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Graduation Thesis – University of Twente

Optimisation strategy of the incoming supply in the sorting process at PostNL depot Hengelo

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Management Samenvatting

In de afgelopen jaren is PostNL Pakketten extreem gegroeid en deze groei zal de komende jaren nog voortduren. Echter ondervindt PostNL Hengelo het probleem dat door deze groei hun sorteerproces lastig is te managen. Om het proces te handhaven tijdens deze groei, dient het adequaat te worden uitgevoerd. Daarnaast ondervindt PostNL Hengelo het probleem dat zij het idee hebben dat hun klanten extreem laat aanleveren, wat een stressvol proces oplevert met het risico dat alle pakketten niet tijdig kunenn worden verwerkt. Zij zijn van mening dat het nastreven van optimale aankomsttijden voor specifieke klanten ervoor zal zorgen dat het proces stabieler en minder stressvol is.

Op dit moment ondervindt PostNL Hengelo het probleem dat de aankomstinformatie van pakketten onvoldoende is. De geplande aanvoerlijn van de pakketten is niet consistent met de daadwerkelijke aanvoer, wat inhoudt dat de pakketten niet op de verwachte aankomsttijd komen met het verwachte aantal pakketten. Daarnaast kloppen de afgesproken tijden en aantallen helemaal niet met zowel de verwachte als ook de daadwerkelijke tijden en aantallen.

De geplande aanvoerlijn wordt bepaald op het hoofdkantoor van PotsNL Pakketten in Hoofddorp. Op basis van deze lijn wordt op het depot de planning voor het proces gemaakt, die daardoor ook niet haalbaar zal zijn. Hierdoor moeten tijdens het proces vaak ad hoc veranderingen worden gemaakt en er heerst veel onzekerheid tijdens het proces. PostNL wenst dat de exacte problemen worden opgespoord en de oorzaken hiervan worden gevonden. Daarnaast willen zij weten wat een adequaat scenario voor het proces is en hoe zij hiermee minder onzekerheid kunnen bereiken. Wat kan PostNL veranderen zodat het proces efficiënter en minder onzeker wordt? Deze doelen leiden tot de volgende onderzoeksvraag:

"Wat is een adequaat scenario voor PostNL Hengelo betreffende de aankomst en het verwerken van de pakketten die arriveren voor het sorteerproces?"

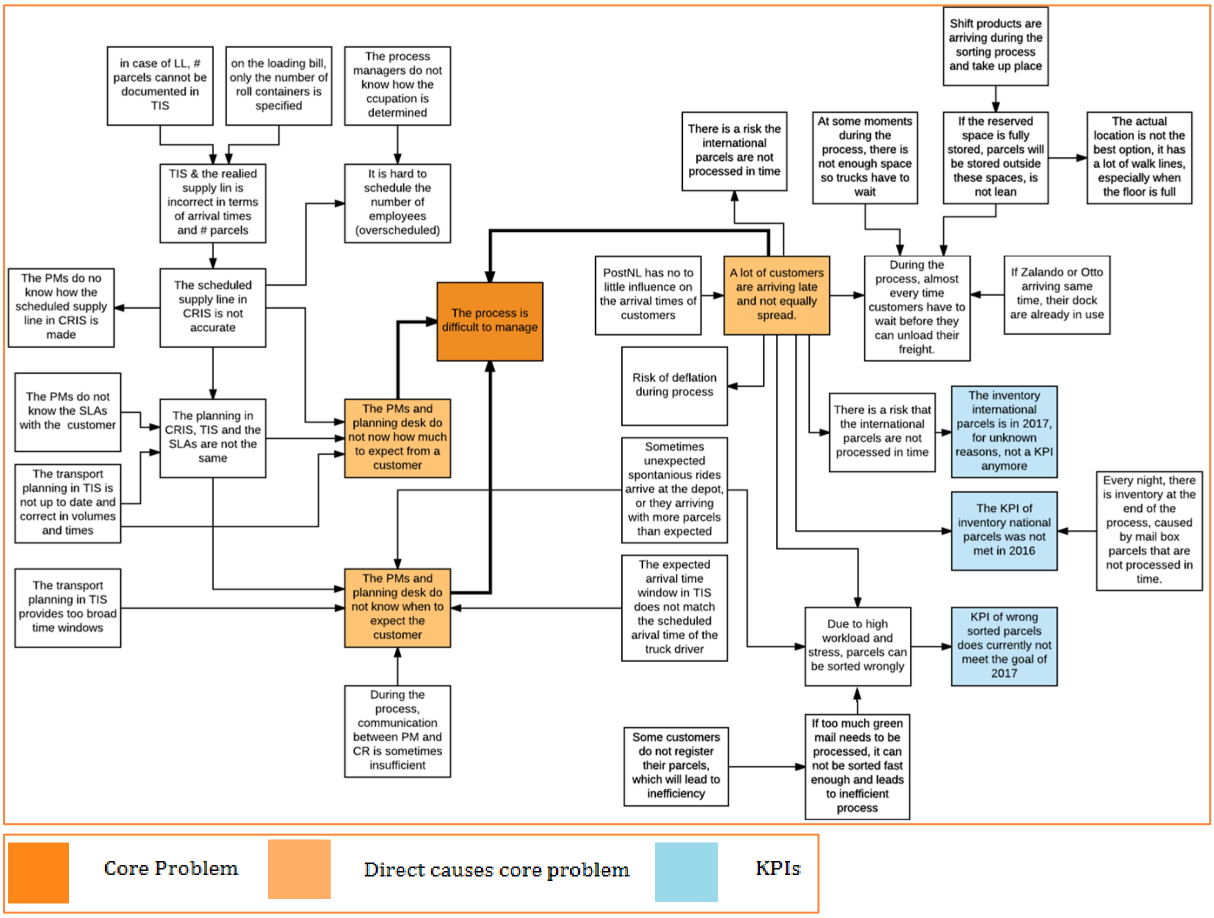
Met een adquaat scenario voor PostNL wordt bedoeld een ideale situatie, waarbij in acht wordt genomen dat sommige externe factoren niet volledig kunnen worden beïnvloed.

Als eerste wordt de huidige situatie van het sorteerproces bij PostNL Hengelo geanalyseerd. Om er zeker van te zijn dat alle aspecten van het proces worden behandeld, is de analyse uitgevoerd volgens de strategie van *Operational Excellence* van McKinsey (2008). Zij zeggen dat om operationele topprestatie te behalen, er aandacht geschonken moet worden aan drie aspecten: (i) het daadwerkelijke proces, (ii) de betrokken management- en informatiesystemen; en (iii) de capaciteiten en het gedrag van betrokken stakeholders. Het doel van de procesanalyse is het vinden van de daadwerkelijke problemen en hun oorzaken.

Figuur I – McKinsey operational excellence

Process analyse

Tijdens de procesanalyse is als eerste het daadwerkelijke process geanalyseerd. Vervolgens zijn de gebruikte systemen die het proces voorspellen, plannen en monitoren geanalyseerd. Als laatste zijn de betrokken stakeholders geïnterviewd om achter hun ervaren problemen te komen en hun rol in het proces helder te krijgen. Uit deze procesanalyse zijn meerdere problemen geïdentificeerd en geclusterd in de volgende probleemkluwe.



Figuur II – Probleemkluwe (in het Engels)

Het hoofdprobleem van de probleemkluwe is alsvolgt geïdentificeerd: het proces is lastig te managen. Dit is een erg breed en algemeen hoofdprobleem en daarom moet er ook vooral gekeken worden naar de oorzaken hiervan. Het probleem heeft meerdere oorzaken. Alle oorzaken zijn geclusterd in drie blokken, die lichtoranje gekleurd zijn in de kluwe.

- De procesmanagers (PM's) en de planbalie weten niet hoeveel pakketten en wat voor soort pakketten ze kunnen verwachten van een klant
- De procesmanagers en de planbalie weten niet wanneer ze een klant kunnen verwachten
- Veel klanten arriveren laat en niet gelijkmatig verdeeld over de avond

Met behulp van de AHP-methode zijn er vijf criteria geïdentificeerd die belangrijk zijn voor het oplossingsmodel. Na de ênquete van de AHP-methode is aan de geïnterviewden gevraagd of ze gezamenlijk de vijf criteria nogmaals kunnen ordenen. Zij hebben de criteria de volgende rangorde gegeven:

1. Duidelijke kennis over de trends van klanten, zowel in tijden als aantallen, deze zijn beter voorspeld dan op dit moment, maar exacte informatie ontbreekt nog steeds. *(was prioriteit 2 van de AHP)*
2. Exacte kennis over de aankomsttijden van klanten, maar de aantallen per vrachtwagen zijn onbekend. *(was prioriteit 1 van de AHP)*
3. Exacte kennis over de aantallen per vrachtwagen van de klanten, maar de aankomsttijden zijn onbekend. *(was prioriteit 3 van de AHP)*
4. Alle voorzieningen zijn er om leegloop te voorkomen, maar meer kennis over aantallen en aankomsttijden wordt er niet verkregen. *(was prioriteit 5 van de AHP)*
5. Alle voorzieningen zijn er om wachttijden voor vrachtwagens te voorkomen, maar meer kennis over aantallen en aankomsttijden dan nu bekend is komt er niet. *(was prioriteit 4 van de AHP)*

Op basis van de procesanalyse en de probleemkluwe weten we nu wat de exacte problemen zijn bij PostNL Hengelo en wat hun wensen zijn met betrekking tot het oplossingsontwerp. Verassend is dat, in tegenstelling tot wat het management verwachtte, de maximale capactieit voor de vloervoorraad is niet het belangrijkste probleem. Beter inzicht in aankomstinformatie is veel belangrijker.

Data analyse

Vervolgens is er een data-analyse uitgevoerd, waar we meer informatie betreffende de aankomst van klanten en het proces zelf hebben verkregen. PostNL gebruikt twee systemen in het aankomstproces van de klanten: CRIS (Control Room Informatie Systeem) en TIS (Transport Informatie Systeem). Beide systemen hebben hun eigen voor- en nadelen, maar we hebben moeten concluderen dat beide systemen niet geschikt zijn voor de data-analyse. Naast dat de bruikbaarheid onvoldoende is, hebben we ook geconcludeerd dat de data die PostNL gebruikt niet accuraat is. Aangezien deze data gebruikt wordt om prognoses van toekomstige processen te bepalen, kan dit als problematisch worden beschouwd.

Om deze redenen hebben wij ons eigen conversie en visualisatiemodel (CVM) gebouwd, waar we de data in accurate informatie geconverseerd hebben en het proces hebben gevisualiseerd zodat we het op een goede manier kunnen analyseren en interpreteren. We hebben de performances van de drie modellen vergeleken. Het grote nadeel van CRIS is dat het alleen verwachte totaalvolumes geeft en geen klantspecifieke informatie geeft. Daardoor is dit systeem al uitgesloten. De volumes van TIS en CVM zijn vergeleken met het volgende resultaat:

Datum	Volumes TIS	Volumes CVM	Daadwerkelijke volumes	Beste model (TIS of CVM)
19-dec	64,540	61,474	61,644	**CVM**
20-dec	67,634	63,564	65,173	**CVM**
21-dec	69,890	65,782	63,264	**CVM**
22-dec	58,742	53,442	58,329	**TIS**
...	...	...	...	**...**
20-jan	41,513	37,962	32,515	**CVM**

Tabel I - Volume verschillen tussen Management Informatie Systemen

In totaal heeft in 22 van de 24 keer het CVM de beste resultaten en is accurater dan TIS. Naast de vergelijking hebben we ook de Mean Squared Error van deze schatters berekend. Ook hier komt uit dat CVM de laagste MSE heeft en dus de meest betrouwbare schatter is.

	Volumes TIS	Volumes CVM	Laagste MSE
Mean Squared Error	$66 * 10^6$	$17 * 10^6$	Volumes CVM

Tabel II - Mean Squared Error

Nu is bewezen dat het CVM het meest betrouwbare model voor de data-analyse is, hebben we twee analyses uitgevoerd:

- Klantenaankomst-analyse
- Procesmodel-analyse

In de aankomst-analyse hebben we gezocht naar waarneembare trends in aankomsttijden en volumes, over een periode van vier maanden. In de procesmodel-analyse hebben we het proces geanalyseerd en gevisualiseerd op een dagelijks niveau. Hier hebben we gezocht naar de consequenties van het sorteren van bepaalde volumes en het hebben van bepaalde aankosmtijden. De volgende conclusies uit de data-analyse zijn naar voren gekomen:

- Uitgaande van de aankomsttijden van de grootste klanten (Otto, Zalando Erfurt en Arvato), zijn er geen waarneembare trends gevonden. De vrachtwagens van deze klanten arriveren elke dag op afwisselende tijdstippen, breed verspreid over de avond.
- Het aantal pakketten dat arriveert per uur is niet constant. Deze aantallen zijn zo verspreid, dat het gemiddelde aantal per uur geen betrouwbare schatter is.
- De vracht per vrachtwagen van de grote klanten is niet consistent. Er is geen vast aantal pakketten per vrachtwagen en het gemiddelde aantal pakketten per vrachtwagen is geen betrouwbare schatter.
- Kijkend naar het proces op dagelijks niveau: processen met hetzelfde totaalvolume kunnen zeer anders verlopen, wanneer de aankomsttijden van de klanten niet hetzelfde zijn. Met alleen kennis over het verwachte totaalvolume kunnen we het proces niet goed voorbereiden en managen. Informatie over aankomsttijden van (tenminste) de grote klanten is noodzakelijk.

Oplossingsontwerp

Nu we hebben geconcludeerd dat er geen geen signalen van trends te vinden zijn in de aankomsttijden en aantallen, weten we dat we niet kunnen vertrouwen op kennis over het verleden om zelf in het depot autonoom de vracht te voorspellen. In het oplossingsontwerp geven we de gevonden oplossingsalternatieven, gebaseerd op de drie aspecten van *Operational Excellence (McKinsey, 2008)*: (i) het daadwerkelijke proces, (ii) de capaciteiten en het gedrag van de betrokken stakeholders, en (iii) de betrokken management- en informatiesystemen.

(i) Proces

Voor het proces hebben we weer gebruikt gemaakt van het CVM om het proces te modelleren. Er zijn twee bevindingen gedaan die tegen de verwachting van het management in gaan. Ten eerste hebben we gevonden dat het niet mogelijk is om een vaste aankomsttijd per weekdag per klant te identificeren. Ten tweede hebben we gevonden dat later arriveren, wat ook geprefereerd wordt door de klanten, gunstig is voor het proces. Dit is verassend, aangezien het management verwachtte dat het eerder arriveren van klanten zou leiden tot een beter proces, wat dus niet het geval blijkt te zijn. Echter moet het wel vermeld worden dat dit alleen gunstig is wanneer PostNL Hengelo weet wanneer en met hoeveel vracht de klanten komen. Dit probleem wordt behandeld in de andere twee aspecten van *operational excellence.*

Voor de huidige situatie, is het verkorten van het proces momenteel niet altijd gunstig of überhaupt mogelijk. Echter, we hebben wel geconcludeerd dat er zeker mogelijkheden zijn om met deze methode kosten te besparen. Met verder onderzoek en het herberekenen van de juiste bezetting en tarieven, zijn er zeker mogelijkheden voor het management om hiervan te profiteren op de lange termijn.

(ii) Communicatie betrokken stakeholders
Door het onderzoek heen hebben we op meerdere momenten geconcludeerd dat de communicatie- en informatiestroom niet toereikend is. Sterker nog, we zien dit als het focuspunt bij het oplossen van het probleem van een te lastig te managen proces.

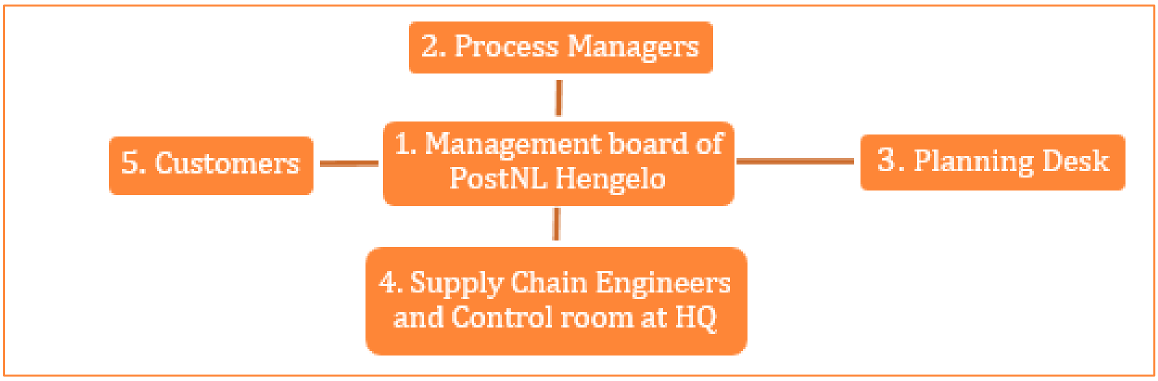
Voor alle stakeholder zijn aanbevelingen gegeven over hoe zij elkaar met de juiste en voldoende informatie kunnen helpen, zodat PostNL Hengelo een beter beeld heeft van wat zij kunnen verwachten tijdens het proces.

Al onze aanbevelingen met betrekking tot het verbeteren van de communicatie hebben invloed op betere informatiestromen. Zoals geconcludeerd is in de data-analyse, is het zeer lastig om de aankomsttijden en de volumes van de individuele klanten te voorspellen, aangezien er op basis van onze analyse geen trends gevonden zijn. Daaroms is het belangrijk dat PostNL Hengelo accurate informatie hierover ontvangt van de klanten.

(iii) Informatie systemen
Tijdens de proces- en data-analyse hebben we geconcludeerd dat de huidige informatiesystemen niet toereikend zijn voor het voorbereiden en monitoren van het proces op de juiste manier. We hebben al laten zien dat we hiervoor een eigen model hebben gebouwd, het CVM, dat de accuraatheid van de data heeft verbeterd. Daarnaast verschaffen we PostNL ook met verscheidene aanbevelingen over hoe zij CRIS en TIS kunnen verbeteren, zodat ook deze systemen betrouwbaarder worden.

Ons oplossingsontwerp hebben we samengevat met implementeerbare stappen die toegewezen zijn aan verschillende stakeholders. Zij zijn verantwoordelijk voor de verbetering van de systemen.

Aangezien wij een groot aantal aanbevelingen voor alle stakeholders en informatiesystemen hebben voorgelegd, hebben wij ons oplossignsontwerp samengevat aan de hand van implementeerbare aanbevelingen, verdeeld over verschillende ambitieniveaus. Op deze manier heeft PostNL Hengelo de juiste handvaten om te kunnen verbeteren richting een optimaal scenario. Elk ambitieniveau staat voor zijn eigen inspanningsniveau en periode. Het bevat een stappenplan dat elke dag gebruikt kan worden om het voorbereiden en het managen van het proces dagelijk te optimaliseren. Het starpunt van alle implementeerbare stappen ligtbij het management van PostNL Hengelo. Zij zijn verantwoordelijk voor het uitvoeren van alle stappen.



Figuur III – Verantwoordelijkheidsoverzicht

De set van oplossingen dat is verschaft, bevat alle aspecten van *Operational Excellence* (proces, informatiesystemen en gedrag), geeft PostNL Hengelo een adequaat scenario betreffende de aankomst en sortering van pakketten die arriveren voor het sorteerproces.

Management Summary

During the past years, PostNL Parcels has increased drastically and it will continue to grow in the coming years. However, PostNL Hengelo finds it currently difficult to manage the process, due to increasing volumes. To maintain the process during this growth, the process needs to be executed in an adequate way. Additionally, the management suspects that customers arriving extremely late at the process and this results in a stressful process. They believe that optimal arrival times for customers will result in a more stable and less stressful process.

At this moment, PostNL Hengelo faces the problem that the information regarding the arrival of parcels is insufficient. The scheduled supply line of the parcels is not consistent with the actual parcel arrival, so the parcels will not arrive on the expected time with the expected volumes. Additionally, the agreed times and volumes again differ from both the expected and realised times and volumes.

The scheduled supply line is centrally determined at the HQ of PostNL Parcels in Hoofddorp. Based on this line, at the depot a planning is made, which will also not be feasible. Due to this problem, ad hoc changes need to be made regularly and a lot of uncertainty arises during the process. PostNL wishes to identify the exact errors and their causes. Additionally, they want to see what an adequate scenario would be and how to achieve less uncertainty during the process. What could PostNL change so that the process can be more efficient and certain? These goals lead to the following research question:

"What would be an adequate scenario for PostNL Hengelo regarding the arrival and processing of parcels that will enter the sorting process?"

An adequate scenario for PostNL is considered an ideal situation, taking into consideration that some external factors cannot be fully influenced.

First, the current situation of the sorting process at PostNL Hengelo is analysed. To ensure that all aspects of the process are covered, the analysis is conducted with the Operational Excellence strategy of McKinsey (2008). They state that to achieve operational excellence, attention must be paid to (i) the actual process; (ii) the involved management & information systems; and the capabilities and (iii) behaviour of involved stakeholders. The goal of the process analysis is to find out the actual problems and their causes.

Figure I – McKinsey operational excellence

Process analysis

During the process analysis, first, the actual process is analysed. Second, the involved systems which forecast and monitor the arrival and processing of parcels are analysed. Lastly, involved stakeholders are interviewed to obtain their experiences regarding the problem and what their role is during the process. From the process analysis, many problems are identified and clustered in a problem knot.

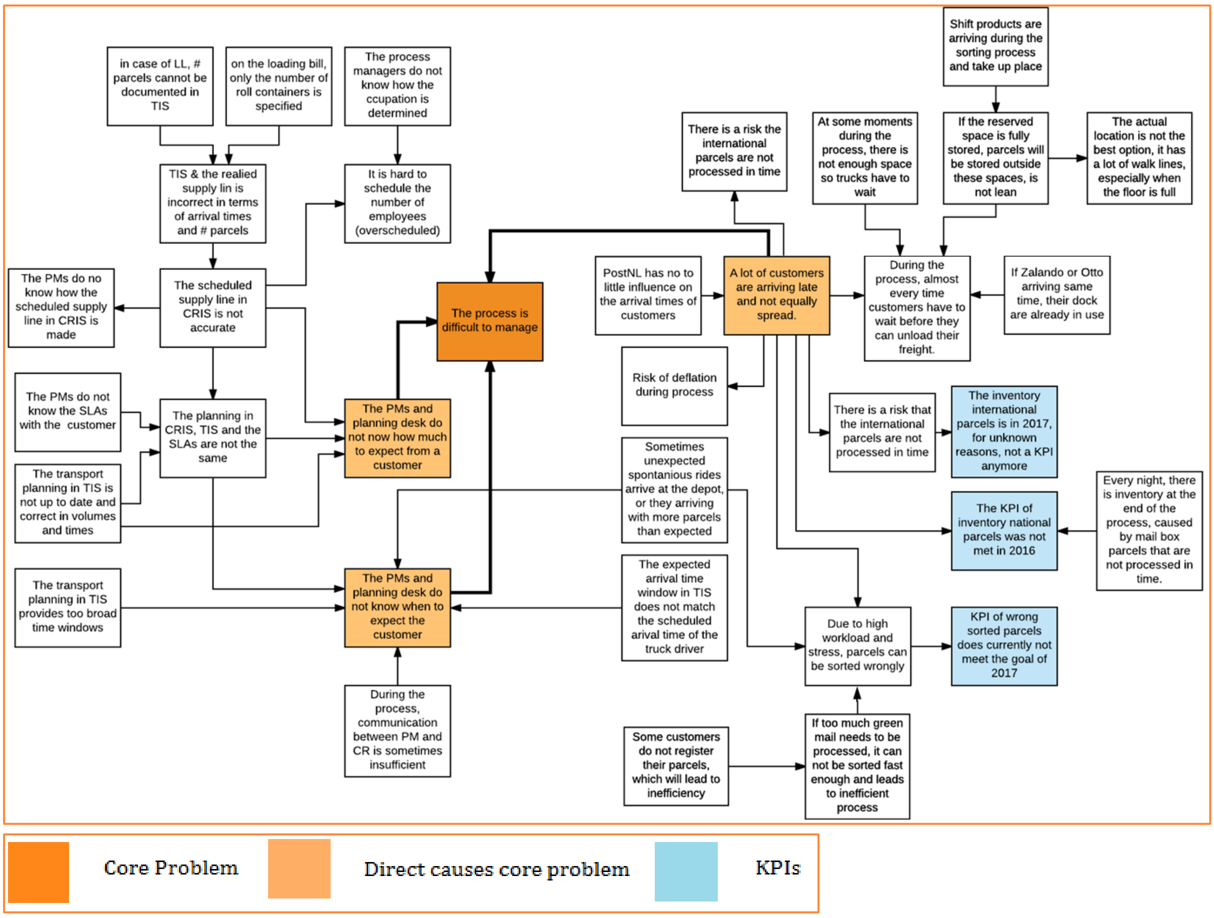


Figure II – Problem Knot

The core problem of the knot is identified as: the process is difficult to manage. This is a very broad and general "core problem", and therefore more attention must to be paid to the causes. The problem has several causes. The causes are clustered in three blocks, that are coloured light orange in the figure.

- The process managers (PMs) and planning desk do not know how many and what type of parcels to expect from a customer
- The process managers and planning desk do not know when to expect the customer
- A lot of customers are arriving late and not equally spread

With the AHP-method, five criteria that are important for the solution design were identified, prioritised on importance. After the AHP questionnaire, the interviewees also prioritised the criteria together in a meeting. They prioritised the criteria in following order:

1. Clear information about trends in arrival times and number of parcels from customers, these are forecasted more accurately than currently, but exact information is still missing. *(was priority 2 from AHP)*
2. Exact knowledge about the arrival times of customers is present, but the number of parcels per truck are unknown. *(was priority 1 from AHP)*
3. Exact knowledge about the number of parcels per truck from the customers, but the arrival times are unknown. *(was priority 3 from AHP)*

4. All the amenities are present to prevent an empty floor, but more knowledge about numbers of parcels and arrival times is not obtained. *(was priority 5 from AHP)*
5. All the amenities are present to prevent queues for trucks to start unloading, in terms of enough capacity on the floor and material handling hardware, but more knowledge about numbers of parcels and arrival times is not obtained. *(was priority 4 from AHP)*

Based on the process analysis and the problem knot, we now know what problems PostNL Hengelo experiences and what they desire to have involved in the solution design. Surprisingly, in contrast to management expectations, maximum capacity of the floor space is not the main problem focus. Better insight in information regarding the arrival is heavily more important.

Data analysis

Next, a data analysis is conducted, where we gained more information regarding the arrival of customers and the progress of the process itself. PostNL uses two systems that are used for the customer arrival process: CRIS (Control Room Information System) and TIS (Transport Information System). Both systems have their own pros and cons, however, we have concluded that both systems are not suitable for data analysis. Besides the lack of usability, we also concluded that the data PostNL uses is not accurate. This is problematic, since the data will be used for forecasting, what results in wrong forecasts.

Therefore, we have built our own *Conversion and Visualisation Model* (CVM), where we conversed the data in accurate information and visualised the process so that we can analyse and interpret it correctly. We have compared the three models' performances. The major downside of CRIS is that it only provides total volumes and no customer specific information. Therefore, it is already eliminated. The volumes of TIS and CVM are compared, with the following result.

Date	Volumes TIS	Volumes CVM	Real volumes	Best model (TIS or CVM)
19-dec	64,540	61,474	61,644	**CVM**
20-dec	67,634	63,564	65,173	**CVM**
21-dec	69,890	65,782	63,264	**CVM**
22-dec	58,742	53,442	58,329	**TIS**
...	...	...	...	**...**
20-jan	41,513	37,962	32,515	**CVM**

Table I - Volume differences between Management Information Systems

In total, in 22 out of 24 of the cases, the new built model for this research is more accurate version. Calculation of the Mean Squared Error on these different estimates of the real volumes shows us that our model is the most reliable estimator, since it has the lowest Mean Squared Error.

	Volumes TIS	Volumes CVM	Lowest MSE
Mean Squared Error	$66 * 10^6$	$17 * 10^6$	Volumes CVM

Table II - Mean Squared Error

Now that the CVM is proven to be a reliable model for data analysis, we have conducted two analyses:

- Customer arrival analysis

- Process model analysis

In the customer arrival analysis, we have searched for noticeable trends over a period of four months, including arrival times and volumes. In the process model analysis, we have analysed and visualised the process on daily level, to find the consequences of specific volumes and arrival times. The following conclusions were made:

- Considering the arrival times of the biggest customers (Otto, Zalando Erfurt and Arvato), no noticeable trends were found. Trucks of these customers arrive every day at different times, heavily spread over the evening.
- The number of parcels that are arriving per hour is heavily spread. The average supply per hour is not a reliable estimator.
- The freight per truck the biggest customers deliver is not consistent. There is no standard number of parcels per truck, and the average freight per truck is not a reliable estimator.
- Focusing on the process on a daily level: processes with the same total volume can work out extremely different, due to different arrival times of the customers. With only knowledge of an expected total volume for that day, no process preparation and management is possible. Information regarding the arrival times of (at least) the big customers is required.

Solution design

Now that we have concluded that no signs for trends were find considering our data, we know that we cannot rely on in-house knowledge and historical arrival times and volumes to predict the customer arrival. In the solution design, we provide the solution alternatives found, based on the three aspects of Operational Excellence (McKinsey, 2008): (i) the actual process; (ii) the capabilities and behaviour of involved stakeholders; and (iii) the involved management & information systems.

(i) Process

For this section, we again used the CVM. Two things were found that contrasted management expectations. First, we found that it is not possible to identify a fixed arrival time per weekday per customer. Secondly, we did find that arriving later, which is what the customers prefer, is beneficial for the process. This is surprising, since management expected that earlier arrival of customers would lead to a better process, which is not the case. However, it must be mentioned that it is only beneficial if it is known which customers to expect and when. These solutions are covered in the other two aspects of *operational excellence*.

For the current situation, shortening process times is not always beneficial or possible. However, we have seen that the possibilities for saving many costs are present. With further research and recalculation of better occupation and the tariffs, there are certainly possibilities for the management to benefit from shortening process times on the longer term.

(ii) Communication involved stakeholders

Throughout the research, we have concluded at several points that the communication and information stream is not sufficient. In fact, we consider this as the focus for the solution into solving the problem of a too difficult to manage the process.

For all stakeholders, recommendations are defined for providing each other with sufficient and the right information, so that PostNL Hengelo knows better what to expect and when.

All recommendations regarding improving the communication are adding value to the information streams. As concluded from the data analysis, it is hard to forecast the arrival times and volumes from the individual customers, since no trends are found. Therefore, it is important that PostNL Hengelo receives adequate information about the customers.

(iii) Information systems
During the process and data analyses, we have concluded that the current information systems are not sufficient for preparing and monitoring the process adequately. We already discussed our own built model, the CVM, which improves the accuracy of the data. Next to that, we also provide PostNL with several recommendations to improve CRIS and TIS, so that they will be more reliable.

The improvement steps for the information systems are assigned to the different stakeholders, that are responsible for executing the improvements.

Since we provided many recommendations regarding the stakeholders and the information systems, we have summarised them for the stakeholders by means of implementable steps, divided per ambition level. This way, the management of PostNL Hengelo has provided handles to start improving towards an optimal scenario. Each ambition level includes its own level of effort and time period. The recommendations include a stepwise approach that can be followed every day to optimise the preparation and management of the sorting process. The starting point lays at the management board of PostNL Hengelo. They are responsible for executing the steps.

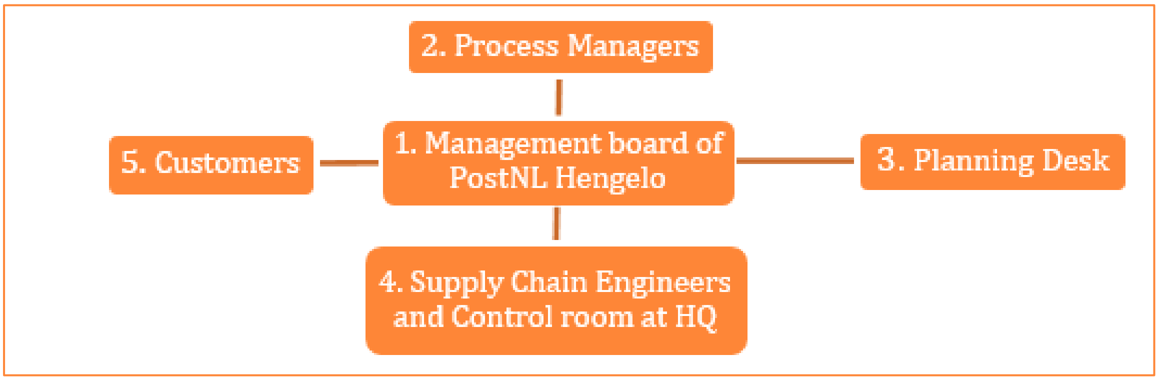


Figure III – Responsibility overview

The set of solutions provided covering all three aspects of the *Operational Excellence* (process, behaviour and information systems), provide PostNL Hengelo an adequate scenario regarding the arrival and processing of parcels that will enter the sorting process.

Preface

This master thesis is the final project of my degree in Industrial Engineering and Management at the University of Twente. During my studies, I developed an interest in logistics. I came in touch with PostNL, the logistic leader in mail and parcels, and my interest in the business started to grow. Therefore, I am very grateful for the opportunity to conduct my research at PostNL Parcels in Hengelo.

Conducting and finishing this report would have never been possible without the help of others. Therefore, I am using the opportunity to thank everybody directly and indirectly involved in the realisation of this research.

First, I would like to thank Henk Berendsen for realising my graduation internship at the depot in Hengelo, for all the effort, support and insights during my internship. Furthermore, I would like to thank Jeroen Bussemaker and all the other process managers and process supervisors for their effort, enthusiasm, and contributing to make it a fantastic experience. I believe I have developed myself at a professional and personal level due to their constructive feedback and guidance. And Soe Sahebzad, thank you so much for the female touch in this masculine world ;). I want to thank the whole team for giving me the great experience at PostNL, I have enjoyed every minute of it.

I also want to thank my supervisors at the University of Twente, Peter Schuur and Wieteke de Kogel-Polak. Their constructive feedback helped me to develop a critical view on my research and improve both the content and the structure of this thesis. And Peter, thank you for introducing me to the touristic hotspots from my hometown, I promise I will pay them a visit now I have finished my thesis.

Maaike Groot Dengerink

Enschede, 2017

Abbreviations and Definitions

Abbreviation	Explanation	Explanation in Dutch
CRIS	Control Room Information System	Control Room Informatie Systeem
CVM	Conversion and Visualisation Model	Conversie en Visualisatie Model (our own built model in Ch. 6)
HFD	The headquarters parcels at Hoofddorp	Hoofddorp
HGL	The depot in Hengelo	Hengelo
NMG	Not suitable for the sorting machine	Niet machine geschikt
SBS	Sorting Decision System	Sorteer Beslis Systeem
TIS	Transport Information System	Transport Informatie Systeem
T&T	Track & Trace	Track & Trace

Corlettes	Cages where plastic bags parcels are transported in. About 600 bags will go in one corlette and is mainly used by customers of clothing stores.
CRIS	In CRIS, the scheduled and realised supply and processing lines are shown. The processing of parcels is visualised in a graph.
Customer	PostNL considers the sender of a parcel as customer, since this is the party who pays for the service.
Depot+	An extended depot with an extra cross dock which contributes to a more efficient transportation process.
Distribution process	The second phase of the whole process in the morning, were parcels will be sorted based on delivery route. They will directly end at the chute of the right deliverer.
Filling level	For every customer, a filling level is calculated. This means the standard number of parcels per grey container, which will be used in calculations for scheduling and forecasting.
Green mail	The address and the barcode of the parcel are not linked to each other, so the parcel is not recognised by the machine.
Lean Principle	The lean principle is developed by Toyota and aims to realise maximum value for the customer and eliminate waste. In the depot, there are several lean activities introduced.
Loose Loading	Parcels are stacked individually in the truck arriving at the depot, and will be unloaded at specific docks with special roll out conveyor belts.
RC equivalent	Equivalent which states the number of standard grey roll containers will fit in a particular size of trolley, based on the number of parcels. Next to that, for every customer there is a standard equivalent calculated of number of parcels per grey container, the filling level.
Service Level Agreements	Contracts made with the customers about the quantity, frequency and arrival times of the parcels in the sorting process.
Shift products	After being sorted per depot and shift, PostNL calls the parcels

	shift products. The shift products will be transported to the other depot for the distribution process.
Sorting process	The first phase of the whole process during the night, were the unsorted parcels are delivered directly from the customer and will be sorted on depot nearest to the receiver of the parcel.
Supply Chain Engineers	This department is located at the HQ in Hoofddorp and is responsible for the planning and control of the logistics during the sorting process.
Supply Line	*Aanvoerlijn.* This line shows the input of parcels for the sorting processes.
TIS	TIS registers all the transport information, regarding the scheduled and arrived trucks and its truck load.
Planning desk	Employees who will handle the arrival of trucks and registration of parcels during the sorting and distribution process.
Processing line	*Verwerkingslijn.* This line shows the progress of the sorting process.
White mail	The parcel is already submitted in the system, so the combination of the address and barcode is already known. By scanning the barcode, the machine knows automatically the destination of the parcel.

Table of Contents

1. Introduction

In the framework of completing my masters study Industrial Engineering and Management at the University of Twente, my research will be conducted at the PostNL Parcels depot in Hengelo, the Netherlands. During this research, we will consider the arrival and dispatching of parcels and the sorting process during the evening. In section 1.1 we give an introduction about PostNL in general and about the PostNL Parcels depot in Hengelo. Section 1.2 contains the motivation of the research, followed by the problem statement in section 1.3. Section 1.4 explains the research question and sub questions. In section 1.5 we set the scope of the project and show the research deliverables in section 1.6. We end this chapter with the outline of the thesis in section 1.7.

1.1 Introduction PostNL

1.1.1 PostNL Netherlands

Although PostNL was officially founded in 2011 as a standalone company, it has a long history. PostNL is formerly part of the state-owned company PTT, which was founded in 1928 and was privatised in 1989. Thereafter, the company has undergone several changes in name: Because of the take-over of the Australian TNT, PTT Post became TPG (TNT Post Group) in 2002 and renamed to TNT Post in 2006. In 2011, TNT Express was demerged from TNT N.V. and PostNL was confirmed as the new name for the remainder of TNT Post. The main reason for this split was the difference in business activities, where the focus of PostNL lays on the Dutch post market.

Figure 1.1 - International network PostNL (PostNL Annual Report, 2015)

PostNL has three core business segments: mail in the Netherlands; Parcels; and International Activities. The headquarter of mail, international activities and corporate activities, is located in The Hague, while 'parcels' has its own headquarters in Hoofddorp. PostNL is the leading mail and parcels solution provider in the Benelux and holds number two positions in Germany and Italy. Next to that, PostNL has Spring, which is a network of global delivery solutions active in thirteen countries. The international network of PostNL is shown in figure 1.1.

PostNL Parcels is the fastest growing business segment, with a total growth of 9.6% to 156 million parcels over the year 2015. The revenue has grown from € 854 million in 2014 to € 917 million in 2015. Looking at the volume developments, this growth will continue for the coming years. The volume development for parcels over the last 16 years is shown in figure 1.2.

Because of this growth, in 2015, 18 Parcel sorting and delivery centres were established and still counting. These depots all have the same layout and will conduct a sorting and a distribution process including loading and unloading of the trucks and vans. 4 from these depots are called Depots+. They are extended with an extra cross dock which resorts the trucks during the night for an efficient transportation process. This way, no transportation between every depot is needed; they can distribute the parcels via a Depot+. Hengelo is not a Depot+.

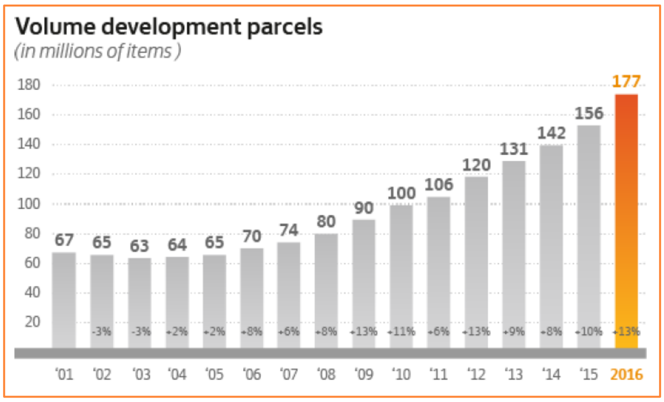


Figure 1.2 - Volume Development Parcels

1.1.2 PostNL Parcels in Hengelo

The depot in Hengelo was established in 2011 as the third depot ‘new style’ in row. Because of the location near to the German border, Hengelo processes a lot of PostNL’s big German customers, such as Otto, Arvato and Zalando, who are having a big part in the total volume parcels processed in Hengelo. It also makes their process different than other depots, since the delivery will be different than other clients.

Just like the national volume of parcels, the volume processed in Hengelo has increased as well. The percentage of growth over the last year is 13.3% to 177 million parcels in 2016.

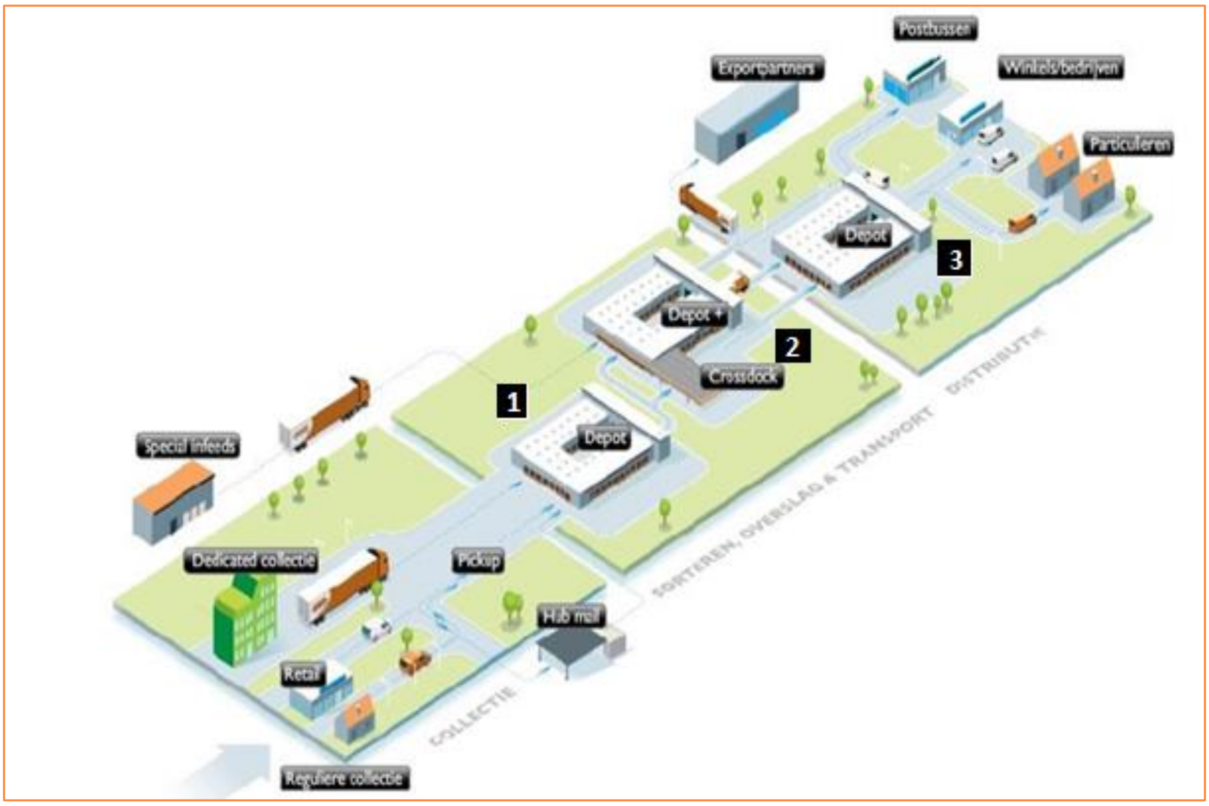


Figure 1.3 – Overview of the sorting process of PostNL (PostNL Hengelo, 2016)

Due to this fast growth, Hengelo faces several difficulties during the sorting and distribution process, which consists of two parts. The first part, the sorting process, will sort all the incoming parcels from the customers. Here, Hengelo is depot number 1 in figure 1.3. These parcels will contain the German customers as well. Parcels will come in various ways: in containers, pallets or corlettes and via loose loading. Corlettes are cages in which small plastic bags will be stored, instead of parcels. Loose loading means that with an extra-long conveyor-belt, the parcels will be directly processed from the truck to the sorting machine. These parcels are individually stored in the truck, instead of in containers. Examples of a corlette and loose loading can be found in figure 1.4 and 1.5.

Figure 1.4 – Corlette

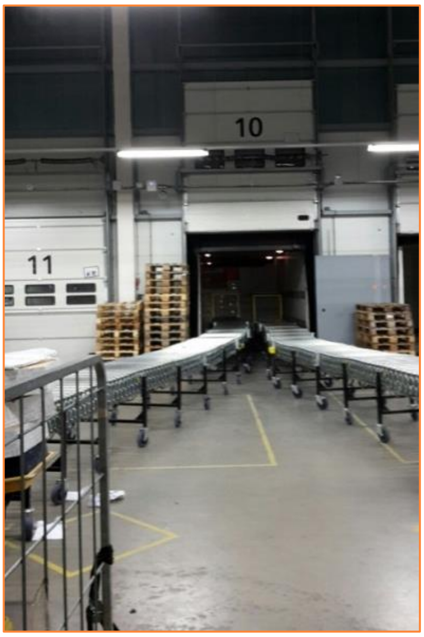


Figure 1.5 - Roll-out conveyor belt into loose loaded truck

Between 19:00 and 02:30, the parcels will be sorted and distributed to the depots nearest to the receiver (number 3 in figure 1.3). The transport will go through a depot+ (number 2 in figure 1.3), to centralise the process and reduce the number of transport routes. In the distribution process in the morning, these parcels will be sorted into the delivery routes. This will be done from 07:00 till 11:00 and will sort the parcels into the routes for the drivers.

The parcels for the sorting process will be delivered from around 11:00 in the morning till late during the sorting process. The timing and control of the parcel's arrival at the depot face some difficulties for PostNL where we will conduct our research on.

1.2 Research Motivation

During the past years, PostNL Parcels has increased drastically and it will continue to grow in the coming years. To maintain the process during this growth, the process needs to be executed in the optimal way. The sorting machine can maintain the growth for quite some time, but the floor space is on some moments occupied with no ability to store more parcels.

Currently, the perception of the process managers is that the reserved space for incoming parcels and sorted parcels is occupied at several times. At these moments, the process manager designates other free spaces to use temporarily. However, these spaces are not fixed and can cause disorder during the process. Next to that, it is not according to the lean principles of PostNL. To be able to use the space optimally and create a more efficient sorting process, we should search for the causes of this problem.

Partly this is due to the maximum total space available, but looking at the overall occupation during the process, there are moments that the floor is almost empty. This is because the arrival of parcels from the customers is not optimal; there is no constant arrival rate. The big problem here is that PostNL Hengelo, but also the headquarters of PostNL Parcels in Hoofddorp, have no idea about when the customers will arrive during the sorting process. Because of this, no optimisation has been achieved yet.

PostNL Hengelo eventually wants an optimal use of the floor space and wants to arrange the process in such a way that it can maintain some growth. To realise this, the sorting process and its parcel supply needs to be known, controlled and optimised. First the arrival information needs to be organised and used well, and secondly the process can be optimised. This way, despite the variable parcel supply, the use of the floor space is ready to be fully optimised.

For PostNL Hengelo, it is important to process all the parcels before the end of the process, because the maximum transit time of a parcel is 24 hours. This means from the moment the parcel arrives at one of the depots of PostNL (or is being collected by a PostNL driver at the customer); PostNL has 24 hours to deliver it to the end-customer, the receiver. For the sorting process at PostNL Hengelo, this means all the incoming parcels need to be sorted and discharged to the next depot before the end of the process, around 2:30.

1.3 Problem Description

At this moment, PostNL Hengelo experiences the problem that the scheduled supply line of the parcels is not consistent with the actual parcel arrival, so the parcels will not arrive on the agreed time and with the agreed volumes. The scheduled supply line is created by the supply chain engineers, at the HQ in Hoofddorp. This line is based on historical data in a system CRIS (CRIS will be explained in Chapter 3).

Based on the scheduled supply line, the process managers at the depot make a scheduled processing line in CRIS and the occupation of the employees will be determined. However, when the scheduled supply line is not correct, this planning will also not be feasible. Also, when customers inform the depot with wrong data in time and numbers, they could never adapt their planning to the actual parcel supply, especially when the number of parcels is more than average. Because of these problems, ad hoc changes need to be made regularly. Next to that, it can occur that there is not enough space left for the arriving parcels, because the supply is higher than the processing capacity.

It is hard to change the arrival of the parcels, since customers are big players and do not want to adjust the arrival of their parcels in their disadvantage. However, PostNL Hengelo is currently clueless about the size of this problem and what would be needed to fix this. They want to have insight in the actual problem, and wish to obtain a solution model of the ideal situation and recommendations about how to achieve this situation.

PostNL Parcels Hengelo first wishes to identify where lay the exact errors and what are the causes. What is agreed on, what is scheduled and what is realised? At this moment, there is too much indistinctiveness. Their perception is that there are problems with the capacity of the floor space, but it needs to be investigated of this is the core problem or not. When this is clear, PostNL wants to see what the requirements of an adequate scenario would be and how to achieve less uncertainty during the process. They want recommendations on how to achieve this adequate scenario and how to deal with the uncertain planning. What could PostNL change so that the process can be conducted more efficient and certain?

At the depot in Hengelo, it is already known that the unknown arrival times and numbers are causing problems, but they do not know how big this problem is and how often it occurs. They want to have insight in what an adequate process would look like. Even though they know it is not achievable to control all the arrival times of customers, with an elaborated solution they have bigger bargaining power. Next to that, they want to know what they can do to achieve an optimised process, despite the unknown arrival times.

1.4 Research Setup

Based on the problem statement described in section 1.3, we formulate the main research question to reach the problem statement as follows:

"What would be an adequate scenario for PostNL Hengelo regarding the arrival and processing of parcels that will enter the sorting process?"

An adequate scenario for PostNL is considered an ideal situation, taking into consideration that some external factors cannot be fully influenced.

To be able to answer this main research question, several sub questions were formulated with the aim to give a deeper understanding of the research. For each sub questions, a brief description is given.

1. **What is the current sorting process at PostNL depot Hengelo and what problems do occur?**
   - 1.1 What is the current process at PostNL depot Hengelo and what problems are observed?
   - 1.2 How is the management and information control of the sorting process organised?
   - 1.3 What is the role of the stakeholders?

To be able to find the core problems and conduct our research, we need to investigate the current process, focusing on the arrival of parcels during the sorting process. This will be done by analysing three steps of Operational Excellence (McKinsey, 2008). Question 1.1 is treated in Chapter 2, question 1.2 is answered in Chapter 3 and question 1.3 is discussed in Chapter 4. All the identified problems are summarised and organised in a problem knot in Chapter 5.

2. **What is an appropriate model to quantify and measure the observed problems?**
   - 2.1 What does the model for process visualisation look like?
   - 2.2 What analysis methods does literature give us?
   - 2.3 What is the current performance of the arrival process?

To optimise the process, the problems need to be identified. Since the sorting process is a complex process, we downsize it by making our own conversion and visualisation model (CVM) where we can identify the problem areas. With the theory from the literature, that we provide in Appendix V, we build the CVM and analyse data in Chapter 6. With this data analysis, we can test the current performance of the arrival process.

3. **What options can be distinguished to cope with the problems associated with the arrival process and what are their pros and cons?**

This question will be partly answered via the data analysis in Chapter 6. Other options are provided in the solution design in Chapter 7.

4. **What are the recommendations for PostNL Hengelo to bring their process towards the ideal situation?**

In this question, we provide PostNL Hengelo with recommendations based on the observations, the data and the theoretical background gained in the previous questions. With the recommendations, we will bridge the gap between the current situation and the ideal scenario. This is done in the solution design in Chapter 7 and concluded in Chapter 8.

1.5 Research Scope

To obtain focus in this study, it is important to introduce some restrictions and limitations. This study will be conducted at the Parcels Depot of PostNL in Hengelo. Therefore, the process analysis will be conducted here and the solution must be applicable at this depot. However, some departments from the headquarters in Hoofddorp will be involved in the process and have their interests and input regarding the problem. We will include these departments in our study as well when necessary.

Within the process in Hengelo, the study limits itself to the parcel arrival of the sorting process. The arrival of the parcels will already start before the actual sorting process and its origin lays outside PostNL Hengelo, as well as some involved stakeholders. However, PostNL Hengelo wishes to obtain an adequate scenario of the process, and recommendations on what is needed to get there.

Considering the customers, during the research we are not able to contact them or change their behaviour extremely. However, we can provide PostNL with recommendations that need to be discussed with the customers.

While identifying and visualising the actual problems, the focus need to be on several aspects of the PostNL service. For the management, these aspects are also covered in KPIs, which we will discuss in Chapter 3.

- Quantity of the parcels: PostNL expects to grow more and more the coming years, and Hengelo wants to be able to handle some more growth.
- Quality of sorting: At the end of every discharge chute, the parcels will be sorted manually over three or four containers with different destinations. If this is done wrongly, parcels will arrive at the wrong depot.
- Time of arrival of parcels: Is the arrival time as agreed with the customers or as planned and if not why? When arrival time is too late, parcels cannot be processed on time.

All these aspects have the same consequence if they are not met, the maximum transit time of a parcel will not be met. <u>PostNL has the main goal that the maximum transit time of a parcel is 24 hours.</u> This means that, starting from the moment the parcel arrives at the depot from the customer, PostNL has 24 hours to deliver it to the end receiver. We also retrospect these parameters in the KPIs of PostNL. If the process is not managed adequately, this goal will not be achieved.

To first identify the problems in the process and develop alternative approaches, a suitable dataset needs to be used. Since the current data is not accurate enough and correct, which will be explained later, we need to create our own dataset to model the current process. This own conversion and visualisation model will be called CVM. Next, we can identify the problems and collect input for the solution design.

We will not focus on the internal logistic problems during the sorting process. There are also problems experienced considering the internal logistics during the process. However, these problems can only be identified and solved when the parcel arrival is controlled and optimised. Since this is the goal of the research, we only focus on this supply during this study.

Although the parcels for the distribution process already sorted in other depots also arrive during the sorting process, we will not take these into account in our solution design. The data we analyse in the study are the parcels straight from the customer that need to be sorted during the sorting process. The parcels that are sorted at another depot and arrive at Hengelo already for the distribution process, have a totally different logistic network with their own rules and restrictions. It is not possible to include these in the study without considering the whole logistic network of PostNL through the Netherlands. We will show in the process model what the influence is of these parcels, called the shift products, on the total floor space, but we will not involve it in our solution design.

1.6 Research deliverables

This research aims to achieve the following deliverables:

- An own built conversion and visualisation model, where we converse the data to make it more accurate and visualise it for data analysis.
- Visualisations for data analysis to show noticeable trends in customer arrival and the process progress.
- Recommendations on how to get the current process towards the ideal scenario. These recommendations are based on the three lean perspectives, which also described the whole process analysis. Recommendations will be given based on the actual process; for the use of management and information systems; and on communication and behaviour of all the stakeholders. The three lean perspectives are further explained in Chapter 2.
- Within the recommendations, a daily stepwise approach is given for preparing and managing the process.

1.7 Outline of the Thesis

The remainder of this thesis is structured as follows. Chapter 2, 3 and 4 and 5 describe the current sorting and distribution process, with an in-depth description of the sorting process and its stakeholders. In Chapter 2, we focus on the actual sorting process. Chapter 3 describes the management and information systems used regarding to the process. Chapter 4 discusses the involved stakeholders and their view on the problem. Chapter 5 summarises all the problems and aims to find the core problem. In Chapter 6 a data analysis is conducted by modelling the process and identify the problem areas from the data analysis. These chapters are followed by a solution design for PostNL in Chapter 7. We conclude this thesis with a conclusion and recommendations in Chapter 8. Appendix V describes the relevant literature and theoretical background for the approaches used in Chapter 4, 5 and 6.

2. Process Analysis

In this chapter, we introduce the three aspects of operational excellence strategy from McKinsey which PostNL Hengelo uses. This is explained in section 2.1. In section 2.2, we start discussing the first aspect of this strategy: the current process, which consists of the sorting process and the distribution process. Next to analysing the current process, we also identify the observed problems during the process. We conclude this chapter in section 2.3.

2.1 Lean at PostNL Hengelo

At PostNL, Lean is an important factor and strategy to achieve improvements in the process. At the depot in Hengelo, the Operational Excellence strategy from McKinsey is an important strategy they keep in mind. McKinsey states that in order to succeed in implementing lean, they don't recognise how management information systems or employee mind-sets might undermine them (Fine, Hansen, & Roggenhofer, 2008).

It is important for PostNL to not look only at the operating process itself, but also at the underlying information systems and employees. McKinsey comes up with a lean model which consists of those three aspects in an organisation: processes; management systems and behaviours (Excelr8, 2013). With the *process* is meant the actual process, or as McKinsey (2008) states: "The way corporate resources are deployed to meet customer needs at lowest costs". For PostNL Hengelo, we will discuss the core sorting processes and logistics. This is treated in the present chapter. The *management systems* are used to define what the process will achieve and how it should be controlled (Excelr8, 2013). These are discussed in Chapter 3. PostNL uses several different systems to schedule and monitor the whole process. To achieve operational excellence, these systems must be used in a correct way. This also leads us to the last factor of McKinsey's lean model: *behaviour*. Behaviour is about ensuring that the management systems are functioning as needed and is used to control the process (Excelr8, 2013). It also includes the way people think and feel about their work, their capabilities and how they conduct themselves in their workplace (McKinsey, 2008). The behavioural aspect is explained in Chapter 4. The three pillars are strongly connected to each other. If all the pillars are included in the lean strategy, operational excellence can be achieved, see figure 2.1. To make sure all three aspects are covered, the current process and its problems are described based on this model.

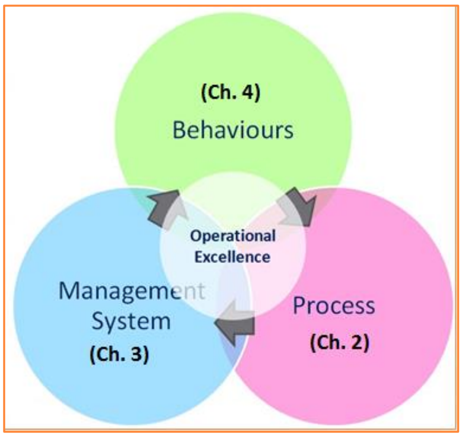


Figure 2.1 - Operational Excellence with Lean (Excelr8, 2013)

2.2 The Sorting Process at PostNL Hengelo

The parcel depot has several processes, but the actual process of when an ordered parcel needs to be transported to the receiver consists of two processes; the sorting process and the distribution process. The sorting process is the first sorting round, where parcels from the customers (for example a web shop) are being offered at their nearest depot of PostNL. There, the parcels will be sorted by the depot which is the nearest to the parcel's destination. During the night, all the parcels will be transported to the that depot. There, the second process will take place, to sort per delivery route. This is done in the morning, so that the deliverers can drive to their end customers during the day. Our research is conducted on the sorting process. To fully understand the sorting process during this research, we first briefly explain the second sorting process, the distribution process in section 2.2.1. All processes are connected to each other and cannot be seen as individual stand-alone processes. Thereafter we dig deeper into the sorting process in section 2.2.2, where the focus will lay on for the rest of the research.

2.2.1 Distribution Process

Even though the distribution process happens after the sorting process, we discuss the process first. The distribution process will be the better-known process; the sorting process preparing the delivery of parcels. During this process, all the parcels from the sorting process will further be sorted for distribution to the receiver. The parcels to be handled are coming from the other depots, and the parcels that remained on location in Hengelo after their own sorting process.

The parcels are being delivered from 23:30, which is still during the sorting process that ends around 02:30, till 07:00. During the distribution process, the parcels are sorted and arranged per shift. By shift is meant a time period of 30 minutes when the parcels will be processed for the drivers at the discharge chutes at that moment. Every shift will use half of the total number of discharge chutes. This is done so that the driver for the next shift can already prepare at the other chutes. This way, the processing of parcels can go on continuously. In total, 8 shifts will be handled during the distribution process. All shifts have their own section on the floor reserved for the unsorted parcels. These sections are shown in the floor plan in figure 2.2.

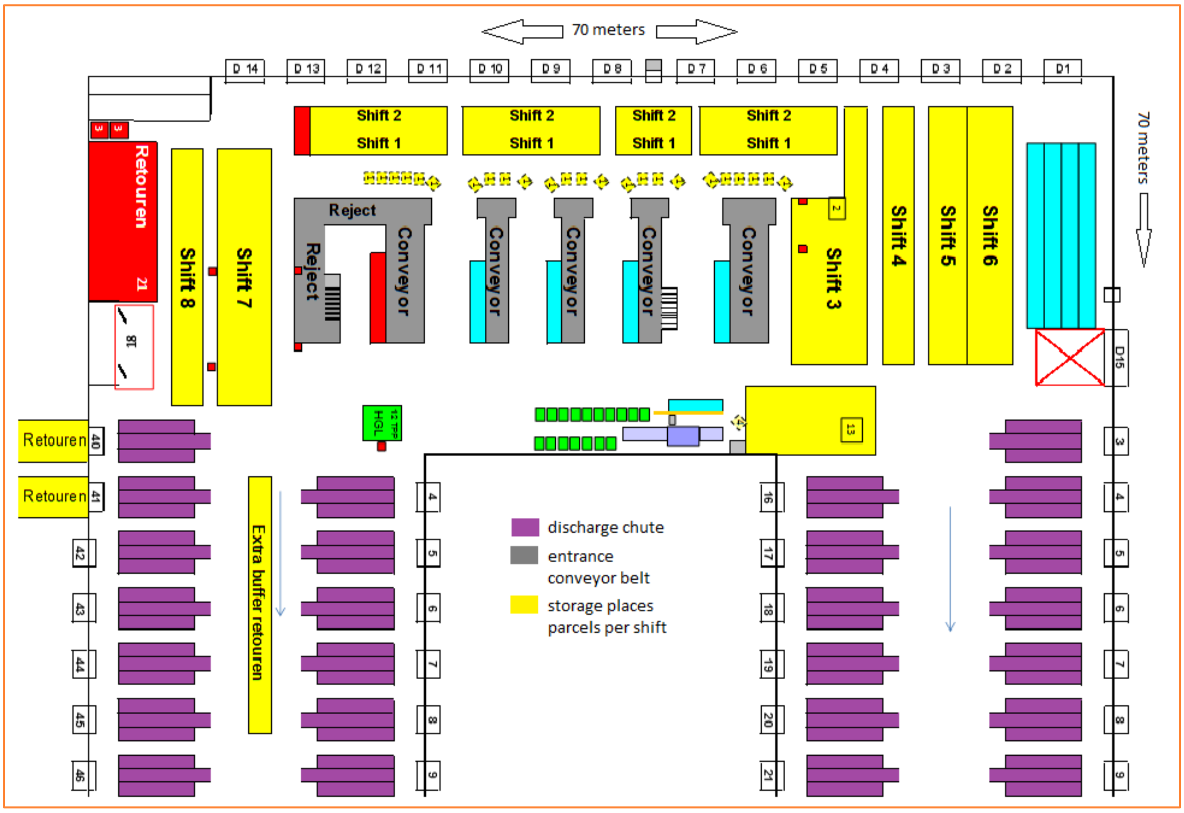


Figure 2.2 – Simplified floor plan during distribution process (PostNL Hengelo, 2016)

The building is 70 meters by 70 meters. The yellow spaces show the spaces used for the shifts. For a detailed floor plan, see Appendix I. From 7:15, the first shift will be processed by carrying the parcels on the conveyor belts. These are shown in the grey areas. The conveyor is a closed loop up in the air, and the discharge chutes are located in both sides of the area, and are the purple blocks. A picture of the conveyor belt and some discharge chutes is shown in figure 2.3. Shift 1 is already in place to be processed, shift 2 is buffered right behind it. When shift 2 is ready to be processed, it will move to the front, and shift 3 will be transported to the initial section of shift 2. This will be done by the internal transporters, who also remove empty containers.

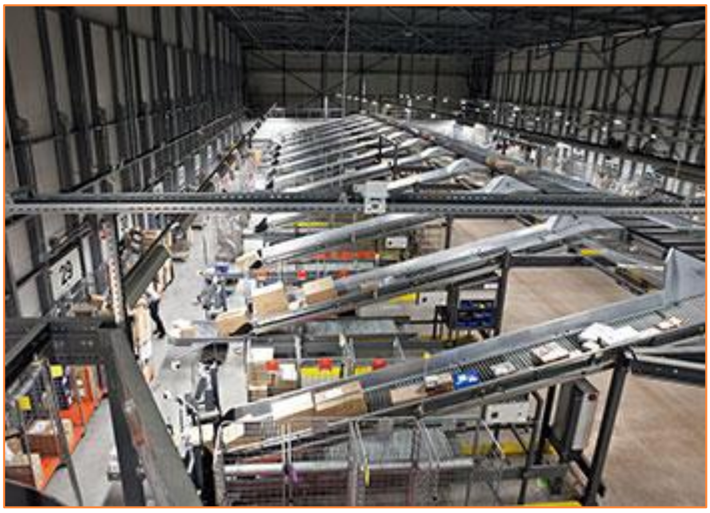


Figure 2.3 – Conveyor belt and discharge chutes at PostNL

When the parcel is on the conveyor, it will be moved into the right place, weighted, measured and scanned. For the parcels that cannot be scanned, the address needs to be checked manually. In Manilla, in the Philippines, employees will read the address, register it manually and return this information to the depot. This will take no more than 4 seconds.

When the destination of the parcel is known, it will be transported to the right discharge chute at one of the two sides of the building. In figure 2.2, the discharge chutes are the purple blocks. At these places, the deliverers will collect the parcels and pack them immediately in their van.

We recall figure 2.2, where we see the depot has two side corridors with discharge chutes. The corridors will continue further than is shown in the figure. During every shift, only one side is in use, so that on the other side already preparations for the next shift can take place.

Sometimes, external error runners do occur. These are parcels that are sorted wrongly during the sorting process, with the result it ended up in the wrong depot. These parcels need to be sorted again during the evening and then send to the right depot.

In total the depot has five entrances for the conveyor belt (the grey blocks in figure 2.2), where the capacity is for 12 employees to work at. One employee can process around 850 parcels per hour, but since the conveyor belts are not always fully occupied, the planning is to process around 8.000 parcels per hour. However, the machine can handle up to 15,000 parcels per hour, so there is space for expansion. The time from the conveyor to the last discharge chute is 1.5 minutes.

Next to the process in the morning, the distribution process also consists of an afternoon distribution process. At the end of the afternoon, the same-day-delivery parcels and the parcels for evening delivery will be processed. These parcels will arrive during the day and at 17:30, they will be sorted. This is a much smaller process with other routes. Since the routes change every day and input information is available in short time, they automatically plan the optimal routes every single day. The sorting process cannot start earlier than 18:00 because of the occupation of the line for this process.

2.2.2 Sorting Process

From 19:00, the sorting process will start. The trucks with the parcels for this process will arrive from 11:00 in the morning till during the process, mostly around 1:00. Most parcels will arrive on pallets or containers, but they can also arrive in corlettes or via loose loading. At the moment the truck arrives, the planning desk will register its arrival including the number of containers. At the planning desk, two or three employees will handle all the arrivals and registration tasks of the customers and parcels. Since they have a core role in the sorting process, their exact work tasks are explained in Chapter 4. This registration process will be further explained in Chapter 3.

At 19:00, all the parcels are already transported in containers to the section right behind the conveyors. The internal transporters will make sure the containers will be ready to be sorted. Employees will distribute all the parcels on the conveyor. Internal transporters will make sure the containers will be transported near to the conveyors and make place for new load. There are two kinds of parcels which need to be processed on the conveyor: the white and green mail. White mail is called all the parcels coming straight from the customer, merely web shops. The destinations of these parcels are already registered and therefore easy to recognise for the sorting machine. The combination of the address and barcode is already known. By scanning the barcode, the machine knows automatically the destination of the parcel. Green mail are the parcels which are collected at postal offices, mostly sent by individuals. When the address of the parcel cannot be read by the machine, a picture of the address will be send to Manilla. The parcels which cannot be read are not reported yet, which means the address is not reported to PostNL by the sender. Parcels from big customers, which are already submitted in the system, are called white mail.

Since the green mail causes a higher workload in Manilla, the depot tries to maintain this workload by processing the green mail step-by-step together with the white mail. Employees of the plan desk will instruct the drivers at which entrance they need to unload. This is based on the amount of space on the floor.

All the parcels will be sorted based on the depot they need to go for the second process, the distribution process. Most parcel will be distributed to the other depot via the cross dock of a depot+, to make the transport more efficient. However, this is not achievable for all depots, because then the trucks won't be on time for the distribution process. Therefore, we also distribute directly to some depots.

When the parcel is on the conveyor and the destination is known, it will be transported to the right discharge chute. At the end of the chute, a sorter will sort the parcels in the right container. These containers not only show the depot destination, but also sorts in the shift the product will be processed during the distribution process. This is shown in figure 2.4. It shows the same floor as in figure 2.2, but with different arrangement of the floor space. The detailed floor plan can be found in Appendix II. Full containers will be distributed to the Outgoing sections, based on the destination depot. The containers will be buffered here until they will be picked up for transportation. Most of the times, it will be combined by an unloading truck. The pick-up normally will start at 23:30.

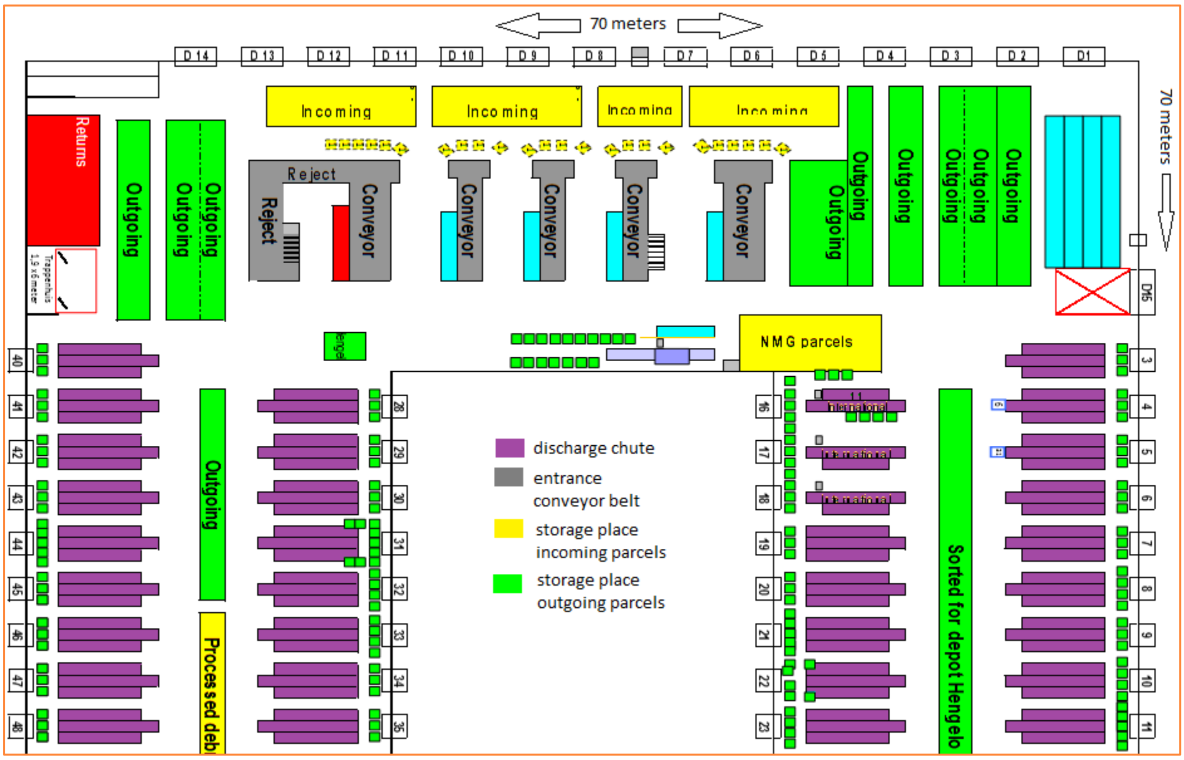


Figure 2.4 - Simplified floor plan during sorting process (PostNL Hengelo, 2016)

Digging deeper into the arrival process of the parcels, the flow chart in figure 2.5 gives a clear overview.

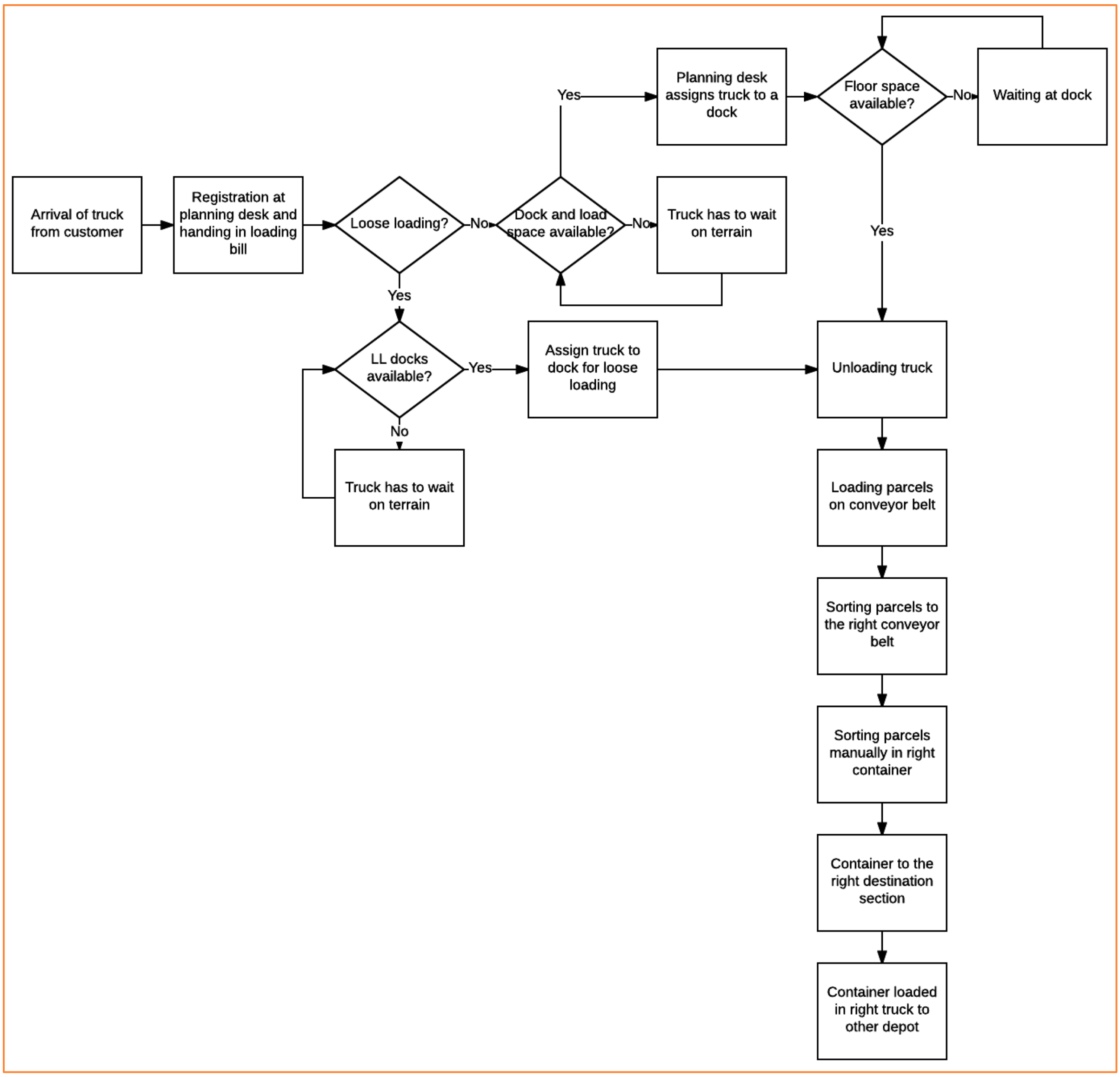


Figure 2.5 – Flowchart of the sorting process at PostNL Hengelo

When a truck arrives at the depot, it will call the planning desk at the gate. They will mark the truck in TIS, the transport system as arrived. TIS is a registration system in which all the data of the scheduled trucks and the arrived trucks will be collected. It is further explained in Chapter 3.

The truck will hand over its loading bill to the planning desk, which will be registered in TIS as well. The planning desk will check if there is a dock available for the truck to unload. If not, the truck must wait on the terrain before it will be assigned to the right dock. Some customers have special docks reserved, for example if they carry loose loading. Since loose loading only can be processed at specific conveyor belts, the truck needs to go to the nearest dock. These conveyor belts are further appointed in Chapter 4. When standing at the dock, it can be possible that there is no floor space available. In that case, the truck should wait for unloading until there is enough floor space. The arrival time which is registered in TIS is the actual time the truck arrives at the depot, but it is possible that the actual unloading time is much later.

From the start of the sorting process, there exist two distribution lines. The incoming, unsorted parcels, and the sorted parcels ready for departure. During the evening, a third distribution line will occur. This mostly happens around 21:30, but the exact time is only known around two hours in advance. The third distribution line are the parcels sorted in another depot, and need to be distributed in Hengelo in the morning, during the distribution process. These products are called shift products. The problem with this flow is that there is no special place reserved for these products, as can be seen in the floor plan we recall in figure 2.3. If possible, space will be made on the floor, by sharing the outgoing spaces for example. However, when there is no space available, the truck must wait with the unloading process. This can be problematic, since it is expensive, inefficient, and not lean. Additionally, it can delay the further route of the truck.

During the sorting process, also the debrief process takes place. During this process, the parcels which could not be delivered to the receiver will be collected. Till 22:00, the receiver can indicate when they want it to be delivered for the second time. After 22:00, these parcels will also be processed in the sorting process. This cannot be done all at once, because they don't have enough capacity at the discharge chutes to process them that fast, since these parcels are all for Hengelo and go to the same discharge chutes.

2.3 Conclusions

In Chapter 2, we have introduced the term Operational Excellence from McKinsey (2008). They state that to achieve operational excellence, 3 pillars must be covered: the process itself; its management information and systems; and the behaviour, mindset and capabilities of their stakeholders. Therefore, we will conduct our research via these three pillars, in order to achieve operational excellence.

Then, we have analysed the first part of the three pillars of operational excellence: the actual process. The process of PostNL consists of two parts: the distribution and the sorting process. Our research focusses on the sorting process, which is the first round of sorting the parcels from the customer till depot level. The process takes place every weekday from 19:00 till 02:30. This means that the last truck with sorted parcels must leave the depot at 02:30 in order to make it on time to the other depot for the distribution process over there. In this chapter, we have explained in detail the process itself. In follow-up of this chapter, in Chapter 3, the involved systems and management information are analysed; and in Chapter 4 the most important stakeholders and their role are explained.

3. Management and Information Analysis

The management and information analysis consists of two parts. In the management analysis, we look at the KPIs related to this problem that the management must achieve and if they are achieved last year. This is explored in section 3.1.

In Chapter 2, the parcel supply process is already described briefly. In this section, the used systems and involved management information is further analysed. In section 3.2, the planning of the sorting process is explained. This is done by mentioning all the methods and software used for this. After that, in section 3.3, the methods used for controlling and monitoring the sorting process are discussed. In section 3.4 we explain the relationships between these systems, followed by the inaccuracies these systems cause during the process in section 3.5. The chapter is concluded in section 3.6.

3.1 Management Analysis

The management of PostNL Hengelo keeps track of their performance via KPIs of their processes. As stated in the problem description, PostNL has the experience there are problems in the sorting process. With the KPIs of the sorting process, we can analyse if they perform below the standard. From the many KPIs installed, three are relevant considering this research:

- *1. Inventory of national parcels*
  The KPI shows the percentage of the total number national parcels which was not processed in time to be transported to the second depot for the distribution process.
- *2. Incorrectly sorted parcels*
  This KPI shows the percentage of the total number sorted parcels which is sorted incorrectly, and therefor arrive at the wrong depot. PostNL Hengelo considers this as the most important KPI of all three. A wrongly sorted parcel means that it arrived at the wrong depot and needs to make a lot extra transport lines, which have bigger consequences than a parcel in inventory, and the extra costs will be higher too.
- *3. Inventory of international parcels*
  The KPI shows the percentage of the total number international parcels which was not processed in time to be transported to the second depot for the distribution process. Since the discharge routes for international parcels have different departure times then national parcels, it is considered as an individual KPI.

In table 3.1, the KPIs of the sorting process and the scores of the past year can be found. Also, the total of KPI 1 and 2 is monitored. The red marked percentages show which goals are not achieve or will not be achieved in the future. The extended version of the KPI scores can be found in Appendix III.

	KPI Total of 1 and 2	1. Inventory of national parcels	2. Incorrectly sorted parcels	3. Inventory of international parcels
Score 2016	0.63%	0.11%	0.52%	0.09%
Goal 2016	0.65%	0.10%	0.55%	0.50 %
Goal 2017	0.53%	0.10%	0.43%	*Not a KPI in 2017*

Table 3.1 - KPIs of the sorting process

The KPIs are all scored in percentages, the total numbers are unknown. The table shows that two KPIs have achieved the set goal of 2016, as well as the total of KPI 1 and 2. Both the KPIs of inventory International Parcels and Incorrectly Sorted Parcels have achieved the goal. The KPI of Inventory National Parcels however did not achieve its goal.

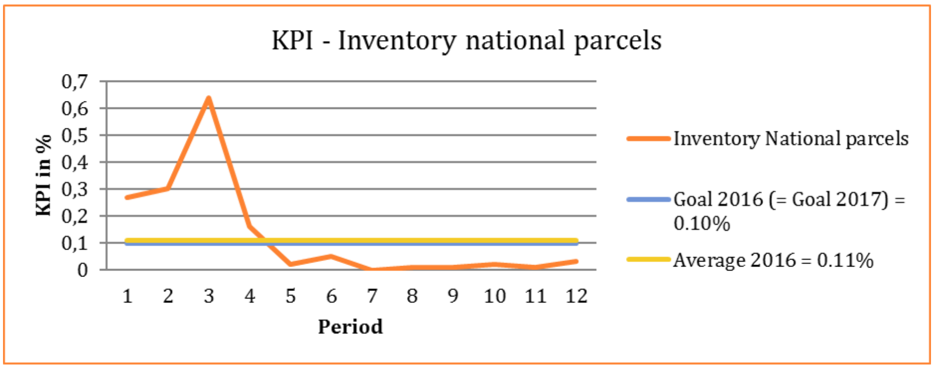


Figure 3.1 - KPI Inventory National Parcels

The KPI of inventory national parcels is not met, with an average percentage of 0.11% inventory in 2016 and a goal inventory of 0.10% for 2016. The graph in figure 3.1 shows clearly that the percentage is dropping increasingly after period 4. Also, period 3 is considered as an outlier, and without this period the goal would be met. The average inventory from period 5 till period 12 is 0.02%. Taking into consideration that the KPI stays 0.10% for 2017, it looks like they improved. However, there are a few things that need to be considered.

Again, we do not know from these percentages if the departure time is met just in time or with enough slack. Just as for the inventory for international parcels, customers want to arrive later during the process in the future. This can increase the percentage again. Secondly, the total number of processed parcels has increased in 2016. If they have fewer inventories after the process, this means they have sorted more parcels. This increase in quantity can lead to a decrease in sorting quality. When more parcels are being processed, people will be sorting faster, which can lead to more incorrectly sorted parcels.

Moving on to the KPI of incorrectly sorted parcels. This is considered the most important one of the here discussed KPIs for PostNL. The goal of this KPI was set on maximum 0.55% wrongly sorted parcels, which was nearly met with an average of 0.52% over 2016. Also, we see that the percentages are only rising since period 10 and reached its maximum of the year in the last period, with a score of 0.62%. The graph in figure 3.2 shows how close the percentages are to the goal of 2016. The goal of 2017 is 0.43%, which they will not achieve in 11 out of the 12 cases if they are not going to perform better in 2017.

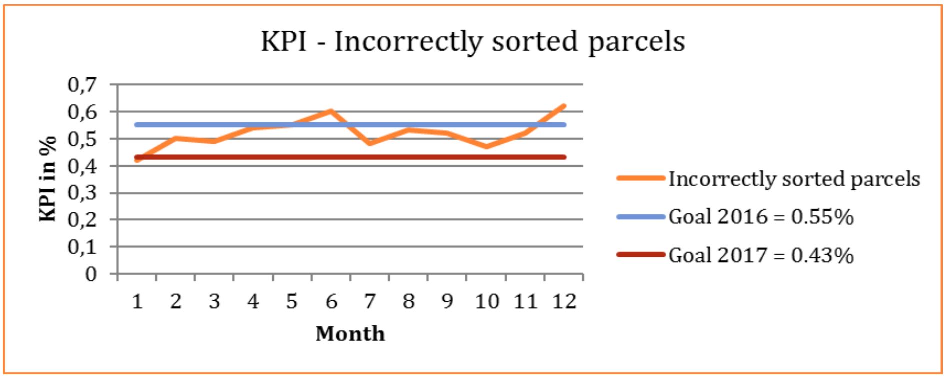


Figure 3.2 - KPI - Incorrectly sorted parcels

Since the KPI of the Incorrectly sorted parcels and the KPI of the national inventory are strongly related, the management also shows the so called KPI Total. The graph in figure 3.3 shows its performance. Looking at this KPI for the sorting process, the number of periods the KPI did not meet the goal of 2016 confirms the fact that PostNL Hengelo experiences problems in the sorting process. The percentage of the KPI Total of 1 and 2 is the sum of the inventory of national parcels and the incorrectly sorted parcels. The average of the KPI Total of 1 and 2 is just below the goal of 2016, with only 0.02%, which gives them not much slack. Additionally, the goal of 2017 is 0.53%, which they will not meet if they don't perform better than last year.

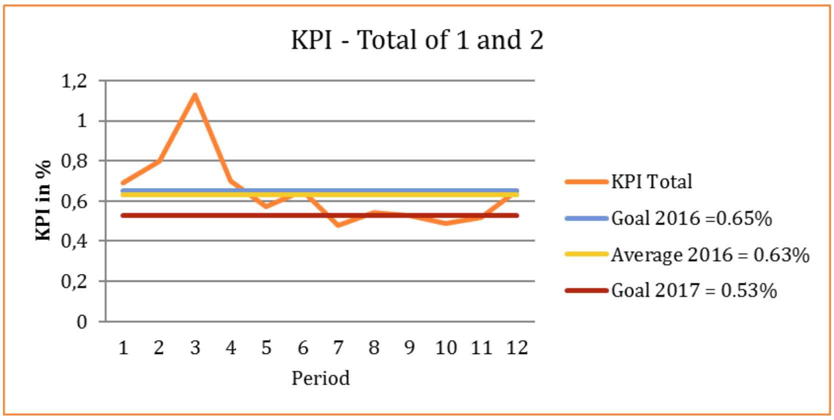


Figure 3.3 - KPI Total of 1 and 2

The KPI of inventory of international parcels has stood below the set goal of 0.50% every period. This means that during every period, less than 0.50% of the international parcels was not processed in time. The international parcels must leave before 01:00 to be on time for the distribution process. In almost every case this time is met, since in 75% of the periods the percentage is 0%. However, we know customers want to arrive later during the sorting process, so the risk that the international parcels are not processed before 1:00 becomes higher in the future. Additionally, we do not know at what time all the parcels are processed at this point. Is this way earlier than 01:00 or do they process it just in time? Remarkable is that this year, no new KPI goal is set for the inventory of international parcels. The reason for this is unknown by the managers at depot Hengelo, but we strongly advise to still monitor this KPI in the future.

3.2 Planning

The arrival of the parcels from the customers is the basis of the sorting process's organisation. The deployment of staff will be based on the arrival information of the parcels. When the arrival times and number of parcels are known, the starting time of the process can be adjusted as well if necessary.

The process of parcel arrival can be divided into two parts: regarding the planning of the sorting process and the activities during the sorting process itself. In this section, the systems used for planning is analysed and in the next section the systems during the sorting process itself is analysed.

During the process, parcels will arrive from 11:00 till late in the sorting process. The last trucks can arrive after 01:00, while the sorting process is from 19:00 till 02:30. Currently PostNL has no influence on the supply of these parcels.

3.2.1 CRIS

The depot in Hengelo will receive a forecast in the form of a scheduled supply line in the Control Room Information System, CRIS. CRIS is a system which monitors the expected parcel supply and the realised supply and processing of the parcels. CRIS will be used both for process preparation as well as during the process for monitoring. This data is visualised in a graph, from which a screenshot of one day as an example is shown in figure 3.4. This figure will reappear in section 3.5. An overview of the whole dashboard can be found in Appendix IV.

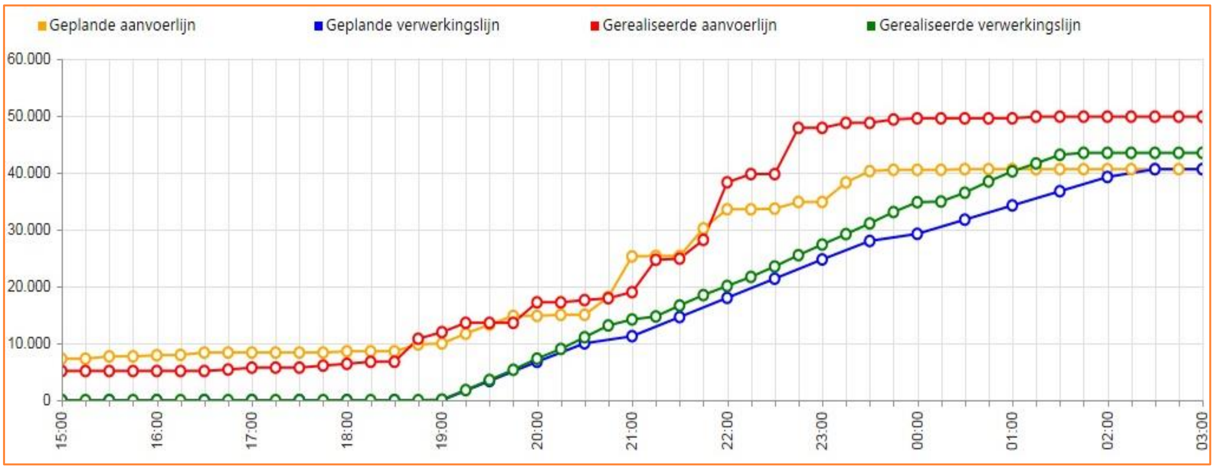


Figure 3.4 – Screenshot of dashboard supply and processing lines in CRIS

The Y-axis provides information about the number of parcels, the X-axis shows the time, where we see that the process starts at 19:00 and ends at 02:30. The graph shows us four lines:

- The scheduled supply line (yellow line)
- The scheduled processing line (blue line)
- The realised supply line (red line)
- The realised processing line (green line)

The yellow line is the *scheduled supply line*. Supply Chain Engineers at the headquarters in Hoofddorp will make a prognosis of the expected number of parcels that day, which will result in this scheduled supply line. CRIS uses historical data from the Transport Information System, TIS. The system TIS will be explained later in this section. In Chapter 4, the process of setting up a Service Level Agreements and the making of the prognosis is explained more in detail.

Based on the scheduled supply line, the depot process manager creates the *scheduled processing line*. This is the blue line in figure 3.4. As can be seen in the graph, the process starts at 19:00 and ends at 02:30, when the yellow and blue line meet each other. When planning the scheduled processing line, attention must be paid to the inventory unsorted products on the floor. The scheduled inventory is the difference between the blue and yellow line. This is a crucial point, since there must be inventory to work continuously, but too much inventory will cause troubles on the floor when there is not enough space left.

The scheduled processing line will be made around 13:00 and then forwarded to the Social Work Office, hereafter SWB. The SWB is the social employment office, who schedules the employees on the floor.

Additionally, CRIS shows us the realised supply line, which shows the registered incoming trucks and its loading. The realised processing line is extracted from the sorting machine, which scans all the parcels on the conveyor. Both lines are further explained in section 3.3. From the graph, it is also noticeable that all lines are not ending on the same level, which indicates ambiguities. Even though this is only one day, analysis has showed us it happens every day, with at some days, bigger differences than other days. In section 3.5 we will further elaborate this.

3.2.2 TIS

In the system TIS, transport information about the trucks is registered. It is an overview of structural and incidental expected rides which in theory can be used for forecasting the expected trucks. The input is coming from standard rides that are expected every day, incidental rides that are submitted during the day. Since information directly from the customer is mostly not available, these are expected rides and not officially confirmed.

For every truck, information is available about loading times; and truckload. If the truck is expected, the scheduled information is given, called the rides in TIS. Most of these rides are standard in TIS, since they are based on historical data. Sometimes a new ride is added or a present ride is changed, if new information is provided directly from the customer. Also, sometimes a truck arrives at the depot without being expected in the transport planning. This is a 'spontaneous ride'. This transport information however is not much used by the depot, due to different problems, explained in section 3.5.

3.3 Real-time

For the real-time monitoring and controlling, the same software will be used as for the forecasting. They also use Track & Trace to monitor individual parcels through the process.

3.3.1 TIS

TIS is also used during the sorting process itself. The planning desk registers the arrival times and truckloads of the customers, which will be archived and used for scheduling in the future. Secondly, this information will be used by CRIS, which will create the 'realised supply line' with this information. TIS could also be used for planning desk and process managers to see the expected trucks for that evening, but as described in section 3.1, this information contains a lot of inaccuracies.

As explained in section 2.2, when a truck arrives at the dock, the planning desk at the dock will register the actual arrival time and truck load in TIS. They manage the arrival and docking of all incoming trucks. As for registering the data, there are several problems identified. For example, for the managers, it is unclear whether the time registered is the actual arrival time on the terrain or the time the truck arrives at the dock. The exact problems are explained in section 3.5.

When the planning desk registers a truck in TIS, they submit the load information from the bill of loading, which specifies the number of containers, not parcels. For the trucks with loose loading, the bill of loading gives the percentage of the truck is filled. This way, no accurate information about parcels per customer are available.

Furthermore, these TIS registrations will be used as input data to forecast future processes. This will be further explained in Chapter 4.

3.3.2 CRIS

We recall the dashboard of CRIS from figure 3.4 in the previous section. There, we introduced four lines, including the *realised supply line* and the *realised processing line*, which we discuss in the current section.

In TIS, we documented the incoming parcels in terms of roll containers or percentages loose loading. In CRIS, these containers and percentages will be translated into number of parcels, so that the *realised supply line* can be created. This is the red line in figure 3.4. The calculation of number of parcels is done by the supply chain engineers in Hoofddorp. First, they convert every type of roll container, pallet or corlette into standard roll containers. This is called the RC (roll container) equivalent. Next to that, per customer they calculate the number of parcels per grey roll container. For most customers, this is 28 parcels per grey roll container. Only the big customers, have their own conversion rate, since they have a substantial part in the total number of parcels.

The *realised processing line* is directly extracted from the Sorting System itself. It shows all the parcels at the time they are scanned on the conveyor belt. Therefore, we can say that this line is the only line where no human activities or calculations are involved and can be assumed as the most trustworthy line in CRIS.

However, from the screenshot in CRIS can be seen that the realised supply line is not in line with the realised processing line, although it should be. Since the realised processing line comes directly from scanning all the parcels on the sorting machine, the problem must lay at the realised supply line. In section 3.5 this problem is further analysed.

3.3.3 Track & Trace

In the Track & Trace system individual parcels can be followed through the whole sorting and distribution process, from sender to receiver. The system shows information extracted from data from the SBS system, which is explained later. In Track & Trace, every individual parcel has a barcode. When a parcel is registered by the customer, it will receive this barcode at the moment it is notified to PostNL. Otherwise, it will receive the barcode once the parcel is accepted by PostNL. From that moment, every step it makes through the process will be shown in Track & Trace. However, these registered parcels cannot be used for an indication in the expected number of parcels, since customers also already register parcels that will arrive in the next days instead of that evening. The registration is a continuous process and not distinguished per arrival batch.

3.3.4 SBS

SBS is abbreviated from *Sorteer Beslis Systeem*, which means Sorting Decision System. It is the whole application behind the sorting machine and it collects all the scans and sorting notifications. It is also the system from where exactly can be measured how many parcels there are sorted on the conveyor, since it extracts its data from the scanner on the sorting machine. It provides the real-time data for Track & Trace and its historical data is used for forecasting in CRIS.

3.4 Internal Relationships between the Systems

In the previous paragraph, the systems and programs used during the sorting process and its preparations are mentioned and their function is explained. To identify the problems with these programs, we need to get a better understanding of their role through the whole process.

In figure 3.5, the relationships between the different systems are visualised in a flowchart. The different swim lanes are the different systems: TIS, CRIS, SBS and Track & Trace. All arrows describe the input flow.

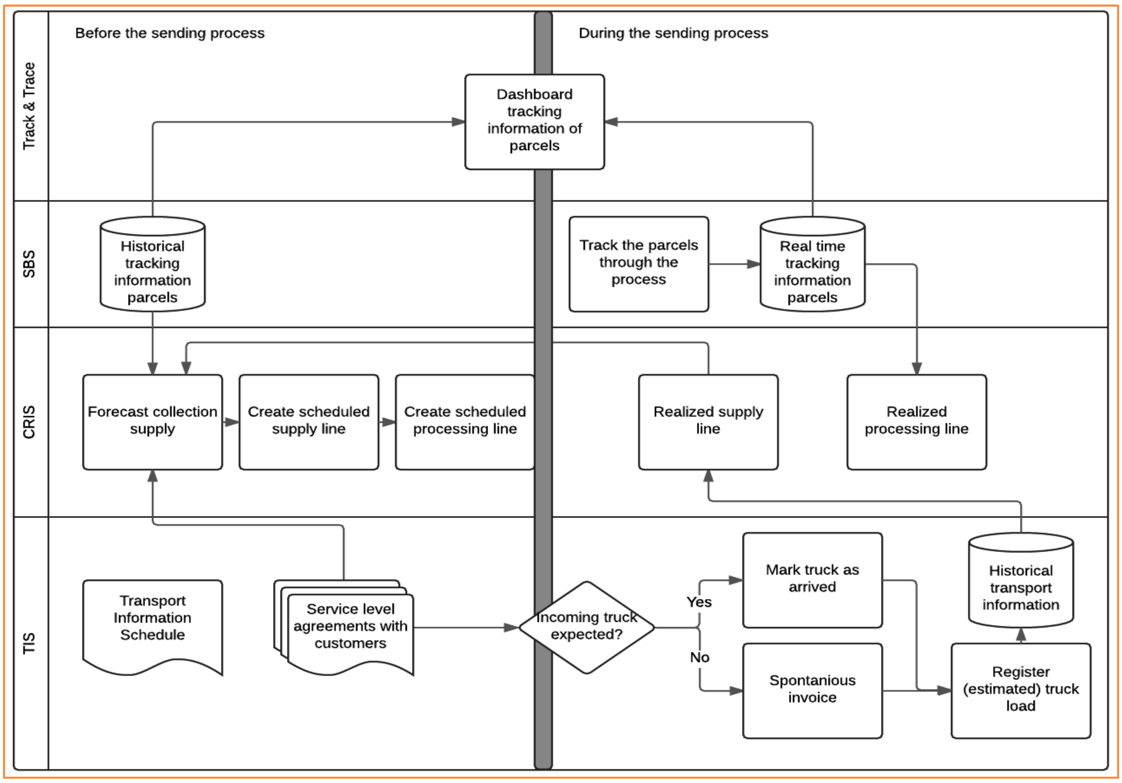


Figure 3.5 - Flow chart of systems used for the sorting process

The bottom swim lane shows the processes in TIS. TIS first has a transport information schedule which is a standalone schedule.

Switching to the real-time function of TIS, when a truck arrives at the depot it needs to be registered in TIS. There can be made a distinction between an expected an unexpected truck. When the truck is expected, the truck is already registered in TIS as 'in transport'. The planning desk only needs to mark it as arrived and register truck load. When a truck arrives unexpected, a spontaneous invoice needs to be made. These parcels will be shown in the realised supply line, but not in the scheduled line, which results in a mismatch. The registration collection will be stored in the database of TIS. Moving on to one swim lane up, the system CRIS. As mentioned before, in this system appears the scheduled supply line, from where the process managers create the scheduled processing line. The scheduled supply line is created from the expected total volume based on historical tracking information and historical realised supply lines, indirect with data from TIS. However, during the research we assume that this information comes directly from TIS, since the historical realised supply lines are only the visualisation of TIS' data and in TIS the changes in data can be made.

In real-time, also the realised supply line is shown. The realised processing line extracts its information directly from the scans collected in SBS. In the swim lane of SBS can be seen this system merely collects data and sends it to other systems. The program on itself has no user interface or dashboard. Track and Trace on the other hand, can be interpreted as the dashboard of SBS. This system does not collect data on itself, but only shows the scans and sorting notifications created in SBS. The flowchart shows clearly that all the systems and its information are interdependent on each other. Inaccuracies or default information automatically leads to bigger problems in more systems.

3.5 Inaccuracies in Data

In the previous sections of Chapter 3 some problems in the systems are already mentioned. In this part these problems will be further explained.

3.5.1 TIS

We have seen that TIS consists of two parts, both the transport planning and the customer arrival registration. In both parts, we found several inaccuracies during the process analysis. To exemplify these, let us consider in figure 3.6 a screenshot of a ride in TIS, which shows both the planning and the customer arrival registration.

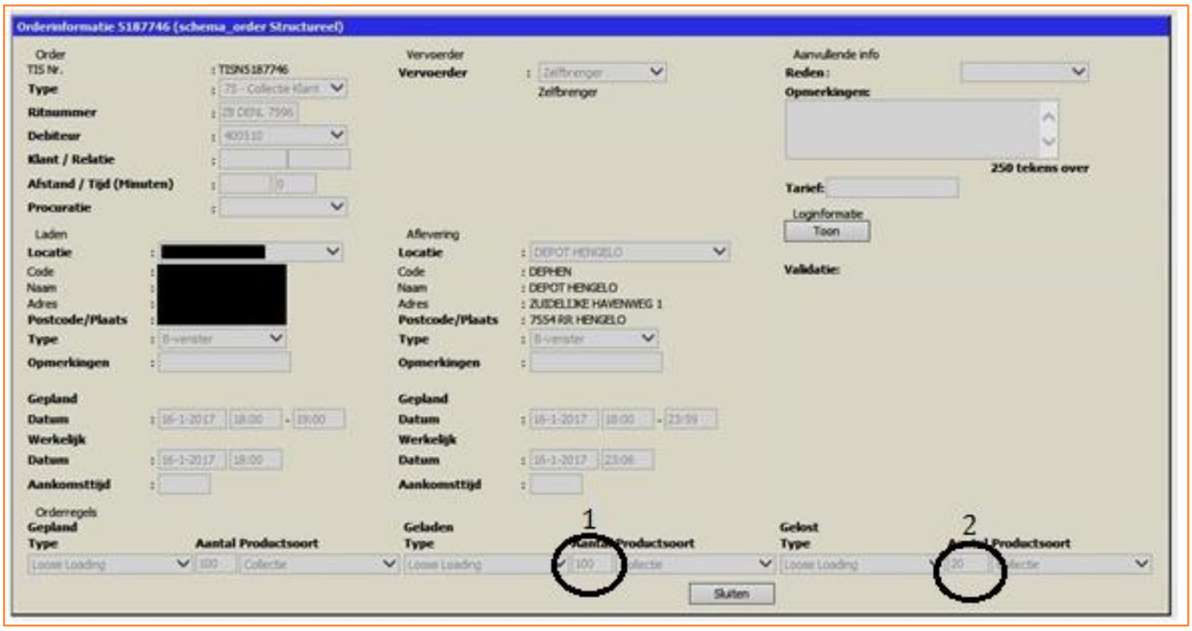


Figure 3.6 - Screenshot from a truck in TIS

- The scheduled arrival time is between 18:00-23:59, which is a broad time window, where PostNL Hengelo could never rely on. The realised arrival time is 23:06, which is at the end of the time window. They have already been expecting it for 5 hours. From experience, PostNL Hengelo can estimate when the trucks are arriving, but they never know for sure.
- The scheduled (and realised) loading time at the customer is also from 18:00. Then, the arrival time could never be 18:00.
- TIS informs about the scheduled and the loaded freight of the trucks, which is 100% (number 1 in figure 3.6) loose loading, which means a full truck. This is what PostNL Hengelo could expect. However, we see that when the truck arrives, the planning desk only unloads 20%

loose loading (number 2). The remainder of the trailer stays empty. This information is taken from the load bill, so it would be known at the customer when they send off the truck.

Although the screenshot is an example of one ride at one day, it is apparent from the data in TIS that the above problems occur frequently, not to say always.

Next to that, we see that it is only able to submit roll containers or percentages (in case of loose loading). It is not possible to submit the exact number of parcels. As we already discussed, this has consequences for the process. In Chapter 6 and 7 we will refer to this problem again.

Most of the rides are submitted in TIS before arrival. However, as mentioned earlier, sometimes a truck arrives at the depot unexpectedly. There can be two reasons for that. It could be that the control room is too late with submitting the information of this ride in TIS and it has already arrived. It could also be possible it was unknown to anybody at PostNL that this truck was arriving. In both cases, the planning desk registers it as a spontaneous ride. However, this truck and its truckload is not considered into the schedule of that evening, and therefore can cause some big problems. The consequences of spontaneous rides are further explained in Chapter 4.

3.5.2 CRIS

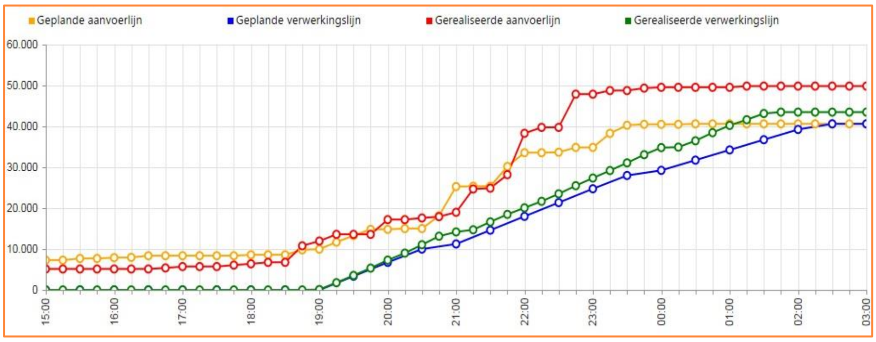


Figure 3.7 - Dashboard supply and processing lines in CRIS

In section 3.2, the difference between the realised supply line and the realised processing line is noticed. We already mentioned that the realised processing line is the only data flow straight from the sorting machine and will therefore be assumed as the correct line. Secondly, we assume that all the incoming parcels are processed during the process and no inventory is left after 02:30. We know from the KPIs in section 3.1 that only a small percentage inventory is left some times, but these percentages were much lower than the difference showed in the dashboard in figure 3.7. These percentages inventory left are so low, (0.11% on average and a lot of times 0.00%), that process managers assume that most times, no inventory is left and thus these lines are false, while in almost every case a difference between the lines is shown in CRIS. Of course, we cannot base our conclusions on one example, but in the data analysis in Chapter 6, we compare the four lines with each other for a longer period, to show that they never end on the same total volume.

No inventory means in theory that the realised supply line and the realised processing line are ending at the same level at time 02:30. However, if we look at the dashboard in figure 3.8, we see this is not the case. At the time 02:30, we see a difference of about 6000 parcels. Even though the conversion rates are adjusted for some customers with high volumes, the realised supply line is not trustworthy. As explained in section 3.3, the realised supply line is created by loading data registered in TIS by the planning desk and converted into number of parcels. There can be found two causes for an inaccurate realised supply line. First, the data could be incorrectly documented in TIS by the planning desk. As for parcels arriving in roll containers this is not likely, since they directly use the information on the loading bill. In case of loose loading it could be possible. This is because the planning desk do not know the exact numbers in this case. They estimate a percentage of the filling level of the truck and document this percentage in TIS. It could be possible they make a wrong guess. More likely is the fact that the conversion rates, made by the headquarters in Hoofddorp are incorrect. Since they use the same conversion rate for almost every customer it is likely to assume this rate will not be accurate for every customer. In Chapter 6, we will model a more accurate model of the sorting process, and we will calculate new conversion rates for that.

Looking at the dashboard of figure 3.8, it is striking that also the *scheduled supply line* (yellow line) and the *scheduled processing line* (blue line) are not ending at the same level as the realised processing line. Since the scheduled *processing* line is exclusively based on the scheduled *supply* line, this indicates an error in the schedule made by the Supply Chain Engineers at the headquarters. Since it is a rolling forecast based on historical data and, again, incorrect conversion rates, unexpected deliveries are not included in this forecast. Again, we sketch these conclusions with one day as example shown in figure 3.7, but in the data analysis Chapter 6, we compare the four lines with each other for a longer period to prove these assumptions.

Overall, looking at the data flows in these systems, there is quite some confusion about the parcel supply. This leads to problems and inefficiency during the sorting process, since it is hard to schedule an optimal process and to carry out this process with an unreliable forecast.

3.6 Conclusions

In Chapter 3, we have analysed the KPIs monitored considering the sorting process at PostNL Hengelo: the management information of operational excellence. Three KPIs are considered important for the sorting process: *Incorrectly sorted parcels; Inventory of international parcels* and *Inventory of national parcels.*

In 2016, The KPI inventory of national parcels overall was not met, but in the last few months it performed better and did meet the goal. However, this had as downside that while the KPI of national parcels performed better, the KPI of incorrectly sorted parcels performed worse. In 2016 it did just meet its goal, but with the tightened goal for 2017 and the worse performance the last months of 2016, it will not meet its goal in 2017. The goal of inventory of international parcels was met in 2016, but is for unknown reasons not a KPI anymore in 2017.

For the planning and monitoring the process, PostNL uses several systems: TIS, CRIS, Track & Trace, and SBS. All systems have their different role in planning and monitoring the process. However, the relationship between the systems is not optimal, which makes it difficult for the employees in Hengelo to obtain the correct and adequate information regarding the sorting process. This makes it hard for the process managers to prepare and manage the process.

In the next chapter, we end our process analysis based on Operational Excellence with analysing the role of the involved stakeholders and their experienced problems. At the end of Chapter 4, we also summarise all found problems in the Chapters 2, 3 and 4. This will be used as input for the Problem knot in Chapter 5.

4. Mindsets, Capabilities & Behaviour

In Chapter 2 and 3, several problems which are experienced by stakeholders are identified. There are also problems which are "caused" by the mindset, capabilities or behaviour of the involved employees themselves. These problems are identified in this chapter. In this section, we do not focus on the processes, but on the behaviour and capabilities of the stakeholders. This way, we obtain a clear picture about their role in the process. Obtaining this information is done by semi-structured interviews. In preparation for the interviews, a literature study is conducted on semi-structured interviews, which can be found in Appendix V. The interviews we refer to in the current chapter can be found in Appendix VI.

To be able to obtain information about the mindset, capabilities and behaviour of the stakeholders, we first need to determine which stakeholders are involved and know their role in the process, including their experienced problems. This is done in section 4.1. The chapter is summarised in section 4.3, where we also recall the found problems in the Chapters 2 and 3.

4.1 Role of Stakeholders and Experienced problems

During the sorting process, different stakeholders are involved, both internal and external stakeholders. Here, we discuss all the involved stakeholders in chronological order, together with their tasks and responsibilities and their connection to KPIs.

4.1.1 Contracting a customer

During the phase a new customer will be contracted by PostNL, several stakeholders are involved. When a customer wants to use the services of PostNL, they gather to discuss the customer's wishes. There, they make agreements on some issues, including:

- What is the frequency of delivering the parcels?
- What is the average number of parcels delivered per time? And the maximum amount?
- What is the arrival time of the unsorted parcels at the PostNL depot?
- Who will deliver the parcels to the depot? The customer or PostNL itself?

Next, the feasibility of the plans will be tested. This means logistic engineers will look at what is the best suitable depot to deliver, based on distance and capacity. Additionally, they will check if the quantity of parcels and arrival time is feasible for this depot. If not, they will try to find solutions within PostNL, such as transporting to other depots or making changes in the current schedule. When this is not achievable, restrictions to the customer will be made. This will be for example a latest arrival time, or a maximum number of parcels which can be delivered so that PostNL can ensure that all delivered parcels will be processed in 24 hours. Eventually both parties will agree upon a Service Level Agreement (hereafter SLA).

Since the SLAs are partly based on the capacity for the sorting process on a depot, it is important that the customer will meet these arrangements as well. If they do not meet these commitments incidentally, they need to communicate clearly about this. This way the probability that some changes can be made is the highest. If the arrival of parcels differs from the agreements structurally, both parties need to discuss again about making changes in the SLAs.

Currently, there is indistinctness about who is responsible for the consequences if there are costs made because of not met agreements. An example is that a truck needs to transport parcels to another depot because the current depot cannot process everything, because the customer delivers too many parcels or delivers them too late. PostNL Hengelo points out that currently these costs will be paid by PostNL itself. They assume this is mainly because no one is investigating the cause of these extra costs. Therefore, no one can be held responsible for it.

Also, the management of PostNL Hengelo has the idea that customers get too much power in terms of arrival times and quantities. PostNL parcels is market leader in this fast-growing segment and to stay at this position, it is important to keep their current customers and contract new customers. The management thinks sometimes agreements are made that are not achievable in advance. Currently, they do not check on regular basis if the SLAs are met.

It is also remarkable that within the depot, not everyone is aware of the actual SLAs made with the customers. People say that they do not know when to expect a customer, while they do not know the initial agreements with that customer. They use TIS for checking arrival times, but TIS gives only broad time windows which most of the times do not match with the actual agreements. Their experience that the time windows in TIS are broad and incorrect, can be confirmed. However, in some cases they could know the actual arrival time by knowing what's in the SLAs. In Table 4.1, the SLAs with the three biggest customers are shown. In Chapter 6, we will compare these agreements with the actual arrival times.

Service Level Agreements with the Top 3 Customers

Arvato

Agreements made for 2 trucks every day. Parcels will be delivered on pallets.

- The first one will arrive between 11:00-12:00.
- The second truck will arrive between 20:00-21:00.

They will be transported to Hengelo with an external transporter hired by Arvato.

However, in the transport planning of TIS the arrival times for respectively truck 1 and 2 are scheduled for the time windows 03:00-13:00 and 08:00-22:00, which is much broader than the specified arrival times in the SLA.

Otto

From Otto, several versions of the SLA are known. However, at depot Hengelo as well as the supply chain engineers in Hoofddorp, the official agreements are not known. This problem is further analysed in section 4.2. The arrival times and number trucks are clear however.

On Mondays, 3 trucks will arrive, the other days 2 trucks will arrive.

- Arrival times Monday: 19:00 (truck 1); 22:00 (truck 2); 00:00 (truck 3)
- Arrival times other days: 23:00 (truck 1); 00:00 (truck 2)

Next to these arrangements, they also have set latest possible arrival times: 00:00 for truck 1 and 00:45 for truck 2. The latest time for the extra truck on Monday is 22:45.

Zalando

From Zalando, there is no distinct SLA available. The only agreements found from the account manager are the standard routes of Zalando in the transport planning from TIS.

Zalando Brieselang

- The scheduled arrival time is between 21:30 and 00:30.
- In TIS, one truck is scheduled. No indication for number of parcels are given.
- Parcels are being delivered on pallets.

Zalando Gossbeeren - The scheduled arrival time is between 14:00 and 22:30. - In TIS, one truck is scheduled. No indication for number of parcels are given. - Parcels are being delivered on pallets. *Zalando Erfurt* According to the transport planning in TIS, Zalando Erfurt arrives with two trucks each day. - The arrival time of truck 1: 12:00-23:00 - Arrival time of truck 2: 21:00-01:00

Table 4.1 - SLA with the Top 3 Customers

4.1.2 Scheduling the sorting process

As for scheduling the process, several stakeholders are involved, from both PostNL depot Hengelo and the headquarters of PostNL Parcels in Hoofddorp.

Supply Chain Engineers

To arrange the deployment of staff and schedule the process, supply chain engineers will make a rolling forecast of the parcel supply every day. The forecast can be distinguished into the prognosis and the planning. The prognosis is the total expected number of parcels for that day. The planning contains expected arrival times and freight of customers and is based on registered freight of customers in TIS, which is done by the planning desk. This will be further explained later in this section. The planning should not be confused with the transport information which is shown in TIS, explained in Chapter 3. Both use different information as input.

In Hoofddorp, the supply chain engineers make the prognosis four weeks in advance. The prognosis only contains an expected total number of parcels for that evening. It is based on historical data coming from Track & Trace, combined with a grow factor and known holidays or special campaigns from a customer which will have influence on the total number of parcels. Service Level Agreements are not included in the prognosis. Unpredictable peaks also cannot be seen in the prognosis.

The planning is created with information from TIS, which was manually registered. Incorrect registrations will thus lead to an incorrect planning in the future. The planning gives insight in the customer-specific information.

The prognosis and the planning together are the basis for the scheduled supply line in CRIS. CRIS uses the planning from the historical data from TIS and the prognosed total volume to make this line. This is done automatically and not manually by the supply chain engineer. If after releasing the forecast it is known that for example a customer will send an extra truck, this information will be documented in the transport planning of TIS. It only happens incidentally that a customer informs the supply chain engineers. If it has major consequences on the total volume, the prognosis and scheduled supply line in CRIS can be adjusted in communication with the depot. After 16:00, these adjustments will not be made anymore. However, at 13:00, the staff will already be determined, so it is hard to adjust the occupation after that.

Process Managers

The process managers have several tasks regarding scheduling the sorting process. They will receive the forecast of the Supply Chain Engineers via the scheduled supply line in CRIS around

12:00. Based on this line, they create the scheduled processing line. This is shown in expected number of parcels to process per hour. As for making the scheduled processing line, they only look at the scheduled supply line, without knowing how this is built up and how accurate it is. They know from experience if the total expected volume plausible, but they for example cannot see exactly which customers will arrive at what time. During the interviews, the arrival times of the customers and thus the course of the scheduled supply line is not accurate. The total expected volume is sometimes found accurate, but not always. However, they feel only a total number does not provide much information. Sometimes, they gain information about an extra or delayed truck, but they cannot know for sure if this is also included in the scheduled supply line.

Determining this scheduled supply line is a relative small, but important task. The number of employees scheduled for that night is based on this line. Process Manager 1 explains that they do not know exactly how the occupation is determined, since this is done by an external party. However, we do know that since the forecast is not reliable, they schedule about 30% more employees than expected to need. In Chapter 7, the determination of number of employees is further analysed. Concluded from the interview with both Process Managers, we see that several parties are involved in the scheduling process without exactly knowing the tasks of one another.

Next to the scheduled supply line, the process managers also receive information via a *transport planning* TIS. This is not the same as the planning mentioned earlier. In the *transport planning* of TIS are the upcoming trucks shown, along with its truck load. We have already discussed the problems with this transport planning, Process Manager 1 mentions that they do not look a lot at these information flows, since it only shows the standard routes, with unreliable arrival times. Planning Desk Employee 2 adds that also an expected loading is documented in TIS, but just as the arrival times it is not reliable. Overall do they not know what to expect and when.

<u>Customer</u>
Next to the historical data which PostNL use to predict the current supply, PostNL Hengelo also receives information on daily basis from several customers. For example, customer Otto provides this information already at 09:00. Unfortunately, this information is never correct, so PostNL cannot use it. The cause of this incorrect information is unknown by them. When this information would be correct, the process managers would be able to use it when making the scheduled processing line.

Another customer, Zalando, provides PostNL with arrival information around 18:00. In contrast to Otto, these numbers of parcels are mostly correct. However, the information provision is too late to make big changes in the schedule if necessary, since it is not possible to schedule more employees or start the process earlier. This detailed information is also not shown in CRIS or in the transport planning in TIS, since the scheduled lines are already created. At most, they can try to predict if Hengelo is able to process everything in their own depot. If not, they can try to arrange an agreement with another depot to help them by sorting a part of Hengelo's parcels. The disadvantage of this is that it is expensive and uncertain if possible.

A successful sorting process starts with a good planning. Therefore, it is important the involved stakeholders need to know what their responsibilities are and communicate well with each other. We already explained that supply chain engineers make the rolling forecast as accurate as possible. They are responsible for a usable prognosis for the depot. If the forecast is expected to be different than usual, they need to try to change this in the forecast or otherwise communicate this as soon as possible with the process managers of the depot.

Here lays also a responsibility for the customer. They must stick to their Service Level Agreements. If this is not possible, they must communicate this as soon as possible to PostNL. This way, the forecast can be adapted or at least the process managers of the depot can be informed. However, this is not the current way of working. We will provide possible solutions in Chapter 7. Also, customers need to register their parcels, which means the parcel can be recognised by the sorting system. Otherwise, manually submitting the address must be done. Currently, not all customers register their parcels.

4.1.3 During the sorting process

During the sorting process, several stakeholders play an important role to make the process successful. On the process itself, in Hengelo, three stakeholders are active: the planning desk, the process manager and the assistant job coaches. The involved external stakeholders are the control room at the headquarters and the customer or transporter.

<u>Process Manager</u>

The process manager is ultimate responsible for the process in Hengelo. The Assistant Job Coaches lead the process on the floor, but the Process Manager need to check if everything is going according to plan. They do this via communicating with the Assistant Job Coach and the Planning Desk, monitoring the arrival of customers and the performance of sorting, and checking if lean rules and safety rules are followed. Next to internal communication, they also need to communicate with the control room at the headquarters in monitoring the process. Currently, they experience with the control room is not sufficient.

<u>Control Room</u>

Where the supply chain engineers forecast the process from the HQ, the control room monitors all the processes and transport information of all the customers and depots during the sorting process. They have insight in the transport situation and the situation of other depots. This way, they can help depot Hengelo with regulating the process during the evening. If, for example, a truck is not arrived yet while they already expected it, they will contact the control room for information. Also, the control room monitors the performances of Hengelo during the process.

If Hengelo cannot process all the parcels, the process manager and the control room can collectively decide to transport the parcels to another depot. This is not an easy task. Especially the big customers have external transporters to deliver their parcels to PostNL. They made agreements with this external transporter about the destination and therefore this transporter cannot change its destination. This means that all the parcels need to be transferred into a calamities truck from PostNL and transported to another depot designated by the control room.

<u>Planning Desk</u>

The planning desk plays a core role during the process. Together with the Assistant Job Coaches, they manage the arrival of customers, loading and unloading of parcels and the actual sorting process.

During the process, at least two employees are present. One employee checks the registration of all the parcels and corrects if necessary and the other employee manages the arrival and unloading of trucks. At the moment a truck arrives, it contacts the planning desk. If there is dock available, the planning desk discusses with the Assistant Job Coach where the truck can start unloading. If there is no dock available, the truck must wait on the terrain. Also, if there is no floor space available, the truck cannot start unloading. Both problems will occur every night at least once, notes the Planning Desk Employee 1.

From the transporter, they receive the loading bill, which gives information about the loading of the truck. This information will be registered in TIS, together with the arrival time. The arrival time is the time the truck arrives at the depot, not the time they start unloading. The waiting time is not documented at all.

Once the parcels are sorted and ready for departure to the second depot, they are called shift products. Some destinations have an earlier maximum departure time than the end of the process. These are the international destinations and the mailboxes. The deadlines for the international parcels are as follows:

- Belgium: 01:00
- Other international destinations: 00:00

This means that parcels with one of these destinations need to be processed before these times. Customers are aware of this and need to make sure to be at the depot on time. For international parcels, the planning desk and the process managers know which customers have a lot of these and try to process these customers as soon as possible. However, every customer can have parcels with a mailbox destination. These must also leave earlier but since they are unpredictable, it occurs every night that not all these parcels are processed on time and they must stay in Hengelo till the next day.

Assistant Job Coaches

The Assistant Job Coaches are responsible for managing the staff on the floor during the process. In preparation for the process, they allocate the staff for the process and discuss the forecast with the process manager and the planning desk. During the process, they keep track of the sorting performance, lean way of storing roll containers and determine when and where the arriving trucks need to dock. They communicate with the planning desk where the truck can start unloading and with the staff on the floor where the freight can be stored. The choice of dock is based on availability and floor space. Also, some customers have a higher priority than others, for example because they contain parcels with an international destination. These customers take precedence over others, if not enough docks are available.

Some customers use specific docks. Zalando uses dock 10 for its loose loading freight. Otto uses dock 8 for its corlettes and dock 9 for loose loading. This is because loose loading is only possible at dock 9 and 10. Otto arrives with two trailers: one filled with loose loading and one with corlettes. It is convenient for the driver to unload them at two docks next to each other.

Pallets that arrive early in the evening will unload at dock 13, so that pallets can be stored at one side of the floor and cause no problems for the other parcels. However, this side of the floor will be blocked when a truck with loose loading starts unloading. So, the pallets need to be processed before the loose loading trucks arrive. In figure 4.1, the docking strategies are shown.

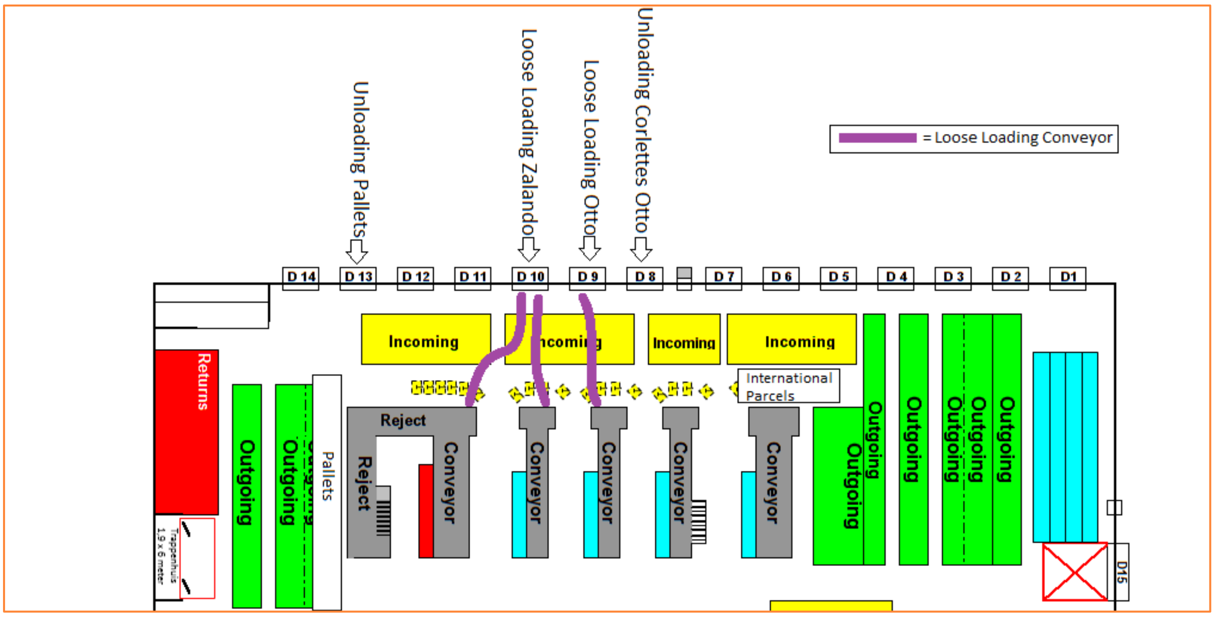


Figure 4.1 - Docking Strategies

4.2 Conclusions

In the Chapter 4, but also in the previous two chapters, we have analysed the problem with the lean strategy of McKinsey (2008), which states that operational excellence can be achieved by focusing on three aspects in the organisation: the actual process, the management information and systems, and the behaviour and capabilities of employees. In all three chapters, problems were analysed in different ways. In Chapter 2, we mainly analysed the actual sorting processes in detail. However, most of these problems were caused by the information systems or the behaviour and capabilities of employees, which were discussed Chapters 3 and 4 respectively.

To be able to use all analysed problems as input for the data analysis and solution design, we need to cluster them and find their similarities and differences. Therefore, in this section, we summarise all the analysed problems in a table and show how we found it.

Not all these problems will be covered in this research, since they lay outside the scope. It is also obvious that there are many small problems, which have the same cause. In the next chapter, we extract the main problems and test the relevance and importance of the problems.

	Problem	Process	Management & Information	Planning Desk	Process Manager	SWB
1	The KPI of inventory national parcels was not met in 2016.		x			
2	The KPI 'incorrectly sorted parcels' does currently not meet the goal of 2017.		x			
3	The KPI 'inventory international parcels' is in 2017, for unknown reasons, not a KPI anymore.		x			
4	The scheduled supply line in CRIS is not accurate.	x		x	x	x
5	The realised supply line in CRIS is incorrect in terms of arrival time and number of parcels.					
6	It is hard to schedule the number of employees accurately and therefore the process will be overscheduled.				x	x
7	The process managers do not know how the scheduled supply line in CRIS is made.				x	
8	The process managers do not exactly know how the occupation of employees is determined.				x	
9	The process managers do not know how many parcels to expect from a customer.		x		x	
10	The process managers do not know when to expect the customers.		x		x	
11	The process managers do not know the exact SLAs with each customer.				x	
12	The planning desk do not know when to expect the customers.			x		
13	The planning desk do not know exactly how much to expect from each customer.			x		
14	PostNL has little to no influence in the arrival times of the customers.	x			x	
15	The transport planning in TRIS is not up to date and correct.	x		x		
16	The transport planning in TIS provides too broad time windows.	x		x	x	

	Problem	Process	Management & Information	Planning Desk	Process Manager	SWB
17	The planning in CRIS, TIS and the SLAs are not consistent.	x				
18	The SLAs made with customers are not met.		x		x	
19	The expected arrival time window in TIS does not match the scheduled arrival time of the truck driver.			x		
20	A lot customers are arriving late and not equally spread.			x	x	
21	An empty floor caused by the bad spread of parcel arrival.				x	
22	On the loading bill, only number of roll containers is specified.			x		
23	In case of loose loading, the number of parcels cannot be specified in TIS.	x		x		
24	During the process, communication between PM and control room is sometimes insufficient.				x	
25	During the process, almost every time customers must wait before the can unload their freight.			x	x	
26	If all trucks Zalando or Otto arriving at the same time, their docks are already in use.			x	x	x
27	At some moments during the process, there is not enough space to store the roll containers and trucks must wait.			x	x	
28	Even though some customers don't mind to wait for unloading or it is agreed with them, they still don't like it when they must wait for several hours.					x
29	If the reserved floor spaces are fully stored, the remaining containers will be stored outside the spaces, which is not lean.				x	
30	If too much green mail will be processed at once, it cannot be (manually) sorted fast enough, which leads to inefficiency.	x		x	x	

	Problem	Process	Management & Information	Planning Desk	Process Manager	SWB
31	Some customers do not register their parcels, which will lead to the same inefficiency as the green mail.				x	
32	There is a risk the international parcels are not processed in time.		x	x	x	
33	Every night, there is inventory at the end of the process, caused by mail box parcels that are not processed in time.		x	x	x	
34	Sometimes unexpected spontaneous rides arrive at the depot, which are not scheduled in TIS, or they arrive with more parcels than expected or agreed on.	x		x	x	
35	The actual location of the planning desk is not logical and causes a lot of extra walk lines, which is not lean.			x		

Table 4.2 - Problems from Analysis

5. Root Causes of the Problem

In the previous Chapters 2, 3 and 4, we have collected a lot observed and experienced problems. However, as can be seen in section 4.3, there are a lot of them and it is still unknown what the relation between these problems is. However, the problems don't stand alone and can affect each other. Therefore, we create a problem knot in this chapter. Additionally, in section 5.2, we will use AHP to prioritise different criteria for the solution design.

5.1 Problem knot

A useful method to give a better understanding of the problems and to present their underlying causes is a Problem Knot (Heerkens, 2012). This is a method to display schematically various problems and their relationship that occur within the process. After analysing the problem knot, key problems can be identified, analysed and solved. Therefore, with the knowledge of the processes, we have constructed a problem knot. This problem knot is shown in figure 5.1.

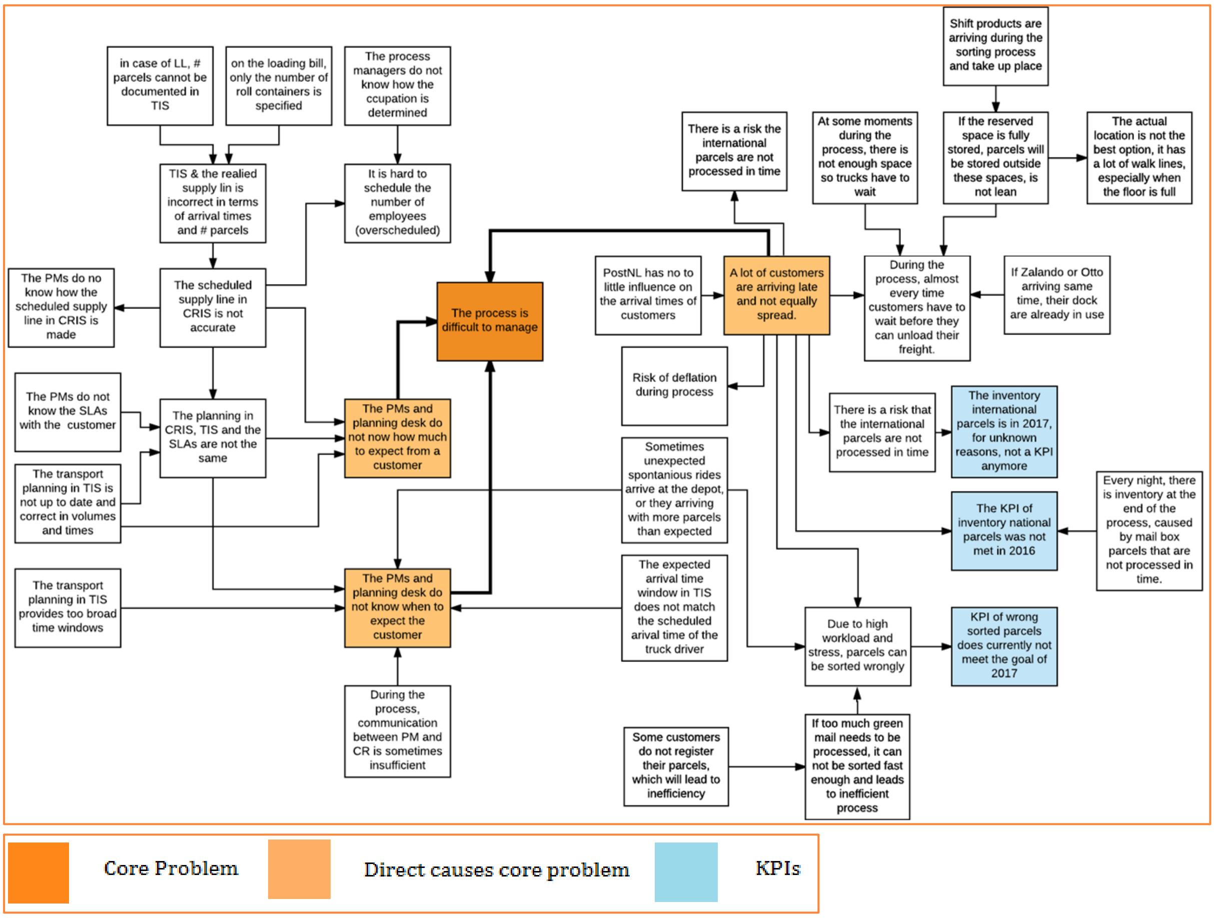


Figure 5.1 - Problem Knot

The dark orange coloured block shows us the core problem of the knot: <u>the process is difficult to manage.</u> This is a very broad and general "core problem", and therefore more attention must to be paid to the causes. This problem has several causes. The causes are clustered in three blocks, that are coloured light orange:

- The process managers and planning desk do not know how many and what type of parcels to expect from a customer.
- The process managers and planning desk do not know when to expect the customer.

- A lot of customers are arriving late and not equally spread.

If we recall the research motivation and problem description from Chapter 1, we see that at first, the perceived problem was associated with insufficient capacity of the floor space. However, considering this problem knot we see this is only a small part of the problem.

Since these three problems have a lot of causes and effects, we can assume that due to time and financial limits, and scope constraints it is not possible to solve all the found problems that are present in the problem knot. Therefore, we need to prioritise the problems, in order to know where to focus on in the solution.

To be able to prioritise problems as input for the solution design, we create criteria that can give focus to the solution. With the Analytic Hierarchy Process, we can prioritise these criteria.

5.2 Analytic Hierarchy Process

The Analytic Hierarchy Process (hereafter AHP) is a multi-criteria decision making tool that prioritises criteria and scores alternative scenarios on these criteria. In Appendix V, we explain the theoretical background and the use of the AHP.

The AHP roughly consists of two stages: prioritising the criteria and scoring the alternative solutions. Since our main goal from this AHP is to find out which problems are the most important, we mainly focus on the first stage. Since we do not already have alternative solutions, but we will create our solution based on the prioritised problems.

Based on the problem knot, five criteria are drafted:

A. Exact knowledge about the arrival times of customers is obtained for the short term, but the number of parcels per truck are unknown.
B. Exact knowledge about the number of parcels per truck from the customers is obtained for the short term, but the arrival times are unknown.
C. Clear information about trends in arrival times and number of parcels from customers for the longer term is available, these are forecasted more accurately than currently, but exact information is still missing.
D. All the amenities are present to prevent an empty floor, but more knowledge about numbers of parcels and arrival times is not obtained.
E. All the amenities are present to prevent queues for trucks to start unloading, in terms of enough capacity on the floor and material handling hardware, but more knowledge about numbers of parcels and arrival times is not obtained.

These five criteria cover the problems mentioned during the interviews. The interviewees are told the extended assumptions under these criteria, but the main assumption is that the current state is the basis, unless mentioned otherwise.

The interviewees, consisting of the process managers and the depot manager, are given a questionnaire. In this questionnaire, all criteria are compared individually. The interviewee was asked to answer which criterion was most important and to what degree, indicated on a nine-point scale.

Criterion	Variance	St.dev	Average						
A	**0.0151**	**0.1227**	**0.274**	0.087	0.371	0.190	0.359	0.239	0.398
B	**0.0381**	**0.1952**	**0.208**	0.051	0.126	0.119	0.359	0.534	0.059
C	**0.0163**	**0.1278**	**0.244**	0.333	0.243	0.453	0.166	0.124	0.146
D	**0.0075**	**0.0868**	**0.118**	0.255	0.032	0.142	0.058	0.049	0.169
E	**0.0097**	**0.0982**	**0.156**	0,.74	0.229	0.096	0.058	0.053	0.228
			Consistency Index	*0.19*	*1.51*	*0.40*	*0.18*	*0.47*	*0.16*

Table 5.1 - Weights criteria - AHP

In table 5.1, the average weights given to the criteria are shown. The relative importance of the criteria is shown in table 5.2. The last column will be discussed further in this section.

Priority	Criterion (after AHP)	Relative importance	Criterion (after team meeting)
1	A	27.4%	C
2	C	24.4%	A
3	B	20.8%	B
4	E	15.6%	D
5	D	11.8%	E

Table 5.2 - Weights criteria - AHP

The table shows the average importance of all scores. However, we see in table 5.1 that between the individual scores, huge differences occur. Not all interviewees consider the highest prioritised criterion as the most important. Additionally, their answers are not consistent, as shown in the Consistency Index. To be consistent, this number must lay below 0.10. No interviewee managed to do so.

The variance of criteria D and E is much lower than the variance of the criteria A, B and C. This is because almost all agreed on that criteria D and E were the least important of all. The other three criteria, however, were found all important, but the interviewees were not consistent on which one was most important of all. Therefore, we are interested in the priority division when they need to agree on the order.

Since this analysis is mainly used to create insight in the importance of the criteria and not extensively used to score alternative solutions, we are still able to use it. However, since the individual outcomes differ so much, a group meeting is organised where the interviewees together need to prioritise these criteria and come to one conclusion. There, we have not only looked at the outcome, but also at the teamwork and personal arguments. Surprisingly, when we asked them to together prioritise the five criteria, they concluded a different order than the outcome from the AHP method. Their outcome is shown in the last column of table 5.2.

However, it took them a relatively long discussion to convince each other about the priorities. One explains that it is also depending on when you receive the information. He explains that exact knowledge about arrival times or volumes only can be obtained shortly before the process. Clear information about trends however can be obtained for the long term, so it is more useful to have when preparing the process. During the process, however, better communication about exact numbers and times will help the process go more smoothly.

They all agreed on that the first three criteria about information were way more important than amenities for preventing queues or preventing an empty floor. They hope that with the sufficient information, they will be able themselves to prevent empty floor spaces and queues.

The reason for this difference can be explained by the fact that the criteria can be difficult to understand. Especially during the AHP questionnaire, an extensive context was not given. During the meeting, there was more context and they could help each other to all interpret the criteria the same way. Therefore, we eventually will assume the prioritised range from the meeting as more important.

5.3 Conclusions

In Chapter 5, we have gathered all the problems analysed in Chapters 2, 3 and 4; and structured them in a problem knot. From this knot, we concluded the core problem as: the process is difficult to manage. Three causes were identified for this problem:

- The process managers and planning desk do not know how many and what type of parcels to expect from a customer
- The process managers and planning desk do not know when to expect the customer
- A lot of customers are arriving late and not equally spread

To translate the problem identified during the previous chapters into criteria for the solution, we have created five criteria and via an AHP analysis and a management meeting prioritised these criteria. Since the outcome was partitioned, we have asked the interviewees to form an arrangement together, via group discussion.

The criteria were prioritised in the following order:

1. C. Clear information about trends in arrival times and number of parcels from customers, these are forecasted more accurately than currently, but exact information is still missing. *(was priority 2 from AHP)*
2. A. Exact knowledge about the arrival times of customers, but the number of parcels per truck are unknown. *(was priority 1 from AHP)*
3. B. Exact knowledge about the number of parcels per truck from the customers, but the arrival times are unknown. *(was priority 3 from AHP)*
4. D. All the amenities are present to prevent an empty floor, but more knowledge about numbers of parcels and arrival times is not obtained. *(was priority 5 from AHP)*
5. E. All the amenities are present to prevent queues for trucks to start unloading, in terms of enough capacity on the floor and material handling hardware, but more knowledge about numbers of parcels and arrival times is not obtained. *(was priority 4 from AHP)*

We can conclude from this arrangement that knowledge is much more important than extra space or amenities to prevent waiting. Also, information about the arrival time overrules information about the freight per truck. We will use this information as input for the data analysis in Chapter 6 and solution design in Chapter 7.

6. Data Analysis

In section 6.1 we show that CRIS and TIS are not sufficient for data analysis usage, so an own built conversion and visualisation model will be introduced. Next, we perform a customer arrival analysis in section 6.2. Here we investigate what problems do occur, in what frequency and on specific days or customers. In section 6.3, we conduct a data analysis on several days and perform a deeper analysis on these processes on daily parcel level. In section 6.4 we present the conclusions from the data analysis which will be used for the solution design in Chapter 7.

6.1 Introduction Conversion and Visualisation Model

In the previous chapters, we have analysed the whole process and its problems. However, most of these problems are experienced by the involved employees or observed when analysing the systems used regarding to the sorting process. Now, we need to find out where exactly the problems occur during the process and which parties are involved. The analysis consists of two aspects. In the customer arrival analysis, we have searched for noticeable trends over a period of four months, including arrival times and volumes. In the process model analysis, we have analysed and visualised the process on daily level, to find the consequences of specific volumes and arrival times.

To conduct data analysis, we need to have an information system to work with. As we already know, PostNL uses two information systems: TIS and CRIS, which are related to each other. However, we have also concluded that both systems contain enormous drawbacks and incorrect data. To obtain a clear overview of the pros and cons, we will conduct a SWOT analysis (Boddy, 2010) on both systems.

TIS

TIS can roughly be used for two instances: the transport planning and the customer registration. The customer registration is used for the forecast of the process, so only this will be treated in the SWOT analysis.

Internal Analysis	External Analysis
Strengths	**Opportunities**
- Contains customer-specific information in terms of volumes - Contains information regarding type of freight - Shows conversion rates - Data can be exported to Excel file.	- Input data is used for forecasting - Possible to register type of freight
Weaknesses	**Threats**
- TIS has no visualisation option - We only know arrival information, no processing information - There is no possibility to register the exact number of parcels - Uses incorrect conversion rates - Data export file does show two different conversion rates - Data export file does not show number of parcels - Shows incorrect expected arrival times or too broad time windows	- Manually errors are made easily - Some customers have a double identity - The data exportation was formerly not available for Hengelo, and this possibility was unknown.

CRIS

Internal Analysis	External Analysis
Strengths	**Opportunities**
- Visualises the supply and processing lines - Provides forecasting information	
Weaknesses	**Threats**
- Incorrect scheduled supply line - Incorrect realised supply - No customer specific information in graph - No possibility to export the data, so must be done manually	- Receives incorrect data from TIS - Sometimes uses own incorrect conversion data

We see that both systems have several drawbacks considering the data analysis we want to conduct. Therefore, we must create our own model which uses the strengths of TIS and CRIS, and solves their weaknesses. The two main aspects of this model are an optimised data conversion, so that the input data will be clean and reliable, and the visualisation of the data helps us to interpret the process. Therefore, the model will be called *Conversion and Visualisation Model,* (hereafter CVM). The main pro of TIS is the completeness of its dataset, which we will use for the model. CRIS its main pro is the way of visualisation, which we will (partly) rebuild in the CVM. This way, we combine the benefits of both systems and add all the other requirements to it to make it suitable for data analysis.

6.1.1 Roadmap building the CVM

For the framework of the CVM, we have used a visualisation model from Hoofddorp, which we have extensively transformed and expanded. The creation of the CVM is done by the steps elaborated in this multi-step-approach. Some of the steps will be explained more extensively further in the section.

1. We will determine the requirements of the CVM based on the SWOT- and the process analysis. Roughly, it includes the data conversion and visualisation, but we must know what data is necessary for our analysis and for preparing and managing the process.
2. We will build the CVM based on an example used at the HQ, but extensively transformed and expanded. The original version holds the idea of visualising the supply line based on yearly averages and create a processing line that is automatically linear built, with equal processing rates every hour. Both lines are not realistic, since they are extensively simplified and outliers are excluded from the graph and must be transformed in more truthfully lines.
3. We will transform the processing line into a variable line, instead of a standard linear line.
4. We will make the supply line compatible for the new input data we will use. The dataset will be visualised via PivotTables.
5. We will use the data set of TIS as input data for the CVM. Concluding from the SWOT analysis, a strength of TIS is that it contains the most complete data set, including customer specific information. In terms of completeness, the dataset is sufficient. However, we have already concluded that the data is incorrect in terms of volumes, due to wrongly determined conversion rates for load units to parcels.
6. We will determine new conversion rates and "clean" the data set, due to the problems mentioned in the previous point.

7. We will transform the clean data to make it compatible for the CVM. This includes expanding the dataset, organise data, and distinguish the freight from the customers from the shift products. We also need to consider the process time, that covers two dates.
8. We will calculate the processing line with the use of historical data.
9. We will set the parameters, for example: maximum capacity, starting time of the process.
10. We will gain extra information regarding waiting times and empty floor situations, if available and necessary.

These steps were conducted during the data analysis, from where some of the steps are further elaborated in the next sections. Before we go further, let us first look at figure 6.1, where the steps are roughly sketched in a flowchart.

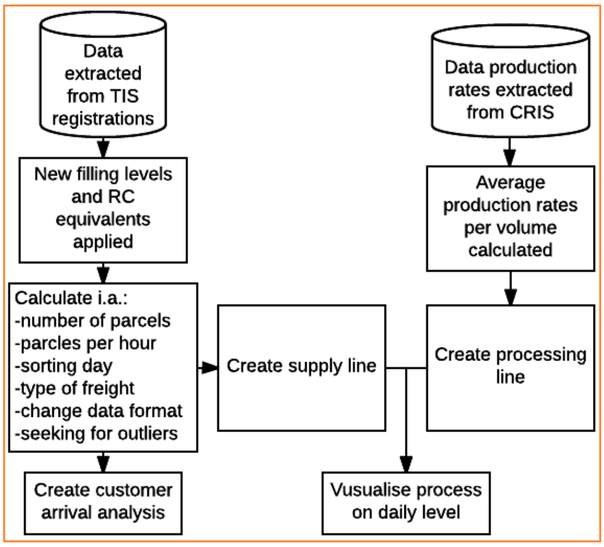


Figure 6.1 – Flowchart CVM

6.1.2 Requirements

In the multi-step-approach from the previous section is explained that much information and data is needed to build the CVM. Partly this is already available, but other parts must be determined or calculated by ourselves.

The current datasets are not reliable and detailed enough for our data analysis. We want to be able to track down which customers and what type of parcels are arriving and being processed at a specific time. As for the input data, the following variables are important for us:

- Customer
- Date
- Scheduled arrival time (rounded to quarters)
- Actual arrival time on the terrain (rounded to quarters)
- Waiting times (if known)
- Type of freight
- Number of containers arrived
- Number of parcels arrived
- Customers containing parcels with international destination

Next to that, we need to set parameters:
- Parcels processed per hour
- Number of employees

We also must determine the following constants:
- Capacity floor space
- Maximum producible capacity per hour
- Starting time
- End time

6.1.3 Choice of Data Source

For the data analysis of this research, we will extract the unedited data from TIS, because TIS is the only system that provides us detailed information about the arrival time (on the terrain) of the customers. The possible waiting time is not documented at all. Furthermore, In TIS we can export the data via management reports, that are suitable for the CVM. In these reports, detailed information about all the scheduled and arrived trucks and its freight is available. However, we already concluded not all this data is correct. Therefore, we need to analyse the data, edit and expand it before we can use it for modelling the process.

Not all the requirements discussed in the previous section are present in the datafile from TIS. For example, TIS shows the number of roll container and their conversion rates, but does not show the exact number of parcels. Also, two different conversion rates are given in the data file, from which it is not clear which one is correct. We must use data from CRIS to determine which rate is used. However, we have seen that the used conversion rates are not correct. Therefore, we need to determine new conversion rates, which we calculate in the next section.

6.1.4 Determination new conversion rates

As explained in Chapter 3, the planning desk registers all the arriving trucks in TIS. However, this is done in units of roll containers, pallets or percentages loose loading. With the use of a roll container equivalent (RC equivalent) every unit will be calculated into numbers of standard roll containers. Next to that, a filling level will calculate the number of parcels per roll container. For most customers, there is only one standard filling level, but several big customers have a different filling level. Still, these two parameters are not determined correctly, which results in incorrect data in TIS. To make the data usable for the CVM, we need to recalculate the RC equivalent and the filling level. We choose to do this for only the three biggest customers, since they have the biggest influence in the total volumes. Recalculating all the filling levels won't make marginal differences in the total parcel volumes and takes a lot of effort. Besides, analysing the RC equivalents and filling level shows that the values for the smaller customers are way more accurate than for the three biggest customers.

Since it is nowhere elaborated how many parcels a roll containers carries and it is also depending on the size of the parcels, we are not able to find an exact RC equivalent and filling level that always suits the freight. However, together with the process managers the number of parcels per unit were re-established by measuring with a sample test and discussing seasonal influences. With that, new RC equivalents and filling levels were calculated, in table 6.1.

Customer	Type unit	Old RC equivalent	New RC equivalent	Old filling level	New filling level
Otto	Corlettes	2.154	**4.33108**	103.9	**103.9**
Otto	Loose loading	0.56	**0.19249**	103.9	**103.9**
Zalando (Brieselang)	Pallets	1.75	**1.75**	64	**42.85**
Zalando (Gossbeeren)	Pallets	1.75	**1.75**	64	**42.85**
Zalando (Erfurt)	Pallets	1.75	**1.75**	59.8	**57.14**
Zalando (Erfurt)	Loose loading	0.56	**0.7**	59.8	**57.14**
Arvato	Pallets	1.75	**1.75**	46.5	**42.85**
Other customers	Roll containers	1	**1**	28	**28**

Table 6.1 - Recalculated RC equivalents and filling levels

6.1.5 Determination of parameters

For the model, we need to set our parameters. These are characteristics that are variable to the input data. For this model, the following parameters need to be determined:

Capacity floor space: The capacity of the floor space depends on the type of carrier of the parcels. However, in the production plan, PostNL has determined that the capacity of the floor is 15,000 parcels. In case of loose loading, the capacity reduces to 12,000 parcels.

Maximum producible capacity per hour: The maximum number of parcels processed per hour is set on 8,000.

Starting and end time: The starting time is 19:00 for <50,000 parcels, 18:30 for 50,000-55,000 parcels and 18:00 for >55,000 parcels. The end time is normally 02:30, but can be earlier if all parcels are processed.

Parcels produced per hour: For the number of parcels processed per hour, the exact historical production volumes of these days are not available. Therefore, we used the historical data from the past three months extracted from CRIS. The used production rates per hour can be found in Appendix VII.

6.2 Customer Arrival Analysis

Now that the input data is determined and we have calculated more accurate filling levels and RC equivalents, we can move on to the CVM. For the customer arrival analysis, we used the conversed data to visualise possible trends. The actual visualisation of the CVM for processing days is shown in section 6.3. The time window of four months (October 2016 – January 2017) is chosen, because of the mid-term length. The parcel industry is a fast-growing industry, which makes it hard to find reliable trends on the long term. However, a too short time window will not give us the opportunity to find trends at all. Additionally, data from earlier than October 2016 was not fully available. Also, need to be mentioned that from the end of November till the end of December, the holidays during this period cause a much higher supply. We need to keep this in mind analysing the data.

First, we will analyse the trends within these months. This is done by looking at total volumes and arrival times at terrain, and trends considering the three biggest customers of PostNL.

6.2.1 Data from Management Information Systems compared

We have already concluded that the systems CRIS and TIS are holding inconsistent data. This is the main reason we have created the CVM. From T&T, we know the total volumes are accurate. However, it does not give us the sufficient information regarding arrival times and customers, and it is hard to work with and run an analysis on. Therefore, we cannot use the data from T&T for analysis. However, the total volumes from the CVM must lay near to the volumes from T&T, to be reliable. We already explained in section 6.1 that our data is extracted from the management reports from TIS and then is transformed into more accurate volumes.

In table 6.2, the differences between the systems are shown. We analysed a period of four weeks, that includes both the high volumes from the holidays, as well as the current volumes from the start of this year.

Date	CRIS Prognosis	Volumes TIS	Volumes CVM	Real volumes	Best model (TIS or CVM)
19-dec	67,414	64,540	61,474	61,644	**CVM**
20-dec	62,671	67,634	63,564	65,173	**CVM**
21-dec	55,700	69,890	65,782	63,264	**CVM**
22-dec	53,126	58,742	53,442	58,329	**TIS**
23-dec	54,529	44,726	43,823	41,099	**CVM**
27-dec	58,109	56,368	55,928	54,819	**CVM**
28-dec	46,119	56,040	51,430	51,446	**CVM**
29-dec	48,712	51,592	49,224	46,060	**CVM**
30-dec	41,119	42,265	39,977	36,864	**CVM**
2-jan	54,114	52,469	44,832	40,558	**CVM**
3-jan	38,466	54,658	48,404	47,452	**CVM**
4-jan	45,360	51,707	45,844	41,874	**CVM**
5-jan	35,710	54,533	48,076	45,574	**CVM**
6-jan	37,624	39,625	36,277	32,340	**CVM**
9-jan	47,665	63,134	55,578	51,564	**CVM**
10-jan	45,018	48,127	42,082	43,041	**CVM**
11-jan	40,414	47,861	41,204	40,479	**CVM**
12-jan	39,012	39,641	40,310	36,119	**TIS**
13-jan	34,508	46,971	36,283	32,688	**CVM**
16-jan	53,121	59,499	54,387	41,310	**CVM**
17-jan	44,655	48,343	45,808	40,739	**CVM**
18-jan	41,817	45,227	38,394	41,415	**CVM**
19-jan	35,307	46,445	42,178	36,875	**CVM**
20-jan	34,308	41,513	37,962	32,515	**CVM**

Table 6.2 - Volume differences between Management Information Systems

As is shown in table 6.2, in most of the cases, the new built model for this research is more accurate version. We do see that sometimes TIS has a better value. There is no distinct reason for that, but because they are both estimators. When we include the prognosis from CRIS, we see that several times this number is the closest to the real volumes. This is logically explained by the fact that the CRIS prognosis directly uses parcel volumes from Track & Trace, which is more accurate than estimations based on roll containers. However, the major downside with this prognosis is that information about customers is not available. Calculation of the Mean Squared Error on these three different estimates of the real volumes shows us that our model is the most reliable estimator, since it has the lowest Mean Squared Error.

	CRIS Prognosis	Volumes TIS	Volumes CVM	Lowest MSE
Mean Squared Error	$40 * 10^6$	$66 * 10^6$	$17 * 10^6$	Volumes CVM

Table 6.3 - Mean Squared Error

The volumes from the CVM still can differ from the real volumes, since it is an estimation from the documented freight in TIS transformed into number of parcels. However, it is reliable enough to work with for the data analysis. Currently, the volumes of TIS are used for forecasting customer specific information, and the CRIS Prognosis only shows the total expected volume. Both estimators have a lower MSE.

It was also noticed that sometimes, the arriving freight was not documented correctly in TIS by the planning desk. This can result in totally wrong volumes. A few times, 20 corlettes were documented, instead of 10 corlettes. This is difference of 4,500 parcels extra. For the customer arrival analysis in this section, we did not correct these errors, since we cannot analyse all the registrations manually for four months. In our daily process model in section 6.3 however, if noticed, we corrected these documentation errors, so that our volumes will be adequate.

6.2.2 Total daily volumes

To be able to manage the process, we need to know how many parcels to be expected. Based on this expectation, the start time of the process and the occupation will be determined.

At PostNL Hengelo, it is known that there are different trends per weekday, but they feel that the volumes for each weekday are comparable. However, this is just a guess, they do not know this for sure. Looking at the last four months, the total volumes per weekday are shown in the graphs below. The average volumes per day are shown in figure 6.2. This graph uses data from the sorting machine, since it is most accurate and we only are interested in total volumes. All the other graphs were created with the CVM.

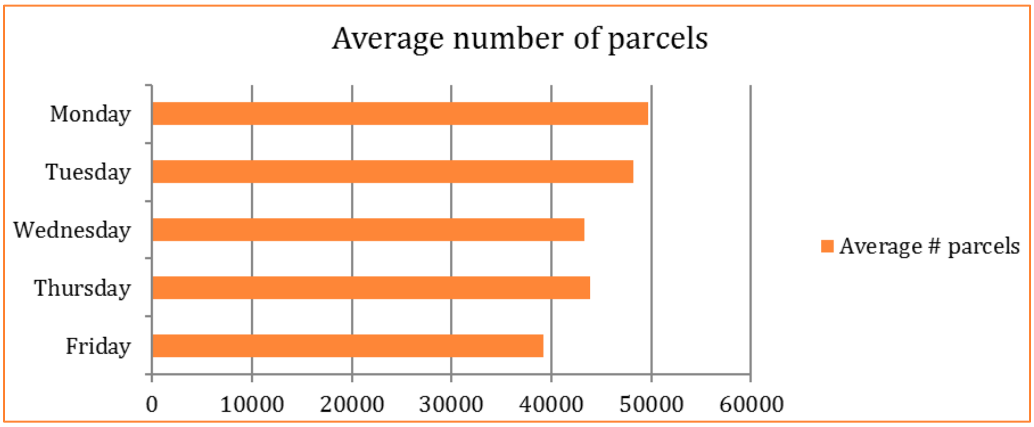


Figure 6.2 - Average volumes per day

We see that Mondays and Tuesdays have high volumes, touching the 50.000 parcels per day. On Fridays, the lowest volumes are being sorted. The process managers indicate that the processes on Monday's and Tuesday's are the most difficult to manage. In Appendix VIII, the extended analysis per day can be found. Since holidays were causing non-random peaks, we excluded these days from the analysis. The following results were found regarding total volumes:

Day	Max	Min	Difference	Average	% of Total
Monday	57,193	40,558	16,635	47,525	22.33%
Tuesday	54,819	40,256	14,563	45,800	21.52%
Wednesday	48,861	37,656	11,205	41,010	19.27%
Thursday	46,060	36,119	9,941	41,045	19.28%
Friday	46,125	32,034	14,091	37,468	17.60%
Total	**253,058**	**186,623**	**66,435**	**212,848**	**100.00%**

Table 6.4 – Summary total volumes per day

On Mondays and Tuesdays, the average difference is relative high. Also, for Mondays and Tuesdays, it is hard to find a trend, but for the Wednesday and Thursdays, the total volumes are close to each other's. The Fridays have more fluctuations, but the average volume is the lowest of all days, around 37,500, which is easier to process and therefore less problematic.

6.2.3 Arrival times

One of the main problems observed during the process analysis, is the lack of knowledge about arrival information of the customers, both in terms of arrival times and freight per customer. From the AHP analysis in Chapter 5, we know that exact information regarding the arrival times or freight is desired, and otherwise more knowledge about trends is needed. This way, the arrival information is easier to predict by themselves. Therefore, we first will analyse possible trends in arrival times and in the next section we will analyse the freight of arriving trucks.

Since it is not achievable to analyse all customers individually, we choose to analyse only the three customers with the highest volumes: Otto, Arvato and Zalando. They have the heaviest impact of the process and gaining more information about their freight will help to ease the management of the process. Zalando has trucks from three load locations, and can be considered as three individual customers: Zalando Erfurt, Zalando Gossbeeren and Zalando Brieselang. Last two, however are relatively extremely smaller customers than Zalando Erfurt. They are comparable to other smaller customers we excluded from this analysis. We especially only chose the biggest customers, since more than one arriving truck makes managing the process difficult, since PostNL does not know what and when to expect. The perception of the employees is that the customer 'Zalando' is difficult to predict and manage, but surprisingly it turns out that only Zalando Erfurt does indeed have a big negative impact on the process management, because of the size difference. Therefore, we have decided to only include Zalando Erfurt in our analysis instead of all load locations. In Appendix IX, more detailed information about Zalando Brieselang and Zalando Erfurt can be found.

The information considering the three biggest customers is divided in the arrival times of the trucks and the volumes they deliver, but also how many and the type of parcels each truck from the big customers contains. As for the arrival times, Otto and Zalando Erfurt are both arriving with maximum four trucks. Arvato is arriving with at most three trucks. The arrival times per truck (divided per hour) are shown in the graphs 6.3; 6.4 and 6.8 further in this section. Let us first take a look at the arrival times of Otto and Zalando Erfurt.

Otto is considered as a difficult customer, since no specific information is provided for Hengelo, as mentioned in Chapter 4. Also, their freight contains corlettes and loose loading, which are both type of freight that are hard to manage and process. An important note is that one truck from Otto contains two trailers, from which one trailer is loose loaded and the second contains corlettes. A truck from Otto with 100% loose loading will take two hours for unloading, based on conveyor belt capacity and assuming only one conveyor belt is used. In the next section, we will focus on the type of freight. We see that Otto arrives with two trucks, and occasionally a third or fourth. Zalando arrives with a comparable number of trucks, however, these trucks do contain only one trailer.

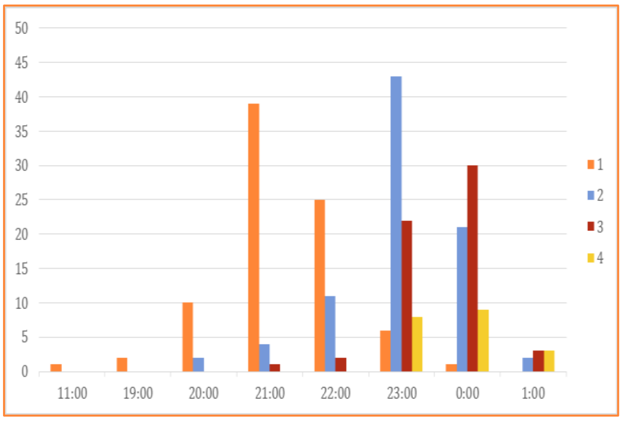


Figure 6.3 - Arrival times per truck Oct 2016-Jan 2017 – Otto

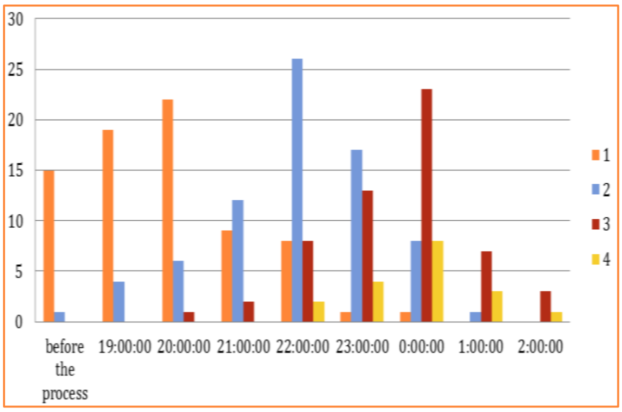


Figure 6.4 -Arrival times per truck Oct 2016 -Jan 2017– Zalando Erfurt

In the graph in figure 6.3 we see the arrival times of the trucks of Otto. The times on the x-axis shows the past hour. The totals of this period are 84 times a 1st truck, 83 times a 2nd truck, 58 times a 3rd truck and even 20 times a 4th truck. For Zalando, 75 times a 1st and 2nd truck arrives; 57 times a 3rd and 18 times a 4th. The graphs of both customers look comparable, and for both we can clearly conclude that there is no strict arrival time that PostNL Hengelo can rely on. For Otto, truck 1 arrives in 47% of the times at 20:00-21:00, but on 30% of the times at 21:00-22:00. For truck 2 is a peak shown at 22:00-23:00 (52% of the times). For Otto, we also see that the arrival times of truck 3 are close to truck 2, which indicates that sometimes the times between their arrival is less than 1 hour. Since the unloading time is 2 hours, the third truck must wait before it can start unloading, because the docks for Otto are occupied. Let us move on to the graph of Zalando Erfurt. There, we see that the truck 1 arrives most of the times before the process or in the first hour, based on the analysed data. Truck 2 can also already arrive before the process, but a peak is shown at 21:00-22:00. Truck 3 shows a peak at 23:00-00:00. The extended graphs of the arrival times of Otto can be found in Appendix X and of Zalando Erfurt in Appendix XI. However, if we zoom in on these times, we get the following graphs.

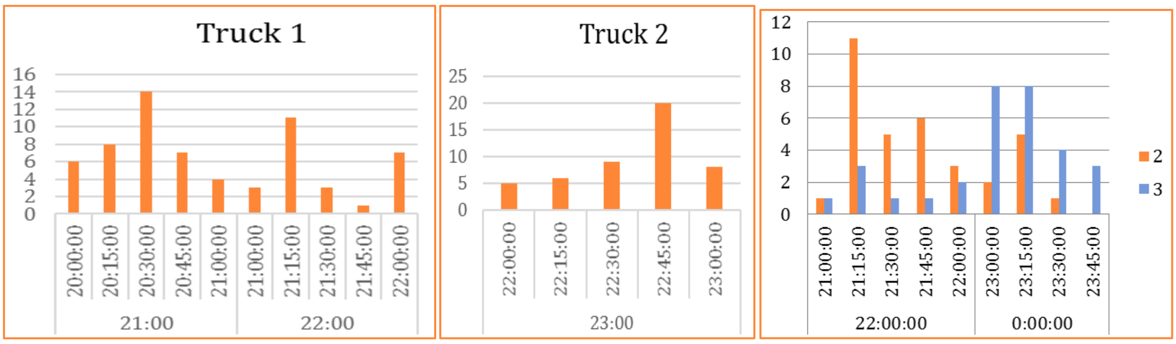


Figure 6.5-6.7 –Otto 20:00-22:00 | Otto 22:00-23:00 | Zalando Erfurt 21:00-22:00 and 23:00-00:00

The first two graphs show the trucks from Otto, the last graph shows the trucks from Zalando Erfurt. For all we see that the peaks themselves are widely spread as well. For example, looking at figure 6.7, at 21:15 a noticeable peak is found for truck 2. However, it counts only 11 trucks, which is only 17% of all the second trucks that arrived every day during the analysed period. The same applies for Otto. Their highest shown frequency is truck 2 arriving at 22:45, but this is only 20 out of 83 times. This is still not enough to use as expected arrival time for PostNL.

In the graphs in the figures 6.3-6.7, sometimes, the bars create a shape of a normal distribution. If this would be the case, it could indicate that there is some expectation possible in the arrival time. However, this analysis is meant to get a global insight in the arrival times and trends that are noticeable in such a way that PostNL Hengelo can predict themselves when trucks would arrive. This will still not be possible if a certain distribution is present, so we will not further investigate the presence of a distribution. We will further discuss this aspect in the discussion in Chapter 8.

The graph of Arvato looks different compared to Otto and Zalando Erfurt, as is shown in figure 6.8. Their 1st truck is, as agreed, always arriving before the process, during the analysed period, which is a noticeable and reliable trend. It does not matter at what specific time they arrive then. Also, they are arriving with less trucks, what makes them easier to manage. The 2nd and 3rd truck are arriving more spread, which makes them more unreliable. Also, the peak of these trucks is both at 21:00-22:00, and thus there is a possibility that they are arriving at the same time. Luckily Arvato has no dedicated docks, in contrast to Otto and Zalando Erfurt. This makes it easier to manage and makes it less problematic when two trucks arrive at the same time. Still PostNL cannot predict with how many trucks they are arriving and at what time. In Appendix XII, the arrival times per day are shown.

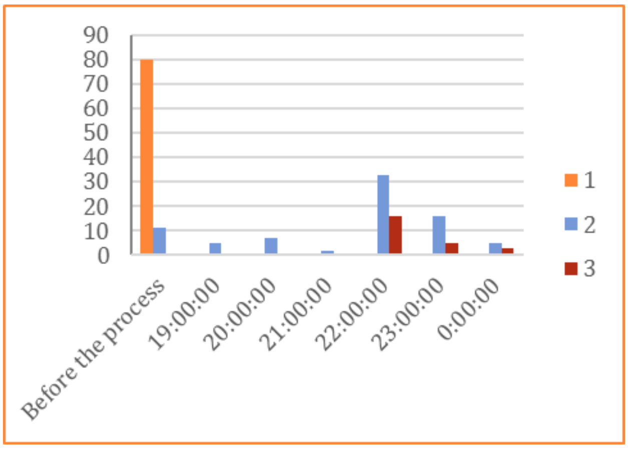


Figure 6.8 – Arrival times of trucks - Arvato

Overall, we see that for all customers applies that the SLAs were not met on regular bases, considering the analysed data. This problem was already mentioned as problem 34 in the overview at the end of Chapter 4, where also the SLAs can be found. Both in number of trucks and agreed arrival times, these customers fail to meet them. We especially want to address the fact that according to the SLA, only at Mondays a third truck of Otto will arrive. However, in the data we have seen that at every day of the week, a third truck can arrive. Even a fourth truck arrives occasionally, which is never appointed in the SLA. The graphs of number of trucks per day can be found in the appendices X (Otto), XI (Zalando Erfurt) and XII (Arvato).

Conclusion
Based on the analysed criteria, the assumption is made that trends in arrival times are unable to find for all the analysed customers. Not only the arrival times are unpredictable, we also see that the customers deliver more trucks than agreed on. This makes it impossible to know how many trucks will arrive and when they will arrive. We only see that the first truck of Arvato is in 100% of the times arriving before the start of the process. Furthermore, when comparing the actual arrival times with the agreed arrival times of the Service Level Agreements, we can conclude that most of the time these agreements are not met.

6.2.4 Freight

According to the AHP analysis from Chapter 5, next to the arrival times, also the freight was important to the employees. For PostNL Hengelo, it is important to know the freight each truck contains. In this section, we will analyse the total freight and the freight of the three biggest customers, in terms of volumes and type of parcels. Also, we will analyse the supply per hour.

Total freight

In the graph in figure 6.9, the freight per hour is shown. The blue bars indicate the maximum freight occurred in the period of the analysis and the orange bar indicates the average freight per hour.

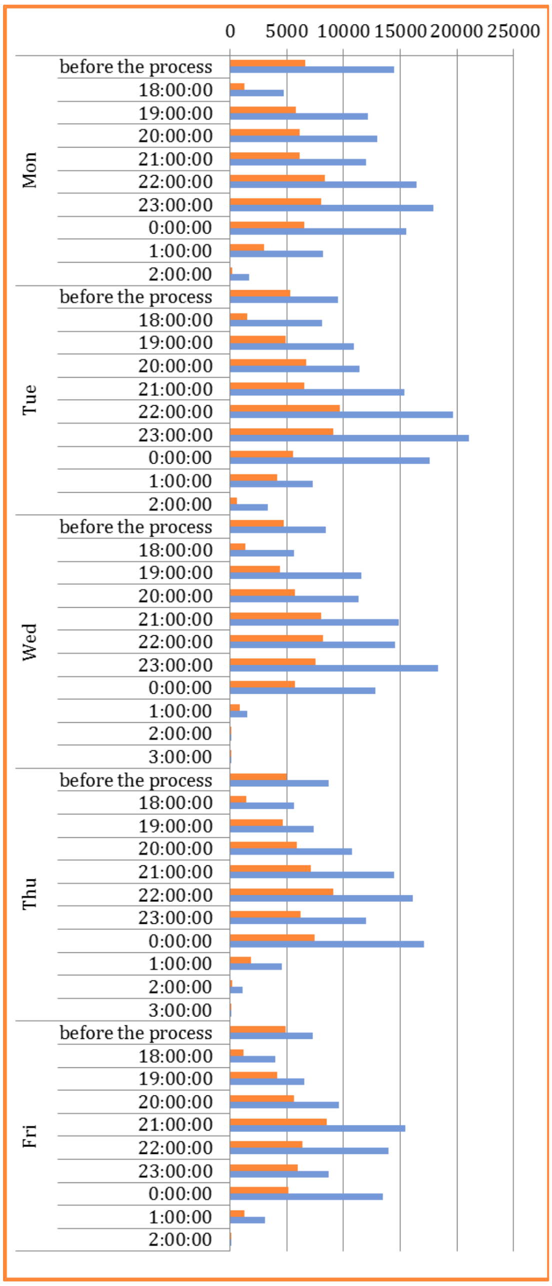


Figure 6.9 - Total freight per hour

We see that for all days, between 21:00 and 23:00, the highest volumes arrive at the depot. On average this will be around the 9.000 parcels per hour during peak time. However, if we look at the maximum freight occurred, we see that these volumes are much higher, most of the times the maximum freight is even double the average freight.

When zooming in on some time windows with a high maximum freight, we conclude that several times this is the result of a wrong registered customer. For example, the maximum freight on Tuesday between 22:00 and 23:00 indicates a volume of over the 20.000 parcels. When analysing this day, we see that a customer with a freight of 6.500 parcels is incorrectly registered one day later than it actual did arrive. This is considered as an outlier, which occurs in every dataset. However, currently the planning desk does not know the consequences of wrong registered data and without this knowledge, the risk for wrong registrations and thus outliers is higher, especially since outliers are currently not being detected.

Concluding this analysis, we see that incorrect registrations happens several times. These registrations eventually result in wrong forecasted processes, so it is important that the awareness is present of the causes of these actions. At this moment, the planning desk is not aware of these wrong registrations and do not know the effects of it.

Control Chart Total freight per hour

In the data analysis considering the freight, we have used averages of the volumes. However, we also want to know how consistent these volumes are and if these averages are reliable estimators. Therefore, we create a Control Chart, hereafter c-chart, (Ozcan, 2009). Here we see the frequency of volumes within the range of randomness and outside the range of randomness. In Appendix V, the theoretical background of the c-chart is presented.

For the c-chart, the upper and lower control limits, UCL and LCL, need to be determined. These limits are depending on the sample average. First, we will determine the c-chart for the total parcel supply per hour. We want a 95.5% confidence interval, so the z-value will be 2. In our case, N=87. In table 6.5, the limits are shown, together with the results of randomness.

	< 19:00	19:00	20:00	21:00	22:00	23:00	00:00	01:00	02:00
Average	6,645	4,793	6,019	7,252	8,343	7,363	6,081	2,372	69
UCL	6,808	4,932	6,174	7,422	8,526	7,535	6,237	2,469	86
LCL	6,482	4,655	5,864	7,082	8,160	7,191	5,925	2,275	53
# random	5	3	3	4	2	3	2	0	0
% random	6%	3%	3%	5%	2%	3%	2%	0%	0%

Table 6.5 - C-chart results

We see that the percentages of volumes that fall within the limit range are extremely low, with a maximum of 6% of the days are random before the process. We will visualise the c-chart for the busiest hour of the process, between 21:00 and 22:00, to see the spread of the arrival volumes.

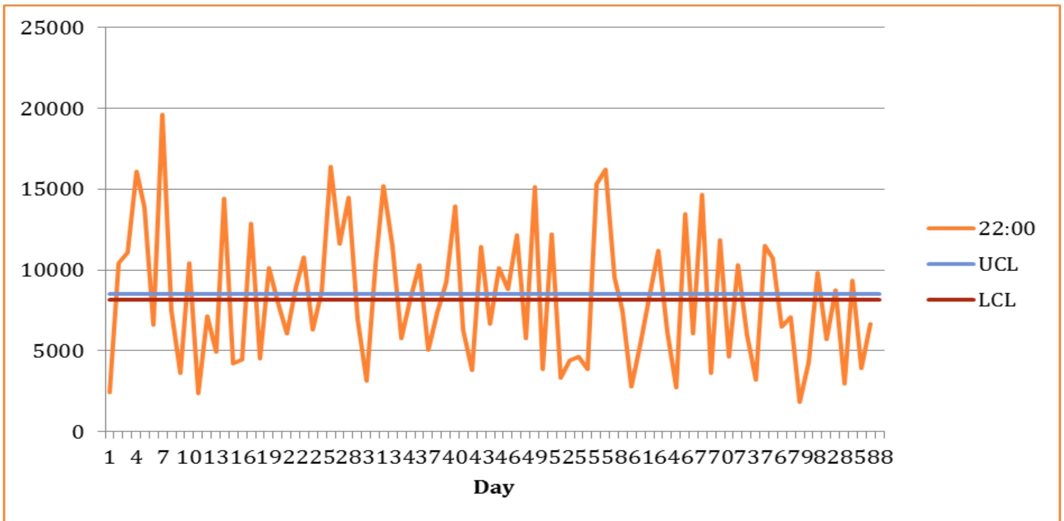


Figure 6.10 – C-chart between 21:00 and 22:00

This graph shows how big the spread of the arrival volumes is compared to the control limits. This applies for all hours, which shows that it is impossible for PostNL Hengelo to rely on an average volume per hour. However, even though values are way out the control limits, they look random. Let us dig deeper in analysing the control chart. The literature states that also patterns can be sought within the values. Generally, this is done to chase anomalies, even though the observations stay within the confines of control limits. Even though we already concluded that almost none value is marked within the control limits, we still will calculate the control patterns for the completeness. The calculations are shown in table 6.6.

	# runs	E(run)	σ(run)	*z*
A/B	51	44.5	4.63	1.40
U/D	62	57.7	3.89	1.11

Table 6.6 – Control Patterns

We see that the z-values are within the range of -2 and +2. This implies that the volumes are random. However, before we concluded that the values were outside the control limits. This is an extremely surprising result. However, it is explainable in our situation. In our situation, even though the result from the c-chart was 'non-random', there is no non-random reason for the volumes to be so spread, and there is no pattern to be found in the volumes. The results of the c-chart are heavily spread, but random as well. This indicates that it is not achievable to rely on the averages from the analysis, since the real numbers are so heavily spread with no specific reason. If we analyse the separate days, we see the same problem. For all days, the percentage of random volumes per hour were extremely low, with an average of 8%. The exact percentages can be found in Appendix XIII.

Still, the fact that both analyses are providing different conclusions, gives an indication the c-chart is probably not extremely suitable in this situation. We will further elaborate on this in the discussion in Chapter 8. However, for now the values not laying between the control limits confirms us that the values are hard to predict and the average volume per hour cannot be found reliable enough to use as forecast, what the goal of conducting the c-chart was.

Customer specific analysis

It was already mentioned before that Otto is the biggest customer (if we consider the three different load locations of Zalando as individuals) of PostNL. In total numbers, the average freight of Otto is 12,593 parcels per day, with a maximum average of 13,894 on Tuesdays and a minimum average of 11,218 on Fridays. The extended analysis can be found in Appendix X.

A truck from Otto consists of two trailers, with in one trailer corlettes and one trailer a loose loaded freight. Both trailers can unload next to each other on specific docks. The capacity of a trailer with loose loading is 2,000 parcels and with corlettes is 4.500 parcels. Considering the average freight of Otto, we can conclude that a lot of days, three trucks are needed. We see the following average volumes in the graphs in figure 6.11-6.14.

Truck 1 Truck 2 Truck 3 Truck 4

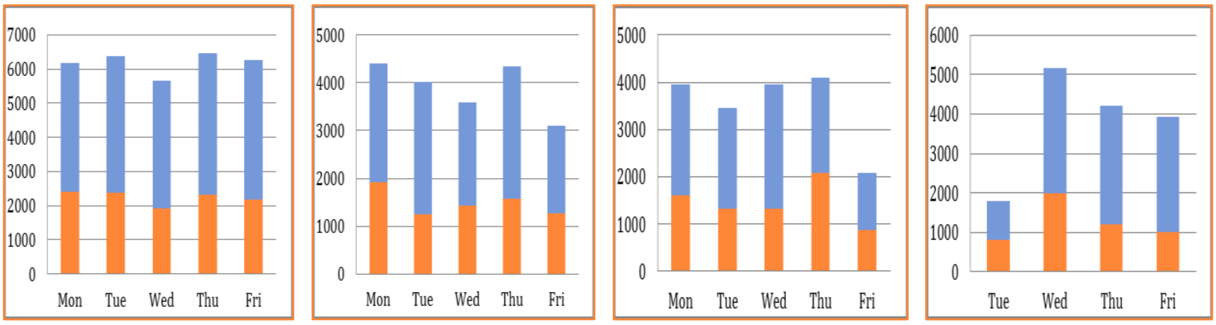


Figure 6.11-6.14 - Average freight per truck

The different colours in the bars indicate the different trailers. The trailers are not dedicated to one type of parcel in the registration, so the average of each trailer contains both corlettes and loose loading. We recall that a truck with the maximum load contains 100% loose loading and 10 corlettes. This equals 6,500 parcels, considering our calculated RC equivalents and filling levels from section 6.1. We see that truck 1 almost contains this freight on average, so PostNL can assume, based on these four months, this truck is fully loaded. For the other trucks, this does not apply. We also see that at all days, more than two trucks can occur. This is remarkable, since a third truck only is agreed on Mondays and a fourth truck is never agreed on, considering the SLA.

Let us move on to Zalando Erfurt, which is the customer with the second highest volume. The average volume per day is 8,714, with a minimum average of 7,640 on Fridays and a maximum average of 10,401 on Tuesdays. The extended analysis can be found in Appendix XI.

Zalando Erfurt delivers on pallets and loose loaded, but only delivers one type of freight per truck, and not both combined like Otto. The capacity of one truck if the freight is on pallets is 3,500 parcels and if the truck contains loose loaded freight the capacity is 4,000 parcels.

If Zalando Erfurt is arriving with only two trucks, both trucks are loose loaded. However, if three trucks arrive, the 1st truck will contain pallets. In data analysis, this makes it hard to distinct whether the 1st truck is loose loaded or not. However, from the data in TIS we have seen that also the 2nd or 3rd truck can contain pallets. We do not know the cause of this. It could be a wrong registration; a switch of trucks or Zalando Erfurt has sent more than one truck with pallets. However, we can conclude from the data that it is hard to forecast the type and volumes of freight. In Appendix XI there is an extended analysis. In the graph in figure 6.15, the average volumes per truck are shown.

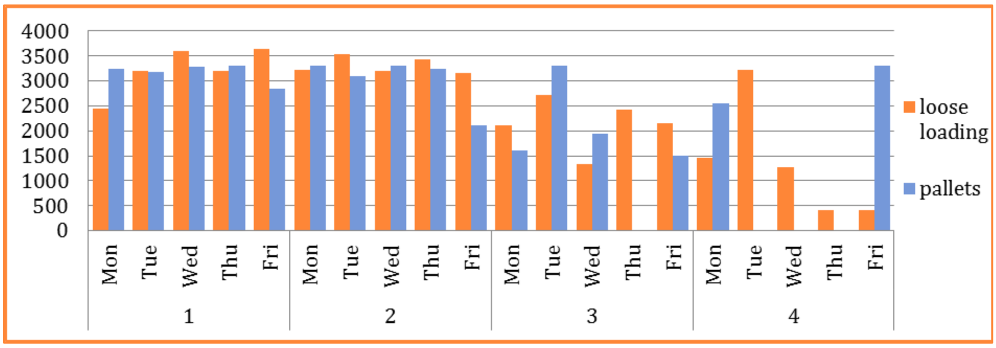


Figure 6.15 - Volumes per truck

We do see that the 3rd and 4th truck does show heavily more variety in average load over the days than the 1st and 2nd truck, but zooming in on the first two, we also see that the differences over the days can go up to 1000 parcels. Considering this data, there is for all trucks no fixed average load that applies for all days. We will analyse the reliability of the average as estimator later in this section.

Moving on to Arvato, their average freight per day is lower than the previous two customers. than on Tuesdays. At Mondays, the maximum average volumes arrive with 5,457 parcels. On Fridays, the minimum average number of parcels arrive, which is 4,180. The extended analysis can be found in Appendix XII.

The parcels of Arvato are only delivered on pallets, with a maximum capacity of 2,700 parcels per truck. We already concluded based on this data that the first truck of Arvato always arrives before the process. The other two truck arrive on variable times. Focusing on the freight per truck, we get the following results. These are shown in the graph of figure 6.16.

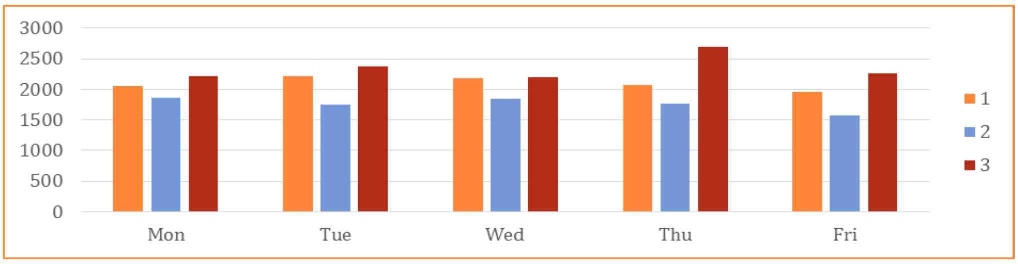


Figure 6.16 - Average freight per truck

The graph shows that the averages of truck 1 and 2 each day are not extremely varying. However, there is scatter present in the actual volumes, which we will show further in this section, so it is still hard to predict the volumes of an arriving truck. Still, we already concluded that the first truck is easy to manage since it has already arrived before the process and thus its freight is known at the start of the process. Remarkable is the high volume in the third truck. Even though it is not arriving every night, when it arrives it is fully loaded on average. Since it is arriving last and Arvato has strict due dates because of the international parcels, it is important to keep track of this truck.

C-charts customers

Since the analysed numbers in the previous section are only averages, we again conduct c-chart analyses on this data as well. The full analysis can be found in Appendix XIII.

We have conducted c-charts both on the average freight per day, as well on the average freight per truck for each customer. For all customers, both per day and per truck, we see the same results as the c-chart conducted on the total freight in the previous section. This means that there is a low percentage of randomness, but the z-values of the (A/B) and (U/D) analysis are between -2 and +2. There, we explained that even though the result from the c-chart was 'non-random', there is no non-random reason for the volumes to be so spread, and there is no pattern to be found in the volumes. We have critically questioned the suitability of the c-chart already, which also applies this time. However, it is again indicated that it is not achievable to rely on the averages from the analysis, since the real numbers are so heavily spread with no specific reason.

The only outlier we have found is the freight of the first truck of Zalando Erfurt, where the 76% of the values lay within the control limits, with an average of 3,195. For this truck, we can carefully conclude, considering the analysed data, that its average is a relative reliable estimator.

6.3 Process Model Analysis

On daily level

In section 6.2, we have analysed big numbers of data from the CVM, to find trends in the past four months. However, the actual customer arrivals during a process day are not clear. We also cannot analyse the number of parcels on the floor and the trucks waiting to unload. To analyse these problems, we need to zoom into the process on a daily level. In section 6.1, we already concluded that the present information systems do not offer us the correct and full information. Therefore, we visualise the processing days with the CVM. We use the same data input as for the customer arrival analysis.

6.3.1 Choice of modelled days

We have modelled all the process days of the analysed time window from section 6.2. However, we only want to analyse a sample of days, which represent the full time window. Therefore, it is important to make a thought-out decision of days for het sample.

From the data analysis in section 6.2, we have seen that the total highest volumes occur on Monday and the highest volumes of Otto and Zalando Erfurt on Tuesday. On Friday, the lowest volumes do occur, but that can result in a higher risk of an empty floor, experience the process managers. Therefore, we want to analyse 1 Monday, 1 Tuesday, and 1 Friday. The analysed time window contains the processing days from October 3th till January 10th. In January, we also have collected data about periods of empty floors and trucks waiting on the terrain to unload. Therefore, we desire to include at least one day in January. Additionally, we want earlier dates from the analysed period for comparison.

December was the month of the holidays. In section 6.2, we have excluded the holidays from the analysis. It requires a different management and therefore, we will not include December in our daily analysis.

From Monday January 9th till Friday January 20th, the planning desk has documented all the trucks that had to queue before unloading and the reason for waiting. Therefore, we will choose the days in January between this time window. Considering all these constraints, in consultation with the depot manager, we will analyse the following processing days:

- Monday October 10
- Tuesday November 1
- Monday January 9
- Friday January 20

6.3.2 Daily Model

In the process model, we have excluded loose loading freight from the total volumes. However, they are shown on the x-axis of the graphs. This is because the loose loading freight will not be stored on the floor, but immediately placed on the sorting machine when unloading, with the roll out conveyor belt. When loose loaded freight arrives, and starts unloading, the conveyor belts will be used. One conveyor belt can process around the 1,000 parcels per hour. For a fully stocked truck from Zalando, this means it will take up to: $\frac{4000}{1000} = 4\ hours$ to unload the freight. Most of the times Zalando will be using 2 conveyor belts. Therefore, we assume that it will take *2 hours* for Zalando to unload a 100% filled truck. A 100% stocked trailer from Otto contains 2,000 parcels. However, it only uses 1 conveyor belt and thus will also take *2 hours.* In practice, for unloading trucks it means first come, first serve. This can lead to the fact that Otto will be unloaded at a Zalando dock or otherwise if necessary. When the loose loading conveyor belts are in use, a floor space of around 3,000 parcels cannot be used. The capacity of the usable floor space will reduce from 15,000 to 12,000 parcels.

First, we show all four graphs of the processes. The big customers are marked in the graphs. The lines on the x-axis is loose loaded freight. We will recall these graphs through this section.

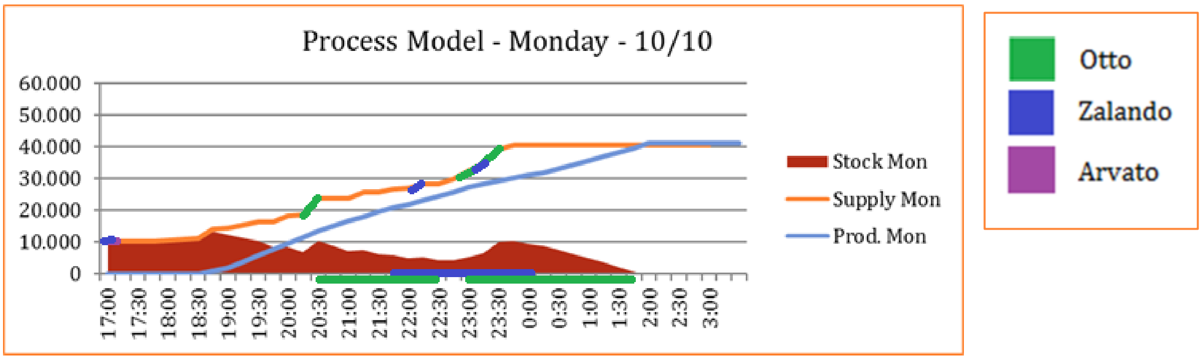


Figure 6,17 – process model October 10th

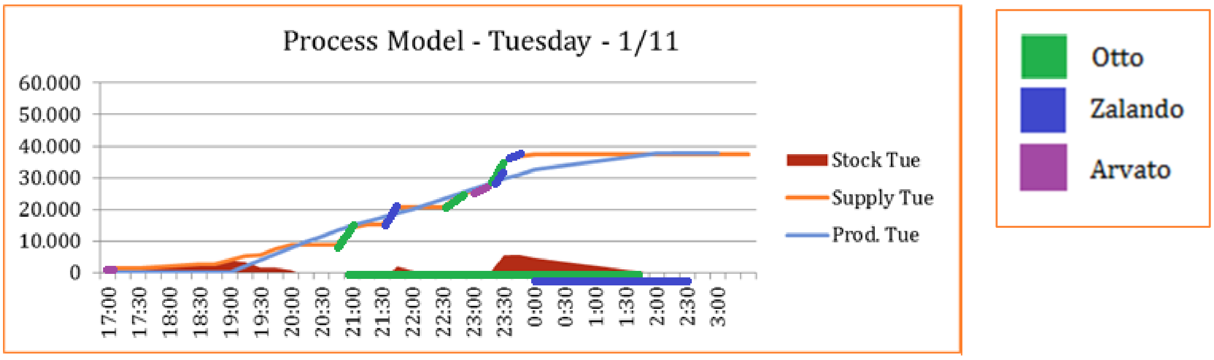


Figure 6.18 - Process model November 1st

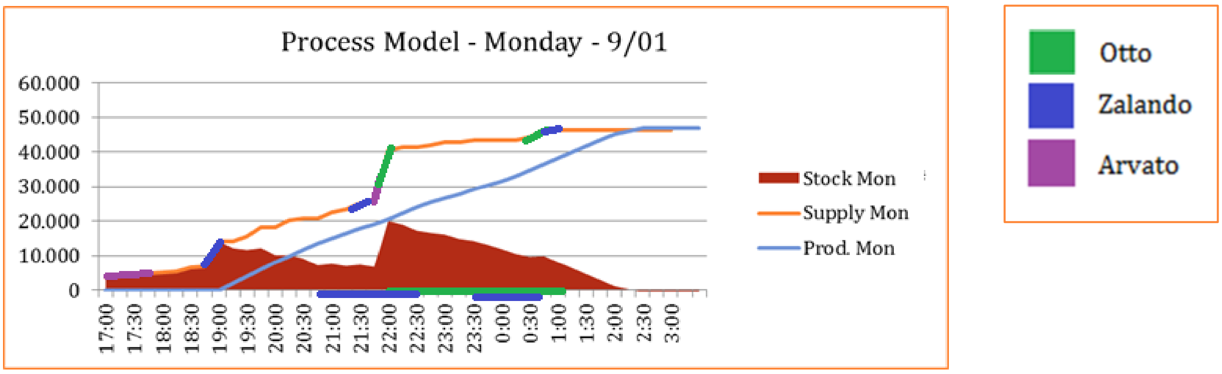


Figure 6.19 - Process Model January 9th

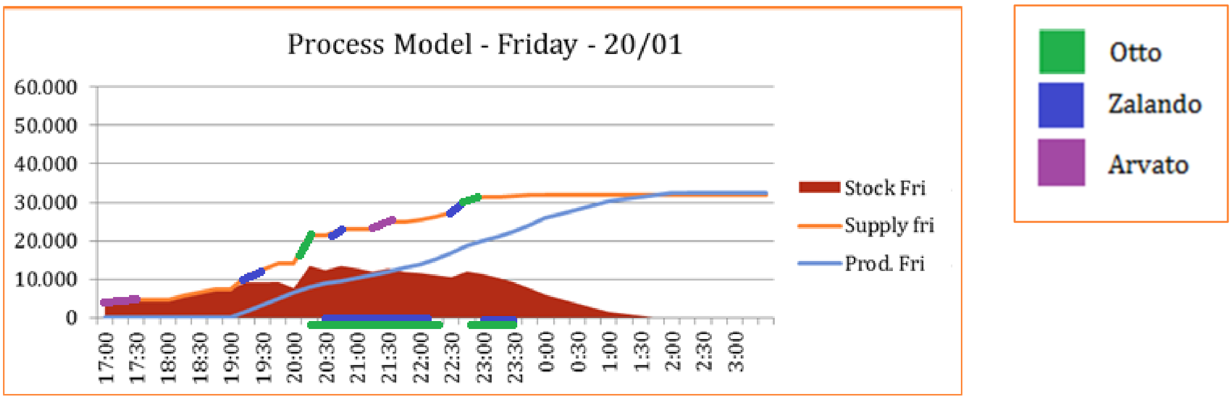


Figure 6.20 – Process Model January 20th

The detailed arrival information of the big customers can be found in Appendix XIV. Let us first shortly introduce all four days.

Monday October 10th

This day is marked as a busy process, with a total volume of 51,785 parcels considering the CVM. The total volume of the big customers is 31,975, which is 64% of the total. This shows how important these customers are for the process. However, even though the high volumes, the total stock during the process is relatively constant and never too high. The highest level is measured at the beginning, showing the importance of starting the process earlier when the total volume is >50,000. If started at 19:00, the stock level would reach the maximum capacity.

Tuesday November 1st

On this day, the total volume was calculated on 49,173 parcels, considering the CVM. However, this volume is after manual recalculations, since we found some incorrect registrations which were influencing the total volume. A trailer from Otto was registered with the wrong type of parcels (loose loaded instead of corlettes), resulting in a difference of 2,500 too few parcels.

What is immediately striking of this process is that at several times there is no stock left to produce, which means the process must pause till the next customer arrives. We will dig deeper into this problem and compare it to the other processes further in this section.

Worth mentioning is that the management of PostNL Hengelo desires to execute the possibility of shortening the processing time in some cases, since it will lead to higher efficiency and a lower risk for an empty floor. Looking at the stock level of this process, it could possibly be beneficial in this case. The possibilities for executing this method are tested in the solution design in Chapter 7.

Monday January 9th

From Monday January 9th till Friday January 20th, the planning desk has documented all the trucks that had to queue before unloading and the reason for waiting. At Monday January 9th, ten trucks had to queue during the process. The first problem we do see occur is when comparing the forecasted volumes with the actual volumes. We recall the table from section 6.2.

Date	CRIS Prognosis	Volumes TIS	Volumes CVM	Real volumes
9-jan	47.665	63.134	55.578	51.564

Table 6.7 - Comparison data January 9th

Here we see that the prognosis from CRIS lays around 4,000 parcels below the real volume. The main problem in this case is that the prognosed volume lays below the 50,000 parcels, while the real volume lays above it. We already stated that for volumes above 50,000, the process will be started at 18:00 instead of 19:00. This way, at 19:00 there will be already a large stock. We see this reflected in the fact that at 19:18 and 19:38 trucks already must wait since the floor is fully occupied.

Looking at the comparison in table 6.7, we see that the volumes of our own process model are higher than the actual volumes. However, it is a comparable difference to the difference between CRIS and the real volume. Additionally, in our model, the specification per customer are known, while the prognosis of CRIS is only a total volume indication. The fact that the volume of the CVM is higher than the real volume is because in our recalculations of the RC equivalent and filling rate, we did not include seasonal change. Our analysed period takes place in the winter season, while parcels are generally larger and so less parcels per roll container (or another type) occur. Therefore, it could be possible that in winter seasons our volumes are higher than the actual volumes. In the recommendations, we will further explain the adaption to seasons for the RC equivalent and filling rate. However, for planning the process it is better to overestimate than underestimate. This way, with our prognosis the process would start at 18:00 instead of 19:00 and results in less queueing trucks.

Friday January 20th

At Friday January 20th, no queues occurred during the process. We see this in the chart in figure 6.19, where the maximum freight on the floor is around 12,000. The total volume of this day is 37,962 parcels. Even though the total volume of that day is the lowest of all four, the stock is relatively high, where it at some point reaches the capacity. This is mostly due to early arrival times, which will be discussed in the next section.

Supply line

First, we analyse the supply line of all processes. With this line, the process is determined. We can see that a different course of the supply line, and thus different arrival times, can change a process drastically, even if the total volume of the days are the same. We see this happening in the first two graphs, on Monday October 10th in figure 6.17 versus Tuesday November 1st. in figure 6.18. These processes have a comparable total volume: respectively 51,785 and 49,173 parcels. However, we do see immediately the difference between the process models, looking at the stock of both days. The main reason for the extreme difference in stock, with comparable total volumes is the difference in arrival times. Monday October 10th shows an equally spread supply line, resulting in a constant stock level. At the start of November 1st's process, there is little stock present, around 3,800 parcels. This means that even though they start the process at 19:00, while the total volume almost reaches the 50,000 parcels, they cannot start with a high production rate, since this would result in an empty floor around 20:00. However, in the CVM we use the average production line based on total volume, because that's where they determine their occupation on, which shows the empty floor moments in the process. Since the prognosis only provides information about the total volumes and not enough correct information about the arrival times of the customers and its freight, the process managers cannot foresee this supply line. <u>This process model in comparison with the previous model of October 10th exactly sketches the problem: a comparable prognosis, but a totally different process which needs to be managed differently. Only they do not know this on beforehand, which makes it hard for them to manage.</u>

The late arrival is partly caused by the big customers. If the process managers received this information on beforehand, they could have prepared the process differently, knowing the highest volumes would arrive from 22:00. Especially if we mention that the share of these customers is 77% of the total volume, with 31,975 parcels.

The process of Friday January 20th is the exact opposite of Tuesday November 1st, as is shown in figure 6.20. The total volume is relatively low, 37,962, but since the customers are arriving early, the stock level is high compared to Tuesday. This again shows the importance of arrival times over total volume. Based on the total volume, the management of PostNL is again interested in shortening the process time. However, this will lead to higher stock levels, which looks not desirable in this case. We will further explore this idea in Chapter 7.

Looking at the supply line of Monday January 9th, the stock level is, in contrast to November 1st, very capricious and at some points very high. We see at two moments a noticeable peak in the arrival of parcels, at 19:00 and at 22:00. Considering the arrival of the customers, which is shown in figure 6.19, we see that at 19:00, Zalando Erfurt arrives with a truck loaded with pallets. Together with two trucks of Arvato, this results in a fully occupied floor space when starting the process.

The second peak is a result of another two trucks of Arvato, together with two trucks of Otto. Note that this peak only shows the freight in pallets and corlettes, while Otto also delivers loose loaded freight. However, corlettes are containing more parcels than pallets and take up less space, so the freight on the floor could look less in reality. The detailed information regarding customer's freight is in Appendix XIV.

International destination parcels
There is a list of customers that also deliver parcels with an international destination. These parcels need to depart from Hengelo earlier than the other parcels to meet the delivery agreement of max. 24 hours. Therefore, PostNL Hengelo has stated that these customers need to arrive before 00:00 to be ensured of this delivery time. At all days, almost all the customers with international parcels arrive before 00:00. Only at Tuesday November 1st, the customer Holland Pharma is arriving after 00:00 (at 00:04), with 539 parcels that could include international parcels. Since it is not far after 00:00 and it is about a small number of parcels, PostNL would be able to process them in time. However, they must prioritise them and possibly change the process management to achieve that. This can drop the efficiency of the process.

Service level agreements
If we compare the actual arrival times with the agreed time according to the SLAs, we see several times they are not met. For example by Otto, we see that they do not meet the agreed arrival times, but they do arrive before the latest possible arrival time. However, since it is every day a different time, it is still impossible for PostNL Hengelo to know when they arrive. Overall, comparing the arrival times with the SLA, we again confirm the problems stated in Chapter 4.

Loose loaded freight
At Monday October 10th, we see the first Otto truck takes up to 2 hours to unload, so the dock will be available when the second truck arrives. However, the third truck needs to wait to start unloading. The same applies to the second truck of Zalando, since the first truck is only finished at 23:30, while the truck arrives at 23:00. We see this problem reoccur at January 9th and January 20th.

At Tuesday November 1st, Zalando is arriving extremely late this evening. Both trucks arrive after 00:00, both full loaded which makes it hard to process in time. The process manager indicates that with these incidents, they need to be inventive and search for ad hoc solutions to process these parcels in time. So even though the start of the process they face risks of empty floor, after 00:00 they face risks of not sorting all the parcels in time.

Additionally, we see that loose loading arriving late can decreases efficiency, for example at October 10th in figure 6.16. After 00:00, they could increase their production rate to sort parcels faster and finish earlier. However, loose loaded freight will be fully unloaded at 02:00 and cannot be processed faster. Increasing productivity after 00:00 would not help in this case to finish the process earlier.

The extended arrival time information including the waiting time of the loose loaded trucks, can be found in Appendix XIV.

6.4 Conclusions

In Chapter 6, we have conducted an extensive data analysis on the sorting process. We have done the analysis on two levels. In the customer arrival analysis, we have searched for noticeable trends over a period of four months, including arrival times and volumes. In the process model analysis, we have analysed and visualised the process on daily level, to find the consequences of specific volumes and arrival times. In short, the following conclusions were made, based on the analysed data:

- Considering the arrival times of the biggest customers (Otto, Zalando Erfurt and Arvato), no signs of noticeable trends were found. Trucks of these customers arrive every day at different times, heavily spread over the evening.
- The number of parcels that are arriving per hour is heavily spread. The average supply per hour is not a reliable estimator.
- The freight per truck the biggest customers deliver is not consistent. There is no standard number of parcels per truck, and the average freight per truck is not a reliable estimator.
- Focusing on the process on a daily level: processes with the same total volume can work out extremely different, due to different arrival times of the customers. With only knowledge of an expected total volume for that day, no process preparation and management is possible. Information regarding the arrival times of (at least) the big customers is required.

We have come to these conclusions, by developing our own data model. This was necessary since the used information systems at PostNL are not sufficient to conduct an adequate data analysis on. We have shown that the forecast for the sorting process is not optimal, and with our Conversion and Visualisation Model (CVM) we show that it is a better estimator than the CRIS prognosis and TIS by calculating the mean squared error. In our own data model, we have re-determined the RC equivalent and the filling level of the three big customers. These new rates are shown in table 6.8.

Customer	Type unit	Old RC equivalent	New RC equivalent	Old filling level	New filling level
Otto	Corlettes	2.154	4.33108	103.9	103.9
Otto	Loose loading	0.56	0.19249	103.9	103.9
Zalando (Brieselang)	Pallets	1.75	1.75	64	42.85
Zalando (Gossbeeren)	Pallets	1.75	1.75	64	42.85
Zalando (Erfurt)	Pallets	1.75	1.75	59.8	57.14
Zalando (Erfurt)	Loose loading	0.56	0.7	59.8	57.14
Arvato	Pallets	1.75	1.75	46.5	42.85
Other customers	Roll Containers	1	1	28	28

Table 6.8 - Recalculated RC equivalents and filling levels

6.4.1 Customer Arrival Analysis

We have analysed the customer arrival during four months, from October 2016 until January 2017. We have analysed the total volumes, the volumes from the three biggest customers, their arrival times and the (type of) freight per truck.

Focusing on the total volumes, we see that on Mondays and Tuesdays the highest volumes occur, with averages of around 46,000 parcels. The volumes on Wednesday and Thursday are average: around 41,000 parcels. On Fridays, the lowest number of parcels arrive, around 37,500. These averages are exclusive special occasions such as holidays.

Next, we have analysed the three biggest customers of PostNL: Otto, Arvato and Zalando. Zalando has three different load locations, from what we concluded that only one load location is significant in this data analysis: Zalando Erfurt.

Considering Otto, we generally can conclude that they are not delivering constant volumes on constant arrival times. Also, the number of trucks they arrive with are not constant and not align with the service level agreements. We do know that they always arrive with a truck consisting of two trailers. One trailer contains corlettes and one trailer is loose loaded. On Mondays and Tuesdays, most of the times three trucks arrive. The other days always two trucks and in 50% of the times also a third truck arrives. However, according to the SLA, only on Monday three trucks should arrive and the other days only two trucks. The arrival times of all trucks are also not consistent. In the SLAs, two arrival times are specified: the agreed arrival times and the latest possible arrival times. Most trucks do not meet the agreed arrival times, but they all meet the latest possible arrival time (assuming the arrival time of truck three from Monday for all days).

Looking from the averages, the first truck is fully loaded every day, which is around 6,500 parcels (2,000 loose loaded and 4,500 parcels on corlettes). The second and third truck contains an average of 4,000 parcels on Monday till Thursday. On Friday, the averages are 3,000 parcels for the second truck and 2,000 parcels for the third truck. Note that not every day a third truck arrives. A fourth truck only arrive occasionally and no reliable average can be found.

Arvato arrives most of the times with two trucks, and in some occasions a third truck arrives. Th first truck always arrives before the start of the process. The second truck has no specific reliable arrival time, however in around 50% if the cases it arrives between 21:00 and 22:00. However, focusing on this specific hour, the actual arrival times is widely spread. the arrival times of the trucks do not always meet the SLA, but they do arrive before the due time of 00:00. After midnight, PostNL cannot ensure to process all the parcels with international destination in time. The average volumes of Arvato are relatively consistent. However, there is some scatter present in these volumes, so it is still hard to predict the volumes of a coming truck.

Zalando Erfurt is comparable with Otto, in terms of number of trucks and arrival times. They also arrive with at least two trucks every day, a lot of times a third truck and in some occasions with a fourth truck. In TIS, also a fifth truck is sometimes registered, but this is a wrong registered customer. The arrival times are variable in the past and therefore unreliable. If two trucks arrive, both are loose loaded. If three trucks arrive, the first truck contains parcels on pallets.

Since we have analysed the averages of the volumes, we also wanted to know if these averages are reliable for the actual expected volumes. With the control chart, we can conclude that these averages are not reliable.

Overall, no noticeable trends were found, considering these four months. Therefore, we can conclude that focus for the solution must lay on better communication, since PostNL Hengelo cannot predict the arrival times and volumes from the customers. Since Hoofddorp has more information and knowledge about the data from customers, with better communication and different way of forecasting the process managers can manage the process in a better way.

For the process managers, more than only the total prognosed volume is necessary to be able to prepare the process adequately, but they only need this information on the day itself (preferably in the morning). They don't need to know it that specifically for the long term. We do see that the CRIS prognosis is relative accurate, but only this prognosis itself does not provide the process managers with enough information. TIS does provide more information about the customers specifically, but this information is not accurate.

6.4.2 Process Model Analysis

After the customer arrival analysis, we have analysed four specific days on process level. There, we have analysed the supply line, the process line and the stock on the floor during the process. The CVM is used both for obtaining the right data and to visualise the process on a daily level. It shows just like CRIS the realised supply line and realised processing line, but with more adequate data. The following days are analysed:

- Monday October 10
- Tuesday November 1
- Monday January 9
- Friday January 20

All days have different total volumes and require different management. We have shown that we can conclude, based on this data, that only the prognosis from CRIS as in total expected volume does not give the most important information, but that the expected arrival of customers is the key information for preparing the process. Therefore, as much information as possible regarding specific customers is desired.

Furthermore, we see that even though the total volume is low, the floor space can still be fully occupied. This is what happened at January 20. Therefore, we can also conclude, considering this data, that with only the knowledge of the expected total volume, we cannot directly decide to start the process later to increase efficiency. The outcomes from the data analysis will be used as input for the solution design in Chapter 7.

7. Towards Operational Excellence (Solution Design)

7.1 Introduction

In the previous chapters, the current way of working is extensively analysed. To achieve *operational excellence* (McKinsey, 2008), attention must be paid to three pillars: (i) Process; (ii) Management and Information Systems; and (iii) Mindsets, Capabilities and Behaviour of stakeholders. We recall the figure of Chapter 2 in figure 7.1.

Figure 7.1 - Operational Excellence with Lean (Excelr8, 2013)

Divided over these three pillars, we have analysed the process. Furthermore, we have conducted a data analysis both on the long term to find trends and short term to model the process on daily level. This data analysis is both already a part of the research outcome as well as input for the solution.

At the beginning of the research period, PostNL Hengelo experienced difficulties in managing the sorting process in the evening, thinking it is caused by capacity problems of the floor space. However, this was not substantiated with any research. The focus laid merely on the process itself, but we have seen that 'process' is only one part of operational excellence. During the analysis, many more problems were identified. Therefore, in Chapter 5 we have clustered the problems in a problem knot and prioritised needs for the solution design.

The solution design will again be presented via the operational excellence theory: solutions for process; management and information systems; and mindsets, capabilities and behaviour. This way, we will ensure to cover all aspects for achieving operational excellence in our solution design.

The main goal of all solution alternatives is to solve the core problem we formulated in Chapter 5: the sorting process is difficult to manage. We already mentioned that this core problem is very broad and general, such that more attention must be paid to the causes. The underlying problems were the following:

- The process managers and planning desk do not know how many and what type of parcels to expect from a customer
- The process managers and planning desk do not know when to expect a customer
- A lot of customers are arriving late and not equally spread

In this chapter, let us cover these problems and provide solutions to solve the core problem. First, we explore the possibilities for optimising the process itself, in section 7.2. Next, we focus on the mindset, capabilities and behaviour of the stakeholder in section 7.3 and last we provide solution alternatives for management and information systems in section 7.4. We summarise the recommendations with an implementation advise in section 7.5 and end with the conclusions in section 7.6.

7.2 Process Solutions

In the problem description in Chapter 1, we have already explained that PostNL wishes to see what an adequate arrival process looks like. Since there are three big customers that have the mere of the influence on the process, we have decided to focus only on these three customers when treating individual customers. For Zalando, we include Zalando Brieselang and Gossbeeren as well. For achieving an adequate arrival process, two optimisation strategies are being analysed: optimising the arrival times of the influential customers and shortening the total processing time. With the input from the data analysis from Chapter 6, we will analyse if these solutions are possible for PostNL Hengelo.

7.2.1 Introduction optimal arrival times

From the data analysis in Chapter 6 we have concluded that based on the analysed data and created graphs, no trends can be found both in terms of volumes and arrival times. This will make it hard to find optimal arrival times for these customers in the search for an adequate process. However, we still want to research the possibility for optimal arrival times, independent of the total volume of the customers.

In Chapter 6 we have analysed the process on daily level, with different volumes and arrival times. There, we have concluded that with similar total volumes but different arrival times, the process looks heavily different. The arrival times do influence the process extremely. In this section, we will determine for each day the improved arrival times for the big customers, so that the arrival process will be adequate, with a constant stock level. If, in this case, identical arrival times are found, despite the difference in total volumes and volumes per customer, this can indicate the presence of optimal arrival times. Then, further research is advised on the robustness of these arrival times. If for every case different improved arrival times are concluded, it shows that these times are dependent on total volumes and volumes per customer. In that case, no standard optimal arrival time applies for each customer, and alternative solutions must be sought to achieve an adequate process.

7.2.2 Introduction shortening processing times

Next to optimising arrival times, we want to analyse the possibility to shorten the total process time. We already mentioned in Chapter 6 that the management desires to test this possibility. Currently, standard process time is from 19:00 till 02:30. Based on this time window, the tariffs and the occupation are determined. In table 7.1, the occupation is shown, determined by the social work organisation (SWB, 2017).

Parcels/ hour	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	>7500
Employees	21	22	23	25	29	32	34	35	37	40	45	50

Table 7.1 - Occupation for the process (SWB, 2017)

However, for PostNL, the occupation is less interesting, since they pay the staff per sorted parcel. At this moment, the tariff is determined on paying 1 hour for 159.62 parcels, so the efficiency rate is 159.62 parcels per hour. The tariff for 1 hour is set on €18.22. Four times per year, this rate will be redetermined.

If the process time reduces, the efficiency will increase. This means that they can increase the efficiency rate and pay 1 hour for more than 159,62 parcels. This results in lower costs for the same volumes. We have calculated the costs or savings when shortening the process with one hour in table 7.2. The extended calculation can be found in Appendix XV.

Volume	Old # employees	New # Employees	Old tariff	New tariff	Cost/savings
20,000	23	23	€ 2.282,92	€ 1.978,53	-13,33%
22,500	23	25	€ 2.568,29	€ 2.419,40	-5,80%
25,000	25	29	€ 2.853,65	€ 2.868,87	0,53%
27,500	29	32	€ 3.139,02	€ 3.001,91	-4,37%
30,000	29	34	€ 3.424,38	€ 3.479,49	1,61%
32,500	32	34	€ 3.709,75	€ 3.416,06	-7,92%
35,000	34	35	€ 3.995,11	€ 3.564,27	-10,78%
37,500	34	37	€ 4.280,48	€ 4.037,08	-5,69%
40,000	35	40	€ 4.565,84	€ 4.522,36	-0,95%
42,500	37	40	€ 4.851,21	€ 4.545,28	-6,31%
45,000	37	45	€ 5.136,57	€ 5.414,23	5,41%
47,500	40	50	€ 5.421,94	€ 5.873,77	8,33%
>50,000	45	Not achievable			

Table 7.2 – Costs and savings shortening processing time

We immediately see that not for every total volume this method is beneficial. This is caused by the effect that the occupation is not equally proportioned. However, we do see that for most volumes, shortening the process time is beneficial. PostNL is advised to redetermine the number of employees needed per volume for the shorter process times. This way, they can obtain beneficial tariffs for every volume, making sure shortening process times is always saving money, if possible.

7.2.3 Constraints

Before we start finding the optimal arrival times or possibility for shortening the processing time, we must determine the constraints regarding shifting the arrival times.

Firstly, the same constraints apply as in the data analysis in Chapter 6:

- End time of the process is 02:30
- Starting time of the process is between 18:00 and 19:00, depending on total volumes.
- Floor capacity is 15,000 When unloading a loose loading truck, the capacity is 12,000.
- The maximum number of parcels processed per hour is 8.000.
- We assume that for these days, all the documentation of customers is accurate.

Furthermore, we introduce new constraints regarding the arrival times of the customers:

- Customers with international parcels must arrive before 00:00. This applies for Arvato.
- The latest possible arrival time for customers with high volumes, are divergent from the maximum arrival time:
    - Zalando Erfurt: 00:30
    - Otto: 00:45 if containing full load; later possible if less load.
    - Zalando Gossbeeren and Zalando Brieselang: 01:30
- Note that these latest arrival times are not processable if all customers arrive at these times.
- Otto and Zalando Erfurt have their dedicated docks, due to the loose loading freight.

To find the optimal arrival times, we will start with the most "problematic" process day of the four analysed processes, since the need of optimising the arrival times is the highest. For these days, it is most obvious what the optimised arrival times will be. This information can be used as input for the other processing days. The following order will be applied:

1. Monday January 9th
2. Tuesday November 1st
3. Friday January 20th
4. Monday October 10th

7.2.4 Optimal arrival times

We recall the graphs from Chapter 6, including the arrival times of the big customers, in figure 7.2 – 7.5. The arrival of the big customers is marked in the graph: loose loaded freight is shown on the x-axis and the other parcels are shown in the supply line.

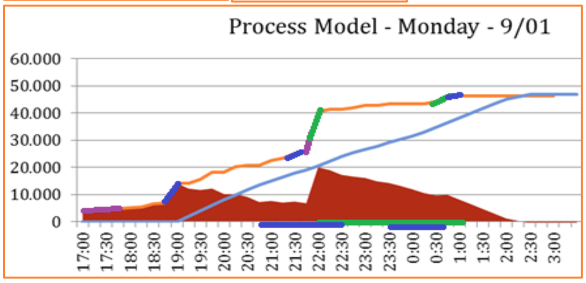


Figure 7.2 - Process Model January 9th

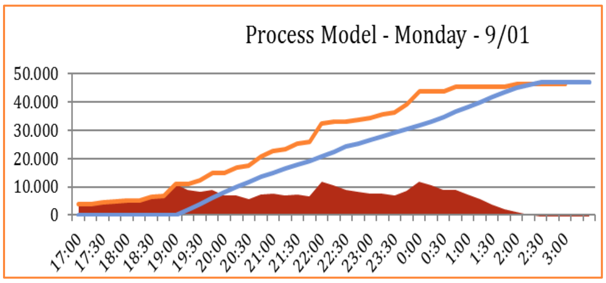


Figure 7.3 – Improved Process Model January 9th

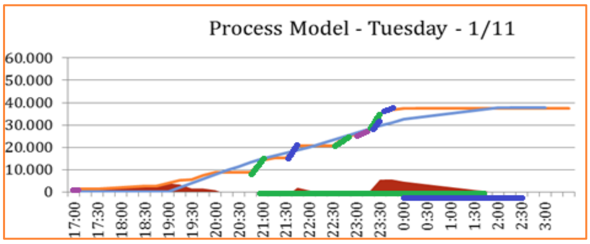


Figure 7.4 - Process model November 1st

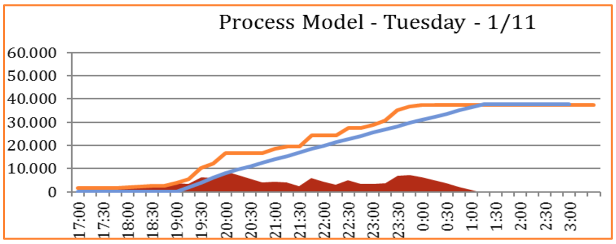


Figure 7.5 – Improved Process Model November 1st

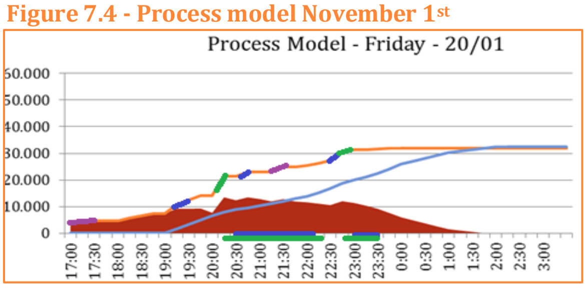


Figure 7.6 – Process Model January 20th

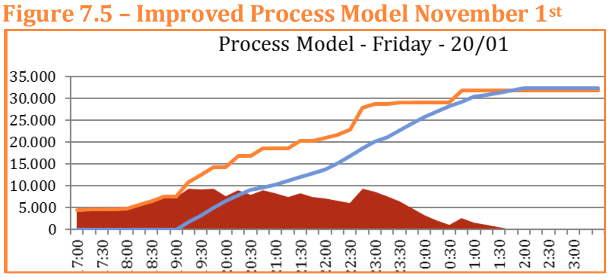


Figure 7.7 – Improved Process Model January 20th

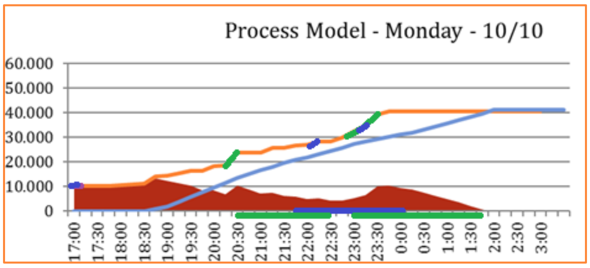


Figure 7.8 – Process model October 10th

January 9th
The goal of shifting the arrival times is the flatten out the stock line in the graph, which means that there occur less peaks in stock level during the process. We have already explained the consequences of a too high stock level (waiting times, uncluttered process) or too low stock levels (empty floor, drop of efficiency). Let us take for example January 9th. In figure 7.2, two increases of stock are shown: at 19:00 and at 22:00. We do see at the supply line that at both times, the big customers arrive. Shifting their arrival times thus will lead to a more evenly spread stock on the floor, which leads to a more even process. We will discuss both peaks separately.

Since there is no standard method to find the optimal arrival time, we will find the new arrival time via trial and error. For all days, we will start at the beginning of the process and find the optimal arrival time(s) for that customer. We will do the same with the next customer, and evaluate the robustness of the previous customer and so on. Finally, we will show the new graph of the process. The step-by-step approach is extensively elaborated in Appendix XVI. The outcome of the iterations with the optimal arrival times of the big customers are now shown in table 7.3 at the end of this section. The optimised graph of January 9th is shown in figure 7.3.

November 1st
As we already have concluded from the analysis in Chapter 6, the process of Tuesday November 1 is different compared to the process of January 9. Instead of exceeding the capacity of the floor space, the floor is empty between 20:00 – 21:30 and 22:00 – 23:15. Therefore, the optimal arrival time of the big customers will be earlier than the original arrival times. The original process is shown in figure 7.4 and the improved process in figure 7.5. There is no empty floor with the improved arrival times, and the lowest stock level is 2,492 at 21:30. Also, the trucks with loose loaded freight do not have to wait anymore. The optimised arrival times are shown in table 7.3 at the end of this section.

January 20th
Next, we optimised Friday January 20th. The stock level during the whole process shows no high peaks, although the level does exceed the maximum capacity of 12,000 at some times. The highest stock level measure is 13,496 at 20:15. The arrival times of the big customers are shown in the graph and in Appendix XVII. at 20:15, the highest increase is shown in the graph, caused by the arrival of Otto 1. By postponing the arrival of Otto 1, the stock level during the process will decrease. However, attention must be paid to the latest possible arrival times of the Otto trucks and there must be at least two hours' difference between the arrival time of Otto 1 and Otto 2, so that the docks will be available. The optimal arrival times are shown in table 7.3 as well.

October 10th
Focusing on the graph of October 10th in figure 7.8 and the arrival of the big customers, we can distinct two possible problems in arrival times: Non-optimal arrival times in terms of too much stock and non-optimal arrival times in terms of unavailable docks. The first problem, reaching the floor capacity, is not a main problem in this process. The only time the floor capacity is almost reached is at the start of the process, at 18:45. At that point, the stock is 14,221 parcels. Based on floor capacity, there is no urge to change the arrival times of the big customers. Therefore, the current arrival times will be assumed as optimal arrival times for this process.

Conclusion

The improved arrival times of the four processing days are shown in table 7.3. The green marked times are redetermined, with their original arrival time given as well.

Load location	January 9th	November 1st	January 20th	October 10th
	Improved arrival time	Improved arrival time	Improved arrival time	No Improved arrival times
Arvato 1	13:00	15.15	11:30	11:30
Arvato 2	17:30	23.15	21:30	13:45
Zalando Erfurt 1	20:45 (19:00)	20.00 (21:45)	19:15	16:00
Arvato 3	20:15	--	--	--
Zalando Erfurt 2	20:45	22.00 (23:30)	20:30	21:45
Zalando Gossbeeren	21:30	21.00 (21:45)	20:45	22:15
Arvato 4	23:45 (22:00)	--	--	--
Arvato 5	23:15 (22:00)	--	--	--
Otto 1	22:00	19.30 (21:00)	22:45 (20:15)	20:30
Otto 2	0:00 (22:00)	21.45 (23:45)	00:45 (22:45)	23:00
Zalando Erfurt 3	22:45	0.15	23:00	21:45
Otto 3	2:00 (0:00)	23.30	--	23:30
Zalando Brieselang	0:45	23.45	22:30	23:15
Zalando Erfurt 4	--	0:15	--	--

Table 7.3 – Overview improved arrival times

From these outcomes, we can conclude that no fixed optimal arrival times are present. This means that no distinct optimal arrival time for each truck exists, but that it heavily depends on the freight of the truck and the arrival times of other customers.

Also, researching the possibility for optimal arrival times depending on the expected total volume is not recommended. It is not achievable to determine the optimal arrival times on daily basis when the expected total volume is known. PostNL cannot desire from the customer that they arrive every day at a desired certain time. Additionally, in some occasions the expected volume is provided to Hengelo only when the customers already left their load location.

The optimal arrival time can be extremely tight, meaning that the beneficial effects are already absent when arriving 15 minutes earlier or later. Considering the long travel distance for these big customers, it is difficult to determine the exact time of arrival.

Furthermore, we can conclude that for most processes later arrival times are beneficial for the stock level. When arriving later, the overall stock level decreases. This is surprising, since at the start of our research, the management indicated that they experienced a stressful process with high stock levels, because customers were arriving late and not equally spread. We see that arriving later is beneficial for the stock level, even when multiple customers are arriving at the same time. Overall it will result in a less stressful process, since a lower stock level results in a leaner process. It must be noted however that this only applies when the arrival times are known, so that the process manager knows what to expect. However, the overall opinion that customers need to arrive earlier for a better process, can be rejected.

7.2.5 Shortening Processing time

As already introduced in section 7.2.2, the management board is also interested in the possibility of shortening processing times. We have already seen that in the current situation it is not always beneficial.

January 9th and October 10th

If we analyse the possibility to shorten the process with one hour for the four selected days, the processing time will become 6.5 hours instead of 7.5 hours. We see that for January 9th and October 10th the hourly production rate will exceeds the capacity of 8,000 parcels per hour, so for these days, shortening the process is not possible.

November 1st

The total volume of Tuesday November 1st is 49,173 parcels. Considering the arrival times of the customers, it would be desirable to start the process later, so that an empty floor can be prevented. The available processing time would be 6,5 hours (from 20:00-02:30). This means that a production rate of $\frac{49{,}173}{6.5} = 7{,}566$ must be achieved, without breaks. This is, however, not possible, since the maximum production rate is 8,000 and with a production rate of 7,566 there is no space for a break or incidents that may happen.

January 20th

The total volume of Friday January 20th is 37,962 parcels. With a current production rate of $\frac{37{,}962}{7.5}$ =5,062 parcels per hour, shortening of the process time could be possible. If the process is shortened with 1 hour, the process rate becomes 5,840. It means that instead of 34 employees, 37 employees will be needed. However, since the total process time is 6,5 hours instead of 7,5 hours, the total working hours of all employees are decreased from 255 (34*7.5) to 240.5 (37*6.5). This results in an increase of the efficiency rate from 159.62 to 169.24 parcels. The new tariff will be $\frac{37{,}962}{169.24} = 224.31 * €18.22 = €4{,}086.86$. The old tariff was $\frac{37{,}962}{159.62} = 237.83 * €18.22 = €4{,}333.26$. The new tariff is a decline of 5.7%. Extended calculation of these savings can be found in Appendix XV.

Although shortening the processing time will yield to savings, it is still hard to implement in the process. We already have concluded that only total volumes do not provide us with the sufficient information to manage the process, and this also applies for this method. In this case, it would not be possible to start the process one hour later, since the floor capacity will be reached at 19:45. Shortening the process at the end can be achieved considering the arrival times of the customers. However, we do see in practice that the SWB scales down the occupation after 00:00 if possible, since their employees are more expensive then.

Conclusion

Even though it is not achievable for all process to shorten the process time, we do, however, advise the management of PostNL to redetermine the occupation so that it will always be beneficial to shorten the process times.

The possibility of shortening the process is not only depending on the total volume (for some volumes, shortening the process time increases costs), but is extremely depending on the arrival time of customers. Since currently the arrival times and volumes per customer do differ heavily, we cannot determine on beforehand if it is beneficial to shorten the process time. Therefore, it is currently not an alternative for an adequate scenario of the process. Further research must be conducted to explore the possibilities.

Since implementing optimal arrival times or for the big customers or shortening the process time is not achievable at this moment to improve the process, let us now focus on the other two pillars of Operational Excellence:

- Mindsets, Capabilities and Behaviour
- Management and Information Systems

For these two aspects, multiple solution alternatives are found that have major beneficial effects on the process.

7.3 Mindsets, Capabilities and Behaviour Solutions

The core problem of the research was concluded as the sorting process is difficult to manage, which consisted of many more sub problems. In the previous section, we have searched for the possibilities to optimise the process. According to operational excellence, the next step in solving this problem is to change the mindsets and behaviour of the stakeholders. This starts with concluding that the communication is not adequate, on several points in the process. The frequency and completeness of the communication between all stakeholders need to be optimised, both before and during the sorting process.

The following table shows a clear summary of the involved stakeholders in this section.

	Customers	Supply chain engineers	Process managers	Planning desk
Before the process	7.3.1.1	7.3.1.2	7.3.1.3	--
During the process	7.3.2.1	--	7.3.2.2	7.3.2.3

7.3.1 Planning of the process

During the planning of the process, several stakeholders are responsible for optimising the communication to ease the process management, namely: the customers, supply chain engineers, and the process managers.

7.3.1.1 Customers

We start with the first stakeholder in the supply chain, the customer. They have a direct link to the supply chain engineers in their daily contact with PostNL. The key is that customers and transporters need to provide PostNL with more information. The following points are covered in the adequate scenario.

– It is advised to update the Service Level Agreements and specify them more clearly, so that all parties can meet these agreements and PostNL can monitor their performance.
– To be assured that PostNL can prepare and manage the process adequately, the customers should communicate more specific and adequately about the freight per truck and their expected arrival time. In case of an external transporter, that party can also communicate this information to the supply chain engineers.
– In addition to the previous point, it must be clear to the supply chain engineers and the depot who will communicate to PostNL and agree upon to whom they will provide the information.
– All customers should register their parcels on beforehand, so that the sorting process will be the most efficient.
– If changes occur in the expected arrival time, this should be clearly communicated to the supply chain engineers. If agreed on, they can also communicate it directly to the depot.

- Since the travel distance from the three big customers is long, they are advised to create a checkpoint in consultation with the process managers, nearer to the depot, for example two hours from it. If they cross this checkpoint, they can give a signal to the depot, that knows that it will take two more hours before they arrive. The expected arrival time from that point will be much more reliable.

7.3.1.2 Supply Chain Engineers

The supply chain engineers have two communication channels throughout the supply chain: the external communication with the customer and internal communication with the depots.

In relation to the customer, we opt for several changes to be agreed on in terms of information provision and communication. The supply chain engineers will be the link with the customers, and the depot. Internally, the communication between the process managers and the supply chain engineers is not considered optimal, according to the process managers. They feel the supply chain engineers does not provide them with sufficient information and that they do not know how the process is experienced. The employees will be able to prepare their process in a better way if the supply chain engineer conduct the following proposals:

- It is advised to update the Service Level Agreements and specify them more clearly than currently, so that every party can meet the agreements. Also, they should monitor them.
- The supply chain engineers should make the customers aware of the importance of informing the adequate information, as stated in the previous section, but it is also very important that deviating volumes or arrival times due to incidents will be communicated to PostNL.
- The supply chain engineers are advised to succeed in obtaining more information from the customer or transporter in terms of freight per truck. Currently, this information is not fully provided, but is needed at the depot in the preparation of the process.
    - If, as proposed for the customer, the communication regarding the expected arrival time is accurate, the supply chain engineers should forward this to the depot. If the parcels are collected by PostNL, the expected arrival time should be known. Information provision is advised to be conducted the following way:

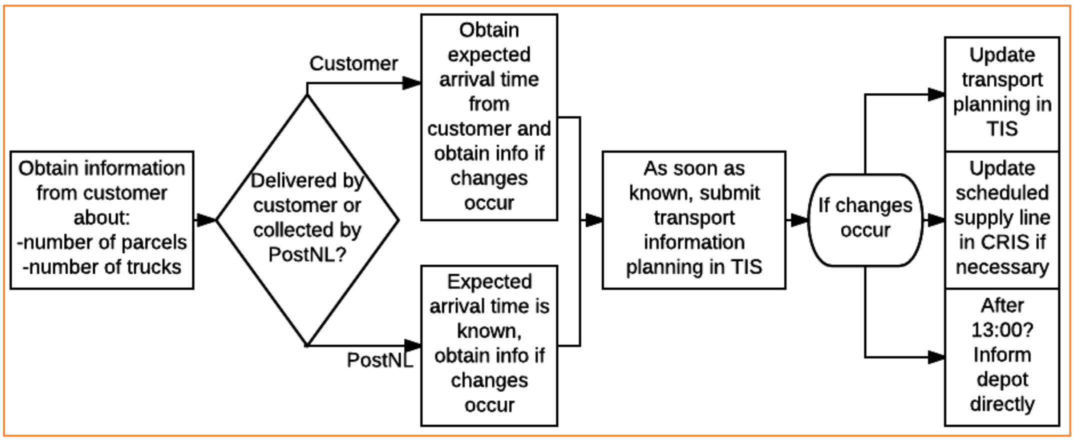


Figure 7.9 – Improved information stream for SCE

    - The time window in the transport information in TIS should be more accurate and kept up to date. Currently, the depot in Hengelo cannot use it as an adequate transport schedule. In the next section, we explain further how this will look.

- Direct communication regarding the departure times and expected arrival times of the customers will help the process managers for the preparation of the process. After 13:00, the scheduled supply line in CRIS is made, so direct communicating changes is necessary.
- Any changes in the expected arrival times or number of trucks that will influence the process must be updated in the systems and communicated to the depot.

– If more trucks than specified in the (updated) SLAs will arrive, or deviating volumes or arrival times due to incidents, this should be communicated from the customer to the supply chain engineers or the control room, and they should forward this to the process managers. Currently, some process managers feel that this information is already available and is hidden from them, so that during the process no claim for repelling to another depot can be made anymore. This way, they try to process it their selves, even though the workload is too much. The supply chain engineers must discuss this problem with the process managers and control room, and make sure that the information is obtained externally and then communicate internally to the depot.
– Provide the process managers with a one-time explanation of the tasks and role of a supply chain engineer. Most employees at the depot do not know the differences between the different functions related to the sorting process. For example, they do not distinguish the difference between the supply chain engineer (planning) and control room (real-time). This results in many misunderstandings and less comprehensions. With more insight in how they make the forecasts, the employees at depot Hengelo can relate more to them and work together on the best visualisation of the prognosis.

We opt to make clear at the supply chain engineers (and control room as well) that for the employees in Hengelo, more information regarding the arrival times is more important than the actual freight. Secondly, trends are preferred to know, that's why updated and correct SLAs are necessary. This will encourage to arrive on more specific arrival times as far as possible.

7.3.1.3 Process Manager

For the process managers, many of the solution steps in terms of communication before the process are much alike the solution steps of the supply chain engineers. They are advised to make agreements on how to obtain the right information for an adequate process preparation. In the previous two sections, we have already discussed the points of interest, such as information regarding freight, arrival times and changes in the planning. Other solution proposals for the process managers are:

– Meet with the supply chain engineers to get to know their role and tasks in the process, and vice versa. Make agreements with each other on what is necessary and preferably to know for a good preparation.
– Make agreements on who is contacting the transporter in case of delay or lack of information regarding the arrival times. Are the process managers allowed to contact the transporters directly or must this go via the control room and supply chain engineers?
– The process managers are advised to gain more knowledge on how the scheduling of employees during the process is determined. At this point, they do not know how this works and have no influence on it. When they know how this is determined, they can provide the SWB with extra information to help the scheduling, such as late arrival of customers.

- In addition to the previous point, they are advised to look together with the SWB at the over occupation of the employees. If the forecast is more reliable, no extra employees must work to cover unexpected higher volumes.
- The process managers should be aware of the SLAs made with the customer, especially if they are updated. Next, they must check if the actual arrival meets the SLA.
- Unmet SLAs, empty floors, extra trucks should be clearly documented in the Daily Reports. This is the only way the depot managers have enough evidence to show problems to the account managers and customers.

7.3.2 During the process

If the adjustments from the previous section are implemented, the process will be automatically progress more smoothly and better to manage. However, the tasks before the process and during the process are dependent on each other, and therefore also attention should be paid on solutions steps during the process. The involved stakeholders are the process managers, the planning desk and the customers.

7.3.2.1 Customers

The biggest responsibility for the customer towards an optimal arrival process lays in the preparation. Again worth mentioning, is that when deviations occur in terms or changed arrival times, the customer or transporter must communicate this to PostNL. As said before, we must agree on who they should inform in these cases, so that all involved parties are aware.

The customer should be aware of the importance of meeting the SLAs. Preferably try to arrive at the depot at the same time every night, as far as possible. If this is not possible in any case, they should be aware that good communication eventually only helps themselves. With the growing volumes, the arrival and sorting process will only be more tight and less flexible, so only with good communication the depot can ensure that all the parcels will be processed in time.

Punishing customers when they not meet the SLAs is not a preferred way to motivate them to do so. After all, letting them pay more for example will only push them to the competitor. Instead, if meeting the SLAs turns out the be hard, PostNL better can stimulate the positive behaviour by rewarding it. However, we assume that if the SLAs are being rearranged and updated, it will for all parties easier to meet them.

Lastly, the customers with international parcels must arrive before 00:00, to be sorted on time. We have concluded from the data analysis that they meet this deadline in almost all cases, but it is advised to pay extra attention, since this is currently not monitored in a KPI anymore.

7.3.2.2 Process Manager

The process managers indicate that the communication with the control room is not of good quality. They feel that the control room is not aware of all the trucks the big customers send, or they do know but do not tell it to the depot. To clear up these (mis)understandings, they must meet and talk through these issues. Clarity and completeness of information is the important goal of this.

The planning desk is unaware of the importance of right registering and that the information in TIS will be used for forecasting. Therefore, the process managers must make the planning desk aware of their important role regarding registering the arriving customers.

The process managers are responsible for the process, but also the monitoring of the process. They show that the realised supply line is not reliable. This is due to the incorrect RC equivalents and filling levels, but also because of wrong registrations by the planning desk. If the process managers notice an unreal peak in the realised supply line, they must check with the planning desk if an incorrect registration is made.

7.3.2.3 Planning Desk

The planning desk has an important role during the process. Their performances are of big influence on the process, and on the forecasts of future processes. However, this is not clear at the depot. It is important that all employees of the planning desk are aware of this.

- The registration of parcels will be done accurately. During the data analysis, several times, inaccuracies were found. These inaccuracies will lead to wrong forecasts in the future, as we have explained in Chapter 3 that the customer registration will be used for the scheduled supply line for future processes. Inaccuracies are for example: wrong number of containers, containers or pallets; or wrong arrival time or arrival date.
- All planning desk employees are advised to register the actual arrival time of the customer on the terrain and not the time the customer starts unloading.

7.4 Management and Information Systems Solutions

In Chapter 6, we have analysed the customer arrival over four months, from October 2016 till January 2017. In short, we have made, among other things, the two following conclusions:

- Based on the analysis and the used data, there is no distinct trend present in terms of total volume per day. So, we cannot say that for example every Monday, the total volumes are almost the same. We have seen that the prognosed total volumes in CRIS could be reliable, but the total volume only does not provide all the information needed for preparing the process.
- The arrival times of the three big customers analysed are not consistent as well. Next to that, their arrival times are not always in line with the agreed times in the SLAs with the customers and the time windows from the transport information in TIS.

From the customer arrival analysis, we can conclude that with no trends to be found, it is hard to predict the arrival times and volumes on beforehand. Therefore, improved information supply between the customer, the HQ at Hoofddorp and the depot in Hengelo is needed. This information supply can be distinguished in communication and knowledge, which is treated in section 7.3; and more accurate data in the used information systems, which we will discuss in this section. We divide the solution in improvements regarding the planning of the process and regarding improvements of systems during the process. The following table shows a clear summary of the involved systems in this section.

	KPI	TIS	CRIS
Before the process	--	7.4.1.1	7.4.1.2
During the process	7.4.2.1	7.4.2.2	7.4.2.3

7.4.1 Planning of the process

In Chapter 3, we have discussed all the used information systems during the planning of the process. In CRIS, the prognosed total volume is given, as well as the scheduled supply line. However, it does not provide information regarding individual customers. In TIS, the transport planning of the arriving trucks is given, but these times are not accurate and it contains broad time windows.

7.4.1.1 TIS

TIS has two functions considering the planning of the process:

- It provides transport information (transport planning) with arriving customers and their arrival time window.
- The customer arrival registrations made during the process (which will be discussed later), will be used as input data for forecasting the supply per customer in the future.

On both functions, we have already concluded that several errors occur. For the transport planning this results in the fact that it is almost not used by the employees of the depot, while it can be valuable for the process preparation. Solutions for these errors we have partly discussed in the previous section since they involved manual adjustments. However, also adjustments in the system itself are required.

The transport planning can be distinguished in customers that deliver their parcels with their own (or external) transporters and parcels of customers that will be collected by PostNL transporters. The following requirements are proposed for an adequate working transport planning:

- The planning should be complete. Even if all the necessary information is not available yet, all the expected rides must be present.
- The transport information planning should become a system that will be updated the whole day, so that the depot can rely on the most recent information in the system.
- The current standard, broad, time windows must be improved to more reliable and narrower time windows, preferably max. 1 hour.
- Information regarding freight should be improved.
    - Loaded and unloaded freight should be equal.
    - Type of freight should be correct.
    - Number of parcels should be specified instead of only number of carriers.

With these adjustments, the transport information planning in TIS can be used by the process managers and the planning desk for predicting the customer arrival and finally the value of the transport planning in TIS will be optimised.

TIS is also used as customer arrival registration *during the process*. However, this is closely related to the *planning of the process*, since this information is used as input data for the scheduled supply line in CRIS. In chapter 4 and 6, we have both identified the problems of the data, both caused by manual errors and errors in the system itself. The solution proposals for the manual errors are discussed in the previous section.

Considering data errors, they are caused by wrongly estimated roll container equivalents (RC equivalents) and the filling levels. The planning desk registers the arrival time of a truck and number of carriers, which TIS turns into number of parcels. The RC equivalents and filling levels are calculated incorrectly, which results in wrong estimations of number of parcels. In the data analysis in Chapter 6, we already have calculated new RC equivalents and filling levels. We recall the table from Chapter 6 in table 7.4

Customer	Type unit	Old RC equivalent	New RC equivalent	Old filling level	New filling level
Otto	Corlettes	2.154	4.33108	103.9	103.9
Otto	Loose loading	0.56	0.19249	103.9	103.9
Zalando (Brieselang)	Pallets	1.75	1.75	64	42.85
Zalando (Gossbeeren)	Pallets	1.75	1.75	64	42.85
Zalando (Erfurt)	Pallets	1.75	1.75	59.8	57.14
Zalando (Erfurt)	Loose loading	0.56	0.7	59.8	57.14
Arvato	Pallets	1.75	1.75	46.5	42.85
Other customers	Roll Containers	1	1	28	28

Table 7.4 - Recalculated RC equivalents and filling levels

We have used these improved RC equivalents and filling levels for our data analysis and showed that they are better estimations than the original RC equivalents and filling levels. Since these numbers have influence on the forecast, effort must be put in optimising these rates. We strongly recommend the supply chain engineers to use the new rates and over the longer term optimise them by themselves.

Concluding, with the more adequate information of TIS, the scheduled supply line must become more safe and reliable.

7.4.1.2 CRIS

CRIS is leading in prognosing the number of arriving parcels. The total volumes are prognosed via the real number of sorted parcels in the past and are reliable enough according to the process managers, however continuous optimisation of this prognosis is always desirable. For the course of the supply line however, several solution alternatives are opted:

- The course of the scheduled supply line is based in the data from TIS, which is discussed in the previous section. This must be taken over accurately by CRIS, so that the supply line will also be adequate if the accuracy of the data from TIS improves.
- It is advised to show the arrival of exceptional freight and big customers in the graph of CRIS. This way, the process managers know if they are arriving early or later in the process and nicely spread or all at the same time. These differences can influence the process despite the total volume. An example of the visualisation of the exceptional freight and big customers is shown in figure 7.10.
- If the volumes change relative to the expected volumes based on historical data, it is advised that this will be communicated from the customer to the supply chain engineers. This change in information should also be updated in the scheduled supply line in CRIS and in the prognosis of the total volume. As mentioned before, after 13:00 (when the schedule in CRIS is forwarded to the depot), it should also be communicated directly to the depot.

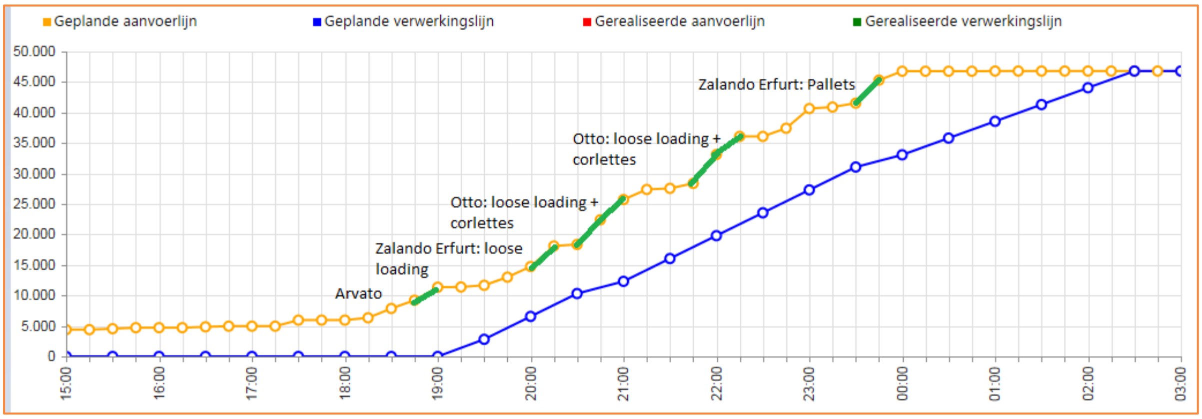


Figure 7.10 - Solution design CRIS dashboard

Note that the figure is only an example of a visualisation. At certain points, the expected arrival of the big customers is shown. If necessary, the type of freight will also be shown. For example, Arvato always delivers on pallets, so mentioning the type of freight is unnecessary. If the number of parcels per truck are known by the supply chain engineers, it is desirable that this will also be present on the dashboard.

7.4.2 Managing and monitoring the process

During the process, the same information systems are mostly used. In CRIS, the process is monitored, including both the arrival and processing of the parcels. Again, no individual customer information is provided. In TIS, the arriving trucks and their freight are registered by the planning desk. This information will be adopted by CRIS and used in their overview of the process.

7.4.2.1 KPI

In Chapter 3, we have introduced the three KPIs present for monitoring the performance of the sorting process.

- *Incorrectly sorted parcels*
- *Inventory of national parcels*
- *Inventory of international parcels*

We have shown that the first two KPIs are strongly dependent on each other. Inventory of national parcels indicates the number of parcels that did not departure on time from the depot, because it was not sorted in time. The KPI 'Incorrectly sorted parcels' indicates the number of parcels that was incorrectly sorted and was departured to the wrong depot. At the start of 2016, the KPI 'Inventory of national parcels' was too high. If one wants the inventory of parcels to drop, he should make sure that all parcels are sorted on time and thus sorting must be done faster. However, then faults are easier made. This will end up in more incorrectly sorted parcels. Additionally, PostNL sees the total volumes to sort increase every year, which means sorting must go even faster. The KPI of 'Incorrectly sorted parcels' was met in 2016, but with the new goal in 2017, it will not meet its goal. Since an incorrect sorted parcel is even worse than a parcel not sorted in time, because of the extra transportation costs, this percentage must drop.

With the solutions presented in this research, the quality of the process will increase and so the efficiency and sorting quality of the sorters. Therefore, we expect this percentage to increase.

However, it is still important to strictly monitor this KPI and search for the causes of it. Are the incorrect sorted parcels caused by many different sorters or only a few individual sorters? In the last case, attention must be paid to those sorters to increase the sorting quality.

In section 7.3, we have already provided the solution alternatives for process managers to monitor errors in the daily reports. We also recommend to extend the daily report with monitoring the KPIs and, more importantly, the reason if it is not met. This way, PostNL creates handles to meet the KPI goals.

The KPI of 'Inventory international parcels' performed well during 2016. However, this KPI was left out the performance scorecard in 2017. At the depot, no one can tell the reason for this. Even though the KPI performed well during 2016, it is important to still monitor its performance in 2017. Especially if customers wish to arrival later during the process, the performance of sorting international parcels on time (which is before 01:00), becomes more important.

7.4.2.2 TIS

We have already concluded that the registered information in TIS is important for the forecasting in the future. However, the information in TIS is not accurate enough for an adequate forecast.

In the previous section, we have showed the improved RC equivalents and filling levels for more accurate data. Also, we earlier mentioned the importance of correctly registering arrival information by the planning desk.

During the process, there is still an issue that results in inaccurate data in TIS, caused by the system itself. As mentioned before, the planning desk can specify the type of freight and next the number of roll containers, parcels or corlettes. For loose loading, they can submit a percentage. However, on some loading bills, the exact number of parcels is specified. Instead of being able to register the exact number of parcels, one must submit the number of carriers where after the system will estimate the number of parcels. In case of loose loading it is even worse, since the planning desk must guess the percentage the truck is filled in most cases. In this case, and estimation of a guess is made for the number of parcels.

It is strongly advised that in TIS, the possibility to register the exact number of parcels becomes available, assuming the information provision about exact numbers is optimised. This way, the forecast will be the most accurate as possible.

The second issue occurred regarding TIS during the process is the incorrectly registered parcels by the planning desk. In TIS, a range check must be introduced, were the planning desk gets notifications if illogical registrations occur. For example:

- The maximum number of corlettes is 10 per truck, since only Otto delivers in corlettes. If the employee registers more than 10 corlettes, a notification must pop up, so they can correct their registration.
- More than 100% loose loading is not possible.
- If the employee registers a customer on another date than the present.
- If the total number registered parcels of the last hour is more than the realistic maximum.

This way, the planning desk will be motivated to be consequent and accurate in their registrations, which will lead to more accurate forecasts.

7.4.2.3 CRIS

During the process, CRIS monitors the process with two lines: realised supply line and realised processing line. The realised processing line extracts its data directly from the sorting system and therefore the number of parcels are the exact numbers. The realised supply line however is not accurate. We have covered this mostly by improving the data coming from TIS, but we have found out that sometimes the data transfer from TIS to CRIS contains some errors, causing by the fact that CRIS uses different conversion rates than TIS. It should be noted that the exact same RC equivalents and filling levels should be used in CRIS, so that the number of parcels are alike the numbers in TIS and the realised supply line is correctly monitored in CRIS.

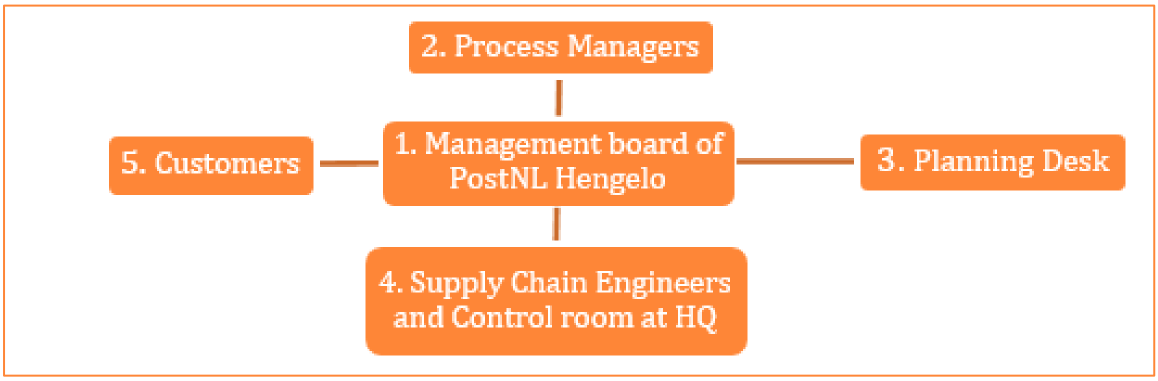
7.5 Multi-step implementation proposal

The solution alternatives provided in the previous sections, contain a lot of information. To implement these solutions, a roadmap is built for PostNL. In this proposal is elaborated how the management of PostNL Hengelo should involve the different stakeholders and when. Also, it explains the importance of the solutions and categorises them on ambition level.

We recall the main goal of all solution alternatives is to solve the core problem we formulated in Chapter 5: the sorting process is difficult to manage.

The multi-step approach we provide for PostNL Hengelo is written for the management team, since they are the main responsible for successfully implementing the solution design. This is way there can noticed some overlap with the previous sections. However, this is done so that the management team can consult this roadmap at any time and it is still complete.

The roadmap is divided into different ambition levels, varying from short-term to long-term solutions. We especially have not restricted the ambition levels to time limits, since there are several follow-up points, that only can start after succeeding points of the previous ambition level. Also, on beforehand, the management cannot estimate how much time they have left to start the process, so we advise to plan these tasks together with the involved stakeholders before starting.



Ambition level 1

The roadmap in ambition level 1 shows the steps that are advised to take in the short term to optimise the process. Ambition level 1 will be mainly focused on internal improvements and communication improvements. These solutions are suitable for implementing immediately, though they will have an enormous effect on the manageability of the process.

Management team & Process managers

1. The first step is that the communication and information streams are advised to change heavily. The management team need to agree on the optimal communication and information stream for the process. On the next page, we show the communication and information plan with the solution alternatives implemented. This plan shows for all the stakeholders their task before and during the process.
2. The management board is advised to agree with the process managers to monitor the documentation of the process accurately. Incorrect peaks in the realised supply line in CRIS should be noticed and explained; spontaneous arrivals or deviant arrival times should all documented in the daily report and discussed with the management board.
3. Continue monitoring the KPIs and inventory international parcels.

Management team & Planning desk

1. Explain the importance of correctly registered customers. Too much inaccuracies were found during the data analysis.
2. Agree upon one “arrival time”, and make sure they register the number of parcels as well if available.

Management team & Supply Chain Engineers

1. Set up a meeting together with the process managers to explain each other’s current roles.
2. Involve them in the implementation of the communication and information plan.
3. Provide them the information regarding the optimised RC equivalents and filling levels. They should be implemented in the forecast of the supply chain engineers.
4. The arrival time window in the transport planning should be narrowed and always be up to date.
5. Agree upon providing all the information regarding changes in the forecast to the depot.
6. Discuss the possibility of direct contact between the customer/transporter and the depot.

Management team & Customers

1. Update the Service Level Agreements, together with the supply chain engineers.
2. Inform the customers about the importance of accurate and detailed information provision, also in case of delay or extra trucks.
3. Agree upon information provision about exact numbers and departure time.

Start of the day

- **Supply Chain Engineers**
  - TIS
    - Customers will be added to the transport planning with an up-to-date expected arrival time window.
    - If extra trucks are schedule or expected than normal, this will be added to the transport planning.
    - Accurate information regarding expected freight and type of freight will be added in the transportation schedule.
  - CRIS
    - Schedule supply line will be created with the improved RC equivalents and filling levels.

Before 13:00

- **Customer**
  - Communicate the departure time and expected arrival time per truck to the Control Room
  - Communicate exact freight per truck to Control Room
- **Control Room / Supply Chain Engineer** (if changes are occured)
  - Update expected arrival time and freight information in transport planning in TIS
  - Update the scheduled supply line and prognosed volume in CRIS
- **Process Managers**
  - Create the scheduled processing line based on the more accurate scheduled supply line --> occupation can be determined more tight since forecast more reliable

13:00 - 19:00

- **Customer** (not departed yet)
  - Communicate the departure time, expected arrival time and exact freight per truck to the Control Room
- **Customer / Transporter** (already departured)
  - If expected arrival time changes, communicate to the Control Room
- **Control Room**
  - Communicate changes directly to the process managers at the depot
  - Update the information in the transport planning of TIS and the scheduled supply line of CRIS
- **Process manager**
  - If major changes occur, communicate with the SWB about changing the occupation.

From 19:00

- **Customer / Transporter**
  - If expecte arrival time changes, communicate to the Control Room (or directly to the depot if agreed on)
- **Control Room**
  - Communicate changes in the expected arrival time directly to the process managers
  - Update transport planning in TIS
- **Process Managers**
  - Document unexpected arrival times or major differences in freight
  - Document wrongly documented information or incorrectly visualisations in CRIS

Ambition level 2

Ambition level 2 provides the solutions that require more effort to implement. This is because of different reasons, for example small changes in software should be made of a collaboration with other parties is necessary. Some steps, the management can start with immediately as well, but they may take longer to finish. However, some steps are a follow-up from previous improvements. This will be clearly mentioned.

Also, now that the communication and information provision is optimal for an adequate process, the information systems must adapt so that they can be used optimally.

Management team & Process managers

1. Once the SLAs are improved and up-to-date, the process managers should monitor the compliance of the SLAs. If not the case, together with the customer there must be sought for the causes. This all must be done under the supervision of the management team.

Management team & Supply chain engineers

1. Enable the possibility to register the exact number of parcels in TIS, instead of only roll containers or percentages loose loading.
2. The flow of information from TIS to CRIS must be executed accurately. Currently this is not the case. It should be investigated why not and improved.
3. Further research should be put in continuously optimising the RC equivalent and filling levels, so that the forecasting can be conducted as accurate as possible. Attention should be paid to the meaning of both the RC equivalent and filling level and it is important to involve seasonal differences, since in summer season the parcels are smaller on average, resulting in more parcels per roll container. It is advised to maintain two different rates per year for the big customers.

Ambition level 3

Ambition level 3 show the solutions that require so much effort that it is not achievable on the short term. Also, the require the succeeding of previous steps. It can also be possible that further research is advise before starting with the implementation. However, for the most adequate process, it is strongly advised to also involve these alternatives in the total solution design.

Management team & customer

1. If SLAs are optimised to the extent that both parties agree upon the best arrival strategy, effort must be put in meeting the SLA. PostNL should motivate the customer to meet them.

Management team & Supply chain engineers

1. The ability to show in the expected and realised supply line of CRIS when the big customers (expect to) arrive, should be created.
2. If the forecast changes after 13:00, it should be able to show these changes in CRIS, next to only communicating it to the depot.
3. Optimise and extend the transport planning in TIS in such a way that it is individually reliable for the process managers and planning desk to know what to expect.

Management team & SWB

1. In section 7.2, we concluded that currently, shortening process times is not always beneficial. The management is advised to, together with the SWB, redetermine the occupation and tariffs for the shorter process time such that it is beneficial for every expected volume to shorten the process, if possible.

7.6 Conclusions

In this chapter, we have shown the solution alternatives based on the three aspects of *operational excellence* (McKinsey, 2008): the process, management & information systems, and capabilities and behaviour of stakeholders. For the process, we have concluded that there are no fixed optimal arrival times for the customers, due to too variable arrival times and volumes. In contrast to management expectations, we found that it is not possible to identify a fixed arrival time per weekday per customer.

However, we did find that arriving later, which is what the customers prefer, is beneficial for the process. This is surprising, since management expected that earlier arrival of customers would lead to a better process, which is not the case. However, it must be mentioned that it is only beneficial if it is known which customers to expect and when.

Shortening processing time is in the current situation not beneficial or possible. This has two main reasons. First, we have concluded that currently, with the recalculated efficiency rates, it is not always beneficial to shorten the process time. In some cases, the costs increase. Therefore, the tariffs need to be redetermined before implementing shorter process times. Secondly, we see that we cannot only from the total expected volume decide to shorten the process. It heavily depends on the arrival times from all customers. We have seen this in the example in section 7.2.6. Further research should be conducted before we can shorten the process times. However, we do see the possibilities and benefits of the strategy, since it can save a lot of extra costs.

For the information systems, multiple solution alternatives are provided, to improve the accuracy of the systems. For the stakeholders, we have provided solutions to improve the communication and information stream, so that the process will be better to prepare and manage. Since we provided many recommendations regarding the stakeholders and the information systems, we have created a stepwise approach on how to implement which improvement, divided per ambition level. This way, the management of PostNL Hengelo has provided handles to start improving towards an optimal scenario.

8. Conclusions, Discussion and Further Research

8.1 Conclusions

In the previous chapters, we have conducted research on the arrival process of the customers to PostNL Parcels depot in Hengelo, to answer the following research question:

"What would be an adequate scenario for PostNL Hengelo regarding the arrival and processing of parcels that will enter the sorting process?"

We have conducted this research via analysing the process considering the three aspects of Operational Excellence (McKinsey, 2008): the process; the management & information systems; and the capabilities and behaviour of the involved stakeholders. We have summarised and organised all findings in the following problem knot.

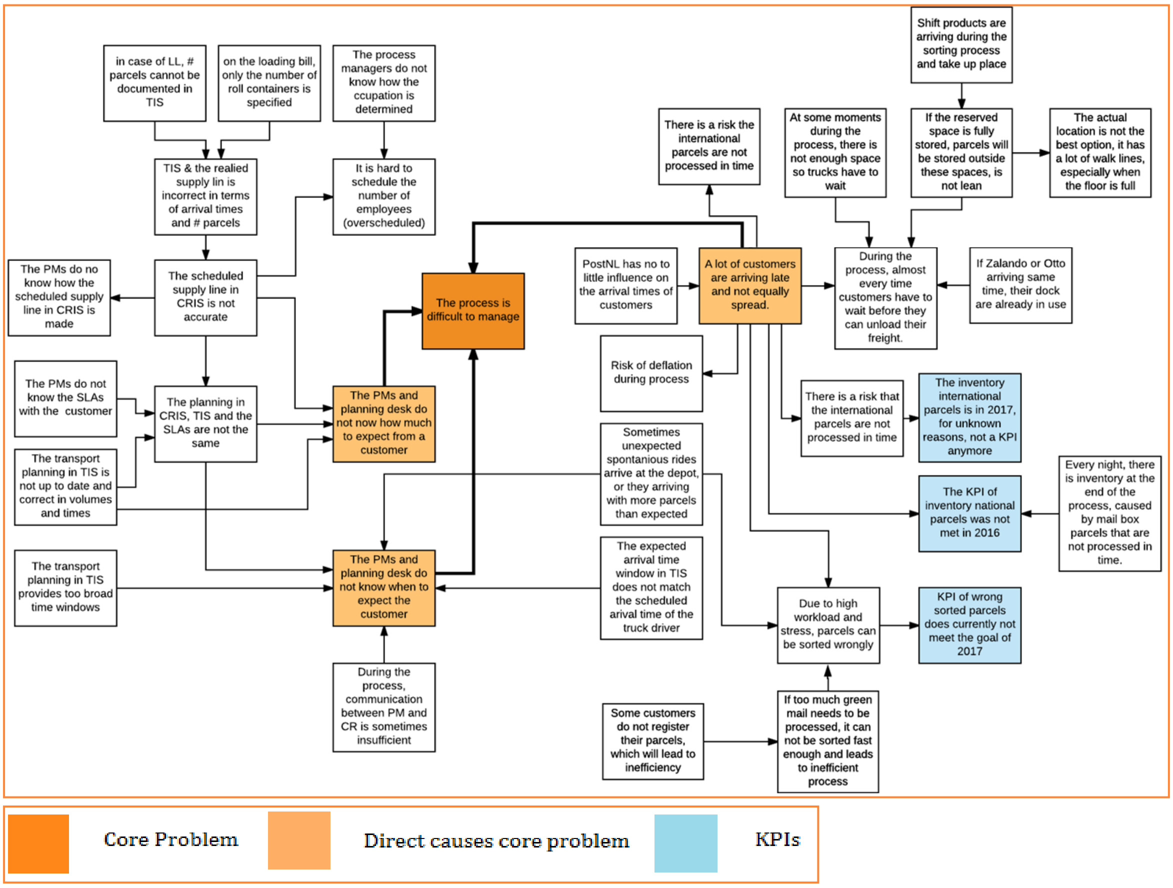


Figure 8.1 – Problem Knot

We have concluded that the core problem is: the process is difficult to manage. The problem has several causes. The causes are clustered in three blocks, that are coloured light orange in the figure.

- The process managers (PMs) and planning desk do not know how many and what type of parcels to expect from a customer.
- The process managers and planning desk do not know when to expect the customer.
- A lot of customers are arriving late and not equally spread.

To gain more information regarding the arrival process of the customers, we have conducted a data analysis. Before analysing the data, we have concluded that the present information systems are not complete and accurate. Therefore, we have built our own model: *the conversion and visualisation model* (CVM). We have conversed the data so that it is accurate and suitable for data analysis and showed that it is more reliable than the present systems. The flowchart of the CVM is shown in figure 8.2.

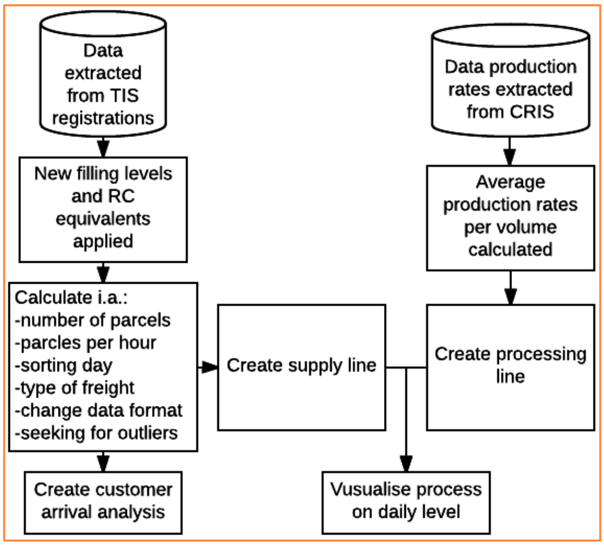


Figure 8.2 – Flowchart CVM

The following conclusions were made based on the data analysis:

- Considering the arrival times of the biggest customers (Otto, Zalando Erfurt and Arvato), no noticeable trends were found that are beneficial for better process management. Trucks of these customers arrive every day at different times, heavily spread over the evening.
- The number of parcels that are arriving per hour is heavily spread. The average supply per hour is not a reliable estimator.
- The freight per truck the biggest customers deliver is not consistent. There is no standard number of parcels per truck, and the average freight per truck is not a reliable estimator.
- Focusing on the process on a daily level: processes with the same total volume can work out extremely different, due to different arrival times of the customers. With only knowledge of an expected total volume for that day, no process preparation and management is possible. Information regarding the arrival times of (at least) the big customers is required.

Lastly, we have created the solution design, again on the three aspects of operational excellence. There, we have provided several alternatives for achieving the goal of the research: creating an adequate scenario so that the process is better to manage.

We have concluded that there are no fixed optimal arrival times for customers to arrive, since it is too dependent on the arrival times and volumes, which are too variable. The same applies for the alternative to shorten the process time. It depends too heavily on the arrival times of all customers whether it is possible and in the current situation, shortening the process does not always save costs. However, we do see possibilities to become beneficial, but further research must be conducted for that.

We do have concluded that for most processes later arrival times are beneficial for the stock level. When arriving later, the overall stock level decreases. This is surprising, since at the start of our research, the management indicated that they experienced a stressful process with high stock levels, because customers were arriving late and not equally spread. We see that arriving later is beneficial for the stock level, even when multiple customers are arriving at the same time. Overall it will result in a less stressful process, since a lower stock level results in a leaner process. It must be noted however that this only applies when the arrival times are known, so that the process manager knows what to expect. However, the overall opinion that customers need to arrive earlier for a better process, can be rejected.

In addition to the process solution, we do have found multiple solutions that are beneficial for preparing and managing the process, suitable for implementing both in short-term and long-term. The focus lays in improvements in information and communication streams and creating more accurate information systems. For the management board of PostNL we have created a stepwise approach on how to implement the improvements, divided per ambition level.

Overall, with the process analysis, the data analysis and the solution design, we have created *an adequate scenario for PostNL Hengelo regarding the arrival and processing of parcels that will enter the sorting process.*

8.2 Recommendations

This research contains a big case study with a process analysis and an extended data analysis. In the data analysis, we have shown with the CVM that the current information systems are not accurate enough. We recommend PostNL to learn from the CVM, and to improve their current information systems with the help of the CVM. Furthermore, we have shown in the solution design both improvements in the "hard skills", the process itself and the information systems, as well in the "soft skills", regarding improved communication and information streams.

Some of the solutions regarding the process are rejected, since we have concluded that they are not possible. However, we have given recommendations to further research the solutions with possibilities, such as shortening the process time. We highly recommend PostNL to further investigate this. More detailed information is given in section 7.2.

We have provided PostNL with many recommendations for improving the information systems and communication streams. To structure these recommendations, we build a stepwise approach divided in ambition level in section 7.5. We recommend to start with these steps for the management board, but also to look intensively to the recommendations provided in section 7.3 and 7.4.

Lastly, the complete research has given us insight in the actual problems at PostNL Hengelo, and what their possibilities are to improve their situation. We recommend to read the full research and enjoy the clarity in the problem it provides us.

8.3 Discussions

Throughout the research, we have faced several difficulties and limitations, that had influence on our research. Let us point out the important points, to critically review our used methods and how we could improve our research in the future.

RC equivalents and filling levels

In the data analysis in Chapter 6 we have re-established new RC equivalents and filling levels by measuring with a sample test and discussing seasonal influences. When comparing the CVM to the established information systems, we have concluded considering the compared days that indeed these rates were more reliable. However, our new rates were based on a sample. When conducting deeper research with the CVM, we could have put more work into calculating the RC equivalent and filling levels, by taking bigger samples and analyzing the difference over the days. Also, currently we have used one filling level and one RC equivalent per customer, while we know there is a seasonal difference present. During winter season, the parcels are bigger on average, resulting in less parcels per carrier. For even more accurate conversion rates, we could have used more rates based on the season.

Distributions in customer arrival data

In the customer arrival analysis, we have searched for noticeable trends in terms of arrival time or arriving freight. We have shown our results in several graphs in Chapter 6 and in the Appendix. There we have concluded that based on the analysed criteria, trends in arrival times are unable to find for all the analysed customers. However, we have based this on the outcomes of the graphs itself. If we wanted to investigate more precisely if for example the arrival times were predictable, we could have sought for distributions in the data. With a distribution present in the data, we would be able to predict future arrival times with a certain chance. Looking at the graphs, we do see at several ones a normal-distributed shape, which could lead to the presence of a distribution. It must be noted that these shapes were recognised in graphs with arrival times rounded to hours. When visualising the exact arrival times, these shapes were less noticeable.

The reason we did not further investigate for distributions in the data, is because we were looking for extremely noticeable trends, that would be beneficial in the daily management of the process, for example that truck X would always arrive between time Y and time Z. When having a distribution present in the data, this would make predicting possible, but always with a certain chance, which would it not make beneficial enough for the depot to work with. However, including this method would give our customer arrival analysis a more complete picture of the situation and would be a very interesting addition in the future.

C-charts

During the data analysis, we have conducted several c-charts, to find out if the average value is a reliable estimator. However, our results from the c-charts were not what we would have expected. The UCL and LCL were very narrow and almost all values lay outside the control limits, which indicates un-randomness. However, considering the U/D and A/B analysis, the values were random. The c-chart we used, is in literature mostly used in healthcare scenes, where consistency is much more important than in transport scenes. Probably were the control limits too narrow for our analysis, and would the c-chart be more suitable with broader control limits. Still, we think that the values were too far from the average to rely on the average as estimator, so we still assume the conclusion made from the c-charts as correct.

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