Study Board of Industry and Global Business Development
Fibigerstræde 16 DK - 9220 Aalborg East
Phone +45 99 40 93 09
lft@m-tech.aau.dk
www.en.ses.aau.dk

AALBORG UNIVERSITY
STUDENT REPORT

**Title: "How to optimize selected inventory processes of BullAnt logistics. "**

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**Supervisor:**
**Malek Maalouf**
(**mml@business.aau.dk**)

**Jeneshan Ginendrarajah**

BullAnt Logistics are at the moment getting more and more demand into their warehouse, which they are trying to meet. One way they believe in to meet the magnitude of the incoming demand is by optimizing their inventory processes. Therefore the research will dig into the existing inventory processes, select inventory processes and apply them RFID technology. This will result in more effective inventory processes.

Number of prints : 80

**Abstract (English)**

In this research, a solution of integrating the RFID technology towards the selected BullAnt logistics inventory processes will be conducted. This is due to achieve a more effective and streamlined level of inventory processes.
The challenges within the selected inventory processes have been identified through in-depth interviews, unstructured observations and quick internships conducted within the company.
The research itself has been following an existing framework with some few amendments made by the researcher.
The methodology used in the research is a multiple case studies combined with qualitative study and slightly supported by quantitative data as well.

**Abstract (Danish)**

I denne undersøgelse er der blevet præsenteret en løsning vedrørende at integrere RFID teknologi i BullAnt logistics lager relaterede processer.
Dette er gjort i forhold til at opnå mere effektive og strømlinede lager processer.
Ved hjælp af dybdegående interviews, ustrukturerede observationer og små praktikforløb i lageret, er udfordringerne deri blevet identificeret.
Selve undersøgelsen har gjort brug af en allerede eksisterende research guide med små ændringer foretaget af forskeren.
Metoden der er blevet brugt i undersøgelsen er et multiple case studie kombineret med kvalitativt og kvantitativt data.

# Table of Contents

# 1. Introduction

3PL providers today are a growing industry in today's world. This is highly due to the fact, that a variety of companies are outsourcing different areas of their businesses to the 3PL providers in an increasing pace. (Saurav Datta, 2011) One of the major reasons for the growth and popularity to use a 3PL provider, like BullAnt logistics, is due to the global competition existing in today's world of businesses. This leads to firms more frequently have to work in close collaboration with external partners like a 3PL provider. (Choy, 2008) By collaborating with the 3PL providers, the firms will have a competitive advantage against their competitors in a highly challengers industries. (Ross, 2013) Recent studies therefore shows, that there still is an ongoing and growing interest for the usage of 3PL providers. (Rakesh Raut, 2016)

This can be backed up by Accenture's, which conducted an intensive survey to ask out how many firms took advantage of the 3PL providers services. The results showed that the 60% of the participants used multiple 3PLs to meet all of their needs. (Shams, 2011) What´s more interesting is that more than 2/3 of the participants have taken advantage of the use of their 3PLs for more than 5 years. (Shams, 2011)

This naturally leads to a challenging environment for 3PL provider like Bullant logistics, as they i.e. have to be more effective in order to accomplish and meet all the incoming orders. Therefore the logistics company, BullAnt, has a focus on improving their processes initially. Another factor in order to maintain the positive growth is to be precise and effective regarding item quantity on hand and item quantity shown in the system. This will in the end satisfy their and also trigger the chances for them to getting bigger orders. Finally they will avoid have to focus on errors caused by inaccuracy and ineffective business processes, which in the long run will give them time to focus on other critical inventory related problems such as returns and dead stock.

## 1.1 Company profile

BullAnt Logistics is a warehouse located around 30 km west for Sydney, in Yennora, and has been operating for almost 5 years.

BullAnt logistics is own by Outliving, which are within the high-end giftware industry.

The staff consists of one warehouse manager and one assisting warehouse manager, who have been responsible for the general management of the warehouse. (Appendix A)

Subsequently there are three different team leaders mainly responsible for the following categories:

- Inbound logistics
    - Goods BullAnt Logistics receive orders to their warehouse and prepare the goods until they are ready to be stored.
- Put away
    - Received shipment has to put away on the racks of the warehouse.
- Order picking
    - Orders from customers are collected by the pickers of the warehouse, who have to pick the orders.
- Order dispatching
    - When the pickers finishes an order and it is ready to be dispatched.

The supervisors are then hereafter in charge of ground floor workers which are assigned to different tasks within the problem areas.

As likely to be the, the organization is very flat, which is also told by the warehouse manager, this can also be seen in the following hierarchy table extracted from an initial interview of the warehouse manager. (Appendix A)

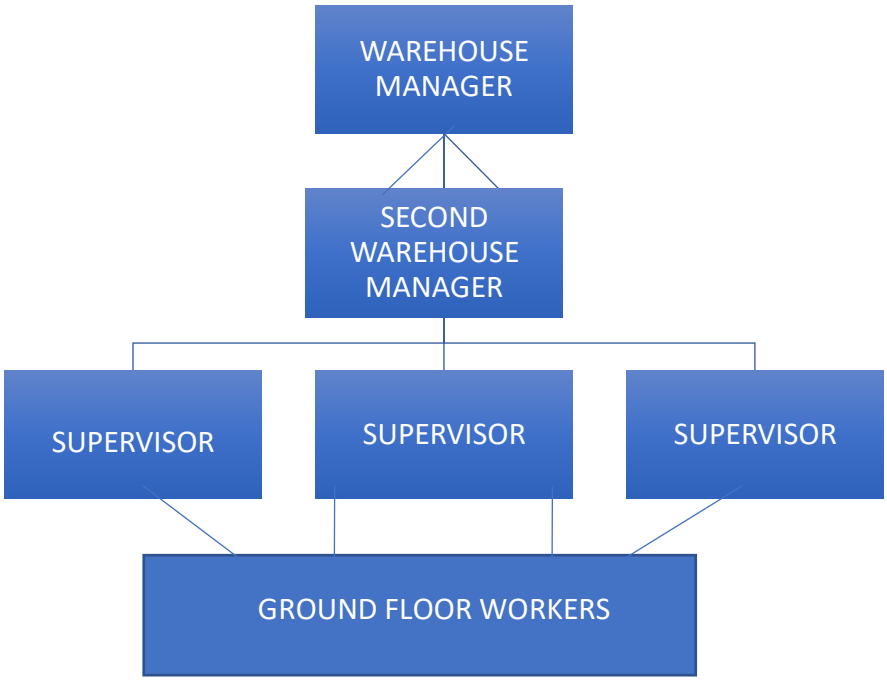


*Figure 1 BullAnt company hierarchy*

## 1.2 Research objectives and research questions – Scoping (step 1)

Currently the company information and its´ challenges are identified through an interview with the warehouse manager. Based on this, the research objectives and research questions can be created.

### 1.2.1 Observations

The objectives of the research done in BullAnt logistics are as follows:

- Identify the current best practices BullAnt logistics has regarding their inventory processes.
- Identify challenges in inventory processes.
- Find solutions for optimizing the inventory processes.

### 1.2.2 Research questions

The research questions within the research, that have to lead up to the objectives are as follows:

1) What are the most critical inventory processes of BullAnt logistics and how can they be identified?
2) How can BullAnt logistics identify the challenges to be eliminated in each of the inventory processes?
3) How can the identified challenges be overcome and thereby lead to more effective inventory processes.

# 2. Systematic literature review

In this paragraph there will be selected and outlined what kind of literature this research is going to be supported by.

## 2.1 Source of literature

The main source to gather the academic literatures will be through Aalborg University´s online library portal/database called "Aalborg Universitetsbiblioket". Literatures gathered here will further revise the user to well-known academic databases like Jstore and Elviser. (University, 2018)

## 2.2 Selection of literature with Venn diagram

At current stage there have to be presented a way of finding appropriate and relevant literature to be reviewed. This process of gathering literature will be conducted by setting up a Venn diagram. The purpose of the Venn diagram is to set up three main areas of the research and identify the sub topics which fits all the main areas. These sub topics will create the foundation for the later literature review.

The Venn diagram itself consists of the three circles, which represents each of the three main areas, inside each of the circle there will be words/ sub topics which will be leading up to its´ respective main area. As the three circle will be intersecting each other, there will be words in the intersecting areas. The words in these areas will be the aforementioned words the literature review will origin upon.

In figure 2, the Venn diagram is seen. The main areas and the appurtenant words are based on the initial interview with the WHM(Appendix A) and the research questions. (section 1.2.2)

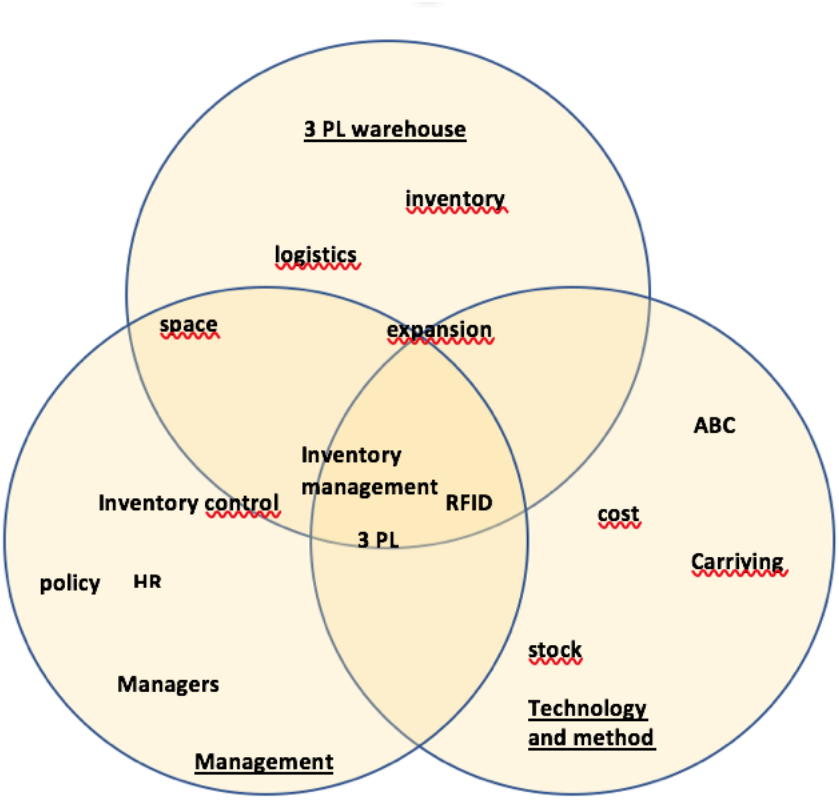


*Figure 2 Venn diagram*

The Venn diagram is now presented where the main areas as seen are:

- 3 PL warehouse
- Technology and methods
- Management

The intersecting words are:

3 PL warehouse, Inventory management and RFID

When summarizing the intersecting words, the following the search string can be created and put into the database:

Initial search string: RFID AND Inventory management OR third party logistics AND 3PL
When the search string is put into the database it gives 45.395 hits. This amount is too big to review as it will take a huge amount of time. Therefore the amount have to be sorted down.
The first step to bring down the amount is to set up criteria's the literature given back have to follow.
The initial criteria´s can be seen in table 1

| Criteria type | Limitation |
|---|---|
| Type of literature | Academic articles |
| Review type | Peer-reviewed articles |
| Age span of literature | 2000-2018 |
| Database | Extracted via Aalborg university library or academic databases |
| Language | English |
| Authors | Actual researchers |
| Duplicates | - |

*Table 1 Literature criteria table*

At current stage the initial search has been given and the criteria they have to fulfill is also given. The search string can be keyed in to the database and the criteria´s can filter out the magnitude of articles given back.
Subsequently, when the criteria´s in table 1 is applied the amount of literature given back is 7.175 articles, which is still a too big of an amount to review for this study.
Therefore the search string have to be more precise. This will be an ongoing process until a lesser and more realistic amount of literature are given back. The ongoing process to bringing down the literature is seen in appendix B.
The search string process shows an amount of 89 articles, which is going to be reviewed. Subsequently after the review, the researcher will have a certain amount of literature which will be qualified for a full read analysis.

The review process in regards to point out literature for the full read analysis is done by a screening of each articles abstract, introduction and conclusion sections.

The review of the 89 articles gives back 28 articles for the full read evaluation. Subsequently the description of how the evaluation of the 28 articles and final selection of articles to be used in the research be explained.

The researcher will rate each of the articles from 1-5, which will determine which articles will be selected for the project. The ratings are seen here:

1 :-Not relevant at all (will not count)

2:- Not relevant except little parts (will not count)

3:- Both relevant and not relevant (will count)

4:- Relevant (will count)

5:- Highly relevant (will count)

The weighing and determination of the ratings to each individual article will be influenced by its' similarity to the projects research questions. (section 1.2.2.)

The full read evaluation of the 28 articles is seen in Appendix C.

Subsequently the full read review of the articles sums up an amount of 11 main articles that will be used to support this research. The 11 articles is shown in table 2.

| Article number | Article name | Authors | Rating |
|---|---|---|---|
| **1** | The impact of the RFID technology on warehouse innovation | Samuel Wamba and Akemi Chatfield | 5 |
| **2** | RFID: From concept to implementation | Robert E. Spekman, Patrick J. Sweeney I I | 3 |
| **3** | A framework for mapping the RFID-enabled process | Angeliki Karagiannaki, Dimitris Papakiriakopoulos | 3 |
| **4** | Implementation of RFID technology in University of Pune Library | Sadanand Y. Bansode, Sanjay K. Desale | 4 |
| **5** | New pick-to-light system configuration: a feasibility study | Andriolo Alessandro | 5 |
| **6** | RFID applications in manufacturing. | Baudin, M., Rao, A. | 3 |
| **7** | RFID field guide: deploying radio frequency identification system | Bhuptani, M. and Moradpour, S | 5 |
| **8** | Increasing efficiency in the supply chain for short shelf life goods using RFID tagging | mikko karkkainen | 3 |
| **9** | Design and implementation of the wireless RFID Glove for life applications. | Lee, C., Kim, M., Park, J., Oh, J., Eom, K. | 5 |
| **10** | Appraisement and selection of third party logistics service providers in fuzzy environment | Saurav Datta et. Al. | 3 |
| **11** | An Exploratory study of outsourcing 3PL services: an Australian perspective | Shams, Rahman | 3 |

*Table 2 Final chosen articles*

## 2.3 Review of articles found

Currently articles to back up the research has been identified and subsequently a review of the articles is going to be presented. In the later section, the latest research within the main topic of the research is going to be presented.

The literature review which is to be conducted, is going to be about the RFID usage and implementation within the 3PL industry specifically regarding the warehouse processes. But what is this RFID technology?

RFID stands for radio frequency identification, and it is a wireless communication system. (Andriolo Alessandro, 2010)

The history of RFID started in 1930, where the American Navy used the technology to help identifying their I.e. transportation units. Since 1930, RFID has been used to as electronic article surveillance in the 60´s, first toll based payments in the 1980´s and I.e. Walmart´s EPC pilot. (Bhuptani, 2005)

But what is the technology of the RFID system consists of? The RFID system consists of an antenna or a coil, a transceiver, and a transponder tag. (Lee, 2010) These tags can store data i.e. the products they represent in the warehouse. More exactly they contain an unique serial number that can be connected to the company´s WMS and thereby actual data. This feature of storing information of one single product, gives the RFID a great set of improvements opportunities  across different inventory processes within the warehouse, such as receiving goods, and picking orders. (Angeliki Karagiannaki, 2011)

Even more the tags can be divided into two tags, passive and active tags. The passive tags, can be run by itself, as it has its own battery embedded. The fact, that the tag has its own battery means, that their power levels are much higher the passive ones. This will also in other words mean that they can be read and written on far greater distances, up to 100 meters. On the other side, there are the passive tags which are run by from the electromagnetic field of the reading device. This makes them much cheaper than the active tags. (Andriolo Alessandro, 2010)

To sum it up it, the technology is a mix of radio frequency-based technology and microchip technology. (Sadanand Bansode, 2009)

One can then ask, what goes prior to this RFID technology, and the answers can vary a bit, but in general the articles mentions, the barcode technology and headphone voice device(HVD), also called voice to pick. (Baudin, 2005) (Andriolo Alessandro, 2010) (Kärkkäinen, 2003)
Mr. Baudin do i.e. defend the use of RFID compared to both of the aforementioned technologies, barcode and VHD. Related to the barcode device, he sees a much bigger advantage using the RFID technology, as it only requires items to be moved close to a reader. It can finally save a lot of manual work, which is found within the usage of the barcode, as with the barcode, the workers will have to scan all items by hand. (Baudin, 2005) This is also agreed by researcher Kärkkäinen, which also adds the fact, you won´have to deal with difficulties scanning damaged and dirty barcodes too. Ulterior Kärkkäinen also points out the avoidence of moving and turning cardboxes on a pallet, in order to scan the barcodes of all boxes. (Kärkkäinen, 2003)
Another of Baudins argument to favour the use of RFID compared to keeping the barcode is, that the RFID technology can withhold much more data, than a single barcode.
The reflect upon where the technology is being used in other industries there will now be presented a section presenting this.
Ulterior there is the comparison, with the HVD, where Baudin arguments for the surrounding noise related errors, and chances for wrong pronunciations in the HVD can be avoided by using the RFID. (Baudin, 2005)

### 2.3.1 RFID in other industries

Subsequently the RFID technology can also be seen in other industries except the 3PL and warehouse industry. I.e. in the homeland security sector, the security personnel can screen people and materials as the pass through an airport, Warf or similar places with a checkpoint. (Robert E. Spekman, 2006) In the library sector the inventory can be found easily, as a result it will decrease the amount of lost inventory. Now patrons can passively just pass through an already sat RFID reader when visiting the library for handing in books, they´ve borrowed. This can be a reality as, the books will include a tag, which subsequently can be read by the RFID reader. (Sadanand Bansode, 2009) (Robert E. Spekman, 2006).

### 2.3.2 Latest literature

#### Impact of RFID technology on warehouse process innovation

A research were conducted in 2010 by Dr. Samuel Fosso and Dr. Akemi Chatfield, who had to find out how big of an impact an implementation of the RFID technology would have on a Canadian 3PL company´s inventory processes.

The research is a case study, where the two researchers decide to implement the RFID technology on both of the selected inventory processes, order picking -and shipping process. Subsequently, when the researchers have proceeded and evaluated how each of the two processes would look like when the RFID technology would be integrated, they decide to merge the two processes.

Ulterior the products of the company have to be tagged with the RFID tags, this has to be done by its own staff as soon as they receive the products to their inventory.

Initially from the picking phase, the pick will be received through email, the clerk collects the pick and gets the products from the dedicated rack. Subsequently he prints the tags, attach them to the picked products. Subsequently he moves the pick through a RFID reader at the shipping portal, which will read all the attached tags. The information of the picks which have been collected will be transferred to the warehouse management system. Hereafter the tags on the picking order which are to be shipped are automatically linked to a shipping order. The tags are automatically validated if they match or not. If a mismatch occurs the clerk will be notified immediately and the shipment is stopped. If everything are going as planned, the shipments proceeds, and the inventory is getting updated.

Figure 3 shows a part of the final merged process of the picking and shipping process of the Canadien 3 PL company.

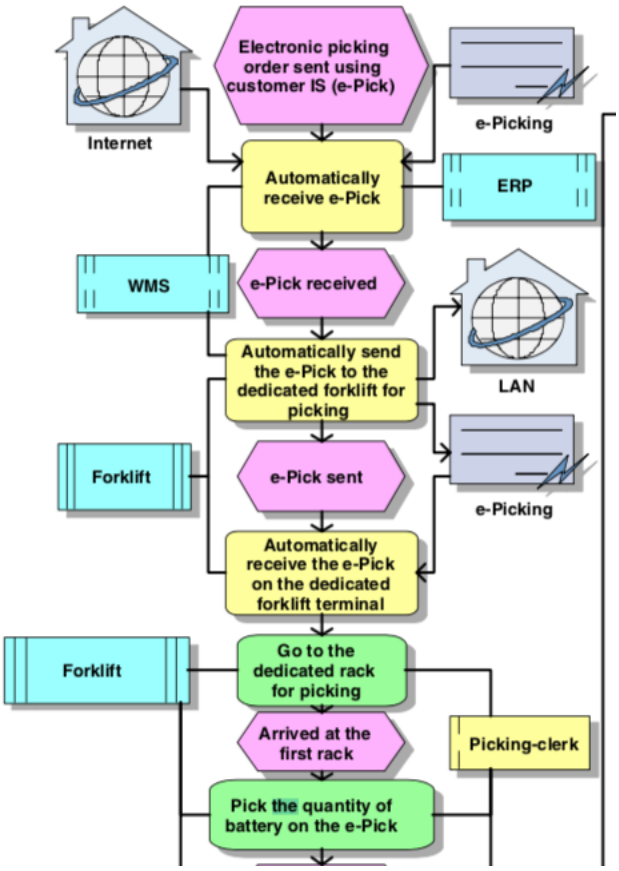


*Table 3 Merged FC from Dr. Fosso research*

When reviewing the research Dr. Fosso and Dr. Chatfield have conducted, the first factor improvement is the labour cost savings, as only one clerk is required for both processes. Subsequently they have also been done time studies of both processes, this resulted in a 17 % decrease for both processes which is equivalent to 40 hours.

However at last, the research have been limited by to only focus on picking and shipping for outgoing items. Therefore i.e. a ROI on RFID can´t be stated before the impact of the technology has been deployed in a wider context.

**Warehouse contextual factors affecting the impact of RFID**

In this research there has been conducted two case studies, where the researchers have been focusing on the contextual factors impacting the RFID technology, they have been implementing. They believe that the different factors impacting the general use of RFID in the warehouses are different as the RFID impacting factors differentiate from one warehouse to another.

This is also the reasoning for why the researchers also suggested to use different types of warehouses, in the matter of size, mechanisation level and other contextual factors.

The first case company, is the a medium sized 3PL provider, while the second case company is a big retail distribution center.

Initially as stated before the researchers wanted to see how the contextual factors effected the a future RFID implementation in to these two case companies. Subsequently they evaluated each of the companies in a framework, to test out their position regarding the identified contextual factors. Figure 5 shows a part of the framework to give an idea of how the researchers evaluated each of the case companies.

| | Structural characteristics | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mechanisation level | | | | Information availability | | Warehouse dimensionality | | | Product carrier of the SKU | | | Departments | | Computer system | | Storage system | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 1 | 2 | 1 | 2 | 3 | 4 |
| Case1 (3PL) | | × | | | × | | × | | | × | | | × | | | × | × | | | |
| Case2 (retail DC) | | | × | | | × | | | × | | | × | | × | | × | | | × | |

*Figure 3 Framework for contextual factors*

At last there is conducted a simulation model for the two type of warehouses used in the research. This is done by using the a software simulation software called SIMUL8. During an interview phase of both cases, they found four processes to simulate:

1) Receiving
2) Storage
3) Picking
4) Shipping

Realistic and historical data input were used such as pallets received pr. day and orders pr. day. The outputs of the simulation were the analyzed. The output data were primarily used to explain the variability in labour -and time utilization between the two warehouses when RFID is deployed.

The end results showed after the simulation phased showed the following regarding the labor - and time savings:

| **Labour utilization:** | **Time saving:** |
|---|---|
| Case 1: 24.95% | Case 1: 56.32% |
| Case 2: 21.50% | Case 2: 27.75% |

The two researchers conclude this newly found results by stating that RFID is much more beneficial for a warehouse which is much less automated, which in this situation is case number 1, the researcher perceive less automated than case 2.

Subsequently the researchers conclude that by implementing the RFID technology it will alleviate the process as for scanning the individual items manually through the barcode. Time to check products for discrepancies for stock to be dispatch out of the warehouse is another factor which can be alleviated. (Angeliki Karagiannaki, 2011)

**A Framework for the Implementation of RFID Systems**

In 2013 three researchers have reviewed multiple literature about the RFID technology related to inventory management and initially proposed a framework for RFID implementation as a part of their research. The framework has been presented to more than 200 potential users across different industries such as logistics and healthcare. The general feedback was very positive with can be perceived by an average score of 3,5 out of 5, where 5 is the best score in accordance to feasibility for usage. (S. L. Ting, 2013)

The framework is depicted in table 4:

| Steps | Description | Reference(s) |
|---|---|---|
| Project Scoping | • Understand the potential and limitations of RFID technology<br>• Define the project objectives | Angeles (2005); Vijayaraman and Osyk (2006); Wu et al. (2006); Attaran (2007); Reyes and Jaska (2007); Sellitto et al. (2007); Ngai et al. (2010) |
| Analysis of the Existing System | • Collect information<br>• Information analysis | Soylemezoglu et al. (2006); Attaran (2007); Jaska (2007); Pålsson (2007); Huang and Tang (2008); Hellström (2009); Kim and Garrison (2010); Ngai et al. (2010) |
| System Design | • Requirement analysis<br>• Hardware/ software selection<br>• Develop a new process | Soylemezoglu et al. (2006); Reyes and Jaska (2007); Huang and Tang (2008); Hellström (2009); Ngai et al. (2010) |
| Prototype Testing | • Debug<br>• System Adaptation | Reyes and Jaska (2007); Soylemezoglu et al. (2006); Ngai et al. (2010) |
| Implementation | • System deployment<br>• Training | Soylemezoglu et al. (2006); Spekman and Sweeney II (2006); Attaran (2007); Reyes and Jaska (2007); Ngai et al. (2010) |
| Continuous Improvement | • Monitoring<br>• Collect feedback from users | Ngai et al. (2010) |

*Table 4 Literature RFID framework*

As seen the table consists of step names, broken down description of the adjacent step and referring literature.

The first step of the framework, in table 4, is to define the scope of the project, which the researcher suggest will help the user of the framework to understand the limitations of the RFID.

After the scoping is defined, objectives should be finalized.

Step two of the framework is the investigation of the current system and procedures which exist in the environment. This process can be done by conducting interviews and observations. When the investigation is done, possible areas of improvement will be visible. The researcher will then be able to prioritize the problem areas in regards to each areas` impact on i.e. productivity.

Ulterior in step 3, which table 4 correctly shows as, system design, either a complete new system has to be made or the existing system has to be modified. Subsequently the three researchers also suggest to pay attention to the selected hardware/software which will work with the system. An example could be that, a right selection of software to which is able to receive information from the RFID is existing. Subsequently in step three, the new system has to be developed, as soon as the required information is obtained.

Step 4 is the testing process of the new system. In this situation the readability of the RFID tags is amongst the things which is being tested. An example could be that the object the tags are attached too only can move in certain speed (S. L. Ting, 2013)

Subsequently the actual implementation step, step 5, which includes actions such as change management, training, system deployment and finally a commission of the software and the hardware to be used.

Lastly, step 6, contains the continuous improvement factor, as there is always room for improvements. In this step, the system should always be evaluated and adapted to the new emerging changes with can i.e. be caused by the market. The researchers also mean suggests that the system should benefit from the feedback they get from the user of the new systems, as they will have some ideas of improvements as well.

**New pick-to-light system configuration: a feasibility study**

Researchers from University of Padna in Italy, Andriolo Alessandra et. Al., have done an interesting research about implementation of RFID in the order picking process within an inventory. (Andriolo Alessandro, 2010)

The researchers aim is to present a whole new concept of picking orders, which will prevent human errors while picking orders, by a control and alert system. In the research the new system, which ultimately have optimized the picking procedures in the warehouse, have also been analyzed from a technical, and economical point of view. This also lead to a comparison with other existing solutions.

The system made by the researchers is called: pick-to-light system. Subsequently the system is composed of three main units. The first unit is a system of lights and tags installed on each shelf representing each PO. Secondly the first unit also consists of one red light on each shelf, which will light up, when the picker picks up the wrong item. The tag will light up in a red colour, when the picker puts on a RFID glow while picking orders. The glow will communicate with the tags on the shelf. The glow is also the second unit in the pick-to-light system.

The third unit in the system, is equivalent to a centralized control system which controls the system of lights on the shelfs. The input data for this system is order picking lists extracted from the WMS, which sends signals to turn on and off the lights on the shelfs.

Furthermore each tag consists of more colours, than the red alert colour, which is controlled by the third unit of the system. Each of the other colours represents the amount of pickers which can work at the same time.

This is best described with an example. In the case study, each tag consists of three colours; red, green and blue. When two pickers start picking, the centralized system initiate the picking orders to the two pickers. The system aligns each picker to a colour, and lightens up each tag colour equivalent to each of the pickers picking order. The pickers now can go from aisle to aisle without any papers or devices and quickly visually find out which orders to pick. Every time a picker picks a product, the light on the shelf where he picked the product will turn off and he can proceed to the next item to pick.

Figure 4 helps understanding the above explained picking system

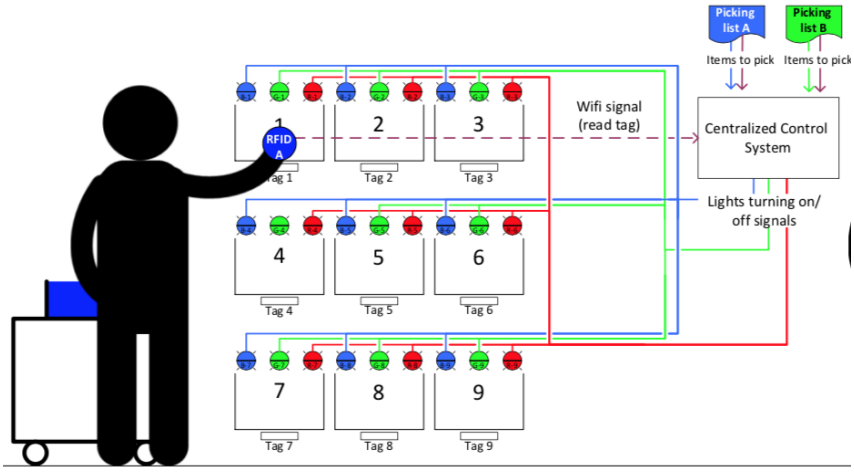


*Figure 4 Pick to light system drawing*

Andriolo and his fellow researchers subsequently analyzed and concluded their pick to light system.

Regarding their results, they are based on only qualitative data, extracted from a warehouse they´ve presented the study to. In this case, the particular areas they succeeded in compared to known methods of picking, such as using handheld barcodes, handheld RFID devices, Pick to voice and traditional pick, are the following:

- **Picking time**
    - As the picker immediately can see visually which stocks to pick without being dependable on any device.
- **Cheapness**
    - This is due to, that instead of tagging or barcoding all the stocks, the tags can just be attached on the shelfs. The biggest cost will be the actual RFID reader glow itself, which has to be given to each picker in action.
- **Reading distance and errors interception**
    - Up to 20 meters, which is an advantage for the picker, as he can be notified immediately if, he is in the wrong location even before touching the stock.
- **Tracking of pickers**
    - It is easy to track down the data from each picker, as the picking is connected to a centralized system.

# 3. Methodology

The purpose of this chapter is to construct a framework which can be used as a tool in order to successfully answer the research questions stated in section 1.2.2.

## 3.1 Research purpose

The purpose of the research will be to propose a solution to optimize and streamline selected inventory processes of BullAnt Logistics. The framework which is going to be presented later is going to accomplish the research purpose.

## 3.2 Research choice

The research choice of the project is going to be a mixed method, as the research will consist of both qualitative and quantitative approaches. (Saunder, 2016)

Although the research will be much more qualitative than quantitative. This is due to the fact of the lacking of required and updated data needed for the purpose of the study. Due to this, as one of the reasoning for, the magnitude of qualitative data is higher than the magnitude of quantitative data.

The qualitative data which is going to be taken advantage of would be unstructured observations, semi -and in-depth interviews. Lastly the researcher will also gain qualitative data by participating in a 6 day long internship within the inventory processes, which are going to be optimized.

## 3.3 Research approach

Whether the research is inductive or deductive has to be answered in this section.

In this section the core research approach is a mix of both of the two presented philosophies, inductive and deductive. One reason for this is due to the reason, that the framework which is going to be used is an already existing framework, which subsequently has been applied some amendments made by the researcher.

The framework which is mentioned is presented in table 4, while the new framework which is due to be used in this research can be seen in table 5.

| Steps | Description | Tools / approaches |
|---|---|---|
| 1.Scoping | - Define what the scope of the project is<br>- Understand the technology there is to be used<br>- Define research objectives | Literature review |
| 2.Analysis of existing processes | - What do exist now?<br>- What to analyse?<br>- Collect information about systems used. | Time study<br>Interviews |
| 3.Development of processes | - Which areas can be helped by the RFID technology?<br>- How will the impact be? | Interviews<br>RFID deployment |
| 4.Implementation | - System deployment<br>- Training of personnel | - |
| 5.Future research/ continuous improvement | - What can be done in the future? | - |

*Table 5 Framework for research*

Another indication for that the study is both inductive and deductive is due to the reason, that the research is going to propose the usage of the RFID technology which is already been presented in the 3PL industry,(section 2.3.1) but haven't been seen in a same context as this research.

## 3.4 Research design

The research design which is applied in the research is both exploratory and descriptive. The research is exploratory as the research questions either has to begin with "what" or "how". (Saunder, 2016) When looking at the research questions in section 1.2.2., this is also a true factor.

Saunders subsequently also states that a research is also exploratory, when one wants to clarify an understanding of an issue, which is unsure in its precise nature. This is also the case in this research, as the researcher is unsure about the nature of the inventory systems, which is a core part to be worked with in the project.

The research is descriptive, as data regarding the inventory systems will be collected.

## 3.5 Research strategy

The research strategy for the research is case study, as researcher Yin explains it "A case study is an in-depth inquiry into a topic or phenomenon within its real-life setting" (Yin, 2003)

Within the case studies, there exists different variations of case studies, one of them is multiple case studies, which is the most feasible for this research. This is due to the fact, that the research is operating with more than one case. (Saunder, 2016)

## 3.6 Time horizon

The time horizon for the research is from February 2018 – June 2018, which is five months. Therefore the research is determined as a cross sectional study according to Saunders. (Saunder, 2016)

## 3.7 Data collection

Data which is going to be collected will be semi -and in-depth interviews applied to the warehouse manager, clerk and pickers.

A datasheet for the record of orders which have been picked will also be achieved. Subsequently a third and fourth source of data collection will be quick internships and observations of the inventory systems.

# 4. Analysis

In the analysis, the continuance of the research framework will go on(table 5). In the framework´s second step, it says, the action to be taken is regarding the analyzing and collecting information about the existing inventory systems the company uses.

As for the part of analyzing the systems, the researcher finds it easy to enlightening the reader about the layout of the warehouse for a better understanding of the inventory systems which will be explained subsequently.

## 4.1 Warehouse layout

As explained before, the warehouse layout will now be enlightened in figure 5.

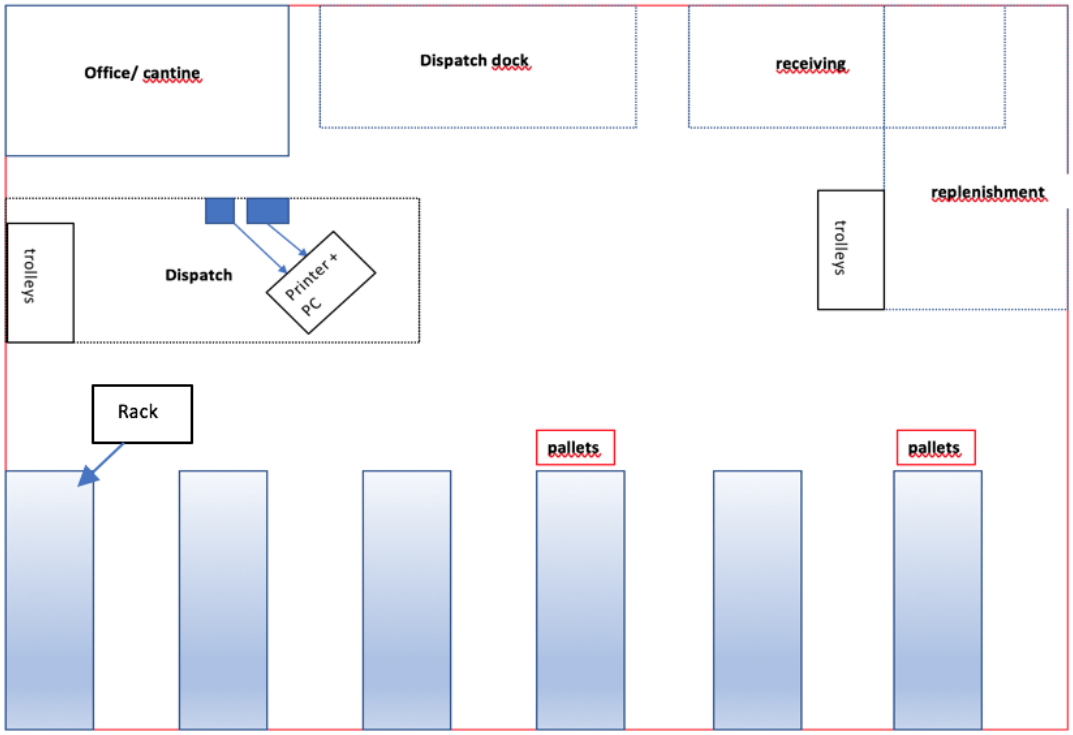


*Figure 5 Warehouse layout*

## 4.2 Analyse of existing processes (Step 2)

There are quite a few inventory processes, divided and interpreted differently in the 3PL industry. (Chatfield, 2010)

BullAnt logistics has also their own determination and interpretation of what is included in their inventory processes. Some of these inventory processes, the ones which have been presented for the researcher, will now be presented. Each of the inventory processes will also be presented by a flowchart developed by a software called ARIS Express. The flowcharts will be consisting of different symbols, which are explained in appendix D.

### 4.2.1 Inventory processes

Three inventory processes have been identified to work ahead with, after having initiated an initial interview with the WHM. (Appendix A)

The three inventory processes are visible in table 6, with an added abbreviation and a small description of what each of the processes includes. Ulterior a more detailed description of each of the processes will follow after the table.

| Name of process | Description of process |
|---|---|
| Put away (PA) | From goods are received till they end up in the racks |
| Order Picking process (OP) | From the orders are to be picked till they are picked and delivered at dispatch area |
| Dispatch process (DP) | From orders are to be packed until they are loaded at pallets and ready to be picked |

*Table 6 - 3 selected inventory processes*

#### 4.2.1.1 Put away process

The PA process is initiated by the clerk checks for numbers of purchase orders(POs) on the WMS through a computer screen.

Subsequently the clerk goes to the receiving area, where the shipment is received, and confirms the number of POs in the shipment. Ulterior the clerk goes to the dispatch area to print pallet labels (PL), which is then collected and brought with him to the pallet area. At the pallet area,

he will pick an amount of pallets which is coherent with the amount of POs , which he drags back to the receiving area with a trolley. The reason why BullAnt logistics has to get the pallets themselves and the equivalent amount of pallets to the amount of PO´s is because, they can´t use their clients pallets. (Appendix A)

When he has got the correct amount of pallets which are aligned with the total amount of product orders, he splits the items of the purchase orders separately into the pallets, so there´s one PO pr. pallet. He does this manually.

Subsequently he sticks the PL´s he has printed before to each of the pallets.

Hereafter the clerk scans a barcode label, which by the supplier is already attached to the POs, which will tell him the quantity, that he should have been receiving. The clerk will then make sure that the right amount of items have been received for each PO. This is done by the clerk opening up one of the boxes of a received PO and count the numbers of inner cartons. When one box´ number of inner cartons are counted, he then adds up the total amount inner cartons for the rest of the boxes within the same PO. Also as one inner carton in most cases contains one product, he can easily confirm if the number of items received matches with the number of items he has counted.

Subsequently after he has confirmed and validated the received amount, he scans the PL with a transfer function, that allows the clerk to transfer the PO to the PL. When this function is done, it will mean that the PO now has been transferred to a specific pallet label. Subsequently this will help the warehouse staff to locate the PO in the future.

Ulterior the clerk loads the pallet on a trolley, scans the pallet label with a put away function and the scanner replies with either a known location to put the pallet or a blank location. When the location suggestion is blank, it means that the WMS isn't familiar with the product, and the clerk has to find an empty spot himself.

In both cases, he then proceeds by ending up in a location, where he has to scan the location, while still being on the put away function menu. He will then put as many of the inner cartons of the POs on the desired location shelf as possible. In cases where he is able to put the entire PO on the shelf, he will have an empty pallet to take back to the pallet area. In this case, the WMS will tell him to destroy the pallet label trough the scanner. In circumstances, where he

cannot put all the POs on the shelf, he has to scan only the POs which is to be put on the shelf and bring the rest to receiving area again. The WMS will deduct only the amount put in the shelf.

As the clerk finishes putting away the whole shipment, he will in far most cases end up with POs on pallet which couldn't all fit in the designated shelfs, these POs have to be consolidated together. The clerk activates the transfer function through the scanner and transfers the remaining POs into as few pallets as possible. When this is done, he will be told to destroy the empty pallet labels, which he will be moving to the pallet area. The consolidated pallet, will remain in receiving for the replenishment staff. (Appendix A)

To give a better understanding of the whole put away process at is current stage a flowchart of the process is created. The flowchart can be seen on figure 6.

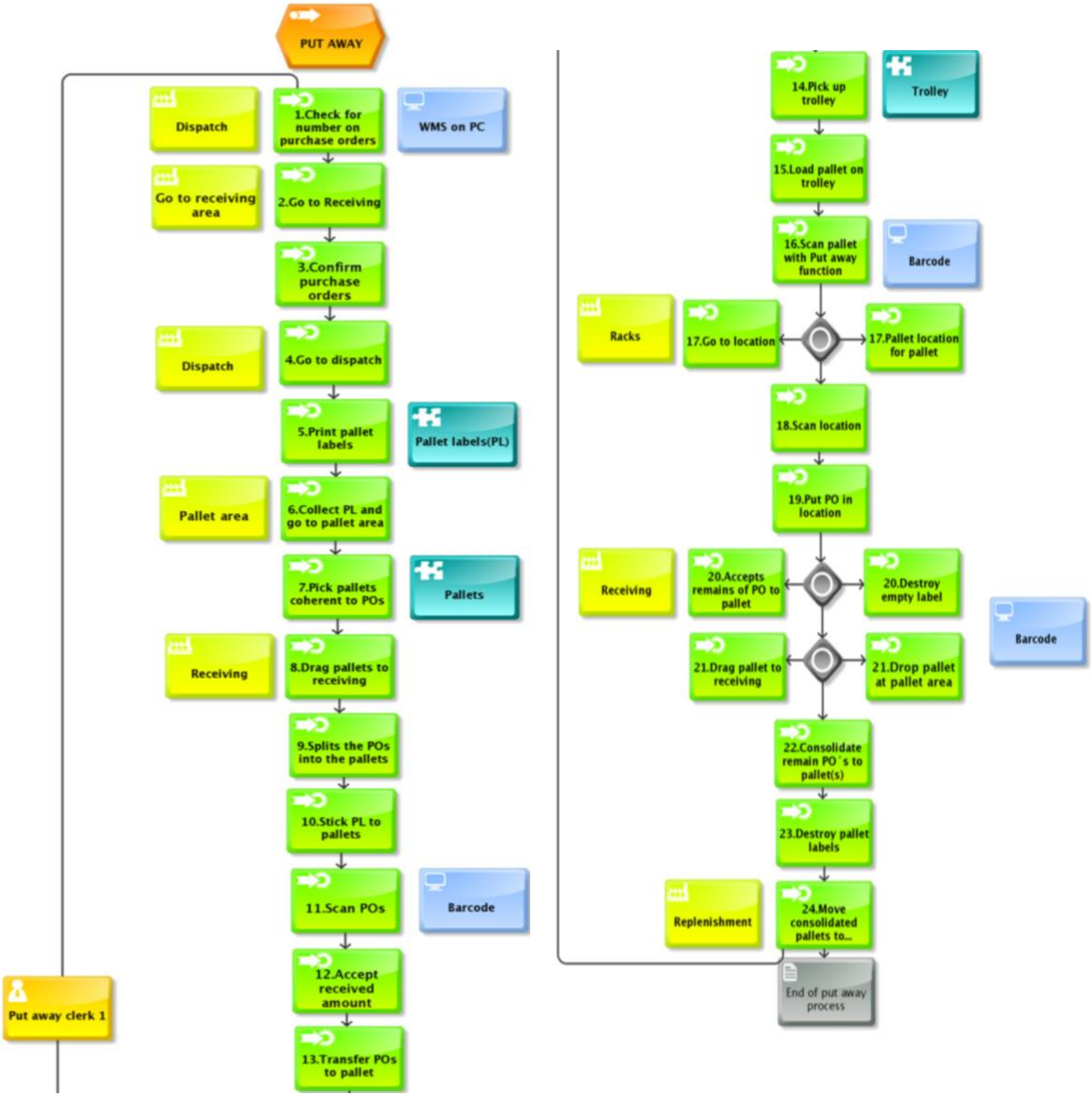


*Figure 6 - Current PA flowchart*

#### 4.2.1.2 Order picking process

The second phase observed and participated in during the quick internships were the order picking phase, OP. This phase can be conducted, when the WHM releases the orders to be picked. The releasing of orders usually happens before the picker signs in for work, therefore the first step will be when the picker grabs a voice headphone device(VHD) and identifies himself to it. A VHD is an equipment, which is a headphone that is connected to the WMS and automatically can extract orders from there.

After the identification process, the VHD will be ready to conduct orders to him. Subsequently the picker picks up a trolley and thereafter collects a print with an order number on it, which he prints from the nearby pc. The print is generated after the pickers has accepted an order to be picked.

The print is then collected and attached to the trolley itself. The picker then says the order number out loud to the VHD, which subsequently tells him which aisle to go to. Ulterior it will tell him what shelf to approach, in order to get the product. When the shelf is approached, he has to confirm shelf location to the VHD, which the VHD will accepts if correct. The device then asks the picker to mention the last 3 digits of a product number, to be sure if the picker has taken the right product.

If the picker has taken the right product, the device mentions how much to take, as a reply the picker answers with the quantity taken. Now the device will deduct the taken amount from BullAnt logistics´ WMS. The procedure goes on like this until the picker has collected all the orders from the order number delivered to him through the VHD. When this is done, the picker returns his trolley with the collected orders to the dispatching area and the dispatching can be initiated. (Appendix A)

Figure 7 shows the OP flowchart.

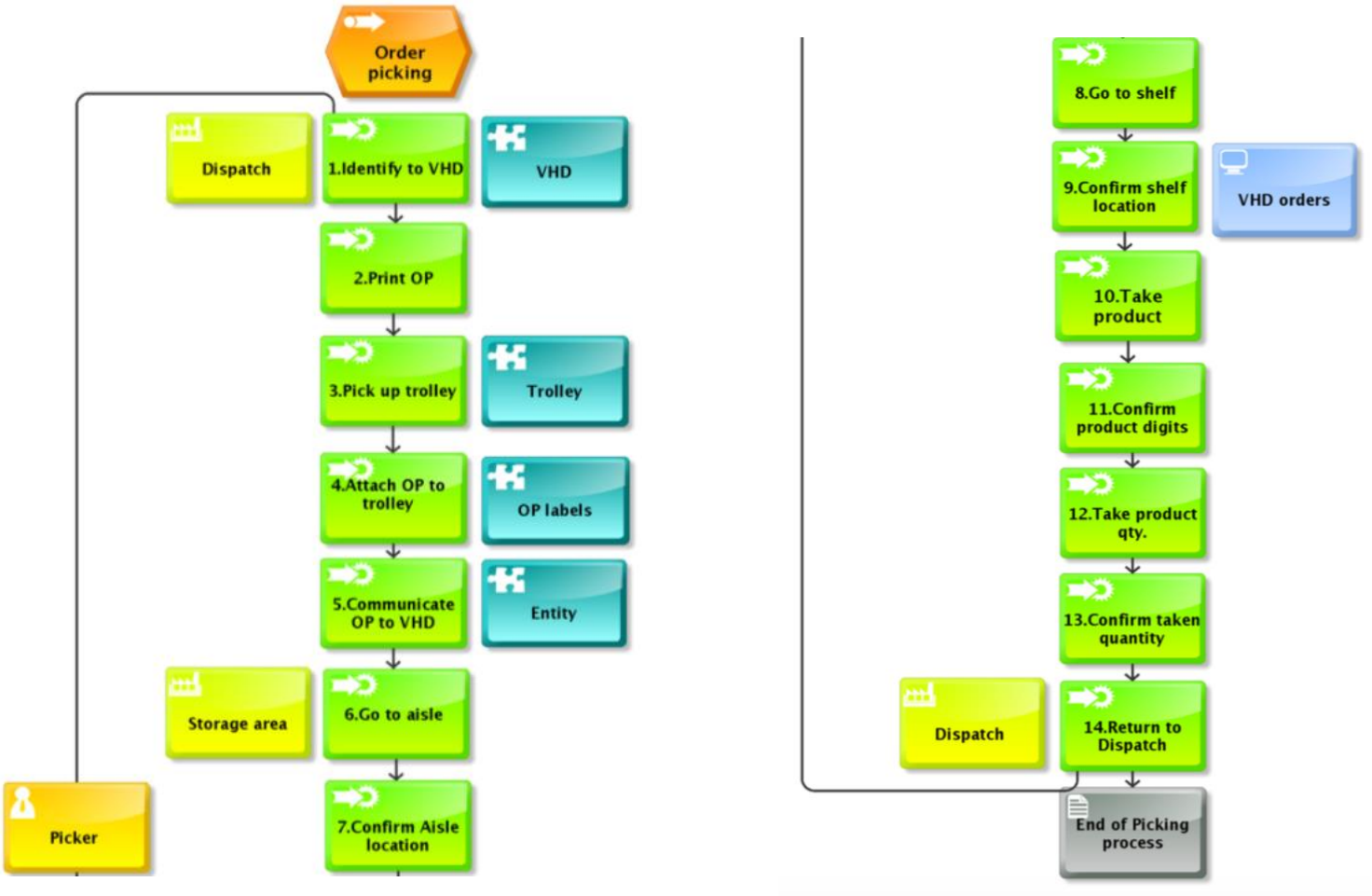


*Figure 7 - Current OP flowchart*

#### 4.2.1.3 Dispatch process

BullAnt logistics dispatch process starts out by the dispatcher clerk, identifies which items that have to be packed, then finds cardboard boxes where all the items can be placed in. Subsequently he goes to the printing area and prints out the a number of labels to be labelled to the boxes. If the dispatcher packs one, it is one label he has to print, if it is two boxes, then he has to print two labels and so forth. When the boxes are ready and packed by the dispatcher clerk, the boxes are then placed on a conveyer which transports the boxes to another clerk. Subsequently the clerk who receives the boxes from the conveyer, register the boxes in the WMS, as they are ready to be picked up from the warehouse. He will then go to the pallet area with a nearby placed trolley and place the pallet close to the conveyer. He then allocate the boxes on pallets and place them on the outbound docking area. (Appendix A)

Figure 8 shows the dispatch flowchart.

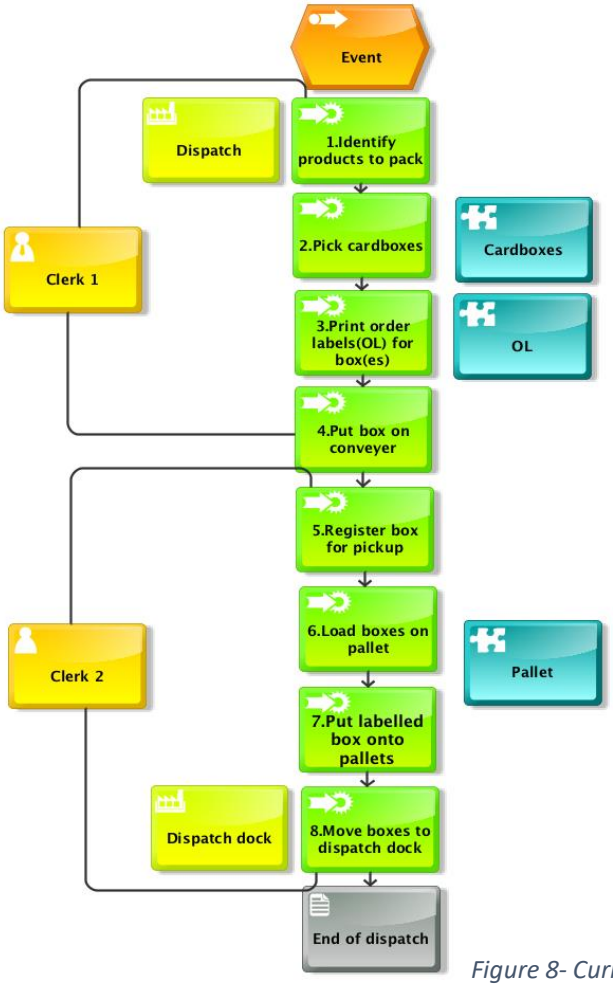


*Figure 8- Current dispatch process*

### 4.2.3 Outline of processes

In the project, it has been decided that the project will go on with the PA and OP process after working with the processes more thoroughly and thereby also gained more knowledge about different processes.

The factors which have been decisive in favor of not including the dispatch process can be listed here:

- DP has fewer steps compared to PA and OP
- The dispatch process is a step BullAnt logistics themselves will change any soon (Appendix A)
- PP and DP are the more labor intensive processes within inventory management. (Samuel Wamba, 2010)

### 4.2.4 Time study estimates

Subsequently according to the research framework at table 5, a time study for the selected processes has to been initiated. By conducting a time study the researcher can figure out how much time each of the processes take and thereby it will be supportive when the critical areas of the processes have to be identified later. The time fixated for the individual processes of the two flowcharts are based on an interview to the WHM, unstructured observations and finally also the quick internships within the processes also gives an indication of how much time each process would take.

Data sheets of the two processes have also been requested, and it turned out that BullAnt logistics only had time records for the order picking process. This datasheet will also be used to document the time.

To be explicit about what the time study will include for each of the inventory processes, OP and PA, the following is summed up:

PA process:

- Time study will include the time spend on put away a whole shipment, which is estimated to include 5 POs, 15 boxes, 150 items. (Appendix E)

OP process:

- Time study will be measured on the time taken for fill one OP list. One OP list will on an average basis consists of 8 orders of each 9 items to be picked. This means that in one OP order list will contain of 72 items to be picked. (appendix F)

In appendix F an outline of the datasheet received from the company is seen alongside with calculations for the abovementioned OP process.

Subsequently in regards for the continuation of the time study, there will also be paid attention too, that some of the processes will repeat themselves multiple times during the measured and estimated time study.

This means that when doing a time study on the PA, step 15-19 and step 21 will be repeated and added 5 times due to the clerk has to put away 5 PO´s in one shipment.

In OP all steps have to be repeated 8 times due to the average number of 8 picking orders pr. picking list.

The estimated time study for the two processes can be seen Appendix G and H.

The final result and total estimated time for each of the two processes can be seen in table

| Process name | Time (minutes) |
|---|---|
| Put away | **78 minutes** |
| Order picking | 64m + (5m startup phase) = **69 minutes** |

*Table 7 - PA and OP processes estimated time*

All numbers are rounded to the closest natural number

## 4.3 Identified challenges in processes

Currently there have been done further analysis for each of the two processes, PA and PO, and additionally a time study has also been conducted. Next step is to identify distinct areas of the processes which are the most critical one for later studies. These areas will be identified with the support of the observations, quick internships and lastly additional interviews with the clerks/pickers. The additional interviews will be more in-depth interviews.

### 4.3.1 Challenges and critical areas in PA and OP

As mentioned in section 4.3, there will be conducted more in-depth interviews and these will lead to more clarification about where the challenges within the two inventory processes are placed. The in-depth interviews can be seen in Appendix I and J. Alongside with the unstructured observations and quick internships, the challenges in both inventory processes can be presented.

Table 8 presents the challenges identified in the PA process, while table 9 presents challenges identified in the OP inventory process.

| Step number in FC | Challenge number | Challenge | Consequence |
|---|---|---|---|
| 6 | PA 1 | Print label readability | readability issues, risk of worn out and loss of label. |
| 8 | PA 2 | Split the PO´s from shipment manually into pallets | Time consuming, might miss some allocating some of the items. |
| 13 | PA 3 | Accept received PO amount | Time to count |
| 17 | PA 4 | Put away function issue | Time used, to go and look for a location to put PO. |
| 20 | PA 5 | PO confusion | Disruption when another PO is at designated place. |
| 23 | PA 6 | Time spend on consolidate remaining POs to pallet | Time, load items, which have to be bring back receiving |
| End | PA 7 | - | Stock accuracy after putaway function |

*Table 8 Challenges in PA inventory process*

| Step number in FC | Challenge number | Challenge | Consequence |
|---|---|---|---|
| 6 | PA 1 | Print label readability | readability issues, risk of worn out and loss of label. |
| 8 | PA 2 | Split the PO´s from shipment manually into pallets | Time consuming, might miss some allocating some of the items. |
| 13 | PA 3 | Accept received PO amount | Time to count |
| 17 | PA 4 | Put away function issue | Time used, to go and look for a location to put PO. |
| 20 | PA 5 | PO confusion | Disruption when another PO is at designated place. |
| 23 | PA 6 | Time spend on consolidate remaining POs to pallet | Time, load items, which have to be bring back receiving |
| End | PA 7 | - | Stock accuracy after putaway function |

*Table 9 - Challenges in OP inventory process*

The identification process of the challenges have resulted in, that 11 challenges have been revealed.

## 4.4 Development of process (Step 3)

Currently the challenges which have to be focused on in the project is given, which now will be set out to be improved.

The challenges in both, PA and OP, will now try to be overruled by an RFID integration in the with all the knowledge gained so far. The knowledge gained so far gained can be listed as:

- RFID knowledge trough literature (Section 2.)
- OP and PA process knowledge (Section 4.2)
- Existing challenges in both processes (Section 4.3)

The research will handle one RFID integrated process at a time, where the major amendments towards the existing processes will be integration of RFID tags and a RFID reader combined the knowledge known for how the RFID technology works. Subsequently a description of the new RFID integrated process will be presented.

### 4.4.1 RFID PA inventory process

Figure 9 shows the PA flow chart after the RFID technology is implemented:

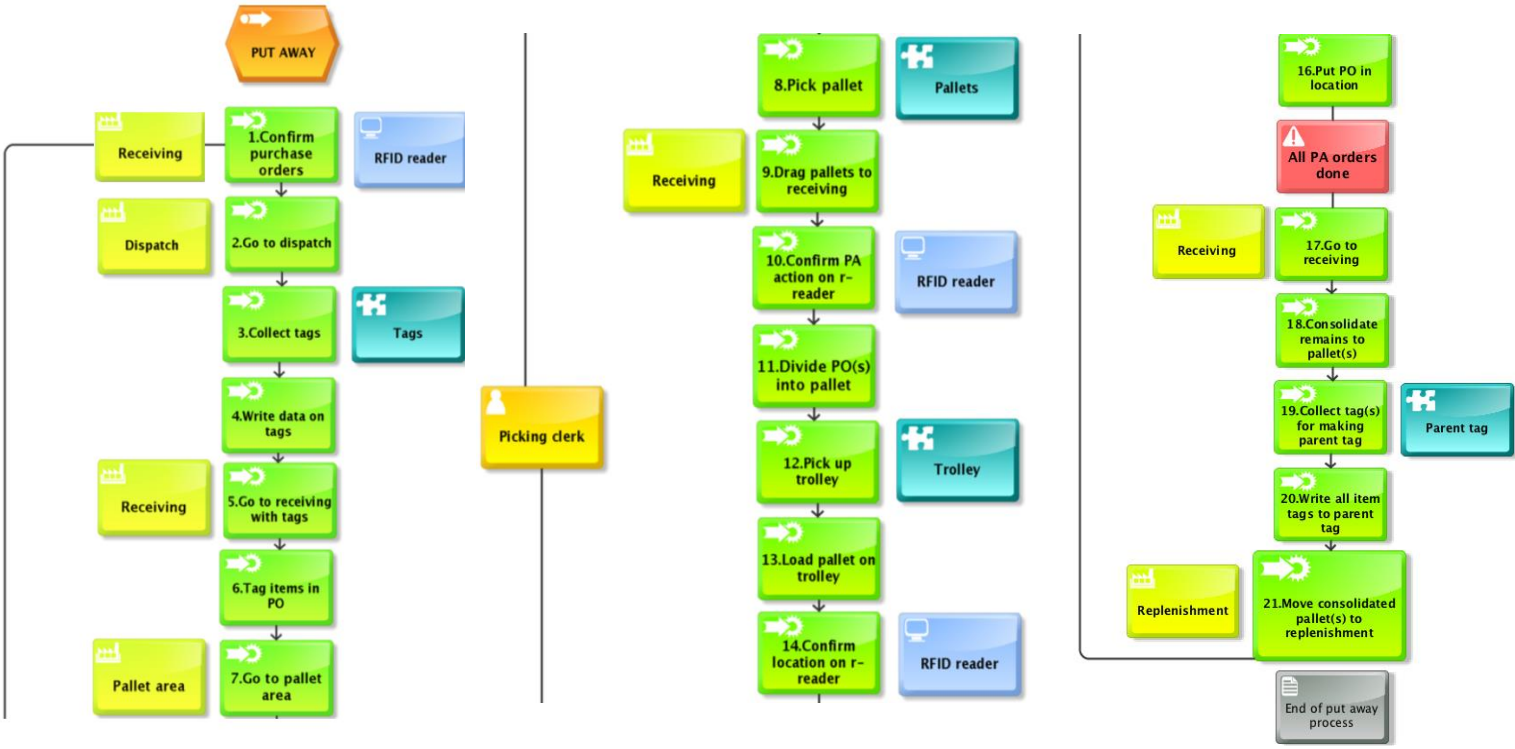


*Figure 9 - RFID Flowchart PA*

The PA RFID process is as follows:

The process starts at the receiving area, where the clerk confirms the received amount of POs with the RFID reader which is connected to the WMS. By using the interface system of the RFID reader, he doesn't have to go back and forth from receiving and dispatch to confirm the amount of POs that have been met.

Hereafter the clerk has to go to the dispatch area and print RFID tags for collection. Subsequently the clerk also collects extra RFID tags for the later pallet consolidation process. While still being the receiving area, the clerk also writes data on the tags, which will be an unique items number for each item received. These item numbers is received from the WMS. Subsequently he goes to the receiving area with the tags, where they shall be attached to each individual item from the PO. Ulterior, the clerk goes to the pallet area and picks an amount of suitable pallets for the amount of POs items received and starts dividing the POs into the pallets. Hereafter a trolley is grabbed, pallet which is ready to be placed is loaded and the clerk scans the PO which have to put away. The RFID reader will let the clerk know, if the PO is known, how much space there are left at the POs usual spot at the rack. This is possible due to the fact, all items currently at the space where the new PO has to go, all are tagged. As they are tagged, they are registered in the WMS system, which will show the difference between total space slots left in the rack.

When the PO is unknown, which will mean, it is a new PO, the reader will come up with suggestions for empty locations placed around the warehouse.

When the clerk has placed the PO at its designated spot in the rack, he goes back to the receiving area and repeats the process for all of the other POs.

As all the Put Away orders are places, the remains which couldn't fit will be consolidated. After the consolidation he creates a parent tag(s) from the excess amount of RFID tags, he brought with him earlier. The parent tag will be written all the item tags from the remains and the parent tag(s) is attached to the consolidated pallet(s).

Ulterior the parent tag is ready to be stitched to the consolidated pallet(s). When this is done, the clerk reads all the tags on the consolidated pallet(s) and transfers them to the parent tag(s). Finally the consolidation pallet(s) are placed in the replenishment area.

Furthermore Appendix J sums up all the steps and estimated time usage for each of the steps in the PA inventory process.

In the RFID integrated PA flowchart there is also steps which are to be repeated for each PO which has to be put away. These steps are also marked in the RFID time study of the PA process. (Appendix J)

### 4.4.2. RFID OP inventory process

The OP RFID integrated flowchart can be seen in the following figure, figure 10:

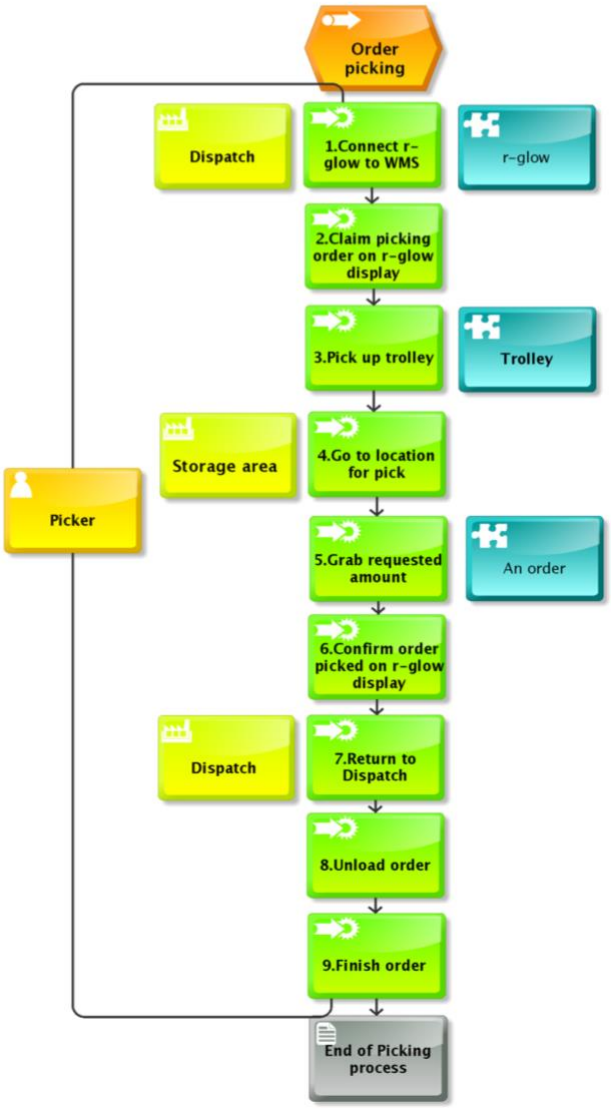


*Figure 10 - RFID OP Flowchart*

Figure 10 shows, that the OP process has been streamlined significantly with the introduction of the r-glow(RFID – glow), which has a RFID reader built in it. The r-glow will be available for the pickers in the dispatch area. This equipment will include a display screen, which is essential for the new and improved RFID process. The picker will then log in with his personal id. When this happens, he will enter a menu of released picking orders. In this section, the picker will find orders released to him by the WHM. Ulterior the picker now can conduct the orders assigned to him. All the orders are sorted out in chronological order, so the picker doesn't have to cross the racks back and forth from each order. Subsequently the picker has to pick up a trolley, go to the designated location, which is seen in the build in display placed in the r-glow.

When an order is claimed, the r-glow will tell the picker where the order is located throughout the display. At the same time the display will also let the picker know the last 3 product digits and quantity to be taken. Subsequently when the picker approaches and grabs the order to be picked, it will communicate with the tags and let the picker know, if he has picked the right item. When a wrong item is picked, the display in the r-glow will light up in a red color. Ulterior when a correct item is picked by the picker, the system in the r-glow will ask the picker to confirm the pick through the display. As the picker confirms the pick, the amount of items picked will be deducted from the WMS.

When all items of an whole order is picked, they are returned to the dispatch area, where the dispatch team proceeds the orders.

Furthermore Appendix K sums up all the steps and estimated time usage for each of the steps in the OP inventory process.

## 5. Implementation (Step 4)

A structural order of how the implementation process for both the PA and OP inventory is as follows:

1) Figure out what RFID software there is capable communicating with the current WMS of the company.

2) RFID reader/ r-glow compatible with software

3) Order tags with the right frequency
    * At the current stage tags with 13,56 MHz, which is equivalent to 1 m (Andriolo Alessandro, 2010), is the right for the company towards the suggested amendments of new inventory processes.

4) Test if tags are compatible with RFID reader/glow and software

5) Be sure of the quantity to buy of RFID tags, reader and r-glow

6) Initiate the implementation

### 5.1 Training

When these initial five steps are finished, the training of the personnel can be conducted. This can be done by the both the warehouse managers(WHM and second WHM) in the company and a consultant/ IT or software engineer.

A likely process of conduct can be succeeded by the consultant / IT or software engineer sets up the system according to the newly designed PA and OP processes. The WMS supports the setup practically but also get to know technical features about setting up the whole system.

Ulterior the team managers can be involved in the initial phase of conducting the inventory systems, which is then forwarded to the ground floor workers.

# 6. Results

Results of the two different inventory processes, PA and OP, can now be evaluated. Both of the inventory processes will be evaluated in general and compared to the challenges set up for them(section 4.3.1.)

Firstly the time and effectiveness of the processes will be presented, which is the most significant factor.

The time differences and overall effectiveness for the PA inventory process is as follows:

**PA**

- Current PA time estimation: 32,7 minutes
- RFID PA time estimation: 77,6 minutes
- Total effectiveness for: 42 %

The time differences and overall effectiveness for the OP inventory process is as follows:

**OP**

- Current OP time estimation: 69 minutes
- RFID OP time estimation: 44,5 minutes
- Total effectiveness for OP: 64 %

The decline in lesser time usage can also be reflected upon more streamlined inventory processes. The steps in the PA has been reduced from the 25 steps to 21 steps, and whole process has been even more simplified as double occurrences of steps is none-existing in the RFID PA process.

Meanwhile the OP process has been reduced by 5 steps, by a total of 14 steps to 9 steps.

Subsequently the results have also been affecting the challenges presented for PA and OP in table 8 and table 9. Therefore the results of the implication of the challenges for the OP and PA process will now be presented. The table is divided as challenge number, the challenge itself and the possible outcome when an implementation would be succeeded. Furthermore each challenge number is marked with a green color for a success and a red one for a failure.

Result implication for the initial challenges for the PA process:

| Challenge number | Challenge | Result with RFID implementation |
|---|---|---|
| PA 1 | Print label readability | Challenge avoided, as the barcode label will be replaced by a tag, which is much easier to read with a RFID scanner. |
| PA 2 | Split the PO´s from shipment manually into pallets | No improvement. |
| PA 3 | Accept received PO amount | BullAnt still has to count the amount. |
| PA 4 | Put away function issue | Due to the tags on the items on the racks, the total space availability will always be visible for the put away clerk. Therefore the WMS will always show the clerk how much space there is available for putting new items on a specific rack |
| PA 5 | PO confusion | As all the items in the warehouse / racks will be tagged, the WMS will always be updated immediately without one has to scan them with a barcode or such |
| PA 6 | Time spend on consolidate remaining POs to pallet | RFID makes it easier and quicker to consolidate |
| PA 7 | Stock accuracy | Accuracy has been improved overall with the RFID integration |

*Table 10 – Result implications for RFID PA*

Result implication for the initial challenges for the PA process:

| Challenge number | Challenge | Result with RFID implementation |
|---|---|---|
| OP 1 | Identification issues to VHD | Improved significantly, as one only has to login through the r-glow |
| OP 2 | General communication issues with the VHD | Improved by the r-glow, as is simplifies the whole process by i.e. immediately telling location on r-glow screen and also recognizes if the right item is taken due to the RFID technology. |
| OP 3 | Communication with Dispatch staff | Via a RFID reader, the dispatch knows which products to pack if a confusion arises, instead of disrupting the pickers |
| OP 4 | Stock accuracy | Stock are updated immediately when a picker picks an item from the rack |

*Table 11 - Result implication for OP*

# 7. Discussion

The first thing to discuss about is the framework, the researcher has modified from S.L. Ting and his fellow co-researchers (S. L. Ting, 2013)

The biggest change is, that there is no prototype testing in the researchers framework, compared to researcher Ting´s framework. Another added feature to the modified framework to this research, is the set of tools and approaches to be used in each of the frameworks steps are visible in the new framework.

Subsequently there are the inventory processes. The first thing which came to mind were all the other inventory processes in BullAnt logistics, as they were not presented with the same attention like the PA, OP and the DP processes. Subsequently the researcher found out the underlying reasoning for why the three initial processes were presented and not i.e. the receiving process. The outcome to this were due to that the receiving process were included in the PA process. This is different from the theory, were the two inventory processes, receiving and PA, processes are two separate processes. To sum this up, the researcher had to be aware of the company´s own interpretation of its inventory processes apart from the theory(section 4.2.)

Also it could have been interesting to question the WHM more in depth about why to bring the focus on the PA and OP processes. There seemed to be biased actions towards this decision, even though the theory also said the one of the mentioned processes, OP, is the most labour intensive inventory process. Another interesting question which could have been presented regarding the outlining of the processes, were to ask the second in charge WHM, supervisors and the ground floor workers about which of the processes, that were the most critical ones. They might have had given different answers and came up with different arguments for it, not that it will have changed the whole focus area, as the WHM is the most knowledgeable worker in the company.

Subsequently another point of the discussion could be to see the outcome if the research chooses to strife more towards a light to pick system implementation presented by Andriolo, Alessandro et. Al. (Andriolo Alessandro, 2010)

If more time have been available, both methods, the research which is currently have been done, and the pick to light system could have been done. Subsequently a comparable analysis would be conducted to evaluate which of the two processes that would have been the most effective one.

Otherwise the researcher is confident about the company will take the research into consideration for a possible change of their processes. The fact, that they have most likely gone from a paper based process, I.e. picking order process influenced by picking orders on paper to VHD and thereby lesser amount of papers to be used in the process is a good indication on that the company are willing to move forward towards streamlining their processes further.

# 8. Limitation

During the research the researcher has been facing some limitations. The limitations will be listed punctually with an attached elaboration of why the listed dot is a limitation:

Data:

BullAnt Logistics only had trackable data on the Picking process, and not the Put away process of the two inventory process the research are based on.

Time:

As the research is a cross sectional study on 4,5 months, it caused a limitation in the extent of, there were a limited amount of time for any implementation.

Amount of researchers:

An alternative perception of the limitation is the amount of researchers on the project, as there is only one researcher on the project. If there has been more than one researcher in the project a more in-depth research could have been in done.

I.e. with a co- researcher the remaining inventory processes, dispatch etc., could have been analyzed.

# 9. Conclusion

The researcher can hereby conclude that the most critical inventory processes of BullAnt logistics are the following:

- Put away process(PA)
- Order picking process(OP)

Both of the processes and their level of criticality have been identified through the following:

- 6 days internships
- Unstructured observations
- Interviews with BullAnt staff

Furthermore it has also been enlightened through academic research, that PA and the OP processes are the most labor intensive processes. (Samuel Wamba, 2010)

The challenges of the two outlined processes, PA and OP, are identified with in-depth interviews to the BullAnt logistics clerks. The identification of the challenges are also supported by the researchers own internships within each of the processes, and the unstructured observations made on the spot. The identification process resulted in a total of 11 challenges were identified, seven challenges in the PA process and four challenges in the OP process.

Finally there have to be suggested a way to overcome these identified challenges in order to achieve the end goal of the research, which are to make the selected inventory processes more effective. The research goal has been achieved by suggesting RFID technology integration to the PA and OP processes.

Within the PA process it is suggested that RFID tags are put on each of the received items of the PO. The RFID reader is also replacing the bar code scanner, and the RFID tags are replacing the barcode labels.

Within the OP process, it is assumed with the RFID integration for the PA process, that all the items to be picked, by the picking clerk, are all attached with a RFID tag each.

The clerk then puts on a RFID glove, with a small display connected to the company´s WHS and tells him where to go. Every time, the clerk then picks an item, the RFID glove reads the tag on the item and subsequently when confirming the pick of the item, the WHM deducts the picked item and quantity from the inventory.

It can finally be concluded based on the suggested technology implementation of the RFID technology to the PA and OP processes, that the PA process will get 42% more effective, while the OP process will get 64 % more effective.

Subsequently regarding the challenges identified, it can be concluded that the 9 out of 11 identified challenges can be improved / eliminated, with the integration of the RFID technology.

# 10. Future research (step 5)

For future research of the project regarding the analysis done for the two inventory processes, PA and OP, there could be taken a step towards an implementation. Initially there could be looked into what kind of RFID software is feasible to BullAnt logistics´ WMS. Subsequently there can be done further determinations of how many feasible tags the company should acquire**.** Hereafter an acquisition of an amount of  RFID gloves and the RFID readers which needed to be bought. When all this is done an implementation plan towards initiating a pilot study can be conducted.

Ulterior a streamline of all the steps within the two processes can be investigated further in the extent of i.e. moving the pallets closer towards the dispatch area. BullAnt logistics can also negotiate or inquire about an exchange of pallets, as they will save time by using their suppliers pallets, instead of moving entire PO´s to their own pallets.

Furthermore the management in BullAnt logistics can negotiate and collaborate with the suppliers regarding tagging their items before they send them. This will streamline the company´s processes even more. If BullAnt has luck persuading their suppliers to tag their items and thereby send entire PO shipments with tagged item, they can install a RFID reader stander dock at their receiving dock. The purpose of RFID stander would be to scan all incoming shipments and the information from the tags will be send to the company´s WMS, which will confirm if all the right orders have been received or not.

Ulterior a structured observation and time study can be made done after the implementation to study in depth all the individual activities done in each process. This will mean that the researcher have to break down each of the steps on the RFID flowchart to analyze each movement to make the processes as most streamlined as possible.

Subsequently when having success with the PA and OP inventory processes, the RFID technology integration can start impacting the remaining inventory processes like the replenishment process. An research towards improving the replenishment process, could be to have RFID readers built in to the forklift, which is used for the replenishment.

Another thing could be to engage the staff more and more into these new kind of process changes, as they are the practical experts of the process changes.

The company could have weekly or monthly meetings about how to improve the processes even further, as this have been lacking in the company. A strong indicator for this is the procedure used to find out the challenges for the OP and PA process. During this phase it was a helpful factor to make the in-depth interviews about the processes directly addressed to the clerks.

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# List of figures

# List of tables

# Appendix A – General about the warehouse and processes

**WHM:** **Warehouse manager**
**R:** **Researcher**

R: Hi WHM, first of all can you tell me a little about the warehouse.

WHM: What do you want to know specifically, all the historical and fact related information, you already know is listed in our web page.
Anyhow, I´ll tell you about the information which is not listed on the webpage…
We have a variety of costumers which is sending us all sorts of products, which packed in inner cartons as you will see later. So basically we receive orders, which we have to coordinate with our customers, the orders are then registered, put away in the racks, picked by the pickers, and then dispatched. This is our most important task, hereafter there are also a variety of all sorts of other tasks like, handling the ever increasing dead stocks, managing returns etc.

R: ok, great, all good, these main inventory processes, how would you like divide them?

WHM: I would divide them as inbound logistics, put away, order picking and order dispatching.
Furthermore you will be interested in the distribution workers and our general hierkhy in the company, as we chatted about before your arrived?

R: Yes!

WHM: If we start from the bottom, there are the ground floor workers, these are the guys who perform the i.e. the picking or splitting purchase orders into separate pallets in the put away process.
For these four areas we have in total 3 supervisors, but we might look for a fourth one when we are capable of handling more orders.
Above the supervisors, we have my assistant, who helps me run the warehouse and takes the responsibility, when I am out of office.

R: Ok, great, as we have already discussed that I will focus on the inventory processes, I also want to know about the processes itself in more details,

WHM: Yes, now problem, I also think we have discussed that we in the company are most interested in the put away, order picking and the dispatch process, as the shipping process is going through some amendments already. This I am aware of you also indicated you were ok with?

R: Yes, that's alright, yes I am.

**Put Away process**

WHMt: When the shipment arrives, the clerk, has to go to our computer, login to the WMS and check for how many PO´s the arrived shipment consists of, as he has to first of all secure, that the rightful amount has arrive, but also to be sure of how many pallets he needs to split the PO´s in.

R: He has to split the shipment into the pallets? Like PO by PO? So I mean one PO pr. Pallet?

WHM: Yes, he has to do that, So he checks the number of PO´s via the computer and then heads to the receiving area, confirms number of purchase orders, pick an equivalent amount of pallets which he has to place at inbound, as we receive our shipment there. The pallets he is getting also has to be from the pallet area, as we cannot use our suppliers pallets.
Now he can split the PO´s into the pallets, he then will also print a number of pallet number which is again equivalent to the number of pallets he has split the PO´s into.

R: Why doesn't he do that in the beginning at the WMS?, as when he checks for the number of PO´s there?

WHM: As we want to be sure and want to have a confirmation on the number of PO´s, then next he puts the pallet labels onto the pallets. Then he will scan the barcode of all the purchase orders, which will tell him how many items of each of the purchase orders he were supposed to receive. The clerk will then make sure that the right amount of items have been received for each PO, by opening up one of the boxes of a PO. Each box of a PO will contain inners(inner carton or SKU). An inner will in most cases contain one product and the maximum of inners in a PO box is around 10.
Later he will tap the transfer function thought the barcode scanner and transfer the scanned PO to the Pallet label it is currently on. Next step for him is to drag the pallet to a shelf location and put it there, this is done by the actual put away function.
This is done, when he scans the pallet label first, which will firstly let him know how many qty. of a PO the pallet has. By the system telling him this, he will also be assured that he has done his scanning correctly. When he then scans the pallet with the put away function, it will either give him a desired and known location to where to put it or it will give him an empty location. Empty location means that he will have to find a location himself, this again will be based on experience. This however also means that the WMS isn't familiar with the

product, as it is a new product. When he then go to a location, he will then have to scan the location, to allocate the PO. But in this case, there will be occasions where he can´t allocate all of the PO´s simply because there are not space enough. This he has to tell the WMS in the barcode scanner, and it will update the qty. of the PO on the pallet and he will then have to drag the pallet back to the receiving area. In cases, where all the PO´s can fit into the location, he can will have to destroy the pallet label.

R: Destroy?

WHM: Yes, eliminate, erase, as now the pallet label is void, it has no value now. And we don't reuse them.

WHM: At the end of process, he will in most cases end up with some pallet with remains from PO´s which couldn't fit in the racks, these have to be consolidated together. This have to be done with the transfer function through the transfer function and empty pallet labels are destroyed. The finish pallets are moved to replenishment. We then have replenishment staff or workers, that will take care of those pallets, as they will be replenished at bulk locations.

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**Order pick process**

R: Now I guess it is picking order process right?

WHM: This process has more processes and it will be easier for you to understand this one especially more through your observations when you do the picking yourself.

R: Yes, ok

WHM: But the picking phase, where we have a few amount of pickers aligned, which again depends on how busy we are. First of all we use this voice headphone device, as we want the pickers to work in a paperless environment and also with both hands. They communicate to this device, and the device basically leads the picker to pick up the products. First of all the device has to identify which picker it is, this makes it easier for me track down an picking error and also the performance level of the device. When the device is ready and have accepted both order to be picked and also the picker who is going to pick it, the order pick can start. The VHD directs the picker to the a specific aisle, which the picker goes to, and then a specific shelf location, where the order to be picked is located. The picker then confirms his location and the VHD tells him how much he has to pick. When he has picked the correct amount, he then brings the order to the dispatch area.

---

**Dispatch process interview**

R: alright, next phase of must be how you guys dispatch the orders?

WHM: yes, that's right, what happens is that, the after the picker has finished one order, either a guy from dispatch or the picker himself packs the orders into cardboard boxes. Of course he has to kind a estimate how many boxes the items can be fitted in. This again improve trough experience, in start, as you did, you might go back and forth as you might have picked less cardboard boxes as needed or more boxes that you needed. When he is finished with packing, he then has to print out labels for as many boxes he has packed. So if he has packed 3, then how many labels?

R: 3

WHM: yes, when he then packs all boxes, like he finished his packing, he puts them on a metal conveyer just near, as you have seen. Then in most cases another clerk do the job, to register the boxes into the WMS. As from they are ready to be picked up from our warehouse. Now he has to make sure, that he has a pallet to place the boxes on. Normally he has to get the pallets at the pallet place. After he then put all the boxes ready for dispatch, he brings the pallet to the outbound area, so now it will wait for being collected to a further shipment.

WHM: yes, that's right, what happens is that, the after the picker has finished one order, either a guy from dispatch or the picker himself packs the orders into cardboard boxes. Of course he has to kind a estimate how many boxes the items can be fitted in. This again improve trough experience, in start, as you did, you might go back and forth as you might have picked less cardboard boxes as needed or more boxes that you needed. When he is finished with packing, he then has to print out labels for as many boxes he has packed. So if he has packed 3, then how many labels?

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put all the boxes ready for dispatch, he brings the pallet to the outbound area, so now it will wait for being collected to a further shipment.

R: Ok, thank you

R: Also, lastly WHM, just some estimation regarding some economical numbers, how many PO´s will you estimate there is in a shipment? And how often do you receive a shipment ?

WHM: Shipment pr. Week ?

R: Yea, if it´s easier to estimate for you?

WHM: Hmm, yea it would be for me, I would say 10 shipments which each 5 PO´s and in average, if you want a time estimate for that as well, I will guess it is around 1 hour and 20 minutes.

R: Alright how about the an estimate on numbers of orders to pick on one picking batch?

WHM: I would guess that will be around **8,** but in this case I can also give you the datasheet, as you will have better numbers from there.

R: Ok, thanks

R: Great, that is just what I needed. Also shortly, how much do a picker / put away clerk earn?

WHM: We offer them a pay of 25 Australian dollars pr. Hour and then they have 1 hour break throughout the day, which we don't pay them for. And you also need to know, we In the company have 250 working days.

R: Ok, thank you.

## Appendix B search string

| Search strings | Hits |
|---|---|
| RFID AND Inventory management OR third party logistics AND 3PL | 7.175 |
| (RFID AND (Inventory management)) OR ((third party logistics) AND 3PL AND framework) | 5.654 |
| (RFID AND (Inventory management)) OR ((third party logistics) AND 3PL AND framework) AND Management | 2.451 |
| RFID AND (Inventory management) AND ((third party logistics) OR 3PL) AND case | 900 |
| RFID AND (Inventory management) AND ((third party logistics) OR 3PL) AND case AND tagging | 167 |
| RFID AND (Inventory management) AND ((third party logistics) OR 3PL) AND case AND tagging AND management | 89 |

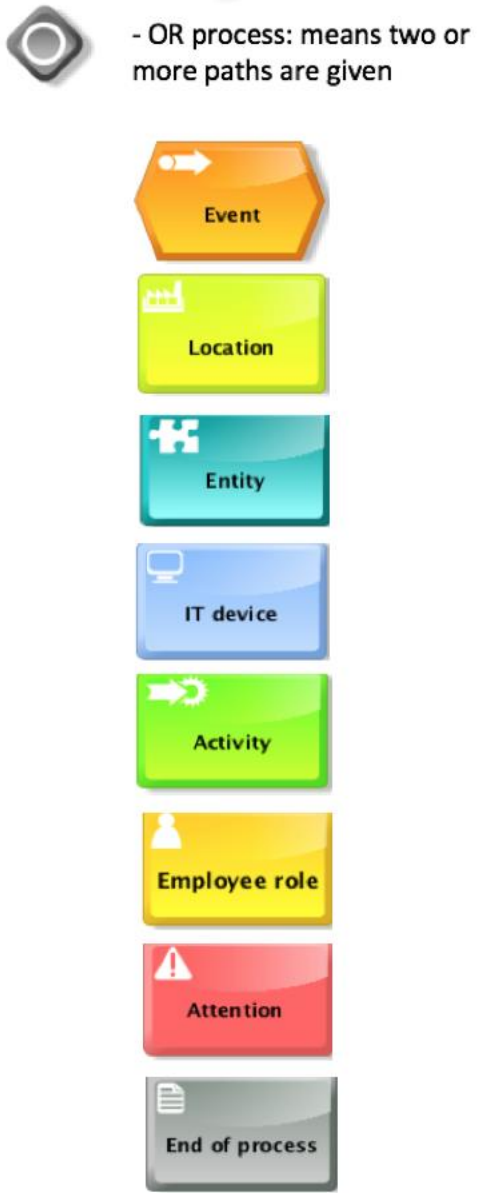
# APPENDIX C – SLR FULL READ TABLE

| article name | year published | authors | rating |
|---|---|---|---|
| The Impact of RFID technology on warehouse process innovation | 2010 | Samuel Wamba & Akemi Chatfield | 5 |
| RFID: from concept to implementation | 2006 | Robert E. Spekman, Patrick J. Sweeney II | 2 |
| RFID-based intra-supply chain in textile industry | 2009 | Siu Keung Kwok and Kenny K.W. Wu | 2 |
| A framework for mapping the RFID-enabled process redesign in a simulation model | 2013 | Angeliki Karagiannaki, George Doukidis* and Katerina Pramatari | 2 |
| RFID implementation with virtual infrastructures | 2010 | John P.T. Mo, William Lorchirachoonkul | 2 |
| Warehouse contextual factors affecting the impact of RFID | 2010 | Angeliki Karagiannaki, Dimitris Papakiriakopoulos and Cleopatra Bardaki | 5 |
| Managing RFID projects in organizations | 2009 | Indranil Bose1 , Eric W.T. Ngai2 , Thompson S.H. Teo3 and Sarah Spiekermann4 | 2 |
| Bridging the gap between RFID/EPC concepts, technological requirements and supply chain e-business processes | 2010 | Bendavid, Ygal; **Cassivi, Luc** | 2 |
| Empirical evidence of RFID impacts on supply chain Empirical evidence of RFID impacts on supply chain performance | 2009 | john visch et. Al. | 2 |

| | | | |
|---|---|---|---|
| Implementation of RFID technology in University of Pune Library | 2008 | Sadanand Y. Bansode, Sanjay K. Desale | 4 |
| Increasing efficiency in the supply chain for short shelf life goods using RFID tagging | 2006 | mikko karkkainen | 3 |
| Determinants of RFID adoption stage and perceived benefits | 2015 | Pedro M. Reyesa,*, Suhong Lib,1, John K. Visich | 1 |
| An Exploratory study of outsourcing 3PL services: an Australian perspective | 2011 | Rahman Shams | 3 |
| Warehouse efficiency improvement using RFID in a humanitarian supply chain: Implications for Indian food security system | 2017 | Arun Kumar Biswal*, Mamata Jenamani, Sri Krishna Kumar | 1 |
| Challenges associated with RFID tag implementations in supply chains | 2009 | Gaurav Kapoor, Wei Zhou, Selwyn Piramuthu | 1 |
| RFID adoption and implementation in warehousing | 2012 | Barbara A. Osyk, B.S. Vijayaraman, Mahesh Srinivasan and Asoke Dey | 1 |
| Appraisement and selection of third party logistics service providers in fuzzy environment | 2011 | Saurav Datta et. Al. | 3 |
| A conceptual framework of RFID adoption in retail using Rogers stage model.pdf | 2014 | Mithu bhattacharya | 1 |
| Benefitting from RFID | 2014 | Dan Mullen | 2 |

| | | | |
|---|---|---|---|
| Making the 'MOST' out of RFID technology: a research agenda for the study of the adoption, usage and impact of RFID | 2007 | John Curtin Æ Robert J. Kauffman Æ Frederick J. Riggins | 2 |
| When is RFID right for your service? | 2009 | Geraldo Ferrer , Nicholas Dew, Uday Apte | 1 |
| New pick-to-light system configuration: a feasibility study | 2010 | Andriolo Alessandro et.al. | 5 |
| rfid global rfid framework | 2011 | Nyoman Adhiarna1,Yoon-Min Hwang2 , Jae-Jeung Rho2 | 1 |
| RFID with tracker | 2012 | Maged Ali and Emal Ektas | 2 |
| RFID Field Guide: Deploying Radio Frequency Identification Systems, | 2005 | Bhuptani, M. and Moradpour, S | 4 |
| RFID applications in manufacturing. | 2018 | Baudin, M., Rao, A. | 4 |
| Design and implementation of the wireless RFID Glove for life applications. | 2010 | Lee, C., Kim, M., Park, J., Oh, J., Eom, K. | 5 |
| A RFID case-based logistics resource management system for managing order-picking operations in warehouses | 2008 | T.C. Poon et.al | 2 |

# APPENDIX D - Flowchart definitions of symbols



# APPENDIX E – PA process in-depth interview with clerk

R: researcher
C: Clerk

R: Thank you for being here today, yes as WHM might have told you, I now has much more insight about all the processes, and also currently outlined to focus on to make two of the processes more effective. One of them, the Put away process, which you currently do some tasks in.

C: yes, …

R: Yea, so I think it is easier, that if we go from step by step, I.e. I have the flowchart of the put away process here, as you can see the, you first start by checking for incoming orders and also how many POs the designated order consist of, right ?

C: Yes that is right, correct so far.

R: …And then you end up by finding a home location for them and finally consolidate the POs who couldn't fit into their locations?

C: yes, that's is all correct, and I easily identify what you've drawn on the flowchart.

R: So yes, so what do you see as the first challenge, when chronologically reading the flowchart?

C: The first one must be, that there is no clear procedure about when and who exactly have to check for the incoming orders, this I think have been aware of?

R: yes

C: All right, then you know, but yes this is causing some confusion and even some times, this has also led to, that shipments arriving at receiving, where we at the moment when it arrives realize that we have a shipment incoming. This will lead to a sudden adaption of what we are doing, and some time, it can cause a confusion. I.e. I could be in a middle of a cycle count of a certain product category and then have to leave that in order to take actions towards the sudden shipment.

R: yes ok, how about this actions towards printing pallet labels? Doesn't it cause any challenges?

C: What do you think of? No that has always been very easy to process. But maybe if you think of an automation process or some sort of supplier collaboration, where we ask the suppliers to print and put on the labels for us?

R: yes, I was thinking some sort of that

C: But yes, that could be a possibility, but we haven't thought of that, we know that kind of actions requires some resources and supplier will ask what he gets out of it.
But I understand your point, but the process itself don't bother any of us, or to say we in the team don't consider that as an area of where the focus has to be.

R: Al right, I think also more toward, the long term usage of these pallet labels, like readability, like when they..

C: Yes, that can be a challenge, you are completely right about that, sometimes we have to point the gun(barcode scanner) at the label, without anything really happens, which cause frustrations. Other times, when the i.e. the pallets are placed in the warehouse, and need to be taken out again, it will sometimes not be visible due to the layer of dust and we have to kind a swipe it carefully away, as we don't want to damage the label itself. In worst cases, which also has happened before, the label, is worn out and literally not readable or even fallen off the pallet. At this point we have to call the WHM, to check what pallet label number were on the pallet and ask him to erase the old one, which all its data on, print a new and finally transfer the new the goods onto the new pallet label, as the system doesn't allow to generate the existing pallet label.

R: Ok

C: Yes, one other thing is when we have to split the entire PO into designated pallets, I mean, so you are aware, that all these challenges I have found as challenges when I was new to the company and what I find as challenge, when I have to especially have to educate new clerks into to the company.

R: Yes, I am fully aware of that.

C: Ok all right, then I will continue, yes as I was saying from the beginning, sorry about that.

R: No worries,

C: yes, the second challenge arises, when have confirmed what we are ought to receive, and we have to split the orders into the pallets respectively, so we have one PO pr. Pallet. This is really time consuming, as when we receive the entire shipment, the supplier won´t have time I assume or just don't want to stack the items purchase order by purchase order when packing the entire shipment. So we of course have to split it

manually, by looking all the received items received PO by PO. This is requiring so much resources, and I think, this will be one of the crucial areas improving the put away function.

R: ok, I will note that down.
Also in that case, how many boxes, I mean inner cartons do one box contain?

C: One box contain a maximum of 10 inner cartons
..One other thing I see on your FC, is that when we have validate the amount we have received. Which again can be simple, but some times when a PO includes many boxes it can be cause miscalculations when confirming the received amount. Especially this issue can be a big problem for some of our new pickers as they may be that strong in mathematics. The problem gets bigger, when we based on human calculations, do a wrong stock adjustment.
Further the next challenge will be, those moments when we have to find a new location for a new product line. As it takes a time to go around, back and forth in the warehouse to find an empty space close to the family PO.

R: What do you mean by family PO?

C: Like every time we have to find location for new PO, it has to be close to other PO, which is similar with that the PO. So there is some kind of order in the warehouse.

R: ok, you only experience this with the new?

C: yes, new POs?

R: ok

C: Or wait there have also been occurrences, where locations to known POs, did have other POs assigned to its space instead, do you follow me so far?

R: yes yes,

C: So imagine, that an inexperience clerk, have to put away a known order, at the time when he has to allocate the PO to its reserved place, there is another PO, then he has to decide whether he should move PO to another empty slot, or move the wrongly assigned PO to another place. As in case, it is an inexperienced clerk, he will call another clerk or even the WHM. And more work time is wasted.
Lastly hmm, I would like to mention the consolidation process, when the all the remains have to be consolidated, which is ok easy, when we, the experienced clerks do it, but this can be a challenge for new clerk or one which is not used to it.
And yes, it can also be a challenge and also causing a bit of annoyance as we cannot see, at start how many pallets we need to get in order for the consolidation process. This

could be great, if there some kind of transperancy for us of some sort, so we somehow new how many POs we need to put on shelf, like we knew how many POs there were room for, so we could spare the time of loading unnecessary amount of PO, which we at the end have to bring back in order to consolidate anyway.

C: All right, I guess that is it, we have been through the whole process, thank you for your time.

## Appendix F – OP datasheet + calculations

| OP number | Date | Picker | Item(Qty.) | Order(Qty.) |
|---|---|---|---|---|
| 114929 | 3/28/18 10:15 | Jonathan | 4 | 1 |
| 114930 | 3/28/18 11:30 | Jonathan | 16 | 3 |
| 114931 | 3/28/18 11:45 | Kevin | 11 | 5 |
| 114932 | 3/28/18 12:00 | Kevin | 60 | 35 |
| 114934 | 3/28/18 12:00 | Kevin | 60 | 33 |
| 114935 | 3/28/18 12:00 | Kevin | 60 | 35 |
| 114936 | 3/28/18 12:00 | Kevin | 60 | 35 |
| 114937 | 3/28/18 12:00 | Kevin | 60 | 40 |
| 114953 | 3/29/18 8:45 | Jack | 32 | 5 |
| 114954 | 3/29/18 12:15 | Darshana | 1 | 1 |
| 114955 | 3/29/18 12:15 | Darshana | 82 | 9 |
| 114956 | 3/29/18 12:15 | Daniel | 18 | 3 |
| 114957 | 3/29/18 12:15 | Daniel | 24 | 5 |
| 114958 | 3/29/18 12:15 | Daniel | 60 | 26 |
| 114959 | 3/29/18 12:15 | Amruta | 60 | 8 |
| 114960 | 3/29/18 12:15 | Amruta | 60 | 8 |
| 114962 | 3/29/18 12:15 | Amruta | 100 | 11 |
| 114964 | 3/29/18 12:16 | Amruta | 114 | 9 |
| 114976 | 3/29/18 12:17 | Daniel | 340 | 24 |
| 114985 | 3/29/18 12:18 | Jack | 4 | 1 |
| 114997 | 3/29/18 12:19 | Mere | 235 | 102 |
| | | | **72.3727** | **8** |

**72/8 = 9 = items pr. Order**

Average items

Average orders

## Appendix G – Time study of PA process

| Step count | Clerk actions | Time (minutes) |
|---|---|---|
| 1 | Check amount of purchase orders | 2 |
| 2 | Go to receiving area | 0,3 |
| 3 | Confirm amount of purchase orders in the whole order | 5 |
| 4 | Go to dispatch | 0,3 |
| 5 | Print pallet labels (PL) | 2 |
| 6 | Go to Pallet area with PL | 0,5 |
| 7 | Pick pallets coherent to POs | 1,5 |
| 8 | Drag pallets to receiving | 3 |
| 9 | Split the POs into the pallets | 7 |
| 11 | Stick pallet labels onto pallets | 1,5 |
| 12 | Scan barcode of all purchase orders | 2 |
| 13 | Confirm and validate received amount | 6 |
| 14 | Use transfer function to transfer POs to their designated pallet | 2 |
| 15 | Load a pallet on trolley | 1 |
| 16 | Scan pallet with put away function | 0,5 |
| 17 | Drag pallet to suggested location/ find an empty location | 2,5 |
| 18 | Scan the shelf location barcode | 0,1 |
| 19 | Put PO on shelf | 2 |
| 20 | Destroys empty label if empty OR accept remains of PO to pallet | 1 |
| 21 | Drags back pallet to pallet area if empty/ if full drags it to receiving area | 1 |
| 22 | When finish allocating PO´s to shelf, transfer and consolidate remaining POs to pallet | 3 |
| 23 | Destroy empty pallet labels | 1 |
| 24 | Move consolidated pallets to replenishment area. | 2 |

**Time: 42,1m + (7,1m x 5) = 77,6 minutes**

# Appendix H – Time study of OP process

**Order picking process**

| Step count | Picker action | Voice device | Time (minutes) |
|---|---|---|---|
| 1 | Identify to VHD | | 5 |
| | | Accepts request from picker | 0,2 |
| 2 | Print order number print (OP) | | 0.2 |
| 3 | Pick up trolley | | 0,2 |
| 5 | Attach OP to trolley | | 0,1 |
| | | Tells which aisle to go to | 0,1 |
| 6 | Go to aisle | | 1 |
| | | Accepts OP request and directs picker to aisle | 0,1 |
| 7 | Confirm aisle location | | 0,1 |
| 8 | | Accepts aisle location, returns with shelf location | 0,1 |
| 9 | Go to shelf location | | 0,7 |
| 10 | Confirm shelf location | | 0,1 |
| | | Accepts shelf location and requests last 3 digits of product code. | 0,1 |
| 11 | Take single product | | 0,4 |
| 12 | Confirm last three product digits | | 0,1 |
| | | Accepts, and enlighten quantity to grab | 0,1 |
| 12 | Grab requested quantity | | 2 |
| 19 | Confirm grabbed quantity to VHD | | 0,1 |
| | | Accepts the quantity taken | 0,1 |
| 20 | Go to dispatch area after grabbed quantity | | 0,5 |
| 21 | Unload order to dispatch | | 1 |

**Total time : 8 x 8(amount of orders) +(5 minutes) = 69 minutes to complete an order**

**(+5 startup phase(VHD identification) )**

**Items pr. Order = 72 items**

# Appendix I – In-depth OP interview

Interview – Order picking with 2 pickers
**R: researcher**
**P1: Picker 1**
**P2: Picker 2**

R: Thank you both of you to be here today, as your manager have told you, I am here to have some insight about the daily challenges you guys face when picking orders.
I have drawn a flowchart for the whole process, so we can proceed in a structured order from the first process when you identify yourself to the VHD and you've returned the picked orders to dispatch. So basically what I want you guys to tell me, is what you see as challenges.

P1: ok, If I may begin?

P2: yes, go ahead

P1: I would say, the first step, when we have to identify to the VHD, we have had few troubles when they haven't been charged fully due to mistakes, but this is only a minor challenge, as things are getting better at this point in regards to more VHD available.

P2: yes, but though it also requires some time when the we hire new staff, as they need to use time to identify themselves to the VHD, as you also are aware of, it is voice recognition device, So of course it will take some time for a new guy to get used to it, and also for the guy to further figure out how it works, but usually after a while, some days, it shouldn't be a problem.

R: ok

P1: Regarding the VHD itself, it is also time consuming for all of us when there is noise in the background, which can interfere our interaction to the VHD. When this happens, which is unfortunately on a frequent basis, few annoying things can happen. This can be things such as wrongly interpreted order numbers by the VHD. Or if are at the right aisle, as the VHD has told us, and we then confirm it to the device, it can interpret it wrongly and say we are at the wrong aisle, which will confuse us.

P2: Yes, I can easily refer to that, this has happened quit a few time for me as well. And also the new pickers have experienced this as well. Of course more than us. But yea, it happens, also when fx. We have to say the last 3 digits of a product code the VHD are asking us. The noise interferers and somehow the VHD, doesn't get all numbers, are getting all the numbers with disrupt, finally also when we have to confirm the numbers

of products we have to take, we can sometime stand there and confirm more than 2 times.

R: ok, that's sounds frustrating

P2: yea, it truly is sometimes…

R: Apart from the VHD, are there more challenges? I guess that was all the challenges regarding the device itself?

P1: hmmm, yes there is, it happens when we have to pick a certain amount of products and due to the supplier packs the products differently, it arises a lot of confusion.
I mean, you know that the one PO can contain of fx. 5 cardboxes, each individual box, we see as a SKU. But each SKU, can withhold more SKU´s within its packing, we call them inner SKU´s or inner cartons.
Here it becomes tricky, as each supplier has different inner SKU´s and some of these inner SKU´s can look like 1 unit, which in some cases are really hard to figure out. One of these inner SKU´s can contain 12 units, so the picker can in some cases, interpret 1 unit as the 12 unit inner SKU and there we have the problem. Then right of a sudden we are 12 unit of the entire PO short, which will not be known until a picker goes to the shelf and about to pick and figures out, that there is nothing to pick, tells the WHM about it, who have to now spend time to figure out where the error is made.
And the somehow lucky costumer who gets the 11 more unit of a product won´t in most cases not tell us, that he or she received far too many products than intended.

R: This seem to be one bigger problem?

P1: yes, this is the far most biggest problem., ehm I don't have any other challenges I can think of yet…, I think that is for me.

P2: Oh, I have one problem, but it is in the latter of the process. It is the communication with the dispatch, as I experience quite often, that they ask me for a confirmation of one order, that I have picked, while I am picking another. Which disrupts and delays my picking of the order I am picking at the moment they ask.

R: Ok I see,

## Appendix J - RFID Put away process

| Step count | Clerk actions | Time (minutes) |
|---|---|---|
| 1 | Confirm POs with RFID reader | 1 |
| 2 | Go to dispatch | 0,3 |
| 3 | Print to collect tags | 0,1 |
| 4 | Write data on tags | 6 |
| 5 | Go to receiving with tags | 0,3 |
| 6 | Tag items in PO | 5 |
| 7 | Go to pallet area | 0,3 |
| 8 | Pick pallets | 0,1 |
| 9 | Drag pallets to receiving | 1,5 |
| 10 | Confirm Put Away action on r-reader | 0,1 |
| 11 | Divide PO(s) into pallets | 1 |
| 12 | Pick trolley | 0,1 |
| 13 | Load pallet on trolley | 0,2 |
| 14 | Confirm location on r-reader | 0,2 |
| 15 | Drags pallet to suggested location/ an empty location | 1 |
| 16 | Put PO on location | 1 |
| | **When all PA actions are done** | |
| 17 | Go to receiving | 0,3 |
| 18 | Consolidate remains to pallet(s) | 2 |
| 19 | Collect tag(s) for making parent tag(s) | 0,1 |
| 20 | Write all item tags from the remains to the pallet tag | 1 |
| 21 | Move consolidated pallet(s) to replenishment | 1,5 |

Total time = 20,7(2,4x5 PO´s) = 32,7 minutes

## Appendix K – RFID OP inventory process

| Step count | Picker action | Times (minutes) |
|---|---|---|
| 1 | Connect r-glow to WMS | 2 |
| 2 | Claim picking order on r-glow display | 1 |
| 2 | Pickup trolley | 0,2 |
| 3 | Go to location for pick | 1 |
| 5 | Grab requested amount of items | 1,5 |
| 6 | Confirm order picked on r-glow display | 0,1 |
| 7 | Return to dispatch | 0,5 |
| 8 | Unload order to dispatch | 1 |
| 9 | Finish order in r-glow | 0,1 |

Total time: 5,3 x 8 + **(2 minutes) = 44,5 minutes**