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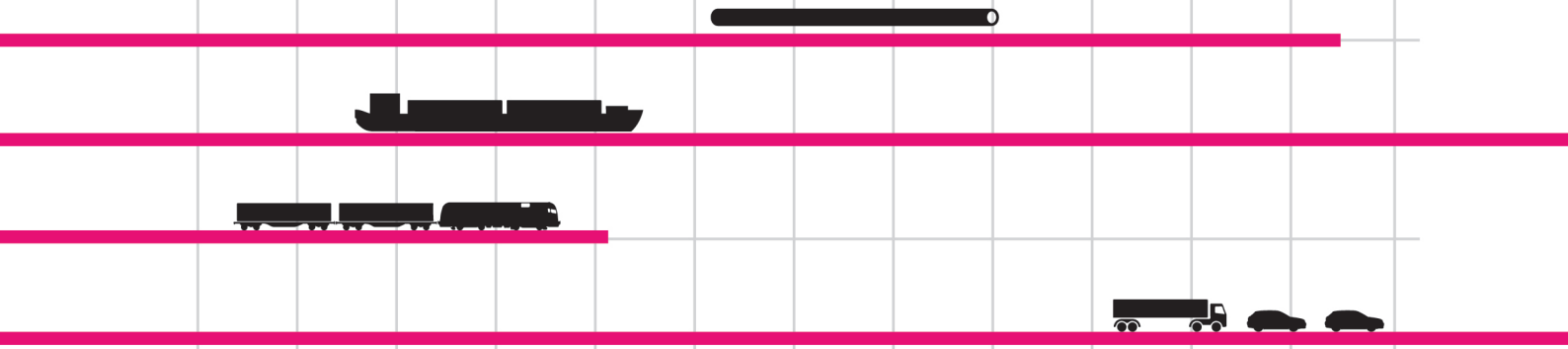
FLUXNET



concept toolbox for

Logistics Oriented Development

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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) to cope 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 (EC, 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, 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 National Road Authorities networks are being planned and operated. Some of the most important are:

+ Competing functions: freight and person transport are both increasing and often competing for the same infrastructure in urban areas;
+ Growing cities: many metropolitan areas face a firm growth, resulting in a concentration of logistics in urban areas;
+ Technical developments: due to E-commerce, there is an increasing trend in home delivery. Robotization will lead to "re-sourcing" of production in Europe and a new relation between "logistical nodes" and urban areas;
+ Stricter environmental requirements: the growing importance of sustainability, health and living quality put a strain on infrastructure.

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 insights the Conference of European Directors of Roads (CEDR) has initiated a study into these interlinkages: FLUXNET - Freight and Logistics Using eXtended Network Empowerment Tools. The objective of the FLUXNET research project is to provide insight in the tools for planning professionals – such

fig 1. Concentration of different infrastructures in the A15 Zone, Rotterdam

fig 2. Milano, example of a growing city

as NRAs, regional planning bodies and municipalities – that help optimizing the multi-modal use of the infrastructure networks by the transport and logistic sector. Special attention has been 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 the research 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 practices is carried out. Abstractions of the tools and strategies that can be derived from the good practices have resulted in the draft for the preliminary toolbox. The third phase consists of a series of four test beds across Europe to have a first expert judgment on the preliminary toolbox. Together with local and regional experts, issues in the field of logistics, transport and land use have been investigated by applying the preliminary toolbox. The result of this phase is a sharpening of the toolbox.

This report presents the results of the FLUXNET study and is dived into four parts.

1. Part 1 – Context describes briefly the importance of the transport and logistics sector for the functioning of urban regions as well as the relevance for the National Road Authorities. To get a better understanding of this sector, the results of a quick scan of trends that will influence the transport and logistics sector and the current spatial order of urban regions are being described. They will challenge the way the National Road Authorities networks are being planned and operated.

2. Part 2 – Toolbox contains the main part of this report and describes the concept toolbox. This toolbox consists of three elements. The first element is a model to represent the spatial infrastructural system that is being used by the transport and logistic sector. Applying this model on a specific region helps to get a better understanding on the transport and logistic system in relation to the spatial order of a specific region. The second element of the toolbox is a series of principals that help improving the multi modal use of the infrastructure networks by the transport and logistics sector. In each region, depending on its specific characteristics and challenges, a custom made selection of principals can be made. The third element of the toolbox is a proposal for the process architecture. Based on the experiences in the four test beds, an outline for a series of activities is being proposed in order to develop an integral strategy for logistic oriented development with all relevant actors involved.

3. Part 3 - Applying the Toolbox reports on the four Test Beds in Europe. The Test Bed in Cologne is described more extensively and is an example of how the different elements of the Toolbox were applied. For the Test Beds in Rotterdam, Norrköping and Milano just the conclusions are being presented.

4. Part 4 – Conclusions & Recommendations sums up four actions for National Road Authorities as a follow up, based on the experiences of the FLUXNET research.

1. Context

01. THE IMPORTANCE OF LOGISTICS FOR URBAN REGIONS

Literature shows a sufficient logistical system is an important factor in the competitiveness of Urban regions. An accurate and effective planning of logistics activities is an important way to get both cost and efficiency advantages for countries (Rodrigue, 2012). Logistics has currently become essential element of trade by taking an active role in this development. In the competitiveness of regions and its companies is found in an optimal balance between the efficiency the logistical structure offers, the availability of the suit labor market an accessible by sufficient modalities, and the availability of the competitive advantages such as image or innovation (Hanekamp, 2016). This implies companies make an integrated assessment between labor market (persons mobility), production efficiency (logistics) and spatial contextual factors for innovation and image. This supports the idea that an integrated approach towards multi-modal networks, logistics and spatial planning will facilitate societal challenges in a more efficient manner than sectoral approaches do.

02. TRENDS

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 report Part 1: Trends and good practises, CEDR 2017; FALCON report Freight And Logistics in a Multimodal Context - WP 1: Handbook: Understanding what influences modal choice, CEDR 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).

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).

fig 3. Urbanized areas in Europe by night

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 ongo-

ing 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

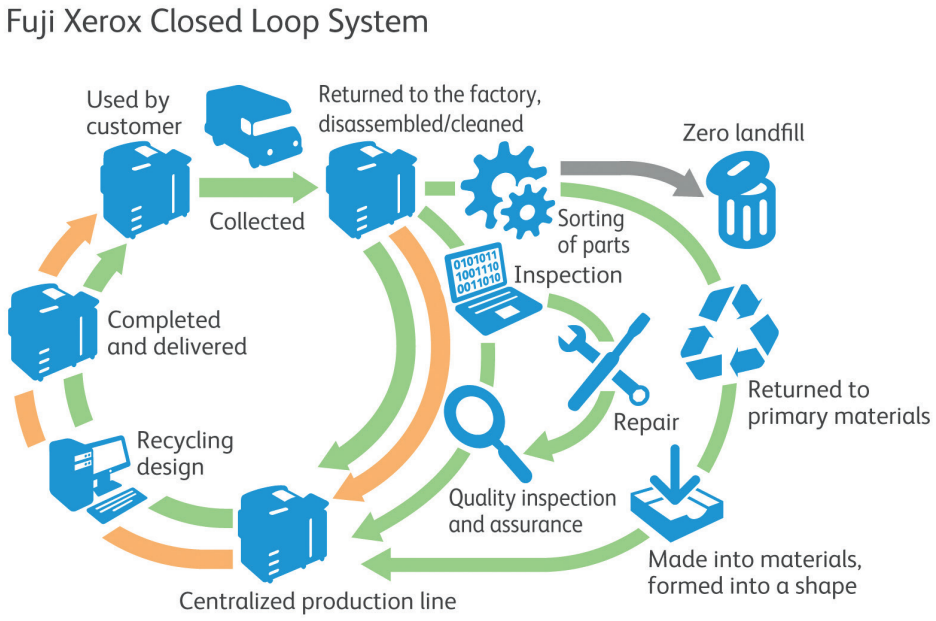


fig 4. Scheme of technological innovations and the effect on a logistics chain, example FujiXEROX

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). 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. If we take into account the implications of these trend for the nitration between logistics, spatial planning and mobility networks we can identify the following major implications:

IMPLICATIONS FOR LOGISTICS

+ Consumers and other downstream stakeholders are increasingly demanding fair and responsible products. Additionally, supply chains are more and more dispersed, increasing levels of risk for multinational businesses. Transparency is expected to grow, to gain visibility into the supply chain as well as to manage risks. (Linich, 2014; DHL Trend Research, 2016)

+ A global commitment to restrict greenhouse gas emissions and halt climate change is leading to stricter environmental regulations. Furthermore renewable energy is increasingly competitive with fossil fuels. This gives rise to a transition towards clean transport technologies for all modes. (Daalhuisen, 2013; International Renewable Energy Agency, 2014)

+ Shippers are under pressure to increase the efficiency of transportation (as freight volumes and transportation costs grow) and to minimise the environmental impact. This increases the demand for synchromodality as (real-time) planning for optimal, flexible and sustainable deployment of transportation modes. (Verweij, 2011; Riessen et al., 2015)

+ To be more cost effective, reach sustainability objectives and deal with a declining availability of staff collaboration between sectors and the flexible use of existing capacities in other networks is promoted. Likewise, freight

fig 5. Economy of scale: example of increasing vessel size

fig 6. Inland terminal Gallarate, Lombardy

consolidation, reduction of empty loads, and dealing with fluctuating demand are likely to be achieved by more sharing of assets such as warehouses, packing facilities, trucks, etc. (Ploos van Amstel, 2012; Morana et al., 2014; DHL Trend Research, 2016)

+ The search of economies of scale by shipping companies has been driving an increasing vessel size. As a result ports have been forced to increase their load handling capacity, enabled by technological developments such as robotisation and automation, and to invest heavily in their accessibility to remain competitive. Only a limited number of ports is able to handle the largest vessels operational. Currently however, the question is if a further increase in size would not result in disproportionally higher port and port hinterlands costs. (International Transport Forum, 2015)

+ With a growing movement of freight, the number of freight-related clusters as enablers of synergy, efficiency, improved economies of scale and sharing is expected to grow as well. (Higgins and Ferguson, 2011; Ploos van Amstel, 2012)

+ After a phase of developing maritime networks and sea ports, transport development is now gradually shifting inland. Inland terminals will become increasingly important in the integration of supply chains and handling increased volumes from gateways. As containers are pushed to the hinterland quickly (deploying extended gate solutions), value added activities move down the stream to the hinterland too. (Capgemini Consulting, 2009; Notteboom and Rodrigue, 2009; Zuidwijk and Veenstra, 2015)

+ Supply chains are becoming increasingly complex and dynamic with sourcing locations being changed increasingly quickly and purchase orders becoming smaller and more frequent. Driven by the demand for custom-

ised products and fast delivery manufacturing is brought closer to regional markets and the end-consumer. (IDC Manufacturing Insights, 2014; DHL Trend Research, 2016)

+ Rising consumer expectations trigger new last-mile options and urban logistics solutions as well as night-time and even same-day delivery. (Hausmann et al., 2014; DHL Trend Research, 2016)

+ Offline and online commerce have been converging and end-consumers now expect a seamless omni-channel experience, including the physical store, online, mobile, and social media. New logistics structures might include warehouses used as showrooms or for customer-facing activities and as pick-up locations. (DHL Trend Research, 2015)

SPATIAL IMPLICATIONS

+ Driven by the complexity of modern freight distribution, the increased focus on intermodal and co-modal transport solutions and capacity issues (both in terms of space as well as freight handling capacity), the development of inland terminals is expected to continue. An ongoing clustering of logistic activities can be expected near gateways, around inland rail terminals and along major highway corridors. (Notteboom and Rodrigue, 2009)

+ Labour market shortages are becoming an increasing problem as the economy and the logistic sector grow and the workforce ages. Furthermore technological developments like robotisation and automation increase the demand for highly skilled workers. The availability of labour is an import factor in the location choice of logistic companies. (European Monitoring Centre on Change, 2008; DHL Trend Research, 2016)

+ The spatial concentration of economic activity in cities, the growth of convenience logistics and on-demand delivery, pose challenges for urban logistics. Deliveries as well as returns generate an increasing amount of traffic, increasing the pressure on urban ring roads and roads into the city. As a result, urban logistics has a growing impact on environmental quality (air, noise, physical barriers) and accessibility (congestion) in cities. (Schöder et al., 2016)

fig 7. Pressure on urban ring roads, example Paris

+ An underground urban freight system would reduce the land demand for road freight lanes and related infrastructures such as parking spaces. The growing congestion in cities and pressure on available space contribute to renewed interest for this type of infrastructure as alternatives for road transportation. Furthermore these systems can operate during the night without impacting noise and air pollution.

+ Similarly, warehousing is undergoing changes with a spatial impact. Warehouses require increasing flexibility in size, services, and location. Rather than large scale central distribution centres, smaller, local distribution centres are emerging, closer to the consumer. Furthermore, warehouses are serving multiple channels more and more. Some warehouse locations might become customer destinations as showrooms or pick-up locations. (Daalhuisen, 2013; DHL Trend Research, 2016)

IMPLICATIONS FOR NETWORKS

+ New types of vehicles, such as autonomous vehicles and e-mobility vehicles are currently being developed. These may increase road capacity, and reduce accidents, costs of new infrastructure (narrower lanes, less congestion), the need for parking and air pollution. On the other hand these vehicles require new infrastructure such as loading facilities and, as a result of increased convenience and the possibility to drive without passengers, may increase actual vehicle travel. (Litman, 2017)

+ Increased last-mile delivery in cities has several impacts on the urban transportation networks. Night-time deliveries are becoming more common; the existing road capacity will be used on a 24/7 basis more often. Other networks such as urban logistics via water, tram and light rail, may become alternatives to road transport. For these modes to function successfully, a good integration of the underlying transportation infrastructure through terminals will be crucial.

+ New delivery concepts which are being explored in the context of last-mile challenges and congestion include personal parcel lockers, delivery to car trunks, and crowd-based delivery. These flexible solutions have the potential to increase the efficiency of delivery trips.

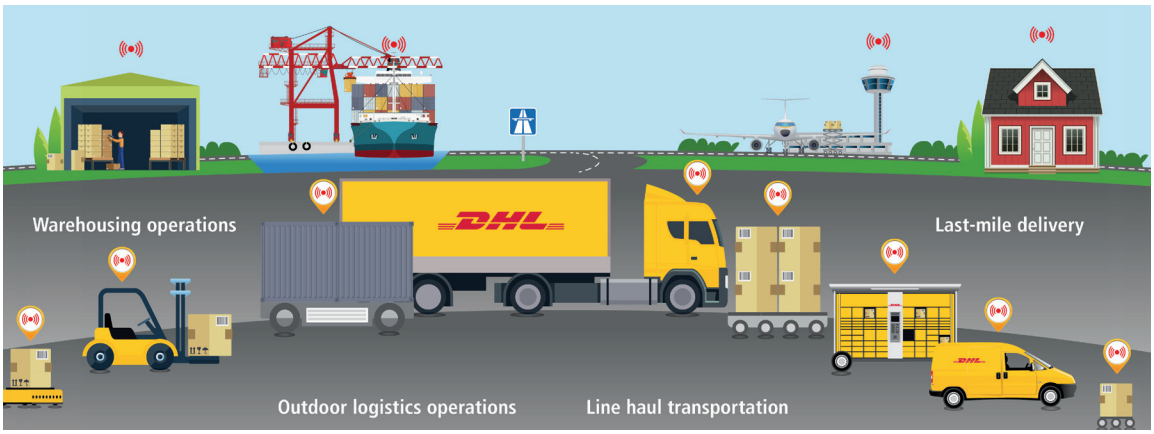


fig 8. Potentials for self driving vehicles in different segments of the DHL logistics chain

+ Also, the pressure on roads will continue to increase as freight volumes grow. Collaboration of logistics providers can improve the efficiency of freight transportation. Some of this pressure might be released by consolidating freight and thereby reducing the number of trips while reducing the number of empty vehicle kilometers.

+ In a logistic system were stock is minimized and brought closer to the consumer, predictability of travel times become increasingly important for logistics providers. For this reliable (real time) information regarding the capacity and condition of the networks is key.

+ In the context of growing freight volumes, it will be increasingly important to provide sufficient spare capacity in transportation networks as well as diversion routes.

+ Current origin-destination patterns will change when warehouses become customer destinations and pick-up points are located more strategically in relation to consumer's daily movement patterns.

These implications indicate a growing importance of interlinkages between land-use, logistics and infrastructure and the need for an integrated approach the dimensions of logistics, land use planning and spatial planning. In the next chapter, a framework for this approach will be discussed.

2. Toolbox

01. LOGISTICS ORIENTED DEVELOPMENT (LOD)

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. We call this Logistics Oriented Development (LOD). At present, the spatial infrastructural system for logistics contains defects resulting in negative conditions for multi modality. LOD aims at repairing these defects in order to improve and optimize the multi modal use of the spatial infrastructural system by the transport and logistic sector. To do so, the following ingredients guide the approach:

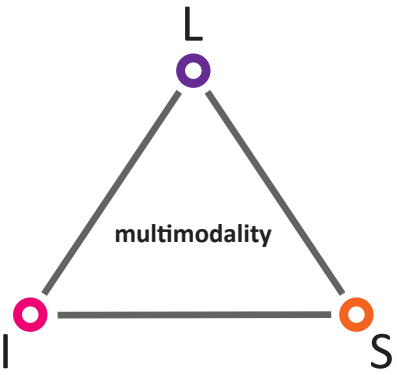


fig 9. The basis of the FLUXNET Toolbox: multimodality can be influenced by considering Logistics (L), Infrastructure planning (I) and Spatial planning (S) in an integral perspective

- 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 to support the common development of a strategy for multimodality by NRAs and other planning authorities. The toolbox consists of three elements.

fig 10. Freight Distribution Centre,Bayernhafen, Nürberg

The first element is a model to represent the spatial infrastructural system that is being used by the transport and logistic sector. Applying this model on a specific region helps to get a better understanding on the transport and logistic system in relation to the spatial order of a specific region.

The second element of the toolbox is a series of principals that aims at improving the multi modal use of the infrastructure networks by the transport and logistics sector. In each region, depending on its specific characteristics and challenges, a custom made selection of principals can be made.

The third element of the toolbox is a proposal for the process architecture. Based on the experiences in the four test beds, an outline for a series of activities is being proposed in order to develop an integral strategy for logistic oriented development with all relevant actors involved.

02. THE FLUXNET SPATIAL-INFRASTRUCTURAL MODEL

The model developed in the FLUXNET research 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.

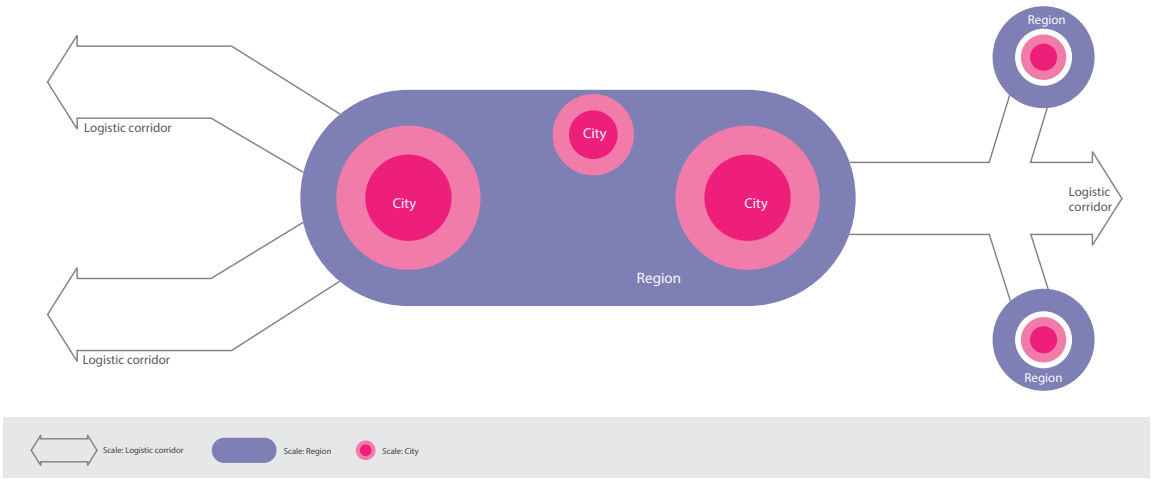


fig 11. The FLUXNET model contains three spatial scales: the scale of the corridor, the region and the city.

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, 2015). The scales are not exclusive. A terminal for example can interact between scales.

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 mode. Often, the same infrastructure is both being used for 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) can be distinguished:

+ Roads
+ Railways
+ Waterways
+ Pipelines
+ Airways

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 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.

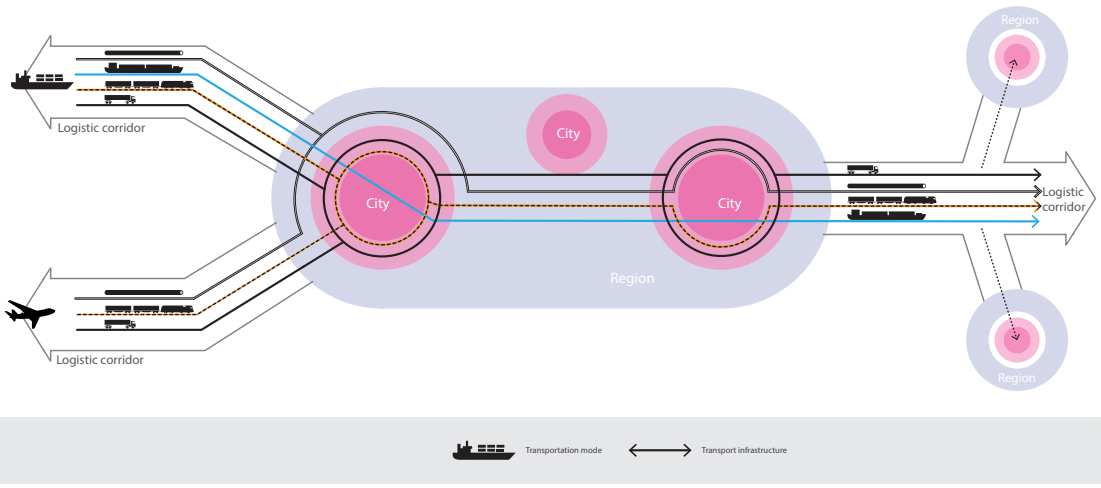


fig 12. The FLUXNET model shows the different modes and infrastructures used by the logistic sector

fig 13. Duisburger Hafen: example of a Terminal Entity

TERMINAL ENTITIES

In current literature, the definition of a terminal is determined by a logistic, technical point of view. Terminals are defined as the points (central and intermediate) where freight originates, terminates, or is handled in the transportation process. (see also FALCON report Freight And Logistics in a Multimodal Context - WP 1: Handbook: Understanding what influences modal choice, CEDR 2017) In this definition, a terminal consists of a loading facility and a quay (water), track (rail) or platform (road). These technical facilities are usually part of a broader spatial complex, like industrial areas or freight villages or distribution centers. From a spatial point of view therefor prefer to use the term Terminal Entities. Spatially Terminals Entities have an impact on their environment in terms of the space they occupy, the traffic they generate 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. The following types of terminals can be distinguished:

Mainland terminals

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)

A cluster 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

Inland extensions of the mainports connected to the latter through frequent transportation 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.

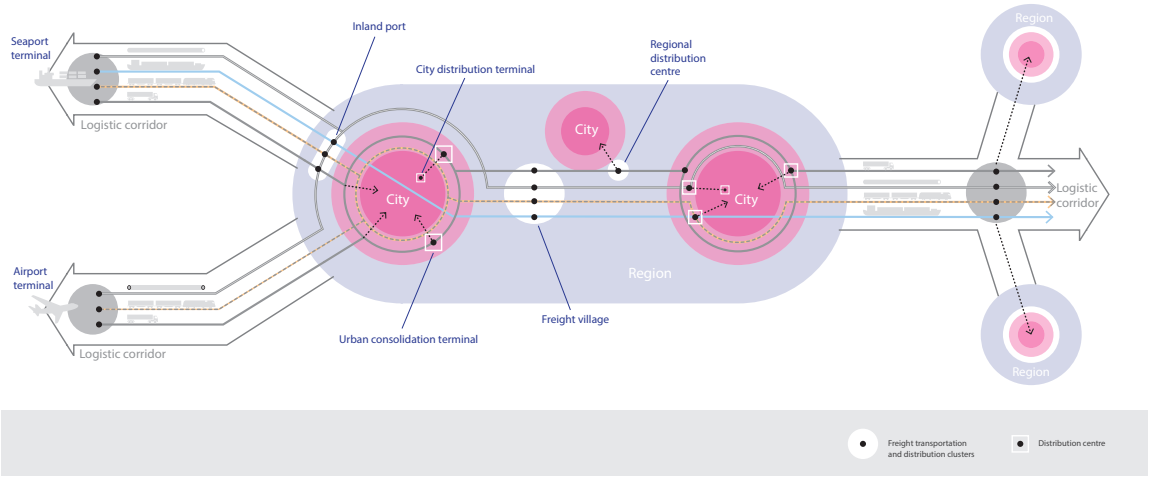


fig 14. The FLUXNET model shows the different kind of terminals that are part of the logistic system

Regional distribution centres

Here 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.

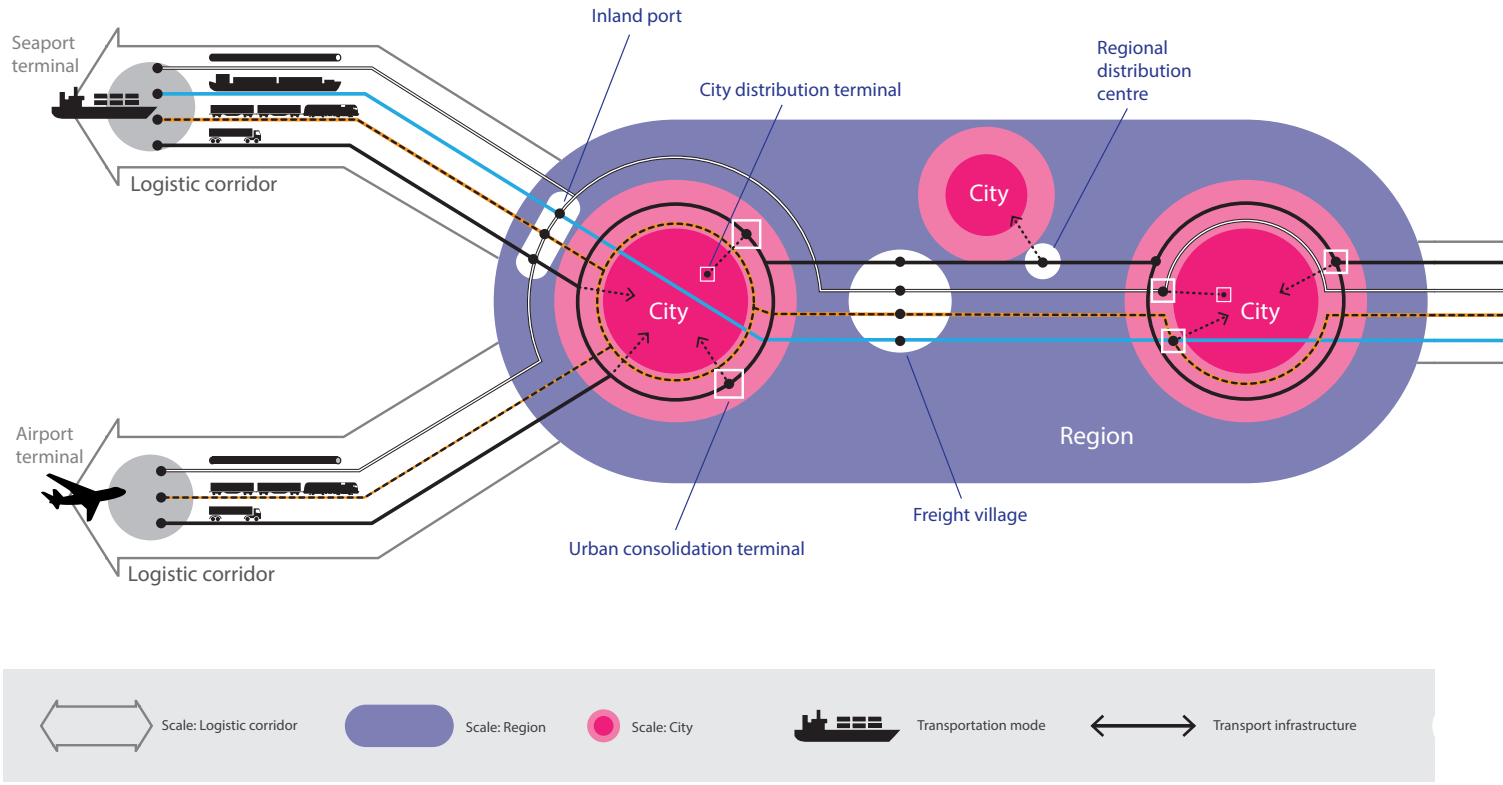
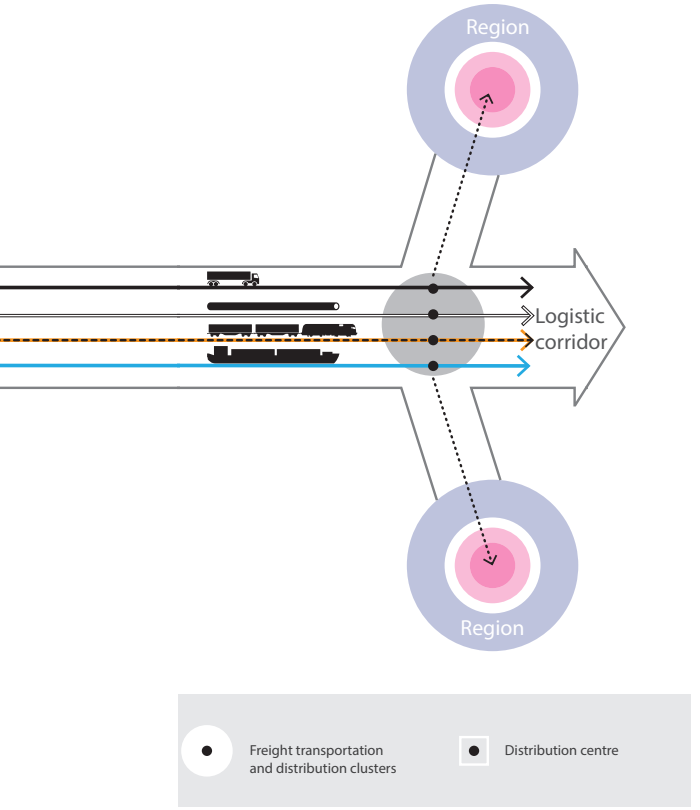


fig 15. Scheme of the spatial infrastructural system for Logistic Orientated Development



The model developed in the FLUXNET research 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.

03. PRINCIPLES TO INFLUENCE MULTI-MODAL CHOICE

As part of the FLUXNET study some 25 good practices have been identified with a broad range of effects on modalities (see FLUXNET report Part 1). All good practices were analyzed by their impact on the FLUXNET spatial-infrastructural model. 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. The principles contain three dimensions:

+ The main spatial-infrastructural elements of the FLUXNET model (terminals, modes and infrastructure);
+ They can function on at different spatial scales (local, regional, corridor scale):
+ These elements can either be either optimized or newly added to the system.

Optimize a terminal stands for improving the internal organization of a terminal. Existing terminals are re-organized in order to increase the efficiency to better serve multiple modes.

Add a terminal stands for (re-) locating a terminal at a multi modal location in order to improve multi-modality and to improve the network performance.

Optimize (the use of existing, sustainable) infrastructural systems means that the use of existing traffic infrastructure (rail, water, road, pipeline) is being optimized by physical or organisational measures.

Add infrastructure stands for realizing a new physical, sustainable transport infrastructure (waterway, railway, pipeline) that complements the existing infrastructure network in order to facilitate a modal shift.

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

		local scale	regional scale	corridor scale
	Optimize a terminal	o	o	o
	Add a terminal	o	o	o
	Optimize infrastructure	o	o	o
	Add infrastructure	o	o	o
	Optimize a mode	o	o	o
	Add a mode	o	o	o

fig 16. Principles for multimodal optimisation can be organized in a scheme that contains three dimensions: spatial-infrastructural elements; the measure how to deal with these elements (optimizing or adding); and three different scale levels

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.

Often, a principle has connections to different fields. For instance: adding a mode at regional level often has connections to adding infrastructure on both regional and local level.

TRIAS LOGISTICA

When selecting principles for a specific region, the principles can be clustered in three levels of intervention. We call this structure the Trias Logistica as it can be considered as a way to structure the priorization of the principles.

Level 1: Minimize the need to transport, for example by locating the terminals on multi modal nodes or mixing functions;

Level 2: Optimize the use of existing sustainable infrastructural systems;

Level 3: Add new, sustainable infrastructure systems.

Which principles belong to which level, varies in every region and must be decided by the actors who apply the toolbox.

Optimize a terminal

PRINCIPLE: RE-ORGANISATION OF A TERMINAL

The efficiency of an Intermodal Terminal (rail-road) can be increased by an internal re-organisation of the terminal.

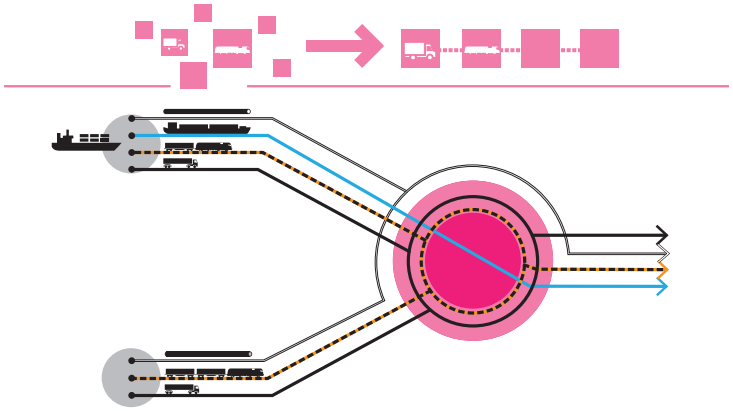


fig 17. Principle: Re-organisation of a terminal

GOOD PRACTISE EXAMPLE: LUDWIGSHAFEN, GERMANY

In Ludwigshafen, Germany, BASF SE has the largest production site for chemicals in the world, where products are manufactured for the European as well as for the global market. All kinds of transport modes are used for the distribution of goods, however, for the European market, transport via road and rail prevails. Each day, some 2.000 trucks and 450 rail cars are loaded for distribution out of the Ludwigshafen site.

The systematic development of intermodal transport between road and rail at BASF started in 2001. In the Ludwigshafen terminal, loaded containers, trailers and swap bodies are collected by trucks at various loading stations, then moved to an intermodal terminal and lifted with a gantry crane onto a rail wagon.

The long distance leg of the transport to customers is then covered by train to another intermodal terminal in the area where the customer is located. There, the loaded unit is lifted from the rail wagon onto a truck again and transported via road to the customer's site. During the leg of the journey by rail, loaded units need not to be accompanied by drivers. Transporting goods this way across long distances in Europe has several advantages:

+ CO2 emissions can be reduced up to 65% when shifting from road to intermodal transport. 25% of BASF s volume shipped out of Ludwigshafen is distributed by intermodal transport, with yearly savings of some 45.000 mt of CO2 emissions.

+ There is a reduction of transport costs because of the allowed higher payload for intermodal transport compared to transport by road.

+ Processes are optimised at production and loading stations, e.g. the possibility of unaccompanied loading of transport equipment at night.

+ One is able to avoid certain restrictions, e.g. no truck transport allowed on weekends and holidays, transport in especially poor weather conditions, or passing through tunnels with precarious goods, etc.

+ There are also fewer problems concerning the availability of drivers who are licensed to transport hazardous goods.

fig 18. Kombiterminal Ludwigshafen, BASF

PRINCIPLE: REDUCING MANOEUVRING TIMES

The efficiency of an intermodal terminal (rail-road) can be increased by reducing the manoeuvring time at the gate of the terminal. An important factor is the electrification of the tracks at the gate.

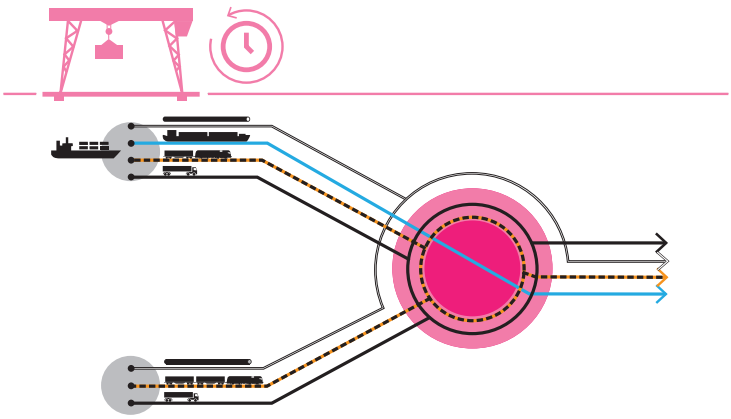


fig 19. Principle: Reducing manoevring times

GOOD PRACTISE EXAMPLE: MORTARA FREIGHT VILLAGE, ITALY

The Intermodal Terminal of Mortara is inside the Mortara Intermodal Logistic Park. The terminal is situated in Lombardy, a natural link for north-south and east-west traffic from Italy. It has a surface over 100,000 m² and offers transfer services of cargo units from truck to rail and vice versa. The Intermodal Terminal has a potential capacity equal to 150,000 ITU (intermodal transport units) per year at full regime, with up to 9 pairs of trains / day with gantry cranes and the expansion of the rail fleet. The intermodal unit has three straight tracks 650-700m long according to European standards and is suited for operation of gantry crane. To improve its efficiency and competiveness with other Intermodal Terminals, two electrification measures were being implemented:

+ an electrified line up to the operational tracks' junction for push/pull operations using electrical locomotives;
+ a pick-up and delivery rail yard with 4 electrified tracks 650-700 m long, allowing the electrically driven arrival and departure of trains directly from the terminal with economic benefits and less time spent on manoeuvres

The measures result in a reduction the pre- and post hauling costs. Electrification is

the most important strategical factor of the Intermodal Terminal in Mortara, as this guarantees the possibility to directly manage the arrival and departure of convoys with electric locomotives, thus reducing manoeuvring times and technical and administrative procedures.

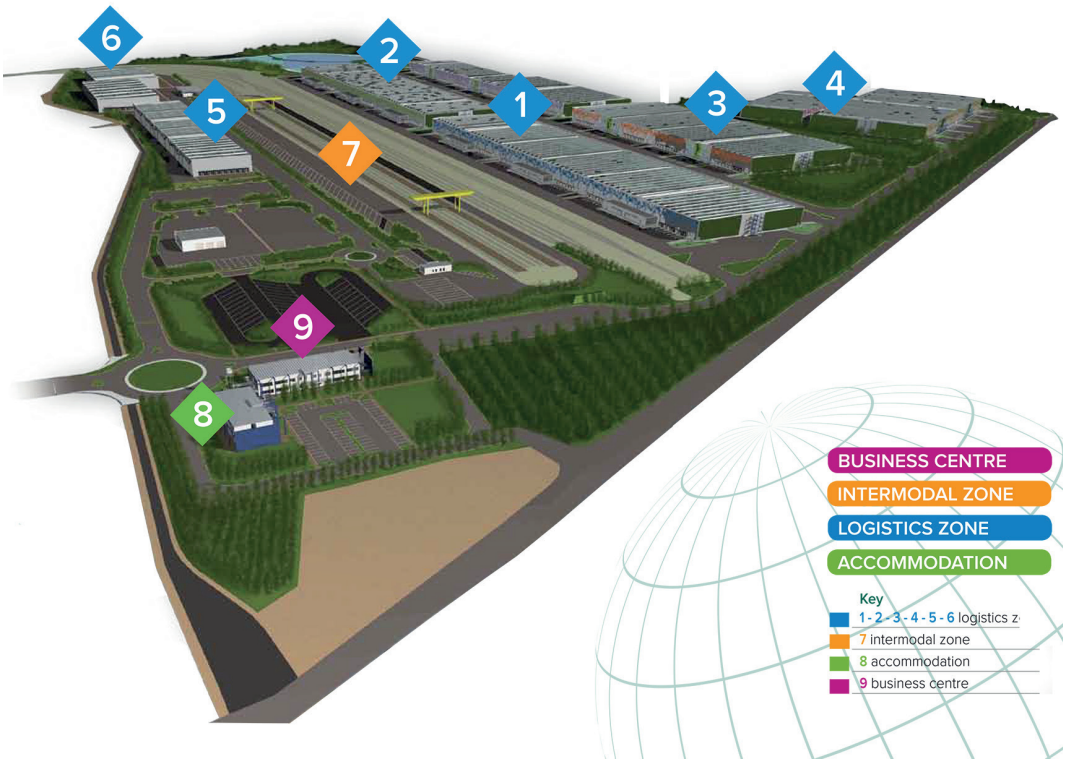


fig 20. Lay-out of Mortara freight village

PRINCIPLE: CONTROL OF APPROACHING TRAFFIC

The first or last part of a delivery often requires some road transport, for example to go from the inland terminal to the final destination. The reduction of waiting time can be realized by monitoring and controlling the incoming traffic towards a terminal.

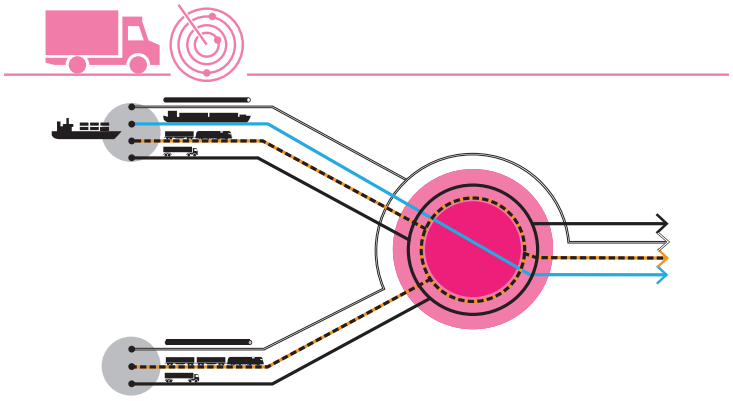


fig 21. Principle: Control of approaching traffic

GOOD PRACTISE EXAMPLE: ROTTERDAM HARBOUR, NETHERLANDS

In the port of Rotterdam, carriers can use the Road Planning service as an easy way to give terminals and empty depots advance notice of the arrival of trucks. They in turn can prepare properly for these arrivals, which helps speed up things for the drivers at the terminal or depot and gets containers on the road more swiftly.

fig 22. Image from the Road Planning System, Rotterdam Harbour

Add a Terminal

PRINCIPLE: MOVING / ADDING A TERMINAL

The relocation of an existing terminal from a unimodal to a multimodal location, or the location of a new terminal on a multimodal location, can serve multiple purposes. From a network perspective, the multi modal use of existing infrastructure as well as the network performance can be improved. From a spatial point of view, placing the right terminal on the right location, can lead to environmental and liveability gains. Smaller terminals with a function for the city or region can be spatially and functionally integrated within the urban fabric. Large terminals can be placed on locations where they cause little conflicts with other uses. The principle of moving or adding a terminal applies to several types of terminals:

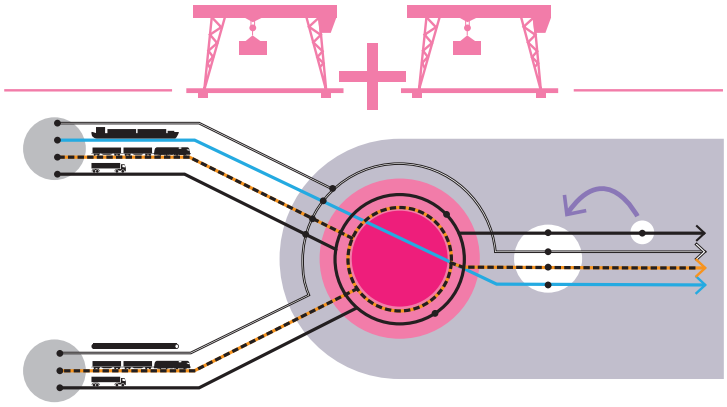


fig 23. Principle: Moving / adding a terminal

- (inter)national sea and air terminals
- regional inland distribution centres or ports
- urban consolidation terminals
- city distribution terminals

fig 24. Extension of the termianl area in the harbour of Rotterdam

GOOD PRACTISE EXAMPLE OF A SEA TERMINAL: MAASVLAKTE 2, ROTTERDAM (NETHERLANDS)

The port of Rotterdam has, in the course of its existence, expanded to the west, towards the North Sea. The reason for this continuous expansion and moving is threefold: to maintain the position of an important economic tractor, to meet the demand for land and to move uses that conflict with the city of Rotterdam. Maasvlakte 2 is the newest step in the development of the port of Rotterdam. In the existing port and industrial areas, there was no room for new large-scale activities. Half of the total area of Maasvlakte 2 (1,000 hectares) is intended for port-related activities. The remaining space is needed for infrastructure (290 hectares), sea defences (230 hectares) and waterways / harbor basins (510 hectares). Maasvlakte 2 is primarily intended to facilitate chemical and container transhipment companies. The new ports have a depth of 20 meters and are therefore accessible to the latest generation of large container ships. Maasvlakte 2 is the starting point of the rail cargo Betuwelijn and is well connected to the European and regional highway network.

fig 25. Nike distribution centre in Laakdal

GOOD PRACTISE EXAMPLE OF A REGIONAL INLAND DISTRIBUTION CENTRE: NIKE DISTRIBUTION CENTRE, BELGIUM

In 2016 Nike expanded the European Logistics Campus in Laakdal with a new distribution centre. In this facility waste generated on-site is recycled and transportation routes to and from the campus have been optimised to reduce CO2 emissions. The facility is supplied over water, by rail and by road. 99% of inbound containers reach the local container park by water, saving 14,000 truck journeys a year. In addition to expressing Nike's sustainability vision, the new campus expansion enables the company to serve its consumers faster.

GOOD PRACTISE EXAMPLE OF AN URBAN CONSOLIDATION TERMINAL

An urban consolidation centre (UCC) is a logistics facility that is situated in relatively proximity to the geographic area that it serves, be that a city centre, an entire town or a specific site (e.g. shopping centre), from which consolidated deliveries are carried out within that area. A range of other value-added logistics and retail services can also be provided at the urban consolidation centre. The key purpose of urban consolidation centres is the avoidance of the need for large trucks to deliver part loads into urban centres. Long haul transportation vehicles of various modes dock at the UCC to unload their cargo. Loads are then sorted and consolidated into smaller vehicles for distribution. Urban consolidation centres may be stand-alone facilities situated close to the city access or ring highways, or may be part of air, rail, or navigation terminals. UCCs may then be viewed as intermodal terminals with enhanced functionality to provide coordinated and efficient freight movements within the urban zone. Good practises can be found in Stockholm, Bath, Wales and Rotterdam.

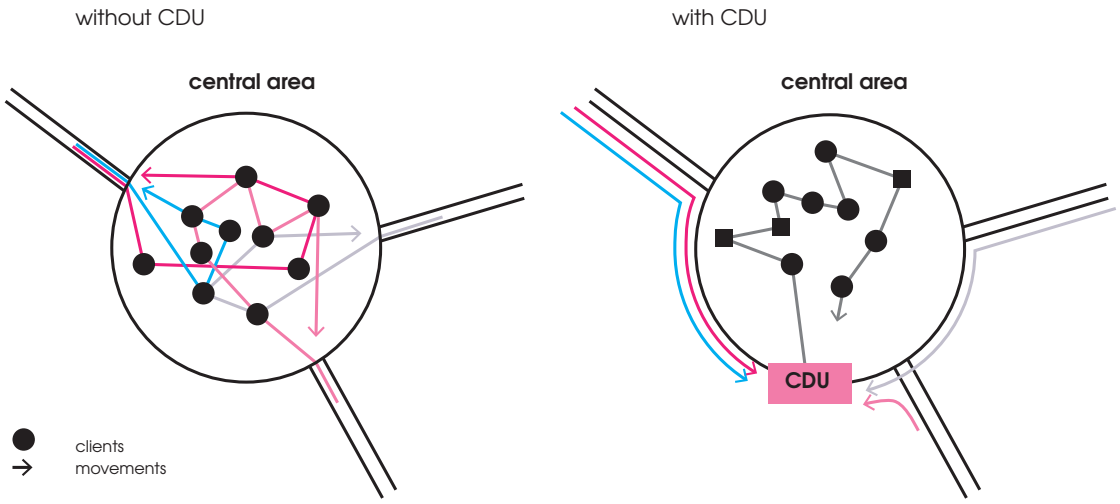


fig 26. Principle of the Urban Distribution Centre (UDC): urban distribution system without UDC (left) and with UDC. (Based on Les espaces logistiques urbain, Daniel Boudouin, Documentation française, 2006)

fig 27. Example of a parcel locker

GOOD PRACTISE EXAMPLE OF A CITY DISTRIBUTION TERMINAL: PARCEL LOCKERS, EU

Automated parcel locker machines are a way for logistics operators to keep pace with the explosive growth of e-commerce. InPost is an example of a major player in parcel locker machine business. This Polish logistics provider exploits thousands of parcel lockers worldwide near petrol stations, supermarkets, universities and public transport stations.

The service provides e-commerce shoppers the option to ship online purchases directly to one of the pick-up locations. Lockers are accessible 24/7 and the self-serve pick-up process takes a short amount of time to complete.

Optimize Infrastructure

PRINCIPLE: OVERCOMING PHYSICAL OBSTACLES

The use of the existing infrastructure (rail, water, road) can be optimized by overcoming or removing physical obstacles in sustainable transport infrastructures. This can be implemented by deepening waterways, adjusting the heights of bridges or building tunnels.

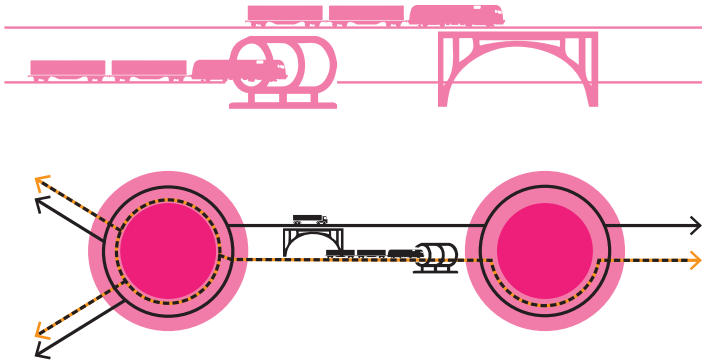


fig 28. Principle: Overcoming physical obstacles

GOOD PRACTISE EXAMPLE: GOTTHARD BASE TUNNEL, SWITZERLAND

Building tunnels can help optimizing the use of transport infrastructure. At the same time, it can serve to avoid spatial cuts in an urban or natural surrounding as well to reduce negative environmental impacts. The Gotthard Base Tunnel (GBT) is a railway tunnel through the Alps in Switzerland. It opened on 1 June 2016, and full service began on 11 December 2016. With a route length of 57.09 km, it is the world's longest and deepest traffic tunnel and the first flat, low-level route through the Alps. The new base tunnel establishes a direct route usable by high-speed rail and heavy freight trains. The main purpose of the Gotthard Base Tunnel is to increase local transport capacity through the Alpine barrier, especially for freight, notably on the Rotterdam–Basel–Genoa corridor, and more specifically to shift freight volumes from trucks to freight trains. This both significantly reduces the danger of fatal road crashes involving trucks, and reduces the environmental damage caused by heavy trucks.

fig 29. Southern entrance of the Gothard Base tunnel

PRINCIPLE: USE OF NETWORKS FOR CARGO TRANSPORT IN PEAK-OFF HOURS

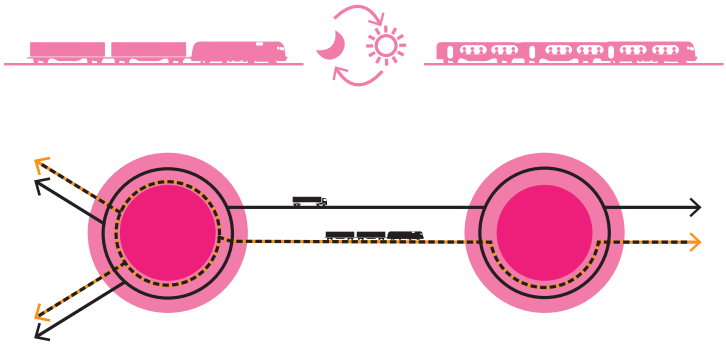


fig 30. Principle: Use of networks for cargo transport in peak-off hours

The regional person rail network can be used at night for the distribution of goods from regional centres into the city during off-peak hours. The last transport leg between a regional distribution centre and retail shops can occur via waterways or by tram.

GOOD PRACTISE EXAMPLE: TRAIN DELIVERY MONOPRIX, PARIS

The high demand for freight in the Paris area poses a big challenge and it is crucial to ensure an efficient and sustainable distribution of goods. Even though the city is at the centre of the radial structure of the French railway network, the share of rail freight transport is very low: in the Île de France region, the share of road transport is as high as 90 per cent and almost 100 per cent in the last mile. The increasing traffic congestion and the negative impacts caused by road transport have mobilised authorities to define measures for sustainable logistics. The initiative of a supply chain using rail for freight transport inside Paris was launched by the Municipality of Paris in 2004 in collaboration with other organisations.

Retailer Monoprix took this opportunity to change its delivery process and use this method to deliver goods such as clothes, health care/cleaning products and beverages to its Paris stores. Since 2007 Monoprix has reduced its reliance on truck deliveries and has been dispatching goods to its stores in Paris using trains and Liquefied Natural Gas (LNG) vehicles for last-mile deliveries. Monoprix uses trains during off-peak hours to transport goods to the train platform from its two distribu-

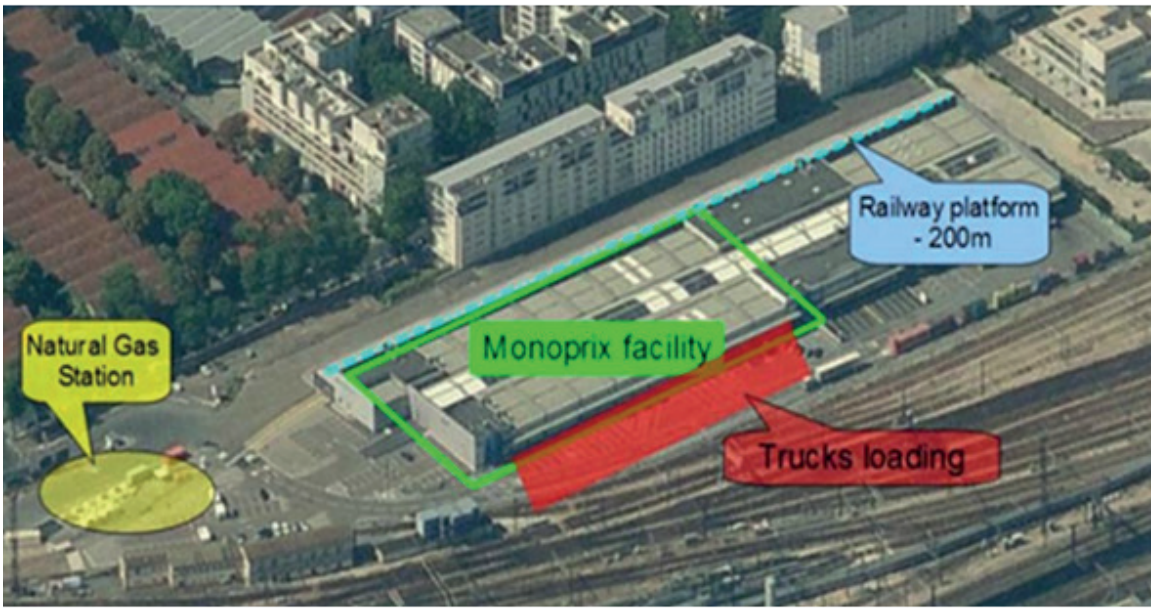


fig 31. Aerial scheme of the Monoprix transfer facility in Paris

tion centres 40 km away and makes the last-mile delivery with LNG vehicles.

With 260 trains a year (equivalent to 12.000 trucks), a reduction of 700,000 km of annual truck movements is realised. As a result CO2 emissions are decreased by 410 tonnes per year (a 47% reduction). Even though not quantified, the fewer number of lorries on the roads is expected to have reduced congestion, road wear and road accidents.

Thanks to the higher loading speed and carrying capacity of rail wagons (because of their side doors), the new delivery process has also reduced the need for space in Monoprix's warehouses.

PRINCIPLE: DEDICATED LANES - SEPARATING FREIGHT AND CARGO TRANSPORT WITHIN EXISTING INFRASTRUCTURE

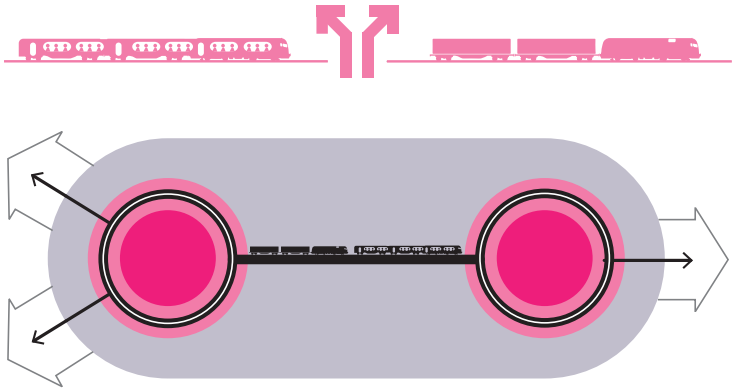


fig 32. Principle: Dedicated lanes - Separating freight and cargo transport within existing infrastructure

Freight and person transport often use the same infrastructure. Cargo trains and trucks have different driving characteristics from vehicles destined for person mobility: cargo vehicles are usually slower, have a longer breaking distance and need more space. This can lead to conflicts, especially in metropolitan areas where the pressure on the infrastructure is high. To optimize the use of the existing infrastructure, dedicated lanes can be introduced for specific target groups: freight versus person transport or transit versus local transport.

GOOD PRACTISE EXAMPLE: KNOTENPUNKT KÖLN, GERMANY

The Cologne region is one of the economically strongest conurbations in Germany. Basis for success is one of the largest and densest rail, road and waterway networks in Europe. However, the region suffers from the increasing unreliability not only of road traffic but also of rail transport. Reliably functioning transport chains are among the crucial ones production factors of industry and logistics companies. Under the bottleneck situation in the Cologne railway junction suffers the entire passenger and freight traffic. At present, high-speed trains, suburban traffic including the S-Bahn and freight trains share the tracks. Delays in just one of these systems immediately strike the other systems.

The measures that are part of the project "Bahnknotens Köln" aim in particular at reaching capacity expansion in freight, long-distance and local traffic transport. The key measure is to separate the regional traffic from the freight traffic by concentrating the regional person traffic on separate trunks. This creates capacity for long-distance and freight transport on other existing tracks.

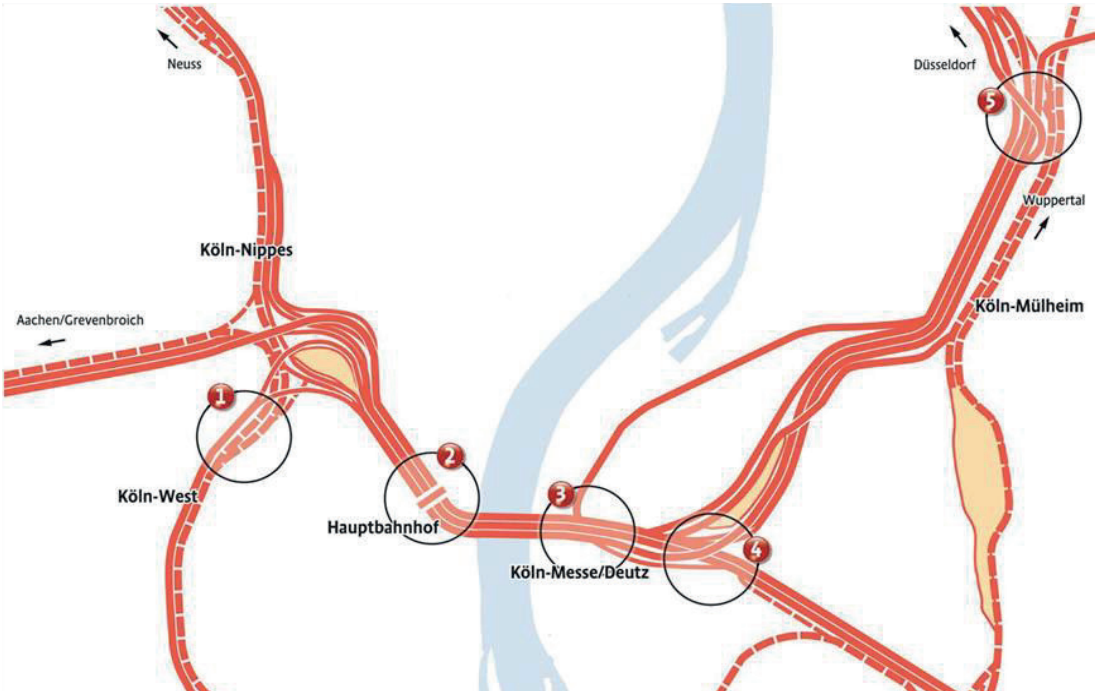


fig 33. Scheme of the measures for the project Bahnknoten Köln

Add Infrastructure

PRINCIPLE: EXPANDING THE EXISTING SYSTEM BY ADDING A NEW RAIL TRACK DEDICATED FOR FREIGHT TRANSPORT

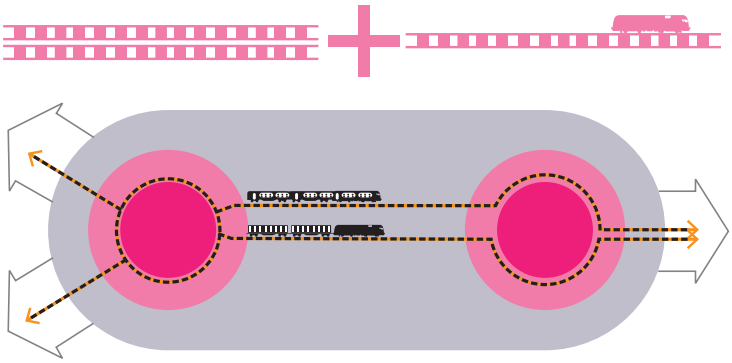


fig 34. Principle: Expanding the existing system by adding a new rail track dedicated for freight transport

The existing pressure on rail infrastructure and the foreseen growth of freight transport by rail, sometimes make it necessary to expand the existing network with new rail tracks dedicated to freight transport. By tracing and spatially embedding the new track in a smart way, existing highly populated urban areas can be relieved from the negative consequences of rail cargo transport areas like noise pollution, dangerous goods and physical barriers within the urban fabric. At the same time, conflicts between person and freight transport competing for the same capacity on infrastructure can be avoided. Instead, a new freight track can result in extra capacity on the existing tracks for person transport.

fig 35. Track of the Betuwelijn

GOOD PRACTISE EXAMPLE: BETUWELIJN, NETHERLANDS

The plans to develop the port of Rotterdam in order to consolidate its primacy in Europe as a gateway to the continental market, from Italy to the Eastern Countries, is accompanied by the willingness of Dutch Government to transfer most of the new traffic volumes from vessels direct to trains, so as not to compromise the environmental balance in the region. However, since the existing railways are also used by passenger traffic, the requested capacity for additional traffic of freight trains should not be available. In 1998 works began to build a new railway, completed in 2007, dedicated to freight traffic only, connecting the farthest area of the port of Rotterdam (Maasvlakte) to the German border near Zevenaar/Emmerich by following the path of the A15 motorway.

The Betuwe Line is a 160 km long double track rail line dedicated to freight and ERTMS (European Rail Traffic Management System) equipped. The goal to reduce the impact of the new structure on the landscape has prompted to run the Rails underground for almost 20 km upon a total length of 160 km, both by the crossing of major streams and near a couple of major population centers, and brought the whole cost of the building to almost 5 billion euros.

PRINCIPLE: EXPANDING THE EXISTING SYSTEM BY ADDING A NEW RAIL TRACK DEDICATED FOR PERSON TRANSPORT

The growth of metropolitan areas can enforce the need for new infrastructure. Person transport can be shifted from car to another sustainable modality by creating new (high speed) train tracks dedicated for person transport. The resulting spare capacity on existing tracks can be used for freight transport.

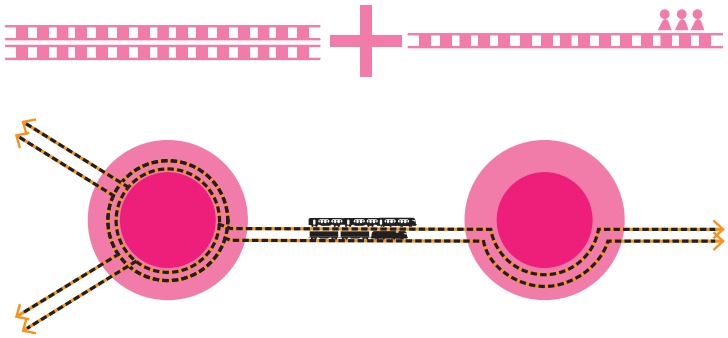


fig 36. Principle: Expanding the existing system by adding a new rail track dedicated for person transport

GOOD PRACTISE EXAMPLE: OSTFLÄNKEN, SWEDEN

Sweden is growing, the metropolitan areas are expanding, and demand for faster, environmentally sustainable transport is rising. That's the reason for the Ostlänken project (the East Link) – a key part of Sweden's first purpose-built high-speed rail line. Sweden's railway of the future will start with a 150-km section from Järna to Linköping. When the entire Ostlänken project is complete in 2028, trains will be able to run at speeds of up to 320 km/h. Ostlänken will offer new travel opportunities and will follow a more direct route than the existing rail line. Along the 150-km new line in the eastern part of Central Sweden, stations with adjacent transit hubs are planned at Vagnhärad, Nyköping, Skavsta airport, Norrköping and Linköping. The new railway will bring the Stockholm, Södermanland and Östergötland regions closer together. Shorter journey times and more convenient transit hubs will encourage people to leave their cars at home and choose a greener, more comfortable mode of transport for commuting

Ostlänken will free up space on existing lines, reducing congestion for other trains. As well as improving the reliability of passenger services, this will create more capacity for freight. This in turn will increase the scope for switching shipments to rail from other, more polluting modes of transport.

fig 37. The track of the new High Speed Lines in southern Sweden

PRINCIPLE: INTRODUCING NEW TYPES OF INFRASTRUCTURE

The growth of road traffic in urban areas leads to critical environmental (pollution) and traffic jam issues. As a result, more and more cities seek for alternative transport infrastructures for freight. One of the concepts that is often being discussed today is the creation of new pipeline or tube systems.

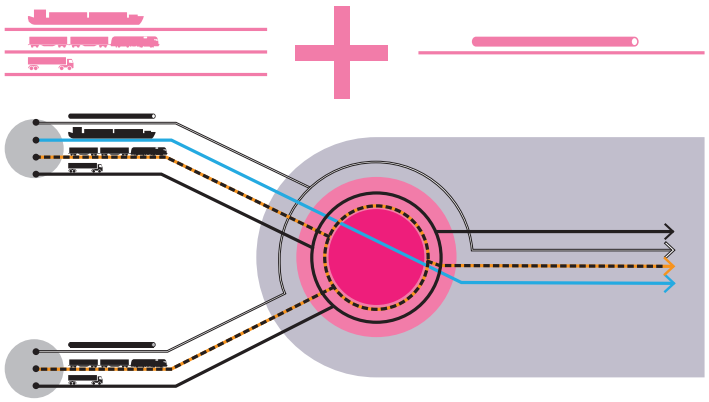


fig 38. Principle: Introducing new types of infrastructure

GOOD PRACTISE EXAMPLE: BRUGES, BELGIUM

Brewery De Halve Maan has been in the old city of Bruges for centuries. Until recently heavy trucks were driving through the old city from the brewery to the bottling facility just out of the city. This resulted in a lot of nuisance and the brewery was advised to move all operations to the industrial estate housing the bottling plant. This would mean the beer could no longer be brewed in Bruges.

To reduce the nuisance while keeping the brewery in the old city, Belgium's first beer pipeline was installed between the brewery and the bottling plant in 2016. The pipeline is made from a 3.5 km long polyethylene tube and it takes about 45 minutes to pump the beer (enough to fill 12,000 bottles an hour) from the brewery to the bottling plant.

No private company had ever been allowed to lay cable under the city's cobbled lanes and around the renowned medieval buildings that have secured Bruges's place on the UNESCO world heritage list.

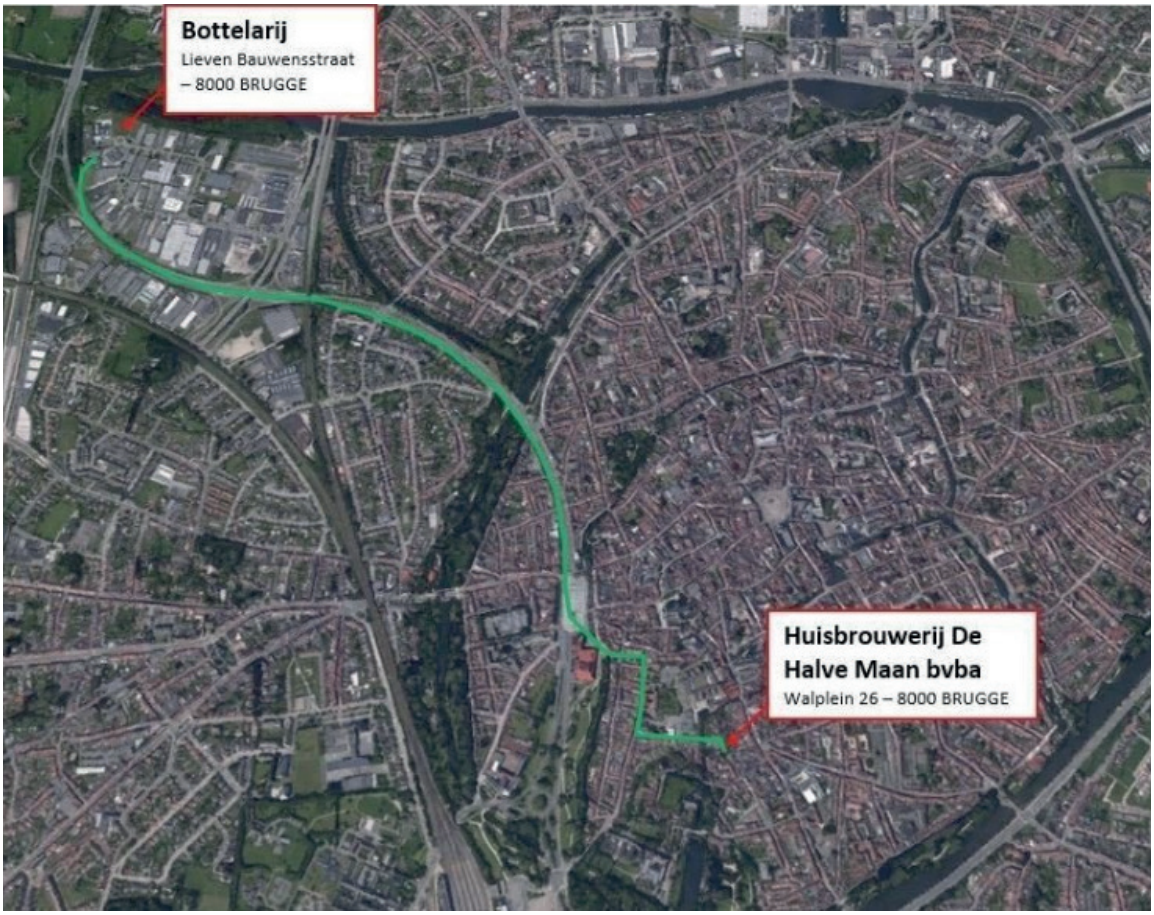


fig 39. Track of the beer pipeline in Bruges

However, the City of Bruges realised the pipeline would reduce the number of beer trucks driving in and out of the city by ca. 500 every year.

GOOD PRACTISE: CARGO SOUS TERRAIN, SWITZERLAND

According to current predictions on goods transport, there will be a 45% increase between 2010 and 2030. Current transport infrastructure alone - both road and rail - will be unable to absorb this growth, making alternative systems imperative. Urgent solutions are therefore needed to tackle the increasing traffic flows – both for the economy but also for society in general. Cargo sous terrain (CST) will consist of two key components: an underground transportation tunnel and an efficient, environmentally friendly distribution system for goods in city centres (City-Logistik).

From 2030 onwards, this comprehensive logistics system will develop into a new infrastructure network for the transport of goods.

The concept consists of building a network of subterranean tunnels or tubes through which driverless wagons, powered along conveyor belt-type tracks by electromagnetic induction, would travel at speeds of between 30km and 60km/hour, carrying cargo on pallets and in containers - an integrated, fully-automated logistics system operating around-the-clock. A provision is made to dig six-metre diameter tubes, at a depth of 50 metres, equipped with three lanes, two running in opposite directions and a third for service use.

On the surface, shippers' production sites or main distribution hubs and smaller sub-hubs, located on the outskirts of towns and cities would be linked, via the underground system. These "outer" and "inner" hubs would each be served by escalators, lowering and lifting cargo to and from the tubes. The final leg of the logistics process, the shipment of goods from the "inner" hub to city centre retail outlets and businesses, would be carried out by hybrid delivery vehicles.

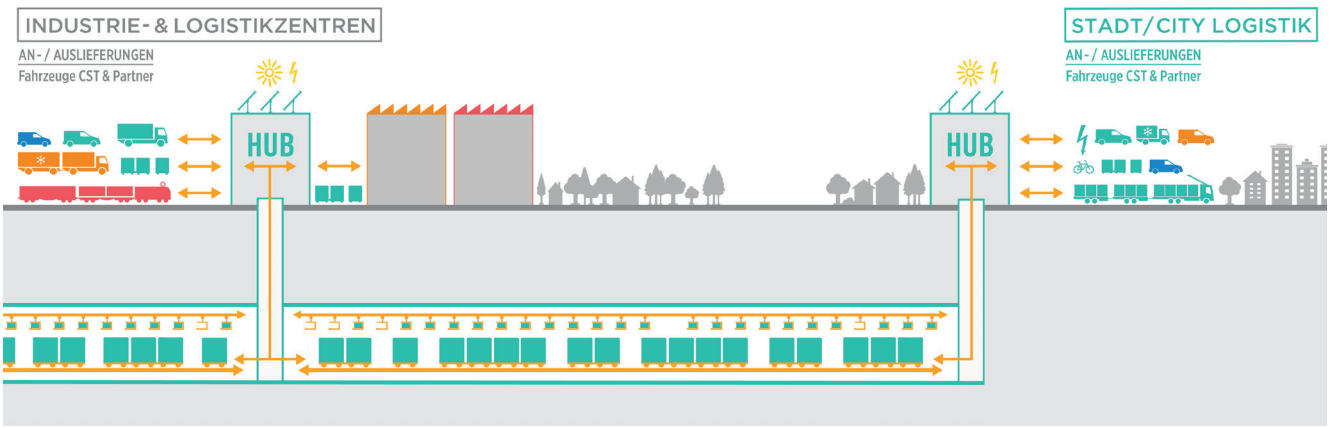


fig 40. Scheme of the Cargo Sous Terrain project

Optimize a Mode

PRINCIPLE: SYNCHROMODAL TRANSPORT

Synchromodal transportation means that a shipper agrees with a logistics service provider (LSP) on the delivery of products at specified costs, quality, and sustainability but gives the LSP the freedom to decide on how to deliver according to these specifications.

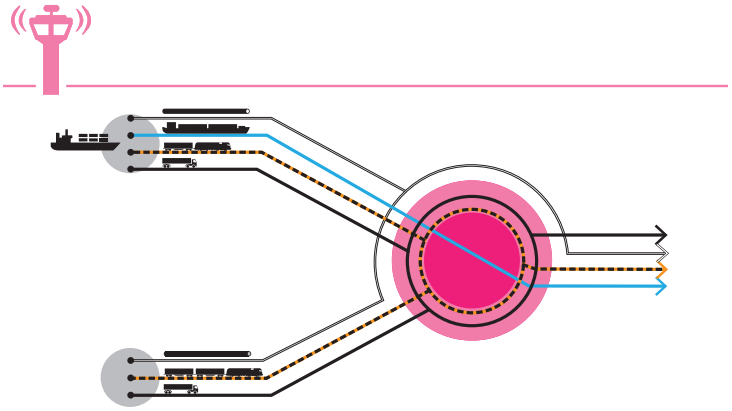


fig 41. Principle: Synchromodal transport

This freedom gives the LSP the possibility to deploy different modes of transportation flexibly. The decision to switch to different modes of transportation may depend on actual circumstances such as traffic information, instant availability of assets or infrastructure and all other factors that might change requirements. So that, actual transport of goods can easily and seamlessly be shifted between different modalities.

GOOD PRACTISE EXAMPLES: BARGE TERMINAL TILBURG

In 2011 a pilot was executed around the synchromodal transportation between the seaport of Rotterdam and three companies with a distribution centre in Tilburg: Samsung, Sony and Fuji. The aim of this pilot was to test the reliability of deliveries when the shipment is booked without a fixed transportation mode. A chain director was appointed to organise shipments and choose transportation modes as they saw fit. For the pilot different configurations of transportation modes were tested. Early notification about shipments by the shipping companies allowed for sufficient time to book rail/barge capacity. This was the main factor contributing to the modal shift achieved. A key requirement for the shipping companies is a high reliability of the transport time.

fig 42. Illustration of synchromodal transport

PRINCIPLE: COMBINING PASSENGER AND FREIGHT TRANSPORT IN A SINGLE VEHICLE

Multimodal transport can be stimulated by using non-logistics vehicles for logistics purposes. This means that the use of existing infrastructure is being optimize and no new space for transport and logistics is needed.

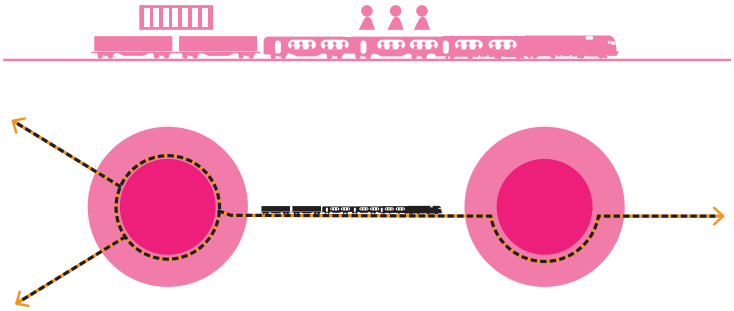


fig 43. Principle: Combining passenger and freight transport in a single vehicle

GOOD PRACTISE EXAMPLE: POST BUS, GERMANY

Since December 2015 customers in Berlin and Hamburg can use the Postbus for urgent parcel deliveries between the two cities. Deutsche Post is testing a service that will give another dispatch solution in addition to traditional parcel shipping and its courier service: Postbus Courier, same-day delivery via its own intercity bus network. Postbus is the first long-distance bus travel provider in Germany that also offers parcel transport in addition to its passenger service. Berlin and Hamburg are the first cities offering the delivery service.

Additionally, Dailex offers a eco-friendly solution for the first and last mile by running a bicycle courier service. Both private users and small businesses are using the service.

fig 44. The Post Bus, Germany

Add a Mode

PRINCIPLE: ADDING NEW TYPES OF TRANSPORT VEHICLES TO THE EXISTING SYSTEM

New types of vehicles can increase the efficiency of cargo transport and result in competitive modes for regular truck transport. This principle applies to different kind of modes: cargo-bikes and lorries for city distribution and high speed rail transport.

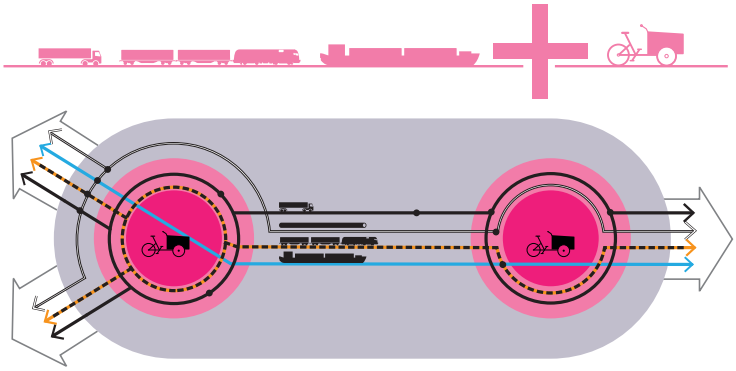


fig 45. Principle: Adding new types of transport vehicles to the existing system

GOOD PRACTISE EXAMPLE: CITYPORTO, PADOVA (ITALY)

Cityporto is the urban goods distribution service by Interporto Padova using methane and electric vehicles. Operators deliver their goods to the logistics platform on the outskirts of the city of Padova, where LNG and electric vehicles are loaded and then distribute the goods to the city centre for the last-mile transport. The vehicles used for the service have priority lanes, free access to the city and are allowed to park inside the limited traffic zones at any time of the day.

After two years, the results were:

+ 200.000 deliveries
+ 540.000 TEU in 2 intermodal terminals
+ Reduction of covered km: 561.400
+ Reduction of gas consumption: 58.200 L
+ Reduction of CO2 emissions: 219 ton

fig 46. Electric vehicle for city distribution in the city of Padova

04. PROCESS ARCHITECTURE

The process architecture described below is a planning methodology that can be used for the common development of a strategy for multimodality by NRAs, planning authorities and stakeholders from the Transport and Logistic sector. The process architecture consists of three phases: Description (analysis), Envisioning (vision formation) and Implementation. Joint Fact Finding is a crucial step in anchoring the results of the planning process. All the relevant actors should be involved in the planning process. During all activities of this process, each actor must return with the results to his own organization and provides support into this organization. The goal of Joint Fact Finding is that each actor internalizes the outcome and that the results are being anchored into each organization.

The process architecture described below is related to the Actor Relational Approach (Boelens, 2009), the IPDD Planning Method (Broesi, 2013) and builds on the insights from the FLUXNET Test Beds (see Chapter 3).

DESCRIPTION

The start of the process is a good description of the Transport and Logistic system in a specific region and the challenges in the field of spatial planning as well as in logistics. This description is important for understanding the different core values of the area, the possible external influences that can lead to transitions in the future, the interests of the leading actors and the possible conflicts and synergies between these interests.

fig 47. Scheme of the process architecture, phase Description

Step 1: Geographical interpretation of the FLUXNET spatial-infrastructural model

+ Mapping the existing system: the FLUXNET spatial-infrastructural model with terminals, infrastructures and modes is being applied to the region. This results in a series of maps that give an integral view of the logistic and transoport system in relation to the spatial context.

+ Inventory of issues and planned projects: The inventory helps to estimate future issues (bottlenecks and challenges) for the area in the field of transport, logistics and spatial planning. In addition, the inventory of future developments describes the bandwidth of possible macro-level developments that will affect their system. This makes clear whether transitions for parts of the system are expected and which uncertainties should be taken into account in planning. This information is crucial in formulating a vision for (parts of) the area and the projects that are related to it.

Step 2: Expert session – validation

+ The results of step 1 are to be validated in a inter disciplinary expert session with (regional) knowledge of Logistics, Spatial design & planning, and Infrastructure planning. The experts will be asked to discuss the applied model, issues and hot spots for logistics.

ENVISIONING

Envisioning represents the stage in the process whereby the actors in an interactive process develop a shared vision based on different interests and the willingness to invest. This process can be done in two or multiple rounds with a series of workshops.

fig 48. Scheme of the process architecture, phase Envisioning

Step 3: Expert session - optimization

+ In this expert meeting, on basis of the FLUXNET principles to influence multi modal choice, opportunities for optimizing the network and spatial development will be discussed. A confrontation of different solutions must sharpen where the conflict points lie and where there are opportunities for project-surpassing capital gains are. The result of this step is an overview of the challenges that will be tackled together and the corresponding measures.

Step 4: Strategy development

The outcomes from step 3 can be structured into a strategy. A regional strategy answers to the challenges for the region and consists of an integral vision, a coherent set of (spatial) measures to achieve this vision and the willingness of specific actors to invest in this. This last point is the real test of the process because the willingness to invest is an indication of the actual interest. Investment includes: money, expertise, human resources, etc. A regional strategy can for example consist of a robust logistic and transport framework for the region but it can also be a series of local interventions that reinforce each other. In this phase, a prelimary cost - societal benefits analysis could be carried out.

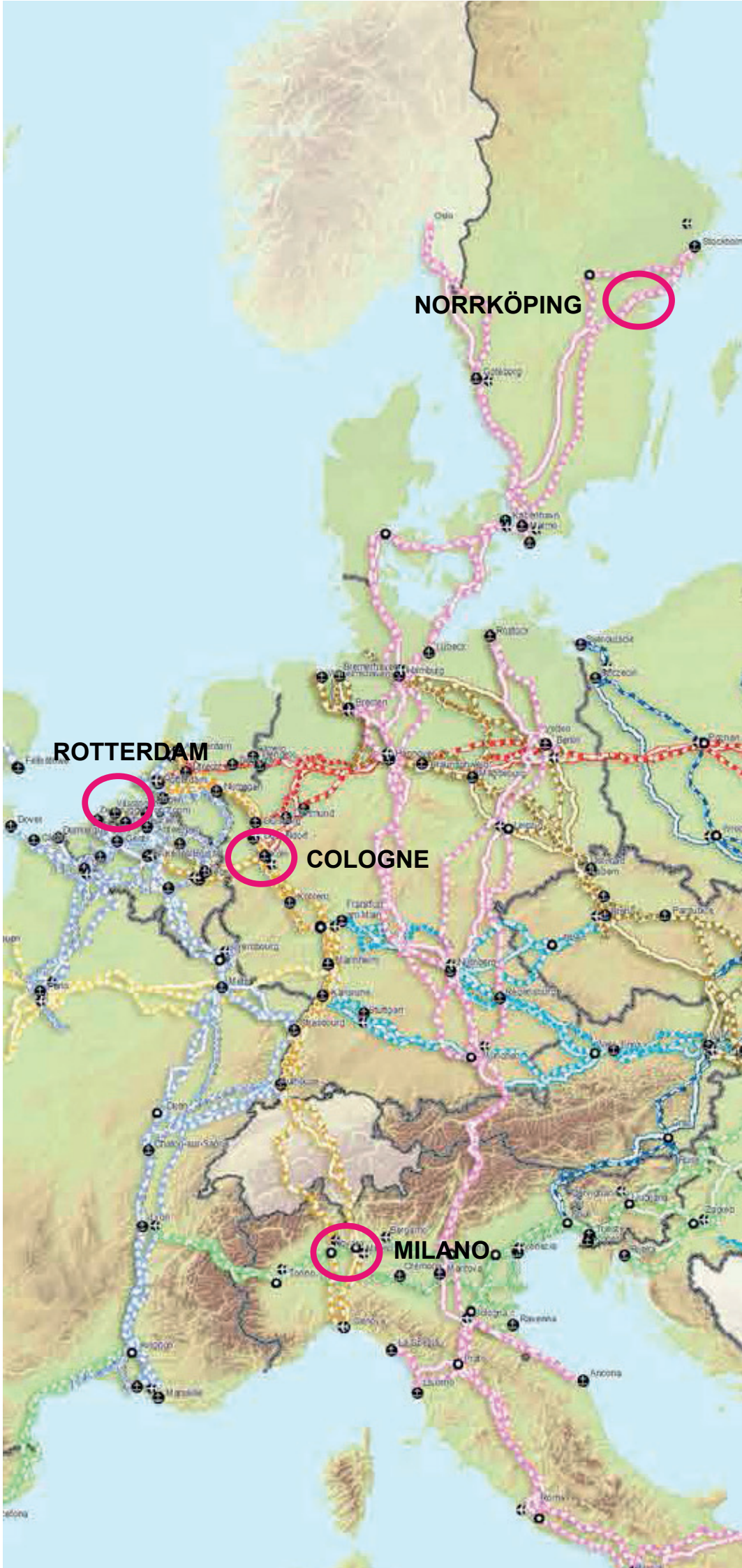
fig 49. Scheme of the process architecture, phase Implementation

Step 5: Implementation

Implementation is the proof of the pudding. One way can be that the actors are asked to sign a pact in which at least the vision, the related measures and the willingness to invest are formally laid down. To make this possible, every actor in his or her own organization needs support and agreement on this final step towards implementation.

+ Defining the right planning instrument. Every governmental actor (NRA, Ministry, regional planning body) is bound to any form of formal planning in its own world. For the implementation of the vision, it is essential to define the proper planning instrument. This can differ per country or region. Examples of planning instruments are an extended SUMP, a formal regional plan or a continuous informal planning process.

Test beds Europe



3. Applying the toolbox

INTRODUCTION

As part of the FLUXNET study four Test Bed sessions have been carried out. A main element of the Test Beds was a workshop with stakeholders from infrastructure planning, spatial planning and the logistics sector. The goal of the regional Test Beds was threefold. Above all, they served to test the preliminary toolbox. The combination of tools from the toolbox was 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 served to identify the specific challenges in connecting land use planning on the one hand and logistic and freight issues on the other hand. Finally, the Test Beds have been a first step in knowledge dissemination. The presentation of the toolbox and the discussion about its relevance is a first step in spreading the knowledge developed in the framework of this research project.

In the following, we will describe the application of the preliminary toolbox for the Test Bed in Cologne (Germany) more extensively. For the Test Beds in the regions of Norrköping (Sweden), Rotterdam (The Netherlands) and Milano (Italy) the main outcomes are being presented.

COLOGNE

01. TEST BED COLOGNE

The region around Cologne is one of the most important economic regions of the EU with a long tradition of production. Currently the region faces a strong economic growth in a mix of production and services economies. This results in a strong pressure on housing and mobility networks. In the framework of this Test Bed, the steps that are part of the phases Description and Envisioning of the FLUXNET process architecture were being applied.

STEP 1: GEOGRAPHICAL INTERPRETATION OF THE FLUXNET SPATIAL-INFRASTRUCTURAL MODEL APPLIED

The FLUXNET team prepared a series of maps for the area along the Rheinschiene. The first series of maps shows an application of the FLUXNET scheme for transport and logistics. Striking in this area is the strong presence of the international corridor system as well as the interconnection between the corridor, (inter)regional and local scale. The second series of maps show an analysis of the bottlenecks. Three main issues can be distinguished in the area between Düsseldorf and Bonn:

+ The region is already facing an infrastructure collapse that will only become worse in the next decade due to a growth of person- and freight transport. The growth of transport is fuelled by developments in the ZARA harbours, the growing population and economy in the region and an intrinsic growth of mobility;
+ Person- and freight transport, as well as transit and regional transport are competing for the same infrastructure;
+ Existing logistic areas are being put under pressure by other functions like housing. There is hardly any space in the urban core area for new logistic centres.

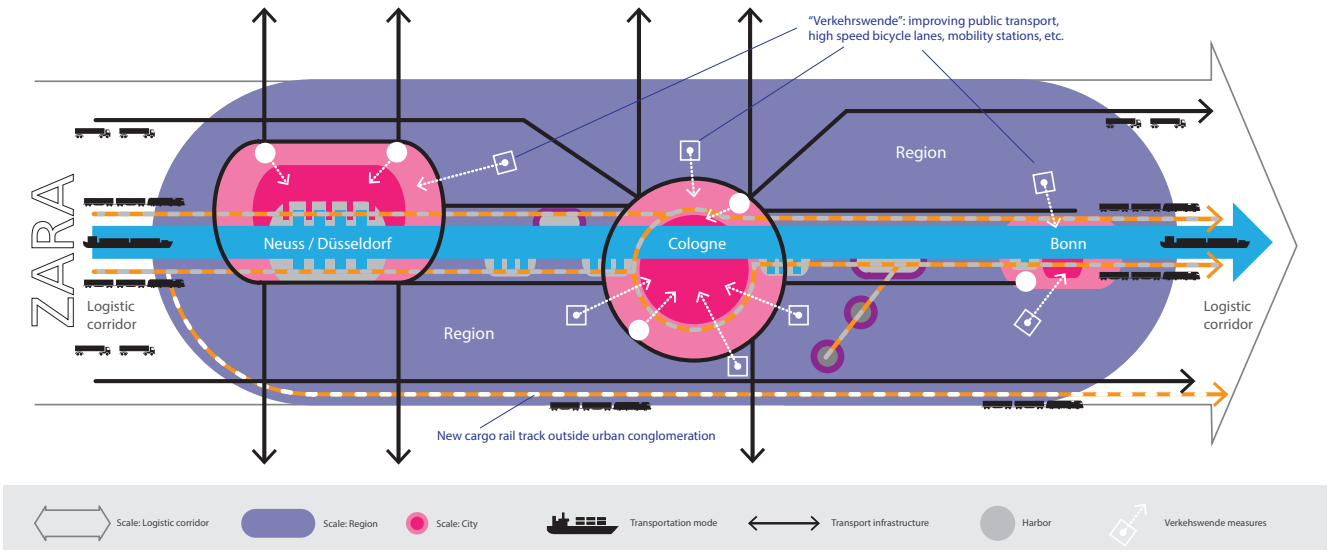


fig 50. FLUXNET model for the region of Cologne/Bonn

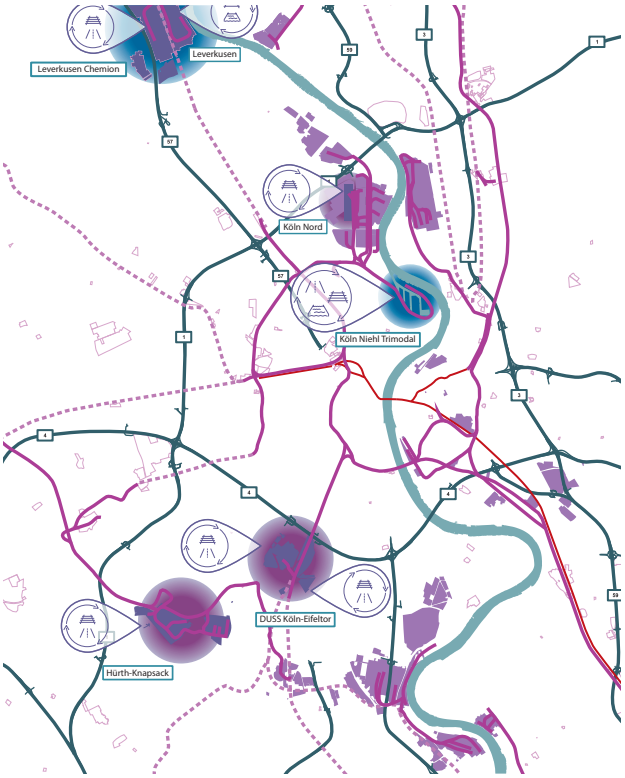


fig 51. The transport & Logistic System in the region of Cologne/ Bonn: zoom-in on the map showing the transport infrastructure and terminals that function on the corridor and regional level

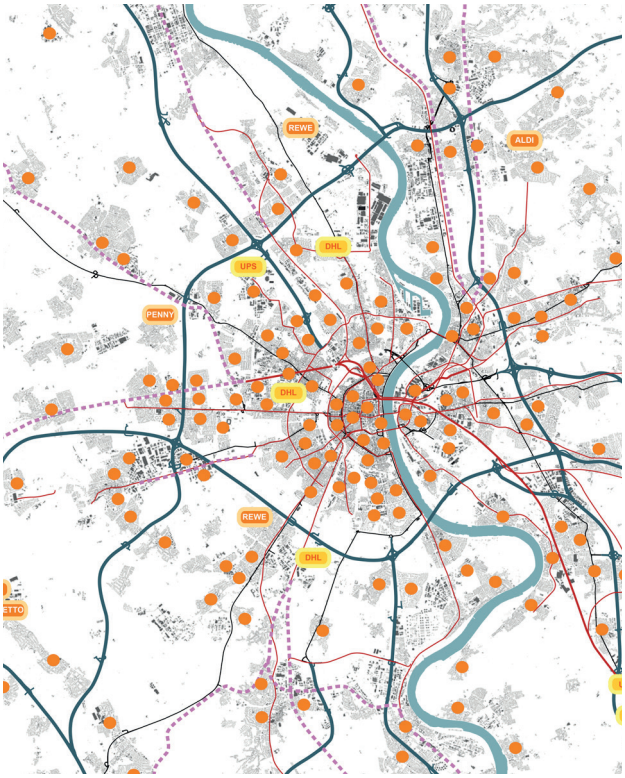


fig 52. The transport & Logistic System in the region Cologne/ Bonn: zoom-in on the map showing the transport infrastructure and terminals that function on the regional and local level

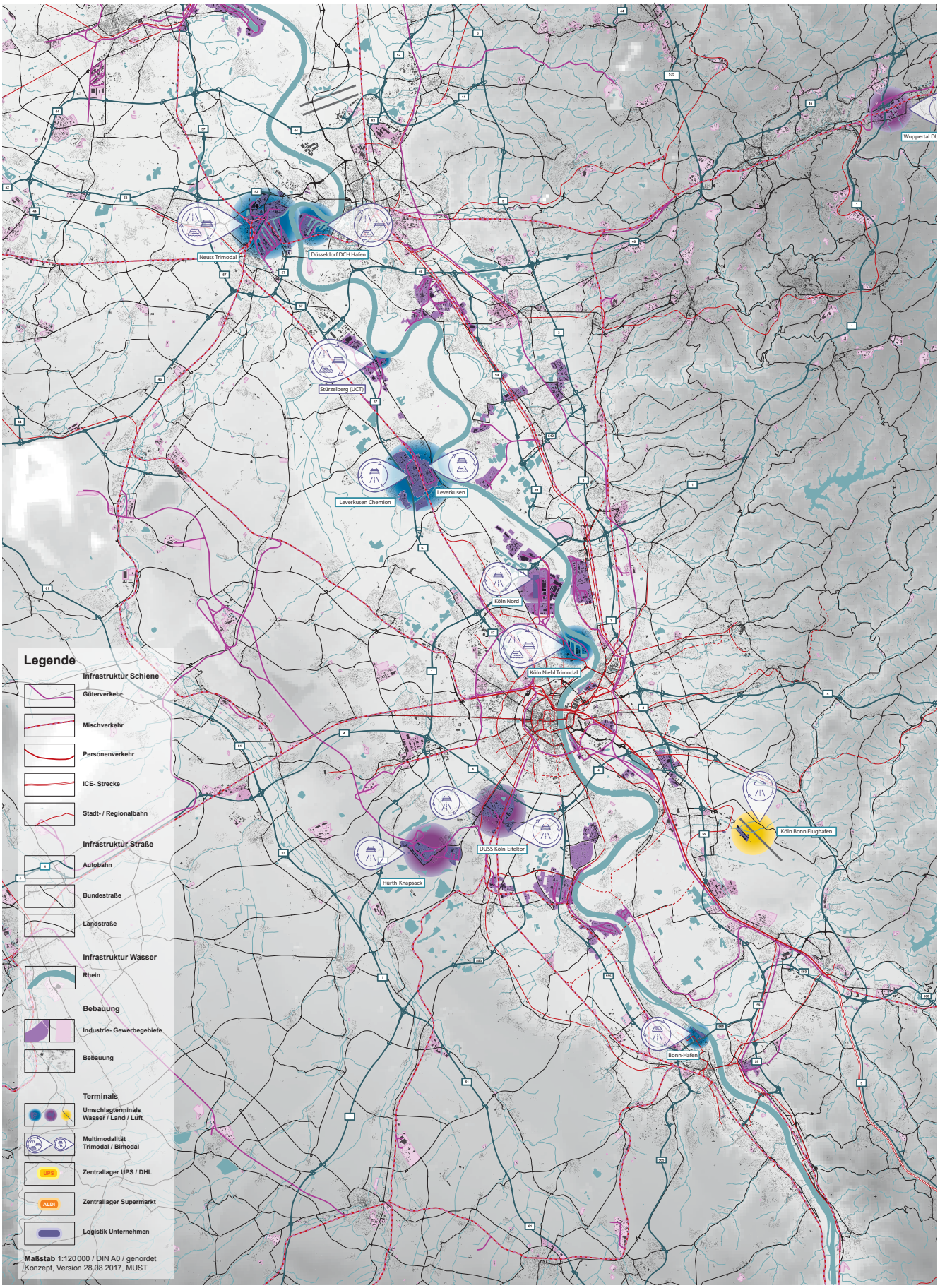


fig 53. The transport & Logistic System in the region Cologne/Bonn: application of the FLUXNET model

The third series of maps shows an analysis of already foreseen measures. These measures are mainly financed by the state (Bundesverkehrswegeplan). It is clear, that the foreseen measures are insufficient to deal with the expected growth of transport: extra measures will be needed.

STEP 2: EXPERT SESSION – VALIDATION

The results of step 1 were validated in an inter disciplinary expert session with (regional) knowledge of logistics, spatial planning and infrastructure planning. The exchange of knowledge was especially relevant as the fourteen participants of the workshop represented different organisations who have an interest in the topic: spatial planners, representatives from harbour and industrial logistic companies, infrastructure planners and providers as well as scientists. The discussion in the first block of the expert meeting resulted focussed on the analysis of the transport and logistic system. This resulted in the following recommendations:

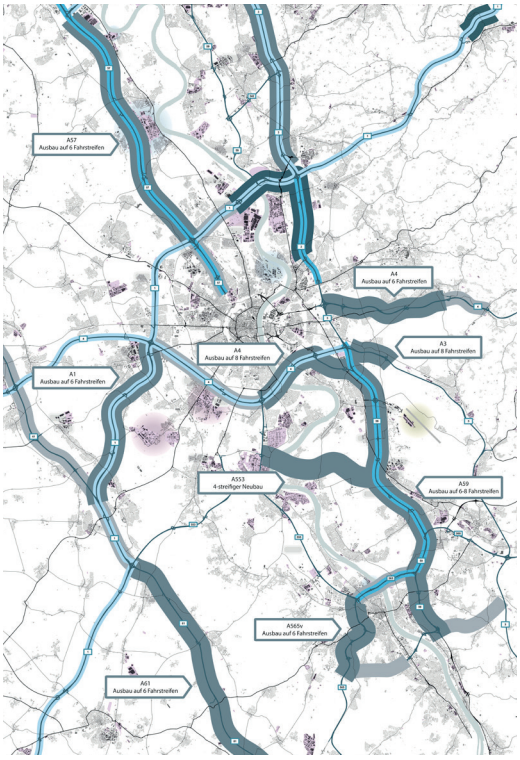


fig 54. Overview of bottlenecks (small lines) and foreseen measures (thick lines) for the highway network

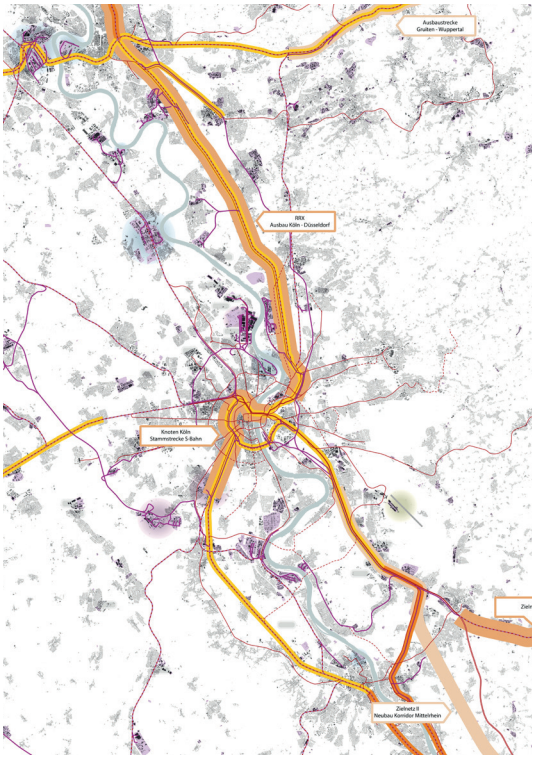


fig 55. Overview of bottlenecks (small lines) and foreseen measures (thick lines) for the rail network

+ FLUXNET scheme: there should be made a clear difference between industrial logistics and end user logistics. In the current scheme for the region, the industrial logistics chain should become more clear;

+ Data on flows: there are no good public data sets that give insight in the flows between different nodes in the transport and logistic system. Specific data are only available within transport and logistic firms and not open for public use, due to business competition reasons. The discussion made one thing clear: what the appropriate and necessary data sets for analysis of a logistic system in a region are, is still an open question. The issue of the source for the analysis is an issue further to be discussed. Different actors (e.g. Bundesministerium, IVV, harbour of Rotterdam, Ministry of Infrastructure and Environment NL) use different scenarios and data for their analysis, resulting in different views on the future challenges. A proper analysis, should take the following aspects into account:

    - Corridor level: the problems in the region are partly caused by developments on corridor level (ZARA harbours). It is important to involve these developments into the analysis of (future) bottlenecks;

    - Logistics & Transport sector: the sector itself is also developing, resulting in new flows of transport in the region. These flows should be considered;

    - Growth in the region: the foreseen growth of people and economy in the region will enlarge the pressure on the infrastructural network. As people and cargo transport are competing for the same infrastructure, this component should be an integral part of the analysis.

+ Political dimension: the theme of freight and logistics is not high on the agenda of local politicians. Logistics is being associated with delivering no local taxes, environmental problems, absorbing lots of space and huge, unattractive buildings. The question is: how can transport and logistics achieve a higher status in the political discussion and consequently in the spatial planning? Existing logistic areas are being put under pressure by other functions like housing. There is hardly any space in the urban core area for new logistic centres.

+ Time dimension: due to the pressure on the cities, people are forced to go and live outside the core urban region. Due to the overloaded infrastructure system, the increasing travel time is becoming more and more a societal problem. centres.

STEP 3: EXPERT SESSION – OPTIMIZATION

In the second block of the expert session, the opportunities for optimizing the network and spatial development were being discussed. The FLUXNET team prepared a series of possible interventions to improve the transport and logistic system in the region, based on the principles from the FLUXNET toolbox. From the toolbox, the following principles were being discussed:

Optimize a terminal

+ Principle: re-organisation of the terminal. Can existing, highway oriented terminals in the region be transformed into multimodal terminals by connecting them to the rail system?

Add a terminal

+ Principle: moving / adding a terminal.
    - regional inland distribution centres or ports: are there opportunities to add new multimodal terminals along the Rhine?
    - urban consolidation terminals; are there opportunities to create urban consolidation centres at the edge of Cologne and Bonn?

Optimize infrastructure

+ Principle: Overcoming physical obstacles. Needs the Rhine to be deepened?

+ Principle: Use of networks for cargo transport in peak-off hours. Does it make sense to use the urban rail network in Cologne and Bonn at night for transportation of goods? And is there still capacity at the national rail network at night?

+ Principle: Dedicated lanes - Separating freight and cargo transport within existing infrastructure. Are there possibilities, besides the foreseen measures in the Knotenpunkt Köln project, to further separate person and freight transport on the rail network?

Add infrastructure

+ Principle: Expanding the existing system by adding a new rail track dedicated for freight transport. What are the chances of adding a new rail track for freight transport outside the urban conglomerations?

+ Principle: Introducing new types of infrastructure. Are there opportunities for introducing new tube systems in the region?

Optimize a mode

+ Principle: Synchromodal transport. Are there opportunities for synchromodal transport in the region?

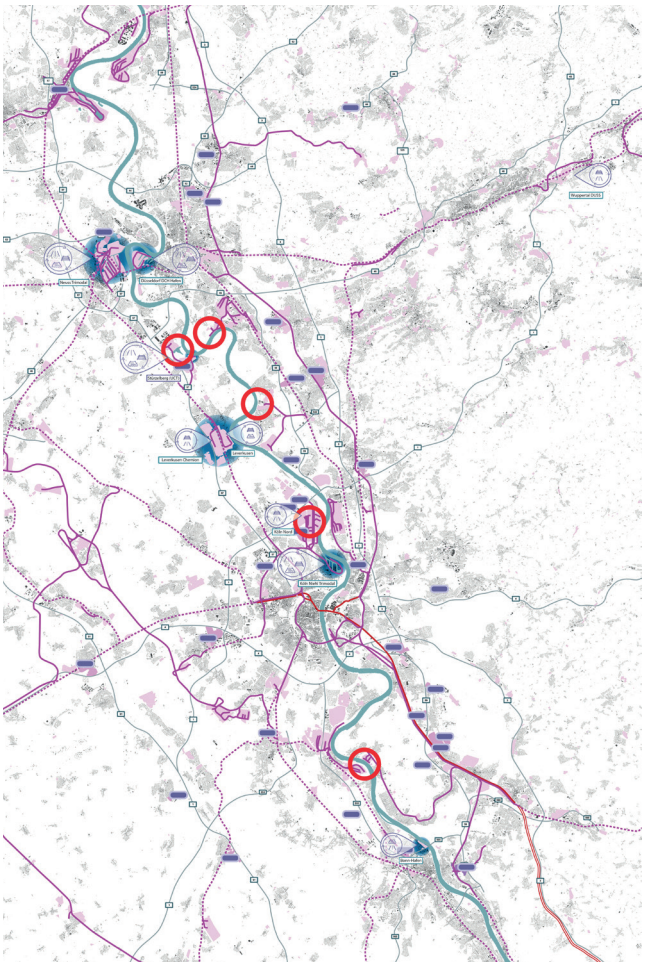
Add a mode

+ Principle: adding new types of transport vehicles to the existing system. What are the views on the concept of the High Speed Cargo train concept?

The proposals were meant to foster the discussion. The following points were derived from the discussion:

+ Application of the toolbox: at the end of the discussion, the steps in the toolbox appeared to be a good way to structure the discussion about possible measures. However, it was clear as well that some measures were not applicable to this region. For example, the idea of shifting transport to off-peak hours was considered to be utopic as there is no more capacity, not even at night, on the network.

+ Orgware measures: the measures in the toolbox are dominated by physical



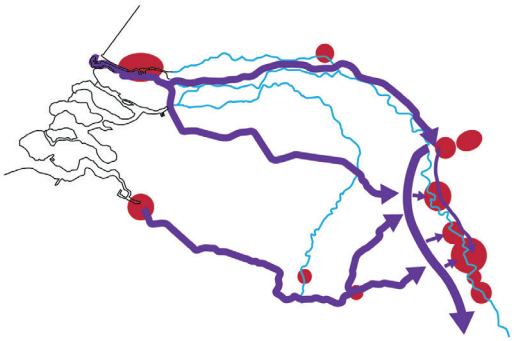


fig 56. Potentials for a new cargo rail track outside the urbanized region

fig 57. (left) Potentials for new terminals along the Rhine

(infrastructure) measures. The advice is to add some organisational measures to the toolbox.

+ Factor time: the pressure on the infrastructural system forces people to live on the "second and third row" in the region. This leads to longer travel times. Measures should also be aiming at reducing travel time.

+ Strategical plan: the participants concluded that a regional, strategical plan for transport and logistics, considering person transport at the same time, would make sense. This plan should put the optimization of the existing system by simple measures in the font.

+ Responsibilities: A major issue along the whole workshop appeared to be the responsibilities of different authorities ("Zuständigkeiten"). For example: the regional plan can identify locations for logistics. However, if these spots are really being developed as such, depends on the local community. Furthermore, spatial planning and infrastructure planning are not integrated. This is illustrated by the fact that traffic model needs for a new housing or working location cannot be based upon assumptions how a location will be developed. Instead, they are based on the current situation, which usually is an empty field. Finally, the decision upon investments in infrastructural measures lays by the state (Bundesverkehrswegeplan), not by the land NRW or the region, making an integral strategy for infrastructural and spatial planning more difficult. It was being recommended to analyse into deep the different responsibilities ("Zuständigkeiten") and juridical conditions by looking at a specific case, for example the renewal of the bridge in Leverkusen.

STEP 4: STRATEGY DEVELOPMENT

The results of the Test Bed Cologne are being used as input for a new regional plan that is currently being produced in the region, the so-called Agglomerationskonzept Region Köln/Bonn.

STEP 5: IMPLEMENTATION

In the framework of the Agglomerationskonzept Köln/Bonn, the discussion about the proper planning instrument for implementing the vision, will follow.

NORRKÖPING

02. 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 development 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.

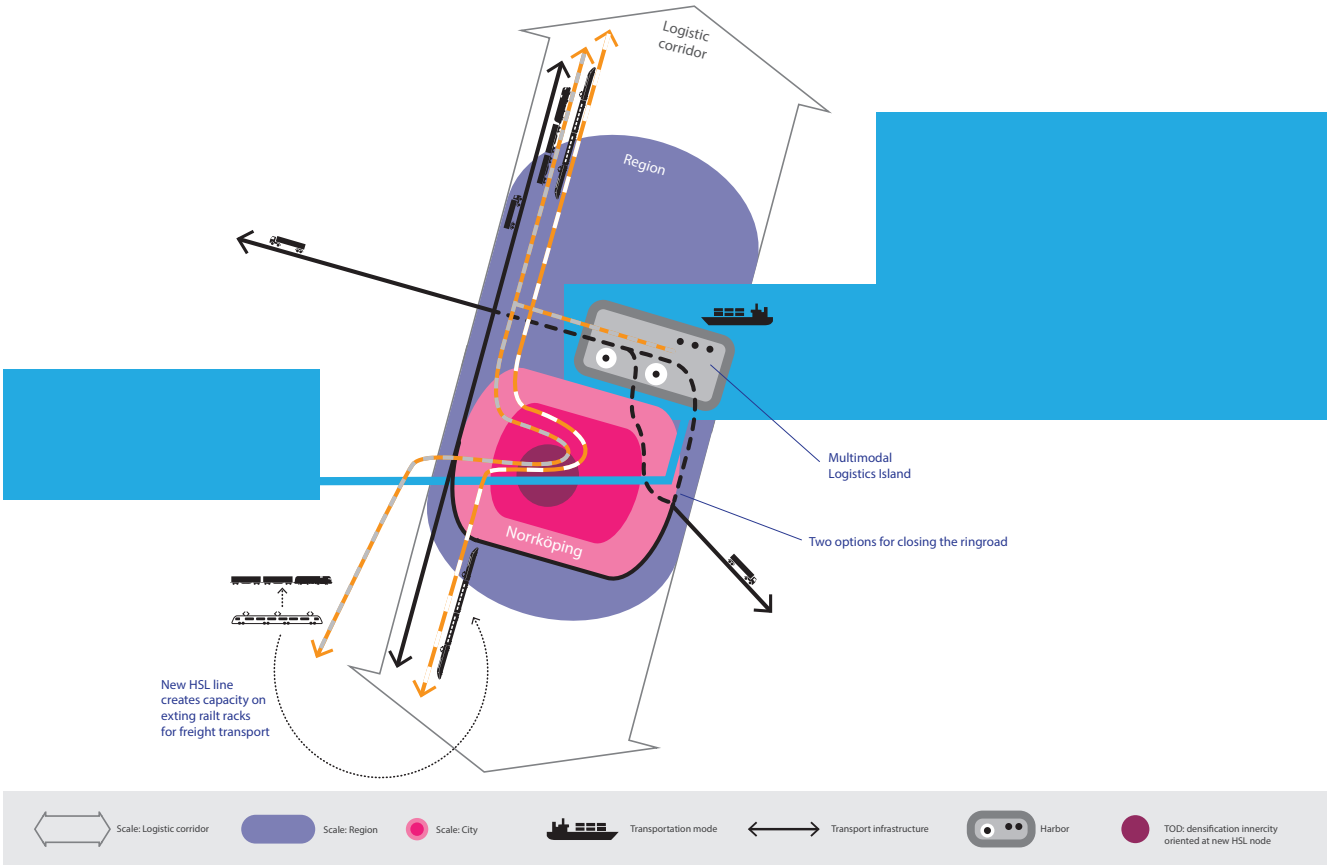


fig 58. Application of the FLUXNET model on the region of Norrköping

CONTEXTUAL FLUXNET MODEL AND TOOLBOX APPLIED

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.

Multimodal inclusive infrastructure strategy

On a 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.

Harbour Island: regional concentration strategy for logistical functions

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

infrastructure by improving synchromodal transport

Transit oriented densification

On a local scale the strategy is 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).

Ringroad: Balancing the interest and effects

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 centre 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.

STRATEGIC RECOMMENDATIONS

Cohesive vision across scales

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. The participants in the workshop concluded the strategy mentioned above should be included in a common vision on spatial development and mobility. 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 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.

ROTTERDAM

03. TEST BED ROTTERDAM

Rotterdam is strategically located in close proximity to the North Sea, which is one of the reasons why it is often referred to as the "Gateway" to Europe. Rotterdam is a large city with a well-equipped, modern port infrastructure, multi-modal accessibility and considerable volumes of goods and passengers. The location is favourable in several ways. They are well connected to the Randstad and hinterland by road, rail and inland waterway. There are highways to the other major cities of the country, being Amsterdam, Utrecht and The Hague. Furthermore, an efficient rail network is provided and used with high intensity (OECD, 2009).

CONTEXTUAL FLUXNET MODEL AND TOOLBOX APPLIED

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 (integrateion). 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?

New hotspots can enforce the relation between harbour and city

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.

Be prepared for the E-commerce spatial spin-off

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.

STRATEGIC RECOMMENDATIONS

Policy awareness

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.

New typologies

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"

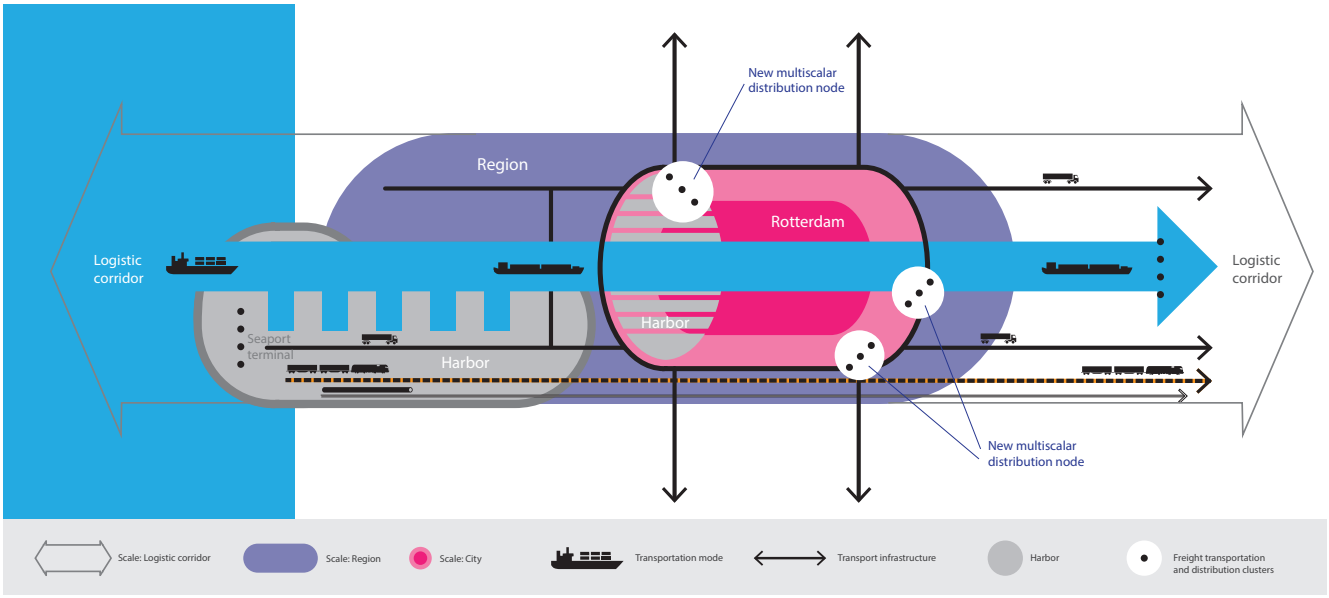


fig 59. Application of the FLUXNET model on the region of Rotterdam

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 downside

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.

MILANO

04. TEST BED MILANO

Lombardy is one of the wider regions in Italy and the most populated. It represents the main economic and logistics center in Italy. The region contributes for about 25% to the national GDP. In his territory are located important industrial, trade and financial bodies at national and international level. With Baden-Württemberg, Catalunya, and Auvergne-Rhône-Alpes, Lombardy is one of the "four motors of Europe" as intensely industrialized areas which cooperate in several fields to promote the social and economic development.

+ Lombardy has a dense, and relevant rail road network that connects the region with the main large cities in Italy as well as Austria, Germany and other central Europe Countries. Milan is the main node for long distance rail services and for rail high speed. Milano Malpensa Cargo is the main airport in Italy for national air cargo transport, with a share of 55% of the total handled in Italian airports, and sixth in Europe. In Lombardy, several terminals for rail – road intermodality are also located. One of the main challenges in the region is the strengthening of the capacities along the Rhine – Alpine corridor by the improvement of long distance services both for freight and passengers. The second goal are hinterland connections between industrial and logistics areas (intermodal terminals) and Ligurian ports (Genova, La Spezia, Savona).

+ According to the Regional Programme for Mobility and Transport (RPMT) of Lombardy (approved in September 2016), cargo flows are mainly transported by road, covering almost 93% of total cargo flows involving the region. Over 50% of that share relates to domestic transport, while the portion related to international traffic is below 3%. Excluding the flows within Lombardy (about 49% of the total), rail transport represents approximately 14% of the total. The role of the railway is more significant when focusing on the modal split of the international cargo flows. On these routes, in fact, the railway represents 67%. Most international railway traffic is formed by intermodal transport (approximately 62%).

CONTEXTUAL FLUXNET MODEL AND TOOLBOX APPLIED

Improving the connections on corridor level

An important conclusion of the workshop is that especially the freight flows on the corridor level, can have a high impact on the transport and logistic system in the region:

+ The share of the Genua seaport in the total transport flows is low. More than 30% of the cargo flows in the Lombardy region is coming from North european sea harbors. The connection between the seaport of Genua and the regions along the corridor in Germany, as well as the the inland terminals offers still a lot of room for improvement;
+ The construction of the Gotthard Base Tunnel is expected to have a major impact on the modal shift. A growth of 200% in tons by rail transport is expected on the part of the corridor between Germany, Switzerland and the Lombardy region;
+ The infrastructural investments in Switzerland, push investments in the rail network of Lombardy. The improvements are primarily focussed to improve the freight transport by rail but have a co-use for person transport;
+ The transport by air has a low share in the total volume of the transport in the region (0,2% of the logistic volume) but a high economic value (22% of the GDP);
+ As far as multimodality is concerned, air transport is hardly compatible with train logistics: the highly valuable goods need to be transported fast, in low volumes whereas the transport by train focusses at big volumes and relatively long transport times. The growth of the transport by air must be followed by improvements in the highway connections in the region.

Connecting infrastructure and terminals on regional level

The existing transport and logistic system cannot accommodate the expected growth of cargo flows. In the workshop following suggestions were made:

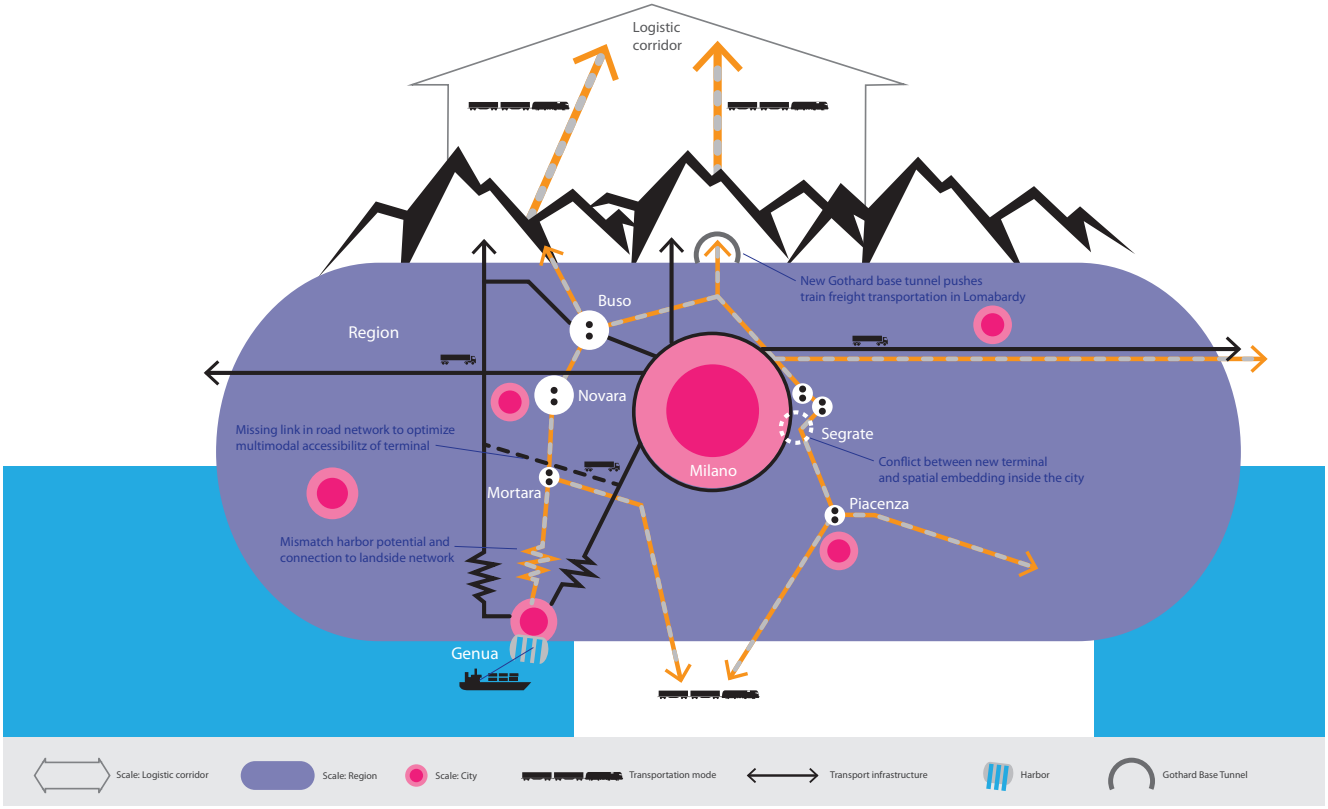


fig 60. Application of the FLUXNET model on the region of Milano

+ Multimodal corridor terminals with proximity to the urban centres have the highest development potential, as they generate more added value.

+ New typologies are needed! Most of the potential locations for new multi modal terminals (e.g. Gallarate) are in a highly-urbanized context, resulting in conflicts between city and logistics development. This asks for smart urban design solutions that ensure a good spatially embedding of the new terminals in their urban context;

+ The regional planning body cannot stir developments of terminals, as many of them are in private hands. Therefore, their focus is on stirring the flows by the planning of infrastructure;

+ To improve the multimodal performance of the region, sometimes the connection by road needs to be improved. The Mortara freight village for example needs a better connection to the highway.

4. Conclusion & Recommendations

CONCLUSION: LOGISTICS SHOULD BECOME PART OF AN INTEGRATED PLANNING APPROACH

The trends discussed in this research indicate the growing importance of interlinkages between land-use, logistics and infrastructure and the need for an integrated approach. 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. 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 are valuable in finding opportunities for improving spatial and network performance (mobility, living quality, environmental quality, etc.). On basis of the research results the following conclusion can be given.

The 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.

On basis of the FLUXNET research, we give the following recommendations for further exploration:

01. LOGISTICS ORIENTED DEVELOPMENT (LOD)

The Test Bed applications show 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" that are valuable strategies prom a persons mobility perspective. In chapter 2 we have redeveloped these strategies, including the logistics topic in the strategy called "Logistis Oriented Development (LOD)". However we have to explicitly state LOD is still a concept that was only tested in this research.

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 further developing LOD. The toolbox presented in this research is a good base for the development of LOD, however is should be seen as a first demo version. It still has to be developed into a validated and tested strategy. We advise to continue the development into a strategy. We propose to further develop LOD by broadening the topic by, for example, additional Test Bed. But more important to go deeper in a living-lab setting: a cohesive geographical entilty (for example a segment of a corridor) where the strategy can be developed, tested, and evaluated over a longer period into detail.

Recommendation: The LOD strategy should be tested and further developed in a follow up practise based research to become fully valid and operational.

02. 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 currently. An integrated planning approach will feed the need for new and more integrated (spatial) typologies. This new generation typologies should be based upon network position, relation to urban areas, and spatial appearance. 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. In our opinion the new typologies should not only be driven by the logic in the logistical system but also innovate on the following issues:

+ Smart usage of spare capacity in the mobility network – including person mobility
+ New relations with labour market
+ Innovative, synergetic mix of functions
+ Innovative, synergetic spatial appearance

During the FLUXNET research we encountered a series typologies in which a combination of spatial, mobility and logistical challenges are represented in such a way that it represents trends occurring across Europe. FLUXNET would like to address the following preliminary typologies.

SMART CORRIDOR-CITY HUBS

Across Europe we see the pressure on Urban Ring roads increasing. Freight from the corridor is using the infrastructure, it is an attractive location for regional terminals and it is the backbone for urban mobility and logistics. In many regions, these are area's that are rapidly transforming in order to meet a need for housing or to improve environmental quality. In the FLUXNET Test Beds, the Smart Corridor-City Hub is concluded to be a concept that can facilitate the development of a region

COMPETITIVE MEGA HUB – URBAN REGION

If we take into account the future competitiveness of mega hubs such as large harbours we can conclude the relation with the city and the urban labour market will become an important asset for an harbour. 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 Europe can be identified. This can be addressed to the development of technology/robotisation and implies a strong link between highly skilled (urban) employments. a trend in which a logistical mega hub and urban development are closely interlinked. 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. The "Competitive megahub-urban region" concept builds upon "terminals" with and excellent urban quality for highly skilled labour and the efficiency brought by the megahub will lead in a renewed competitive advantage in the future.

fig 61. Visualization of an architectural design for big boxes

fig 62. Spatially embedding big boxes in the region is a big challenge

BIG BOXES IN THE REGION

Trends such as the boost of E-commerce can lead to XXL warehouses serving urban agglomerations. The location and position the mobility can firmly influence network performance (capacity, robustness). Currently this development is not coordinated. In many situations, there might be little incentives for issues such as multimodality, sustainable land use, end-user proximity, network robustness (multi-modal) since there are no incentives In the current functioning of the network and planning network. This can result in a development boom in uni-modal locations instead locations with a proximity to the region and multi-modal connectivity.

SPATIAL EMBEDDING DESIGN

In many situations, we observe a lot of societal resistance against traditional logistic typologies (terminals, big boxes, etc. The development of technology gives the opportunity to integrate the function of a terminal with other types of land-use. Examples are the combination between a terminal and a campus, traditional shops that also serve as an urban terminal for city logistics. Another example can be an Urban transit point on a corridor ring road (transferium) that serves a modal shift for person in the last mile but is also an urban consolidation point.

By means of spatial design the spatial appearance could become embedded into the local spatial context and could result in an improved spatial quality, better stakeholder involvement and more societal acceptance of these type of land use.

Recommendation: we recommend to start developing and experimenting with a new generation of typologies in order to deal witch the challenges logistics, infrastructure and spatial development face.

03. THE ROLE OF AN NRA

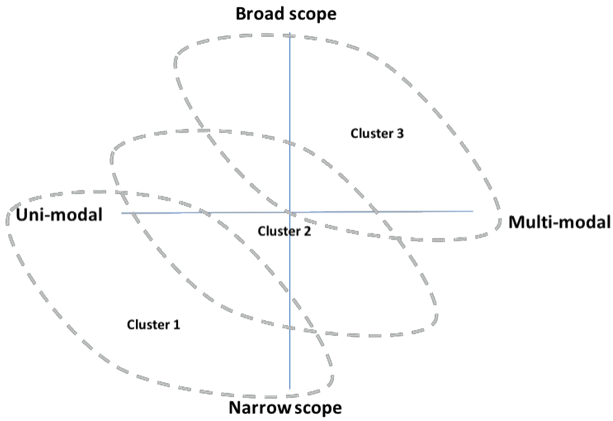


fig 63. Different roles of NRA's

The NRA's in Europe differ a lot. Some are uni-modal (highway) and some have become multi-modal (like for example Trafikverket). Also, the scope of an NRA's activities ran vary quite a lot. In many situations, we see tradition scopes that focusses on maintenance and project management become broader and start including environmental issues, economy and spatial issues. We think the insights from the FLUXNET project can be helpful to NRA's on every position in this diagram:

A. Cluster 1, the uni-narrow positions: The FLUXNET insights can help an NRA to better understand the interests of stakeholders (like logistical organizations, regional or local planning authorities or infrastructure authorities. In this case, the FLUXNET toolbox can be used as a stakeholder management instrument to improve understanding and relations.

B. Cluster 2, the mid-positions: The toolbox can be used for project management as a scoping instrument to identify synergetic scopes

C. Cluster 3, the multi-broad positions: The toolbox can be used as an integrated planning instrument in order to achieve societal goals.

Recommendation: we recommend paying special attention to the difference in roles of the European NRA's in the implementation of LOD

04. EUROPEAN PLANNING VEHICLES

Recommendation: LOD approach should be integrated into European and National investment and planning instruments. For example:

+ TENT-T guidelines
+ SUMP
+ Ladder of sustainable development

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