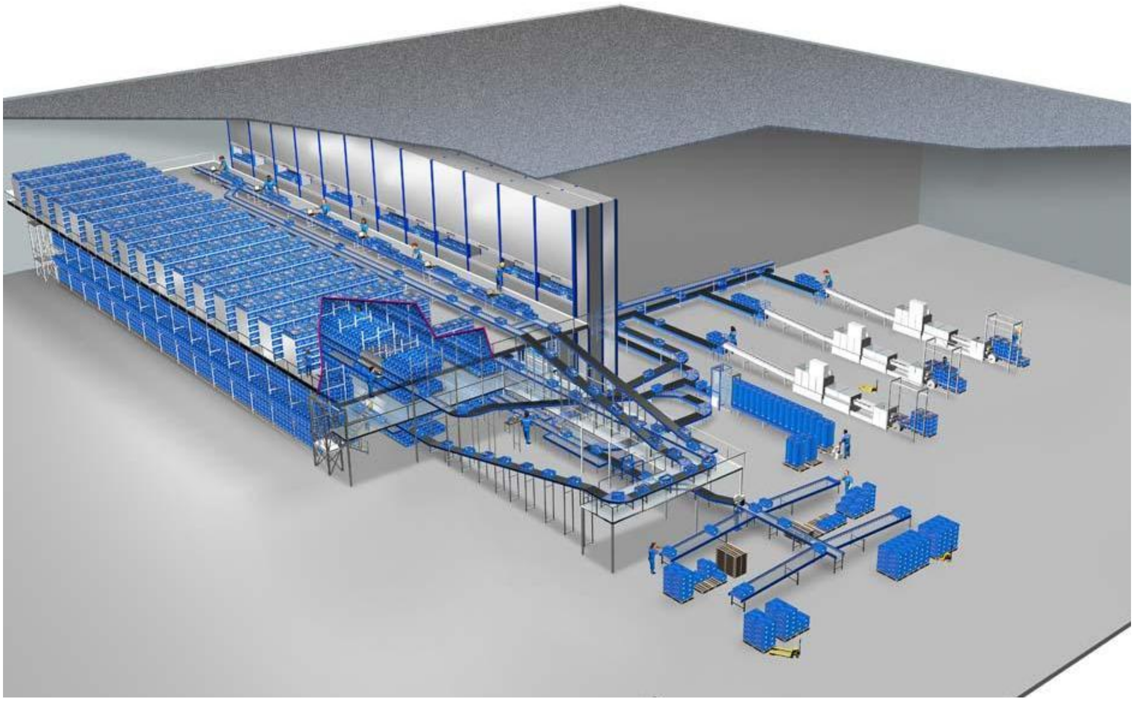
Thesis report

Thesis:

Zone software feasibility study



Graduate:	Bart Jansen
Student number:	1562581
Course:	TEET-VABACHEX-12
Date:	4-1-2013

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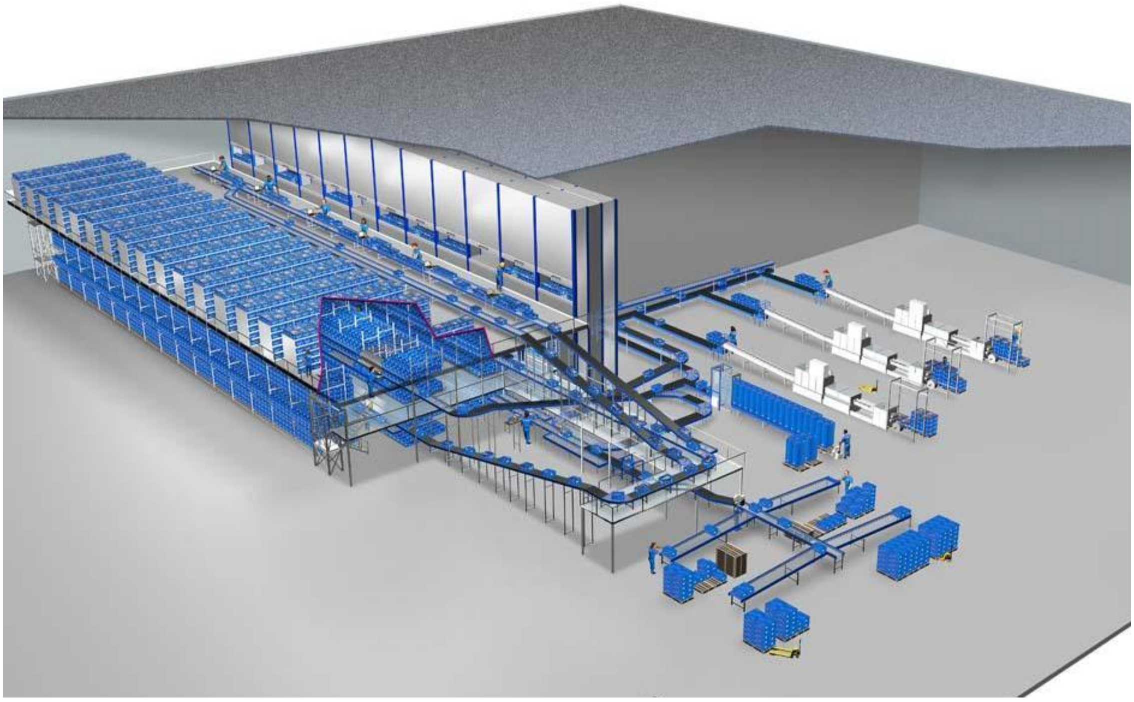

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Date:	04-01-2013
Location:	Vanderlandelaan 2 in Veghel
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Revision index

Version	Date	Name	Chapters	Definition
1.0	15-10-2012	Bart Jansen	All	Document set-up
1.1	12-12-2012	Bart Jansen	All	Adjustments made after feedback from supervisors and coaches.

Preface

During the last year of my study at the University of Applied Sciences in Utrecht a thesis has to be done. My study is a Bachelor of Engineering in Industrial Automation. The thesis has to be done at a company. The company where my thesis is done, is Vanderlande Industries. After a visit, which was organised by the students' association "Vereniging Industriële Automatisering", I got interested in this company. That is why I contacted Vanderlande Industries. This way I got in touch with Piet Goossens. After making an appointment with Piet the project for the thesis was discussed. This project seemed very interesting to me, so I started working on it.

When starting to work on the project, it appeared to have a different content as was first expected. It also appeared to me it would be a hard project to explain to a third person, because the content of the project is really Vanderlande specific. A lot of foreknowledge is required to get a good image of the project. However, all together I am convinced this thesis report is clear and gives a good description of the project and the results gained from it. Working on the project was very interesting, very instructive and very enjoyable to do.

There are some people I would like to thank.

I like to thank Albert Moes, as my thesis supervisor he commented my reports, guided me through the period of the thesis and advised me in structuring the project.

I like to thank Piet Goossens, as company supervisor and client he overlooked the bigger picture of the project. He showed how important it was to work in a structured way and that, based on priorities, a major project can be done within a certain amount of time.

I like to thank Fred Hermes, Joep Bax and Karel Hendriks. Their knowledge of the engineering at Vanderlande helped me during the project. Their comments and suggestions helped to complete the project the way it has been done.

My thanks go to Fred Weeda for his years as Academic Advisor. His guidance through the study was greatly appreciated. His love for the profession really inspired me, his loss during the study had a great impact on me.

Lastly, I like to thank my family for their support during the study and the thesis.

Veghel, 04 January 2013,

Bart Jansen

Summary

The project included a feasibility study to improve the engineering process which is used at Vanderlande Industries' Distribution department. The way of improving the process has been discussed for years, however all knowledge which was present was never properly documented, this was one of the targets for the project. The project had to be performed by an independent person, because this person would have no prejudices.

The main goal of the project was to determine, whether or not to apply zone software in the Distribution department and if so, in what way it should be applied. During the project it became clear that it would be beneficial to apply zone software in the Distribution department. So the next thing to be done was determining what way it should be applied. Vanderlande Industries' Baggage department already applied zone software, so it was helpful to study their way of approaching zones. The Distribution department had their own idea for approaching zones. Both approaches were thoroughly studied and weighed against each other to determine which would be best.

One possible standard zone was chosen as a test case, to see what a zone would look like with one, or the other approach. The zone chosen as a test case was the SDI sort zone. When the approaches were applied to this zone, it appeared that for the software and electrical hardware both approaches could be applied without any major difficulties. For the mechanical aspects of the zone it would be a challenge to apply the same principle as is used in the Baggage department. The Distribution approach would deliver fewer challenges for the mechanical aspects of the zone. However applying the Distribution approach would bring other negative aspects, for example: The wish of the client to have the same principle used for zones Vanderlande wide.

The mechanical aspects are mainly related to the fact, that there is a lot of different equipment available in the Distribution department, much more than in the Baggage department. However the Baggage approach comes out best, under certain circumstances.

To show the differences in the zone software, the SDI sort zone software was designed and realised. Once standardised using the Distribution approach and once standardised using the Baggage approach. The software blocks were tested on a Vanderlande test system called the DOTM-loop. As was expected, both of the approaches delivered a functional and working zone block.

The final recommendation is: The Baggage approach should be used to define the zones for the Distribution department. The feasibility study shows this will be beneficial.

Index

Prologue

This thesis project is performed to study if it is feasible to improve the engineering process. The project from start-up till closing down is shown in this thesis report, which is divided into nine chapters, see Figure 1. Each chapter describes the following:

1. Company
The first chapter shows the company where the thesis project is performed. It describes their core-business, the organisation of the company and the department where the thesis project took place.

2. Organisation & work method
The second chapter shows the organisation of the thesis project. The persons who played a role in the thesis project and what role they performed. Also the work method which is used in the project is explained.

3. Project
The third chapter shows the content of the project. The background of the project, the problem statement, the goal, the improvements, the requirements and preconditions and the end products are described here.

4. Analysis
The fourth chapter shows an analysis of the project. An overview shows why the project is of importance to the company. An analysis is done and several choices are made. The last part of this chapter is the method that is used to test the improvements.

5. Design
The fifth chapter shows the design that is made based on the choices made in chapter four.

6. Realisation
The sixth chapter shows the way the project is realised. A global phasing of the project is shown and what was realised per phase.

7. End product
The seventh chapter shows the results of the project. An evaluation of the results is done and a recommendation to the client is given in this chapter.

8. Process & planning
The eighth chapter shows the project approach and the planning that is used for the project is shown. A time and cost calculation is shown and the project is evaluated.

9. Reflection
In the reflection the competences are shown based on the activities done during the project.

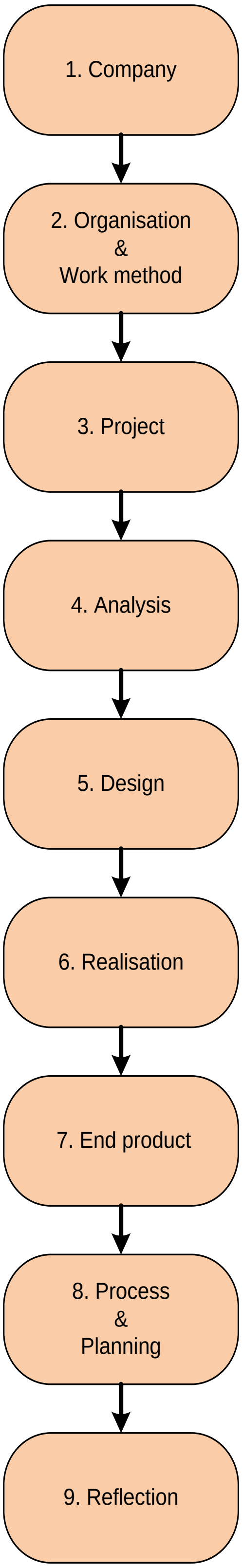


Figure 1. Thesis report structure.

1 Vanderlande Industries

1.1 Core-business

The core-business of Vanderlande Industries is designing and delivering transport systems. Their transport organisation is divided in three main departments: Baggage Handling, Post & Parcel and Distribution. The department, where the thesis project is done, is the Engineering Unit Distribution (EUD).

1.2 Organisation

Global

The head office of Vanderlande Industries is located in Veghel. The office in Veghel is the biggest location of Vanderlande Industries, approximately 1100 people work there. Vanderlande Industries has a global headcount of approximately 2100 people.

Engineering Unit Distribution

The department's headcount is approximately 50 people. The department's organisation is shown in Figure 2.

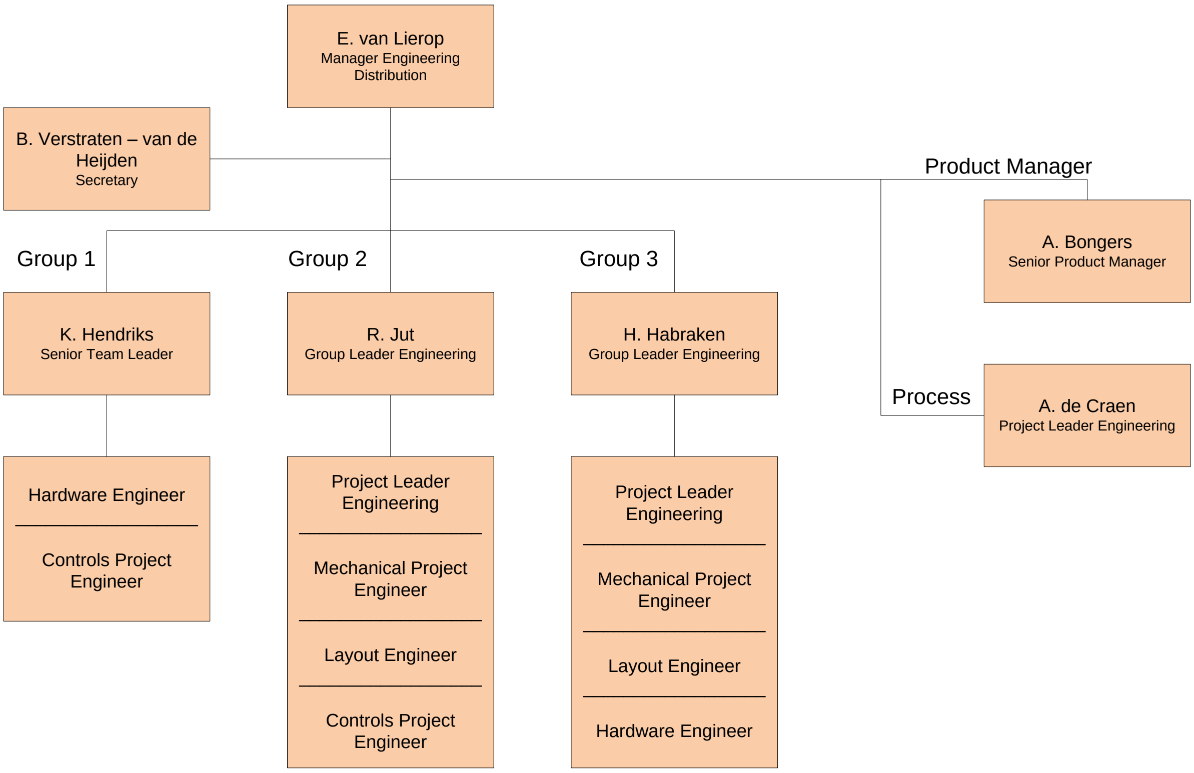


Figure 2. Organisation chart EUD.

Within this department the project was done for Group 1, which is under supervision of Karel Hendriks. Piet Goossens was the company supervisor for the project, due to a change in the organisation during the thesis he is not shown in the organisation chart. His function change was of no harm for the project.

The thesis project was not a common project for this department. Common projects exist of the entire engineering of distribution systems. The thesis project included a part of the PLC engineering process of the department.

2 Organisation and work method

2.1 Organisation

The next persons were directly involved in the project:

- Piet Goossens.
- Albert Moes.
- Fred Hermes.
- Joep Bax.
- Bart Jansen.

The role of these persons is shown in Figure 3. From the organisation chart it will be clear what the hierarchy of the persons involved in the project was.

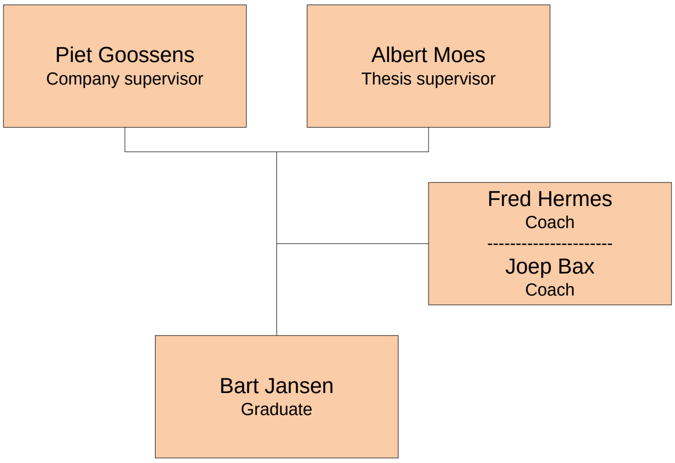


Figure 3. Organisation chart for the project.

Piet Goossens was the client and also the company supervisor. Two coaches were assigned by the company. Fred Hermes and Joep Bax were of great importance for the project. They supported the project in a more technical substantial way.

Albert Moes was assigned as thesis supervisor from the University of Applied Sciences. He kept an eye on the progress of the project. He judged and gave feedback on the reports given to him. He also judged the professional way of working, together with Piet Goossens.

The project was done by Bart Jansen. His personal data is shown in Table 1.

Name	Student number	Phone number	E-mail address
Bart Jansen	1562581	+31 6 40 61 15 76	1562581@student.hu.nl

Table 1. Bart Jansen's personal data.

2.2 Work method

Because the project was done by one person, this person did all the tasks that needed to be done. A planning was made for the project, see paragraph 8.2. This planning was reviewed weekly to secure the progress of the project.

The thesis period was as follows:

- 21 weeks or 105 days.
- Five-day working week.
- Eight-hour working day.

A weekly meeting was planned with the company supervisor. The progress of the project was reviewed during these meetings. These meetings were planned every Friday.

The thesis supervisor visited the company once. This visit was to get a better impression of the project and the company itself. The visit took place on September 12th 2012. The thesis supervisor was contacted weekly via e-mail. This way the progress of the project was reported.

In case of absence, because of illness or private reasons, it was reported to the next persons:

1. The company supervisor.
2. The department's secretary.
3. The thesis supervisor.
4. The agency Randstad.

3 Project

The coming chapter describes the content of the project. It will also become clearer why this project is of importance to Vanderlande.

3.1 Background

Vanderlande has a standard way for arranging their transport systems. What this arranging looks like, is explained in the following paragraphs.

3.1.1 Hardware

3.1.1.1 Sections

Conveyors are parts of a transport system that are seen repeatedly. Different sorts of conveyors are:

1. Roller conveyor (Figure 4a).
2. Single belt conveyor (Figure 4b).
3. Multi belt conveyor (Figure 4c).

Figure 4a. Roller conveyor.

Figure 4b. Single belt conveyor.

Figure 4c. Multi belt conveyor.

Recurring parts of transport systems, such as these, are called “sections” at Vanderlande. Equipment is installed around the conveyor for it to function. This equipment is called “objects” at Vanderlande. One section can contain one or more objects.

An example of a section is shown in Figure 5. This section is a single belt conveyor. The objects in this section are:

1. Photo Electrical Cell (PEC).
2. Pulse Position Indicator (PPI)[1].
3. Local Motor Starter (LMS).
4. Motor.

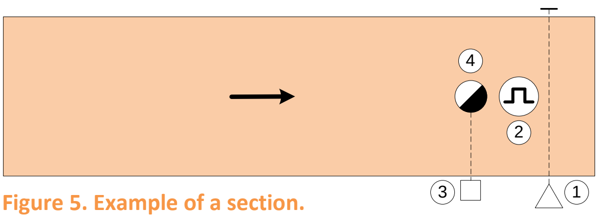


Figure 5. Example of a section.

The PEC is used to mark the end of the conveyor. The PPI is used to track a product on the conveyor. The LMS and the motor are used to move the conveyor. Depending on the type of the LMS the speed can be controlled.

This section is frequently used in Vanderlande transport systems. That is why this section is made a standard section. Standard sections are used to simplify the engineering process of Vanderlande transport systems.

[1] A PPI is also known as a wheel encoder.

3.1.1.2 Zones

A zone fulfils one function of a transport system. This is done by connecting one or more sections. An example of a zone is shown in Figure 6.

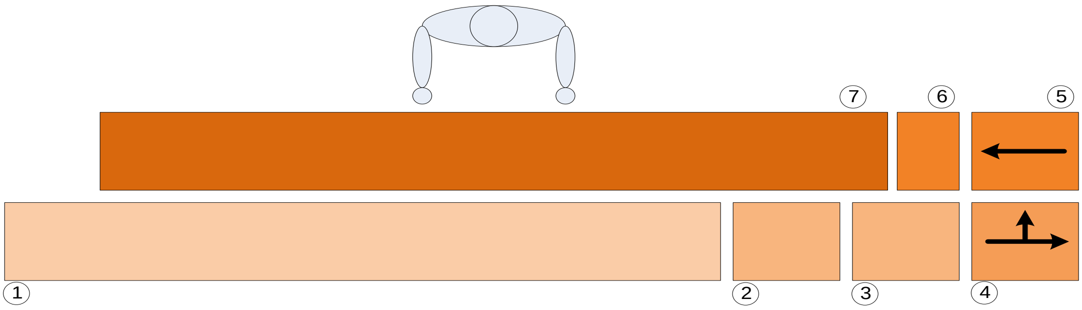


Figure 6. Example of a zone.

The zone in the example has as function to pick an order. An order is collected in a box, a tray or a tote, to make it easier to transport through the system. The sections in this zone are:

1. Transport conveyor.
2. Accumulating conveyor.
3. Accumulating conveyor.
4. Transfer conveyor.
5. Transfer conveyor.
6. Driven roller conveyor.
7. Undriven roller conveyor.

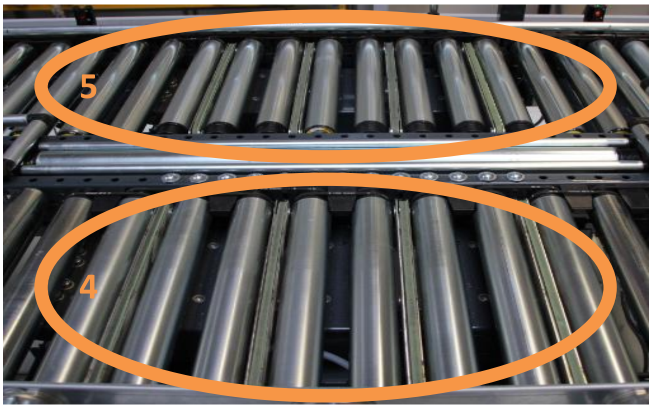


Figure 7. Example of transfer conveyors.

The task each section fulfils is:

- The transport conveyor (1) transports the tote through the zone.
- The accumulating conveyors (2 and 3) control the stream of totes through the zone.
- The transfer conveyor (4) feeds the tote into the zone (to conveyor 5), or sends the tote to a next zone. An example of a transfer conveyor is shown in Figure 7, the transfer conveyor being the belts that lie in between the roller conveyor. The transfer conveyor pops-up when necessary.
- The transfer conveyor (5) receives a tote and sends it in the direction of the operator.
- The driven roller conveyor (6) speeds up the tote so it is able to roll out over the undriven roller conveyor (7).
- The undriven roller conveyor (7) is the workstation of the operator. The operator does his task and manually places the tote back on the transport conveyor (1).

3.1.1.3 Layers above

Thus far three layers have been explained. The zones which consist of sections. The sections which consist of objects. The objects which are the lowest layer. The layers above are arranged in a similar way in a Vanderlande transport system. One or more zones form an area. One or more areas form a system. One or more systems form a plant. One or more plants form an enterprise. Enterprise being the highest layer.

The complete hierarchical structure is shown in Figure 8. For comparison the physical hierarchy of S88 is shown next to it. This project focused on the zones and sections.

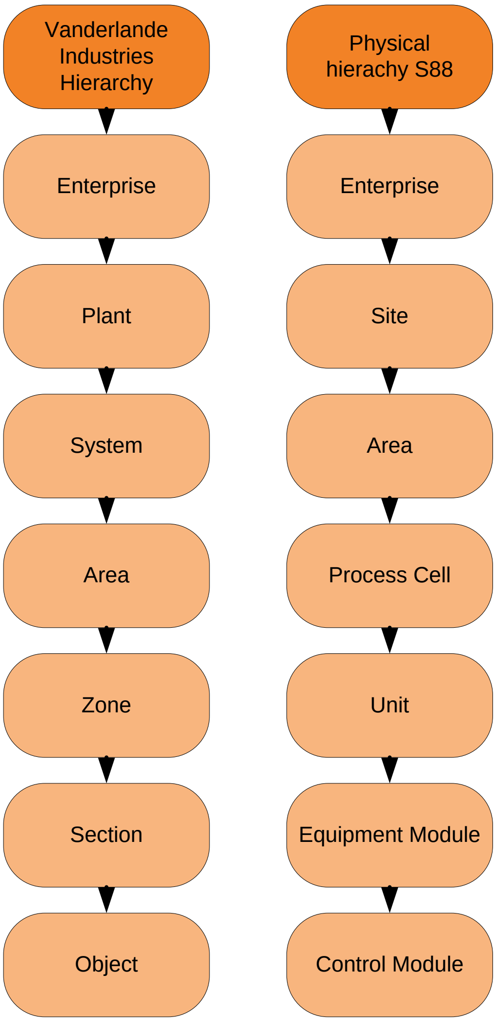


Figure 8. Vanderlande Industries vs. S88.

3.1.2 Software

3.1.2.1 PLC engineering

The structure of the PLC software is similar to the structure of the hardware. Each object has a software block to control it. As described earlier in this chapter, standard sections are defined for the hardware. These standard sections got their own PLC software block, which consists of object software blocks. One PLC section block controls one conveyor. To connect these blocks a Generator Suite was developed at Vanderlande. More about the PLC software is described in paragraph 5.1.

3.1.2.2 Generator Suite

The Generator Suite is a tool which Vanderlande uses to automatically connect PLC section blocks. The connection that is made, is to let the PLC section blocks communicate with each other and to a higher situated layer.

The Generator Suite collects data from an Excel sheet. With this data the Generator Suite can connect the PLC section blocks. However, only about 85% of these connections are made correctly. The other 15% of the connections are missing code. This code has to be added manually. A lot of engineering time was needed to make these adjustments. This was something that the EUD wanted to improve. More about the Generator Suite is described in Appendix iv. Generator Suite. More about the connections is described in paragraph 4.1.5.1.

3.2 Problem statement

When using the Generator Suite in combination with the PLC section blocks, 15% of the connections are missing code. Vanderlande came up with a possible improvement to reduce this problem. This improvement had to be developed and a feasibility study had to be done. The possible improvement was: Expanding the Generator Suite and making PLC zone blocks for a standard zone programming. This made the problem statement: Is it beneficial to add standard zone programming to the current section programming?

3.3 Goal

The goal of this project is to perform a feasibility study on standard zone programming. Based on this study a recommendation is done to the company. The recommendation tells if this is a good improvement to reduce the problem. To support the recommendation a prototype of the software is developed. The software being the PLC zone blocks and the adjusted Generator Suite.

3.4 Project

To clarify the project, the differences between the ways of programming are explained. The explanation is based on Figure 9. The zone which is described here is a possible standard software zone*. The zone exists of seven sections. If this is programmed using section programming, this means 1x7 sections are programmed. If another similar zone is used in the system, the seven sections are programmed again. Each time it is programmed, extra code has to be written to restore the connections. If standard zone programming is used, this code does not have to be written, because this code is already written in the zone block. More about the differences in programming is shown in paragraph 4.1.5.1.

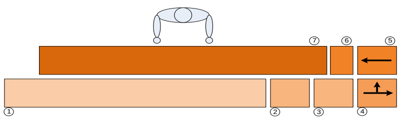


Figure 9. Zone example.

*Why is this zone a possible standard software zone? It was not determined for all zones what the standard software zone was in the Distribution department. There were too many possibilities for standard software zones. Studying all zones would take too much time. That is why only one zone was studied and standardised during this project. This zone is described in paragraph 4.2.2.

3.5 Product description

To clarify the project, some studies have been done. These have been determined with the company supervisor:

- Study the pros and cons of zones compared to sections:
  This study was done for mechanics, hardware and software. This study was done outside of the Distribution department. Especially in the Baggage department, because the zone concept is already implemented there.
- Based on this study a definition was made for a zone in the Distribution department:
  This is a mechanical, hardware and software definition for this zone.
- Study by which Vanderlande standard the zone will be programmed:
  At the moment there is a transition between the existing standard (Standard Software Structure, SSS), to the new standard (Equipment Control Software, ECS). Further information on these standards is given in paragraph 4.1.2.

The results of these studies come back in the end products given at the end of the project.

3.6 Requirements and preconditions

3.6.1 Requirements

- Keep the difference in the definition of "zone" minimal (see paragraph 4.2.3).
- Use either the SSS or the ECS standard (see paragraph 4.1.2).
- PLC software should be written in STL (see paragraph 4.1.3).
- Provide a well-founded study report.
- Documentation has to be clear and written in Oxford English.

3.6.2 Preconditions

- Limited budget for the project.
- Project has to be completed in week 4 of the year 2013.

3.7 End products

Provide the following end products:

- Software prototype.
- Software Design Specification.
- Study report (including conclusion and recommendation).
- Thesis report (includes all products mentioned above).

4 Analysis

This chapter shows what knowledge is applicable to this project and the feasibility study that is done regarding the zone software. The last part of the chapter shows what method is used to test the results gained from the feasibility study.

4.1 Overview

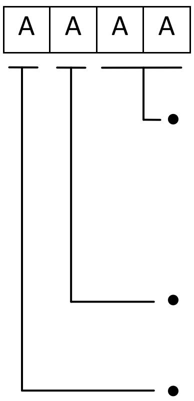
This was not a complete new project. The concept of using standard zones has already been thought of within the Distribution department. Documentation on zones already existed but was lacking depth in the software, for this documentation see [18] Distribution intranet page. The documents describe a zone in mechanical and hardware properties. The zones had to be checked on the possibility for a software zone. But as mentioned before, not all software zones could be standardised in this project.

4.1.1 Numbering

Within Vanderlande a standard is made for numbering their transport systems. The numbering standard is the same for the hardware and the software of a system. The standard describes an Area.Zone.Section.Element (A.Z.S.E) numbering. Each number describes the following:

Area number

The area number consist of four digits, each digit describes the following:



- The last two digits are used to group zones which fulfil the same function, for example “order picking”. They can either be numbered sequentially (1-2-3-etc.), or numbered by “grouping” areas (10, 20, 30, etc.). For example Area 11 and 12 have similar zones. This can be used for larger projects.
- The second digit is used for the Area class, for example the conveyor system or the mechanical parts (for example fencing).
- The first digit is default 0, but can be used project specific, for example if the system is across different buildings.

Zone number

The zone number consists of two digits. These digits refer to a function in the system, for example order picking. The zones can be numbered in various ways:

- Sequentially (1-2-3-etc.).
- Numbered by “grouping” zones (10, 20, 30, etc.). For example Zone 11 and 12 fulfil a similar function.
- Customer numbering in the building, for example according to the numbering of the dock doors.

Section number

The section number consists of two digits. The digits refer to the sections, for example conveyors or weighing scales. Sections can be numbered in various ways:

- Sequentially (1-2-3-etc.).
- Numbered by “grouping” sections (10, 20, 30, etc.). For example Section 11 and 12 are a similar section.

Element number

The element number is used to give each object in a section a number, for example a PEC. These numbers are for internal use only, so these numbers are not displayed on Vanderlande systems.

Exception

To summarise, the digits displayed on a Vanderlande system are, 4 Area digits, 2 Zone digits and 2 Section digits, also shown as AAAA.ZZ.SS. If the first digit is a “0” it is not displayed. For example: 0001.01.01. is displayed as 1.1.1.

Example

See Figure 10 for an example of the numbering.

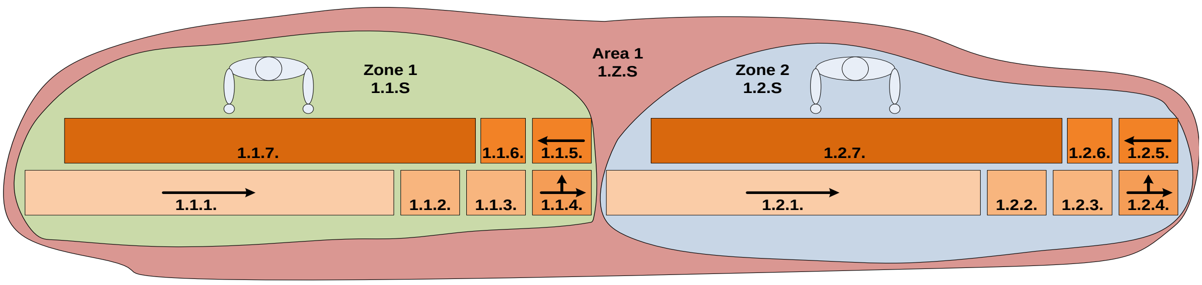


Figure 10. Example numbering.

In the example there is one area, which consists of two zones. Each zone consists of seven sections. The numbering is as follows:

1. The area is numbered “1”.
2. The zone which appears first is numbered “1”. Each zone that follows is sequentially numbered.
3. In the zone the seven sections are numbered in a similar way the zones are numbered. The first section is numbered “1”, each section that follows is sequentially numbered.

4.1.2 Vanderlande Industries standards

Because this paragraph describes confidential information for the company it is shown in Appendix ii. Vanderlande Industries standards.

The standard chosen for this project is the ECS standard, based on the following arguments:

- It is the newer upcoming standard.
- The Distribution department has to switch to the ECS standard anyway.
- Helpful in the development of the ECS standard.

4.1.3 Programming language

The PLC software at Vanderlande is usually written in STL. There is no reason not to do so for this project. That is why, for this project the PLC software is written in STL.

4.1.4 Gamp-model

The software development was done by means of the GAMP-model, also known as V-model, see Figure 11. This means everything that is realised in the System Build, has to be verified if it is realised according to the documentation. This is done by means of a Factory Acceptance Test (FAT). The FAT is split up into two parts. The Operational Qualification and the Performance Qualification. The Installation Qualification is not included in the FAT, because this check is made implicitly, for example: Is the software written in STL? This check is done while writing the software.

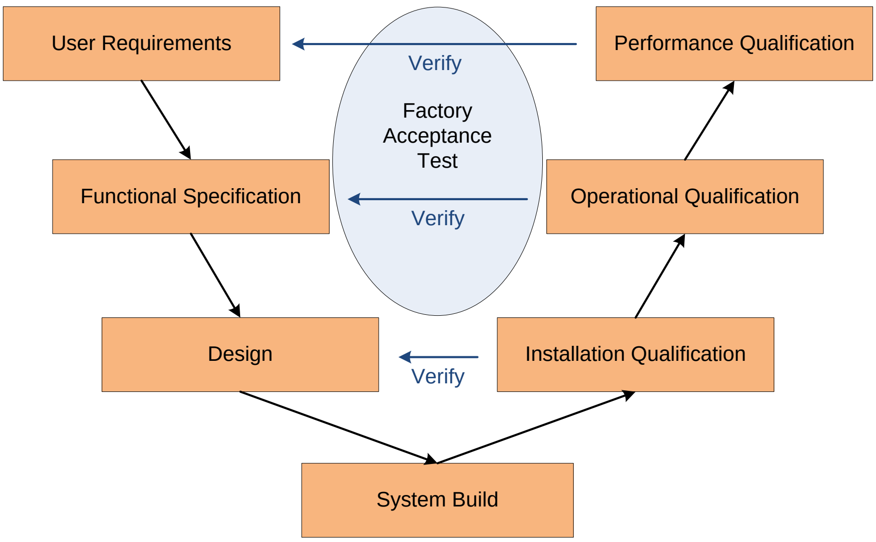


Figure 11. Gamp-model

Operational qualification

The operational qualification covers the functioning of the PLC zone block. The operational qualification shows if the zone blocks functions the way it was specified. More about the operational qualification is shown in paragraph 4.3.

Performance qualification

The performance qualification covers the functioning of the Generator Suite. Main thing that this test shows is if the Generator Suite can deal with the PLC zone block that is made. More about the performance qualification is shown in paragraph 4.3.

4.1.5 Zones vs. sections

Before getting to the zones, a step back is taken. What is the advantage of using standard zones instead of standard sections? A baggage example is used to explain this, see Figure 12.

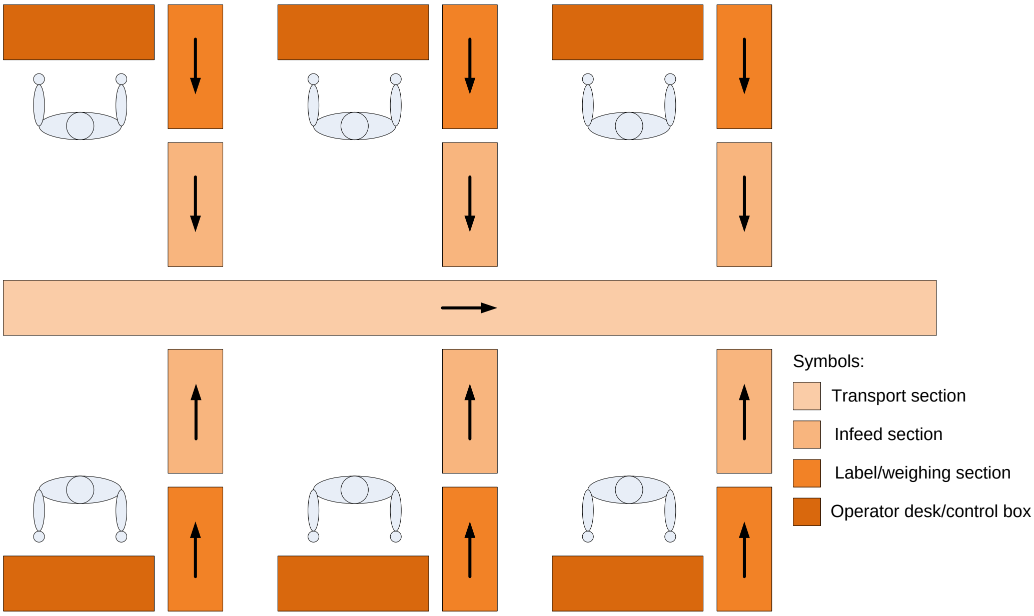


Figure 12. Sections.

In the example the check-in of an airport is shown. The baggage is loaded onto the label/weighing section. After the operator gives a signal via a control box, the baggage item is transported to the infeed section, which automatically merges it onto the transport section. This functionality is programmed six times.

A function is added to the transport section, so it is able to generate windows, where the baggage items can be inducted. A window is the space an infeed section can reserve to induct the baggage item. To clarify this, see Figure 13. Each infeed can only reserve one window.

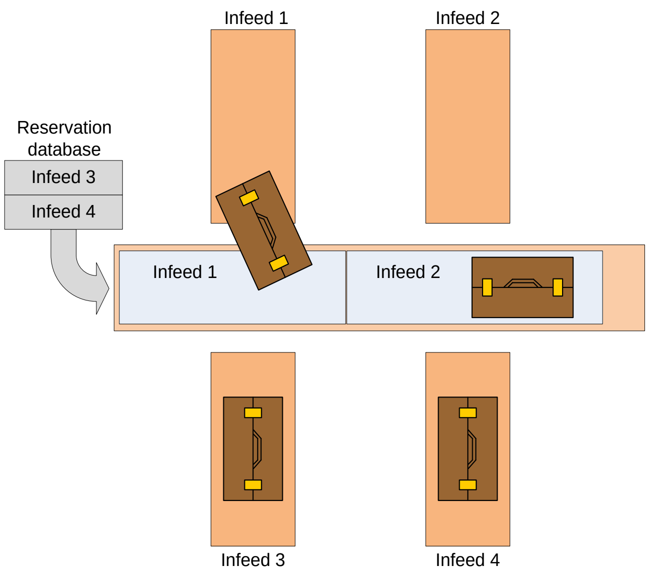


Figure 13. Reserving/generating windows.

In Figure 12 the individual standard sections are shown. As can be seen, a combination of sections is recurring. Making standard zones will result into Figure 14.

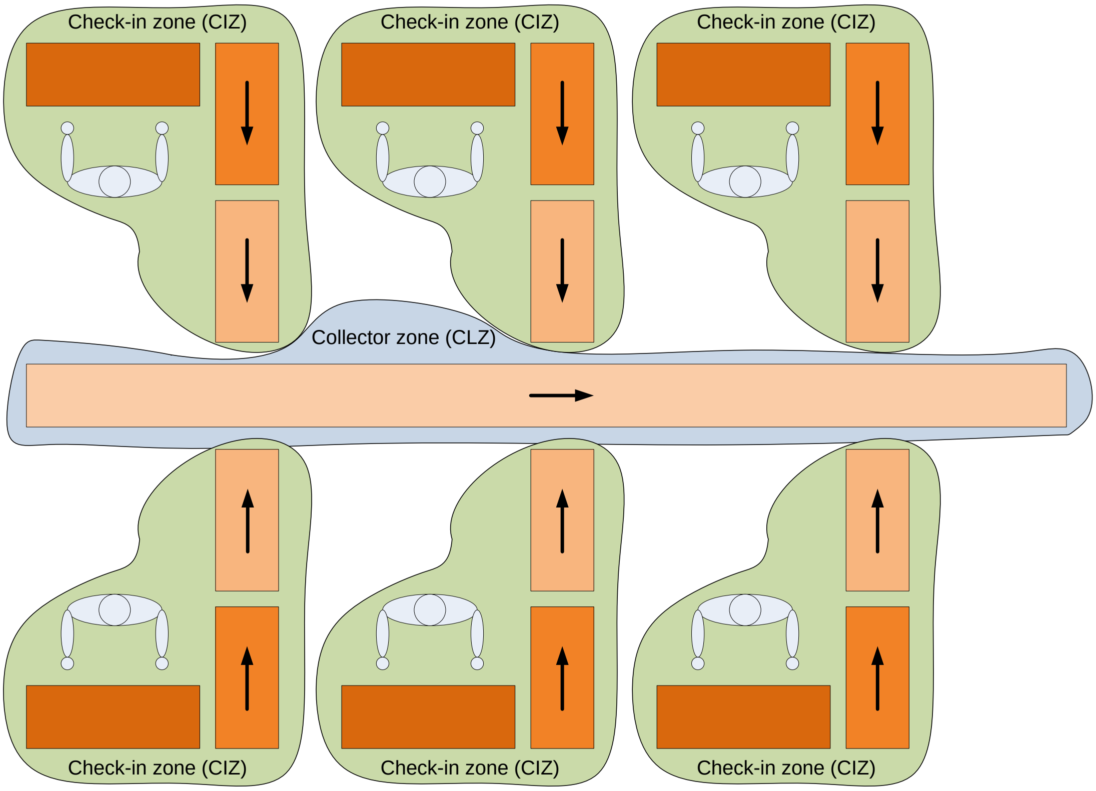


Figure 14. Zones.

The Baggage department proved that the advantages of standard zones are:

1. Drawing a layout is faster:
   When drawing a layout of a system, instead of dragging each individual section into the drawing, the complete zone can be dragged in.
2. Testing is easier:
   When testing the functionality, only one zone has to be tested, if it works functionally it can be said that similar zones will function as well. The hardware testing only has to be done for all zones. Comparing it to separate sections, each section has to be tested individually on functionality.
3. Programming is faster:
   When programming using the standard zones, the blocks can be called and parameterised. When using the standard sections, the blocks have to be parameterised and then connected to each other. If necessary, extra code has to be written which would have been written already in a zone block. See paragraph 4.1.5.1.
4. Numbering is clearer:
   When using sections, the numbering would be 1, 2, 3 till 19. Because zones are used an extra number can be added to group the conveyors, for example: 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 etc. See paragraph 4.1.1.

The disadvantages of standard zones are:

1. Less flexibility in the system:

Because a zone consists of a standard amount of conveyors, with a determined position, the system is less flexible for project specials.

2. Can result into a lot of different standard zones:
   Because Distribution systems are available in a lot of different varieties, special PLC zone blocks are needed for each variety, see paragraph 4.2.3.

4.1.5.1 Case study

To show the differences in programming a case study was done. For this case study, two projects as-built by Vanderlande were used. From these projects, one similar area was studied, the difference was: In one project standard section programming was used, in the other project standard zone programming was used. The studied area is shown in Figure 15. The conveyors in this area are:

1. Sort conveyor.
2. Vertibelt, see Figure 16.
3. Outfeed conveyor.

The study will show the amount of code that has been added manually for the area to function.

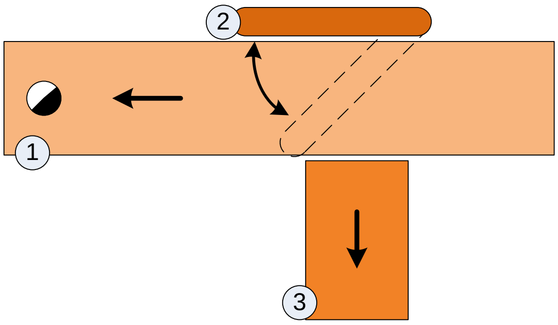


Figure 15. Case study area.

First, the code as generated by the Generator Suite was studied, next the code which was implemented in the project was studied. The result from this is shown in Table 2.

	Section	Zone
Generated code	71.8%	92.9%
Added code	28.2%	7.1%

Table 2. Result case study.

Figure 16. Vertibelt.

Using the section programming, the Generator Suite generates about 72% of the code. This means for this specific area 28% of the code was missing and had to be added manually. Comparing this to the zone programming, about 93% of the code was generated by the Generator Suite, so only 7% of the code was missing and had to be added manually. This is a great improvement compared to the section programming.

The exact code from the study is confidential information for the company, it is shown in Appendix iii. Difference zone- and section programming.

4.1.5.2 Conclusion

A wish the client had, was to have the same principle used Vanderlande wide, this means applying zone software in the Distribution department. Taking the wish of the client into account, the result of the case study, and weighing the advantages and disadvantages against each other the next conclusion was drawn:

- The use of zone software should be applied in the Distribution department.

4.2 Analysis

4.2.1 Choosing a zone

To have a clearer target for the study a specific zone was chosen, which would be used as a test case, because there would be focus for one zone only. In cooperation with the company supervisor and one of the coaches, the next zones were discussed as an option for this test case:

1. Storage zone.
2. Zone Picking System zone (ZPS zone).
3. Merge zone.
4. Distrisorter sort zone (SDI sort zone).
5. Outfeed zone.

Each zone and its pros and cons are explained individually.

Storage zone

A storage zone is a zone where products can be stored. In Figure 17 an example is shown. The dashed line is to show the separation between the two cranes. There are two parts for this zone, the crane and racking, and the in- and outfeed conveyors to and from the crane. Vanderlande does not control the crane of the storage zone, this is done by a subsidiary of Vanderlande called Beewen.

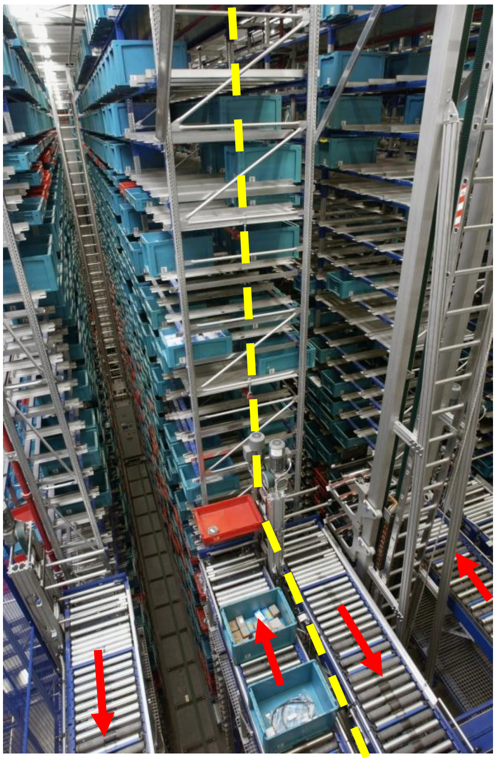


Figure 17. Storage zone.

Vanderlande controls the in- and outfeed conveyors of the crane, see Figure 18. The sections marked in orange are controlled by Vanderlande. The blue sections are controlled by Beewen. The storage zone for this project:

Pro	Con
Learning goal	Costs (hardware)

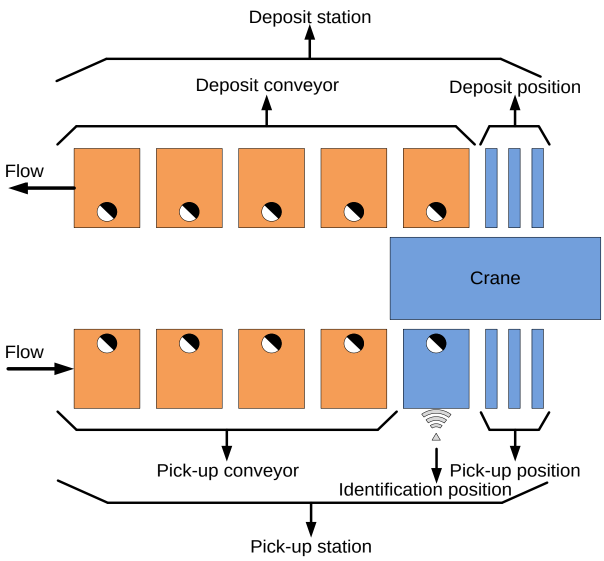


Figure 18. Vanderlande/Beewen control.

Zone Picking System zone

The ZPS zone is a zone as described earlier in the document (paragraph 3.1.1.2), see Figure 19. The function it fulfils is the picking of an order. The ZPS zone for this project:

Pro	Con
Learning goal	Frequently used
Practical (time wise)	Complex

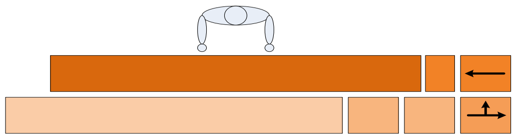


Figure 19. ZPS zone.

Merge zone

A merge zone is a zone where products merge onto one conveyor, see Figure 20. This kind of zone is already applied at the Baggage department. The merge zone for this project:

Pro	Con
Practical (time wise)	Learning goal
Frequently used	
Complex	

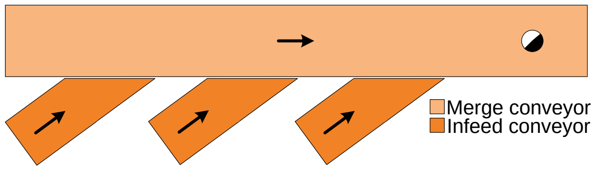


Figure 20. Merge zone.

Distrisorter sort zone

An SDI sort zone is the opposite of a merge zone. Instead of products merging on a conveyor, the products will be sorted of the conveyor into separate outfeeds, see Figure 21. Because the Distrisorter (SDI) is a unique product for the Distribution department, this zone block does not exist in the Baggage department. The SDI sort zone for this project:

Pro	Con
Learning goal	
Practical (time wise)	
Frequently used	
Complex	

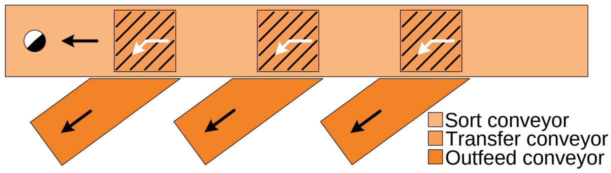


Figure 21. Sort zone.

Outfeed zone

There are different kinds of outfeed zones. The outfeed zone can be a consolidation shipping zone which would be connected to sort zone. The outfeed zone for this project:

Pro	Con
	Learning goal

Conclusion

For choosing the zone, the above mentioned pros and cons are put in a table and weighed against each other, see Table 3. If a "–" appears in the requirements the zone is crossed out.

	Storage zone	ZPS zone	Merge zone	SDI sort zone	Outfeed zone
Requirement					
- Learning goal	+	++	-	+	-
- Practical (time)		+	+	+	
- Costs (HW)	-	?	?	?	
Nice to have					
- Frequently used		-	+	+	
- Complex	n	-	+	+	
- Section related		n	n	n	
Choice		Second		First	

Table 3. Choosing a zone.

Symbol meaning:

++ = Very good   + = Good   n = Neutral

-- = Very bad   - = Bad   ? = Unknown

As shown in Table 3, the SDI sort zone comes out as the best fit for this project. A second choice for a zone would be the ZPS zone, however no time was left to study the second zone. From now on, the focus of the project lies on the SDI sort zone.

Remark: The focus lies only on the SDI with the divert actions, there is also an induct, an accumulation and a cross variant of the SDI. These are shown in [1] Multiveyor (zone) application guide. and are not covered in this feasibility study.

4.2.2 SDI sort zone

A picture of an SDI is shown in Figure 22. The SDI being the multi belt conveyor including the transfer conveyors, the rollers which are mounted in between and can pop-up when necessary.

Figure 22. SDI picture.

There are several different SDI's, in Figure 22 an SDI with a 90 deg double sided transfer is shown. There also is a 90 deg single sided transfer and a 45 deg single sided transfer. The different kinds are shown in Figure 23.

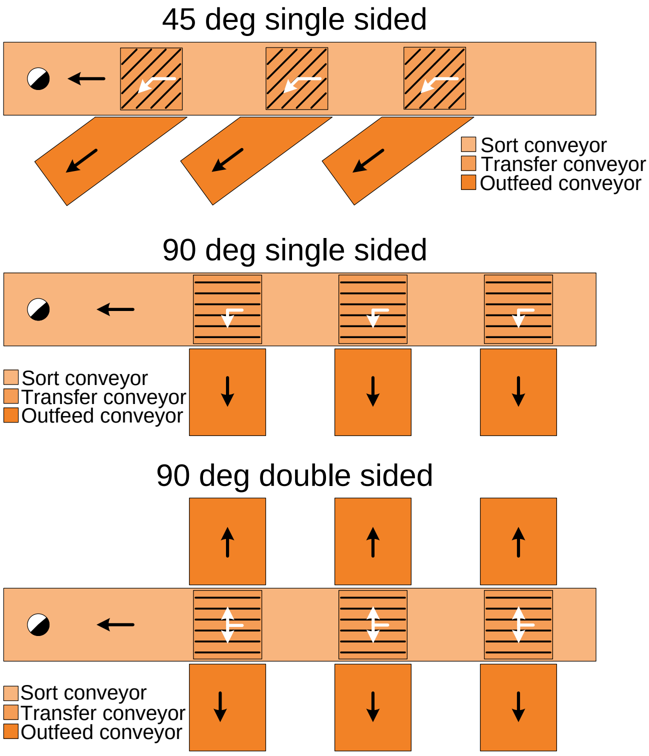


Figure 23. Different kinds of SDI's.

The single sided SDI's can be either left aligned (as shown in Figure 23), as well as right aligned. No different PLC zone block is needed to realise this. However there is a Motor Driven (MD) or a Power Take Off (PTO) variant of the 90 deg single sided transfer. A different PLC zone block is needed to control these. A 45 deg transfer is always a PTO.

The PTO driven variant is mechanically connected to the motor drive of the sort conveyor. This means, the more transfers are mounted in the sort conveyor, the greater the load gets for the motor drive. If an MD variant is used, the motor drive of the sort conveyor is not subjected to the amount of transfers that are mounted in the sort conveyor.

The main sort conveyor is always a multi belt conveyor for an SDI. The 45 deg transfers always consist of pop-up wheels, see Figure 24. The 90 deg transfers always consist of pop-up rollers, as shown in Figure 25. Making the SDI into a PLC zone block required some efforts. How this was done, is shown in paragraph 4.2.3.

Figure 24. Wheel transfer.

Figure 25. Roller transfer.

4.2.3 Zone definition

There are two approaches to define an SDI sort zone. The Distribution approach and the Baggage approach. Both will be illustrated, see Figure 26a and Figure 26b.

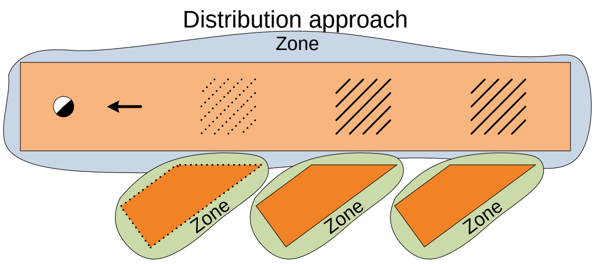


Figure 26a. Distribution approach.

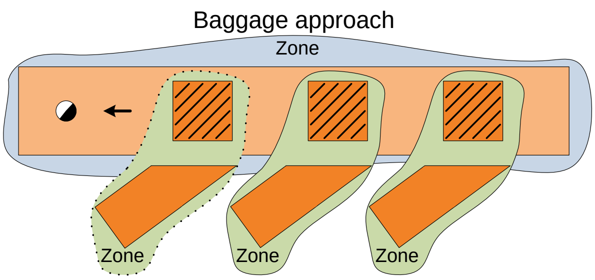


Figure 26b. Baggage approach.

The differences are visible from the figures. The functional, mechanical and costs differences of the approaches are described in the following paragraphs.

4.2.3.1 Distribution approach

The Distribution department's idea is to split zones in a mechanical way. This would create one sort zone. This zone includes the control of the main sort conveyor (the multi belt shown in Figure 24 and Figure 25) and the control of the diverts (the transfer conveyors shown in Figure 24 and Figure 25).

Explanation of the Distribution approach:

1. Logical numbering in the sections, see Figure 27:

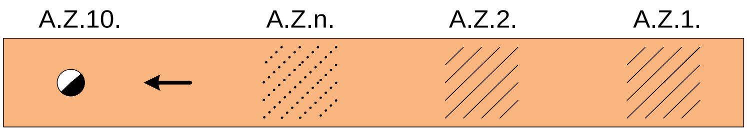


Figure 27. Logical numbering in sections.

   The advantage of logical numbering in the sections is, it can easily be seen which diverts belong to which SDI.

2. Divert is mounted "in" the sort conveyor:
   Because the divert is mechanically joint to the sort conveyor, there are some restrictions that have to be taken into account, see paragraph 4.2.3.3.
3. The divert and the outfeed are in a separate zone, see Figure 28:

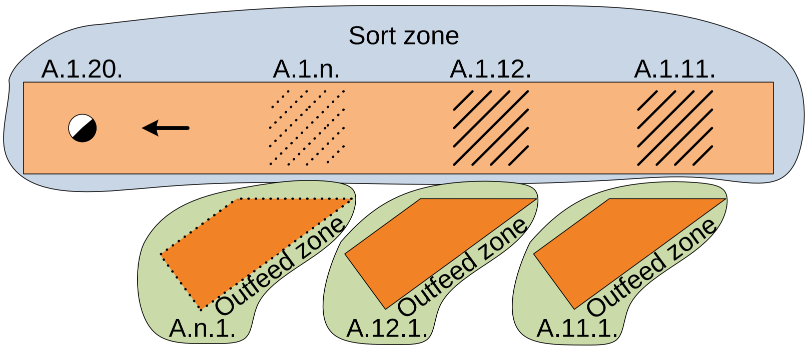


Figure 28. Separate divert and outfeed.

   The outfeed and the divert in a separate zone can result into a PLC separation. This means the outfeed can be controlled by a different PLC then the divert.

A disadvantage of this approach is, that it will result in a lot of different standard zones, in Table 4 an example is given.

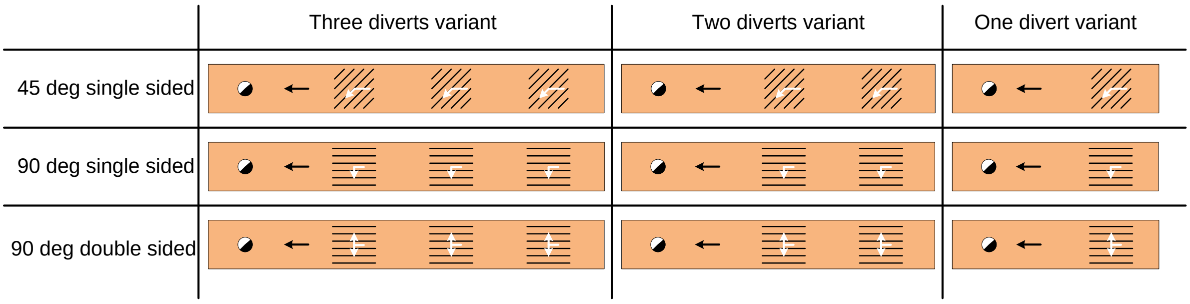


Table 4. Example different standard zones.

These are just some examples of the zones, there are many more. The amount of variants can easily pass fifty different kinds. The induct, accumulation and cross variants have not even been taken into account with this amount.

4.2.3.2 Baggage approach

The Baggage department uses the principle of splitting the zones by function. That is why they would split the SDI sort zone into two separate zones. One sort zone with the function of sorting and one divert zone with the function of diverting the product off the sort zone.

Explanation of the Baggage approach:

1. Logical numbering in the zones, see Figure 29:

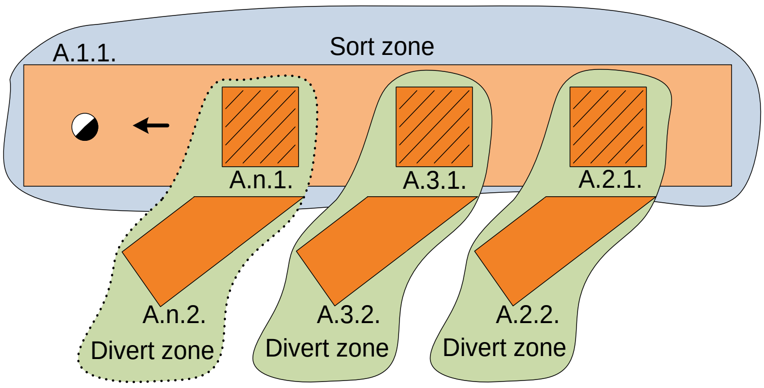


Figure 29. Logical numbering in the zones.

   Advantage of numbering like this is, the High Level Control (HLC) can always monitor on the same section number. This is because the section number for each zone is set, so for each zone it is the same.

2. The divert is mounted “on” the conveyor:
   In Baggage systems the divert is physically separated from the sort zone. This means the amount of diverts is not a restriction for the sort zone. An example of a Baggage divert is shown in Figure 30.
3. No PLC separation:
   There is no PLC separation between the divert and the outfeed. They are controlled by the same PLC.

Figure 30. Vertibelt mounted on the side.

The Baggage approach will also lead to a lot of different standard zones. An example is given in Figure 31a and Figure 31b.

As shown there is one sort zone in the Baggage approach, this one zone is sufficient to cover all the main sort conveyors.

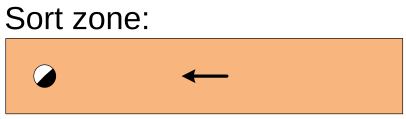


Figure 31a. Baggage approach sort zone.

There are three divert zones shown, but there are many more. There are three types of transfers, but each transfer gets an outfeed conveyor. There are many types of outfeeds, for example:

1. Gravity Roller (GR).
2. Gravity Roller Junction (GRJ).
3. Chute (CH).
4. Live Roller Junction (LRJ).
5. Live Roller Bridge (LRB).
6. Multi Belt Junction (BJM).
7. Accumulating Roller conveyor Drum driven (ARD).

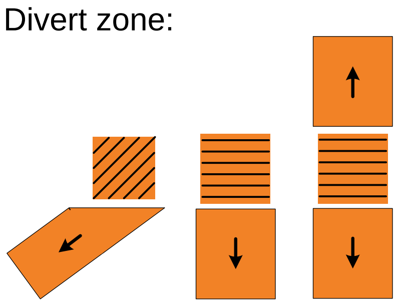


Figure 31b. Baggage approach divert zones.

Each divert needs a special zone block to control. Many zone blocks will require a lot of maintenance to the software library. The number of different kinds of zones will be about the same as with the Distribution approach.

4.2.3.3 Mechanical aspects

The mechanical aspects for the Distribution department differ from the aspects as known for the Baggage department. Both are described below.

Distribution aspects

When looking at the Distribution department's Material Handling Systems (MHS), and especially at the SDI's, there are some things that can be pointed out:

1. Sort conveyor width:
   There are a lot of different sort conveyor widths available, see Table 5.
2. Product size:
   The products can differ in size and material, see Table 6 and [15] PDB Product Handling Units.
3. Divert size:
   The width of the divert is related to the sort conveyor width.
4. Position transfer and sort conveyor related:
   The position of the sort conveyor and the transfer in it is related.
5. Position transfer and outfeed are related:
   The sort conveyor/transfer speed determines the position of the outfeed.
6. Lot of different sections:
   Comparing MHS against each other a lot of different sections are found.
7. Mechanically related:
   Some objects in a MHS are mechanically related, for example PTO diverts in the sort conveyor.

Conveyor width [mm]	Max. nr. of belts
420 till 1020	2 belts
420 and 520	3 belts
520 till 1020	4 belts
620	5 belts
720	6 belts
820	7 belts
920	8 belts
1020	9 belts

Table 5. Multi belt widths.

	45 deg transfer		**90 deg transfer**	
	Min.	Max.	Min.	Max.
Length	170mm	1000mm	170mm	1000mm
Width	140mm*	700mm	250mm	900mm (twin belt) 1000mm (multi belt)
Height	20mm	900mm	20mm	900mm
Weight	3N	500N	1N	500N
	Weight < 10N or > 400N: Vmax = 100m/min Weight between 10 and 400N: Vmax = 120m/min			
Remark	*Product width between 140 and 170mm only possible if: 1. Products are aligned; 2. Product is uniform loaded (weight evenly spread).			

Table 6. Product dimensions.

Baggage aspects

When looking at Baggage Handling Systems (BHS), and especially at the sorters, there are some things that can be pointed out:

1. Sort conveyor width:
   The sort conveyor width for all BHS is standard 1200mm.
2. Product size:
   The products have a standard maximum, minimum and average size. As according to the International Air Transport Association (IATA) standard, see Table 7 and [16] PDB Product baggage requirements.
3. Divert size:
   The dimensions of the diverts are standard.
4. Position divert and outfeed related:
   The position of divert and outfeed are related and are fixed.
5. Same sections:
   Comparing BHS against each other, many of the same sections can be found.
6. Mechanically separated:
   The objects in BHS are all stand alone units, for example no PTO objects can be found in a BHS.

Normal baggage	Minimum	Maximum	Average
Length	300mm	1000mm	700mm
Width	300mm	750mm	500mm
Height	50mm	650mm	400mm
Weight	20N	500N	180N

Table 7. Baggage dimensions.

Distribution vs. Baggage

When comparing the Distribution aspects to the Baggage aspects, it can be said they completely differ from each other. Some points of attention have to be taken into account when trying to apply an approach on a Distribution system. These points of attention are:

1. Different SDI widths:
   The wider the sort conveyor gets, the wider the transfer has to be. Each sort conveyor width has a transfer width which should be applied. It may not be possible to have a too small transfer fitted into a wider sort conveyor.
2. Transfer position:
   The position of the transfers in the sort conveyor is restricted, for example the motor drive is usually at the end of the sort conveyor. A transfer cannot be placed on top of a motor drive, so it may not be possible to place a transfer in this position.
3. Sort conveyor and transfer alignment:
   The sort conveyor and transfer should be aligned, it may not be possible to have the transfer and sort conveyor misaligned, see Figure 32. If these are misaligned, the connections that need to be made in the software will be missing and have to be added manually.
4. Transfer and outfeed alignment:
   The transfer and outfeed should be aligned, it may not be possible to have the transfer and outfeed misaligned, see Figure 33. If the alignment is not correct the products cannot be sorted into the right outfeed, this could result into a blockage. This alignment is depending on the speed of the sort conveyor.
5. Number of transfers:
   In case of PTO transfers there is a restricted amount that may be mounted in the sort conveyor due to the belt pull[2].

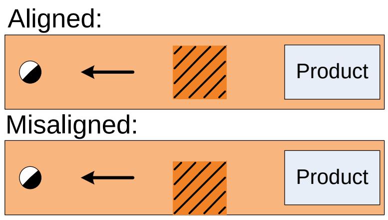


Figure 32. Sort conveyor and transfer alignment.

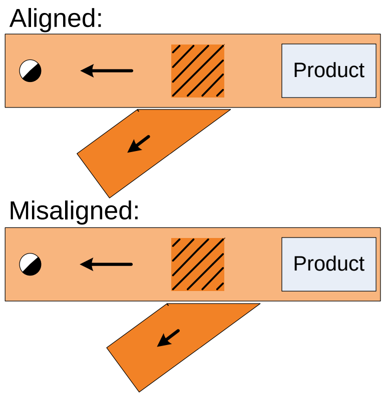


Figure 33. Transfer and output alignment.

Baggage approach

When the Baggage approach is used to define the zones in a Distribution system, the following restrictions can be found:

1. The sort conveyor and transfer width are not directly related.
2. The transfer position cannot be restricted in the zone layer of the drawing software;
3. The sort conveyor and transfer cannot be aligned within the zone layer of the drawing software.
4. The transfer and outfeed can be aligned within the zone layer of the drawing software.
5. The number of transfers in case of PTO cannot be restricted on the zone layer of the drawing software.

[2] The belt pull: Is the pulling force that is applied to the belt due to conveyor length/amount of PTO.

The risk of making a mistake, when a system is mechanically specified, is expected to be high. This is mainly, because most of the restrictions cannot be made into the zone layer of the drawing software. Another way has to be found for applying these restrictions.

The alignment of the transfer and outfeed can be made in the zone layer, however a point of attention is, it is depending on the speed of the sort conveyor and has to be checked if it is correct.

Distribution approach

When the Distribution approach is used to define the zones in a Distribution system, while taking the earlier mentioned points of attention into account, the following restrictions can be found:

1. The sort conveyor and transfer width are directly related.
2. The transfer position can be restricted in the zone layer of the drawing software.
3. The sort conveyor and transfer can be aligned within the zone layer of the drawing software.
4. The transfer and outfeed cannot be aligned within the zone layer of the drawing software.
5. The number of transfers in case of PTO can be restricted on the zone layer of the drawing software.

As can be seen most of the restrictions can be applied within the zone layer of the drawing software. The only restriction that cannot be made into the zone layer is the transfer and outfeed alignment. This alignment can either be judged case by case or a zone boundary crossing rule has to be applied.

Conclusion

It is expected that the risk of making a mistake is higher when using the Baggage approach instead of the Distribution approach. Because in the Baggage approach less restrictions can be made on the zone layer. To apply these restrictions, zone boundary crossing rules have to be used. For example by adding an extra area layer in the drawing software.

Another big point of attention is the alignment of the transfer and the outfeed. This alignment is depending on the speed of the sort conveyor. Using the Baggage approach, this factor has to be taken into account in the zone layer of the drawing software and checked if the alignment is correct. Using the Distribution approach the alignment can be judged case by case. This seems favourable for the Distribution approach.

The five earlier mentioned points of attention are the biggest issue for the Distribution department to choose one approach or the other. It is desirable to apply as many restrictions as possible in the zone layer of the drawing software.

Specifying a system may take some more time, but if it is the first time right it will eventually save time and costs.

4.2.3.4 Cost aspect

To get an idea what the costs per approach are, an example of both follows:

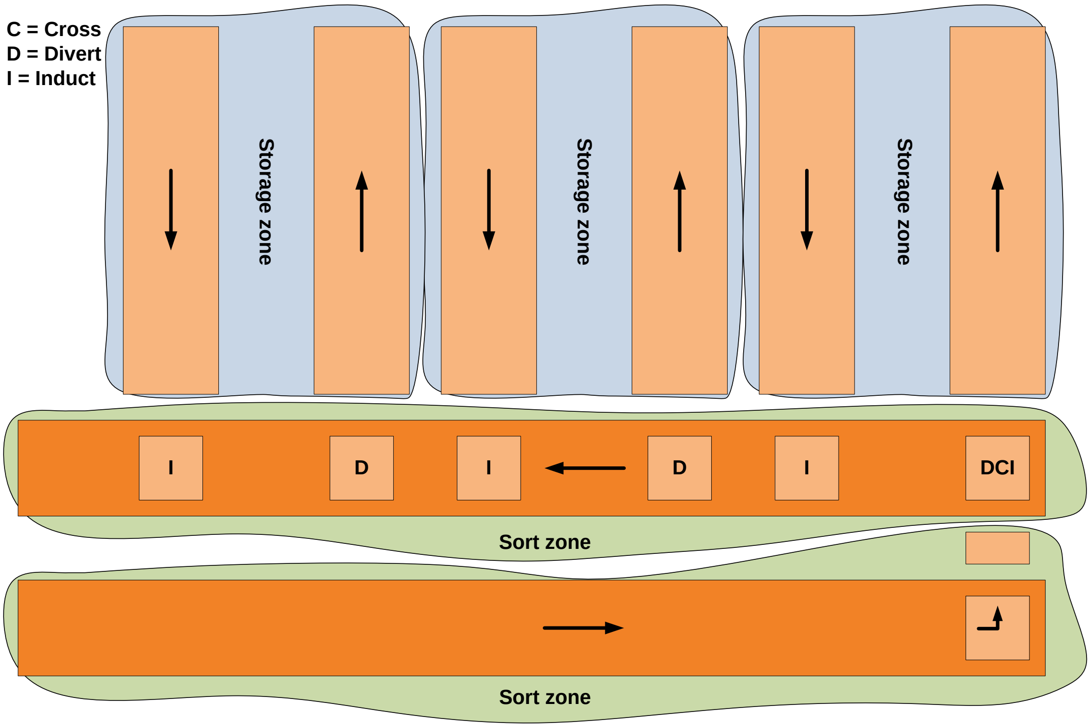


Figure 34. Example Distribution approach.

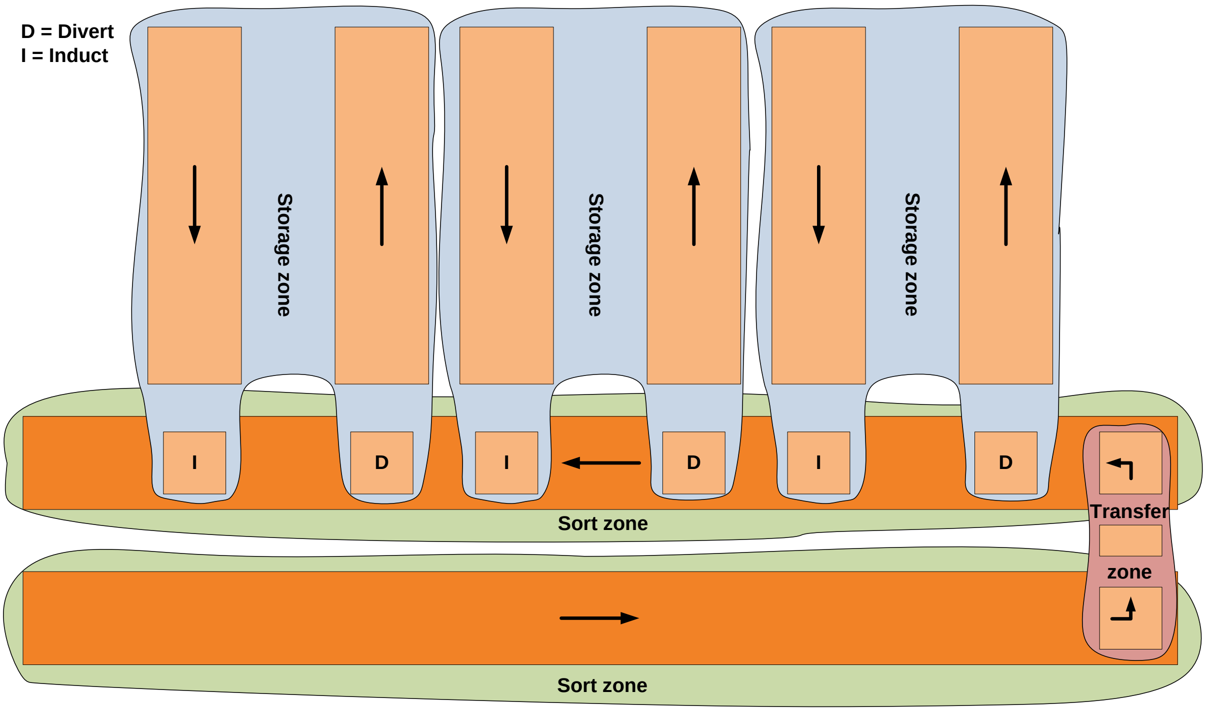


Figure 35. Example Baggage approach.

In Figure 34 the Distribution approach is shown, in Figure 35 the Baggage approach is shown. Both examples show a storage warehouse. Although a sort zone is applied in the example, it is a combination with a merge zone. The windows, which are emptied due to diverting actions to a storage zone, can be used to induct the products coming out of that storage zone.

As can be seen the Distribution approach gives more functionality to one section, while the Baggage approach applies more sections with less functionalities. Using one approach or the other will result into:

- Distribution:
  Extra engineering time is needed, because some of the software features, like starting and stopping of the divert and outfeed are not connected to each other. This has to be programmed manually. However costs can be saved on materials. Compared to the Baggage approach, less ASI-modules are needed and one transfer is saved. The functionality of the saved transfer is added to another transfer.
- Baggage:
  Less engineering time is needed because the software features are already correct. However extra material costs are made. Another advantage of using this approach, is the testing/commissioning time is lower. Because it can be said that if one zone functionally works properly, the rest will function in a similar way because it is the same zone block. Using the Distribution approach each section has to be tested individually to check if they function in a right way after the adjustments.

Another advantage of less engineering time is, systems have less turnaround time. This means it will take less time to complete a system. This way a more competitive position can be reached on the market.

PLC Engineering hours (D):	40		Distribution costs:		Baggage costs:	
PLC Engineering hours (B):	30					
Commisioning hours (D):	12					
Commisioning hours (B):	5					
Estimated costs per hour:	€ 50,00		€ 2.600,00		€ 1.750,00	
ASI-modules (D):	5					
ASI-modules (B):	6					
Estimated costs per module:	€ 150,00		€ 750,00		€ 900,00	
Amount of transfers (D):	7					
Amount of transfers (B):	8					
Estimated costs per transfer:	€ 1.000,00		€ 7.000,00	+	€ 8.000,00	+
		Total:	€ 10.350,00		€ 10.650,00	

Table 8. Costs.

Table 8 shows an indication of the costs per approach. However this is just a rough estimation to get an idea of the costs. Only the costs where the two approaches differ have been taken into account.

As shown in the table, the costs from the two approaches don't differ substantially.

4.2.3.5 Vanderlande wide same principle

For the client it was desirable to have the same principle used Vanderlande wide. This means applying the Baggage approach. This approach is used in the Baggage department and also used by the loop sorter team. This is a special team to apply loop sorters, they apply them for the Baggage department, the Post & Parcel department and for the Distribution department. These loop sorters are controlled by a Flow System Controller (FSC).

Loop sorter

What is a loop sorter? Vanderlande knows two kinds of sorters, loop sorters and line sorters. The SDI is a line sorter, this means one line that sorts products left, right or both, see Figure 36. A loop sorter, on the other hand, is not a straight line, but as can be deduced from the name is a loop, see Figure 37.

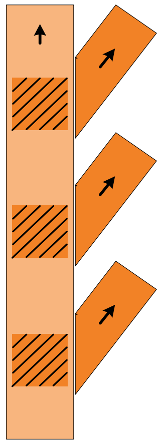


Figure 36. Line sorter.

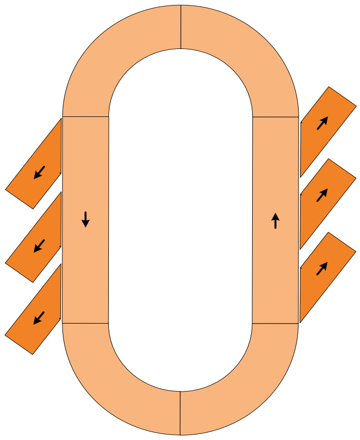


Figure 37. Loop sorter.

Consideration

When a loop sorter that is controlled by an FSC, is implied in a Distribution system, the Baggage approach of defining a zone is used for the loop sorter. If the Distribution department would use the Distribution approach for defining its zones, this would mean that in one system, two different approaches are used for defining zones.

4.2.3.6 Choosing an approach

It is expected that using the Baggage approach will be more time efficient than using the Distribution approach. Mainly the commissioning hours can be saved, because more of the same zones are used in one system. Some engineering hours can be saved by using more of the same zones in one system.

The costs are expected to be almost equal for both approaches.

The mechanical risk factor of the zones is expected to be higher in the Baggage approach. This is because in the zone layer of the drawing software, fewer restrictions can be made. These restrictions can be made in the zone layer when using the Distribution approach.

Both zone approaches are multidisciplinary useful, this means both approaches can be used for each discipline on the Distribution department.

A wish the client had, was to have the definition of a zone not differ too much from the other departments. This would mean using the Baggage approach. Reason for this is that engineers from the different departments can be exchanged easily when this would be necessary.

Both approaches will lead to a lot of different standard zones. This is because of all the different kinds of sections that can appear in a Distribution system.

As proof of the pudding, one system as-built by the Distribution department was compared. The system was once standardised using the Distribution approach and once standardised using the Baggage approach. This was done to show how many different zones appear in a system when using one or the other approach. The result of this was, that using the Baggage approach, less different zones appeared in the project.

	Distribution approach	Baggage approach
Requirement		
- Time saving	n	+
- Costs	n	n
- Mechanical risk factor	+	n
- Multidisciplinary useful	+	+
Wish/Nice to have		
- Vanderlande wide principle	--	++
- Number of standard blocks	-	-
- Less different zones per project	-	+
Choice	Second	First

Table 9. Choosing an approach.

Symbol meaning:

++ = Very good	+ = Good	n = Neutral
-- = Very bad	- = Bad	? = Unknown

Weighing the approaches against each other, results into Table 9. As can be seen the Baggage approach comes out best for defining a zone. However, this is under certain circumstances, these are:

- The Distribution's sales department has to sell more of the same standard zones instead of the specials in a project. Doing so, more engineering time can be saved and the application of standard zone software is useful.
- It has to be acceptable for the department to redesign their drawing library, the hours spent on the current library will then partly be lost.
- Everyone in the department must be willing to change the way of working.

If these circumstances are acceptable for the Distribution department, they should apply the Baggage approach for defining their zones.

4.3 Method

The operational qualification will be done by testing the function of the zone block. In Veghel an Innovation Centre (IC) is located. In the IC different sorts of systems are displayed. These systems are all capable of running. The function of the zone block can be tested on one of these systems called the DOTM loop, see Figure 38. Three items are marked in the drawing, these are formed to standard zones and programmed. The design of the zones is described in chapter 5.

The performance qualification is a test for implementing the PLC zone block. This is performed by using the Generator Suite to check if it can make use of the PLC zone block. For the Generator Suite to be able to do this, the zone block will be added to the Generator Suite library.

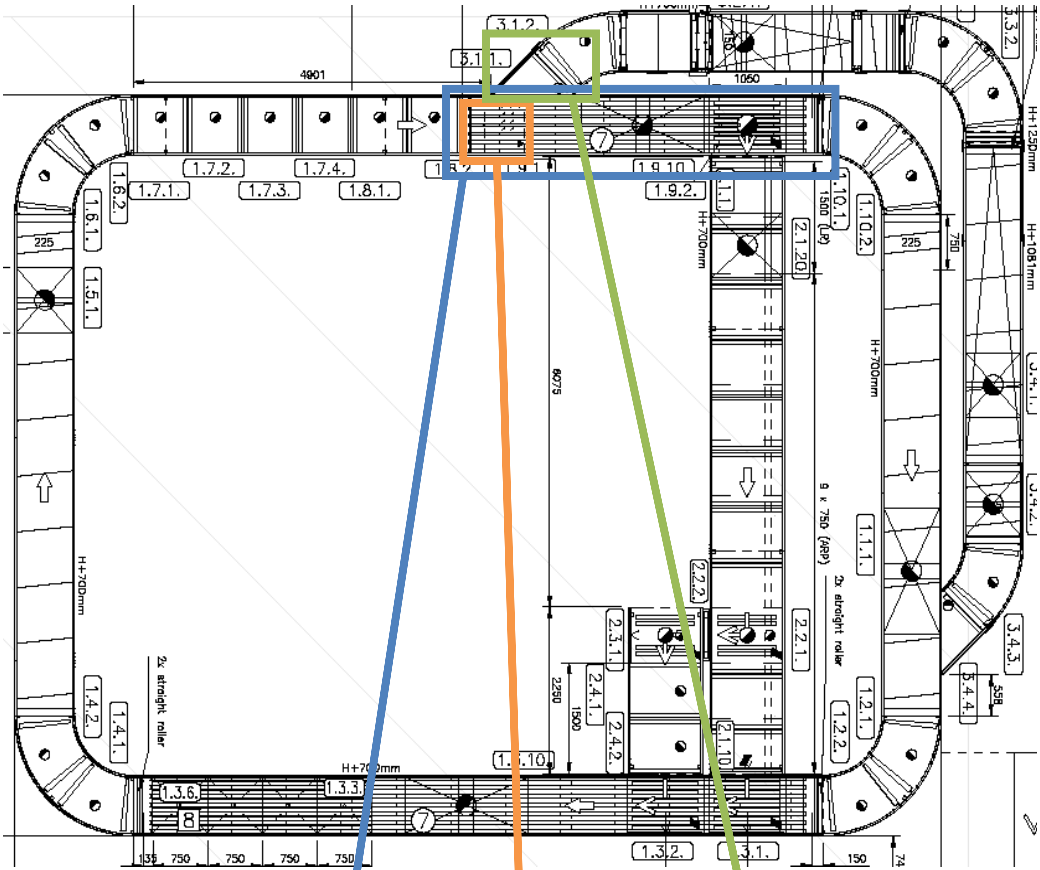
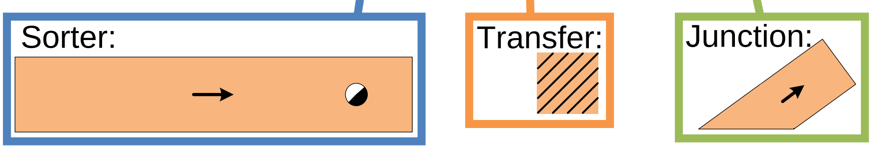


Figure 38. Layout DOTM loop.



5 Design

5.1 PLC design

Not all variants of the SDI zone could be made, because there were too many for this project. Therefore the zones as they appear in the DOTM loop were designed. Once defined using the Distribution approach and once defined using the Baggage approach. This means four zone blocks were designed.

5.1.1 Distribution design

The Distribution design is a somewhat more flexible zone. This will become clear when seeing the Baggage design.

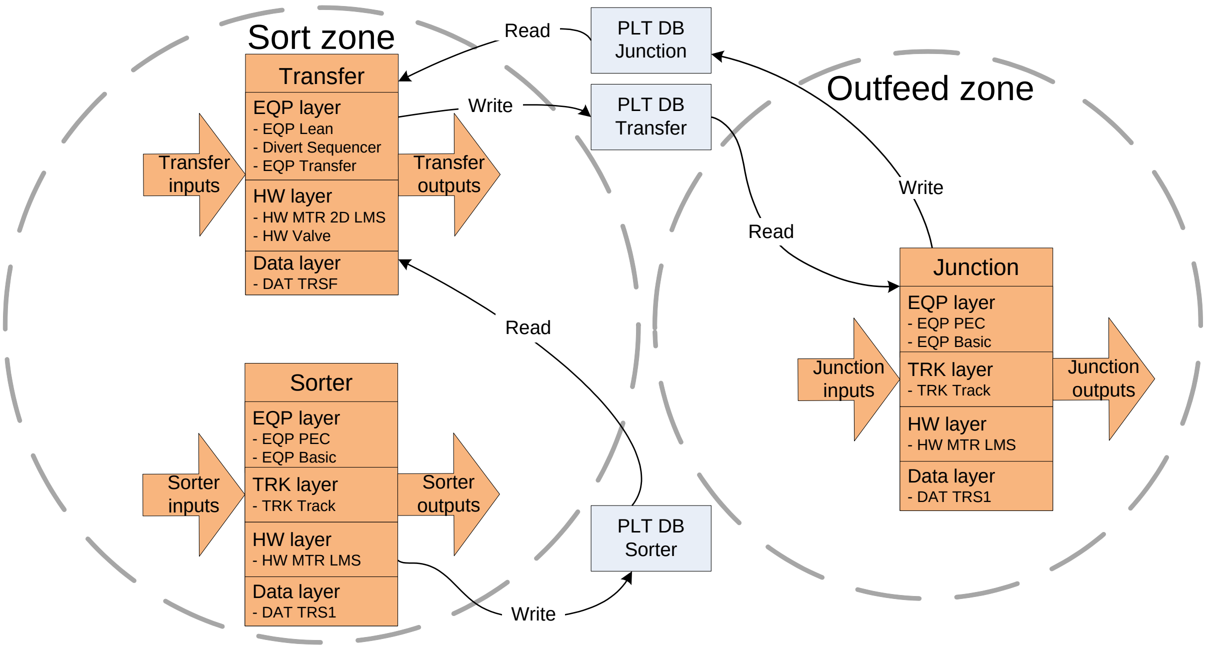


Figure 39. Distribution design.

The Distribution design is shown in Figure 39. The software in/outputs are directly connected in the zone. So when the zone is called from the area layer no parameterising has to be done, this is already done in the zone layer. This makes the zone more flexible because it is easier to add/adjust code in the zone if this would be necessary. For example if an extra transfer conveyor is added to the sorter. The code and explanation of the Distribution zones are shown in Appendix v. Design.

5.1.2 Baggage design

The Baggage design is a completely fixed zone, it is not intended to be adjusted. When it is called in the area layer the parameterising has to be done. This means all in-/outputs from the zones are redirected to the area layer. The Baggage design is shown in Figure 40.

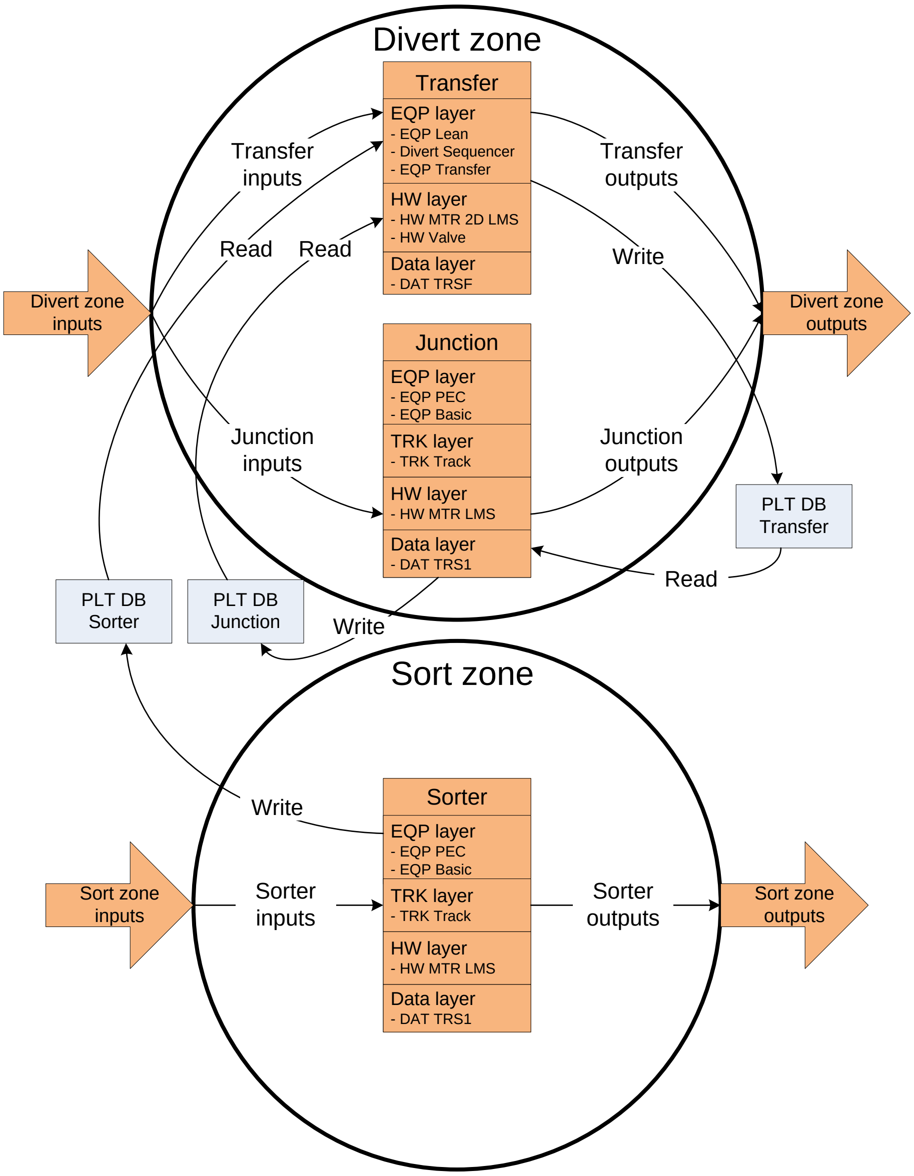


Figure 40. Baggage design.

When, for example, an extra transfer conveyor is added to the sorter, the divert zone is called and parameterised. When comparing this to the Distribution zone, the code has to be written manually and then parameterised. Making a mistake when writing the code, is bigger when the Distribution zone is used. The code and explanation of the Baggage design are shown in Appendix v. Design.

6 Realisation

The project was done on site at the company. A weekly meeting was planned with the company supervisor to review the progress of the project. Each week a new goal was determined based on the planning. In this meeting it was also reviewed if this goal was accomplished. When necessary the planning was adjusted.

To make sure the project was accomplished successfully, the agreements which were made were recorded. The next documents were presented during the project:

- Start document:
  The start document describes the way this project was suppose to be handled. It defines the requirements and preconditions which were related to the project. The start document also contained the planning of the project.
- User Requirement Specification (URS):
  The URS contains the requirements given by the client. The results of the project had to meet the requirements which were described in the URS.
- Software Design Specification (SDS):
  The SDS gives a clear description of the software. The way it is constructed and how it is suppose to function. It also describes the choices made to create the software.
- Factory Acceptance Test (FAT):
  The FAT document shows, if the results meet the requirements in the documentation that is written.
- Study report:
  The study report shows the recommendation to the client and on what arguments it is based.
- Thesis report:
  The thesis report shows the way the project was done. It describes every choice which was made and on what arguments it was based. The thesis report contains (parts of) all documents as mentioned above.

The documents mentioned above were read and provided with feedback from:

1. The company supervisor.
2. The thesis supervisor.
3. The coaches.
4. The graduate.

6.1 Global phasing

A global planning that shows the milestones of the project is shown in Table 10.

Week nr.	Phase	Milestone	Description
2. 27-08 till 31-08	Starting phase	Concept start document	Present the concept version of the start document.
3. 03-09 till 07-09	Starting phase	Concept URS	Present the concept version of the URS.
7. 01-10 till 05-10	Starting phase	Final start document	Present the final version of the start document.
8. 08-10 till 12-10	Starting phase	Final URS	Present the final version of the URS.
8. 08-10 till 12-10	Research phase	Zone choice	Choosing a specific zone to focus the project on.
10. 22-10 till 26-10	Research phase	Standard choice	Choosing a standard to write the software in.
13. 12-11 till 16-11	Research phase	Final zone document	Present the final version of the zone document.
13. 12-11 till 16-11	Research phase	Final SDS	Present the final version of the SDS.
13. 12-11 till 16-11	Realisation phase	Writing software	Start to write the PLC software according to the SDS.
15. 26-11 till 30-11	Realisation phase	Concept thesis report	Present the concept version of the thesis report.
16. 03-12 till 07-12	Realisation phase	Final software	Finalize the PLC software according to the SDS.
17. 10-12 till 14-12	Realisation phase	Test/fine tune software	Test/fine tune the software that is written.
20.31-12 till 04-01	Realisation phase	Final thesis report	Present the final version of the thesis report.
21. 07-01 till 11-01	Test phase	Perform FAT	Perform a FAT and record the results gained from it.
24. 28-01 till 01-02	Finalisation phase	Defend thesis	Defend the project that is done for the thesis.

Table 10. The project's milestones.

6.2 Realisation per phase

6.2.1 Starting phase

In the starting phase, more insight was gained in the project. Two documents were made in this phase, the start document and the URS. The final version should have been accomplished within five weeks, because the start document was not approved by the assessors from school this was delayed. The final documents were presented in the eighth week of the project. This had no negative influence on the rest of the project.

6.2.2 Research phase

During the research phase several choices had to be made. More knowledge was gained in the way of working within Vanderlande. Knowledge on which standards are used and how their engineering process works. The zone which was chosen in the URS was documented and described in detail. At first a separate document was written for this, but to prevent documentation to be written twice, this document was directly processed in the thesis report. This means no separate zone document was made. Originally eight weeks were planned for the research phase but due to the longer starting phase this was brought back to six weeks. This was done so the realisation- and testing phase weren't shortened in the planning.

6.2.3 Realisation phase

The realisation phase got delayed. This happened, because a lot of time was spent in weighing the Distribution- against the Baggage approach. Eventually the decision was made to use the Baggage approach for realising a zone. The SDI sort zone was designed using the Baggage approach and the feasibility study would show if this would be the right improvement. The SDI sort zone was designed, while actually the realisation phase should have started.

During the realisation phase the discussion for using either the Distribution or the Baggage approach was going on. However the focus of the realisation stayed on the Baggage approach, because it would not take too much time of the project, it was decided that also the Distribution approach would be designed and realised. This was decided so the differences could be shown for the software. Both of the zone approaches were realised and were working.

For doing some tests to see if the zone blocks were working, the DOTM-loop was available. The recommendation is based on these tests.

6.2.4 Test phase

Some testing was already done in the realisation phase to get an idea for the recommendation. In the test phase the FAT is performed, the gained results are processed and then a proper recommendation can be done to the client.

6.2.5 Finalisation phase

In the finalisation phase one week is calculated in the planning as toleration for possible delays. The last week in the planning was calculated for the presentation to defend the thesis, because the exact date is not yet known.

7 End product

7.1 Result

The result from the zones vs. section study showed, that using standard zone software would be beneficial for the Distribution department.

The results from the feasibility study show that the Baggage approach would be best for defining the zones in the Distribution department. However this is under certain circumstances, these are described later on in this chapter.

As proof of concept the zone blocks as, designed in chapter 5, were realised. Both designs (Distribution and Baggage) are working and functional.

7.2 Evaluation

The first and maybe most important result of the project was to see if it would be beneficial for the Distribution department to apply standard zone software. If the result would have been negative, the rest of the project would not have to be done.

The main goal of the project was to perform a feasibility study on standard zone programming. A big challenge was to capture all the ideas for zones in the department. From these ideas the two approaches, as described in paragraph 4.2.3, resulted. A feasibility study was performed to see which approach would be best to implement in the Distribution department.

The proof of the concept was additional to the realisation of the project. It was expected that both designs would be functional. This proof of concept showed that the engineering time difference between a Distribution approached zone and a Baggage approached zone is not substantial. This is contrary to what was expected previously, but because of the other advantages, the Baggage approach still comes out best for defining a zone in the Distribution department.

7.3 Conclusion

Using the Baggage approach for defining the zones in the Distribution department can only be done under certain circumstances. These are:

- The Distribution's sales department has to sell more of the same standard zones instead of the specials in a project. Doing so, more engineering time can be saved and the application of standard zone software is useful.
- It has to be acceptable for the department to redesign their drawing library, the hours spent on the current library will then partly be lost.
- Everyone in the department must be willing to change the way of working.

If these circumstances can be met, it is recommended that the Baggage approach is used for zones in the Distribution department.

7.4 Recommendation

My recommendation to the Distribution department is to continue the development of standard zones and the standard zone software. However, the way of defining zones should be changed such that it is similar to the Baggage department. This has the following advantages:

1. Vanderlande wide the same principle is used.
2. When a loop sorter is used, that is controlled by an FSC, the Baggage approach is used for configuring the zones. If the Distribution decides to use the Distribution approach, this would mean that in one project two different kinds of zone approaches can be found.
3. Less different kinds of zones appear in one project.
4. Should result into more standard fixed zones and less specials.

To my opinion, only one disadvantage comes along when changing to a different approach: The current library in the drawing software has to be adjusted/remade. However, the drawing library is being adjusted at the moment, so the moment to change is now.

8 Process and planning

8.1 Project approach

No costs were made that are related to the project. The materials and software needed to complete the project were already owned by the company, no costs needed to be made for this. The only costs made were a trainee fee. This was a monthly fee, but these costs are not included in the project.

The Gantt chart was created using MS-Excel. This was reviewed weekly, fortunately the planning only had to be adjusted once. The Gantt chart shows the activities that had to be done each week.

The PLC software that was realised was written using Siemens Step7. The coding language was STL.

8.2 Gantt chart

The entire Gantt chart is too large to display here, it is shown in Appendix i. Gantt Chart. A description of each item in the Gantt chart is as follows:

- Write the start document:
  To gain more insight on the project a start document was written.
- Adjust the start document (later added to the chart):
  The start document was not accepted the first time, so it had to be adjusted.
- Present start document concept:
  Present the concept of the start document to the supervisors.
- Write URS:
  The requirements from the client were clarified in the URS.
- Present URS concept:
  Present the URS concept to the supervisors.
- Make Siemens Step7 assignment:
  Experience in working with Siemens Step7 was gained by making an assignment that trainees usually have to do.
- Company supervisor meeting:
  Weekly meeting that was planned with the company supervisor.
- Fieldbus lesson:
  The University of Applied Sciences had to be visited twice to follow a Fieldbus lesson.
- Study the Vanderlande standards:
  A study was performed on the content of the Vanderlande standards.
- Write study report on standards:
  A study report is written on the standards and a choice was made which standard is used in this project.
- Present study report concept:
  Present the concept of the study report to the supervisors.
- Study zones:
  A study was performed on different variants of the zones in the Distribution department.

- Zone choice:
  A choice was made what zone would be a possible software zone, from the zones that were studied.
- Document the chosen zone:
  The zone that was chosen to standardize was documented in a zone document.
- Write SDS:
  The SDS describes the software zone. This has become a part of the zone document.
- Present SDS concept:
  Present the concept of the SDS to the supervisors.
- Write software:
  The zone software was written according to the SDS.
- Test/adjust software:
  The zone software was tested and adjusted where necessary.
- Perform FAT:
  Perform the FAT and show the results to the supervisors.
- Write thesis report:
  During the entire thesis period the thesis report was maintained.
- Present thesis report concept:
  Present the concept of the thesis report to the supervisors.
- Present final thesis report:
  Present the final version of the thesis report to the supervisors.
- Final work activities:
  This period was planned as tolerance to the planning.
- Defend thesis project:
  In this week the thesis project had to be defended.

8.3 Time and cost calculation

No purchases were made for this project, therefore no costs were made. As a time calculation for the project, each week contained 40 working hours on the project. This means 21 week x 40 hours = 840 hours are worked on the project.

8.4 Project evaluation

At the start of the project, my idea of the project was different than what it turned out to be. My idea was it would be a more practical project, it turned out to be more theoretical. However, the project was very interesting and very instructive, so even though it was different from my first expectations it was a great project to work on.

The project contained a discussion that had been going on for years in the Distribution department. The challenge was to record all the different ideas and find a way through them. An independent person should do so, because that person would not be prejudiced. This part of the project was done successfully to my opinion.

The progress through the project went smoothly, at first I needed to get used at being at Vanderlande, but once I got used to it, it was an enjoyable place to work.

The general guidance through the project was very pleasant and professionally done by Piet. The weekly meetings helped me to keep an eye on the planning and secure the progress of the project by setting goals for each week, it was clear that Piet had great experience in this and knew very well how to do this.

The more technical substantial guidance through the project at first was limited. This was mainly due to the fact that, firstly I had to get used to the environment of the EUD and secondly because Fred Hermes was not in the office and I didn’t want to bother anyone else with my questions. Most of the answers I found out on my own, but for some I had to ask someone for more insight. However after some time (about 5 to 6 weeks into the project) this was straightened out. That was the moment the project got really clear to me.

After these 5 to 6 weeks, also a weekly meeting with the coaches, Fred and Joep, was planned for the more technical substantial guidance. During these meetings was reviewed, if the progress of the project went well and if the discussions that were going on were properly understood and documented. Next to these weekly meetings they were always available for any questions I had.

As a company and especially for the EUD I can only say, it is a very open, inspiring and interesting company/department to work. A lot of knowledge is present and they are willing to explain this. The guidance during an internship/thesis project is good and when you get stuck they will help you out. Vanderlande is a company I would recommend to perform an internship or a final thesis.

9 Reflection

9.1 Reflection technical competences

The technical competences as defined by the Bachelor of Engineering degree are:

1. Gaining insight.
2. Designing.
3. Planning.
4. Carrying out.

The gaining insight part of the project went smoothly but was hard at some points. It was hard to get to know the Vanderlande standards and way of working, but once I got used to it, it was a very clear and structured way of working. However it still took some time to really get to know what the project was about exactly, because it was a complicated project for an outsider to perform. But on the other hand it had to be performed by an outsider for a complete independent view on the project. All together I think the insight gained on the project was successful.

What had to be designed for the project was not clear to me at first. My idea for the realisation was different than Piet meant for it to be. However this was straightened out when the Start document was disapproved and some parts had to be re-written. In an early stage of the project it got clear what had to be designed. Starting on the design however, took some time because of the discussion about the approaches. The decision, on which approach would be used, should have been made earlier, but this decision was made without too much delay and a design was made for the project.

The planning made for the project was quite accurate, it had to be adjusted once due to the disapproved Start document. The planning was reviewed weekly with Piet and no further adjustments had to be made. The planning could be followed quite accurately and any delays that came up were resolved within a week.

The carrying out part of the project was different than expected at first. More research and less realising had to be done. But it was very interesting to carry out the project. To my opinion the carrying out was a success and a good result was provided from this project.

To summarize this, the competences as defined by the Bachelor of Engineering degree are successfully met. A point of attention for me is the competence of designing, because the decisions that needed to be made for the design, took some time before they were made.

9.2 Reflection professional competences

The professional competences of an Industrial Automation student are:

1. Knowledge and insight.
2. Application of knowledge and insight.
3. Judgement.
4. Communication.
5. Learning capabilities.

To perform the project, knowledge and insight in the Industrial Automation was needed. The project was spread over the different disciplines that appear in the EUD. Knowledge was needed in the mechanical and electrical hardware discipline. This was needed to imagine what problems could come along for these disciplines, but the most knowledge and insight was needed to understand/implement the PLC software. Vanderlande has a real extensive standard, which is very specific for Vanderlande systems, a good insight was needed to understand the standard. To my opinion, I succeeded in showing that I am capable and have the right amount of knowledge and insight that was needed for this project.

The application of knowledge and insight has been shown by designing and realising the two zones. By testing the written software in the DOTM-loop some commissioning of a system has also been implemented in the project. Doing so, it could be shown that I can apply the knowledge and insight gained during the study and thesis.

A point of improvement for me is the judgement competence. When all the facts were gotten straight, the best approach for defining the zones came out. However a helping hand was needed to make the judgement and say, this really is the best approach and it will be used for the rest of the project. This is something I can improve, making such decisions on my own and be able to support my decisions based on the right arguments.

During the project a lot of communication was needed. Engineers from all disciplines had to be involved. This way each discipline could be taken into account when weighing the approaches against each other. Also writing the thesis report in English is a way of communicating. This was requested to do, because Vanderlande is a multicultural company and the corporate language in Vanderlande is English.

The learning capabilities were especially needed at the start of the project. A lot of studying was done at the standards and working methods of Vanderlande. Some of this documentation was very technical and complex to read. However, I got through it quite well and knew how to apply the things I learned. To my opinion I have shown my capability of learning and applying the things I learned.

9.3 Job profile

From this project I learned how to perform a major project within a certain amount of time, by setting the right priorities a good result can be achieved. This project was one right up my alley, the subject was very interesting and instructive. However, it was very theoretical, some more practical tasks would have been desirable. The experiences through the study and the thesis showed me, that my interests lie in the designing and realising of systems, similar to the ones Vanderlande builds.

When working in teams during the study, my role was often an advising role, especially when it was about electronics or software. People would come to me for advice and I tried to help them as best as I could. That is what my drive is, to help people out and, in the way I see it, solving a puzzle. When it comes to complex systems, I see it as a challenge to solve the problem the best way possible. It is really pleasing to see a system come together and part by part getting it to work until the complete system works. For me, that is what makes this field of profession so beautiful to perform.

Terms and abbreviations

Terms

Accumulation	Accumulating is a function that reduces or enlarges the gap between products.
Area	An area is a part of a system, it consists of one or more zones.
Divert	Diverting is a function to remove a product from a conveyor.
Downstream	Downstream is a part of the system that comes after another part.
Enterprise	An enterprise is the highest layer in the Vanderlande hierarchy, it consists of plants.
Generator Suite	The Generator Suite is a tool which is developed by Vanderlande to simplify their engineering process.
Induct	Inducting is a function to place a product on a conveyor.
Object	An object is the lowest layer in the Vanderlande hierarchy.
Plant	A plant is a part of an enterprise, it consists of systems.
PLC Section Block	A PLC Section Block is a piece of PLC software that can control one conveyor.
PLC Zone Block	A PLC Zone Block is a piece of PLC software that can perform a function in the system.
Section	A section is a part of a zone, it consists of objects.
System	A system is a part of a plant, it consists of areas.
Upstream	Upstream is a part of the system that is in front of another part.
Zone	A zone is a part of an area, it consists of sections.

Abbreviations

ARD	Accumulation Roller Drum driven
AUX	Auxiliary interface
A.Z.S.E	Area.Zone.Section.Element
BF	Belt Floorveyor
BHS	Baggage Handling System
BJM	Multi Belt Junction
CH	Chute
CPE	Controls Project Engineer
DB	Database
DOTM	Distribution On The Move
ECS	Equipment Control Software
EOS-PEC	End Of Section – Photo Electrical Cell
EUD	Engineering Unit Distribution
FAT	Factory Acceptance Test
FIF	Flow InterFace
FSC	Flow System Controller
GAMP	Good Automated Manufacturing Process
GR	Gravity Roller
GRJ	Gravity Roller Junction
H2H	Head to Head
HLC	High Level Control
HWE	HardWare Engineering
IATA	International Air Transport Association
IC	Innovation Centre
LE	Lay-out Engineer
LLC	Low Level Control
LMS	Local Motor Starter
LRB	Live Roller Bridge
LRJ	Live Roller Junction
MD	Motor Driven
MHS	Material Handling System
MPE	Mechanical Project Engineer
PDB	Product Data Book
PEC	Photo Electrical Cell
PLC	Programmable Logic Controller
PLE	Project Leader Engineer
PLT	Position Leading Trailing
PME	Product Manager Engineering
PPI	Pulse Position Indicator
PTO	Power Take Off
SDI	Distrisorter
SDS	Software Design Specification
SSS	Standard Software Structure
STL	Structure List
TRS	Transport Section
TRZ	Transport Zone
URS	User Requirement Specification
VB	VertiBelt
VIA	Vereniging Industriële Automatisering
ZPS	Zone Picking System

Figures

Tables

References

Nr.	Document number	Description	Hyperlink*
[1]	11224-620-PD388 EN B	Multiveyor (zone) application guide.	Click
[2]	G0094-620-SOZA1 – EN - 008	Product book Sorter Zone (SOZ)	Click
[3]	G0094-620-VBZA1 – EN - 014	Product book Vertibelt Zone (VBZ)	Click
[4]	G0094-620-TRZA1 – EN - 010	Product book Transport Zone (TRZ)	Click
[5]	G0027-482-30001 – EN – A01	Safety engineering guide	Click
[6]	A_DOC069225-EN-G	PDB DOTM Multibelt conveyor	Click
[7]	A_DOC068110-EN-I	Appendix DOTM Multibelt conveyor	Click
[8]	A_DOC114426 EN A	Tension way calculation MB drive	Click
[9]	A_DOC111407-EN-I05	Appendix DOTM EM components & support	Click
[10]	G0068-520-00001 - EN - A01	ADD Transfer Divert Section	Click
[11]	G0026-453-00003.EN.016	PLC Architectural Design (SSS)	Click
[12]	G0026-453-70001.EN.022	S7 Coding Standard (SSS)	Click
[13]	A_DOC072963 – EN – A	PLC Architectural Design (ECS)	Click
[14]	A_DOC068371 – EN – C	S7 Coding Standard (ECS)	Click
[15]	11224-620-PD222 – EN – G	PDB Product Handling Units	Click
[16]	11224-620-PD487 – EN – D	PDB Product baggage requirements	Click
[17]	A_DOC066955 EN C	Numbering Distribution equipment	Click
[18]		Distribution intranet page	Click
[19]	A_DOC054873 EN B	QZ44 Quickstore 4.4 zone	Click
[20]	A_DOC068438	PIZ4 Pick@Ease.4 Workstation zone	Click

*Note: Hyperlinks only work in Vanderlande Industries network.

Appendices

Appendix i. Gantt Chart

Project:	Zone software feasibility study
Performed by:	Bart Jansen
Version:	1.2

Legenda:	
	Activity in Veghel
	Adjustment to the planning
	Activity in Utrecht
	Weekend
	Holiday

		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
		20-08-2012 till 26-08-2012	27-08-2012 till 02-09-2012	03-09-2012 till 09-09-2012	10-09-2012 till 16-09-2012	17-09-2012 till 23-09-2012	24-09-2012 till 30-09-2012	01-10-2012 till 07-10-2012	08-10-2012 till 14-10-2012	15-10-2012 till 21-10-2012	22-10-2012 till 28-10-2012	29-10-2012 till 04-11-2012	05-11-2012 till 11-11-2012
Task	Begin/end date	Mo Tu We Th Fr Sa Su	Mo Tu We Th Fr Sa Su	Mo Tu We Th Fr Sa Su	Mo Tu We Th Fr Sa Su	Mo Tu We Th Fr Sa Su	Mo Tu We Th Fr Sa Su	Mo Tu We Th Fr Sa Su	Mo Tu We Th Fr Sa Su	Mo Tu We Th Fr Sa Su	Mo Tu We Th Fr Sa Su	Mo Tu We Th Fr Sa Su	Mo Tu We Th Fr Sa Su
Write the start document	20-08-2012 till 14-09-2012												
Adjust the start document	24-09-2012 till 05-10-2012												
Present start document concept	31-08-2012												
Write URS	27-08-2012 till 12-10-2012												
Present URS concept	07-09-2012												
Make Siemens step7 assignment	03-09-2012 till 14-09-2012												
Company supervisor meeting	Each Friday												
Fieldbus lesson	11-09-2012 and 25-09-2012												
Study the Vanderlande standards	03-09-2012 till 26-10-2012												
Write study report on standards	01-10-2012 till 02-11-2012												
Present study report concept	08-10-2012												
Study zones	17-09-2012 till 05-10-2012												
Zone choice	08-10-2012 till 12-10-2012												
Document the chosen zone	15-10-2012 till 16-11-2012												
Write SDS	05-11-2012 till 16-11-2012												
Present SDS concept	12-11-2012												
Write software	12-11-2012 till 06-12-2012												
Test/adjust software	03-12-2012 till 04-01-2013												
Perform FAT	02-01-2013 till 11-01-2013												
Write thesis report	17-09-2012 till 18-01-2013												
Present thesis report concept	30-11-2012												
Present final thesis report	08-01-2013												
Final work activities	21-01-2013 till 01-02-2013												
Defend thesis project	28-01-2013 till 01-02-2013												

Project:	Zone software feasibility study
Performed by:	Bart Jansen
Version:	1.2

Task	Begin/end date	Week 13 12-11-2012 till 18-11-2012 Mo Tu We Th Fr Sa Su	Week 14 19-11-2012 till 25-11-2012 Mo Tu We Th Fr Sa Su	Week 15 26-11-2012 till 02-12-2012 Mo Tu We Th Fr Sa Su	Week 16 03-12-2012 till 09-12-2012 Mo Tu We Th Fr Sa Su	Week 17 10-12-2012 till 16-12-2012 Mo Tu We Th Fr Sa Su	Week 18 17-12-2012 till 23-12-2012 Mo Tu We Th Fr Sa Su	Week 19 24-12-2012 till 30-12-2012 Mo Tu We Th Fr Sa Su	Week 20 31-12-2012 till 06-01-2013 Mo Tu We Th Fr Sa Su	Week 21 07-01-2013 till 13-01-2013 Mo Tu We Th Fr Sa Su	Week 22 14-01-2013 till 20-01-2013 Mo Tu We Th Fr Sa Su	Week 23 21-01-2013 till 27-01-2013 Mo Tu We Th Fr Sa Su	Week 24 28-01-2013 till 03-02-2013 Mo Tu We Th Fr Sa Su
Write the start document	20-08-2012 till 14-09-2012												
Adjust the start document	24-09-2012 till 05-10-2012												
Present start document concept	31-08-2012												
Write URS	27-08-2012 till 12-10-2012												
Present URS concept	07-09-2012												
Make Siemens step7 assignment	03-09-2012 till 14-09-2012												
Company supervisor meeting	Each Friday												
Fieldbus lesson	11-09-2012 and 25-09-2012												
Study the Vanderlande standards	03-09-2012 till 26-10-2012												
Write study report on standards	01-10-2012 till 02-11-2012												
Present study report concept	08-10-2012												
Study zones	17-09-2012 till 05-10-2012												
Zone choice	08-10-2012 till 12-10-2012												
Document the chosen zone	15-10-2012 till 16-11-2012												
Write SDS	05-11-2012 till 16-11-2012												
Present SDS concept	12-11-2012												
Write software	12-11-2012 till 06-12-2012												
Test/adjust software	03-12-2012 till 04-01-2013												
Perform FAT	02-01-2013 till 11-01-2013												
Write thesis report	17-09-2012 till 18-01-2013												
Present thesis report concept	30-11-2012												
Present final thesis report	08-01-2013												
Final work activities	21-01-2013 till 01-02-2013												
Defend thesis project	28-01-2013 till 01-02-2013												