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TNO report

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ToGrip - Use case 3 Off-peak road haulage visits at container terminals

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Summary

This research was aimed at understanding the distribution patterns of road hauliers at container terminals and the applicability and potential of logistics concepts that would result in a higher share of evening/night distribution. This research objective is highly relevant since many terminals reach their capacity limits in daily peak hours, resulting in waiting times and/or scarcity of available slots in these hours, whereas the evening and night hours are experienced by substantial underutilisation.

Several ports experimented with measures to better balance the truck arrivals over the day, but with limited success. It requires a holistic approach to solve the wider issues in optimising port-hinterland interfaces, single measures may look effective in first instance, but wider deployment may be challenging or the effects may be counterproductive in downstream activities. Nevertheless, just a modest shift of 5%-10% towards the off-peak hours would relieve the pressure and reduce terminal waiting times considerable, so it is worth exploring the concepts, even if the applicability is limited to typical niche markets and scalability is rather limited.

The study concentrates on four concepts that seem to have potential to boost the terminal use by trucking companies in off-peak hours.

These four concepts include:

- chain collaboration targeted to explore (incidental) flexibility in opening hours at the consignee; This concept is being complemented by three hub concepts, being:
- the use of a trucking company's own facility as decoupling hub;
- the use of a neutral decoupling hub; and
- the use of the customer facility as a decoupling hub.

Interviews were undertaken to further explore these concepts in more detail and to explore the applicability, challenges, potential impact and scalability aspects of these concepts. The interviews did not indicate a strong potential for using the customer's location as a decoupling hub, so a SWOT analysis was made for the other three concepts.

Chain collaboration agreements (with compensation schemes) aimed at offering incidental flexibility in opening hours, offer a potential to overcome the obstacles that withhold consignees today to offer extended opening hours for delivery. There seems to be momentum to explore this on a larger scale, following a series of disruptive events in maritime container logistics impacting supply chains and demanding for more collaboration. Targeted support tooling with standard example arrangements and compensation schemes for incidental opening hour flexibility can facilitate the adoption of extended opening hours on request.

Alternatively, decoupling hub concepts could push the off-peak terminal use by trucking companies, whilst respecting the limitations in opening hours of consignees.

A trucking company's own private decoupling hub seems feasible to use if this location allows for temporary storage or parking facilities, and no considerable investments in terrain hardening need to be made. And even then, it would require dedication and focus to apply night distribution, since it seriously impacts the operating and human resource policy of the trucking company.

A neutral decoupling hub may be a solution for those companies that lack an own facility. A typical application of this concept is when confronted with serious terminal congestion whilst planning to execute a multi-terminal tour (so-called 'Rondje Maasvlakte'). Then, the hub can be used to swap the export container destinated for the congested terminal and compose from the hub a single terminal tour. There are several uncertainties in this operating model that could result in a negative business case after all. So, despite this concept is being experimented with by one of the interviewed companies, there is reluctance to apply this yet on a wider scale.

Using a reefer hub for off-peak pick up looks more promising. The market dynamics in reefer container use and the perishable characteristics of the cargo make the neutral hub concept appealing to use. This concept is under development in Nieuw Reijerwaard, where parking and charging facilities for 20 reefer truck-trailer combinations are being built. The underlying business case sounds promising and the interview findings support this.

Even a modest shift towards off-peak use could relieve the pressure on the port-hinterland system and reduce terminal waiting times, so even if the applicability and scalability is limited to niche markets, it is still valuable to support the uptake and wider deployment of these concepts. The study recommendations give direction to how and where this support can materialise. This includes, among others, the development of support tools for targeted chain collaboration and exploration of reefer hub feasibility in other Greenports then Nieuw-Reijerwaard.

Contents

1 Introduction

1.1 Background

The scope of this research is on container hinterland transport via road, waiting times and distribution patterns. It is about concentration of truck visits in daily hours and the limited use in off-peak hours (e.g. evening and night hours). Though modal shift may be an effective measure to relieve the intensity of trucks visiting the container terminals, modal shift is out of scope in this study. Nevertheless, it is worth understanding the context and modal split of the port. In small ports, road transport may be the only hinterland modality. In all major European container ports are alternative hinterland modes in use. In Rotterdam, road transport is the most important hinterland mode and the road share is higher than in surrounding main ports.

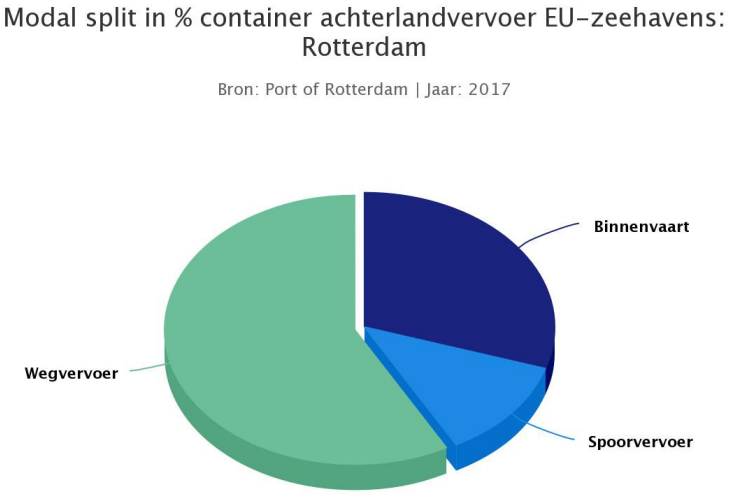

Figure 1: Modal split in container hinterland transport in Rotterdam in 2017.

In Rotterdam, 58% of container hinterland transport is done by road.
This is pretty high in comparison with other large container ports. Road transport share in Antwerp is with 55% a bit lower, in Hamburg 52% and in Bremerhaven 51%. Whereas inland waterway transport is relative strong represented in Rotterdam and Antwerp, the German ports have a much higher share of rail transport. In all these cases, road transport of containers represents more than half of the total hinterland container volume.

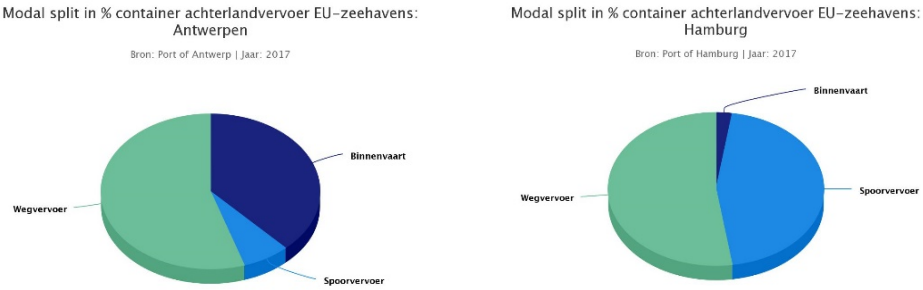

Figure 2: Modal split in container hinterland transport in Antwerp and Hamburg in 2017.

With the growing container volumes and bigger call sizes, the port-hinterland interface experiences pressure on the hinterland capacities, resulting in waiting times.

Container hinterland transport by road is confronted with three different waiting times: on the terminal, on the road (road congestion) and at the reception facilities and of shippers/consignees.

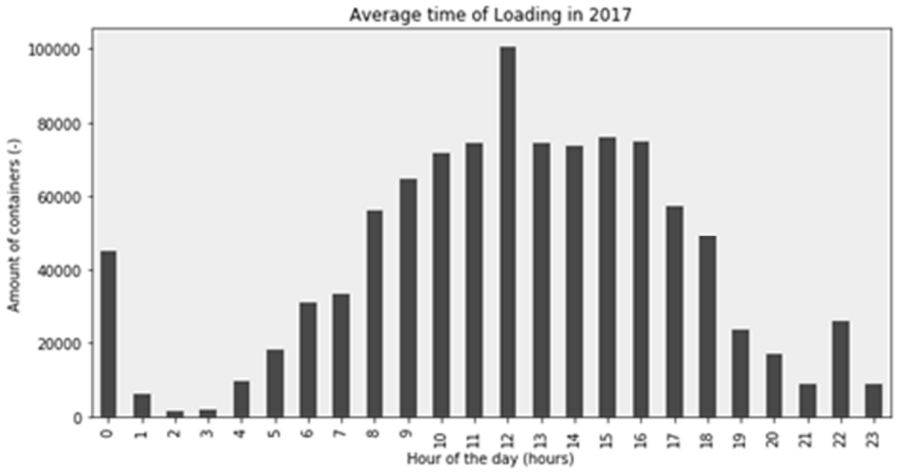

Figure 3: Aggregated daily distribution patterns of truck visits in 5 Rotterdam container terminals in 2017 (TNO, 2019).

From ToGrip use case 1 it became clear that the majority of containers are being delivered or picked up from the terminal during the day, see Figure 3. The peaks on 00:00 and 12:00 should be neglected, see for details ToGrip Report on reliability in port-hinterland interface (TNO,2019 R10845). In that report, we observe increasing pressure in the late afternoon hours, with corresponding negative effects on congestion at the ring of Rotterdam. On top of that, the processing capacity (# moves and truck arrivals) reaches its maximum during peak hours, resulting in truck waiting times and terminal congestion. At the same time, utilisation rate remains low in evening and night hours. Therefore, a shift from peak to off-peak activities could mitigate these negative effects and increase productivity. However, there must be good reasons why off-peak usage is so low, peak shaving does not come naturally.

In the transport ecosystem several peak shaving and optimisation concepts are being experimented with. These include night reception at the consignee and several hub concepts, which all include the split of the journey into two trips: for incoming containers one from the sea terminal to the hub and one trip from the hub to the consignee or for outgoing containers one trip from the consignor to the hub and one from the hub to the terminal. Several hub concepts have been experimented with, including the incidental use of own facilities as temporary buffer storage, but none of these concepts seem to be deployed on a large scale.
A structured analysis of these concepts and their scalability is lacking.

1.2 Research objective

The information about these different concepts is ambiguous and fragmented. Little is also known about the scalability of these concepts.

The overall research objective is to understand the distribution patterns of road hauliers at container terminals and the applicability and potential of logistics concepts that would result in a higher share of evening/night distribution.

This research objective can be split into the following research questions:

- Why is evening/night terminal usage by road hauliers rather limited?
- What causes this reluctance to make use of evening/night distribution?
- Where is evening/night distribution being applied successfully?
- Which logistics concepts are being used that boost the use of evening night terminal transport?

Therefore, this research focuses on the following points:

- Getting a clear overview of all the options for spreading across off-peak hours
- Perform a strengths and weaknesses analysis of the alternative concepts
- Analyse the scalability of the successful concepts

1.3 Approach

The research approach included the following steps:

- Literature review, analysing past experiences with terminal congestion reduction and peak shaving concepts.
- A Stakeholder Analysis, understanding the position of the stakeholders
- Concept inventory, structuring and categorising the different concepts from desk research
- Interviews with stakeholders
- Business case considerations
- SWOT analysis and scalability analysis of successful concepts
- Reporting

The stakeholder analysis was performed by collecting input from subject matter experts from TLN, evofenedex, Deltalinqs and Port of Rotterdam on the position of the key stakeholders in this research, being:

- Container hauliers
- Shippers/consignees
- Terminal operators
- Freight Forwarders

Interviews have been performed with representative stakeholder companies.

1.4 Report outline

The report is structured as follows. In the next chapter a short overview will be given from the literature about off-peak usage, its concepts and potential bottlenecks. After that in chapter 3 we will discuss the key concepts that could support more off-peak usage. Next, in chapter 4 the interview findings are discussed. From these findings a SWOT analysis is presented in chapter 5. Where chapter 6 continues with several business case considerations. Finally, a conclusion and recommendation will be given.

2 Literature review

Throughout the world at different ports a variety of concepts has been experimented with. Worldwide ports are experiencing and anticipating an annual increase of container movements. According to the website of the Port of Rotterdam container volumes have been rising since 2010. In 2020 the container throughput at the port was 14.3 million TEU and continues to rise. Similarly, the Israelian port expects an annual growth of 5,3% until 2030 (Bentolila et al., 2016). So, both the port of Rotterdam and the port of Haifa experience increased pressure on their terminals. This problem is not limited to these ports, but continues to cause problems worldwide. These developments demand a lot from the capacity to handle containers at the terminals. On top of that waiting times at the terminals increase causing prices to rise as well. In the maritime sea container literature several programs and pilots addressing this problem have been studied.

Several ports in the world notice that the peak hours are at or almost at their maximum capacity, while their off-peak hours are merely used. Australia's 5 major ports see only 20% of their timeslots being occupied during off-peak times, that is during weekday afternoons, night times and weekend days (Lubulwa, Malarz, & Wang, 2011). An even more concerning percentage was reported at the port of Haifa. Here before 2011 3.7% of all containers were moved at the terminal during the night time. Similarly, the ports of Chicago reported similar issues at their terminal with worsening consequences for the hinterland traffic such as congestion and higher costs in the hinterland logistics chain (Labelle, & Frève, 2015).

Alex Nugteren (Nugteren, 2021) studied truck arrival shift policies for port-hinterland alignment at the Port of Rotterdam. This research analysed the impact of a shift of container movements to off-peak hours on waiting times. She used data from four terminals and explored shifting scenarios. She used four time window clusters: morning (09:00-09:59), midday (10:00-14:59), afternoon (15:00-20:59) and night (21:00-03:59). For our study, we concentrate on the night window. In total, 6.9% of the truck arrivals are at night, with differences between the terminals (ranging from 5.5% to 9.6%).

Several pilots have been initiated to overcome the imbalance between peak and off-peak movements at the terminal. One of these programs is called the "Good night program" at the Haifa port in Israel. This program included the introduction of monetary incentives when making use of off-peak hours.
The incentive was set at $26.30 per 1 TEU moved from or to the port by road transporters between 10 pm and 6 am. After the introduction of this monetary incentives the off-peak deliveries increased from 3.9% before 2011 to 7.9% in 2013 (Bentolila et al. 2016). Besides the program not being able to increase off-peak movements to the target percentage the monetary incentive was also found to be at its maximum. Increasing the amount would have surpassed the external benefits of the costs for the incentive.

Another initiative was introduced at the terminals of the Los Angeles port.
An administrative organization was established called PierPass they would handle fees during peak hours (3 am to 6 pm) to cover the costs made for facilitating off-peak usage such as labour costs, operating costs and administrative costs.

In 2005 the fee was $40 per TEU. By 2014 it had increased to $66.50 per TEU. It greatly increased the movement of containers during off-peak hours. From 15% in 2005 to 33% in 2006 and eventually 50% in 2011. Despite the success PierPass now made a loss due to the higher off-peak hour costs and lesser fee payments (Lubulwa, Malarz, & Wang, 2011).

The Southampton container terminal in the UK managed to cut congestion at and around the port. They coupled the usage of IT systems with peak pricing when accessing the port. The IT systems consisted of a timeslot management system combined with monitoring systems. £1 was charged for trucks during peak hours and £25 when not showing up for the planned timeslot. This combined strategy eventually led to a spread of container movements during peak hours (European Conference of Ministers of Transport, 2007).

So, there exists a mixed success in the applications and measures in the different ports. These initiatives are all aimed at the road transporters in the logistics chain for containers. While Holguín-Veras et al. claim that policy making will be ineffective, since there are too many actors with different behaviours and incentives in the chain. In the logistics chain consignees or shippers are found to be the “key stumbling block” (Holguín-Veras, 2005). They make the costs of enabling off-peak deliveries while carriers and terminals are profiting. Thus, a transfer of market saving should take place from terminals to consignees.
The above-mentioned policies are aimed at the hinterland transporters and with it these costs are moved onto this sole actor. While instead policies should be aimed at the complete logistics chain for containers.

Altogether these measures have not managed to reach the desired goal of shifting enough container movements to off-peak hours, such that waiting times at the terminals will decrease. Obviously, alternative measures such as modal shift or enlarging the transhipment capacities of container terminals may also solve the issue and take away the need for more off-peak terminal usage. The literature review also highlights that often the complete logistics container chain is not fully engaged. A sound understanding of the typical hinterland processes, different stakeholder behaviours and stakes is needed to assess the true potential of these concepts. There are many different factors at play that influence the feasibility of successful concepts, such as the combination of trips (export, import or empty), the distance of the trips, the size of the transporter and shipper, the location of the transporter and the shipper, the type of container and the type of cargo.

It requires a holistic approach to solve the wider issues in optimising port-hinterland interfaces, single measures may look effective in first instance, but wider deployment may be challenging or the effects may be counterproductive in downstream activities. However, several concepts aimed at different niches in this market would help shift container movements from peak to off-peak hours.
This research is aimed at investigating what else is restricting transporters to shift to off-peak hours. While also considering new concepts which make it possible for the logistics chain to adapt towards this shift as a whole.

Resent supply chain disruptions triggered the attention of the Port of Rotterdam towards this topic, and during our research some relevant parallel initiatives are worth mentioning.

A project funded by the European Commission's Horizon 2020 Green Deal program was recently awarded. This project called MAGPIE (Smart green ports as integrated efficient multimodal hubs) will execute ten pilot projects and demonstration projects that focus on sustainable and smart logistics in port operations, including Port of Rotterdam. One of the Rotterdam demonstration projects constitutes the deployment of all-electric heavy trucks for short distance trips from the port to a decoupling hub.

Another relevant initiative is the CATALYST living lab (funded by amongst others TKI Dinalog and NWO). CATALYST is a public private partnership and aims to develop and accelerate Connected Automated Transport (CAT) innovations for safer, more efficient and sustainable heavy-duty road transport. TNO is project coordinator. In the 'smart yards' research line CATALYST investigates through various scenarios the impact of CAT innovations combined with logistics concepts. Specifically, one of these scenarios involves smart dollies (autonomous vehicles designed for yard operations) that are in charge of last-mile transport from a decoupling point towards final destination at terminals in a port. Through simulation studies it is explored which scenario contributes best to efficiency (reducing congestion), safety and sustainability. In case positive results are obtained, real-life pilots will be prepared as a next step.

Summarizing, there are several hub concepts already applied or currently being explored or developed. Together with a group of subject matter experts among the ToGrip project partners we selected the promising hub concepts to be explored in more detail in this study. The next chapter provides an overview of these concepts, that should help shifting truck visits container to the off-peak hours.

3 The key concepts supporting more off-peak terminal usage

The stakeholder interviews with subject matter experts from Transport & Logistics Netherlands (TLN), Port of Rotterdam and Deltalinqs, and the literature research revealed a number of concepts that could contribute to peak shaving or more use in off-peak hours. These concepts are being applied in other ports (literature), or are good practises already being applied in Rotterdam.
They include: chain collaboration, and a number of decoupling hub variants.
A decoupling hub is used to split the road hinterland trip into two consecutive trips: for incoming containers one from the sea terminal to the hub and one trip from the hub to the consignee or for outgoing containers one trip from the consignee to the hub and one from the hub to the terminal. Such a decoupling hub allows to optimise against the opening hours and expected waiting times at the terminal as well as respecting the opening hours and other limitations on the side of the consignee.
The decoupling hub variants include using an own facility as decoupling hub, a neutral swap hub, a neutral reefer hub, and using customer's facility as decoupling hub. An elaboration of these concepts follows in the next sections.

3.1 Chain collaboration

This concept entails a collaborative exploration of options to relax the delivery window and agree on the terms and conditions (e.g. frequency, procedure, cost and gain sharing arrangements). The collaboration includes the following chain actors.

Table 1: The chain collaboration actors considered.

Actors	Role description
Shipper / consignee	Offers cargo to be transported, coordinating the transport of goods or receiving the goods.
Forwarder / Logistic Service Provider	Organises the shipment and often manages the customs processes for international shipments. LSP may also offer warehousing services and other value added logistics services. Some transport goods themselves others simply coordinate the process.
Trucking company in hinterland container road transport	Executes the containerised road transportation to and from the port.
Container terminal operator	Operates a facility where cargo containers are transshipped between different transport vehicles, for onward transportation.

3.2 Use own facility as decoupling hub

In this variant, as shown in the Figure below, the road haulier decouples the trip and uses its own facilities to park the complete truck-trailer combination, the trailer with the container or only the container.

Transport between the terminals and the own hub could take place in the evening and night hours, whereas the delivery at the consignee or pick up of export containers at the shipper could be executed in accordance with the opening hours of the consignee or shipper.

Figure 4: Visualization of a decoupling hub at a company's own facility.

3.3 Neutral decoupling hub

In this variant, the decoupling hub is not an own facility, but also other transport operators may use this facility for parking and storage purposes. In the research, we explored the feasibility of several geographic variants of such a neutral hub: near the container terminals, just outside the Ring Rotterdam (e.g. Southeast, or north of the Ring Rotterdam), in major logistics hinterland hubs, such as Tilburg, Venlo, Zwolle etc.

We also explored two operating variants for hubs in the vicinity of the terminals: only operate the hub or alternatively operating (efficient) terminal shuttle services on behalf of the transport companies or on behalf of the consignees.

Figure 5: Visualization of a neutral decoupling hub.

3.4 Use customer facility as decoupling hub

In this variant, the transport company picks up the container at night at the terminal and delivers it at night at the premises of the consignee. This is made visible in the Figure below. Access to the facility is granted, but the container is not being unloaded. Either the container is being unloaded and stalled on a destined spot at the premises, whereas the consignee can use a dolly to move the container the next day to a dock, or the trailer combination is put in front of a destined dock location and the truck unit leaves. The latter has implications for the chassis availability of the trucking company. This option may work if the transport company has frequent deliveries to and from this customer facility.

Figure 6: Visualization of a decoupling facility at the customer.

4 Interviews

4.1 The interviewees

During this research the following 8 interviews took place during the period from April to July 2021:

- Marco Post, director of operations from Post en Zonen Transport;
- Bas Sterrenburg, director of operations at EKB;
- Jan Verlaan, co-owner and responsible for finance and ICT at JGT;
- David Heitzer, Supply Chain Manager of Intratuin;
- Michiel Brokke, manager Global Forwarding at Kien Logistics;
- Alexander van Eeden Petersman, Director and owner of Vepco Transport;
- Ad Schoenmaker, Director of Ritra Cargo;
- Michiel Jak, consultant for the Province Zuid Holland, exploring subsidy and business plans for Nieuw Reijerwaard.

These persons were carefully selected by the subject matter experts from TLN, evofenedex, Deltalinqs and Port of Rotterdam, considering their different perspectives, roles and business models in the logistics hinterland chain. Next a description of all the interviews will be given. Hereafter these results will be combined to provide deeper insights.

4.2 The interview structure

The interviews are of a semi-structured form. A general guideline with topics and sub-questions were formulated beforehand. During the interviews these questions served as a starting point. From there on the interviewer could ask more in-depth questions about the topic and the given answer. This way, issues and topics affecting the off-peak terminal usage easily came to the surface. The topics and the respective sub-questions differ per interviewee category. We differentiated on road transporters, freight forwarders and shippers. The topics per category are listed below. The respective questions are included in an annex to this report.

Road Transporter:

1) General;
2) Off-peak usage;
3) Flexibility and time differentiation;
4) Hubs and decoupling;
5) Hub exploitation and location;
6) Shuttle service for the hub;

Shipper:

1) Off-peak receiving availability;
2) Flexibility and price differentiation;
3) Hubs and decoupling;
4) Hub exploitation and location;

Transport agency:

1) Off-peak usage;
2) Price differentiation;
3) Hub concepts;
4) Shuttle service for the hub.

4.3 The interview findings

For the interviews we made a structure mainly focused on hubs and off-peak usage, but it quickly became clear that the logistics hinterland market contains a wide variety of activities and niches. This results in a variety of solutions that could work in some cases, but not in others. In this paragraph we will describe the four major concepts, whereas in the next chapter some of the most promising concepts will be discussed in strengths and weaknesses analysis.

Road transport operators

The table below gives an overview of all the transporters that were interviewed for this research. A quick summary is given of their size in terms of the fleet. Their business operation and target market focus are also quickly summarized with the distance their fleet, on average, travels from the port of Rotterdam to the client. Finally, an indication is given whether they make use of hubs and off-peak deliveries or pick-ups.

Table 2: Typology of the interviewed transport companies.

	Company A	**Company B**	**Company C**	**Company D**	**Company E**
Size	165 Trucks	100 Trucks (+60 external)	120 (700 in EU) Trucks	100-120 Trucks	9,000 Containers
Distance	30 – 100 km	Till 200 km	Till 800 km	200 km	50 km
Hub	No	Yes	No	Yes (neutral)	No
Off-peak	No	Yes	No	Yes	Yes

Company A generally makes short trips from the port of Rotterdam to the client. At the client the container is emptied and afterwards delivered to the empty depot near the terminals at Rotterdam.

Company B concentrates on medium distance trips. After a delivery at the customer, they pick up an empty container and deliver it back to the terminal. Company B actively explores its own hub, this hub concept is in development. They aim to pick up containers during off-peak hours at the terminals of Rotterdam and deliver them to their hub location.

Company C is by far the largest international container road haulage operator in Rotterdam and delivers at long haul distances from the port of Rotterdam. They focus on so-called one-way transport. This means that every trip to and from the terminal is with a full container.

Company D is active in the same market segment as company A. At the client they deliver a full container and when unloaded they bring it back to the terminal. This could be via the hub, since they also make use of a hub concept combined with off-peak pick-ups.

Company E offers logistics services for frozen and chilled foods. Their main customer is a producer of frozen potato products, with large production facilities near Rotterdam and a large cold storage and distribution warehouse at Maasvlakte II. The frozen potato producer exports more than 4,500 deepsea containers per year, with substantial volumes via the nearby MV2-container terminals. Truck drivers from company E pick up an empty container from an empty depot. They load this container at the cold storage warehouse. From here they depart to the terminal to deliver the export container. This process goes on day and night, making use of off-peak hours.

Shippers and consignees
Among the shipper/consignees we interviewed a large franchise organization which sells garden products and tools, and outdoor/indoor furniture. They operate a central distribution center, receiving many products by deepsea containers. Hinterland transport is primarily being supplied by barge, whereas the last mile is completed by road transport. These logistics operations are handled by three different freight forwarders, but often dealing with the same transport companies.

Freight forwarder
In order to get a clear view of the complete hinterland chain we also interviewed a freight forwarder. This company manages the forwarding of their customer's contracts of carriage. They take 25,000 orders annually mainly focused on the import of consumer goods in the fashion, supplements and home accessories.

Neutral (reefer) hub operator
We interviewed a consultant, who supported the Province Zuid Holland in the business plans for Business Park Nieuw Reijerwaard. Nieuw Reijerwaard will become a secure truck parking facility (capacity of 150 trucks) in the armpit of the highways A15 and A16 (Ridderkerk / Barendrecht). There are plans to create also 20 parking and charging facilities for reefer containers on top of the 150 parkings.

Swap hub near terminal
In the hinterland transportation chain container transporters are dependent on a lot of factors. One of these factors is the waiting time at the terminals, unloading time at the client and traffic. On top of that the road transporter of containers is also dependent on the opening times of the client. It does not allow them to pick up and deliver containers during off-peak hours.

The neutral hub is used in combination with their own location to pick up containers during the night with an LZV (long heavy truck). These containers are then delivered to the client during the day. On top of that Company D creates trips where they only have to go to one terminal. As shown in Figure 7, they switch a container destined to terminal X with a container destined for terminal Y where they also have to pick one up. By doing so the trip will have its destiny at only terminal X instead of X and Y, and thus mitigating the expected waiting time at terminal X. Swapping containers remains a gamble and it is not yet a commercially sound solution according to Company D, who uses this hub concept in practise. In some cases it saves them a little amount per container and sometimes they make a small loss on a container.

“You have to fully commit to this system in combination with off-peak hours or not commit to it at all”, is what the interviewee of company D stated. To take full advantage of this neutral hub there should be more containers to swap as well as a fully committed shuttle service during off-peak hours between the terminals and the hub. Currently Company D does not always have a container to make a swap possible.

Figure 7: Visualization of the neutral hub concept. with a shuttle strategy from terminal to the hub and a swap strategy from hub to terminal.

Chain collaboration

During the interviews it quickly became clear that there is a complex triangular cooperation going on between three transport chain actors: road transporters, freight forwarders and shippers.

Between the transporter and the shippers there exists a lack of communication, fed by the fact that contractual relations between the two are also lacking. It is the freight forwarder who often has contractual agreements with both shippers and with truck operating companies. During one of the interviews it came to the attention that shippers and transporters act in different worlds and thus behave in that manner. Road transporters indicate that they could deliver more reliable if they would be able to deliver after closing hours of the shipper. While on the other hand, shippers sometimes indicate they may consider to accept delivery after opening hours, but only if the on-time performance of these deliveries would be really high. So, there is clearly a potential match, however the lack of communication and the lack of contractual relationship between shipper and transport operator cause that the off-peak delivery option is not even be explored and certainly not executed. It needs triangular collaboration between consignee, freight forwarder and trucking company to apply this extension of opening hours at the consignee and reschedule the trip.

An example of how this could be facilitated is by agreeing with the three stakeholders about different scenarios of deliveries. Normally the transporter should deliver on time at the agreed day or time for the standard price P. However, in a first scenario, due to factors outside the transporter’s reach of influence, a delivery could be delayed or a transporter could see fit to deliver it that day, but outside the customer’s opening hours. When a delivery can still happen the same day but after the customer’s opening hours a deduction on the agreed price should be given P-C. Here C are the additional costs made by the shipper or customer. A second scenario could be in case the transporter prefers to deliver the next day.
The shipper would then value the delivery for less, P - V. Here V is the decrease in value of the delivery for the shipper.

On an annual base these three stakeholders could also agree on the percentage of shipments being made in every scenario. These agreements give both the transporter and the shipper certainty as well as a way to build to trust. By making agreements which give room to changes in delivery moments transporters are also able become more reliable. Transporters are able to also make more trips per day increasing revenues which could shift partially from transporter to shipper. This shift is in the form of either the additional costs C made by the shipper or the decrease in value V for the shipper.

From these interviews we can conclude that more chain cooperation could result in more efficient and reliable deliveries. However, this requires more investigation in the market. We have spoken to stakeholders from the triangle as pointed out earlier. All road transporters and shippers were positive towards more efficiency and reliability through possibly more chain cooperation and transparency. “Shippers are certainly open to entering into this conversation, everyone can benefit from something again. In terms of reliability, profit and efficiency.” Said one of the shippers.

A neutral reefer hub

Many of the logistic service providers of perishable fruit and vegetables in the direct vicinity of the hub location lack a night shift to unload maritime containers and they also lack the storage facilities for reefer containers. However, there is a need to quickly pick up these containers from the terminal, unload them and return them in empty depots (avoid container detention fee), there is general scarcity among reefer containers and ocean carriers steer on short container detention periods.
This outlines the need for a decoupling hub in order to pick up these reefer containers also in evening and/or night hours. The intended location of this reefer hub - Nieuw Reijerwaard - is near a number of fruit importers and service providers in perishable logistics.

The electricity facility for the reefer plugs (needed at night) can be combined with the charging needs for electric urban logistics vehicles, required for zero emission policies in Rotterdam and other surrounding cities. The energy grid provider (ENGIE) can use the hub location with the energy provision also as a green energy hub for mobility and logistics.

Truck operator’s private decoupling hub

In order to increase reliability of the agreed delivery time window, truck operators must, among other factors, avoid waiting times at the terminal and avoid congestion on the road. One of the transporters found a way to realize this. By creating their own parking lot for containers they are able to shuttle between their private terrain and the terminal. Company B informed us during the interview that they “are already creating [their] own hub location to pick up during the night.” Their goal is to shuttle 3 times during off-peak hours with an LZV, which means that by 1 driver 9 TEU can be picked up and stored at their private terrain. The containers are taken off, which saves container chassis. This system makes it possible to start the delivery early in the morning before the general rush hour. This results in more reliable deliveries and more satisfied customers. “The customer just wants his cargo on time.” This process is calculated to cost around 40-60 euros more per container.

5 SWOT analysis of the key concepts

Based on the findings from the interviews a SWOT analysis can be made of the different concepts. The analysis looks at strengths, weaknesses, opportunities and threads. It helps in identifying what kind of impact the initiative may have both positive and negative.

5.1 Chain collaboration

The essence of multi-actor chain collaboration is to offer more flexibility in delivery windows at shippers and consignees. However, shippers have limited opening hours and often do not have any contractual relationship with transport operators. This is partially due to a lack of communication. Since everything is put in one-on-one contracts there is no reason for forwarders to facilitate the communication between transporter and consignee. This is how the chain has been operating and is still operating. As a consequence, these limitations cause inefficiencies in the execution of the hinterland transport of containers.

The strength of this concept is that it could result in relaxation of the opening hours and therefore allowing for more efficient execution of containerized hinterland transport and higher utilization rates of the trucks. Moreover, it can improve the reliability in agreed delivery time and relieve pressure on unloading processes. Finally, exploring the feasibility of this measure is rather easy, it is just a matter of sitting together, discuss the conditions and agree upon compensation schemes. Relaxation of opening hours comes with a cost, so it demands for compensation arrangements. In most cases, the costs are limited to additional operating costs for hiring personnel in evening hours, contrary to the decoupling hub concepts that involve hub investment costs. The additional delivery may also have an upstream chain impact. Waiting times on the terminals may be affected due to more evening/night pick-ups instead of next day, resulting in shorter container dwell times on the terminal.

A weakness of this concept is the lack of contractual relationship between shipper and transport company. It would require contractual adjustments to facilitate this kind of flexibility. It would demand for building flexibility in the tender procedures between shipper and freight forwarder, and trust that this flexibility is not being misused for internal optimization purposes by one of the parties.

The concept offers opportunities. First, the recent occurrence of major disruptive events such as port strikes, Suez blocking, terminal hacks, blank sailings, and the extreme price volatility in container shipping demands for this type of multilateral collaboration. There seems to be momentum to explore this kind of collaboration. Moreover, the concept is easily scalable. Exploring more flexibility in opening hours, combined with an acceptable compensation arrangement can easily be explored between many shipper- freight forwarder – truck operator combinations.

Deeply ingrained habits and reluctance to change pose a threat in a rather fragmented market where there is low urgency from the shipper to change the existing delivery patterns. Willingness to explore and discuss this type of flexibility might get bogged down, not resulting in any change in practice.

The SWOT highlights for this concept are summarized in the table below.

Table 3: SWOT analysis of the chain collaboration concept for more off-peak terminal visits.

Strengths	Weaknesses
- Less terminal waiting times - Higher truck utilization - More reliable delivery times - Ease of implementation, low investment costs	- Current contracts and incentives do not support this type of flexibility
Opportunities	**Threats**
- Recent supply chain disruptions create momentum for chain collaboration - Easy scalable to other transport chains	- Ingrained habits and reluctance - Much talking, no actual flexibility

The far majority of the interviewees were positive about the chain collaboration option. Not only as a practical agreement for cope with delivery outside the opening hours of consignees, but also to discuss on a regular basis other kind of operational issues and bottlenecks.

5.2 Truck operator's private decoupling hub

Some trucking companies use their own facility as a decoupling hub. They occasionally pick up containers in evening or night hours, store the trailer on their own facility, and deliver the containers the next day to the consignee. Among the interviewees there is one such example. They aim to pick up and store a number of containers equal to 9 TEU at their location and deliver these the next day at the consignee.

This operating procedure has some advantages. The trucking company can avoid long waiting times on the terminals in the peak hours and can optimize the utilization rate of their truck-trailer combinations. Moreover, they can plan the delivery trip to the consignees the next day and avoid road congestion during that trip. It also relieves the terminal stack capacity by reducing the container dwell times. These advantages are applicable for all of the decoupling hub concepts.

This private hub may have an additional advantage. If the terrain hardening is already available, it requires limited additional investments and no service fee for the hub operation and hub use. Contrary, if it would require terrain hardening investments, the associated investment costs are considerable.

The concept also entails a number of other weaknesses. First of all, not many transport companies have a suitable location in the vicinity of the deepsea terminals, with parking facilities for truck-trailer combinations. Moreover, the interviews reveal that the instances when this option is being considered is only incidental and in most cases not structural.

The applicability of this private hub concept also has its limitations. Considering using a decoupling hub seems only feasible for transport trips over a certain distance. For shorter trips, the additional handling becomes too complex and the preference would be to drive directly to the destination. For international haulage over long distances, the gain in total lead time is rather limited, and pick up the next morning (the current practice) may also be an acceptable option. So there seems to be a limited target market for off-peak shift, interviews indicate distances around 200 km on average.

Using night distribution has also serious implications on the working hour planning of the truck drivers and the human resource policies. Only in case of a structural volume of night deliveries, these companies can hire truck drivers with preferences for night hours.

Along with other interviewees it was mentioned that off-peak trips in combination with a decoupling hub are not structural, since demand is not high enough. But in the specific case of this example the transporter handles a number of containers which contains enough incidents to build a structural business case around it. Since the company is then able to occupy both drivers and equipment during off-peak hours at a regular base. For transporters with smaller volumes the incidents may not occupy an off-peak driver enough to make it profitable.

So, in general, it is hard to scale since the range is very specific as well as the size of the transporter's company. Once it may be possible it requires a large initial investment. The terrain requires a strong foundation since heavy containers may be stacked, besides it requires a larger truck and off-peak personnel.

There are exceptions in this concept that might work. A highly automated process makes it possible for one of the interviewed companies to have a continuous stream of trips from warehouse to terminal to empty depot. The custom paperwork as well as the loading of the container are completely automated. This saves a lot of costs. On top of that they are mainly dependent on one client from which they were separated to become an independent organization.

This business case around this similar concept differs in the range, type of container and company size. It has a far smaller trip distance, less than 50 km. The container that is being used is a reefer container, which has tighter demurrage and detention rules. This puts more pressure on the handling of these containers. And finally, it is unique in the sense that it was a part of a consignee company. So, it has a close and transparent relationship with the customer. This customer is large enough to maintain this continuous stream. However, an issue this concept runs into is the limited opening hours of empty depots. This forces them to have spare empty containers near their client to maintain a continuous flow of trips.

The SWOT highlights for this concept are summarized in the table below.

Table 4: SWOT analysis of the private decoupling hub concept for more off-peak terminal visits.

Strengths	Weaknesses
- Less terminal waiting times - Higher truck utilization - More reliable delivery times - Ease of implementation and low investment costs if facilities are already present	- Applicability is limited, many companies lack the facilities, investment costs in hardening are high - Only valuable in occasional situations and limited to midrange transport distances
Opportunities	**Threats**
- Process automation and digitization can boost the business case	- The concept competes with the neutral decoupling hub

5.3 Neutral decoupling hub

Instead of using own facilities some transporters use neutral locations, or locations with secure container storage. When being too small for an own private hub location, this could work as a solution in incidental cases. Two types of neutral hubs show potential: the swap hub and the reefer hub.

With the growth in number of container terminals, the container transport companies regularly plan multi-terminal trips (‘Rondje Maasvlakte’), in which they load and deliver containers from more than one terminal. In the case of severe terminal congestion on a particular terminal, such a multi-terminal trip may result in missing reserved slots in other terminals. One of the interviewees explored the swap hub concept for this kind of issue/situation. If the company initially planned for a multi-terminal trip, there is severe terminal congestion on one of the terminals, and the closing time of the export container allows for a later delivery, the truck operator drives to the swap hub. There he changes the export container destined for the congested terminal by another export container or empty destined for another terminal and make a single terminal trip from the swap hub. In the next day(s), the trucking company plans for a terminal trip via the swap hub to the originally congested terminal.

This concept only works if the trucking company has a feasible swap container available at the hub. And even then, it may result in efficiency gain, but it may eventually also result in higher costs.

If the concept works as designed, it would result in reduced waiting times, and relieving terminal congestion. For this concept to work it requires that the location of this neutral hub is near or on the way to the terminal, preferably nearby. Moreover, you have to fully commit to this system in combination with a structural off-peak process or not commit at all, according to the interviewees.

The neutral reefer hub example responds to the scarcity in reefer container availability, the corresponding short container demurrage/detention periods and the perishable character of the cargo inside reefers. This puts pressure on the hinterland parties to quickly pick up import reefer containers from the terminal and deliver quickly to the consignees, sometimes also using evening or night hours. If the consignee does not facilitate night reception and the company does not have charging facilities for reefers, the reefer hub seems to fulfill a need.

The reefer hub advantages are similar to other hub concepts, next chapter quantifies some of these advantages for reefer hub Nieuw-Reijerwaard.

The SWOT highlights for the two variants of this concept (swap hub and reefer hub) are summarized in the table below.

Table 5: SWOT analysis of the neutral decoupling hub concept for more off-peak terminal visits.

Strengths	**Weaknesses**
- Less terminal waiting time - Higher truck utilization - More reliable delivery times - Easy to use in incidental situations	- Additional complexity in fulfillment of the transport order (2 trips) - Extra costs of hub use - Financial risk for the hub operator -
Opportunities	**Threats**
- Growth in multi-terminal trips (swap hub) - Growth in refrigerated container use (for the reefer hub) - Better visibility dashboards on terminal congestion (swap hub)	- The concept competes with private decoupling hubs (with reefer plug facilities)

The next chapter elaborates on some business case considerations for some of the considered concepts.

6 Business case considerations

When starting this project, we hoped to get a clear overview of the operational and planning parameters, and the planning logic of hinterland container road haulage. This would allow us then to build generic business cases for the promising concepts relieving the pressure on the peak hours on the terminals. However, when conducting the interviews, it quickly came to our attention that the business models, strategies and market segments are so scattered and differ so much that this would be too complex to model within project frame. Moreover, they would not deliver generally applicable business cases for the hub concepts.

The typical operational business models of road hinterland haulage of containers show differences and exceptions in many details and restrain the market from being separated in a few segments. These differences stem from for example the distances of the average trip, size of the company, location, what kind of trips they carry out, in which markets they are focused, what other modalities are used and what kind of relationship there exists between the forwarder, consignee and transporter or that the consignee organizes its own transport.

Nevertheless, we retrieved some interesting business case considerations, which are highlighted in the next sections.

6.1 Waiting times at terminal

By identifying the bottlenecks in the hinterland for moving terminal visits from peak to off-peak hours concepts could be identified to increase off-peak movements and decrease waiting times at the terminals. These concepts have been discussed previously based on scalability and feasibility. However, how much they should be scaled is not a matter of as much as possible, but instead there is a certain optimum. By shifting a percentage of the peak movements to off-peak hours you have a non-linear effect on the waiting times. For many of the terminals there is already an optimal decrease in waiting times when shifting 5-10% of the movements to off-peak hours (Nugteren & Najafabadi, 2021). Above a shift of 70% an increase in the waiting times was found, since you are moving the majority of your peak movements to off-peak movements and thus create a new peak moment.

6.2 Neutral reefer hub (Nieuw Reijerwaard)

The business case for the reefer hub Nieuw Reijerwaard sounds promising. The information was retrieved from a MoVe KTA subsidy application, supported by the interview findings with the consultant that helped submitting the subsidy application. The secure parking is forecasted to cost around 3 million Euro. Additional investments for the reefer hub include additional parking places (20 times 10 KEuro per place) plus charging infrastructures (100 KEuro). Operational costs of service fee and energy usage are into included in the analysis.

The societal business case is based on congestion reduction: vehicle loss hours and corresponding emission reduction. The business case assumes 20 reefer container trips per day – 5 days a week - avoiding road congestion with a minimum societal cost of EUR 10 per trip.

This results in a societal payback period of six years.

For the companies the benefits have been quantified as follows:

- Truck operators: Avoiding terminal and road congestion corresponds to EUR 75 efficiency gain per container trip minus additional costs of night distribution (EUR 10 per container trip) results in net gain of EUR 65 per container trip. Average costs of a reefer container trip MV2-Barendrecht was around EUR 250 (price level 2019).
- Shipper/consignee: additional costs: EUR 10 for the hub fee and EUR 20 for the additional transport from hub to their premises (compared to direct transport). Advantage is the better reliability of the shipment arrival and its availability. Shipper and truck operator have to negotiate how this cost disadvantage and the expected cost advantage of transport operators should be split/shared, or being included in overall tender agreements.
- Terminal operator: better spread of outgoing reefer containers, short turn-around and increasing terminal utilization in off-peak.
- Hub operator: cost-neutral operation, the service fee compensates the costs.

6.3 Chain collaboration for incidental off-peak deliveries

As discussed earlier the transport operator experiences challenges in planning and execution within regular opening hours. In such a situation the idea of a trilateral agreement could work. How to specify the agreement details is up to the collaboration partners. However, such an agreement should contain several elements in order for it to work. We highlight here the key agreement elements that needs specification, using the input from the interviews on topics mentioned to consider in such a collaboration. As such, this checklist could evolve in a kind of blueprint collaboration contract. Such a blueprint agreement may be instrumental to make the collaboration principles work in practice.

The blueprint agreement elements include the following steps and activities:

- The transporter informs the consignee when issues arise in the execution of the transport planning, which demand for flexibility in the transport planning.
- The transport operator and the consignee (and the freight forwarder) explore different alternative options, depending on the alternative planning options and the shipper/consignee’s needs and requirements. The most obvious options applied today is delivering the container the next day. When the consignee or shipper marks the container as high priority or simply wishes to receive the container and exceptional evening/night delivery may be an alternative option.
- In such a case the involved parties refer to the agreed blueprint agreement. The consignee has to organize his resources more flexible for unloading activities outside opening hours. The parties agree on the time window reliability and compensation arrangements of the additional costs for the consignee. Also, the standard tender agreement should incorporate the exceptional procedure and determine guidelines for the frequency of occurrence.

- The blueprint agreement also includes monitoring of the frequency of alternative requests and ration between requests and the different alternative delivery options. The collaboration includes also an evaluation of the collaboration based on these KPIs, in order to learn and optimize the collaboration.

Both the consignee and the transporter should negotiate a service level that is more flexible over a certain upper bound percentage of the total deliveries. These flexible services contain dynamic planning of deliveries by both the transporter as well as the consignee. When called for these flexible services a percentage of these alternative plans should be met. This is of course agreed upon during the tender offer, however the performance should be monitored and evaluated followed by a monetary settlement. In such a settlement the additional costs and benefits of both the consignee and the transporter should be taken into account. Both facilitate late night shifts which contain late night hours and over hours.

Idea is that the efficiency gained by transport companies when making use of incidental evening/night delivery offsets the marginal costs by consignees offering this incidental flexibility. In that case, the transport company compensates the consignee for the additional labor costs. The additional gain for the shipper is a more reliable delivery process with flattening peaks in dock execution, and possibly an additional discount on the total tender contract.

7 Conclusions and recommendations

This research was aimed at understanding the distribution patterns of road hauliers at container terminals and the applicability and potential of logistics concepts that would result is a higher share of evening/night distribution.

This research objective is highly relevant since many terminals reach their capacity limits in daily peak hours, resulting in waiting times and/or scarcity of available slots in these hours, whereas the evening and night hours are experienced by substantial underutilisation. Only a small shift of 5-10% to off-peak hours would relieve the port-hinterland system and reduce terminal waiting times.

Recent disruptive events, such as the Covid-19 crisis, port capacity drops, Suez Canal obstruction, scarcity of empty containers and booking slots, empty sailings and enormous price volatility in maritime container transport put pressure on the hinterland system and demands for efficient utilisation of the hinterland capacities to quickly recover from supply chain disruptions.

The limitations in opening hours of consignees are an important explanation for the limited use of night truck visits at the container terminals. And more flexibility in consignee opening hours does not come naturally, due to operating cost considerations, contractual arrangements, habits, incentives, and lack of mutual trust.

Nevertheless, chain collaboration agreements (with compensation schemes) aimed at offering incidental flexibility in opening hours offer a potential to overcome these obstacles. There seems to be momentum to explore this on a larger scale, as indicated by the interviewees. Targeted support tooling with standard example arrangements and compensation schemes for incidental opening hour flexibility can facilitate the adoption of more flexibility on request.

Alternatively, decoupling hub concepts could push the off-peak terminal use by trucking companies, whilst respecting the limitations in opening hours of consignees. Three type of hubs are already being used today or show potential.

First hub variant is the private hub of trucking companies themselves. If the trucking company has a location that allows for temporary storage or parking facilities, the investment costs are low and using this private hub is a serious consideration for a limited number of the hinterland transport assignments. However, it has serious implications on the operating model and the human resource strategy. If a company needs to invest in hardening is terrain, the business case is not feasible. In that case trucking companies can consider the use of a neutral decoupling hub facility.

Two typical neutral hub examples show potential: the swap hub and the reefer hub. The swap hub is used to replan a multi-terminal tour to the Maasvlakte (‘rondje Maasvlakte’) in case of serious terminal congestion. The hub is being used to swap export containers with future terminal closing times and compose a single terminal tour from the hub. The swapped export container needs to be delivered on a later moment to the congested terminal. On paper, this concept seems commercially sound occasionally in case of serious terminal congestion.

But there are quite some uncertainties in the dynamic planning concept using a swap hub, which may even result in higher costs after all. Digitisation and affordable real-time planning solutions support the implementation of this complex planning concept.

The other neutral hub concept is a reefer hub, which is being developed in Nieuw-Reijerwaard. The market dynamics in reefer container use and the perishable characteristics of the cargo make this a promising niche market for neutral hub use. The business case also sounds promising, so this decoupling concept shows potential for more off-peak terminal use.

In all concepts, the interviews reveal that a direct trip between terminal and consignee is the preferable way, and the concepts only show potential in typical situations. And even then, it demands dedication and a critical mass to apply such hub concepts successfully in the business operating model of the trucking companies.

Recommendations
The research has resulted in the following recommendations.

- Facilitate and stimulate targeted chain collaboration initiatives aimed at creating incidental flexibility in consignee opening hours. Such a targeted approach could be supported by dedicated tooling that supports the implementation of this measure.
- Develop tooling that supports the exploration of typical chain inefficiencies and the implementation of corresponding solutions. More specific, transform the opening hour flexibility agreement checklist into an example arrangement with compensation scheme and disseminate this tool among the community partners.
- Boost digitization and explore typical data sharing infrastructure applications that support dynamic planning of containerized road transport.
- Explore reefer hub feasibility in other Greenports then Nieuw-Reijerwaard.
- Explore in more detail the impact of restricted opening hours of empty depots.
- Assess and quantify the truck arrival shift potential, taking into account, all port and hinterland bottlenecks, monetarise the commercial stakeholder impacts and the societal (traffic, sustainability) impacts.
- Elaborate on these findings by performing an integrated analysis of both terminal and road congestion and hinterland optimization, combining both logistics and traffic data.

With these recommendations, the adoption of truck arrival shift policies can get a boost. The societal impacts could provide the basis for additional financial support measures, for instance in neutral decoupling hub infrastructures.

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9 Signature

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