Niki Virtanen

# Redesign of the Packing Area of Large Drives

Metropolia University of Applied Sciences

Bachelor of Engineering

Mechanical Engineering

Bachelor's Thesis

27 August 2018

| | |
|---|---|
| Author<br>Title<br><br>Number of Pages<br>Date | Niki Virtanen<br>Redesign of the Packing Area of Large Drives<br><br>45 pages<br>27 August 2018 |
| Degree | Bachelor of Engineering |
| Degree Programme | Mechanical Engineering |
| Professional Major | Production and Manufacturing Engineering |
| Instructors | Esa Keihäs, Production Development Manager<br>Timo Junell, Senior Lecturer |

This Bachelor's thesis was commissioned by ABB Oy, Drives and the objective of this Bachelor's thesis was to examine automation solutions which could be implemented to improve the company's packing process.

The study was carried out as follows. Firstly, a comprehensive knowledge of the current processes of the Large Drives packing line was collected and the author did an information retrieval about possible automation contractors. Secondly, offers to carry out new solutions to the packing line were requested from automation contractors. Thirdly, the analysis of process steps which create difficulties to automation solutions was made. Finally, from automation contractors' offers and packing automation analysis, suggestion scenarios of the new packing process were designed with computer aided design software.

As a result, ABB Oy, Drives obtained a better knowledge about packing automation solutions suitable for the Large Drives packing line and process steps which need to be changed to increase the degree of automation. The solution proposals made in this thesis were visualized by CAD drawings presented in the chapter "The new packing line".

In conclusion, the suggestions for the automated production line should be considered if the new packing area is designed and ordered, but packages and some process steps need to be changed. Packing contractors contacted in this thesis were excellent in their area of expertise and the author recommends that both companies continue to the next step of the procurement process of the packing areas' development solution.

| Keywords | Packing, Automation, Frequency Converter |
|---|---|

| | |
|---|---|
| Tekijä<br>Otsikko<br><br>Sivumäärä<br>Aika | Niki Virtanen<br>Large Drives pakkaamoalueen uudelleensuunnittelu<br>45 sivua<br>27.8.2018 |
| Tutkinto | Insinööri (AMK) |
| Tutkinto-ohjelma | Konetekniikka |
| Ammatillinen pääaine | Tuotanto- ja valmistustekniikka |
| Ohjaajat | Tuotannonkehityspäällikkö Esa Keihäs<br>Lehtori Timo Junell |

Tämä insinöörityö tehtiin ABB Oy:n Drives-yksikölle. Työn tavoitteena oli tutkia automaatioratkaisuja, joita voitaisiin hyödyntää yhtiön taajuusmuuttajien pakkausprosessissa.

Insinöörityö toteutettiin useassa osassa, joista ensimmäisessä osassa kerättiin kattava käsitys pakkauslinjan toiminnasta sekä kartoitettiin mahdollisia automaatiotoimittajia projektia varten. Toisessa osassa automaatiotoimittajilta pyydettiin ratkaisuja pakkausprosessin toteuttamiseksi. Kolmannessa analysoitiin haasteellisia prosessin vaiheita automatisoinnin kannalta Lopuksi automaatiotarjouksien ja pakkaamon prosessin analysoinnista saatuja tietoja hyväksi käyttäen suunniteltiin kehitysehdotuksia uusiin pakkausratkaisuihin.

Insinöörityön tuloksena tilaajan käsitys taajuusmuuttajien automaattisista pakkausratkaisuista parani ja yhtiö sai tietoa prosessin niistä vaiheista, jotka tulee muuttaa automaatioasteen kasvattamiseksi. Työssä myös osoitetaan muutosta vaativat kohteet ja esitetään kehitysehdotuksia muutosten toteuttamiseksi. Insinöörityö antaa tilaajalle vaihtoehtoisia kehityssuuntia uuden pakkaamoalueen toteuttamiseksi ja osoittaa kohteet, joiden suunnittelu vaatii erityistä huomiota.

Johtopäätöksenä esitetään, että automaattista pakkaamista tulee harkita vaihtoehtona manuaalisille ratkaisuille, jos uusi pakkauslinja suunnitellaan ja tilataan. Ennen tilaamista pakkausten ja joidenkin prosessivaiheiden muuttaminen on kuitenkin välttämätöntä. Insinöörityössä selvitettyjen tietojen perusteella automaatiotoimittajilla on tarvittavat tiedot automaattisten pakkausratkaisujen toteuttamiseksi.

| | |
|---|---|
| Avainsanat | Pakkaaminen, automaatio, taajuusmuuttaja |

Metropolia

## Contents



Metropolia

## List of Abbreviations

| | |
|---|---|
| LD | Large Drives, Product group |
| DP | Drive products |
| ESD | Electrostatic discharge |
| CTO | Configure to Order |
| MTS | Make to Stock |
| SBU | Standard Base Unit |
| ERP | Enterprise Resource Planning |
| PDM | Product Data Management |
| AGV | Automated Guided Vehicle |

# 1 Introduction

## 1.1 Background

Manufacturing of the electronic devices is a very competitive field of industry and demands for the processes and products are strict. Products should be manufactured as cost-effectively as possible and at the same time provide the adequate quality. Companies are constantly looking for ways to become better at their area of expertise.

Automation has been a major improvement to boost the productivity of the manufacturing industry and to create processes more powerful. Automated packing is used in a vast scale of different kinds of industries to make the packing process faster and more reliable. There are countless solutions to pack different products in different packages, but in most cases the package must be designed to meet the requirements set by the specific product.

This thesis was commissioned by the production line which assembles, tests and packs frequency converters. The product mix of this production line was going through a change where the capacity and flexibility of the line needed an upgrade. The consignee wanted to know if there are automatic solutions which can be implemented to improve the process and what actions are required to take this step towards more automated process. This Bachelor's thesis was focused on the packing part of the process.

## 1.2 Objectives and delimitations

The goal of this Bachelors' thesis was to suggest development solutions for the Large Drives packing area. To give these directions the author's task was to make a study of possibilities for the packing automation which can be applied to the Large Drives packing process and factors that should be considered when automation solutions are ordered.

The first objective of this thesis was to collect information of the current state of Large Drives packing process and packages. From this information the author created a specification for automation contractors so they could create offers for the new packing lines' automation solutions and find process steps which cannot be automated. Simultaneously with the automation study the author prepared packing line solutions with less automation. Both development directions aim at phased packing, which should decrease waste of operating time and makes the packing area more versatile.

The second objective of this thesis was to combine the gathered information from an automation study and a manual packing line study and create scenarios based on offered automation solutions, future capacity estimations and product mix demands. From these scenarios the most probable alternative is chosen and based on that scenario the investment calculations and plans to proceed in the development process are made.

The third objective was to give suggestions to what changes the current process needs that the automation solutions could be implemented and estimate the profitability of the investment.

This project was limited to include only process steps from the tester output of the device to the outbound delivery of the package. This thesis does not give detailed design for packages but points out the factors which should be changed to meet the requirements that automation solutions set. The scenarios introduced in this thesis include only process steps which are considered, and these suggested scenarios do not give exact methods or procedures how the process step should be executed by automation or as manual working steps.

## 1.3 Research methodology

To obtain the adequate knowledge of the current status of the packing process the author interviewed supervisors of the Large Drives and quality and production development engineers which have had projects considering the packing area. The author also had a two-day practical training in the packing area. To gather the volumes, product dimensions and other relevant information about the packing area the author made the information retrieval from different internal databases of the company.

The limitations for automations were examined by interviewing packing contractors, employees of the packing area and supervisors of the packing line. To create suggested scenarios the author organized interviews of supervisors of the packing area and automation contractors. The author also participated in workshops considering the future of packing in the company. To evaluate the profitability of the most probable scenario the investment calculations were made. The product mix distribution between different lines in created scenarios was made by operational comparison to find out which devices follow the similar packing process.

## 2 ABB Oy, Drives

This Bachelor's thesis was made for ABB Oy, Drives which is part of the company's Robotics and Motions Division. This thesis project took place in Large Drives packing area in the Drive Products Unit in Pitäjänmäki, Helsinki. ABB Oy, Drives is a market leader in frequency converter manufacturing. In Finland ABB's Drives unit develops and manufactures low voltage frequency converters and software tools for all fields of industry. In the Drives factory in Helsinki there are 1300 employees and it is a leading unit in research and development of ABB's products. Globally ABB's frequency converter business provides jobs for 6000 people in over 80 countries. (ABB Oy, Drives. 2018)

Large Drives production line manufactures mainly ACS580 – general purpose drives and ACS880 – Industrial drives, examples of the 880-product family are presented in image 1. The size range of these product families vary from small 7 kg wall mounted drives (R1 Frame size) to large 200 kg cabinet installation drives (R11 Frame size). ABB large drives production line is specialized in R7- R11 frame sizes of these product families. The power range of these products is from 0.55 kW all the way up to 630kW. (ABB Oy, Drives. 2018)

Image 1. ACS 880 Product Family (ABB Oy, Drives. 2018)

# 3 Planning and control of operations

## 3.1 Layout types in manufacturing industry

To start with, this thesis gives development suggestions to enhance the performance of packing. Suggestions given to stakeholders apply to the whole packing process, not just one part of it. Because the components of process are highly dependable on each other it is important that improvement suggestions take all components into account. If components are changed or moved it influences the process and it is important to understand the theory between different layout choices. (Slack, Brandon-Jones, Johnston. 2013: 193-195)

The layout defines positions of transforming resources and diverse tasks related to the operation or process in observation. The positioning of these factors creates flow directions for the object on its way from various materials to a complete product. Layouts should be designed and implemented carefully, because an inferior layout can make process time unnecessarily long, material flow complicated, and it can also create increased costs and the process is difficult to forecast. If the current layout of the process has been discovered ineffective and there are changes required to do for the layout, it could affect customer satisfaction and the available processing time. Possible costs and difficult re-layouts could be the reason, why these changes are not made often. When designing a new production line there should be a clear vision of objectives that the new layout should reach and the process that the packing line should execute. (Slack et al. 2013: 193-195)

In manufacturing industry layouts can be divided into four basic layout types. In the following listing the types are presented for suitability from the smallest batch size to the largest. Solutions that satisfy the company’s needs often require a mix of different layout types and in this thesis, only layouts which apply to large batch sizes are considered possible alternatives. Therefore a fixed-position layout and a functional layout are not suitable. (Slack et al. 2013: 193-194)

Fixed-position layout

In the manufacturing industry, the fixed-position layout has been applied when the product is too large or impossible to be moved. The fixed position layout is suitable for processes which produce a small number of similar products. A good example of a fixed - position layout is maritime industry, where materials, operators, machines and even plant move around the ships' body. Advantages of this lay out type are a variety of product mix and mix of tasks for operators to execute. The mentioned things cause raised unit costs of products and waste of processing time to additional movement. (Slack et al. 2013: 194)

Functional layout

In a functional layout materials and resources which go through a similar process are positioned in the same location. In manufacturing industry the functional layout means that the objective moves from function to function, depending on the requirements of the objective. In a frequency converter manufacturing assembly, testing and packing are different functions and therefore located in different places. The functional layout is relatively resilient against disruptions and has a capability to handle a large product mix. The disadvantages of this layout type are a complex flow of processes and a high number of products in queues between functions. (Slack et al. 2013: 194)

Cell layout

In cell layout resources, for example materials of product, that need modifying or actions, are moved to cell and processed. In cell layout resources which are transformed in a cell must be selected before the operation. In a cell layout the variety of product mix is limited. The cell layout offers a good flexibility of products made in process without raising production costs too high. Cell layouts can be expensive and difficult to rearrange especially when the production cannot be interrupted. (Slack et al. 2013:197)

Product line layout

In product line layout tools, the plant and materials are arranged to make a product move through the process in a pre-selected order. This makes the flow of the process clear and the process control easy. Materials which are transformed in a product line should have the same process steps and because of the fixed process steps the manufactured products should be very similar. Changes to process steps can be complicated and take considerable time. Therefore, the product line's product mix should be relatively narrow. Product line layouts usually require large investments, because transforming resources should be able to handle large volumes. Layouts with several consecutive operations that are dependent on earlier process steps are sensitive for disruptions. For example, malfunction of a single machine can paralyze the whole production line. (Slack et al. 2013: 198)

Choosing of packing equipment

> "Unlike the manufacture of household appliances or automobiles, packaging machinery manufacture is highly specialized business that does not produce large number of identical machines. It is therefore, not possible to visit a few stores, compare prices, buy a unit and plug it in" (Soroka. 2002: 468)

Packing machinery is customized for requirements set by products to be packed. Because customized solutions, packing machinery is engineered or designed to order. The complexity of the required packing machinery can make delivery times long and this should be considered in an early phase of designing the modernization of the existing machinery or ordering new packing machinery. In Finland most of the packing machinery builders are relatively small companies and specialize in a narrow field of packing. In some situations, packing lines require components from different manufacturers and integration between machines must be considered when calculating implementation time and expenses of the packing line. (Soroka. 2002:465-470)

Ergonomics in packing

Lifting heavy objects increases the risk of musculo-skeletal disorders. Working methods should be designed that the load of work is reasonable. Prevention of the harmful lifts and other process steps is often easier and more inexpensive than fixing the problems afterwards. The solutions to find a safe and healthy working environment should be figured out in cooperation with the employer and employees. Ergonomic hazards of the lifting can be measured with tools given by occupational safety administrations. According to the guides set by occupational safety professionals, lifts can be made more safe. (Sosiaali- ja terveysministeriö, Työsuojeluosasto. 2000)

## 3.2 Planning and controlling of the process

In the manufacturing industry the planning and control of the operation define scheduling and organizing the variety of activities required to create a finished product. Planning of the operation focuses on long term decisions and controlling of the operation focuses on activities which are relatively short term. Deviation between planning and control is not clear and they are strongly related to each other.

The volume and the variety of the manufactured products have a great impact on the way how the operations of manufacturing process are planned and controlled. The products made in the observed manufacturing process roughly define the volume-variety ratio that the production unit executes.

Predicting the demand can change significantly between different operations. In some operations the demand can be predicted accurately but this kind of operations require very clear indicators that point out the need to manufacture products. The opposite of the operation which have clear demand indicators are operations, where the demand is difficult to predict, this kind of operations usually produce very specific and detailed products or services and require heavy customization. (Slack et al. 2013: 288-296)

When responding to the demand there are different ways to fulfil the orders that customers have given to the manufacturer. The major factor which defines how the operation is executed is in which point the product is attached into specific order. The point where the order has been set to the specific product is called the order penetration point. If the order penetration point is in the early phase of the manufacturing process, the process control method is pull oriented. If the customer orders a product which is ready, or require minor customization, the process control method is push oriented. When choosing the strategy to fulfil orders the manufacturing unit must decide in which point the materials are converted and customized into finished products. The planning and control strategies which are used in manufacturing are observed in the next four chapters. (Slack et al. 2013: 288-296)

### Make to Stock

In the make to stock production model ordered products are manufactured before the customer order. When the customer places an order the products are delivered from the stock of the finished goods. The production of this model relays on forecasts of the future demand. This control method makes short delivery times possible because the order penetration point is set close to the customer. (Logistiikan maailma. 2018)

Assemble to Order

Assemble to order or configure to order is a control method where products are made to a semi-finished state and assembled or configured after the customer places an order. In this production control method products can be changed and customized to fulfil customers' needs more precisely. Delivery times are usually longer than in make to stock production and the order penetration point is further from the customer. (Logistiikan maailma. 2018)

Make to Order

In the make to order production the manufacturing of the product starts when the customer places an order. The product is manufactured from materials and resources which can be acquired before the order is placed. The time between the order and delivery could be long, but benefits in formability and a large variety of customization options are in some processes mandatory features. (Logistiikan maailma. 2018)

Engineer to Order

When the process follows the engineer to order process control the designing of the product starts after the customer's order is made. Products which are engineered to order are usually to a very specific purpose of use and require a high amount of customization. The order penetration point is far from the customer and delivery times usually long. (Logistiikan maailma. 2018)

## 4 Investment calculations

An investment is a combination of assets invested and profits acquired from the specific project. Usually investments are long term decisions and the profitability of the investment should be calculated carefully.

Investments cause a large variety of different costs. Investment costs include all the costs that are formed before the investment has been implemented. The following listing indicates the common investment costs in industry.

- acquisition of space for investment
- acquisition of machinery and equipment
- training of investment's implementation
- implementation costs of the investment

In addition to the investment costs there are also operation costs of the investment. Operation costs are formed after the investment is implemented and include the following factors.

- production costs
- maintenance and service costs

The target of investment is to create profit. Profits of the investment can be divided into two groups.

- returns from the investment
- residual value

Making the final decision about the investment can be complicated in the manufacturing industry. In many cases the estimation of the profits is problematic, because some of the profits cannot be measured directly. The profits that are not direct profits are called indirect profits and for example in this thesis savings from better ergonomics are one of the indirect profits that are difficult to estimate financially.

The financial impacts of the investment can be described with the following diagram (Image 2).

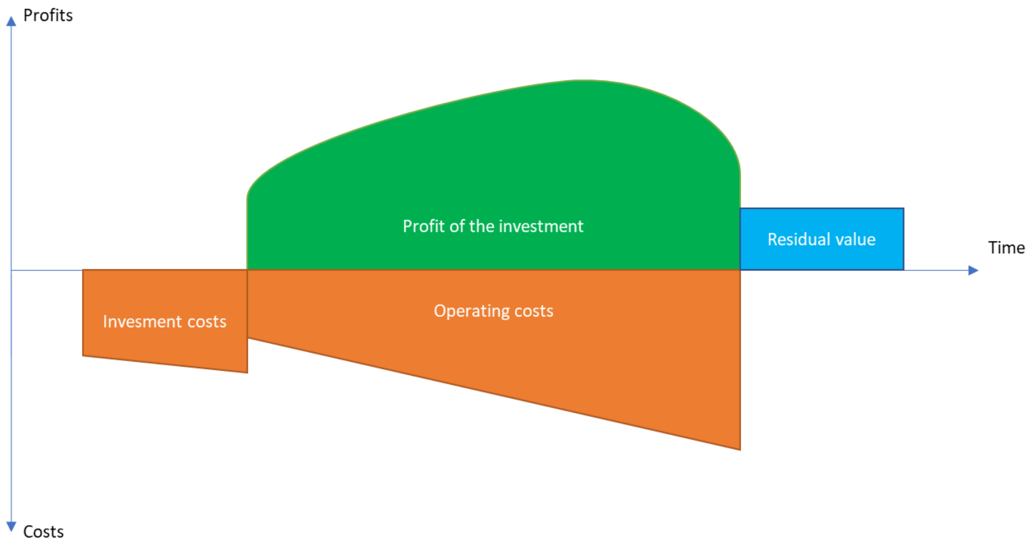


Image 2. Financial impacts of the investment.

(Pulkkinen et al. 2001: 186-188)

Net present value method

The financial profitability of the investment can be analysed with multiple different calculating methods. For large production or packing machinery construction the net present value is one tool to calculate the profitability of the investment. In this method profits and costs of the investment are discounted to match the implementation moment of the production instrument by using imputed rate of interest.

The formula to calculate investment's net present value is following.

$$\sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0$$

In this equation:

$C_t$ = net cash inflow during the period ($t$)

$C_0$ = total initial investment costs

$r$ = discount rate

$t$ = number of time periods

If the result of this equation is positive the investment is profitable.

(Investopedia, 2018)

Payback period method

The payback calculation method finds out the time which is needed to net profits to exceed the costs of the investment. The payback period calculating method does not consider the rate of interest in calculations.

The payback period is calculated by dividing the investment costs by the annual income.

$$\frac{Investment\ costs}{Annual\ net\ profits} = Payback\ period$$

(Pulkkinen et al. 2001: 189)

Annuity method

In the annuity method the cost of the investment is divided equally by years of the service life of the investment. A single year's capital costs are called the annuity. The annual capital costs build up from amortizations and interest charges. The investment is financially profitable if annual net profits are larger than annual capital costs. (Haverila et al. 2009: 203)

The annuity which corresponds with the investment costs is calculated by multiplying the investment costs by a capital recovery factor.

$$K_1 = H * c_{n/p}$$

Where,

$K_1$ = annuity corresponding the investment costs

H = investment costs

$c_{n/p}$ = capital recovery factor

The annuity which corresponds with the residual value is calculated by dividing the investment costs by a prolongation factor.

$$K_1 = \frac{J}{s_{n/p}}$$

Where,

$K_2$ = annuity corresponding the residual value

J = residual value

$s_{n/p}$ = prolongation factor.

(Pulkkinen et al. 2001: 195-196)

# 5 Current State of the process

The packing capacity of the large drives packing area has difficulties to meet the current and future capacity requirements set by a Large Drives production line. The product mix of large drives is in a transition phase because of the ramp-down of the older large drives product group. This change slightly decreases the variety of packing materials used on large drives frequency converters, but also creates pressure to pack frequency converters from other production lines in the large drives packing area. The current packing materials of LD products vary significantly between different frame sizes (R6-R11) and create a situation where the storage of packing materials take much space from more effective functions. The current process has peaks in the production output and the packing line has difficulties to handle an instable work load. With a variable work load packing area's utilization degree can occasionally be low. (Keihäs, 2018)

## 5.1 Current layout

The current layout of the packing area is cramped and makes an effective material flow hard to execute. The current layout follows the principles of the cell layout and makes picking distances long, because packing materials are located all over the packing area. The cramped layout combined with long picking distances create a remarkable waste of the capacity and the production area.

## 5.2 Customization component tracing in the packing process

ABB large drives frequency converters are used widely in different kinds of industrial solutions and often require customization in the software or hardware of the product. With these customizations the usability of the product is enhanced. In a packing process some of the hardware customization parts are attached to drives or packed in separate boxes inside of transportation packages. Customized parts that a client can change when placing an order are called "Plus Codes". With Plus Codes, the client can order a different control panel, an additional fieldbus adapter or an I/O extension module. (ABB Oy, Drives. 2018)

Some of plus code components are not traced in the packing area and the right content of the package is fully dependable on the operator's visual inspection. According to large drives quality engineer the current working methods might cause incorrect deliveries in devices which contain customization components. Incorrect deliveries create additional transportation costs and can affect customer satisfaction and implementation time negatively. (Martikainen, 2018)

## 5.3 Picking time of customization components and manuals

Long picking distances of customization components, manuals and packing materials create a remarkable waste of the capacity and production area. An additional movement to picking manuals and customization parts in the cramped packing area is exhausting for operators and could increase the process time of products in the packing area. The risk of an occupational accident is also increased when carrying loads in an industrial environment.

## 5.4 Process steps

Process steps examined in this project take place in 5 different positions. Dividing a process into different positions makes the process flow easier to understand. In current arrangement actions 1, 2, 6 and 7 are executed by ABB's employees and rest of the actions are responsibility of an external contractor. In the image 3 there is a layout based process flow chart about the process steps in the large drives packing area and after the image process steps are explained more accurately.

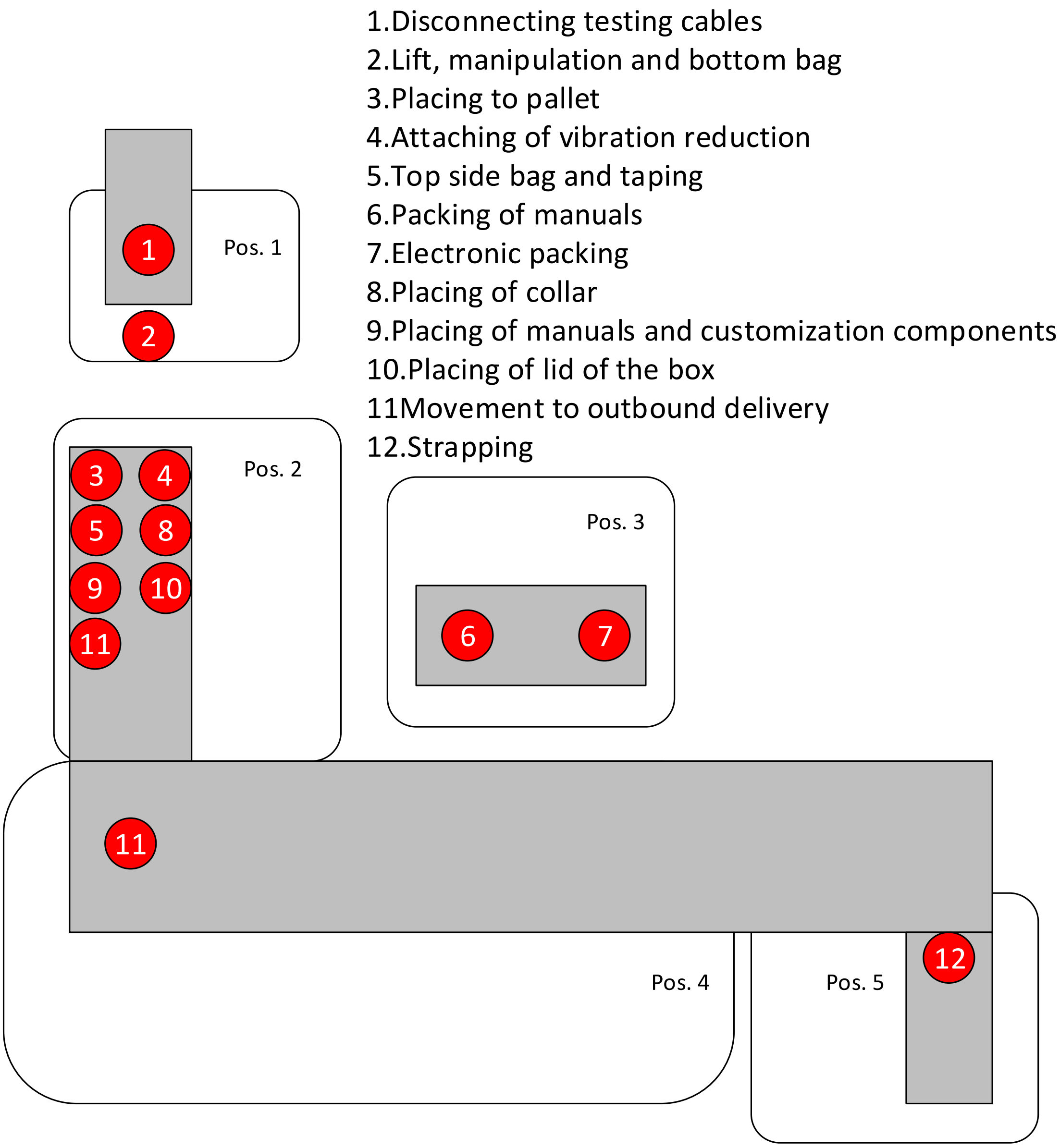


Image 3. Layout based process flow chart

1. Position - Unloading of a tester

The operator disconnects test cables used in the test process. Test cables are solidly attached to a test pallet and the connection between the device and the pallet must be detached before the device could be moved forward. Test cable connections between cables and the device are detached by a pneumatic nut runner. Test pallets are transported back to a loading point of the tester. After the disconnection of the cables, the operator connects the device to a crane with breech rings. The number of used breech rings and lifting accessories depends on the device’s frame size. When the device is lifted the bottom side of an ESD bag is wrapped under the device or the ESD bag could be placed on top of the transportation pallet in some devices. In large frames the placing of the bag is easier and more ergonomic with two operators.

2. Position - Customization work station

When the device is manipulated to the transportation pallet and the position is fixed, the device is fastened to the pallet with screws. Top half of the ESD bag is dragged on top of the device and taped around. After the bagging phase separate customization parts and manuals are placed on the pallet with the device. The cardboard collar and the lid are placed on the pallet and the transportation information (Packing list) and stickers are attached to the package. Then the pallet is sent to the dispatch department.

Positions 3-5

In position 3 the devices’ information is registered to the ERP and possible customization parts are picked from the shelf and placed to the pallet. In position 3 also manuals and other documents are bagged and prepared to be moved on top of the device. A semi-automated roller conveyor moves the pallet to the dispatch department. The position 5 is a strapping machine, which attaches 3 straps around the transportation pallet.

## 5.5 Current packages

Packing materials are dependable on the device’s frame size, international protection marking (IP) and plus codes of the devices. The current package generation has two different solutions to form a cardboard box. The box which is applied for smaller frames includes only one cardboard sheet which is folded and placed on top of the pallet. Cardboard boxes for larger frames are formed from two separate cardboard sheets. The components of the box are a sleeve and a lid. The lid of the box requires additional folding to achieve the required stiffness and form. The components of the package are demonstrated in Image 4.

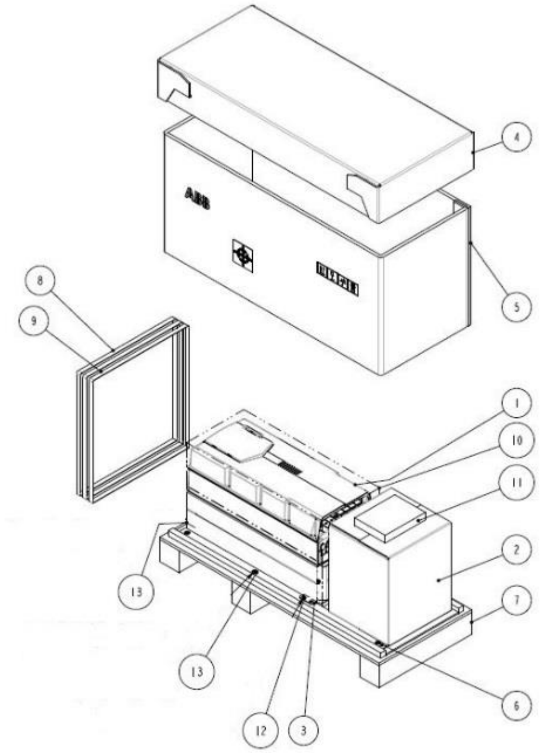


Image 4. R9 Package

Harmonization of R6-R9 packages

Multiple material code variations create additional storage expenses and therefore the package design should aim for as small quantity of material codes as possible. With a large variety of different material codes the availability of the packing materials is hard to keep on a good level. With fewer material codes, the interruptions due to material shortages can be decreased. The smaller variation in transportation pallet sizes and cardboard box dimensions makes the possible automation system easier to design and implement. On the other hand, if smaller frames are packed in large boxes, packing materials are more expensive than smaller alternatives. Also, freight costs have increased because of the empty space inside of boxes. The final impact on packing expenses is difficult to calculate, because there are multiple changing factors which are hard to predict.

## 6 Future of the packing process

Constrains

The first objective of the designing process of the new packing line was to set constrains for the line to be designed. In this process the natural starting point for observation was when the converter is tested and the tester had transfers the device out to the output track. The end of the packing process is when the package has gone through a strapping machine to the buffer for outbound transportations. Functions between these points are observed in this project. Before the packing process, the frequency converter goes through a testing procedure.

Process control methods

The packing of large drives products can be divided into four different process models. The factors that define the process model are the size of the device and the process control method.

MTO – Make to Order

In this process model the product that comes out from the testing procedure requires changes or additions to the basic software of the device. The installation of the software can take up to 30 minutes. If devices that require heavy configuration are directed to the same route as standard base units, there can be delays in the pass-through time of other devices.

Direct SBUs - Small Frames

Standard base units or SBUs require no software changes or other configuration procedures in the observed process phase. SBUs can be made to stock in the production line and this method could be used to balance demand peaks of later process phases, for example in the packing process. Manufacturing SBU products follow the principles of the push process control. ( Logistiikan maailma. 2018)

Large Frames – R10 and R11 – Make to Order

Devices with frames R10 and R11 are significantly larger and heavier than R7-R9 frames. For this reason, packing materials for R10 and R11 framed devices do not share packing materials with smaller devices and the lifting equipment requires more reach and load-bearing capacity compared to lighter devices. The length of large frames sets requirements for roller conveyors, work stations and the pallet handling equipment and these requirements should be considered when the new line is designed. R10 and R11 framed products have also smaller volume than smaller frames and have more customization options too. Therefore, these products are made after order has been confirmed.

System drives

High Power Drives' modules are manufactured in the System Modules production line and modules require no configuration in the observed process phase. Modules are packed in the independent packing cell and manipulated through the same conveyor as Large Drives devices.

Ergonomics

In this project the ergonomic way to work is a major driver to increase the degree of automation. Ergonomics should be considered in the early phase of designing new manufacturing machinery.

Devices with frames R7-R9 are smaller and transportation pallets and plastic bags can be handled by one operator. Larger devices with frames R10 and R11 require help from the second operator. For example, if R10 and R11 transportation pallets are lifted from the pallet cart to the roller conveyor by a single operator, there is a risk for inferior ergonomics and therefore increased sick leave absences. R10-R11 Pallets are wide, long and relatively heavy to lift without the relief of load. When lifting the load, the centre of gravity should not be far from the operator's body. When lifting the large transportation pallet, the shape of the pallet creates a situation, where the right lifting method cannot be executed. With automation solutions or smarter lifting equipment lifts made by the operator can be reduced and working would be more ergonomic.

Customer Configuration

The customer configuration is a procedure where the device is configured to meet customers' demands. In this procedure the specific software is installed and some of components are changed. The current process of the Large Drives devices does not have the customer configuration procedure in Pitäjänmäki factory.

Limitations for automation

The decision of which process steps are smart to automate can be difficult to make. Most of these steps are possible to automate, but the cost of the investment can be too high compared to the value added in the observed process step. From this project's point of view, there were process steps which prove to be very difficult to automate. In the following chapters the process steps are introduced.

Disconnection of testing cables

Frequency converters are placed in the testing palette after they have gone through all manufacturing process steps in the production line. In the testing palette the device is not aligned to a specific location in the palette, but testing cables are connected between the palette and the device. In the testing palette there is a socketing to connect the palette to the testing infrastructure. Testing cables are attached to the converter with bolts. The location of bolts varies in testing sockets between different frames. With two irregular dimensions, the device's location in the pallet and the location of the tightening bolt of test cable, can automation of this process step be difficult to execute with a robotic solution. In Image 4, the testing palette and the frequency converter are still connected.

Plastic bag wrapping

Placing the device inside of two plastic bags or a shrink-wrapping film prove to be a challenging process step to automate. The manipulation of plastic bags simultaneously with lifting the device, require multiple industrial robots and increase costs of the automation system. The shrink wrapping requires heating the wrapping film and some of the heat is transferred to the device as well. The additional heat in the shrinking process may cause defects in the surface or the functional quality of the device. In Image 6, the bottom side of the frequency converter is isolated with plastic bag.

Image 5. Frequency converter with a bottom isolation bag

Cardboard boxes

There is currently the large variety of different cardboard boxes and methods that cardboard boxes are folded from sheets. Different folding methods are difficult to execute with automation and may require multiple grippers and increase costs of the automation investment. In Image 7, there is the cardboard box folded from two sheets and in Image 8, the box is made from one sheet.

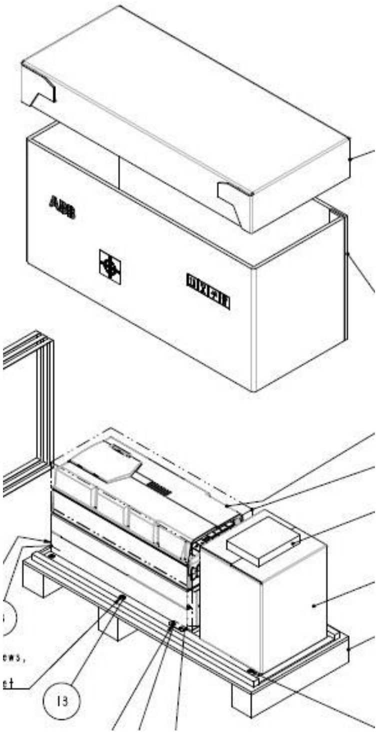


Image 6. Cardboard box with foldable lid

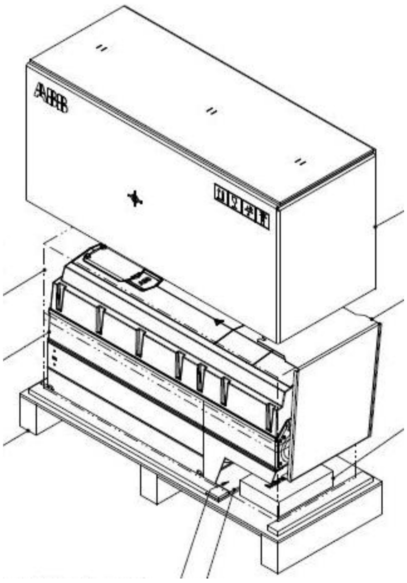


Image 7. Cardboard box from single sheet

**Irregularity of lifting points**

When lifting heavy objects like large drives frequency converters it is important to ensure that the device is properly attached to the lifting equipment. The variety of the lifting equipment used in a drives factory is wide and automation narrows down some of these options. The current lifting in the packing area is executed with breeching rings, chains and hoists. This method requires manual work from the operator and cannot be done by automation with reasonable costs. This method is easy to adjust for new product families.

Methods that use suction cups require pre-defined slots for cups to create proper attachment. An irregular mechanical structure in devices' edges limits the use of the suction cup gripper.

Grippers with locking bars are one option to lift devices in the packing line. Locking bar grippers require two pre-defined locations for a gripper to lock bars. The current and next generation of large drives products require highly adaptive grippers to execute all the lifts in the packing line, because of the large variation of frame sizes and lifting points.

Transportation vibration reduction

The current package requires devices to be attached to the transportation pallet with clamp sheets or plywood strips. Strips and clamp sheets need precise manipulation and visual inspection that components are properly in contact. A Holder and a pallet are attached with screws, the locations of which change in different frames. The vibration reduction methods must be changed or made manually to make automation solutions possible.

Costs of the investment

The volume of large drives production line sets limits for packing machinery costs in this project. Investments made in the packing area should have a reasonable payback period and costs cannot be too high compared to the volume of devices packed in this line.

Area

Fully automated production lines and packing cells take a lot of space and since there are still process steps that cannot be automated there must be space for manual functions as well. Automation solutions in the packing area can have an effect on the material flow of the process. If some of the current processes' overlapping functions could be eliminated the additional space can be obtained to packing lines' purposes.

# 7 New packing line

In this chapter the author created three scenarios which were based on the manual packing methods and two scenarios with automatic packing solutions. Automation solutions are loosely based on automation contractors' designs and have no specific details about the contents of offers created by automation contractors. (Automation company X, 2018)

The capacity of the packing area should be increased to meet requirements set by production lines and testers. The decision about the final capacity specification should be made before the procurement process is started and there should be accurate forecasts about the volumes which go through the new packing line.

The area estimations of this project were made with 2D modelling software AutoCAD. Components and materials used in the packing area were manipulated with AutoCAD to estimated locations. Drawings were also used to visualize different layouts for stakeholders.

## 7.1 Automation contractors

This bachelor's thesis examines possible contractors to build a packing line or automation cells for the large drives products. In the beginning of this project, the author and the instructor decided to limit options to only cover domestic automation contractors and packing machine builders, because the project was demonstrated in the Pitäjänmäki factory of ABB. To obtain the contact information of reliable automation contractors the author reviewed the instructor of this thesis and colleagues from the production development team. The author also did a comprehensive information retrieval about formerly unknown packing automation companies.

## 7.2 Specification for automation contractors

The Information for the packing line specification was gathered from the ABB intranet, PDM tool and other internal databases such as ERP and demand forecasts. The author also worked in the packing line for two days as an operator trainee to gain a better understanding of the process and working methods. This training period was experienced extremely valuable for this project. For more exact details of the process description and working methods, the packing lines' supervisor's support was a crucial help. (Kaasinen, 2018)

In the first step of the procurement of the packing line, the author's task was to create a rough specification of the requirements for the new line. This specification was introduced to automation contractors and packing machine builders.

The contents of the packing line specification:

- dimensions of devices produced in the large drives
- dimensions of packing materials used in the process
- product mix of the line
- process description of the current process
- layout drawings of the packing area
- capacity estimations
- maximum tact time for each process step
- special requirements for frequency converter packages
- conditions of the contract

Contractors were also invited for an on-site project introduction.

With the specification and the on-site introduction, contractors were asked to provide a budgetary offer for a packing line's solution. In this step of the procurement process, contractors were asked either to provide a complete solution for the whole packing process or components to execute some of the process steps. From budgetary offers the author created development plans for the new line. A comparison of different development directions was made between cases created by the author. Contractors were asked to sign a non-disclosure agreement with ABB Oy. The sensitivity of this project required a non-disclosure agreement to be signed before any detailed information of the packing area specification was introduced to the contractor's representatives.

### 7.3 Manual packing solutions

The author created a CAD drawing of packing area's current layout which contained only fixed objects that were not possible to move or replace. With post-it notes and pencils both shifts created a development suggestion for the layout. These two suggestions were combined with the supervisor Mikko Kaasinen and transformed to the CAD drawing.

The feedback from employees who work with the process is very valuable. With the everyday experience from working methods, employees can bring different aspects to ergonomic problems and risks for the work safety and waste of the processing time. Some of these hazards are difficult to consider when designing new solutions, because stress factors for the employee safety can appear within a long period of time.

The purpose of this survey was to gather alternative suggestions for the process execution with a limited automation and give ideas how to locate the materials in the area.

Scenario 1

In this case the current roller conveyor is demolished and replaced by two parallel roller conveyors. Ideas for this case were gathered from employees of the packing line and suggestions do not have any cost estimations or proposals for the technical execution.

This solution follows the production line layout principles and aims at more linear production. In this solution, all the transformed resources go through the same process steps. The process steps of these two lines are designed to be different.

The production line on the left is designed to handle volume products which do not need much configuration. The material flow of this line is optimized and all materials needed to finish the packaging process are brought to a close distance to the operators' work station. The line on the right is designed to process products which need more customization or have a longer processing time. There are more process steps in this line, but the cycle time of this line is slower. This line also needs a larger variety of packing materials than the volume line.

As the production is changed to fit better larger batch sizes, the variation of the products processed in the packing area is more limited than before and changes for products and especially packages must be designed more carefully. The product line sets limits to working directions for operators. The former layout type with workstations, moving in different sides of the device was possible but not efficient. For example, reaching to attach clamping plates to reduce the vibration on both sides of the device could be ergonomically an inferior working method.

The layout presented in this scenario divides the packing area into two separate sections. The material flow of the two lines must be individual and the lines should not have common materials. Also, the movement of operators is limited because of a narrow space between the testing output and the packing line. The layout of this suggestion is presented in Image 9.

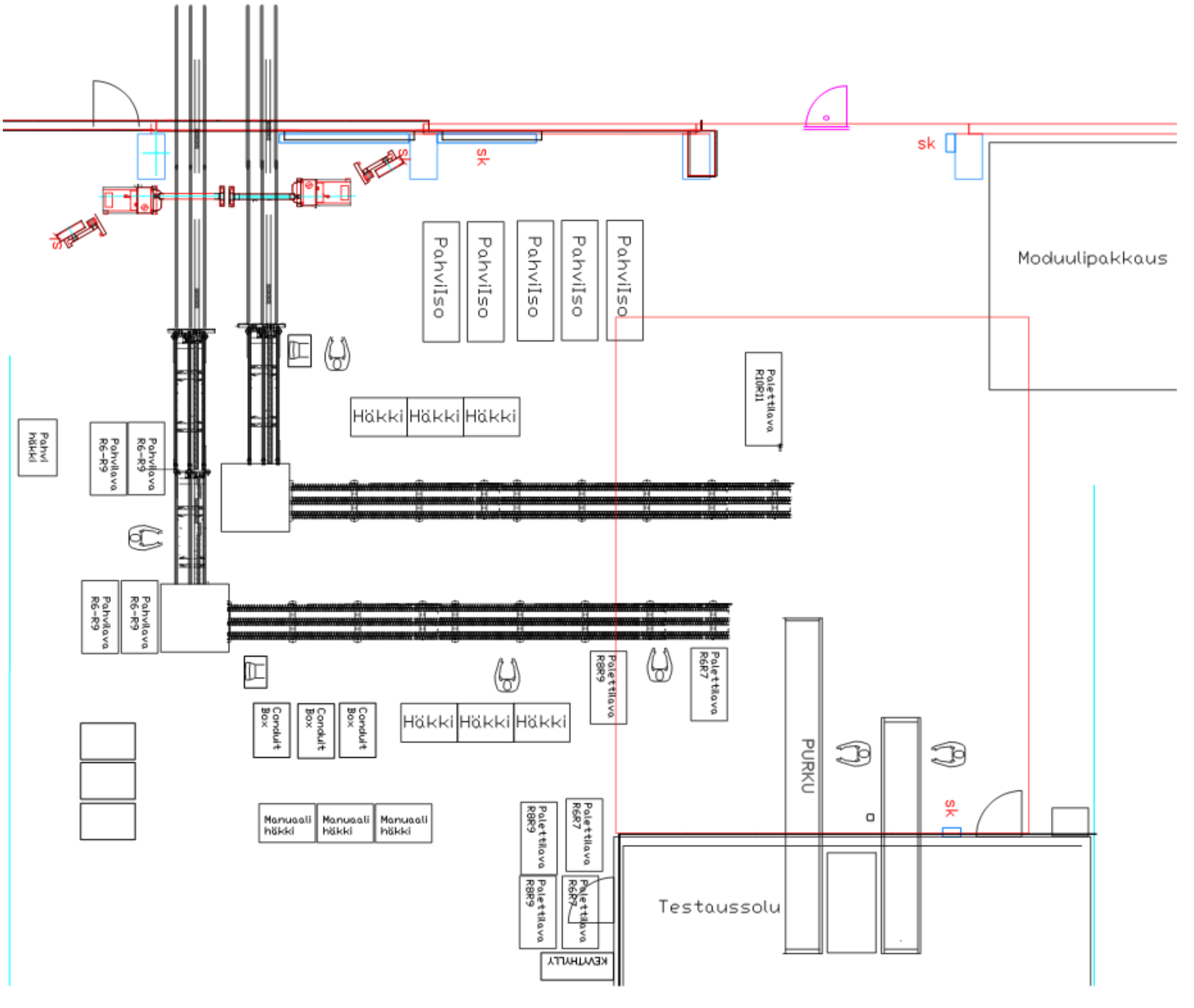


Image 8. The layout of scenario 1

Scenario 2

In this scenario large investments in the Large Drives packing area are delayed while waiting decisions concerning other modernization projects of the Large Drives manufacturing process. With this scenario the process control of the large drives packing stays the same and only minor improvements are made to the packing machinery. The current conveyor system is modernized and reprogrammed by an external contractor. The current conveyor system is relatively slow and does not suit for current or future process properly. For example one scale is required in the input workstation of the conveyor to make the material flow of the line more efficient. Also the logic of the buffer and movement of packages require changes.

Scenario 3

In this scenario two outfitting work stations are demolished to make room for customer configuration work stations. One of the conveyor workstations is extended and packing materials are brought closer. This workstation packs normal devices and prepares devices which are moved to the customer configuration. Devices which go through the customer configuration process are directed through the conveyor to workstations. Large frames are packed at the top workstation of this layout. The layout of this scenario is presented in Image 8.

The risks factor of this layout is the limited capacity of the packing and configuring devices. Compared to the current layout, work stations are reduced. Even if the work stations are made more linear, there is a risk that customer configuration requires too much resources from the regular packing process. More research about customer configuration process is needed before this layout can be considered as a possible solution for packing lines' layout.

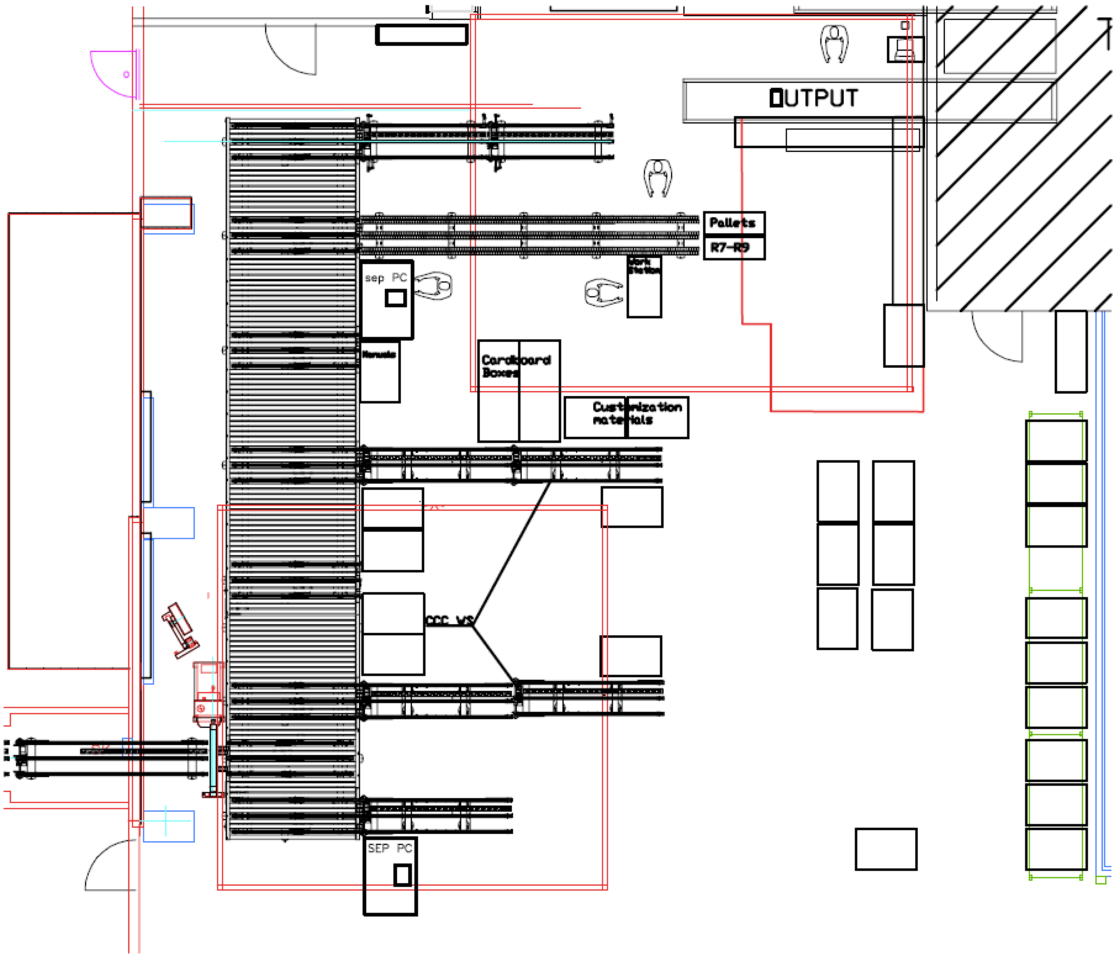


Image 9. The layout of scenario 3

## 7.4 Automated packing solutions

The detailed information about technical execution of solutions that automation companies have offered to ABB cannot be presented in this thesis, because of the non-disclosure agreements.

From the offers received from contractors, the author could estimate the space used for automation components and process steps that are hard to automate. Both scenarios focus on automating later parts of the packing process and leave the outfitting process as a manual work step.

Scenario 4

The scenario 4 is based on a situation where customer configuration work stations and an automated SBU buffer have been taken part in the process. The manipulation between the automation cell, SBU buffer and manipulation line is executed with a manually moveable hoist. If the input and output method of the SBU buffer is possible to execute with an industrial robot, then most of the manipulation in the beginning of the process should be done with that same robot. The third alternative solution to manipulate devices in the area is a belt conveyor. The variation of the frame sizes sets limits to the belt conveyor and therefore it is not drafted to this scenario. A possible layout of this scenario is presented in Image 11.

This scenario expands the variety of order fulfillment strategy types which are possible to execute in the Large Drives packing area. The buffer creates option to produce devices to stock and customer configuration workstations can configure devices after the buffer.

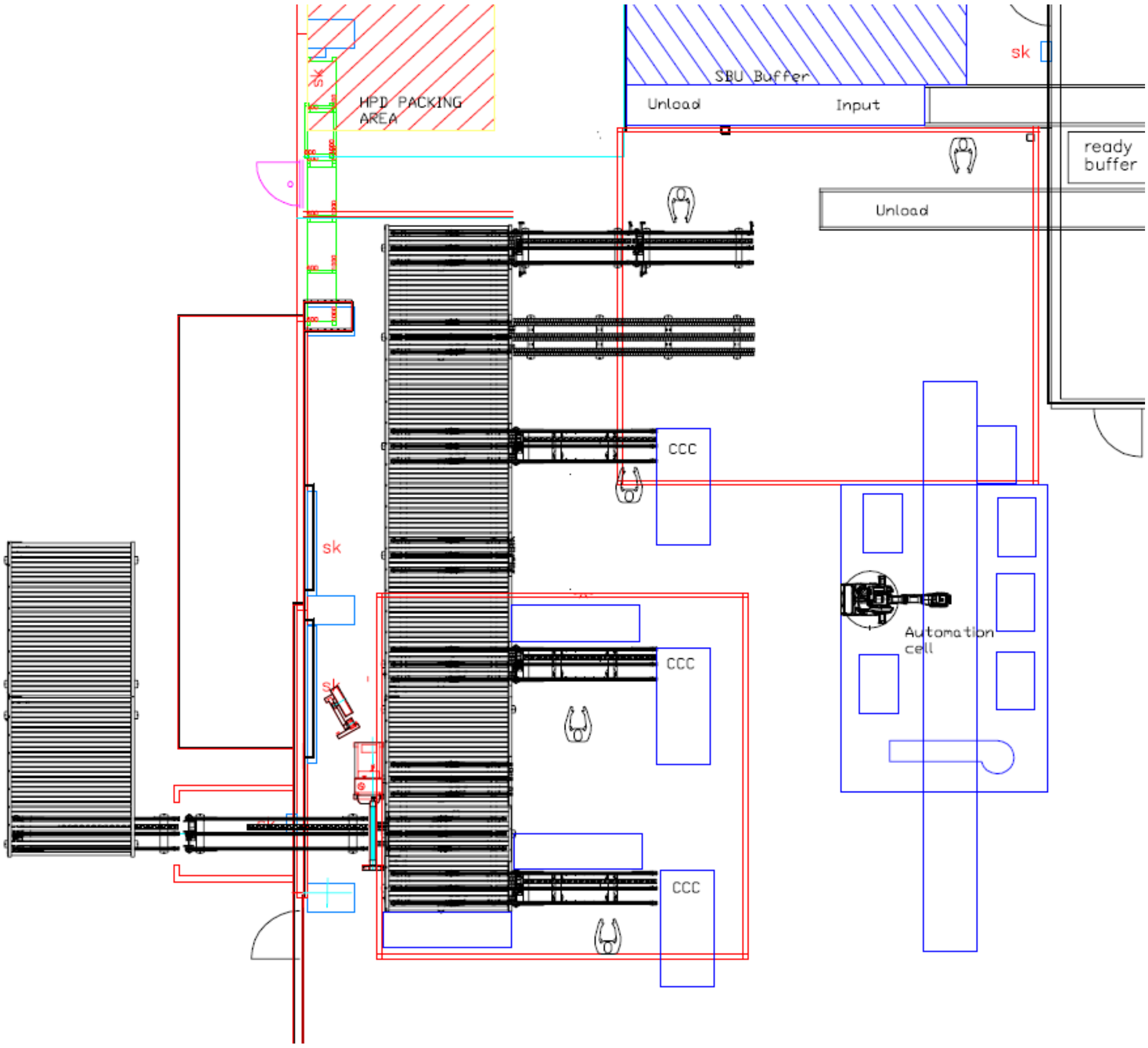


Image 10. Scenario with the automated packing cell and customer configuration work stations

Scenario 5

This scenario takes influences from results of the design workshop organized by the logistics team of the consignee. The other participants of this design workshop were three representatives from the packing contractor, one production development engineer and one representative from the Large Drives production supervising team.

In this scenario different order fulfilment strategies divide the packing process into three process models. These process models are following:

- make to order
- make to stock
- configure to order

In addition, modules from the System Drives are packed in the manual packing line.

The packing process is divided into the packing phase and the outfitting phase. In former scenarios and the current process model, the outfitting and packing have been made in the same work stations but in this scenario materials and work stations of the outfitting part of the process are separated from packing materials and work stations.

The outfitting work stations can process all the devices going through the packing area and after the outfitting the packing process is divided into three packing lines. One packing line is focused on process small frames and takes advantage of automation solutions. Two other lines are focused on larger frames and system drives' modules. These two lines are manually operated, at least in this part of the modernization project. In Image 12, the process is demonstrated with a flow chart. This flow chart can be compared with the flow chart of the current state. The flow chart is introduced in Appendix 4.

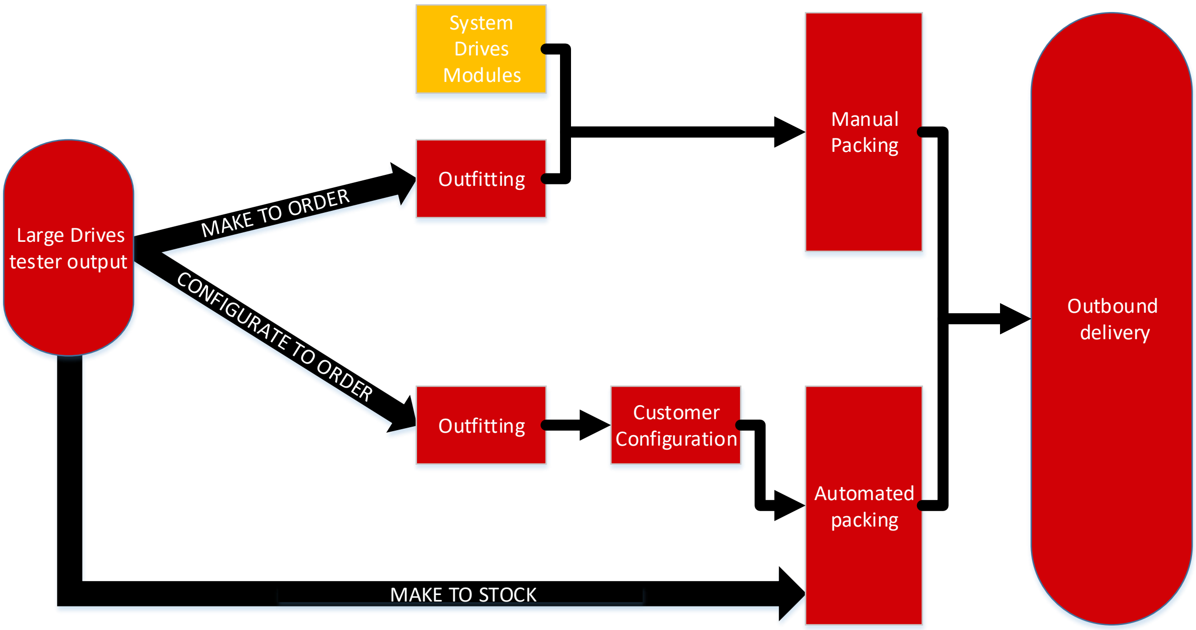


Image 11. The Process Flow of the scenario 5

In Image 13 the possible layout of this scenario is presented. The layout demonstrates only main components of the layout and has only packing and outfitting materials for two manual lines. The final locations of the automation cell materials are defined when more detailed plans are made.

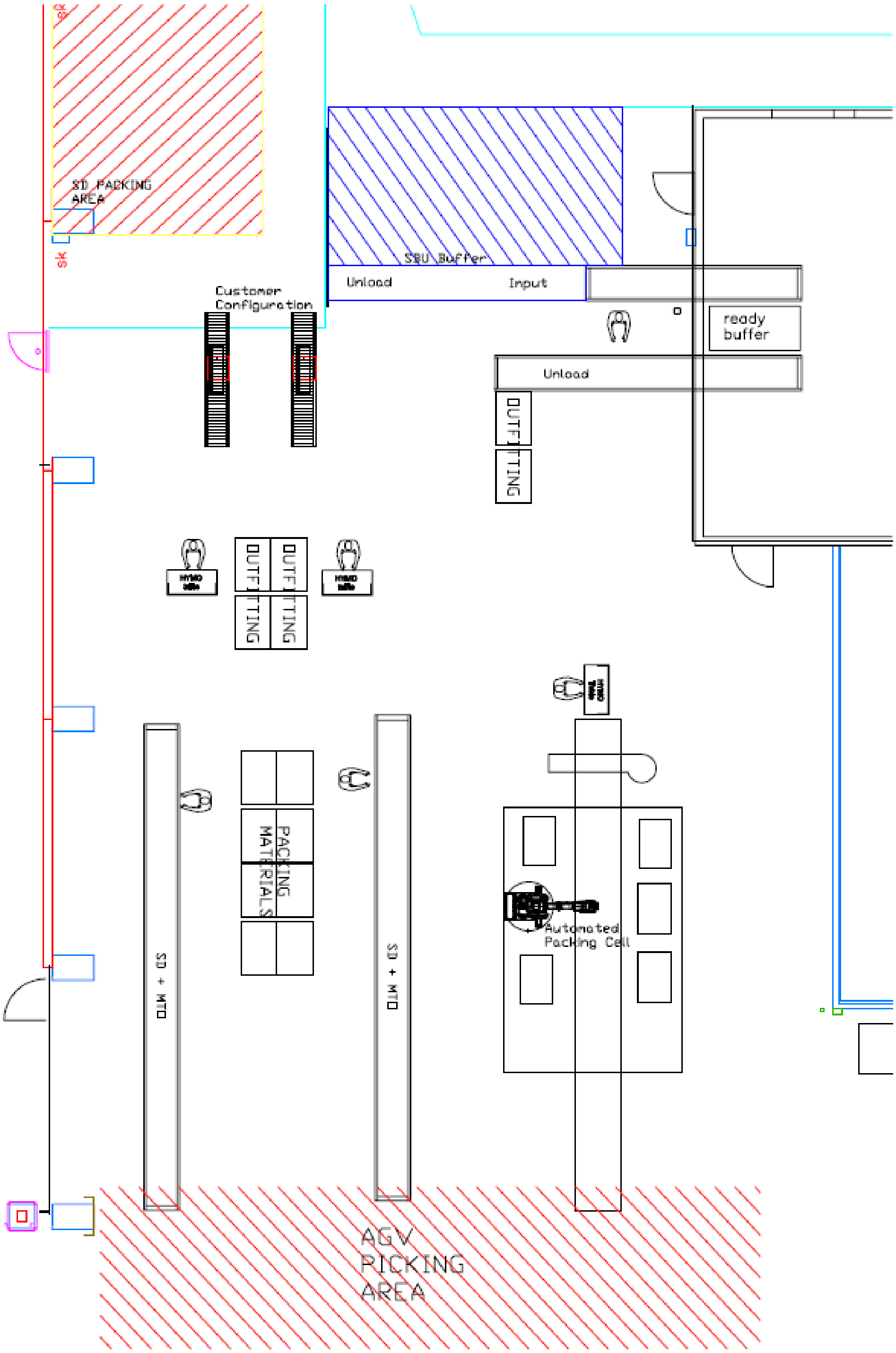


Image 12. The layout of the scenario 5

The layout of the fifth scenario is a mix of the functional layout and the production line layout. The outfitting part of the process is executed with a functional layout and the packing part of the process follows the production line layout. The outfitting layout takes advantage of the versatility of the functional layout and makes possible that the large variation of different kind of devices can go through this part of the process. In the packing part of the process similar devices are directed to designated lines and the packing lines' have materials to transform the device to the ready-to-send stage.

Devices are directed to specific lines based on mutual materials, packing methods or dimensions. Especially in the process steps which are made in the automation cell the similarity of the processes is important. The comparison between different process control methods is made with an operational comparison chart. The operational comparison chart is presented in appendix 2.

The result of this comparison shows that all the smaller frames have significant similarities in the packing part of the process, if the packages are harmonized to the stage that they have same folding methods and components. The large frames and devices from system drives could be directed to same production lines even the process is different in some steps. Manually operated lines aim to handle larger variation of products and adapt to possible changes in packages.

Automation solutions which could be used to execute packing lines presented in this scenario are based on the automation contractors' offers. The phase time of the automation cell was set at maximum of 5 minutes for on package. The feedback from automation contractors indicates that the final packing time with automation stay clearly under 5 minutes. Therefore the speed of the automation system does not create constrains or bottlenecks for the packing process.

## 7.5 Financial impact of the new packing line

The financial impact of the packing machinery investment is calculated from savings which the automated packing cell could create. The savings are formed from reduced packing service charges of the packing of R7 - R9 modules. The used methods of investment calculations are the net present value method and discounted payback period method.

The calculations are made from following factors:

- procurement costs of the automated packing cell
- annual operational costs of the packing cell
- annual savings from the automated packing
- capital costs

The calculations are based on the following formula of net present value

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0$$

Where,

$C_t$ = annual savings of the packing cell investment

$C_0$ = investment cost of the packing cell

r = rate of the discount

t = number of time periods

The profitability of the investment was also calculated by discounted payback period method. The calculations are based on the same factors as NPV calculations.

More detailed information about the investment costs and annual operational costs are needed to make the calculations accurate and useful for the company.

The calculations made from the current data the estimated discounted payback period was 4.11 years and the net present value for 4 years' service life was -16450€.

# 8 Results and conclusions

## 8.1 Results

The current state of the process

The study made about the current state was adequate to proceed to the next phase of the project. The study gave valuable information about the packing areas functions and points that needed attention.

From the information of the study of the current state, the specification for automation contractors was made. From contractors the author received budgetary offers about the future execution of the packing line. The detailed designs of the execution were delimited from this thesis because of the agreements between the consignee and contractors. The on-site introduction and interview of the packing area and the budgetary offers gave directions and suggestions which procedures and materials might need changes before the automation solutions are possible to implement. From these sources of information, the author created the listing about the limitations for automations. As the result of the chapter 6.5, the author received major pain points of the packing process which have proved to be challenging to automate without changes. The process steps are the following

- disconnecting of test cables
- isolation of devices
- design and folding method of cardboard boxes
- vibration reduction of devices during transportation

Scenarios

One part of this thesis was to create different scenarios about the future of the packing area. The five scenarios introduced in the chapter 7 suggest different kinds of solutions to solve the future of the packing of the Large Drives and the System Drives frequency converters. The scenarios are based on the author’s opinion in addition to workshops and interviews organized with different stakeholders. Scenarios 1-3 are manual solutions and solutions 4-5 include the partially automated packing line. All the scenarios are based on multiple estimations and give only suggestions about solutions which could be considered when designing and ordering the new packing machinery. The fifth scenario meets the requirements best and therefore, most of the calculations and conclusions are based on that scenario. The estimated investment calculations were made for the scenario 5 and the result of calculations were that the investment's discounted payback period was 4.11 years. The investment calculations prove to be too inaccurate to be used for decision making in this part of the modernization process.

To increase the automation degree of the packing process, there are steps that need to be optimized for automation before the automation system is ordered. The chapter 5.4 Limitations for automation points out the process steps where the changes are needed. A fully automated packing line requires heavy changes for the test cable attachment, outfitting process and packages. Changes to the cable attachment and package changes must be made in collaboration with the product engineering team and packing specialists of the company. For a partially automated solution, for example the one suggested in the scenario 5, the minor changes to processes and materials are adequate.

The steps that need to be changed to proceed to the automated packing solution are vibration reduction and an isolation method of the device and the structure of the cardboard box. With changing these factors, the variation of different working methods in different frames could also be harmonized and the unified procedures can be implemented in all the devices which go through the Large Drives packing area. Implementing solutions which are designed for automation, the level to automate the next step of the process is lowered.

## 8.2 Conclusions

The assignee does not have resources to design or build the automation cell or the automatic production line. The possible automation solution will be ordered from the contractor specialized in producing automated packing machinery. The procurement of the automation cell or automated production line requires deep knowledge of the process which is going to be automated. To move forward in the procurement process, the more detailed specification about the automation optimized process should be created in cooperation with packing designers and automation contractors. The final specification which leads to the purchase order requires large amounts of resources from all the parties participating in the procurement process.

Investment calculations made in this thesis' appendix 3 are based on scenario 5. To achieve decent accuracy in the calculations, more detailed offers and revenue estimations are required. The calculations made in appendix 3 are made by using the net present value method and discounted payback period method. The raw data for the investment calculation was too inaccurate to reliably estimate the profitability of the investment. When there is more accurate raw data available, the calculations should be done again to estimate the profitability of the investment to justify the decision to acquire the new packing machinery.

The goal of this Bachelors' thesis was to give development directions for the large drives packing area. As a result of this thesis, the steps to proceed towards automation were given and possible layouts and components were introduced.

The mandatory steps to proceed towards an automated packing line is to harmonize the packages and replace the vibration reduction method with a more suitable for automation. By harmonizing and improving the packing materials also the availability of the materials can be improved. The order fulfilment strategy, process description and investment calculations must be confirmed to proceed in the development project. After these changes are done and decisions are made, the procurement process with automation contractors could be started.

The author suggests that the packing process is divided into automated and manual sections and small frames and large frames are directed to different packing lines. The packing process of large and small frames has clear differences and for that reason processes are challenging to execute in the same packing line. In this stage of the modernization process, the author suggests that only the packing of small frames is automated. The outfitting of all devices remains to be carried out manually and larger frames and system drives' modules are also packed manually in the adaptive packing line suitable for both device types. The scenario 5 supports the automation vision the best and the author suggests that the future direction of the development follows this scenario. In the future, the degree of automation should be increased by automating the packing of all the devices and considering the implementation of automated guided vehicles to intensify the internal logistics of the packing.

The automatization of the packing process is challenging with only one investment and the author suggests that the modernization process is given different steps to achieve the desired automation degree and all the automation solutions are not planned to be implemented at the same time. The following diagram indicates the possible steps of the modernization process that could be applied to the Large Drives packing area.

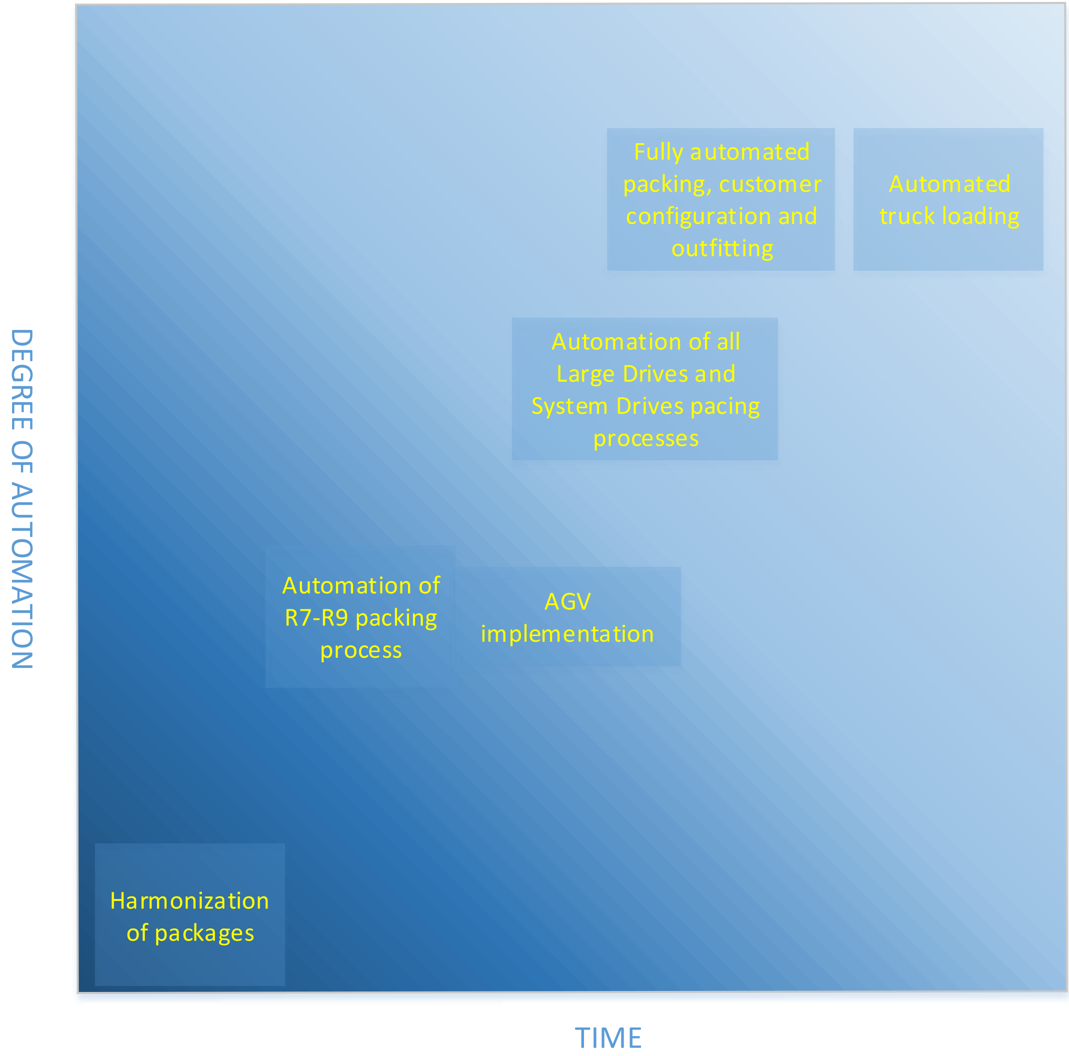


Image 13. Diagram about steps to increase the degree of automation

The improvement project of Large Drives continues after this Bachelor's thesis and the re-designed packing line is only one phase of the improvement that the manufacturing process of Large Drives frequency converters are going through in the future.

## 8.3 The future of project

After this thesis project there are still multiple steps to take before the automation system is ordered and implemented to enhance the packing process. The process order of different product types packed in the packing line should be harmonized to match to each other. At least the products which go through the same packing line should have very similar process steps. The process steps and packing materials should be examined with all considered parties to make sure that there are no conflicts between the automation process and packing requirements. Packages of the products which are directed through the possible packing automation cell require changes. Changes should be made in folding methods, vibration reduction and the taping procedure. The new design of packages should be decided with the automation contractor which is going to provide the packing automation cell.

Outfitting and packing of the devices are made in different locations in the suggested scenario. The outfitting process and space requirements should be examined carefully before the exact location of the packing cell and other packing lines are decided. There are also some process steps in the outfitting process which could possibly be made in the production line.

The movement of devices within the packing area should be executed with tables with a roller rail. Ergonomics and usability of these tables are crucial for work efficiency and safety of the packing employee. There should be a pilot project considering the execution of the movement and working tables. Workshops about the outfitting project have already been organized in the Large Drives, but more information and decisions are still needed

## 9 Summary

This Bachelor's thesis aimed to give answers to questions that the changing process and new requirements set for packing instruments.

The current process was examined with adequate accuracy and budgetary offers were received from two automation contractors. Offers and contractor interviews gave valuable information about possible automated packing solutions which could be implemented in the packing area. The automation study also pointed out the process steps which should be changed before the procurement process could start.

One of the five scenarios created in this thesis was successful and suits for the future process control strategy of the company. The author recommends that the fifth scenario is considered when designing new layouts and ordering the future packing machinery. The investment calculations of the fifth scenario prove to be too inaccurate to be used in support decision making.

The manufacturing process of Large Drives frequency converters are going through significant changes in the future. Collaboration between packing, assembly, testing, logistics and product development is even more important when the process is redesigned. New product generations should be designed for automation and every step towards automated packing and production increases the knowledge of requirements that functional process set.

Before the automated packing solution is implemented, packages and working methods should go through careful examination to make sure that ordered instruments are suitable to execute the desired process. Insufficient capacity or lack of functional abilities could create a situation where the packing part of the process slows down the output of the whole production line.

## References


ABB Oy, Drives. 2018. ACS880, SINGLE DRIVES, CATALOG. Online document. http://new.abb.com/docs/librariesprovider54/publikationer/quick-guides/acs880.pdf?sfvrsn=8c6fe213_2. Accessed April 12, 2018.

ABB Oy, Drives. 2018. ABB Oy, Drives. Online document. http://new.abb.com/fi/abb-lyhyesti/suomessa/yksikot/drives. Accessed May 15, 2018.

ABB Oy, Drives. 2018. Online document. New features and functions available on ACS880 drives increase user benefits. http://new.abb.com/drives/media/new-features-and-functions-available-on-acs880-drives-increase-user-benefits. Accessed April 12, 2018.

Automation company X. 2018. On-site introduction to packing automation project, Interview. March 1, 2018.

Haverila, Matti J; Uusi-Rauva, Erkki; Kouri, Ilkka; Miettinen, Asko. 2009. Teollisuustalous.

Investopedia. 2018. Net Present Value – NPV. Online Document https://www.investopedia.com/terms/n/npv.asp. Accessed 15 May, 2018.

Kaasinen, Mikko. 2018. Packing area development. Interview. 26 January, 2018.

Keihäs, Esa. 2018. Packing area development. Interview. 16 January, 2018.

Logistiikan maailma. 2018. Logistiikan maailma: Production. Online document. http://www.logistiikanmaailma.fi/en/logistics/production/. Accessed 8 April, 2018.

Martikainen, Minna. 2018. LD packing area Re-Design. Interview. 12 April, 2018.

Pulkkinen, Pekka; Holopainen, Martti; Keinänen Kalevi. 2001. Talous- ja rahoitusmatematiikka.

Slack, Nigel; Brandon-Jones, Alistair; Johnston, Robert. 2013. Operations Management. Pearson Education Limited.

Soroka, Walter. 2002 Fundamentals of packing technology. Institute of Packaging Professionals.

Sosiaali- ja terveysministeriö, Työsuojeluosasto. 2000. Käsin tehtävät nostot ja siirrot työssä. Online Document. http://www.tyosuojelu.fi/documents/14660/2426906/K%C3%A4sin_teht%C3%A4v%C3%A4t_nostot_ja_siirrot_ty%C3%B6ss%C3%A4_TSO_23_2014.pdf/88c24e48-bf5d-456f-bcf4-073d177bdd6a. Accesed april 8, 2018.

Suomen Pakkausyhdystys Ry. 2018. Pakkausalan hankintaopas. http://tuoteluettelo.pakkaus.com/pub/tuote?id=16755&lan