85	Needs improvement			1200
Part issues		5530	92.1666667				
Cycle time			1040				1040
Total time lost							7173.466

Table 6

From the table above, we have a total time saving per year of about 7175 hours; time lost could be more than 3705 but only accounted for parts missing, kitting verification, and parts picking when kitting for the job and left out the part exhaust, part issues, etc. This can be equivalent to two full-time employees. Exhaust parts have a lot of wasted time and need much attention, 2400 hours a year. If splicing is utilized, there is possible of more than half of the time saved. I will be studying how better component

splicing and using extra feeders can benefit shrink these hours down. The number of hours lost/wasted can pay for the intelligent storage for about two years.

Improved prcesess flow after new smart storage afater installation.

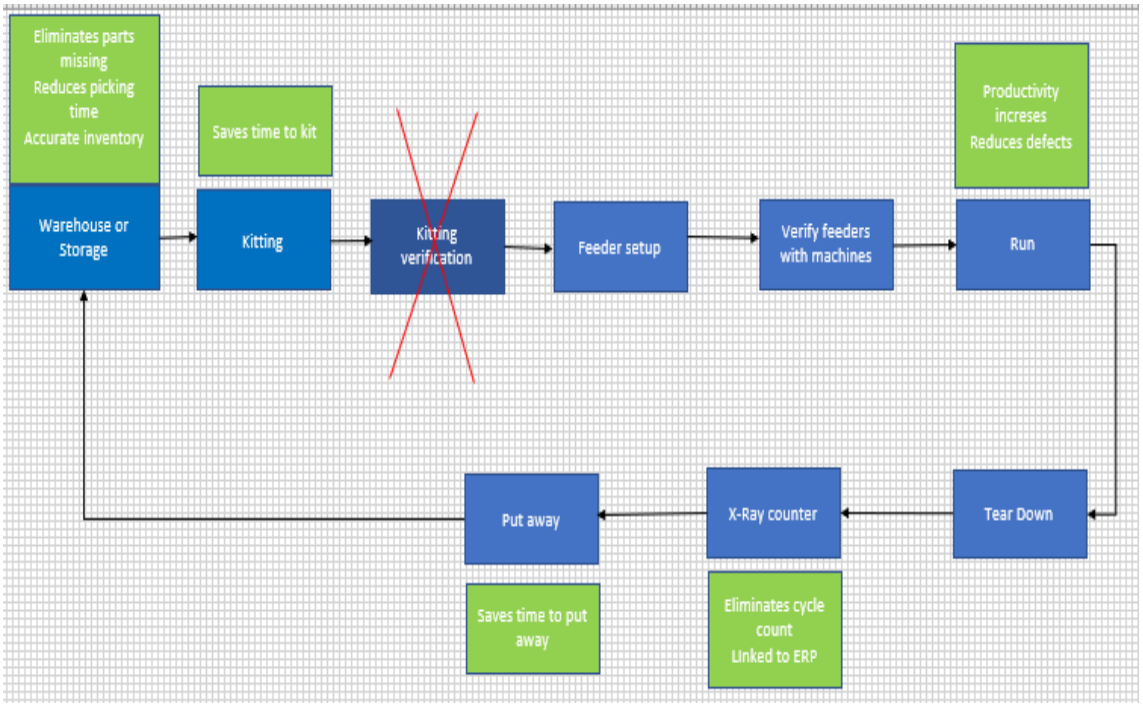


Fig 20

New process flow

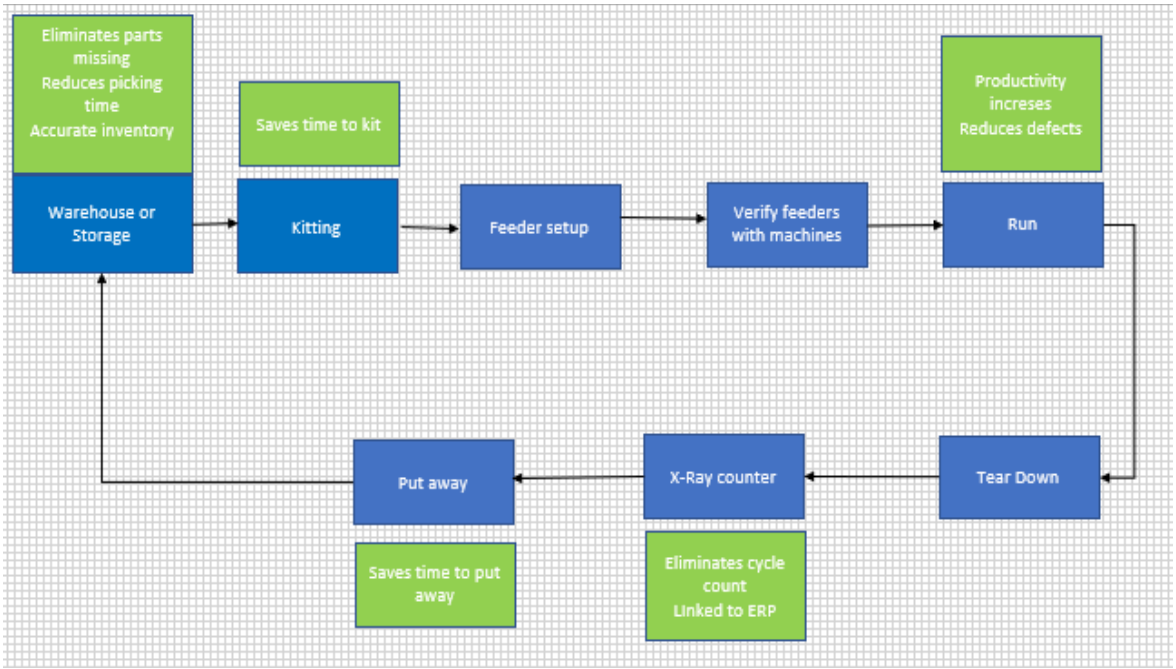


Fig 21

Process control

Receiving and Inspection, Warehouse and SMT Systems Control and Documentation

Proper records and accuracy of material management depends on the following:

1. Receiving standard procedures and methodologies to be put in place for the incoming goods
2. Placement of proper purchase order (POs)
3. Proper packaging information (accurate packing slip)
4. Proper tools

5. Proper methods of collecting data for improvements
6. Trained personnel/skilled labor
7. Proper location for all material in storage
8. Regularly of inventory updates
9. Proper notification to all involved departments
    a. Buyers
    b. Suppliers
    c. Owners
    d. Accounting for billing

In this type of accuracy and proper management documentation control of information requires some short of capital and can be cost-effective over manual systems. Most company have done great improvements but still more needs to be done to incorporate to the ERP systems which can integrate easily to other automated and retrieval systems (AS/RSs) for quicker and faster processes.

Important Key Notification to Manage Process

Right buyer—right supplier – right storage – right application – right stock – right movement

- Buyer determines the accuracy of purchase orders and timely invoices to suppliers
- Suppliers makes sure that right quantity, quality, and all packaged information are accurate

- Right storage- providing an organized material space for easy access and identification
- Right application- regularly monitored and protected for accuracy and faster retrieval of information
- Right stock – have adequate inventory for quick customer respond
- Right movement of material – how quick you access and retrieve right parts JIT.

Chapter 6

Benefits of Warehouse Improvement Provides in Relation to SMT Process Optimization

Process is like food chain science, as the grass dries up some animals dies away and vice versa. Manufacturing processes can have the same effect as the waste increase, productivity goes down south.

Importance of Semi-automated Warehouse

1. Minimizes or eliminates human error
2. Productivity will go up by using automated equipment and picking assistance devices such as picking by light or conveyorized transportation.
3. It adds value to non-value-added activities e.g., reduces a lot of movements by utilizing equipment like robotics
4. Increased product security – reduces product damages as compared to manual handling

5. Inventory control – use of warehouse management system (WMS) with smart storge can make it possible to identify and monitor stock in real time.
6. Can create employee satisfaction more especially when doing heavy work or jobs which consumes a lot of time kitting.
7. It can eliminate manual cycle count.
8. It can let people do more important tasks as the automated process does the non-human labor
9. Reduces DPMO hence customer satisfaction
10. Faster delivery (Just-in time)

Conclusion and Summary

Surface Mount Technology does a great work in the manufacturing of electronics devices which are used for different application from medical, aerospace, phones manufacturing, house appliances and all other stuff that we encounter daily. I chose to study and research SMT and warehouse to improve material management and ensure quality productivity and efficiency is achieved. Why? Defective products hurt consumers and as I mentioned, we use these electronics all the time. By improving these processes, you reduce employee frustration and increase morale of doing good job with much attention. Not only that, but it has also become hard to get people to work and fulfill the current demand for production and this be an added benefit to human resource.

I found that Quality, productivity, and overall equipment efficiency is impacted by many things in workplaces. Poor process flow is one of them as you get things mixed and end up producing defective or shipping wrong products to consumers. There is a huge waste of time in many of the processes in most companies and which does not add value to the product but deprive opportunity to build quality products. Some of the issues studied and evaluated were cycle time, missing parts, kitting of parts, not picking enough parts for production, lack of traceability, restocking parts on wrong bins/shelve and one other thing I noticed while studying, were labels being put on wrong part or labeling right parts with wrong label. Guess what? This made a pick and place equipment to building defective products of 600 printed circuit board assemblies (PCBA) and ended up slowing production in other departments as well as creating more rework to the process.

If the improvement of receiving & inspection and warehouse is implemented with modern technology equipment such as scanning and labeling incoming goods properly, using a smart storage system to retrieve and put away parts, and having procedures in place; it will eliminate parts available going missing, reduce the amount of time used in kitting parts since it will be picked by light instead of paper copy and match. It eliminates cycle counts if an x-ray counter is implemented and increases productivity. I found the company loses about 7175 hours which is equivalent to three full-time employees for one machine, and this can save human resources from sourcing out those extra workers. From the calculated wasted time, it can be able to pay off the equipment for a timeline of fewer than two years. The below table provides each category's exact amount of timesaving.

Yearly time lost in hours

Items/Descriptions	Times saved
Kitting of materials	1565 Hours
Missing parts	55 Hours
Cycle Time	1040 Hours
Put away parts	1229 Hours
Part Exhaust	1200 Hours
Kitted component verification	2086 Hours

Table 7

Return on Investment

The table below provides return on investment (ROI) estimates by taking annual time saved from kitting of material, missing parts, cycle count time, restocking, parts exhaust, and verification of kitted materials. Then convert it into dollar amount by labor of $ 28 per hour per operator. This can give at least $ 200 000 per year. Which is equivalent to four employees, and depending on what smart storage you pick, for example Cluso, it can pay off in about 11 months or less than a year. If more study can be done, it can be even better on ROI, and of which there is more study needed on material exhaust and part missing and traceability.

ROI Table

Item Descriptions	Time saved in hours Yearly
Kitting of material	1565
Missing parts	55
Cycle count time	1040
Put away parts	1229
Part Exhaust	1200
Kitted component	2086
Total time	**7175**
labor cost includding benefits	$28
Yearly total savings	$200,900
These calculation is excluded from ROI	
Average monthly labor hours spent due to loading wrong components/scrap/Re-work	
Monthly hours purchasing spends on buying unexpected shortages	
Floor spaacing	
ROI	**Depends what system picke**
Example	
Cluso	$193,585
ROI	11.5630662 Months
The months for ROI will decrease if the three (15,16 and 17) lines are factored in	

Table 8

Reference

Chen, J., Cheng, C.-H., Huang, P., Wang, K.-J., Huang, C.-J., & Ting, T.-C. (2013). Warehouse management with lean and RFID application: a case study. *International Journal of Advanced Manufacturing Technology*, *69*(1–4), 531–542. https://doi-org.ezproxy.mnsu.edu/10.1007/s00170-013-5016-8

Shelf life modelling for first-expired-first-out warehouse management (mnsu.edu)

Liu, Y., Ji, S., Su, Z., & Guo, D. (2019). Multi-objective AGV scheduling in an automatic sorting system of an unmanned (intelligent) warehouse by using two adaptive genetic algorithms and a multi-adaptive genetic algorithm. *PLoS ONE*, *14*(12), 1–21. https://doi-org.ezproxy.mnsu.edu/10.1371/journal.pone.0226161

Cardona, L. F., & Gue, K. R. (2020). Layouts of Unit-Load Warehouses with Multiple Slot Heights. *Transportation Science*, *54*(5), 1332–1350. https://doi-org.ezproxy.mnsu.edu/10.1287/trsc.2020.0993

Yan-Cong Zhou, Yong-feng Dong, Hong-mei Xia, & Jun-hua Gu. (2014). Routing Optimization of Intelligent Vehicle in Automated Warehouse. *Discrete Dynamics in Nature & Society*, 1–14. https://doi-org.ezproxy.mnsu.edu/10.1155/2014/789754

Mao, Y., & Zhang, L. (2019). Design and Implementation of Port Bulk Storage Management System Based on Internet of Things Technology. *Journal of Coastal Research*, *98*, 62–66. https://doi-org.ezproxy.mnsu.edu/10.2112/SI98-016.1

Chen, J., & Zhao, W. (2019). Logistics automation management based on the Internet of things. *Cluster Computing*, *22*, 13627–13634. https://doi-org.ezproxy.mnsu.edu/10.1007/s10586-018-2041-2

Elliott, M. (2000). Warehouse management system software. *IIE Solutions*, *32*(9), 42.

Robert C. Rosaler. Standard Handbook of Plant Engineering, Third Edition. MATERIALS HANDLING: PLANNING, Chapter (McGRAW-HILL, 2002, 1995, 1983). https://www-accessengineeringlibrary-com.ezproxy.mnsu.edu/content/book/9780071361927/chapter/chapter12

Dr. Edward H. Frazelle. World-Class Warehousing and Material Handling, Second Edition. INTRODUCTION TO WAREHOUSING, Chapter (McGraw-Hill Education: New York, Chicago, San Francisco, Athens, London, Madrid, Mexico City, Milan, New Delhi, Singapore, Sydney, Toronto, 2016). https://www-accessengineeringlibrary-com.ezproxy.mnsu.edu/content/book/9780071842822/chapter/chapter1

Robert C. Rosaler. Standard Handbook of Plant Engineering, Third Edition. MATERIALS HANDLING: WAREHOUSING AND STORAGE, Chapter (McGRAW-HILL, 2002, 1995, 1983).

https://www-accessengineeringlibrary-com.ezproxy.mnsu.edu/content/book/9780071361927/chapter/chapter16

https://www.edibasics.com/what-is-edi/

https://www.mhi.org/fundamentals/material-handling

https://www.criticalmanufacturing.com/blog/material-optimization-in-the-smt-and-electronics-assembly-industries/

https://www.interlakemecalux.com/blog/semi-automated-warehouse

SMT Reel Storage – Inovaxe – Innovative Material Handling Solutions

https://www.scienscope.com/reel-smart-lite/

https://core-emt.com/smd-storage-solution-ultraflex-3600-3900

https://www.youtube.com/watch?v=pVIcjsh7JhM