Europese ervaringen met integrale planning van infrastructuur en ruimtelijke ordening voor goederenvervoer en logistiek

European experiences with integrated planning of infrastructure and spatial development for freight logistics

Robert Broesi - MUST - broesi@must.eu
Tertius Hanekamp - TEMAH - th@temah.nl
Jos Arts - Rijksuniversiteit Groningen - jos.arts@rug.nl

Bijdrage aan het Colloquium Vervoersplanologisch Speurwerk
23 en 24 november 2017, Gent

Samenvatting
De verwachte groei van het vrachtverkeer in Europa vraagt om een optimalisatie van multimodale transport ketens. Nationale infrastructuurbeheerders moeten van instrumenten worden voorzien om de keuzes op het vlak van multimodaliteit door de transport- en logistieksector te kunnen beïnvloeden. Dit kan eraan bijdragen dat nationale infrastructuurbeheerders de optimale werking van hun netwerken kunnen garanderen en zij toekomstige investeringen efficiënt kunnen inzetten. De traditionele focus van deze beheerders op infrastructuurplanning leidt meer en meer tot problemen bij het inspelen op maatschappelijke veranderingen en houdt bovendien geen rekening met de drijvende krachten in de transport- en logistieksector.

In het FLUXNET-onderzoek wordt een gereedschapskist ontwikkeld die is gebaseerd op een slimme combinatie van instrumenten voor ruimtelijke en infrastructuurplanning en die rekening houdt met aspecten als multimodaliteit, ketenoptimalisatie, innovatieve logistieke concepten en ruimtelijke omgeving. Het onderzoek is praktijkgebaseerd en -georiënteerd: een analyse van trends en *good practices* is gebruikt om te komen tot de constructie van de concept gereedschapskist. Deze wordt in meerdere regio's in Europa getest aan de hand van workshops, de zogenaamde *Test Beds*, waaraan experts op het gebied van logistiek, infrastructuur- en ruimtelijke planning deelnemen.

Dit paper gaat in op de voorlopige resultaten van het FLUXNET-onderzoek. Het geeft inzicht in de belangrijkste trends op het gebied van logistiek en transport, de opzet van de gereedschapskist en de toepassing ervan in twee Test Beds in Zweden en Nederland. Waarvan de voorlopige resultaten worden besproken. Geconcludeerd kan worden dat de trends in ruimte, logistiek en infrastructuur ertoe leiden dat deze steeds meer samenhangen, dat een integrale benadering hierbij belangrijk is en dat de ontwikkelde gereedschapskist kan helpen bij concrete planningsopgaven om te komen tot een meer integrale aanpak.

1. Introduction

The freight and logistics sector is strongly interwoven with the networks of the National Road Authorities. Road transport accounts for about 75% of goods transport on land today. Freight transport activity is projected to increase, with respect to 2005, by around 40% in 2030 and by little over 80% by 2050 [EEA, 2010]. To align the means of National Road Authorities (NRAs) for coping with the growing demand it is paramount to increase efficiency of freight transport. A part of the solution is the optimisation of multimodal transport chains, because the advantages of the different modes in different contexts can best be used [European Commission 2011]. To guarantee network performance and efficient investment strategies National Road Authorities will have to be empowered with tools to influence the modal choice by the freight and logistic sector. This implies that the NRAs' traditional focus on car infrastructure and small scope infrastructure planning will have to change. The need for a shift in approach is reinforced by several trends that will fundamentally challenge the way the NRAs' networks are being planned and operated. Some of the most important trends are (Fluxnet 2017): The rise of technology, social awareness, the era of the city, economic growth patterns, demanding consumers. In the next chapter these trends will be discussed more elaborately. These trends show a strong interlinkage between spatial demands, logistics and infrastructure. A shift towards an integrated planning approach for infrastructure and land use planning, considering the drivers of the freight and logistic sector, is needed.

In order to gain more insight the Conference of European Directors of Roads (CEDR) has initiated a study into these interlinkages. The objective of this FLUXNET research project is to provide insight in the tools for planning professionals – such as NRAs, regional planning bodies and municipalities – that help optimizing the multi-modal use of the infrastructure networks by the freight and logistic sector. The study will result in a 'toolbox' with good practices, lessons and relevant planning approaches. Special attention is being paid to the connection between land use and infrastructure planning. This will help to further explore the potential benefits of integrating multimodal transport networks, liveability and spatial planning.

The methodology used in this study consists of three phases. The first phase aims at constructing a preliminary toolbox. An *analysis of trends* in logistics and freight transport is conducted. In the second phase, a global *scan of approximately 25 good practice*s is carried out. An abstraction of the tools that can be derived from the good practises have resulted in the draft for the preliminary toolbox. The third phase consists of a *series of test beds* to identify new potential living labs and at the same time to have a first expert judgement on the preliminary toolbox. This phase has also been used for a first dissemination of the acquired knowledge. A series of four potential living labs have been investigated together with local / regional experts in the field of transport and land use issues. The result of this phase is a *sharpening of the toolbox*.

This paper presents the preliminary results of this FLUXNET study. The aim of the paper is to analyse the links between spatial demands, logistics and (multimodal) infrastructure and to explore smart combinations of land use and infrastructure planning, considering the driving forces in the freight and logistic sector, in order to enable NRAs to improve

multimodal use of their networks with respect to the freight and logistic sector. To this end the paper starts with a discussion of trends. Subsequently, it provides the preliminary results of the development and the application of the toolbox in two 'Test Beds' in Sweden and the Netherlands. Based on these insights, we will formulate some preliminary conclusions.

2. Trends in freight and logistics

A quick scan of study reports, strategic advisory notes and articles has been performed to identify trends in the field of freight and logistics, which are relevant for this research (Fluxnet, 2017). The quick scan focuses on business and social trends with a spatial impact and whose implications are relevant with respect to the scope of National Road Authorities (NRAs). Technological developments have been considered as drivers for trends. The aim of this quick scan is to provide a framework for analysis of the good practices, not to give a complete overview of all developments in the fields of freight and logistics, nor to capture the complexity of the business. Throughout the reports and articles used for this quick scan we have identified 5 main trends:

1) *The rise of technology:* Innovations in technology are changing how the world does business, and technology is dramatically changing how entities in the logistics industry function in nearly every aspect. These innovations range from increased efficiency of the transportation system to automated warehouse robots. Technology becomes an integral part of the shipping process. This will lead to an increased efficiency in the logistical system. It will also unleash opportunities for unconventional hybrid spatial solutions (for example an automated micro warehouse fitted in to a city's public space) [Daalhuisen, 2013; International Renewable Energy Agency, 2014].

Fig. 1: XXL warehouses are usually the result of growing e-commerce and can dramatically influence network performance

2) *Social awareness*: Both consumers and companies show a growing environmental and social awareness. Consumers increasingly prefer fair and sustainable products and delivery methods that have limited impact on the environment, through emissions and noise for instance. Furthermore, a growing demand for increasingly scarce resources (energy and materials) forces companies to manage these resources in a responsible way as costs are rising and environmental legislation is becoming stricter. For instance, fuel costs are driving supply chain decisions regarding suppliers, production locations, transportation, etc. [Linich, 2014; DHL Trend Research, 2016].

3) *The era of the city:* The urban population in 2014 accounted for 54% of the total global population, up from 34% in 1960, and continues to grow. It is estimated that by 2017, the urban population growth, a majority of the people will be living in urban areas, even in less developed countries [WHO, 2017]. This will imply denser urban areas with challenges on the environmental and spatial impact of logistics networks.

4) *Economic growth patterns:* As the world's population and economy continue to grow so do global trade volumes. This growth is enabled by ongoing containerisation of goods and shifting production to Asia and Eastern Europe. This growth will lead to a consolidation of flows of goods as well as upscaling of companies and gateways connected to the global freight transportation network. As vessels and aircrafts will become bigger (and carry more freight) these flows are likely to go through a limited number of large ports and airports that have the capacity to handle the increasing number of big (peak) loads efficiently [International Transport Forum, 2015]. The growing trade volumes and infrastructure required to handle these will inevitably lead to scarcity of raw materials and space as well as congestion [Higgins and Ferguson, 2011; Ploos van Amstel, 2012]. The trend of a sharing economy will mean less production and less global trade for large consumption goods. Containerisation and cargo handling is still growing but at slower rate. In the hinterland, economic and population growth will be increasingly centred in cities. This means we will see a concentration of incoming and outgoing flows through distribution centres at the edges of cities to supply consumers, shops, hospitality companies and offices with goods. Handling of freight in terminals will be smarter and the modal choice will be more dynamic. Some freight will travel to or from the hinterland fast, other freight can travel at a lower speed through inland terminals closer to regional markets [Daalhuisen, 2013; Verweij, 2011; Riessen et al., 2015; IDC Manufacturing Insights, 2014; DHL Trend Research, 2016].

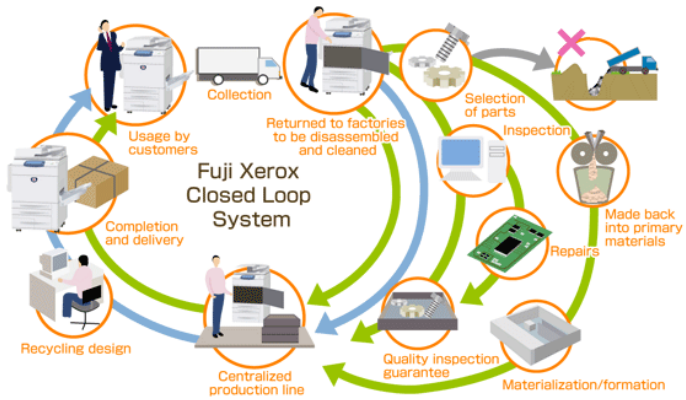

Fig. 2: Circular economy will change the logistic flows of the production process

The trend of circular economy will also increase the re-use of resources on regional scale. An important role for logistics to close the supply chain loop. Also, the trend of reshoring will have a bigger demand on logistics on regional scale. Changing consumer demands (more sustainable), rising costs abroad and the complexity of foreign production will accelerate local production by means of further robotization and digitalization. In short, logistical distribution systems will become more hybrid, adapting to the combination of global production and trade on the one hand and value added activities closer to regional markets (i.e. cities).

5) *Demanding consumers:* With the development of mobile technology consumers have 24/7 access to multiple distribution channels. This requires models that allow consumers to shop at anytime, anywhere and have their goods delivered or returned the same day, or even hour. With trust in online shopping growing, more types of products are ordered online such as groceries and pharmaceuticals. Apart from the need for a higher delivery speed and more flexibility when it comes to delivery (Just in Time), both in terms of place and time, there is an increasing need for product customization. This is enabled by developments such as additive manufacturing, automated warehouse operations and robotics. As products are being customized and delivered on-demand, supply chains are becoming more complex and required to be more flexible. Purchase orders are becoming smaller and more frequent [Hausmann, L., Herrmann, N.-A., Krause, J., Netzer, T., 2014].

These five mayor trends have an impact on how freight and logistics are being organized. They also influence spatial developments such as location decisions, the configuration of infrastructure and terminals and the different transportation networks. This implies that NRAs can improve network performance with a more inclusive approach.

3. Towards a toolbox for integrating land-use, logistics and infrastructure

In order to achieve an integrated approach towards logistics, land-use and infrastructure planning, the FLUXNET study explores the potential benefits of integrating multimodal transport networks, liveability and spatial planning. To do so, the approach is guided by the following ingredients:

- Logistics and freight transport is considered in relation to infrastructure- and spatial planning;
- Different geographical scales (corridor, region, local) are considered simultaneously;
- Different types of logistic and freight transport (long range, regional, urban) are being looked at;
- Persons and freight transport are considered in the same equation;
- Spatial design is used for integrating disciplines, facilitating discussions and creating a common base for a planning strategy.

To support the integrated approach that takes the above-mentioned ingredients into account, a toolbox is developed for NRAs and other planning authorities. The first step in the construction of the toolbox has been an analysis of 25 good practices. These practices show a broad range of intervention; from shared use of assets to the construction of new infrastructure. All the good practises help improving the multi modal use of different networks by the transport and logistic sector. The inventory of the good practises made clear, that there are no planning strategies or technical tools yet that envisions an integral approach for logistics, land-use and infrastructure planning. The good practices can be considered to be single measures that try to improve a spatial infrastructural system that is being used by the transport and logistic sector. Following this insight, a toolbox is developed that consists of two elements:

- a model to represent the spatial infrastructural system that is being used by the transport and logistic sector;
- a series of principles that aims at improving the multi modal use of this system by the transport and logistic sector.

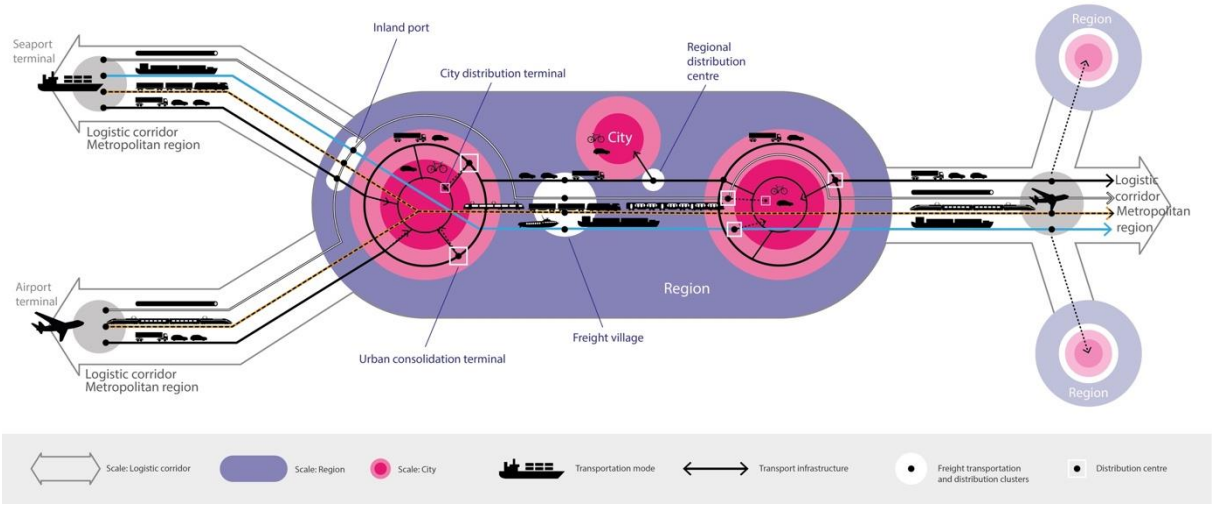

Fig. 3: the FLUXNET model showing different scales, modes, infrastructures and terminals

Figure 3 depicts the model developed in the FLUXNET study [Fluxnet, 2017], which shows a spatial infrastructural system that consists of transport infrastructure, terminals (nodes) and modes. It can be used in a planning discussion between infrastructure providers, planning authorities and actors from the transport and logistic sector to visualize the linkages between, scales, modes, infrastructure and terminals:

- *Spatial scales:* The model contains three spatial scales: the scale of the corridor, the region and the city. Thinking in these scales can be used to identify the function of the logistic services in the spatial arrangement of an urban region. [NUVIT, 2016]. The scales are not exclusive. A terminal can interact between scales (see below).

- *Infrastructure:* Freight flows involve movement along transport infrastructure between terminals. This transport infrastructure is required to enable the movement of vehicles transporting freight from one location to another. Each infrastructure facilitates a specific transport mode. Often, the same infrastructure is both being used for both the transport of goods and the transport of persons. This can lead to competing demands and thus conflicts for the same infrastructure. The following transport infrastructures for moving goods (and persons) have been distinguished: roads, railways, waterways, air routes and pipelines.

- *Terminals:* Terminals are the points (central and intermediate) where freight originates, terminates, or is handled in the transportation process. Spatially terminals have an impact on their environment in terms of the space they occupy, the traffic they generate, environmental hindrance and the role their location plays in changing production patterns. Functionally, these terminals perform specific economic functions (transfer, interchange, storage) and serve as clusters of specialised activities (for example assembly, warehousing, consolidation, etc). The following types of terminals

can be distinguished [Rodrigue et al., 2017]:

- Mainland terminals (seaports, airports): So-called 'mainports' such as seaports and airports are the largest terminals in the logistic system. They act as gateways from which raw materials, semi-finished products and goods are transported to and from the hinterland. In a gateway multiple transportation networks are cross-linked. Apart from transportation these locations often host a wide range of value added services and often function as commercial or industrial clusters.
- Freight transportation and distribution terminals ('freight villages'): Clusters of industrial, intermodal, distribution, and logistics infrastructure and supporting services dedicated to facilitating the flow of goods. These freight villages have good connections to mainports, urban and industrial areas.
- Inland ports*:* These are inland extensions of the mainports connected to the latter through frequent transportation infrastructures and services. Inland ports provide similar services as the mainport. They handle different types of freight (both containers and bulk) and offer "value added services" such as inspection and customs-services.
- Regional distribution centres: Here, the consolidation of large incoming our outgoing trade volumes takes place as well as transhipment between rail, road and barge. Some intermodal terminals perform a number of value-added services.

- *Modes:* A mode is the means by which a shipment is being moved from point A to point B. Each mode of transport has a fundamentally different technological solution, and some require a separate environment. Each mode has its own infrastructure, vehicles, and operations, and often has unique regulations. Each mode also has separate subsystems. A transport mode is seen as a combination of the following:
  - Transportation infrastructure: networks and terminals
  - Vehicles and containers: bike, tram, van, truck, ship, train, airplane, tube (container)
  - A stationary or mobile workforce
  - Propulsion system and power supply (traction)
  - Operations: driving, management, traffic signals, railway signalling, air traffic control, etc.

4. Principles for multimodal optimization

At present, the spatial infrastructural system for logistics contains defects resulting in negative conditions for multimodality. The approach used in the FLUXNET study aims at repairing these defects in order to improve and optimize the multimodal use of the spatial infrastructural system. This should support the shift of cargo transport over the road to other modes like water, train and pipelines.

As part of the study some 25 good practices have been identified with a broad range of effects on modalities. For example: a Belgian beer brewer managed to reduce the number of truck in the historic city by realizing a pipeline to the bottling plant. This implies the construction of new infrastructure (pipe) to create a modal shift from truck to pipe. All good practices were analyzed by their impact on the model depicted in Figure 3. The analysis focused on the impact of the measures on the different elements of the FLUXNET model: modes, infrastructures and terminals. Furthermore, a difference was being made if the measure was optimizing or adding an element to the spatial

infrastructural system. The analysis led to an abstraction of the main principles behind the good practices. The result is a (preliminary) *list of principles* that can be used in to optimize the multi-modal functioning of the spatial infrastructural system for transport and logistics:

- *Optimize a terminal* stands for improving the internal organisation of a terminal. Existing terminals are re-organised to better serve multiple modes.

- *Move or add a terminal* means that an existing or a new terminal is being (re-) located at a multi-modal location to improve the multi-modal connection to the infrastructural network. This can be implemented by regional spatial plans that determine the locations for transport and logistic terminals.

- *Optimize infrastructure* means that the use of existing traffic infrastructure (rail, water, road, pipeline) is being optimized by physical or organisational measures. This can be implemented by:
  - Synchromodal transport: for every transport order, the logistics service provider (e.g. a chain director) chooses the best possible transport mode, carefully balancing time, cost and service levels. On the same corridor, this can sometimes result in the use of road transport, in other situations rail transport or the use of inland barges;
  - Separating freight and person transport within existing infrastructure: Dedicated lanes are introduced for specific target groups, like cargo versus person transport or transit versus local transport;
  - Interchanging capacity between freight and person mobility: freight or person traffic is shifted to another modality after which the resulting spare capacity is used for freight of logistics;
  - Removing obstacles: adjusting the height of bridges, deepening waterways, etc.
  - Using off-peak hours' capacity of person rail: the regional person rail network is being used at night for the distribution of goods from regional centres into the city during off-peak hours. Cities with existing tram tracks can unburden the road network with cargo trams;
  - Using water networks for city cargo transport: the last transport leg between a regional distribution centre and retail shops can occur via waterways.

- *Add infrastructure* stands for realizing a new physical, sustainable transport infrastructure (waterway, railway, pipeline) that complements the existing infrastructure network to facilitate a modal shift. This can be implemented by:
  - Constructing new rail line infrastructure or waterways to increase the capacity of sustainable transport modes;
  - Introducing a subterranean tube system between cities. Tube logistics will decrease the amount of trucks on the road.

- *Optimize a mode* stands for optimizing the use of an existing vehicle on existing infrastructure with the aim to create an alternative for conventional truck transport on the local / regional / corridor road network. This can be implemented by combining passenger and freight in a single vehicle. Non-logistics vehicles (e.g., public transport) are being used for logistics purposes.

- *Add a mode* stands for adding a new vehicle type to existing infrastructure with the aim to create an alternative for conventional truck transport on the local / regional / corridor road network. This can be implemented by developing new types of transport vehicles like the High Speed Cargo Train or cargo bikes. New types of vehicles can increase the efficiency of cargo transport and result in competitive modes for regular truck transport.

	Local level	Regional level	Corridor level
optimize **a Mode**			
add **a Mode**			
optimize **Infrastructure**			
add **Infrastructure**			
optimize **a Terminal**			
add /move **a Terminal**			

Fig. 4: Principles for multimodal optimisation at different spatial scales.

The principles can be categorized according to the scheme above (Fig. 4). Often, a principle cannot be restricted to one field only. For instance: add a mode – regional level has connections to different fields.

5. The Toolbox applied: preliminary result of two Test Beds cases

As part of the FLUXNET study four Test Bed sessions have been carried out. A main element of the Test Beds is a workshop with stakeholders from infrastructure planning, spatial planning and the logistics sector. The goal of the regional Test Beds is threefold. The main goal is to test the preliminary toolbox. The combination of tools from the preliminary toolbox are discussed with local / regional experts, in the field of freight transport and logistics, spatial planning and experts from an academic institute. Secondly, the Test Beds serve to identify the specific challenges in connecting land use planning on the one hand and logistic and freight issues on the other hand are being identified for specific areas within the Ten-T corridors. Finally, the Test Beds are a first step in knowledge dissemination. The presentation of the toolbox and the discussion about its relevance is a first step in the dissemination of the knowledge developed in the framework of this research project. In the following, we will describe the outcome of the Test Beds in Norrköping (Sweden) and the region Rotterdam (The Netherlands).

Test Bed Norrköping

Norrköping is a town 150 km south of Stockholm. As spin-off effect of Stockholm's growth, it is transforming rapidly with the connection to a high-speed rail, a new station, the transformation of the inner-city harbour into a residential area, etc. The transformation is combined with the ambition for a sustainable and healthy transport system in which pedestrians, biking and public transport are feeding this transformation. Norrköping is concentrating the harbour activities on the 'Harbour Island'. For facilitating the harbour development, a new connection to the highway corridor is proposed. This will result in a new urban 'ring' structure that will serve the harbour and the urban car traffic. The current development of the region focuses on the following strategy (Fluxnet test bed 2017:

- Increased connectivity of the labour markets: the high-speed line will improve the connectivity of the labour markets related to the line;
- Urban densification: the city is facing a demand for housing which is fulfilled by means of transforming inner city industrial sites;
- Transit Oriented Development: the city is formulating an urban mobility strategy that will feed the development and usage of the new station and rail line;
- Urban quality: the city has the ambition to realize a very high standard of urban quality to compete with other labour markets;
- Moving industry: The city is moving heavy industry development onto the harbour island in order to be able to develop the urban areas with a high quality environmental quality.

An application of the toolbox ingredients on the Norrköping region served as a kick-off for the discussion. The discussion lead to conclusions and recommendations, which are summarized here.

Awareness: Due to several global trends and issues, logistics and freight traffic will be a crucial topic to address in spatial and infrastructural development strategies. Logistics deserves a more prominent role in the discussions.

A cohesive approach for logistics and spatial development should be articulated. In the current strategy of the Norrköping region, a cohesive vision on logistics should be added. Most ingredients are already present however not articulated it in a cohesive manner. This strategy may include the following ingredients regarding different scales (analogous to Figure 4).

Corridor scale: the region applies a very sophisticated strategy in which the new high-speed line (HSL) creates extra capacity on the existing rail network for cargo transport. This improves the modal shift for the harbour terminal. Furthermore, the use of off-shore shipping lines van be optimized. Regarding the Toolbox ingredients: add infrastructure by the construction of the HSL line and optimize the use of infrastructure by interchanging capacity between person- and rail infrastructure.

Regional scale: the Harbour Island will be developed as a multi modal collection of nodes. Some are related to the harbor, some to regional warehouses. Toolbox ingredients: optimize a terminal (by adding facilities and infrastructure) and optimize the use of infrastructure by improving synchromodal transport

Local scale: the strategy based on an urban densification transformation model should include an extra chapter about logistics. This could contain the following toolbox ingredients:

- Reduce the number of logistical movements in the current and new city by integrating pick-up and delivery points;
- Use as many sustainable transport modes as possible for logistical movements. Create a model shift by combining passenger and freight mobility (tram), new vehicles (e-vehicle, cargo bike), re-use of infrastructure (water).

Fig. 5 Logistic system Norrköping on corridor level. In Norrköping, a new HSL line will improve the connection for person transport and at the same time create more capacity for freight transport on the existing rail infrastructure. Together with an improvement of off-shore shipping lines, the multimodal use of the networks on corridor level is being improved.

Scale interference: the ring road services all three scales. On the corridor level, it connects to two highways and to the harbour. On the regional / local level it relieves the city from passing vehicle traffic. However, it can also become a very attractive alternative for the model shift, which is proposed. This implies the realization of the ring road should consist of a package deal transforming the urban mobility that makes it less attractive to serve and increasing car traffic from the urban area. It should be avoided that the alignment of the ring road blocks future expansion and transformation of the harbour into urban areas. Toolbox ingredients: add infrastructure by adding a ring road.

Regarding the Test Bed Norrköping the participants in the workshop concluded the strategy mentioned above should be included in a common vision on spatial development and mobility. The intention was formulated to include the importance of logistics and a common strategy in the Sustainable Urban Mobility Plan (SUMP) that the city of Norrköping is currently producing.

Test bed Rotterdam

Rotterdam has one of the most modern harbour terminals of the world. Many of the logistical handling becomes fully automated. In combination with an increasing importance of safety and customs regulation the harbour will become more and more isolated from the city. On the other hand, a trend in which industrial production is returning to the region can be identified. This can be addressed to the development of technology/robotisation and implies a strong link between highly skilled (urban)

employments. Due to this trend a logistical mega hub and urban development are closely interlinked. Central questions for the session were: What does this new emerging relation (isolation & integration) imply for the development of the Harbour and the development of the City? What are the implications for the multimodal network (corridor). Where will the different scales interfere? What ingredients from the Toolbox could support this?

On the *corridor scale* major investments are planned and already have been made in the highway network: the A15 has been expanded, the A4 has been linked and the new A22 tunnel and A16 highway are being procured. Forecasts show no major bottlenecks on the highway network due to these investments. However, it should be said this investment strategy is built upon the current competitive advantage of the harbour. If we consider the future competitiveness of the harbour, the relation with the city and the urban labour market will become an important asset. This is not explicitly considered in the current strategy. In the discussion locations in which corridor connectivity, production capacity, urban quality and a highly skilled labour market intersect, can be crucial for adapting to a new competitive advantage. Locations with a high potential in this category are Stadshavens, the Greenery and the Merwe-Vierhavens.

Regional scale: An important conclusion of the workshop is that many of the large impact trend will have a (network) logic on a regional scale. Trends such as the boost of E-commerce can lead to XXL warehouses serving urban agglomerations. The location and position of these large warehouses can firmly influence the network performance (capacity, robustness). Currently this development is not being coordinated. Due to the well-functioning highway network with sufficient spare capacity, there might be little incentives for issues such as multimodality, sustainable land use, end-user proximity, network robustness (multimodal). This can result in a development boom in unimodal locations such as the Zuidplaspolder and Moordrecht instead of multi-modal locations such as Spaansepolder with has a lot more proximity and sustainability potential.

The *local scale* is currently flooded with new logistical concepts: pickup points, e-bikes, e-vehicles, etc, however in the city's mobility strategy logistics and urban distribution are not considered. We see the same signal in the SUMP the Swedish city of Norrköping is preparing. Logistic and freight transport are becoming more and more challenging, however there is still relative little interest and awareness on a policy and strategy level. The group concluded these issues deserve a prominent place and must be considered to facilitate the quality of the urban development and to guarantee the performance of the mobility network.

Scale synergies: Regarding scale synergies and challenges concluded locations that show potential synergy between scales, modalities and spatial development are interesting challenges to address to have a new perspective on the issues. The 'Brainpark' location for example is strategically located on the Ten-T corridor, it has the potential to use several modes and is an interesting location to build a new distribution logistics hub.

Planning vehicles: Another instrument discussed in the workshop is the 'Ladder Sustainable Spatial Development' (SVIR, 2012). This instrument can be expanded with terminals. It could be altered in such a way it could guide a sustainable development such as XXL warehouses.

Social isolation: An important issue that could be highlighted in the trend more explicitly, is the social downside of the trends mentioned in the FLUXNET study. For example, developments such as re-sourcing do not lead to new jobs for low-skilled workers. This implies a major social challenge for the Rotterdam Region.

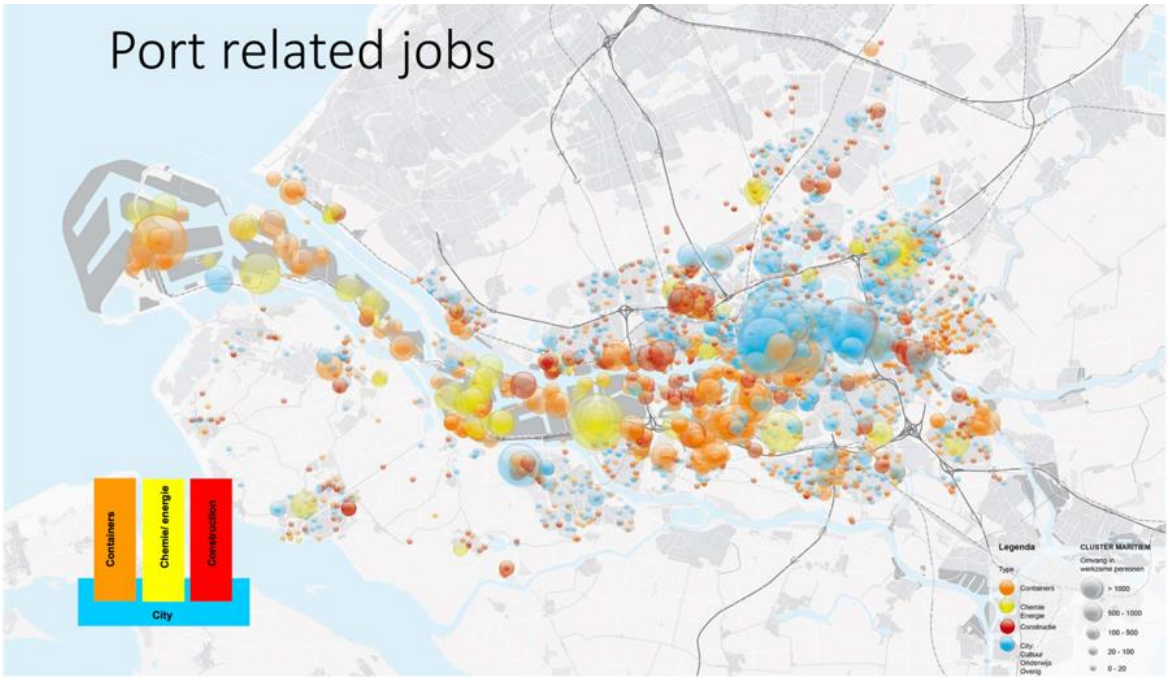

Fig. 6 The Rotterdam region shows an increase of port related jobs in the city and a decrease of jobs in the harbour. This confirms a changing relation between the hub and the urban region.

6. Conclusion and recommendations

The analysis of trends indicates the growing importance of interlinkages between land-use, logistics and infrastructure (section 2) and the need for an integrated approach (section3). The research and test beds show the relevance of the FLUXNET approach, in which logistic is considered in a model that covers infrastructure, modalities, and spatial development. The discussion of the test beds (section 5) show that it is a valuable instrument for planner to improve grip on logistic related planning issues. It provides a broad starting point for a planning discussion. When the model is applied to a specific geographical region, the principles (section 4) are valuable in finding opportunities for improving spatial and network performance (mobility, living quality, environmental quality, etc.). On basis of the preliminary results of the test beds some recommendations for further exploration can be given.

Logistics should become part of an integrated planning approach

Both Test Bed applications show logistics is an important topic and will most likely become even more important in the (near future). Currently we observe the approach towards logistics is fragmented across geographical scales. NRAs have a strong focus on the corridor level and the current positioning and functioning of the (main) terminals. On the local level we can observe municipalities innovating on environmental friendly solutions on a large scale. On the regional scale, we foresee the possibility of a major

transition due to circular economies and the rise of XXL warehouses. However, on basis of our testbeds we see little awareness among planning authorities to guide these developments in an efficient manner. We can conclude there is a need for a cohesive planning approach that explicitly addresses logistics in balances strategy of spatial and infrastructure planning across corridor, regional and local scale. NRAs across Europe could make a significant contribution to this.

New strategies are needed
In order to deal with this challenge, planning authorities (such as NRAs) need to be empowered with a planning strategy that incorporates the impact of logistics into a spatial and infrastructure planning approach. We see examples in the field of person traffic such as 'Transit Oriented Development' (TOD) and for spatial Development such as the 'Ladder Sustainable Development', however none of these strategies explicitly deal with the challenges logistics require from planning authorities. In the next stage of the FLUXNET study we will analyse the lessons from the research and Test Beds and structure them into a strategy that can guide planning authorities.

New spatial typologies should be investigated
Currently, typologies used in the field of logistics are approached from a functional point of view in the logistics system. An example is the way terminals are structured. An integrated planning approach will feed the need for new and more integrated (spatial) typologies. In the research we encountered a series of typologies in which a combination of spatial, mobility and logistical challenges are represented in such a way that it represents trends occurring across Europe. The first two Test Beds already raise the issue of the 'Megahub in a competitive region (For example Port of Rotterdam in relation to the urban labour market)', the 'Big boxes (XXL warehouses and their spatial and mobility network effects)' and the 'Smart corridor-city hubs' (the location with scale synergies).

Overall it can be concluded that these typologies should be investigated further. Therefore, we will address these emerging typologies more elaborate in the next phase of the FLUXNET study.

Acknowledgements
The FLUXNET research was commissioned by the Conference of European Directors of Roads (CEDR). A group of four front running countries directed the research: Germany, The Netherlands, Norway and Sweden. Next to CEDR, the authors also want to thank the cities of Norrköping, Rotterdam and the Review board for their cooperation in the FLUXNET research.

References
- Arts, J., T. Hanekamp & A. Dijkstra (2014), "Integrating land-use and transport infrastructure planning: towards adaptive and sustainable transport infrastructure", paper 5th Transport Research Arena Conference (TRA, 14-17 April 2014 Paris), Proceedings TRA 2014 Conference (#17927), IFSTTAR, Paris, 10pp.
- Daalhuisen, G. (2013), Warehousing in 2020: trends in de sector. Logistiek.

- DHL Trend Research (2015), Omni-channel logistics: A DHL perspective on implications and use cases for the logistics industry. DHL Customer Solutions & Innovation.
- DHL Trend Research (2016), Logistics trend radar, Troisdorf, Germany.
- EEA (2010), Towards a resource-efficient transport system TERM 2009: indicators tracking transport and environment in the European Union, EEA Report No 2/2010.
- European Commission (2011), WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, Brussels.
- CEDR (2017), FLUXNET - multimodality integrated with land use, freight and logistics, Part 1: Trends and Good Practices
- Hausmann, L., Herrmann, N.-A., Krause, J. & Netzer, T. (2014), Same-day delivery: The next evolutionary step in parcel logistics. McKinsey & Company.
- Higgins, C. & Ferguson, M. (2011), An exploration of the freight village concept and its applicability to Ontario. McMaster Institute for Transportation and Logistics.
- Higgins, C., Ferguson, M. & Kanaroglou, P. (2012), Varieties of Logistics Centers. Transportation Research Record: Journal of the Transportation Research Board 2288, 9–18.
- IDC Manufacturing Insights (2014a), UPS-enquête over wijzigingen in de (toeleverings)keten.
- IDC Manufacturing Insights (2014b), UPS - The Fifth Annual Change in the (Supply) Chain Survey,
- International Renewable Energy Agency (2014), Power Generation [WWW Document]. URL http://costing.irena.org/technology-costs/power-generation.aspx (accessed 02.09.2017)
- International Transport Forum (2015), The Impact of Mega-Ships. OECD, Paris.
- Linich, D. (2014), The path to supply chain transparency.
- NUVIT (2015) - Networking for Urban Vitality, practical cases and innovation agenda, Rijkswaterstaat, November 2015.
- Riessen, B. van, Negenborn, R.R., Dekker, R. (2015) Synchromodal Container Transportation: An Overview of Current Topics and Research Opportunities, in: Corman, F., Voß, S., Negenborn, R.R. (Eds.).
- Rodrigue, J.-P., Comtois, C., Slack, B. (2017). The geography of transport systems, Edition 4. ed. Routledge, New York.
- SVIR (2012), Structuurvisie infrastructuur en Ruimte. Ministerie IenM.
- Verweij, K. (2011). Synchromodaal transport: efficient en duurzaam via netwerkregie
- WHO (2017), http://www.who.int.