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UTILIZING RFID-TECHNOLOGY IN IN-HOUSE LOGISTICS

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ABSTRACT

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This thesis was commissioned by a large international company focused on telecommunications. The scope of this thesis work was to study how RFID technology can be used in in-house logistics. The main focus for using RFID is to automate stock transfer in SAP system. This study uses RFID gate and RFID tags. Company X uses a material train for transporting material from warehouse to production. When transferring goods from warehouse to production, material stock is transferred manually. Material handlers create material transfer in SAP ERP Systems.

In the studied plan, material train passes through an RFID gate which reads all the tags inside the train. The information contained in the tags automatically transfers the stocks in the SAP system. The aim of this plan is to reduce the time taken to transfer material stock as well as to introduce new technology that later can possibly be implemented and utilized in other stages of production.

In the theoretical part of the thesis is studied more deeply functions of in-house logistics, storage solutions, SAP Warehouse system, RFID technology and RFID applications. The system was designed to first explore the existing current state by using Value Stream Mapping method. A thorough study of the current state helped greatly for defining the future state and to see the problem areas. The Gap analysis was carried out for the implementation of the new method, which shows the next actions or proposals to reach the target mode. To find out the costs of the new system, offer request of the RFID gates and tags were sent to subcontracting company. After knowing the cost of manual work and investment cost payback calculations were made.

The output of this thesis work was an operating model how the transfers can be carried out in the most efficient way possible using RFID technology. In the solution proposal, what changes it requires to the system, the layout and the sap software to function, benefits that the solution offers and costs.

Keywords:

RFID, VSM, SAP

SISÄLLYS

Vocabulary

BIN = Bin is the smallest available unit of space in a warehouse

FIFO = First-In-First-Out

IDOC= Intermediate Document, is an SAP document format for business transaction data transfers.

RFID = Radio Frequency Identification

SAP = Company called System Analysis and Program Development

SUPERMARKET = Temporary storage area

TRANSACTION = Function triggers in SAP system

VSM = Value Stream Mapping

1 INTRODUCTION

This thesis was commissioned by a large international company focused on telecommunications. In this thesis the company is referred to as Company X. The main objective of this thesis is to study how RFID technology can be used in in-house logistics. The main focus for using RFID is to automate stock transfer in SAP system. This study uses RFID gate and RFID tags.

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In the studied plan, material train passes through an RFID gate which reads all the tags inside the train. The information contained in the tags automatically transfers the stocks in the SAP system. The aim of this plan is to reduce the time taken to transfer material stock as well as to introduce new technology that later can possibly be implemented and utilized in other stages of production.

1.1 Scope of the thesis

The output of this thesis work is to design an operating model how the transfers can be carried out in the most efficient way possible using RFID technology. In this thesis is not intended to take a planned system for practice, instead the aim is explain what the plan would require to be fulfilled. It is also important to find out the costs and benefits of the plan. Thereafter payback time can be calculated. In the theoretical part of the thesis is studied more deeply functions of in-house logistics, storage solutions, SAP Warehouse system, RFID technology and RFID applications.

2 IN-HOUSE LOGISTICS

This chapter focuses on the in-house logistics, internal transposition and functions in in-house logistics. Chapter also focuses warehouse functions and SAP systems that are used in the factory of Company X.

2.1 The definition of logistics

Logistics is a process which includes a series of different operations. Logistics can be described as combination of purchasing, production, distribution and marketing. More closely logistics includes the purchase of raw materials, components and services, storages, handling of materials, end products sales services, distribution and delivery of after-sales service. The key is to manage all these activities in such a way that the results are high-quality and economical. Logistics cuts through a number of the company's operations and so it creates an essential part of the company's value chain. (2, pp. 13 - 14.)

To function well industrial goods production needs functional logistics, which task is to ensure getting the required materials for the production at the right time, to enhance the management and control of internal material flows in production and to manage the storage and transport of finished products (2, p. 72). In an industrial environment these tasks can be divided into inbound logistics, in-house logistics and outbound logistics (see figure 1). Inbound logistics consist of the reception, inspection, unloading and shelving of the goods. In-house logistics includes the handling of materials and products inside the organization. Outbound logistics consist of collecting, packing, distribution and transportation of products. (3, pp. 20 – 21.)

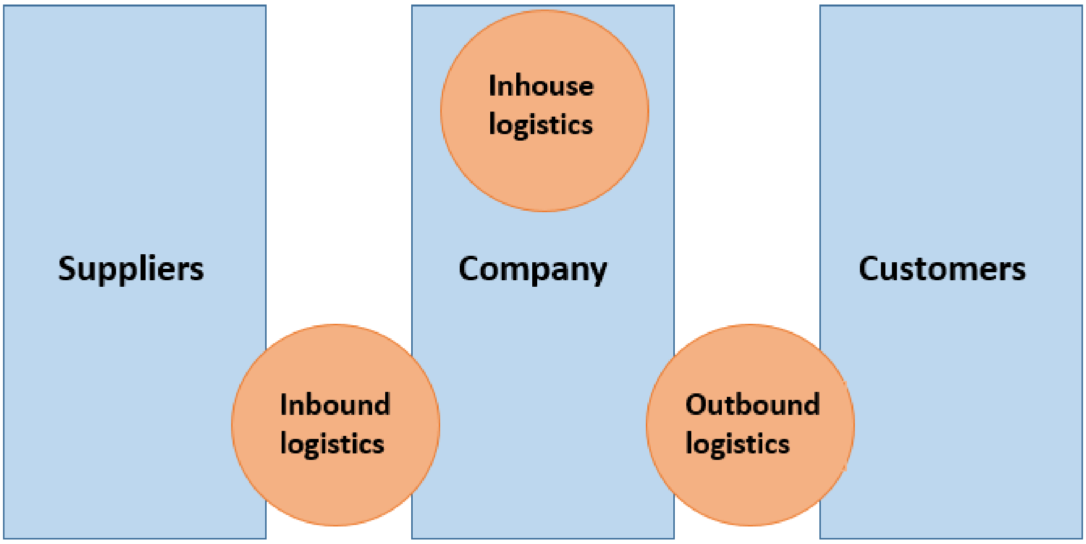

FIGURE 1. Company's inbound, in-house and outbound logistics (3, p. 21, modified)

2.2 Internal transportation in in-house logistics

In-house logistic transfers are an integral part of the material flow of the production. In warehouse operations the tasks of the in-house logistics transport are to transfer the incoming goods from reception of goods to the warehouse, from warehouse to production and from the production to the further transporting actions. The in-house logistics transport uses company's own transporting equipment according to need for transportation. When planning the transport, the regularity of material flows and volumes of transportable goods have to be taken into account. The regular material flows can be dealt with using a special internal transport routes. Transport can be done either with a specific carrier or with the integrated conveyor system. (4, pp. 140-141.)

Company X, the client company of his thesis work, uses material train to transfer goods from warehouse to production line. The material train used by the company is comparable to the material train in figure 2. Material train improves the internal transport of material and materials are transferred to the production just in time. Operators do not have to walk carrying parts, instead the materials can be transferred at one time with the material train and unnecessary overcrowding in the production area can be avoided.

FIGURE 2. Example of material train (5)

2.3 The in-house logistics functions

This thesis focuses on in-house logistics, which main task is the material handling, such as shelving, picking, inventory and packaging.

2.3.1 Shelving

Warehouse Operations begins from unloading of the incoming goods from the truck at the loading dock. The condition of the goods and the amount of shipment is checked, and after that the goods are recorded to inventory book and transferred to the warehouse stocks. After that the goods are transferred to the shelf location. Shelf location means the place where the goods are stored, such as shelf, the box or pallet shelf. (4, pp. 131.) With the product placement can be affected to the collection efficiency and the labor costs in warehouse. Items can be placed on shelves in the categories or items can be sorted by depending on how often they are picked. Those products, which are picked the most, are placed for short picking distances and for the most ergonomic picking height on the shelf. The ABC analysis can be used for product placement. In the ABC analysis the products are divided into A-, B-, and C-classes in accordance of times of picking. In this case, the products which are picked mostly are placed in the shelf locations near the aisle and in ergonomic picking height. (6.)

2.3.2 Picking

Picking starts the manufacture of the customer delivery. Picking can be done in two ways: the picker goes to the material or material comes to the picker. In the picker-to-goods strategy picker takes an order and travels through the warehouse either on foot with a trolley or using forklift truck, collecting items until the whole order is completed. Orders can be for components, individual items, full boxes or full pallets. The picker follows the route by reading a paper pick list, following voice commands or reading instructions on a radio terminal (figure 3). When distances between picks are long the picking can be very labor intensive and the pick phase can lead to bottlenecks. Picker-to-goods strategy is still widely used because it is flexible, single state operated and urgent orders can be prioritized. (7, pp. 98 – 100.)

FIGURE 3. Radio terminal (8)

In goods-to-picker strategy the picker remains in place and goods are automatically transported to picker. Typical automated warehouses are high stocks using automated elevators and carousel stocks, where storage locations are circulating and bringing the goods to picker's spot. When goods come to picker the advantage is that the work station can be made an ergonomic and safe. However, the system may require a considerable investment. (9, pp. 385 – 386.)

2.3.3 Inventory

When performing the inventory, quantity of goods is calculated and then compared to the stock accounts data. Through inventory the correct information of warehouse stock is ensured. The balance errors can be caused of a variety of reasons and it is important that the inventory is done often enough. (9, p. 393.) The Inventory can be carried out at regular intervals or continuously. The inventory at regular intervals can be scheduled for a quiet period in the warehouse, or at the change of the accounting year. Continuous inventory can proceed by stages, even going through the entire warehouse. Tracking can be supported with different tracking systems such as barcodes and the RFID systems. (2, p. 17)

2.3.4 Packaging

Packaging is important for the protection of the product and the environment. Packaging enables economical handling, transportation and storage of the products. Good package also provides information about the product and its use, market the product and prevents theft. Barcodes and RFID tags can be used for labeling of the package. Labeling is identifying the packages and facilitated handling and traceability during storage and transport. The packaging process begins with the sorting of packages, for example, according to customer orders or packaging standards. Products are packaged, closed, labeled, marked, and after that the individual packages may be further packaged in group packages and pallet. After packaging, the products are transferred to dispatch center to wait for transportation. In packing centers the most important quality factors are the rational use of packaging, clear labeling and compliance with agreed delivery dates. (3, pp. 67, 71 - 73.)

2.4 Storage solutions

The warehouse is physical space, for example, place or building where raw materials, semi-finished products, work in process (WIP) products and finished products can be stored. Stocks are divided into basics stocks and safe stocks. Basic stocks have that part of the stock, which changes according to the consumption and supplement. The goods in basic stock move to the next member in the chain. Safety stocks are maintained to mitigate the risk of stock shortfall. Safety stocks secure the variation of delivery time, delivery volume and consumption and as well quality problems. (2, pp. 35 - 36.) In the table below are presented different kind of warehouses based on the industry, product and implementation:

Industry	Warehouses in manufacturing: • raw material warehouse • work in process warehouse (WIP) • the finished product warehouse • component storage • maintenance warehouse • consignment stock • packaging materials • using supplies • sorting warehouse • the flow-through stocks	Warehouses in stores: • wholesale warehouse • central warehouse • distribution warehouse • pick-up storage
Product	• cold storage and refrigerated warehouse • pallet storage	• warm storage • small parts storage
The technical implementation	• high stocks • outdoor storage • narrow aisle warehouses • floor / courtyard stocks • manual / automatic warehouses	• low stocks • indoor storage • semi-automatic warehouses

FIGURE 4. Variety of warehouses (3, p. 82, modified)

2.4.1 Traditional Pallet and Small Parts warehouse

Usually the form, quality and quantity of pallet loads prevent them to be stacked on top of each other and because of this the pallet storage needs pallet shelves to function. In ordinary pallet racks have 4-5 pallets on top of each other, so the shelves can be really high. The pallets can be moved and raised into the shelves with stacker and different sorts of forklift trucks (figure 5). Stackers are manually operated and working with them can be slow and heavy. Therefore the most used machines for handling pallet loads are different kind of forklift trucks. However advantage of stackers compared to trucks is that they are inexpensive. Forklift trucks are equipped with warm cabin or safety cate and also with a variety of options for forks. Forklift trucks' lifting capacity is from 1, 2 tons to over 10 tons. (9, pp. 327 - 330, 340.)

FIGURE 5. Pallet warehouse with forklift truck (10)

The small parts warehouse usually consist of Small Parts Shelves which are bent steel sheet produced. The shelf construction element is designed so that it is easy to formulate many kind of shelves with them and shelves may be further modified according to the needs and expand easily. The goods are normally stored in plastic boxes with sizes ranging from the size and shape of the stored goods (figure 6). The shelves can also be built 2-3 storey stores where the floor levels are built upon the shelves. (9, pp. 341 – 342.) The Small Parts Shelving aisle width is typically 600 - 800 mm and the height of the collection will be up-to 2100 mm when the goods will be handled without a ladder. Goods, which are handled most, should be placed on the middle level shelf. The deeper the shelves are, the harder it is to use the highest and the lowest storage locations. For moving the small parts can be used platform carts and collecting carts. Incoming goods can also be moved with a forklift truck to at the end of small parts shelves, to be unloaded into the shelves. (9, pp. 344 - 346.)

FIGURE 6. Small parts warehouse (11)

2.4.2 FIFO

The term FIFO comes from the words First in First out. This storage technique uses the shelved goods in age order. FIFO uses a flow-through shelves so the oldest shelved goods will be taken to use first. FIFO also ensures the introduction of the material within its lifetime. Shelves consist of tracks with rollers or wheels in such a way that the aligned lift moves by gravity either end of the track or in the queue. The goods are loaded into the rack on one side and unloaded at the other side. (Figure 7). Generally lift loads are transferred in and out of the shelf by using forklifts. With flow-through shelves a compact storage can be arranged and they are suitable storage solution when the goods titles are few but goods amounts are high. (9, pp. 364 - 365.)

FIGURE 7. Operational principle of flow-through shelf (12)

2.4.3 Supermarket Warehouse

The Japanese auto industry has invented to apply the display and filling principle of groceries to the industry. In stores the products are displayed to the buyer, and when the buyer takes the product off the shelf, it is filled with a new one. Supermarket Warehouse is intended for short-term storage of parts and components and it is near to their place of use. Supermarket warehouse is kind of production buffer warehouse. It facilitates material flow and warehouse management. Supermarket has a lot of different parts, but not in large quantities. When taking part or component from supermarket, it is supplemented by new equivalent. If the parts are not used, they remain in the supermarket and replenishment is not performed. Supermarket has just standard parts and quantities are optimized according to demand. The need for supplement is told by Kan Bans which are signals such as cards, empty boxes or empty carts. For example, an empty box, which is marked with the number of parts, is sent to the warehouse to be filled and is brought back to the supermarket as supplemented. It is important that the boxes are small and manually movable, which facilitates the filling and removes the need for the use of forklift trucks. Typically the transport of material in production is seen as worthless work, but if the materials are storage in supermarket in a practical way, it would facilitate the work of production operators. (13.)

FIGURE 8. Typical supermarket warehouse *(13)*

2.5 SAP ERP

A company called System Analysis and Program Development (SAP) was founded in German in 1972. Company's vision was to develop a standard application software for real-time data processing. Nowadays SAP ERP system has integrated, fast, and flexible business processes that increases company's competitiveness. It provides applications, data, and analytical tools for resource management software across procurement, manufacturing, service, sales, finance, and HR. Business organizations can customize the SAP software to suit their own requirements. SAP ERP consists of a variety of functionalities called a module that are integrated with each other. (14.)

The function triggers in SAP system are called transactions. IDoc, short for Intermediate Document, is an SAP document format for business transaction data transfers. New transactions can be created to SAP for the company's self-developed functions. Sometimes a company organization or operating processes are necessary to edit or customize to fit the SAP model. Editing can be done either by adapting the organization to the process model that SAP is offering it or customizing the software to fit the company's own processes. It is not always worth to customize SAP ERP functionality but to build an external system, which is integrated with SAP. (15, pp. 13, 21.)

2.5.1 SAP Warehouse Management

Warehouse Management module is a functional application inside of SAP ERP system. WM module can fully automate warehouse and distribution operations, including inbound processing and receipt confirmation, cross-docking, outbound processing, warehouse and storage management, and physical inventory management (figure 14). Warehouse management features support workforce management as well as slotting and advanced inventory optimization techniques. WM can improve asset utilization, increase throughput and safety, and ensure on-time compliant and accurate order fulfillment. (16.)

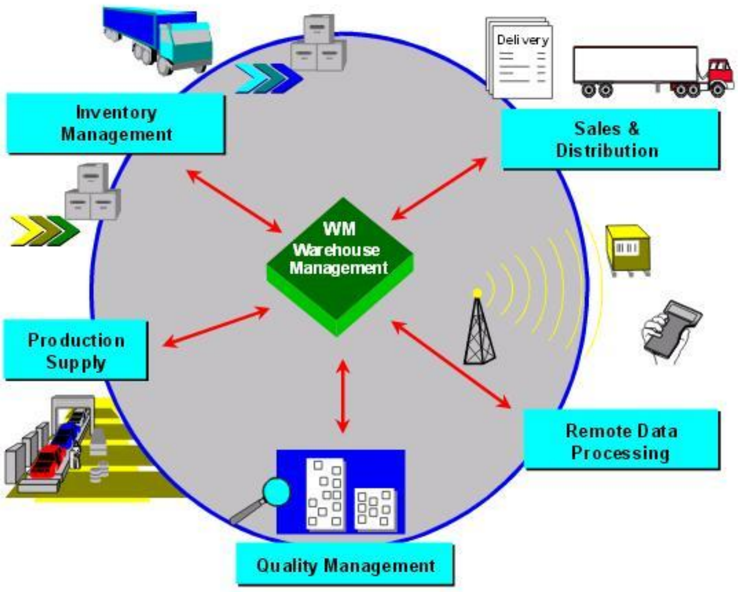

FIGURE 9. Warehouse Management operations (14)

Warehouse number is a storage ID in the system (figure 10). The warehouse is organizational unit in the SAP system, which can separate the physical stocks. Storage types are defined areas within the warehouse. Such area may be, for example area for fast moving materials. Type of storage consisting of storage sections which can be the various levels of shelves. Storage sections consist of storage bins. The storage bin is the smallest available unit of space in a warehouse. Storage bins maintain the material quant. Quant is a certain number of pieces of material in the bin location. Quant contained in the bin location increases or decreases in volume as a result of additions and deletions. (17, p. 13.)

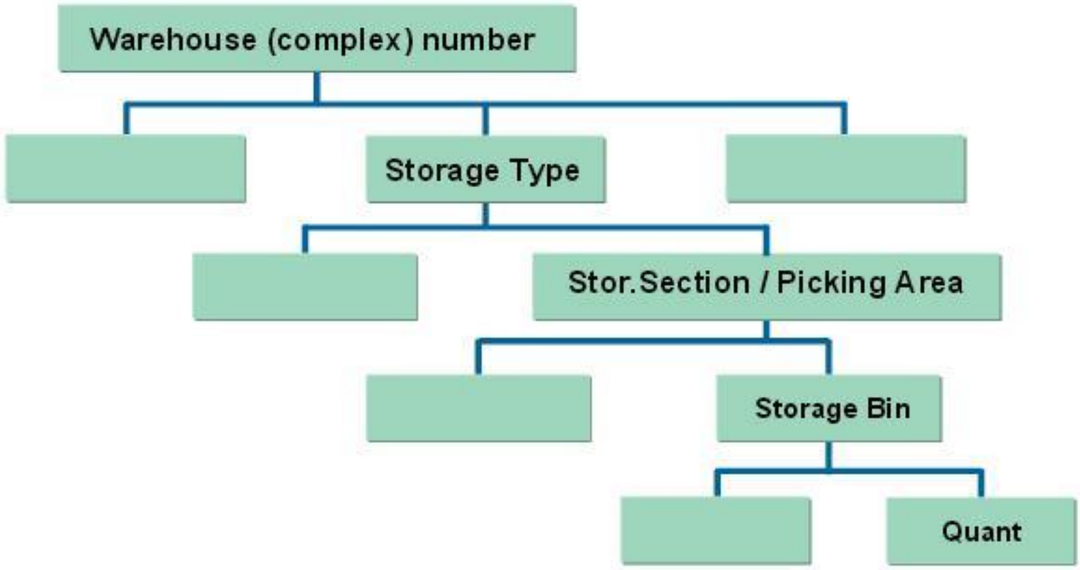

FIGURE 10. Warehouse Structure in the Warehouse Management System *(17)*

WM module supports the FIFO method for controlling the collection. The idea of the method is that the oldest Quant is collected first. The system calculates the reception date of the storage period of the material, which logs into the system upon receipt. The physical transfers of materials are done with transfer orders (TO) in WM module. The data in transfer order reflect the material to be transferred, the quantity and location of the transfer, for example, the shelf location. Once the transfer order is reset complete in the system, the stock transfer is updated. (17, p. 14.)

3 RFID TECHNOLOGY SYSTEM

This chapter focuses on the RFID identification technology. Chapter also presents two cases how RFID technology has been utilized in internal logistics and what benefits it has been obtained.

3.1 Basic Concept of RFID

Radio frequency identification or RFID uses radio waves to automatically identify and track objects. The most common method is to store a serial number or information that identifies a person or object on a microchip that is attached to an antenna also called an RFID tag. RFID tag can be a label, card, tag, implant, etc. The antenna enables the chip to transmit the information to a reader. The reader converts the radio waves into digital information which can be passed on to computer for make use of it. (Figure 11.) (19.)

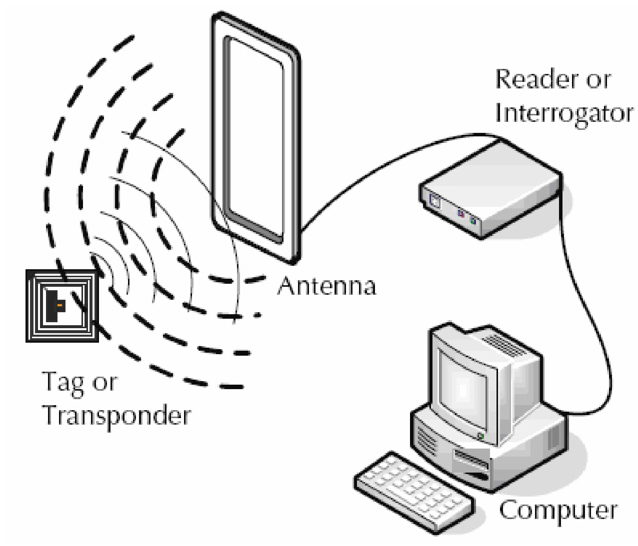

FIGURE 11. RFID system (20)

Difference to barcodes, RFID tags do not need to be target directly to readers. The tags can be read from a distance, fast, different positions, and through most of the materials. Tags can hold more information and have a better security than barcodes. Also the RFID tag contents can be changed contrary to the bar code which is unchangeable after printing. RFID tags are better able to stand unclean industrial conditions than conventional bar codes. (21.)

3.2 Tags

There are many different types of tags. Features of tags such as memory capacity, processing capability, the reading distance and the physical size will vary according to use. The form and size of tags may vary depending on the application or material of the object to which the tag is attached. Tags designed for different applications are summarized below:

- Glass capsule tags are used, for example, under the skin of animals to identify.
- Smart labels are very thin tags that can be printed and glued such as stickers. Smart labels are used in airports in automatic identification of luggage. (Figure 12)
- In access control can be used debit card-like smart cards or identification wristbands. Such, for example, is used in the workplaces and the lift tickets in ski resorts.
- Disc tag has a hole in the center, so that they can be attach by a screw to the object. (22, pp. 25 - 29.)

FIGURE 12. RFID smart labels (23)

3.2.1 Passive, battery-assisted passive and active tags

Tags are divided to passive, battery-assisted and active tags based how they are operating. Passives tags do not have their own power source. They draw power from radio waves send by the reader with integrated antenna. With induced electric, tag is able to transmit the needed information to the reader, as well as to run the commands sent to it by the reader. Because the passive tag does not have its own power source, the reading distance is short and it cannot be connected to sensors. The advantages of passive tag are low price, long life cycle and small size. (22, p. 38.)

Battery-assisted passive tag contains a power supply, but does not have its own transmitter. It communicates with the reader in the same way as a passive tag. Through its own power supply, tag can strengthen the backscatter process of signals. It has a higher reading distance than the passive tag, and it is capable of transferring large amounts of data with better transfer certainty. Own power supply adds the size and the price of the tag, which is why it is not used as much as a passive tag. (22, pp. 38 – 39.)

Active tag includes a power supply, which is usually lithium battery. Own power supply increases the reading distance and the amount of memory. Active tag can also transmit additional information relating to the object, which is collected from sensors. The age of battery can be a number of years and the battery can be replaced or disposable. Long reading distance and the use of sensors allows the use of active tags in different applications. Disadvantages of active tags are expensiveness and a larger size, and the fact that the active tag cannot operate without a power supply. When power supply runs out of power, the tag may send false or incomplete information. Installation a new power supply generates costs. (22, p. 39.)

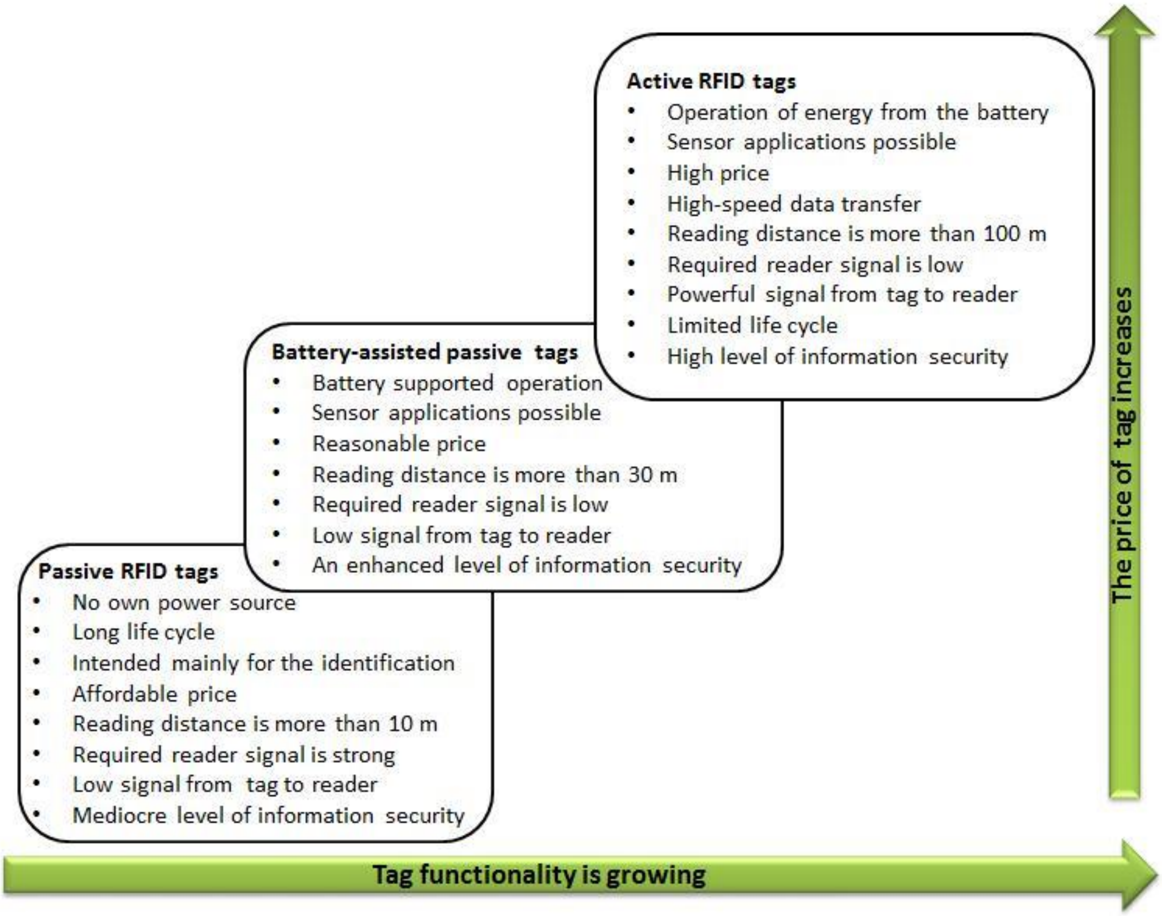

FIGURE 13. RFID tags' properties (24, modified)

3.3 Readers

Reader uses its antenna to stimulate tags, read their data, and transmit it to a computer. The reader is connected to the tag using radio waves. Reader can also write data to tag's memory, lock tag, so that the information in the tag cannot be changed or even destroy tag's data. The reading distance is highly dependent on the sizes of antennas in the reader and tag, and how strong electromagnetic field the reader causes. Usually, there are number of tags in reading zone so the reader has to use anti-collision method so that it is able to identify the tags and to separate them from each other. Anti-collision methods are defined in standards for each type of tag. (22, pp. 30 – 31.)

There are a variety of reader devices for different purposes. Portable, hand-friendly readers can be used for inventory (figure 14) and reader devices contained within the phone can be used for checking of the tickets. RFID technology is often used in a supply chains and tracking of goods in the manufacturing process, for which have been developed a lot of special reading devices. When selecting the reader device, the regional restrictions on the frequency and regulations of field strengths have to be taken into account. Also, the reader's suitability with the tags has to be ensured. The reader can read data according to only one standard. There are readers that can read data which is stored in the chip according to various standards. These readers are called multi-readers. (22, pp. 31 – 32.)

3.4 RFID Applications in Logistics

RFID technology can be used in logistics in tracking and tracing of goods, monitoring and controlling the inventory, controlling the funds, prevention of theft, and in access control. Logistics supply of products and raw materials to the right place at the right time for many companies is expensive and challenging. The problems are often due to the fact that the various supply chain partners do not know each other's movements, ongoing projects, schedules, the location of transported products and raw materials, or exact numbers of products in stock. RFID offers a solution to these problems in the supply chain. Active tags are usually used for the monitoring of higher value and longer reading distance demanding products and passive tags to monitor low-end products. Tags provide information about the different stages of the supply chain, therefore the manual labor is reduced and the accuracy of the information is enhanced. (22, p. 122.)

A number of companies have been transferred to the JIT (Just-in-Time) production, where stocks are attempted to minimize or eliminate altogether, and get products to pass the production process to another without intermediate storage. This can be accomplished by adding tags to finished products as well as their transport boxes. When the delivery lot leaves the factory, the reader devise set to the loading dock checks whether the contents of the consignment corresponds to the order by reading the identification codes of the products. If the reader accepts the consignment it can be loaded on a truck. If the application is connected to the information systems of the next member in the supply chain, information of shipment is stored to the recipient's database. Now also the recipient of an order knows that the item has left the factory. When the recipient's loading dock is also equipped with a reader, the arrived products with their numbers can be registered and the company's warehouse data be upgraded. For example, the store shelves can also be equipped with RFID readers, which keep track of stock of products. When the products are reduced from self to a certain extent, the system sends a message directly to the manufacturer, which starts a new delivery process. (22, p. 12-13.)

3.4.1 Case Valtra Inbound

Valtra is the leading tractor manufacturer in the Nordic countries. In the factory in Suolahti, Valtra uses RFID in automated material supply process and in material buffer management. The system is based on RFID enabled forklifts that read material pallets while transporting them from the material buffer to the consumption area and trigger replenishment orders. The system is based on pallets that have reusable RFID tags. Goods receiving dock doors and inbound conveyors are equipped with RFID readers for automatic goods reception (figure 15). RFID software controls the RFID readers and integrates the information to ERP system. RFID software system presents real time inventory information of the material buffer. For single materials the buffered quantity can be followed. The buffered amount, pending replenishment orders and inbound shipments are visible. (25.)

With implemented RFID technology, the system has provided better visibility on material flows and has reduced production disruptions. Manual labor in incoming of goods has reduced and, more accurate inventory information has been created. The system provides real time replenishment for material consumption which has speeded up the turnover rate of inventories. (25.)

FIGURE 15. RFID system in inbound process in Valtra (26)

3.4.2 Case ABB Inbound

ABB Oy drives factory in Helsinki develops, manufactures and markets frequency converters. Factory uses RFID technology in inbound reception. The technology is being used to track shipments of raw materials between ABB's factory and 15 component suppliers. It starts when an empty container fixed with an RFID tag triggers an automatic order, which shows up on the supplier's extranet via XML message. The supplier then executes the order and puts an electronic shipping document into the RFID tag of a full container. Inventory is automatically ordered and the shipment tracked and logged electronically using special RFID tags and scanners. At ABB's end, the goods are automatically entered and registered in the Enterprise Resource Planning (ERP) system (figure 16). The system automates goods receiving and is reducing manual labor and human errors in the process. It also created faster replenishment times for Kanban. System provides significantly faster stock turnaround times and lower inventory levels. (26.)

FIGURE 16. RFID system in inbound process in ABB (26)

4 LEAN TOOLS

Lean is a philosophical way of thinking, which comprises the organization of activities. In accordance with the principles of Lean is to create efficient processes with a minimum of resources and taking into account to the whole activity of the company. The idea is to focus just on the customer value generating activities. Lean thinking includes a number of tools which are aimed at achieving the objectives of the lean-operation. These tools are not the meaning of Lean in itself, instead they are intended to manage the prevailing phenomena. Lean is formed from systematic, daily routines and tools that are needed to establish and maintain an effective process. The action is organized in such a way that it only focuses on the core process and all non-valued work is eliminated from the process. The pursuit of perfection is driving the organization towards to an improved performance and error-free operation.
(28, p. 2.)

4.1 Wastes

The mindset of lean is to improve the company's productivity. It is not intended to enhance productivity by speeding up workflow, but by eliminating unnecessary things in production. In the Lean these things are called wastes. Toyota has identified seven forms of wastes. Later, there has been added the eighth form of waste. These kinds of wastes in business are waiting times, non-processed work, unnecessary storage and transporting (figure 17). Changing the operating model requires a whole new kind of attitude to work. (28, p. 15.)

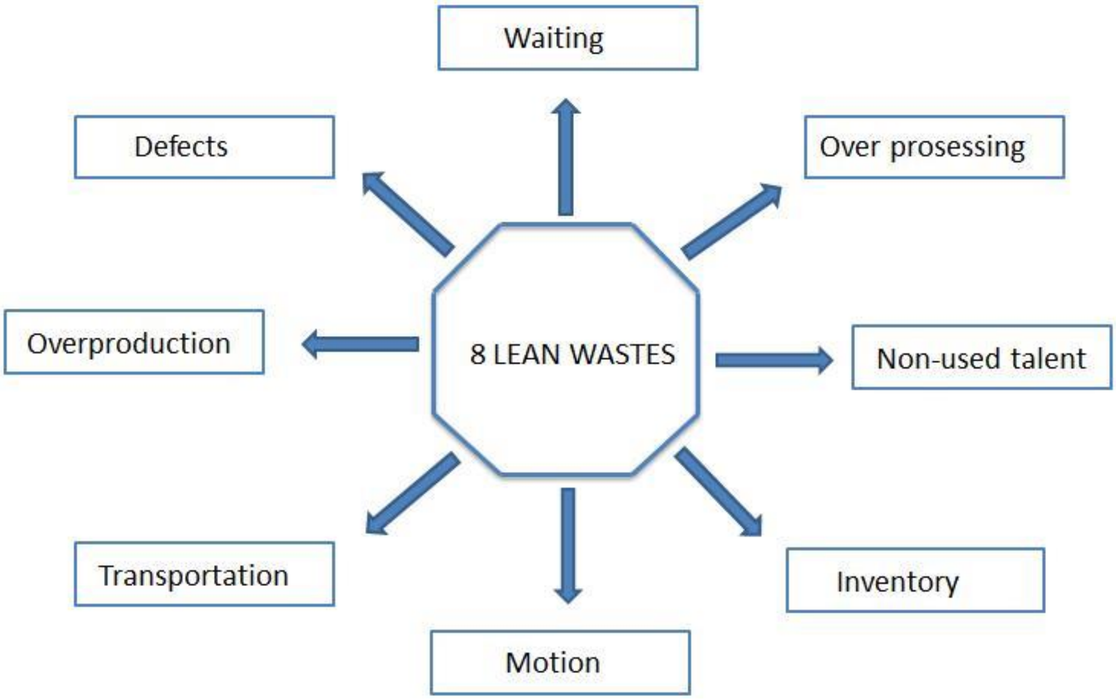

FIGURE 17. 8 Lean wastes (28)

In designing a new operating model in this thesis especially the unnecessary transportation, moving and storage were taken into account. Any kind of extra moving of machines, appliances or components is considered to be in the waste area. Transportation of products both within the organization, as well as out from the company, does not add any value to the product in any way. Problems caused by the stocks includes additional space requirement, commitment of the capital into the goods, requirement of the maintenance of database and book-keeping of storage.

4.2 Value Stream Mapping

Value Stream Mapping (VSM) was developed by a Japanese automotive company Toyota in the 1950s. VSM is a tool that is used for process development. In order to improve the process, it must first be observed and understand. It is important to identify the current state so that is known what the process aims at and how the target is achieved. The current state is described by Value Stream Maps with chart and symbols (figure 18). It is a graphic description of the process steps, contacts, inventory, and process times as precise as possible. Describing the current state generates a new way of thinking and it will help identify areas where process improvement is necessary. These are the non-processing steps as wastes, unnecessary work and storage, bottlenecks and security and device defects. After understanding the current state and problems in current state, developing to reach the desired future state can begin. (29.)

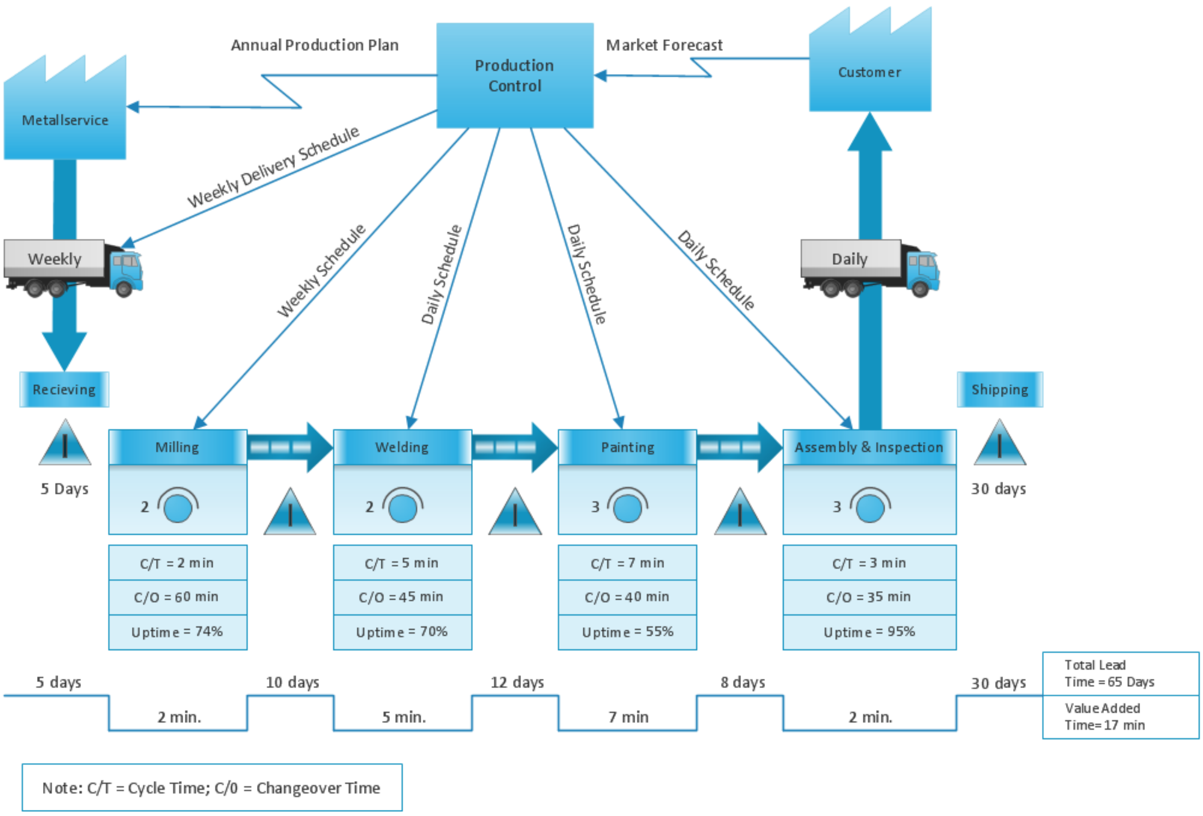

FIGURE 18. Example of value stream mapping (30)

4.3 GAP analysis

GAP analysis is a method to describe and compare the difference between the current state and desirable future state. When the current state and the future state is described, the differences in processes can be concretized and listed to development measures (figure 19). The method shows the next actions or proposals to reach the target mode. It also ensures that the planning has been taken into account in all relevant areas. It is a good idea to consider whether the described future state is viable or is the gap so large that the process change is not possible or reasonable to implement and whether the risks are manageable. (31.)

Future State	Current Situation	Next Actions/Proposals
Answer 90 per cent of calls within 2 minutes.	Approximately 50 per cent of calls are answered within 2 minutes.	1. Develop a call volume reporting/queue modeling system to ensure that there are enough staff during busy periods. 2. Recruit any additional people needed. 3. Develop a system that allows callers to book a call back during busy periods.

FIGURE 19. Basic example of Gap analysis on how to improve call-handling in contact center (32)

5 CURRENT STATE

Before starting to design a new operating model, it is really important to identify the current state as precisely as possible. The method selected for this study of the current state was value stream mapping. Value stream mapping allows walkthrough of the material flow from incoming of goods in warehouse to aboard of the material train. A thorough study of the current state helped greatly for defining the future state and to see the problem areas.

5.1 Value Stream Mapping

Because the material flows vary depending of materials, it was decided to make four different value stream mapping routes:

- Route 1: Hand assembly components
- Route 2: Sub assembly lids
- Route 3: Mechanics that goes in Thermal Gel dispensing
- Route 4: Sub assembly bodies that goes in connector pressing

5.1.1 Route 1

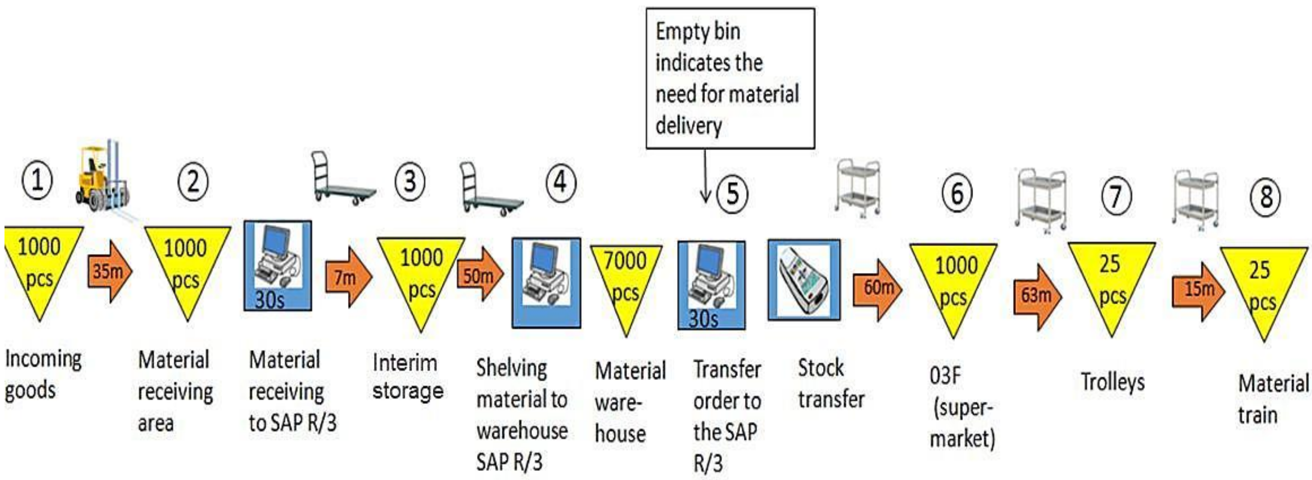

FIGURE 20. Screenshot of value stream mapping of route 1

1	The receiving material arrives in containers and is left in the loading area.
2	Incoming goods are visual inspected by material handler. After that the shipment is booked into SAP R/3.
3	Material is moved to Interim storage area waiting for shelving.
4	Material is shelved to warehouse by using SAP R/3 systems. Barcode-number is read with the Radio Terminal and the system is proposing automatically a free shelf for material. The material is placed in a free shelf.
5	Material is collected from warehouse to production when there is an empty bin in supermarket. Material handler picks up the bin and read barcode on the bin. System creates automatically a transfer order to the SAP R/3. Transfer order shows automatically in Radio terminal which shows the shelf location for the material. SAP R/3 is handling material as FIFO and material is collected as FIFO. Material handler fills in the bin and transfers the stock from warehouse to production with Radio terminal.
6	Filled bins is delivered to the supermarket area and placed into shelves.
7	Bins are placed to train trolleys.
8	Trolleys are placed in material train which transfer bins to the production lines.

5.1.2 Route 2

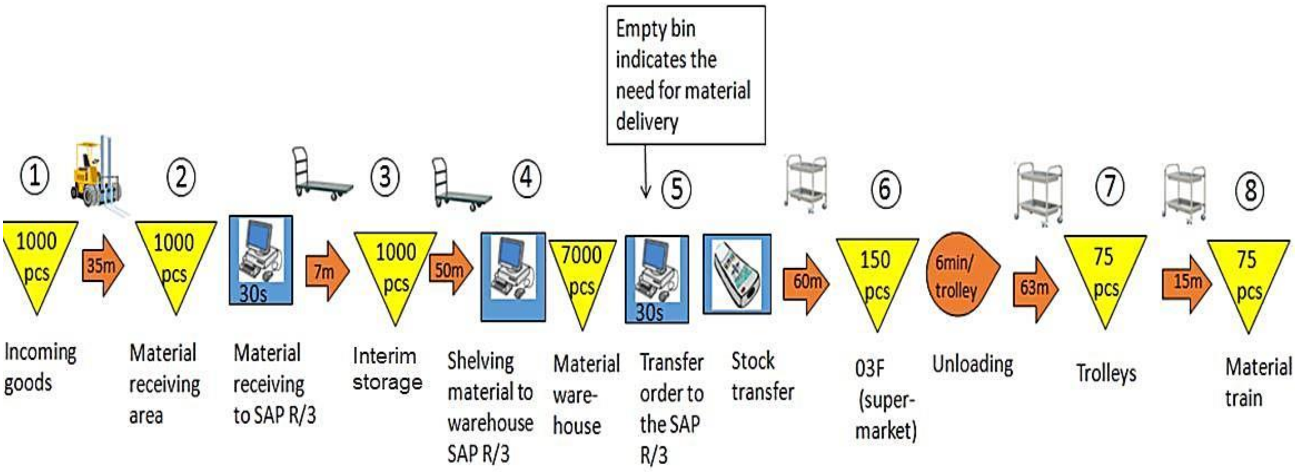

FIGURE 21. Screenshot of value stream mapping of route 2

1	The receiving material arrives in containers and is left in the loading area.
2	Incoming goods are visual inspected by material handler. After that the shipment is booked into SAP R/3.
3	Material is moved to Interim storage area waiting for shelving.
4	Material is shelved to warehouse by using SAP R/3 systems. Barcode-number is read with the Radio Terminal and the system is proposing automatically a free shelf for material. The material is placed in a free shelf.
5	Material is collected from warehouse to production when there is an empty bin in supermarket. Material handler picks up the bin and read barcode on the box. System creates automatically a transfer order to the SAP R/3. Transfer order shows automatically in Radio terminal which shows the shelf location for the material. SAP R/3 is handling material as FIFO and material is collected as FIFO. Material handler transfers the stock from warehouse to production with Radio terminal.
6	Material is delivered to the supermarket area. Material is unloaded from boxes and placed in to shelves.
7	Material is placed to train trolleys.
8	Trolleys are placed in material train which transfers material to the production lines.

5.1.3 Route 3

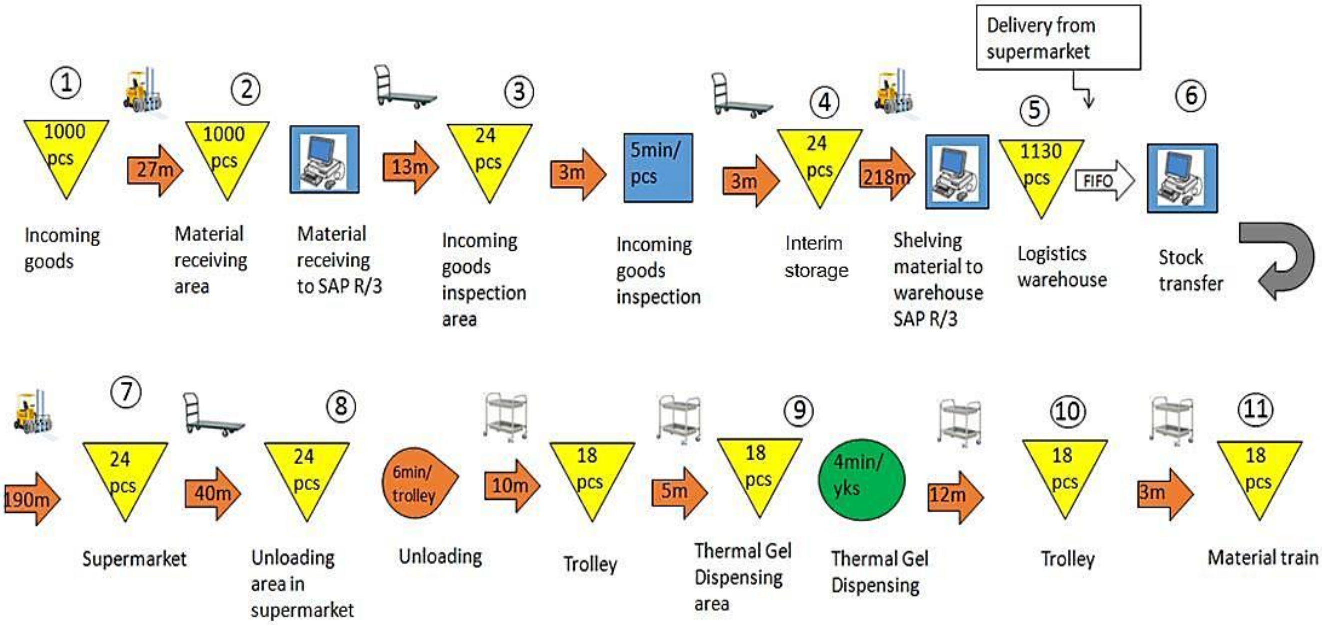

FIGURE 22. Screenshot of value stream mapping of route 3

1	The receiving material arrives in containers and is left in the loading area.
2	Incoming goods are visual inspected by material handler. After that the shipment is booked into SAP R/3.
3	Material is moved to Incoming goods inspection area to be inspected.
4	Material is moved to Interim storage area waiting for shelving.
5	Material is shelved to logistics warehouse by using SAP R/3 systems. Barcode-number is read with the Radio Terminal and the system is proposing automatically a free shelf for material. The material is moved to logistics warehouse and placed in a free shelf.
6	Material is collected from logistics warehouse to production when there is a delivery request from supermarket. Request is shown in a screen near the logistics warehouse. The forklift driver in logistics warehouse transfer stock from logistics warehouse to production in SAP R/3 and moves the ordered container to supermarket. SAP R/3 is handling material as FIFO and material is collected as FIFO.
7	Material is delivered to the supermarket area.
8	Material is unloaded from containers and placed in to trolleys.
9	Trolleys are moved in to Thermal Gel Dispensing area. Every unit gets Thermal Gel Dispensing.

10	Material is placed to train trolleys.
11	Trolleys are placed in material train which transfers material to the production lines.

5.1.4 Route 4

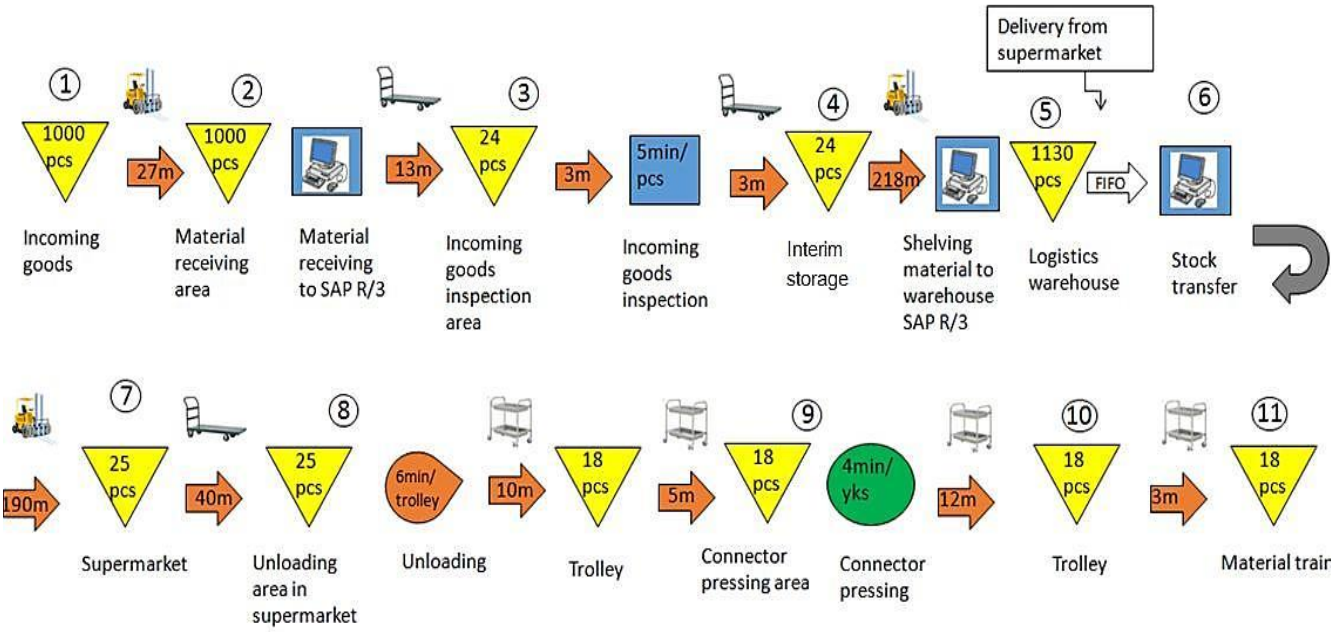

FIGURE 23. Screenshot of value stream mapping of route 4

1	The receiving material arrives in containers and is left in the loading area.
2	Incoming goods are visual inspected by material handler. After that the shipment is booked into SAP R/3.
3	Material is moved to Incoming goods inspection area to be inspected.
4	Material is moved to Interim storage area waiting for shelving.
5	Material is shelved to logistics warehouse by using SAP R/3 systems. Barcode-number is read with the Radio Terminal and the system is proposing automatically a free shelf for material. The material is moved to logistics warehouse and placed in a free shelf.
6	Material is collected from logistics warehouse to production when there is a delivery request from supermarket. Request is shown in a screen near the logistics warehouse. The forklift driver in logistics warehouse transfer stock from logistics warehouse to production in SAP R/3 and moves

	the ordered container to supermarket. SAP R/3 is handling material as FIFO and material is collected as FIFO.
7	Material is delivered to the supermarket area.
8	Material is unloaded from containers and placed in to trolleys.
9	Trolleys are moved in to connector pressing area. Connector pressing is made to every unit.
10	Material is placed to train trolleys.
11	Trolleys are placed in material train which transfers material to the production lines.

6 FUTURE STATE

Value stream mapping can shows many problem areas, but this study only focused on stock transfer process. In the desired future state stock transfers are transferred automatically in SAP system. This would save the man-hours it takes to make transfer order and transfer the stocks in SAP. This would also make material handlers work simpler and reduces human errors. The chosen technology for making stock transfers automatic was RFID technology.

In the studied plan, material train passes through an RFID gate which reads all the tags inside the train. The information contained in the tags automatically transfers the stock in the SAP system. The aim of this plan is to reduce the time taken to transfer material stock as well as to introduce new technology which can later be implementedion. The knowledge of new technology is also useful because it can potentially be utilized in elsewhere in the production.

6.1.1 Challenges

Planning for introduction of the future state appeared following challenges:

- Have to make sure that FIFO system will be taken in used. In the current state SAP system automatically gives empty shelf location according to FIFO.
- Because the material warehouse is free place storage, material handlers cannot know without SAP where each material are located.
- Material transfer happens after the train passes the RFID-gate. This causes the fact that according to SAP ERP material is in shelves in warehouse even though material have been moved to supermarket. This causes stock errors in SAP system.
- The amount that is marked in tags has to put in bins. This causes that material handlers are required to count the components that increases the amount of work.
- Supplier specific pack sizes and pack patterns vary. Because of this material cannot be moved to production lines in their own packages.
- How the gate transfer right amount stock in special cases e.g. trolley have less than the normal amount of mechanics.

6.2 Planned options

In this thesis three different operation model options were developed, taking into account the above-mentioned challenges. The options are described below.

6.2.1 Option 1

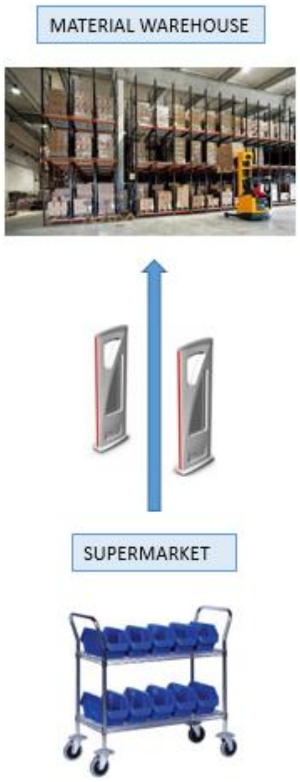

FIGURE 24.

- RFID gate is located to the door of material warehouse
- When material handler picks up cart and passes through the gate, system will create transfer order to SAP from all the empty bins
- Material handler collects components from shelves and makes stock transfer with the Radio terminal

6.2.2 Option 2

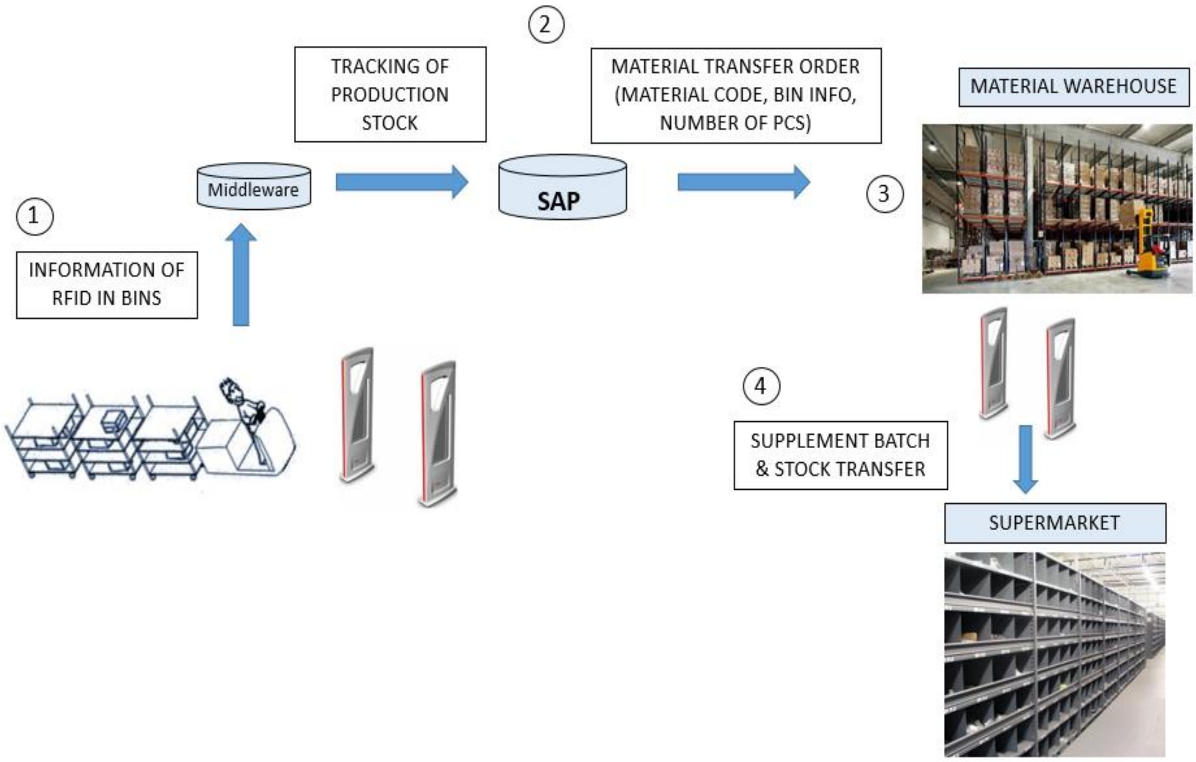

FIGURE 25.

1. When train passes the RFID gate, information of empty bins goes to the RFID middleware.
2. The middleware checks up production stock and creates material transfer order to the material warehouse if needed. Transfer order shows shelf location for collection.
3. Material handler sees the material transfer orders in the screen in warehouse, picks up bins from the supermarket and fills them according to the transfer order.
4. RFID gate is on the door of the material warehouse. When the filled bins are moved through the gate, the stock transfers from warehouse to production according to transfer order.

6.2.3 Option 3

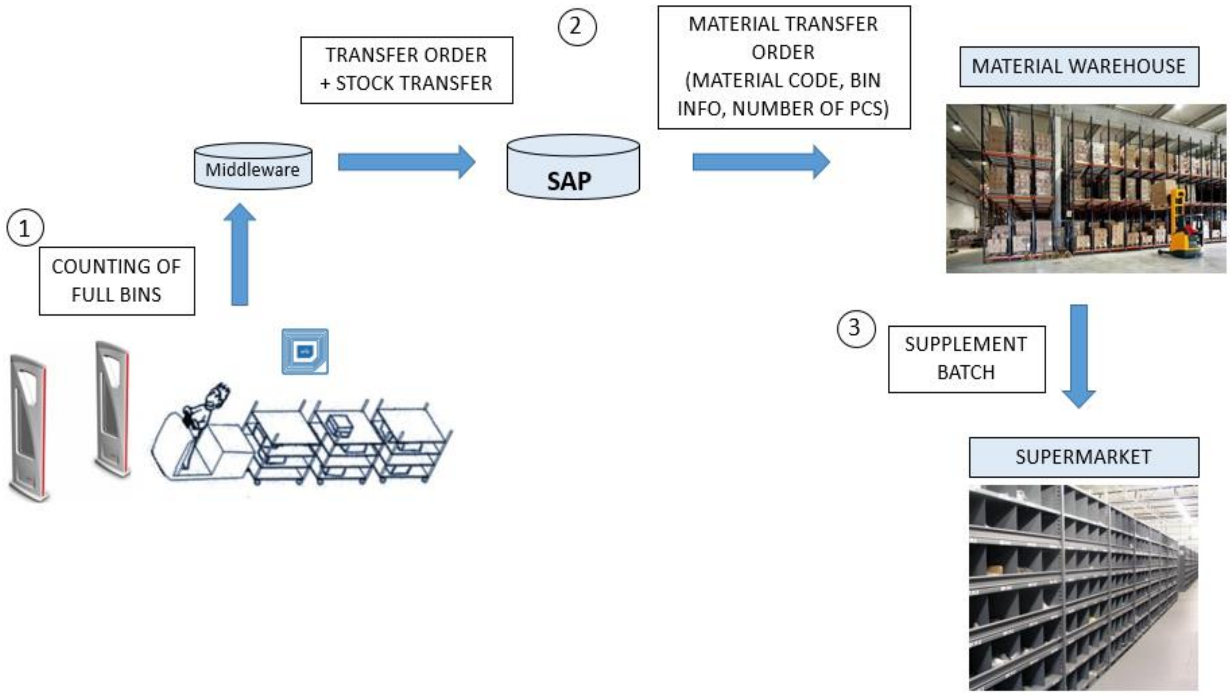

FIGURE 26.

1. When train passes the RFID gate, the middleware counts how many full bins have passed the gate.
2. When “a sufficient amount of bins“ have passed the RFID gate, the middleware makes transfer order to Radio terminals in material warehouse. The order has shelf location defined. At the same time stock transfer from warehouse to production is made.
3. Material handler picks up the empty bins from supermarket, fills and delivered them back to supermarket.

6.2.4 The chosen option

Option number 2 was selected. This option was chosen, because it covers the most of requirements. Option number 1 is simple and relatively easy to implement with only one RFID gate. However, option will only automate a picking request, and does not transfer the stock information automatically in SAP system. Options 2 and 3 have automated transfer orders and automated stock transfers which require that two RFID gates and middleware were added in to the systems. Option number 2 seemed more logical so it was chosen instead of option number 3.

6.3 GAP Analysis

To plan actions to reach selected option 2 state in future, the GAP analysis is done. The first column describes the future state which is the selected option 2. In the following column is described the current state that is how the process works currently. The last column describes the actions which would make option number 2 to be able to implement.

Future State	Current state	Next Actions/Proposals
- When train passes the RFID gate, information of empty bins goes to the RFID middleware - The middleware checks up production stock and creates material transfer order to the material warehouse if needed. Transfer order shows shelf location from where collection has to be made - Material handler sees the material transfer orders in the screen in warehouse, picks up bins from the supermarket and fill them according to the transfer order - RFID gate is on the door of the material warehouse. When the filled bins are moved through the gate, the stock transfers from warehouse to production according to transfer order	- Empty bins are placed in the cart in supermarket area - Material handler picks up empty bins and makes a transfer request to SAP manually - After a while, transfer request appears on the radio terminal and material handler collects the components from shelf location given by SAP - Stock transfer is made with the radio terminal	- Find out if the SAP changes are possible - Find out what kind of RFID gate and tags are needed - Make a comparison of different RFID suppliers - Find out what kind of middleware is needed and what it requires - Find out the costs

7 PAYBACK CALCULATION

This chapter is hidden.

8 SOLUTION PROPOSAL AND CONCLUSION

This chapter contains the solution proposal, what changes it requires to the system, the layout and the sap software to function, and benefits that the solution offers.

8.1 Operation model

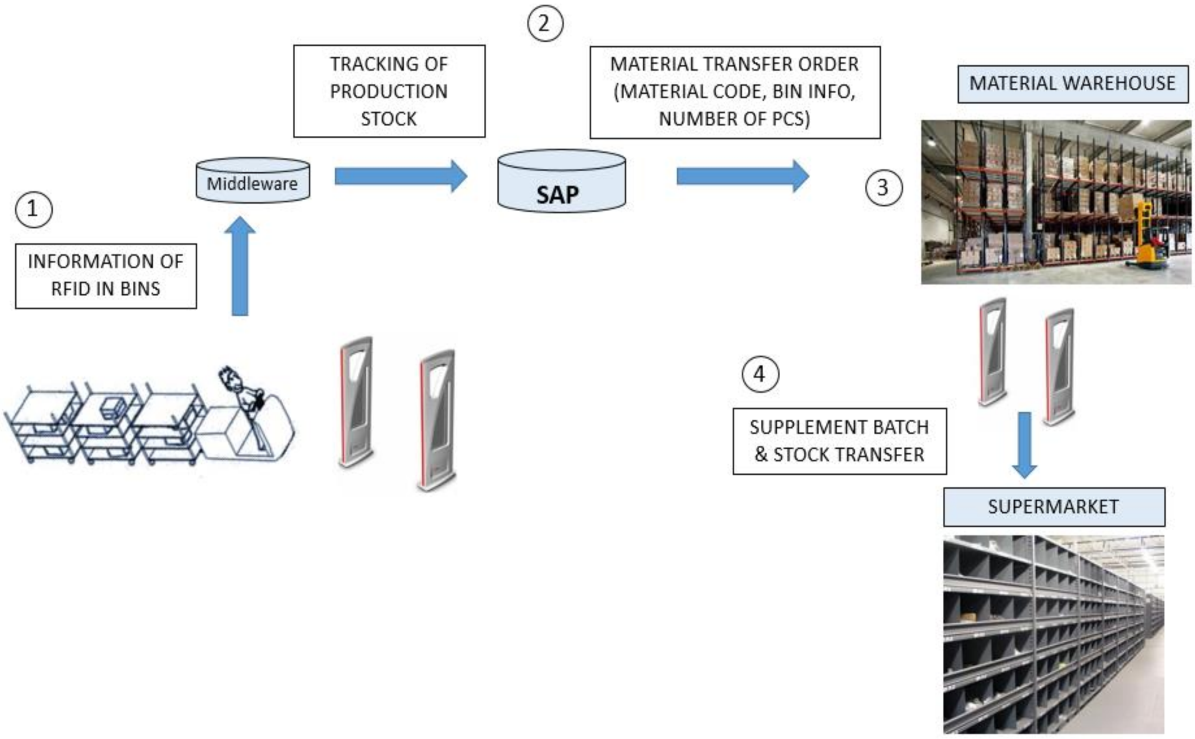

FIGURE 25.

1. When train passes the RFID gate, information of empty bins goes to the RFID middleware.
2. The middleware checks up production stock and creates material transfer order to the material warehouse if needed. Transfer order shows shelf location of collection
3. Material handler sees the material transfer orders in the screen in warehouse, picks up bins from the supermarket and fills them according to the transfer order.
4. RFID gate is on the door of the material warehouse. When the filled bins are moved through the gate, the stock transfers from warehouse to production according to transfer order.

8.1.1 System

This system or the RFID gates are not designed or manufactured by the company instead gates and RFID tags are purchased of subcontracted from an RFID technology-oriented company. Tags can be re-used; The RFID tag has only an ID code that is linked to the material / supplier information in the server database. When data changes are needed, the data can be modified in the server web interface.

8.1.2 Layout

Selected plan does not require any significant changes in the layout. The only changes are to locate the RFID gates on the path of material flow. One of the gates is placed close to the supermarket warehouse and so that the train passes through it when entering the production. The second gate is placed in the doorway of the material warehouse so that it is between the material warehouse and supermarket warehouse.

8.1.3 SAP

In the proposal solution, the middleware processes transfer request. RFID tags triggers middleware to send a message on iDocs to SAP for the needed information as material code, warehouse number, storage type, storage location and quantity (figure 30).

On the way back to the supermarket area the train transports empty containers of material which might need replenishing through the RFID gate from warehouse to production. These containers will contain RFID tags which trigger RFID middleware to send a message to on iDocs to SAP containing which material went through and also possible vendor requirements. If production stock is smaller than minimum bin quantity, the transfer request is needed. Some material can have several vendors. If there is required a certain supplier, the vendor information is specified in the transfer request. The information whether the material is ordered directly from the supplier or the company's central warehouse is also needed. Then transfer order is created to BIN in the amount of replenishment quantity. System uses FIFO so the oldest reception date of the storage period of the material is chosen.

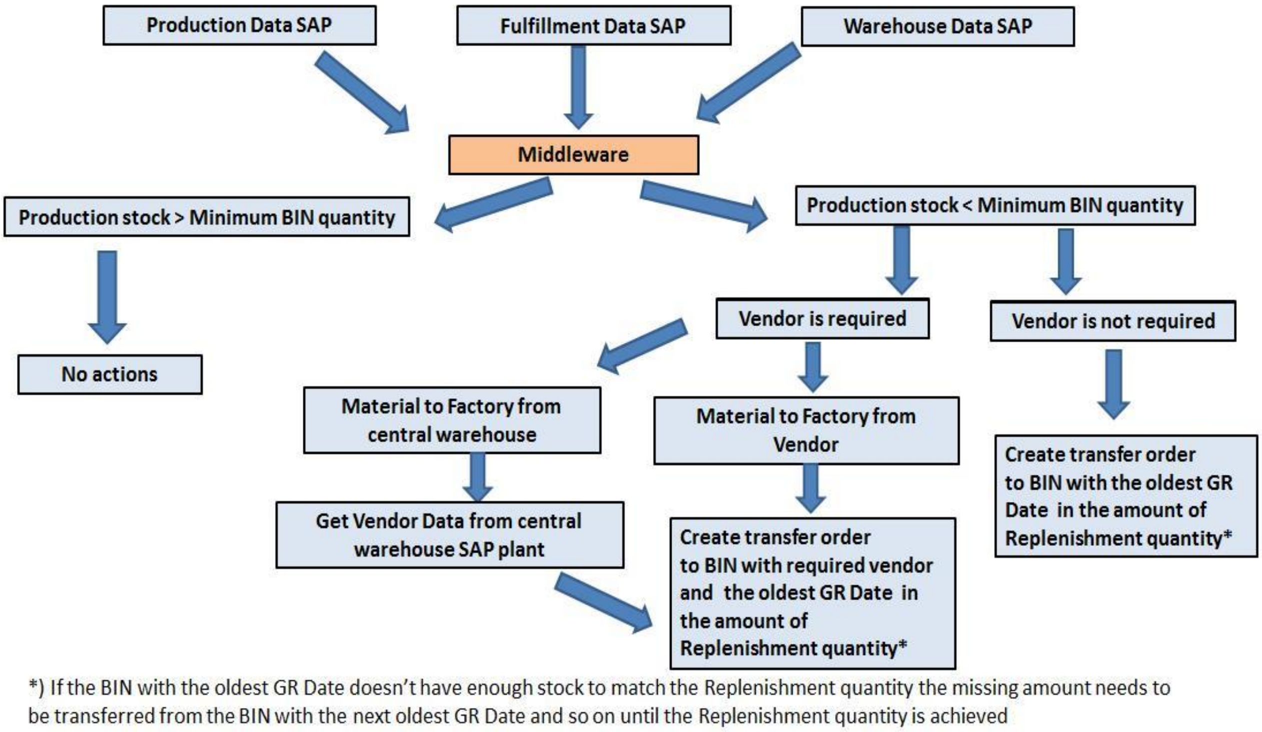

FIGURE 30.

8.2 Benefits

Benefits that automating material transfers offers are that it reduces manual work and work time of material handlers. Material handlers can focus other work functions instead. By implementing designed system, business benefits are 7440 euro per year. The factory has a lot of visitors as customers and partners, who are also often walked around the production area. This new system brings "political" customer value with "wow" effect to the factory. The system also provides an opportunity to explore new RFID technology application that can be used in other company factories.

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