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SPINTRENDS

Overview of future trends in mobility and spatial development

Overview of innovative measures / concepts to deal with growing mobility demand

May 2019

V02

IMPRESSUM

Title	SPINTRENDS Overview of future trends in mobility and spatial development Overview of innovative measures / concepts to deal with growing mobility demand
Project number	867460
Revision	v02
Date	22.05.2019

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1 INTRODUCTION

1.1 Context

The European transportation network represents a backbone of our daily life. However, the use of road networks has changed over years and transportation infrastructure is faced with new challenges. In order to enable future-proof road networks strategic plans (like CEDR Action Plan and EU Policy) were developed to address already started and future trends affecting mobility of persons and freight.
Societal and economic trends and conditions are leading to changed requirements. Ongoing trends, like urbanization and e-Commerce are prominent examples highlighting effects with mobility growth in urban areas, leading to bottlenecks in Daily Urban System (DUS). The mobility growth leads to increasing use of networks and congestion of the road network, resulting in more users than the (existing) network can handle. Urban regions have an important role here with high mobility demand and attracting mobility of both person (commuters) and freight (logistics). This includes urban and spatial development based on drivers from policy, economy society and technology.

In this context, the Conference of European Directors of Roads (CEDR), launched within its research programme the Call 20 17 Collaborative Planning of Infrastructure Networks and spatial Development with three sub-themes:

A: Exploring effective approaches for future-proof road networks based on trends in mobility and spatial development
B: Planning and designing the interface between (trans)national road networks and local transportation ('last mile')
C: Assessing the added value from spatial development as a factor in infrastructure planning.

The main issue of the call, and focused by the project SPINTRENDS, is to identify the mobility related tends and explore effective approaches of collaborative planning for future-proof road networks. Therefore, SPINTRENDS is designed to assist the European NRA's with a vision document and a roadmap that will empower the NRA's planning practice for a collaborative planning arena.

1.2 The project SPINTRENDS – a study on SPace and INfrastructure TRENDS

SPINTREND relates specifically to Topic A: Exploring effective approaches for future-proof road networks based on trends in mobility and spatial development. The overall objective of this project is to finally provide CEDR with a vision document and a roadmap toward a collaborative planning approach.

The research in SPINTRENDS builds upon a basic idea:

managing road networks (NRA) + managing demand of the future (spatial planning) = effective and future-proof road networks

This is accompanied by further hypothesis:

a) Applying innovative measures/concepts will result in robust road networks
b) Collaboration with other parties will be vital for future-proof road networks

Therefore, SPINTRENDS will help on the way towards a clear strategy for NRA's which enables them to make the shift from a reactive and controlling institution that focusses only on its own network, to a proactive NRA. Therefore, it is crucial to use a collaborative planning approach. This could a direct form of collaborative planning: the infrastructural and the spatial development are 'one project'. Another, more indirect form of collaborative planning, is characterized

by an optimal harmony between the infrastructural project and for example urban development that results in improved regional economic competitiveness or livability in region.

According to the DoRN's expected output five key results of SPINTRENDS were identified:

- **KR1: Overview of future trends** in mobility and spatial development
- **KR2: Overview of innovative measures/concepts** to deal with growing mobility demand
- **KR3: Vision** to support NRAs in their decision-making about managing their networks and influencing demand
- **KR4: Roadmap** that clarifies the route towards collaborative planning for future-proof road networks
- **KR5: Disseminating the results**

The overall approach (see Table 1 and Figure 1) for the research to tackle these issues puts practice based research in the centre. It consists of four content related work packages accompanied by the project management.

Table 1: Work packages and key results

Work package	Research objectives	Key result
WP1: Project management	--	--
WP2: Exploring trends in mobility and spatial development	Most up-to-date mobility and spatial development trends are explored, collected and understood to build the basis for the vision and the roadmap	KR1: Overview of future trends in mobility and spatial development
WP3: Exploring innovative measures / concepts	Innovative measures and concepts are explored and understood	KR2: Overview of innovative measures/concepts to deal with growing mobility demand
WP4: Compiling a vision document and a roadmap	A vision and a roadmap that clarifies the route towards collaborative planning for future-proof road networks are developed	KR3: Vision to support NRAs in their decision-making about managing their networks and influencing demand KR4: Roadmap that clarifies the route towards collaborative planning for future-proof road networks
WP5: Dissemination	Disseminate the projects result to raise awareness throughout the pool of stakeholders	KR5: Disseminating the results

Based on the outputs of WP 2 (KR1: Overview of future trends in mobility and spatial development) and WP 3 (KR2: Overview of innovative measures/concepts to deal with growing mobility demand), the expected vision document (KR3: Vision to support NRAs in their decision-making about managing their networks and influencing demand) will be compiled. These three key results will finally lead to the roadmap for collaborative planning (KR4: Roadmap that clarifies the route towards collaborative planning for future-proof road networks). The results of SPINTRENDS will be disseminated continously along the project timeline (KR5: Disseminating the results).

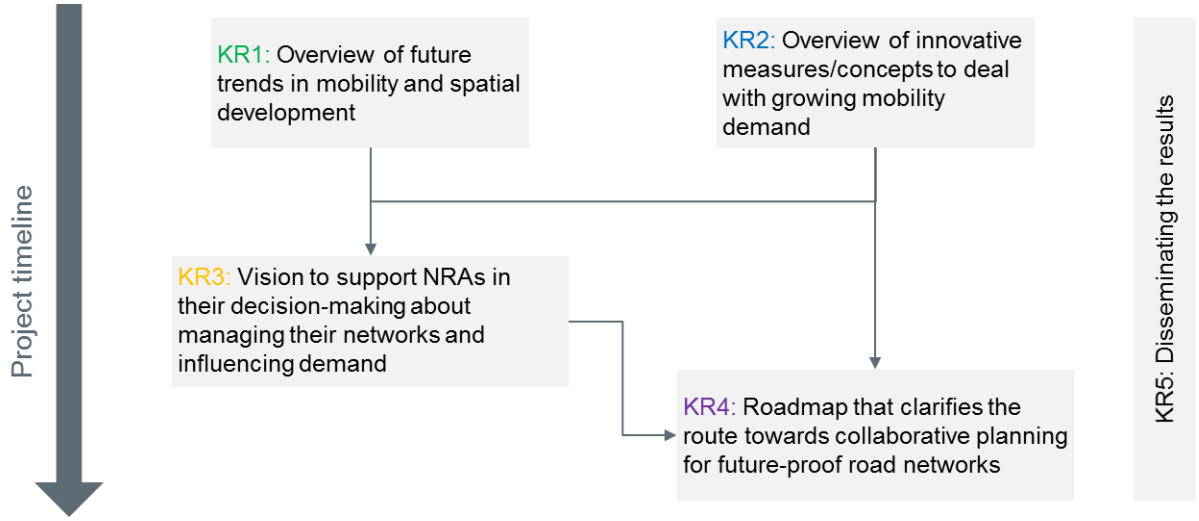


Figure 1: Overall approach of SPINTRENDS

The expected benefits from SPINTREND will contribute to the interests of NRA's directly and indirectly. The achievements will lead to an improved integration of various transport modes in the daily urban system in cooperation with integrative planning approaches. This may

- enhance the performance of highway networks. This improves their functionality as access modes to urban regions and as modes for long distance transport on the European Ten T corridors.
- contribute to the economic competitiveness and quality of living environment in urban regions. Together, these outcomes could strengthen NRA's social license to operate not only with a more integral scope but also across Europe, noticing the importance of the quality of the intra-European road network.

1.3 This report

The core of this report are the catalogues with trends and concepts from across Europe. However, in order to explore and analyze these examples in a structured way, first a research approach and a conceptual framework was developed. Chapter 2 of this report is dealing with the collected trends in mobility and spatial planning, while chapter 3 is dealing with innovative, generic concepts in the context of planning and managing road networks and demand management. Chapter 4 refers to the inventory of good practices study from the cooperative project SPINDESIGN. Chapter five finalizes this report with brief concluding remarks and a short preview towards the next steps of the SPINTRENDS study.

2 TRENDS

The focus of the trends study was to identify and describe major trends and related influence factors in mobility and spatial development. Finally, a structured overview of trends and interdependencies as a basis for vision development will be provided.

2.1 Research approach

The trends study consists of three main steps: collection of trend information, preparation of a catalogue of concepts, and compilation and preparation of a structured overview of trends.

Step 1: Collection of trend information

The first step is the collection of trend information and related factors affecting the trends in three essential areas for spatial planning. Based international screening of publications, policy documents and media, information on major trends in three core areas were collected:

- Mobility Supply: new technologies, modes and services
- Mobility Demand: behavior trends, societal trends
- Spatial Planning: transitions in planning cultures, institutional changes

Step 2: Preparation of a catalogue of trends

Step 2 aims at a structured analysis of the collected material and the clarification of open issues. At the beginning was a classification according to the related influencing factors of these trends into general dimensions:

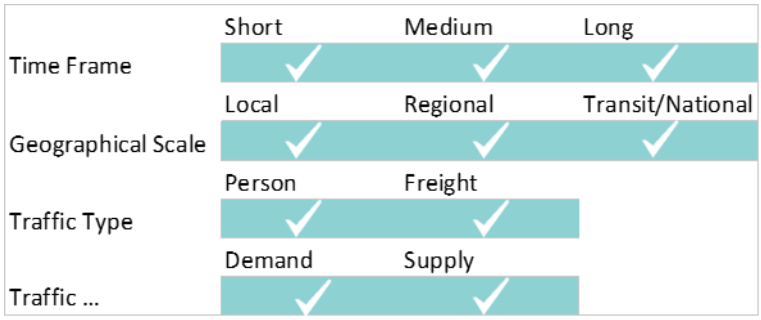
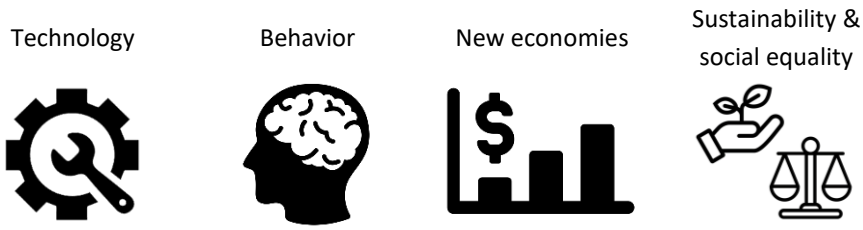


Figure 2: General dimensions for trends classification

Afterwards the various trends of the collection were assigned to four categories:



Step 3: Compilation and preparation of trends

The last step aims at preparing the material for the development of the vision and roadmap. To achieve this, all information will be consolidated, condensed and prepared in written and visualized form.

2.2 Catalogue of trends

This chapter presented the descriptions of the selected trends from three core areas of mobility supply, mobility demand and spatial planning. The following trends are included in this trends study:

- Technology:
  - Alternative Fuels
  - Autonomous and Connected Driving
  - Integrated Traffic Management
  - Using digitalization for new mobility concepts
  - Maintenance, renovation and renewal
- Behavior:
  - Urbanization
  - Active modes of transport
  - Multi-modality (passenger transport)
  - Synchromodal logistics
- New economies
  - E-commerce
  - Circular economy
- Sustainability & social equality
  - Demographic changes
  - Social inclusion
  - Changes in labour market
  - Environmental awareness, livability and climate

2.2.1 Technology

Alternative Fuels

	Short	Medium	Long
Time Frame	✓	✓	✓
	Local	Regional	Transit/National
Geographical Scale	✓	✓	✓
	Person	Freight	
Traffic Type	✓	✓	
	Demand	Supply	
Traffic …		✓	

Technology

Global warming is one of the major challenges in the 21th century. Traffic, especially motorized private transport with private cars account for a large share of the global CO_2-emissions. As the kilometers driven do not seem to decrease in the near future, it is important to switch to more environmental friendly ways of transport. The electrification of the drive train is inevitable to guarantee a more sustainable transport in the future.

Especially in Europe, the switch to electric vehicles seems necessary, as after the diesel emissions scandal several cities started to think about banning cars which do not meet certain standards from their centers (BNEF 2018).
The European Commission already detected the necessity to act and committed to the support of electric vehicle. For that reason, the EU finances a major part of the initiative “Green e-Motion”, which is involved in different activities around electric mobility. Partners from industry, utilities, electric car manufacturers, municipalities, universities and technology and research institutions are active in the Green eMotion initiative (EC 2018). The main objectives were

- Setting a framework for pan-European interoperable electromobility which is commonly accepted, user-friendly and scalable.
- Integrate smart grid developments, innovative ICT solutions and different types of EUs various urban mobility concepts.
- Enable a European wide market place for electromobility to allow for roaming
- Providing a unique knowledge base

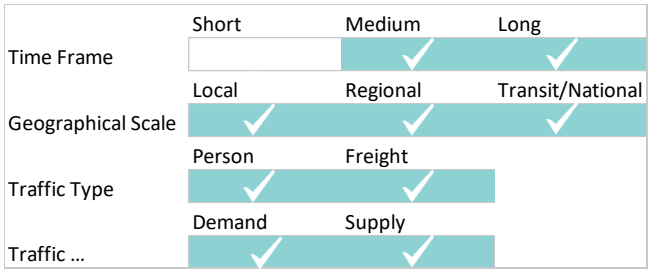
(Green eMotion 2018)

The predictions for reaching the goal of a fully electrified vehicle fleet are not consistent in different publications. The PWC report “Five trends transforming the Automotive Industry” estimates for example, that by 2030, 55% of all new car sales in Europe will be fully, and up to 95% partly electrified (Kuhnert 2017, p. 27).
In the Bloomberg New Energy Finance “Electric vehicle Outlook 2016”, an electric vehicle share of 14% of all passenger vehicle sales is predicted for 2025 in Europe. Globally, a 55% electric vehicle share is estimated for 2040. With the increased sales volume, also the number of electric vehicle models available on the market is going to increase from 155 in 2017 to 289 different models by 2025 (BNEF 2018).

The increasing number of electric cars requires an appropriate, demand oriented charging infrastructure along the road network. In urban areas, this network is quite dense in most of the Western European countries, while in rural areas there is still a lack of area-wide charging infrastructure. On the highway network there are some initiatives to ensure the possibility of charging over the whole network. As the predictions of the future number of electric cars vary on very broad scale, there has to be a two step approach when implementing charging infrastructure. In a first phase, an area-wide coverage of basic charging infrastructure should be ensured to enable the use of this car type independent of destination and route. In the second phase, the infrastructure has to be successively expanded and consolidated in line with actual demand.

Electricity is the most popular type of alternative fuel right now, but there are also others. One of them is Hydrogen. It is not a very widely known option and it is developing very slowly though it can be one of the least emissions causing fuels. The hydrogen infrastructure is at its early phases and is evolved in Germany, the UK and Scandinavia. Hydrogen can be installed anywhere, because it is made through electrolysis, that only needs water and electricity (TMR 2015).
ITM Power in the U.K. specializes in extremely clean hydrogen fuel, that powered by wind and solar energy. The costs are 10 British pounds (€11,56) per kg, about four times as expensive as gasoline. If these costs are reduced, hydrogen could be competitive within a decade (BI, 2016).
Since 2013, when the hydrogen vehicles first came out commercially, a total of 6,364 hydrogen fuel cell vehicles were sold worldwide. Moreover, hydrogen fuel cell vehicle sales in 2017 were almost double the total sales in the previous years. This is published in the report, "Hydrogen Fuel Cell Vehicles - A Global Analysis, March 2018." Based on the article, a respectable hydrogen fueling ecosystem will not be ready until 2020. By 2021, at least 11 automakers will have rolled out hydrogen fuel cell vehicles, including Toyota, Lexus, Hyundai, Kia, Honda, Mercedes-Benz and BMW (R&M 2018).

Autonomous and Connected Driving



Autonomous Driving:

One of the most disruptive innovations of the future of mobility are autonomous vehicles. While some vehicles with automated features are already available, the time of implementation of autonomous vehicles with no human interaction can still not be predicted precisely.
To have a common definition of the automatization of vehicles, the Society of Automotive Engineers (SAE) developed the standard J3016 (see Figure 3). This standard also helps to understand the evolution of autonomous driving, from the past until now but also into the future.

It is estimated, that 40% of all miles driven by private persons in Europe will be automated by 2030 (Kuhnert 2017). Another publication predicts that by 2040, 80% of the mileage in urban areas will be performed by autonomous and shared vehicles (Goodall 2017).
The autonomous vehicle has the potential to change the transport system radically. To direct the development in a favored direction, action is needed. Governments, city councils etc. must work out regulations, for example in the fields of safety, data use and privacy (Goodall 2017). Additionally, there must be policies to avoid that driverless cars are moving around without passengers. The aim has to be that cars are used more effective, which means less cars but more rides per car. This will result also in a less demand of parking space. One solution therefore are sharing concepts, describes in detail later in this report.

With the implementation of autonomous vehicles, also the transport infrastructure has to change. The integration of the vehicles with the transport infrastructure is crucial for an effective operation of autonomous mobility. Therefore, traffic signal control systems, parking information systems etc. have to be developed and respectively adapted. Autonomous cars will likely be connected with each other and with the infrastructure. This brings a lot of possibilities, but also concerns about privacy and data security (Casey 2018).

Therefore, autonomous driving will have a major impact on:

- Changes in the value of travel time
- Issues for the period of "mixed traffic" (conventional and autonomous cars side-by-side)
- Infrastructure issues

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Figure 3: SAE levels of automation according to SAE J3016 (SAE, 2018)

Connectivity

Vehicle of the future will not only be autonomous, but necessarily also connected with each other and the outer world (e.g. KPMG 2018) with the help of internet connectivity. This means, that cars can communicate with each other, but also with the transport infrastructure such as traffic lights (Kuhnert 2017 p. 7)
This connection can happen in two ways: either embedded with a built-in antenna and chipset or tethered using hardware to enable a connection via smartphone. The integration of apps is also becoming more important. One example is Google Maps, which started to replace built-in GPS-systems (Maola 2016).
As different surveys show, the interest of costumers on connected cars is growing. The consultancy McKinsey found in 2014, that for over a quarter of car buyers, connectivity is more important than other features like engine power or

fuel efficiency. According to Business Insider UK, 62% of costumers in the U.S. are aware of the term “connected car”. The trend to connected cars appears also in forecasts: 82% of all cars shipped are expected to be connected in 2021 (Maola 2016).

Both, automated driving as well as connectivity, has its own advantages and can help to improve the mobility system in the future. But there are much more possibilities when combining automated driving and connectivity to ensure automated connected driving – this will make it possible to exploit all advantages.

Integrated Traffic Management

	Short	Medium	Long
Time Frame	✓	✓	
	Local	Regional	Transit/National
Geographical Scale	✓	✓	✓
	Person	Freight	
Traffic Type	✓		
	Demand	Supply	
Traffic …	✓		

Technology

Focus is on:

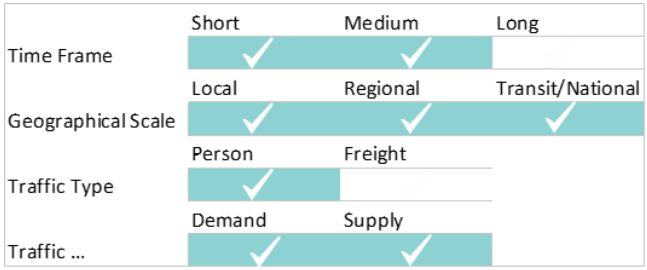
- Multi modal
- Municipalities, provinces, transport operators
- System-aware routing

Integrated transportation and traffic management are key elements of the multimodal transport networks of the future - giving each operator the ability to more effectively manage and convey information about their systems to their travellers (CUBIC 2018).
In just a few years, traffic management has been changed from a regular, passive task for the highway authority to a significant policy device. Traffic management has improved the safety and operations on highways as well as urban road, while it is moderately economical, flexible and quickly deployable. One issue is that there are often different transport operators for the urban and the rural area as well as for the different modes of transport. This means that a smooth cooperation is needed to ensure a seamless traffic management system.

Technological innovations in the field of traffic information, driver assistance systems and interventions in hazardous situations will make it possible to develop further traffic management innovations. For example, the widespread possibilities supplied by the conversation between in-vehicle and roadside systems. New cooperative systems will be platforms for services beyond traveler information alone – like individual guidance, routing, hazard warnings and crash avoidance. Given a sufficient penetration within the particular vehicle fleet, new traffic management systems will become possible due of the presence of increasing proportions of probe vehicles with increased accurate positioning data resulting in preventative intervention. Secure and convenient financial transactions may also be possible through such a platform, useful for any kind of pricing mechanism desired in the future (TRAFFIC QUEST 2012).

Integrated Mobility Platforms (IMPs) are a key solution to urban traffic management. By integrating different modes of transport, IMPs drastically simplify route planning and make traveling more effective, while being able to provide highly customer-tailored solutions. As an outcome, IMPs are being established all over the world, with various kinds of integration levels and value propositions (i.e., Citymapper, GoEuro, Google Maps, Moovel, Moovit, Qixxit, Rome2Rio) (ADL 2018).

Using digitalization for new mobility concepts



Mobility as a Service (MaaS)

The concept of mobility as a service is closely connected with sharing. In brief, the concept describes the shift from owning private vehicles to the consumption of mobility as a service. This service would offer both private and public transportations companies, as well as different modes of transport such as public transport, bike-sharing, taxis etc. It is generally provided via an application, in which the user searches for any route and gets suggestions for the best way in terms of time, money or other factors. An important attribute of MaaS is, that the user has to complete only one single operation for the entire trip instead of booking each transport mode separately (Goodall 2017).
Most probably, autonomous vehicles will play an important role for Mobility as a Service concepts of the future. As autonomous vehicle will be expensive, sharing them and using them only when needed seems a reasonable solution.
With the rise of alternative mobility solutions such as MaaS a few questions arise. MaaS may have the potential to make transport more efficient and comfortable, but there is also the risk of increasing traffic even more. Especially when using autonomous vehicles, a considerable amount of empty drives will take place, when autonomous cars are on the way to their next user. Therefore, it needs effective optimization algorithms to keep the number of empty trips as low as possible. On the other hand, individual mobility is getting much cheaper if owning a car is not necessary any more.

Sharing concepts

Sharing concepts are on the rise. Especially in mobility, sharing has the potential to solve some of the most urgent problems of the 21th century. Instead of owning a car, which is only in use for an average of one hour per day (Freese 2014 p. 10), people will choose their way of mobility and vehicle more flexible in the future. Sharing provokes a shift in today's understanding of an efficient mobility and will change the way people use vehicle nowadays. The concept of possessing a car may become outdated very soon.
Studies show, that half of car owners in industrialized countries are open to share their vehicles with others (Freese 2014). By 2030, more than one in three kilometers will be driven with a shared vehicle (Kuhnert 2017).

This tendency leads, of course, to some major changes in the usage of vehicles. Cars will be used much more intensely, which means that service and replacement cycles are going to be much shorter than they are now (Kuhnert 2017).
Sharing also have some social components: It makes mobility with cars more affordable, because it will not be necessary to own a car any more. Furthermore, especially shared autonomous vehicle will be highly accessible, as there is no driving license needed and even people who are not physically able to conduct a car will have the possibility to take part in shared, autonomous mobility (Kuhnert 2017).
Car sharing is not the only possible way of sharing in the mobility sector. Ride sharing is also likely to increase in popularity in the future. There are different approaches of ride sharing, for example sharing with private cars and private drivers or sharing with employed drivers (Freese 2014 p. 10).
Another interesting approach is shared parking. Nowadays, up to 30% of all the traffic in city centers are only attempts to find a parking space. Using private parking spaces in combination with a smart communication tool, this number can be decreased. Today, there are already some peer-to-peer solutions available in a few cities (Freese 2014, p. 10)

Maintenance, renovation and renewal

Time Frame	Short ✓	Medium ✓	Long ✓
Geographical Scale	Local ✓	Regional ✓	Transit/National ✓
Traffic Type	Person ✓	Freight ✓	
Traffic …	Demand	Supply ✓	

Technology

The majority of the European road network was built in the period 1960-1980. After the construction of the roads road traffic has increased significantly, but also the intensity of the use has increased. More traffic, closer to each other, heavier vehicles and heavier loads. In some situations, this has led to a situation in which the infrastructural objects are used more intensively than initially intended resulting in wear in the objects. There are examples of infrastructural objects across Europe failing to take the load the traffic puts on it. Examples are the A1 bridge in Leverkusen, the Merwedebridge and the bridge in Genoa. In many European regions renovation programs are currently executed in order to reinforce the infrastructural object. The renovation program's usually take significant budgets, sometimes even more expensive than newbuild since it takes a lot of temporary measures to keep traffic running. In Nordrhein-Westfalen for example only the bridges require an investment of many billions in order to keep them functioning.

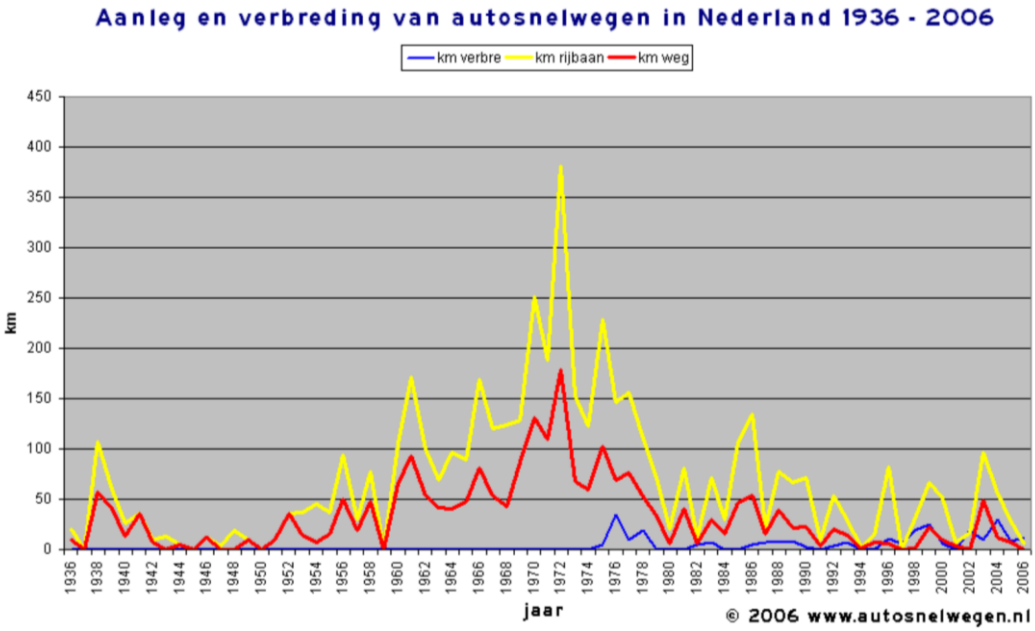


Figure 4: Majority of the roads in the Netherlands we constructed in the period 1960-1980

2.2.2 Behavior

Urbanization

	Short	Medium	Long
Time Frame	✓	✓	✓
	Local	Regional	Transit/National
Geographical Scale	✓		
	Person	Freight	
Traffic Type	✓		
	Demand	Supply	
Traffic …	✓		

Behavior

To growing urbanization will lead to an increased mobility demand in cities. Even today around half of the world's population lives in urban areas, and this number will increase even more in the future (UNFPA 2018b). The mileage will continue to increase therefore (Kuhnert 2017, p. 9). This will necessarily demand better mobility solutions in cities. A lot of European cities even now face the challenge of congestion and bad air quality due to too much traffic. In the future, better solutions will be needed to solve these problems.
The increasing urbanization will also imply denser urban areas with challenges on the environmental and spatial impact of logistics network. The spatial concentration of economic activity in cities lead to an increasing pressure on urban ring roads and roads into the city.
Due to the good public transport supply in urban areas, accompanied by various sharing concepts, there is a decrease in car ownership of city inhabitants within the last years in the Western hemisphere. Unfortunately, in rural areas there is the completely contrary trend as the public transport supply there is often not even a bit as good as in urban areas.

But not only the city center will be concerned by the growing urbanization. The concept of city-regions will get more important. A city region does not only include the city itself, but also the surrounding region. The inclusion of different spatial categories needs a new understanding for personal, but also freight transport. The result are de-centralized logistic facilities and therefore an extending transport network. This will be a major challenge for urban and transport planners in the future (mobility4EU).

At the same time, suburban lifestyles are adopted by more and more people. Considering the fact that spatial structure has a very strong influence on mobility demand, this fact leads inevitably to more traffic. Since the last few decades, the development goes from dense cities more to polycentric patterns and an increased level of urban sprawl (Rudinger 2006, p. 63).

Furthermore, a contrary trend is expected when it comes to land use. While density in the inner city is prioritized and the transport network in cities is about to face related challenges in terms of capacity, areas formerly used for transport/industrial purposes (ports, industrial areas) on the outskirts are freed up, which in turn can be developed (Poppeliers et al. 2018).

Active modes of transport

	Short	Medium	Long
Time Frame	✓		
	Local	Regional	Transit/National
Geographical Scale	✓		
	Person	Freight	
Traffic Type	✓		
	Demand	Supply	
Traffic …	✓		

Behavior

Active transport incorporates all modes of transport relying on human power for propulsion. The most familiar modes are undoubtedly walking and cycling, which account for 20-40% of all journeys made in the EU. Other less common modes are kick-scooters and skateboards, kayaking, skiing and running (Harvey, 2018).
The choice to use a cycle to commute is influenced by safety, awareness and direct trip-based benefits – especially for shorter distances. Other factors are the perceived health and environmental benefits, especially for longer distances.
All active modes will be affected by the existence of more cycle lanes. They have positive health effects arising from reduced toxic air as car fumes reduce. Additionally, actives modes are very common within multi-modal trip chains, especially in cooperation with public transport.
The projected increases in the number of elderly is likely to mean many more people using the less active modes (such as e-bikes) than the fully-active modes. Given this, e-bikes are likely to proliferate if they have a choice of power-only operational mode (EU 2019).

The trend in using actives modes is supported by the increasing number of sharing provider for various actives (or semi-active) modes like bike-sharing and e-scooter (electric kick scooter)
Bike-Sharing:
Bike-sharing systems are very popular and are now present in more than 1,000 cities worldwide. They will help making cycling more attractive. These schemes allow users to rent bikes for a short time period at small costs. Moving from ownership to a service-based rental model can be more convenient for users and removes some drawbacks of bike ownership such as maintenance costs and risk of theft. It can also be easily combined with other modes of transport within the Mobility as a Service (MaaS) model (2018).
E-Scooter (electric kick scooter)
Nowadays, the electric scooter-trend already reached some major cities around the world, such as Vienna, Brussels, Paris and Prague. E-scooters are eco-friendly, cheap and can probably help to solve traffic problems in city centers. European politicians are currently working on legislation around personal light electric vehicles, or e-scooter. This will open up the market in every country around the continent. Some experts mentioned that the worldwide micro-mobility market has the ability to grow to an astonishing 150 billion euro's in 2030 (Bicle 2019).

Multi-modality (passenger transport)

Time Frame	Short ✓	Medium ✓	Long
Geographical Scale	Local ✓	Regional ✓	Transit/National
Traffic Type	Person ✓	Freight	
Traffic …	Demand ✓	Supply ✓	

Behavior

Multi-modality is increasing in passenger transport over the last years, more and more trip chains are multi modal. This behavior change is often supported by new technologies.

To ensure a behavior change the issue of consumer acceptance must be taken into consideration. Travel behavior is a complex topic and depends on a great variety of different factors. There is also not only one kind of travel behavior change, but it can be categorized in mainly two types: Short-term-behavior, which means the variability in travel behavior from day to day and from week to week, and secondly the long-term development of travel behavior throughout people's life. Habit is the most important reason why changes in behavior do not happen. Therefore, behavior change measurements should target the formation of new habits to ensure long-term effectiveness (Scheiner 2018, p. 41).
The implementation of new technologies in mobility such as autonomous vehicles is not only determined by the development itself, but also by the acceptance of the future consumers. This fact is often underestimated by manufacturers as well as researchers. Users choices are often not easy to understand, because the individual choice of the means of transports is depending on a lot of factors like costs, comfort, but also prestige and peer pressure (Pankratz 2017).

Synchromodal logistics

Time Frame	Short ✓	Medium ✓	Long
Geographical Scale	Local	Regional ✓	Transit/National ✓
Traffic Type	Person	Freight ✓	
Traffic …	Demand ✓	Supply	

Behavior

A growing demand of flexibility of logistics leads to increased robotization on road, rail and water in combination with digitalization. Synchromodality enables "to choose among the best options not only in real-time but even in case the goods are already on track" (Prandtstetter et al. 2016: 2) and therefore fosters fast and efficient freight delivery. At the same time, good collaboration between the stakeholders is needed to put synchromodality into practice. This involves sharing data, liability issues and cross-border regulations, to name a few (Poppeliers et al. 2018).

2.2.3 New economies

E-commerce

	Short	Medium	Long
Time Frame	✓		
	Local	Regional	Transit/National
Geographical Scale	✓	✓	
	Person	Freight	
Traffic Type		✓	
	Demand	Supply	
Traffic …	✓		

New economies

Shopping faces a fundamental change in recent years, as the growth of technology (e.g. internet, mobile solutions, etc.) creates new opportunities. The Internet has evolved to an important sales channel for retailers. In the beginning of online shopping, it was considered to be unsafe and unsecured. This changed dramatically and nowadays it is considered as a very convenient and smart way to shop all over the world.
As a consequence of this, the market share of online shopping is increasing. In contrast, the share of traditional shopping is decreasing. From this one can deduce that there is an impact on both passenger and freight traffic. There is more freight transport towards homes, as in most cases online shopping includes home delivery of the goods. And there are less shopping trips, as they are substituted by these home deliveries. (Francke, 2015)
Due to the increasing number of logistic trips, especially on the last mile for home deliveries, there is the need for new logistic concepts. These concepts have to ensure a better consolidation and bundling process. Therefore, shippers must be encouraged to cooperate to enable consolidated deliveries.

The trends in our daily ordering behavior and consumption (eCommerce) also lead to increased competition in logistics and to competition for space and infrastructure. The focus here is on the necessary logistics areas and the proximity of the logistics locations to the city is becoming increasingly relevant.
In addition to the increasing demand for logistics properties close to the city, urban planning is also required in the area of delivery (for example loading zones). Loading zones are essential interfaces for efficient delivery in inner-city areas. The integrated planning of location, size and possible use (but also restrictions) of loading zones is essential to enable efficient and sustainable delivery traffic and to avoid negative effects such as traffic delays due to stopping and loading in second row.
The planning and availability of logistics areas is also essential in trans-regional planning. Integrated planning of spatial, logistics and traffic enables suitable concepts for areas and infrastructures to be provided for logistics.

Circular economy

	Short	Medium	Long
Time Frame		✓	
	Local	Regional	Transit/National
Geographical Scale	✓	✓	
	Person	Freight	
Traffic Type		✓	
	Demand	Supply	
Traffic …	✓		

New economies

Sustainable urban mobility will completely change the development and production. A current example for the mind shift is the development of a unique concept tire acting as air filter (Sustainable Brands 2018) which is inspired by the idea of circular economy.

Circular economy aims to reduce waste by reintroducing “waste” into the production once again as secondary raw materials. There is even a new business model which handles the ownership: “With the new “As a Service” business model – i.e. flexible part-time rentals – products remain in the ownership of their manufacturers throughout their entire life cycles” (Trend One 2018). The trend is towards including the costs attached into the product design.

One of the companies engaged in this area is Tesla which has a claim to handle battery waste correctly and therefore invests money in R&D. Meanwhile, Tesla managers founded a start-up called “Redwood Materials” which is a recycling company (CNBC 2018).

2.2.4 Sustainability & social equality

Demographic changes

	Short	Medium	Long
Time Frame		✓	✓
	Local	Regional	Transit/National
Geographical Scale	✓		
	Person	Freight	
Traffic Type	✓		
	Demand	Supply	
Traffic …	✓		

Sustainability & social equality

The change in demographics and especially the ageing of the society leads to a change in mobility behavior. The share of people over 60 of the world's population was already 12,5 percent in 2016, and this tendency is going to continue according to different estimations. In 2050, the share is going to be up to 22 percent (UNFPA 2018a). But people are not only going to become older, but also fitter and more mobile. This is going to lead to an increased demand of mobility of this age group in contrast to former times when people the older they get, the less mobile they were. To ensure social inclusion, transport providers will have to make sure in the future even more than today, that as much groups as possible can have access to mobility. Moreover, customers are demanding more than ever. Thanks to digitalization, personalized and accessible modes of transport will be common practice (mobility4EU 2016).
Another factor that will lead to an increased demand of mobility in the future, is the decreasing of household sizes in Europe. Furthermore, the working mobility will increase due to the increasing employment rate (IFMO 2008, p.34 f.).

Social inclusion

	Short	Medium	Long
Time Frame		✓	✓
	Local	Regional	Transit/National
Geographical Scale	✓		
	Person	Freight	
Traffic Type	✓		
	Demand	Supply	
Traffic …	✓		

Sustainability & social equality

Social and transport challenges due to demographic ageing, poverty, migration and geographical disadvantage will increase in the near future. The social role of transport needs to be incorporated into transport policies, with closer attention to the specific mobility needs of the most vulnerable user groups. Improved accessibility for the elderly and people with reduced mobility, as well as higher quality services and reasonable fares, must be considered, together with improved efficiency to keep public transport financially viable. In addition, new environmentally and energy-efficient public transport services and the promotion of their use are essential in order to reduce the negative impacts of car use. Addressing mobility issues related to social inclusion requires interaction between transport and welfare policies, which could result in more complex decision-making processes.
New transport technologies may support public transport policies in mitigating social exclusion and provide flexible cost-effective services. Increasing the involvement of private providers and NGOs with voluntary work may also yield low-cost solutions to specific needs. Given the increasing demand for greater attention towards the mobility and

accessibility needs of disadvantaged population groups and territorial areas, there is greater awareness at EU and national/local level of the importance of transport to social inclusion.

Various tools are available to support the policies, for example:
European Structural Funds can be used to promote integrated planning of transport and social inclusion policies and to support pilot projects addressing the accessibility needs of disadvantaged groups and areas. EU programs for innovation in the transport system (e.g. Horizon 2020) could prioritize EU funding to transport related research projects aimed at enhancing transport accessibility for vulnerable groups and promoting the dissemination of applied research results on transport planning. (EP 2015)

Changes in labour market

	Short	Medium	Long
Time Frame	✓	✓	
	Local	Regional	Transit/National
Geographical Scale	✓	✓	
	Person	Freight	
Traffic Type	✓		
	Demand	Supply	
Traffic …	✓	✓	

Sustainability & social equality

The labor market changed fundamentally in the 21th century, and this has also major influence on modern mobility. Productivity is increasing more and more through new developments and technology. Labor conditions therefore changed, employees are much more flexible today than a few decades ago. Working hours are getting also shorter, which will lead inevitable to more leisure trips. This changed conditions require more flexibility in mobility. Time, frequency, distances, new peak hours and flexible ticketing must be considered.

Environmental awareness, livability and climate

	Short	Medium	Long
Time Frame	✓	✓	
	Local	Regional	Transit/National
Geographical Scale	✓	✓	✓
	Person	Freight	
Traffic Type	✓	✓	
	Demand	Supply	
Traffic …	✓	✓	

Sustainability & social equality

People are getting more and more aware about topics like climate change, energy efficiency and the protection of the environment. This might lead to more sustainable patterns in individual mobility and to a rise in environmental friendly transport modes like walking and cycling, especially in cities. But apart from the private level, actions from policy makers are needed and will be taken most probably. Cars may be banned from city central zones and regulations and other actions against pollution might be taken. Car manufacturers will have to fit these new requirements, and the road infrastructure must adapt to this new vehicle technologies such as electric cars (mobility4EU 2016).

Urban conglomerations make a leap forward in mitigating climate change (such a decarbonizing transport, renewable energy production and CO2 storage) and adapt to the effects of climate change. Current developments put a strain on spatial quality, environmental quality and health (such as air quality and the accessibility of recreation and green areas). Especially near the metropolitan centers land is a scares and precious resource with many conflicting demands (housing, warehouses, infrastructure, industry, agriculture, nature, etc.). The growing importance of sustainability, health and living quality lead to stricter environmental requirements and put a strain on infrastructure. Under these circumstances new infrastructure projects have a low public acceptance, are very expensive and can decades to implement. Traditional planning approaches to infrastructure expansion no longer seem able to deal with this.

3 CONCEPTS

The focus of the concepts study was to identify and describe innovative, generic concepts in the context of planning and managing road networks and demand management. With the specific focus on NRA related areas a catalogue of concepts was developed, reflecting the targeted problem situation, the concept category and details of implementation as well as the link to related measures with learnings and success stories.

3.1 Research approach

The concepts study consists of three main steps: screening of generic concepts, preparation of a catalogue of concepts and the assessment and highlighting of successful solutions.

Step 1: Screening of innovate, generic concepts

The way towards the catalogue of concepts started with the screening of innovate, generic concepts in the context of planning and managing road networks and demand management. Therefore, a literature research and workshops with the specific focus on NRA related concepts were performed. The scope was on both, passenger and freight transport. The results of this first step was a collection of various concepts.

Step 2: Preparation of a catalogue of concepts

Based on this collection, a structured compilation of innovative concepts, the catalogue of concepts, was set up. For this task, a template was developed to summarize the findings collection of various concepts, characterised by:

- Concept description – a generic description about idea, motivation and objectives
- Concept Overview – a typical graphic to illustrate the concept
- Concept Details, structured as:
    - Time frame: short, medium, long term
    - Geographical scale: local, regional, transit/national
    - Traffic Type: person, freight
- Concept Categories – the relevant dimensions of transportation are highlighted:
    - Infrastructure
    - Mobility
    - Hubs/terminals
    - Spatial
- Linked measures - reference to best practices on implemented measures
- Concept Assessment - based on the 5I Approach, including:
    - Innovation
    - Information
    - Maintain (In stand)
    - Shape (Inrichten)
    - Infrastructure

Step 3: Assessment and highlighting of successful solutions

Finally, the concepts mentioned in the catalogue will be rated by experts, recruited from e.g. NRAs and DoTs. The experts will be invited to assess the concepts based on simplified ratings, like a pairwise comparison. With this approach, successfully proved measures will be identified and highlighted.

3.2 Catalogue of concepts

This chapter presented the factsheets of the selected generic concepts from different areas of transportation. The following generic concepts are included in this concepts study:

- Mobility as a Service
- Logistic Chains
- Park and Bike
- Multimodal Nodes
- Park and Ride
- Transit Oriented Development
- Greenfield Development
- Brownfield Development
- Area-oriented Strategies
- Develoment Oriented Transit
- Expanding infrastrucure
- New Infrastructure (Cycling/walking/PT)
- Network Management
- Public Transport
- Traffic Management
- Use Optimization
- Talking traffic & ITS (C-IST)
- Vehicle Innovation
- Cross-Domain Decision Processes

SPINTRENDS WP3 Exploring innovative concepts

Mobility as a Service

Concept Description

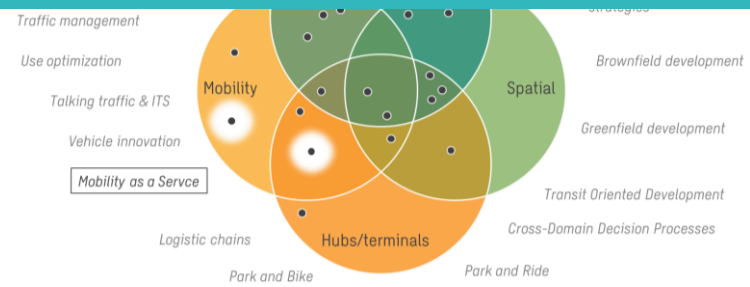
Mobility as a service (MaaS) entails a shift from owning your own modes of transportion (predominantly private car ownership) to a society in which people make better use of the different transportation services available to them. This should lead to a significant change in how travel and should help relieve the negative effects of car travel. Making use of these multimodal services is possible because of the development of recent developments in technology and ICT, more specifically the introduction of the smart phone. Specific apps for mobile phones (for example Whim) were developed, which provide an integrated platform for all transportation services and offer tailor-made door-to-door travel options with a single ticket. The introduction of MaaS will restructure the transportation sector. MaaS operators are in direct contact with the costumers of the private and public transport suppliers. Moreover, they buy transportation services from these suppliers and integrate them into a single service.

Concept Overview

Concept Details

	Short	Medium	Long
Time Frame		✓	✓
	Local	Regional	Transit/National
Geographical Scale	✓	✓	
	Person	Freight	
Traffic Type	✓		

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation	✓	• Mobipoints • Mobility as a Service - Helsinki
Information	✓	
maintain (in stand)		
shape (inrichten)		
infrastructure		

SPINTRENDS WP3 Exploring innovative concepts

Logistic Chains

Concept Description

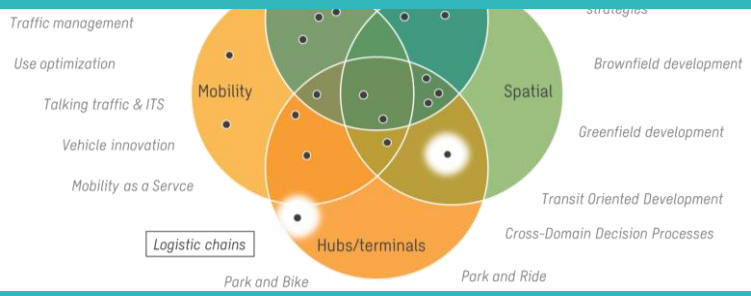
A logistics chain involves many essential sides: accounting, warehousing, packaging, handling, distribution, and even security. It describes the path of goods from the creator to the end user and comprises all successive steps of a logistic process. A concrete concept to foster logistic chains may relate to one or more of these steps. One challenge here is the re-use infrastructure of logistics chains for different industries and sectors. Examples for concepts in the context of logistic chains are transport hubs, container terminals or autonomous delivery vehicles.

Concept Overview

Concept Details

	Short	Medium	Long
Time Frame		✓	✓
	Local	Regional	Transit/National
Geographical Scale	✓		
	Person	Freight	
Traffic Type		✓	

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation	✓	• Produktive Stadt Wien • ELP Strasbourg
Information		
maintain (in stand)	✓	
shape (inrichten)	✓	
infrastructure	✓	

SPINTRENDS WP3 Exploring innovative concepts

Park and Bike

Concept Description

An approach to mitigate negative impacts of motorized vehicles in densely populated regions is introducing park-and-bike (P&B) facilities. P&B describes an operation in which e.g. commuters, are traveling by private vehicles, gather at a common site and transfer to a bicycle. The operation allows commuters to use their vehicle for the initial major portion of the trip to a P&B close to radial roads and cycle tracks and move by bicycle into a densely populated area. This concept allows commuters to avoid traffic congestion and high parking costs in reaching major activity centres (e.g., central business districts), while centres can be kept free of noise and tail pipe emissions.

Concept Overview

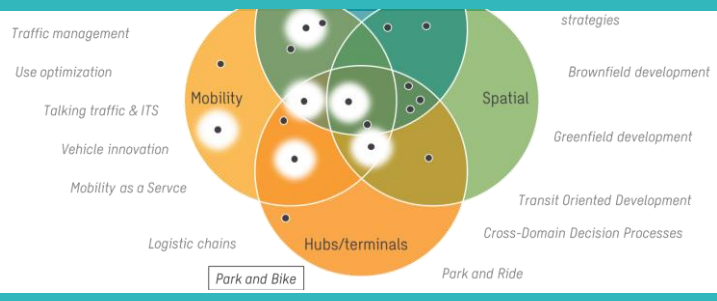
Concept Details

	Short	Medium	Long
Time Frame		✓	✓

	Local	Regional	Transit/National
Geographical Scale	✓	✓	

	Person	Freight
Traffic Type	✓	

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation	✓	• Zaanstad Corridor
Information	✓	• Bijlmeer Arena – Amsterdam
maintain (in stand)	✓	• Mobipoints
shape (inrichten)	✓	• Congestion Charge – Stockholm
infrastructure	✓	• Ringrail – Helsinki

SPINTRENDS WP3 Exploring innovative concepts

Multimodal Nodes

Concept Description

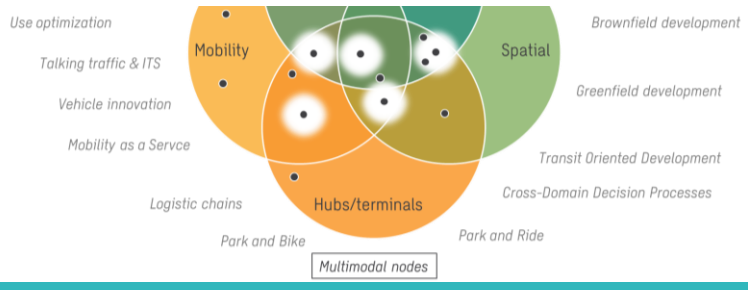
Multimodal nodes are connecting points, linking different transport modes and types of traffic (long-distance and urban/regional transport/transport modes). A measure in this context should enable an easy, efficient and safe switch from one transport mode to another. Multimodal nodes are essential for the effectiveness of the European transport corridors as well as for regional development and social cohesion.

Concept Overview

Concept Details

	Short	Medium	Long
Time Frame		✓	✓
	Local	Regional	Transit/National
Geographical Scale	✓	✓	✓
	Person	Freight	
Traffic Type	✓	✓	

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation	✓	• Gate – Genoa • Science Park – Turku • Bijlmeer Arena – Amsterdam • Mobipoints • Ringrail – Helsinki
Information		
maintain (in stand)		
shape (inrichten)	✓	
infrastructure	✓	

SPINTRENDS WP3 Exploring innovative concepts

Park and Ride

Concept Description

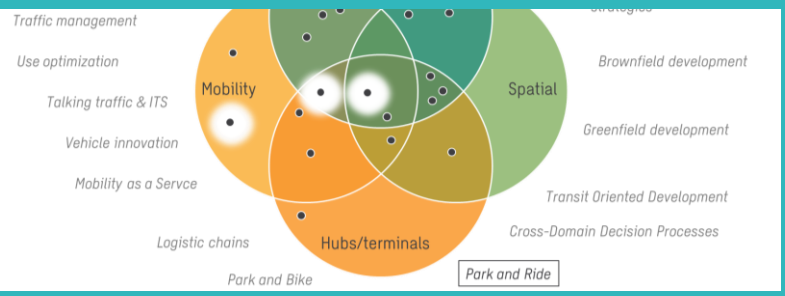
An approach to increase the ridership of public transportation is introducing park-and-ride (P&R) facilities. P&R describes an operation in which commuters, traveling by private vehicles, gather at a common site and transfer to public transportation. The operation allows commuters to use either the automobile or transit in the geographic area to which it is best suited. Private vehicles are used for the initial portion of the trip to a P&R facility located in a low-density suburban or urban fringe area, where (fixed-route) transit services are not justified, while transferring to transit allows commuters to avoid traffic congestion and high parking costs in reaching major activity centers (e.g., central business districts).

Concept Overview

Concept Details

	Short	Medium	Long
Time Frame		✓	✓
	Local	Regional	Transit/National
Geographical Scale		✓	
	Person	Freight	
Traffic Type	✓		

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation	✓	• Bijlmeer Arena – Amsterdam
Information	✓	• Congestion Charge – Stockholm
maintain (in stand)	✓	• Ringrail – Helsinki
shape (inrichten)	✓	
infrastructure	✓	

SPINTRENDS WP3 Exploring innovative concepts

Transit Oriented Development

Concept Description

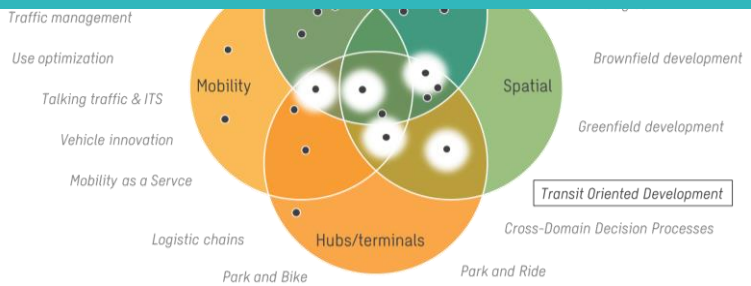
Transit Oriented Development (TOD) entails the development of new high density commercial, residential and leisure functions close to a central transit stop, like a train or metro station. The other way around, it could also mean developing new central transit stops in already high density mixed-use areas. These areas are known for their compact, pedestrian oriented design. TOD should stimulate the use of public transportation and reduce the dependence on private cars.

Concept Overview

Concept Details

	Short	Medium	Long
Time Frame			✓
	Local	Regional	Transit/National
Geographical Scale	✓	✓	
	Person	Freight	
Traffic Type	✓	✓	

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation		• Nordhavn – Copenhagen
Information		• Produktive Stadt Wien
maintain (in stand)		• Zaanstad Corridor
shape (inrichten)	✓	• Science Park – Turku
infrastructure	✓	• Ringrail – Helsinki

SPINTRENDS WP3 Exploring innovative concepts

Greenfield Development

Concept Description

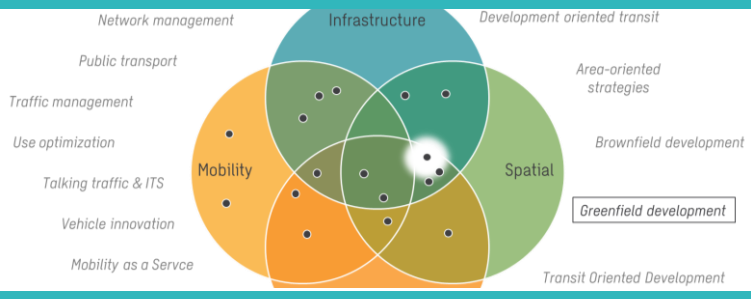
Some rapidly urbanizing countries are struggling to accommodate the growing population and where a shortage of housing supply and strained infrastructure systems have forced urban planners to pursue greenfield strategies. The main challenge then is to make this a sustainable greenfield development. This means making use of modern day technology to make these new neighbourhoods highly energy efficient and environmentally friendly. In these new neighbourhoods public transportation is prioritized above transportation by car, there are numerous bike lanes and a lot of functions are within walking distance. Other examples include underground waste collection systems and the use of big data for traffic management and the provision of city services

Concept Overview

Concept Details

	Short	Medium	Long
Time Frame			✓
	Local	Regional	Transit/National
Geographical Scale	✓	✓	
	Person	Freight	
Traffic Type	✓	✓	

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation	✓	
Information	✓	
maintain (in stand)		• Nordhavn – Copenhagen
shape (inrichten)	✓	
infrastructure	✓	

SPINTRENDS WP3 Exploring innovative concepts

Brownfield Development

Concept Description

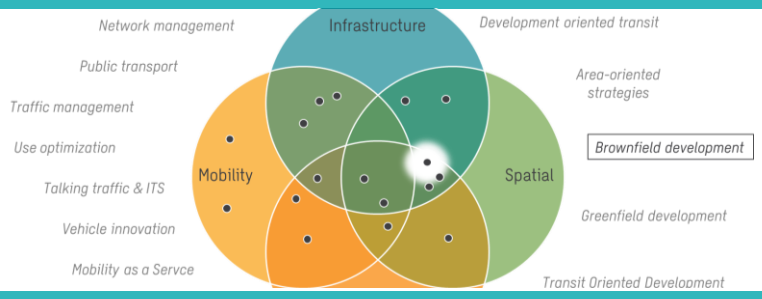
Many cities have witnessed old industrial and port sites becoming underused or even totally abandoned. These brownfields are often located close to the city centre and part of the urban fabric. The redevelopment of these sites is however often hindered by high costs and thus needs government intervention. For example, sites are regularly contaminated and thus treatment is necessary first. Nonetheless, urban planners in many European cities have supported brownfield redevelopment as an alternative to greenfield development in order to avoid further urban sprawl.

Concept Overview

Concept Details

	Short	Medium	Long
Time Frame			✓
	Local	Regional	Transit/National
Geographical Scale		✓	
	Person	Freight	
Traffic Type	✓	✓	

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation		
Information	✓	
maintain (in stand)		• Nordhavn – Copenhagen
shape (inrichten)	✓	
infrastructure	✓	

SPINTRENDS WP3 Exploring innovative concepts

Area-oriented Strategies

Concept Description

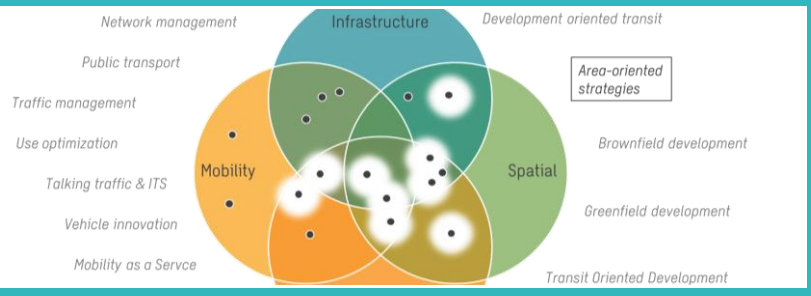
Traditionally, the planning and realisation of road infrastructure and spatial planning have been separate worlds ('silos'). As an innovative alternative to traditional line-oriented planning approaches, contemporary planning practice is searching for more comprehensive, area-oriented approaches for the planning of road infrastructure. In general, these approaches should be able to incorporate better the complex array of needs, demands and opportunities of the area surrounding both newly planned road infrastructure and existing road infrastructure. Area-oriented approaches imply that the development, or redevelopment, of road infrastructure projects is accompanied by the development of the area as a whole, including an assessment of all interests involved in the decision-making process.

Concept Overview

Concept Details

	Short	Medium	Long
Time Frame		✓	✓
	Local	Regional	Transit/National
Geographical Scale	✓	✓	
	Person	Freight	
Traffic Type	✓	✓	

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation	✓	• A2 Tunnel – Maastricht • Nordhavn – Copenhagen • Ring Road – Antwerp • Produktive Stadt Wien • Zaanstad Corridor • Science Park – Turku • Bijlmeer Arena – Amsterdam • Railport Scandinavia • Ringrail – Helsinki
Information	✓	
maintain (in stand)		
shape (inrichten)		
infrastructure	✓	

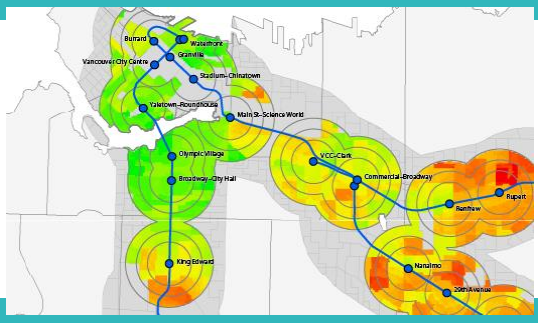
SPINTRENDS WP3 Exploring innovative concepts

Develoment Oriented Transit

Concept Description

Development-oriented transit (DOT) is a variation on the concept of transit-oriented development (TOD) that highlights a transit planning process and outcome that acknowledges and balances, and may even prioritise, the land development – city building objective over the transit/transport planning objective.

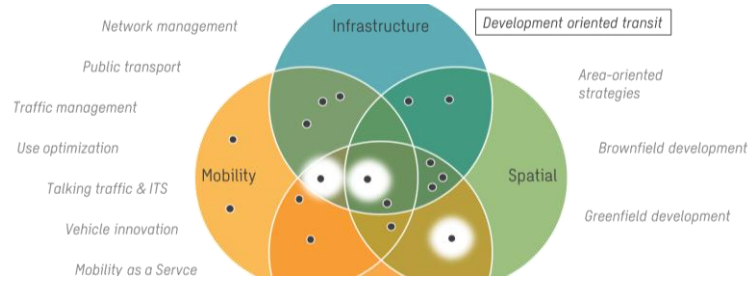
Concept Overview



Concept Details

	Short	Medium	Long
Time Frame			✓
	Local	Regional	Transit/National
Geographical Scale		✓	
	Person	Freight	
Traffic Type	✓	✓	

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation		• Produktive Stadt Wien • Bijlmeer Arena – Amsterdam • Ringrail – Helsinki
Information		
maintain (in stand)	✓	
shape (inrichten)	✓	
infrastructure		

SPINTRENDS WP3 Exploring innovative concepts

Expanding infrastrucure

Concept Description

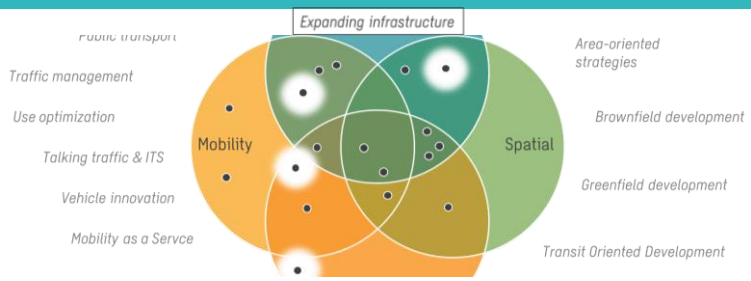
The need to expand and maintain infrastructure is straining resources of many cities, provinces and countries. Local and national governments are looking for alternatives
to traditional methods of financing, building and managing infrastructure. One such alternative is through public-private-partnerships. The most far-reaching form of public-private partnership are the so-called DBFM (Design, Build, Finance and Maintain) and DBFMO (Design, Build, Finance, Maintain and Operate) contracts. They give private consortia of banks, constructors and service suppliers a concession to invest in new or existing public infrastructure. Concession periods are 15 years or more, granting private parties operation monopolies in order to enable them to recover their investments.

Concept Overview

Concept Details

	Short	Medium	Long
Time Frame			✓
	Local	Regional	Transit/National
Geographical Scale	✓	✓	
	Person	Freight	
Traffic Type	✓	✓	

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation		• A2 Tunnel – Maastricht
Information		• ELP Strasbourg
maintain (in stand)	✓	• Railport Scandinavia
shape (inrichten)	✓	• Better Use of Inland Waterways – Noord Brabant
infrastructure	✓	

SPINTRENDS WP3 Exploring innovative concepts

New Infrastructure (Cycling/walking/PT)

Concept Description

socially compatible mobility. Depending on envisaged travelling distances as well as spatial and environmental conditions, different (innovative) concepts for new infrastructure are available.

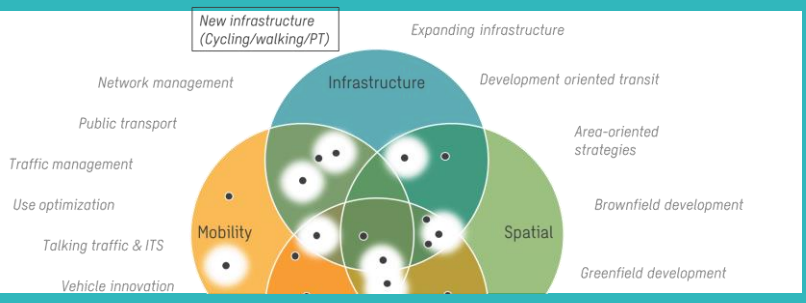
• Bike freeway, also known as a cycling superhighway, fast cycle route or bicycle highway, is an informal name for a bicycle path that is meant for long-distance traffic. Due to higher average speeds than normal cycling infrastructure, they should be an alternative for the car in commuter traffic.
• Walking as the most natural and sustainable form of mobility can be promoted by appropriate concepts, e.g. by unbundling motorised traffic and pedestrians.
• Railways are not a new technology, although several concepts can be regarded as innovative. These concepts regard travel speed, frequencies of trains, reliability, information and management.

Concept Overview

Concept Details

	Short	Medium	Long
Time Frame		✓	✓
	Local	Regional	Transit/National
Geographical Scale	✓	✓	✓
	Person	Freight	
Traffic Type	✓	✓	

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation	✓	• Airdrie – Bathgate Rail Link • Gate – Genoa • Zaanstad Corridor • Science Park – Turku • Congestion Charge – Stockholm • Ringrail – Helsinki • Better Use of Inland Waterways – Noord Brabant • Baana – Helsinki
Information	✓	
maintain (in stand)	✓	
shape (inrichten)		
infrastructure		

SPINTRENDS WP3 Exploring innovative concepts

Network Management

Concept Description

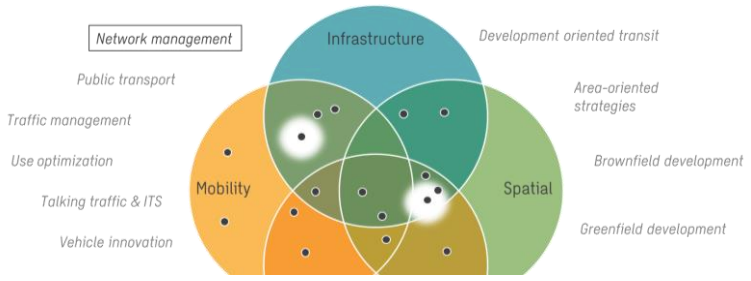
The goal of network management is to manage transportation networks so that they don't spiral out of control. The task of network management comprises the monitoring of resources in the network and documentation, network troubleshooting, making policies and regulations, defining QoS, traffic shaping, load balancing and assessing fault tolerance. Each of these terms are very important in the network monitoring construct because each one is directly related to all the rest in assisting with troubleshooting and network optimization.

Concept Overview

Concept Details

	Short	Medium	Long
Time Frame	✓	✓	
	Local	Regional	Transit/National
Geographical Scale	✓	✓	
	Person	Freight	
Traffic Type	✓		

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation		
Information	✓	• Ring Road – Antwerp • Better Use of Inland Waterways – Noord Brabant
maintain (in stand)	✓	
shape (inrichten)		
infrastructure	✓	

SPINTRENDS WP3 Exploring innovative concepts

Public Transport

Concept Description

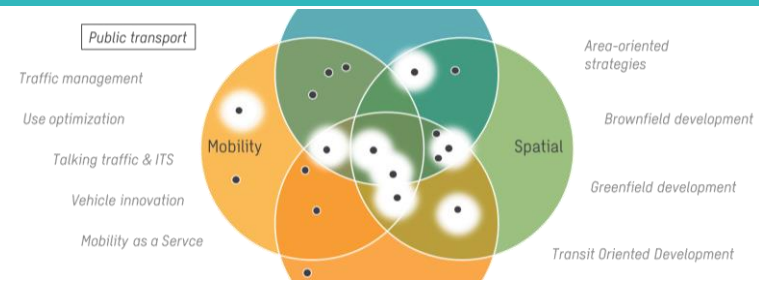
As the backbone of our metropolitan areas, public transport is an essential contributor to make cities better places to live in, to work in and to launch a new business in. Urban mobility should be a priority for local leaders in order to help cities achieve inclusive growth and climate goals.

Concept Overview

Concept Details

	Short	Medium	Long
Time Frame		✓	✓
	Local	Regional	Transit/National
Geographical Scale	✓	✓	✓
	Person	Freight	
Traffic Type	✓		

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation		• Airdrie – Bathgate Rail Link • Gate – Genoa • Produktive Stadt Wien • Zaanstad Corridor • Science Park – Turku • Bijlmeer Arena – Amsterdam • Mobility as a Service - Helsinki • Ringrail – Helsinki
Information	✓	
maintain (in stand)	✓	
shape (inrichten)	✓	
infrastructure	✓	

SPINTRENDS WP3 Exploring innovative concepts

Traffic Management

Concept Description

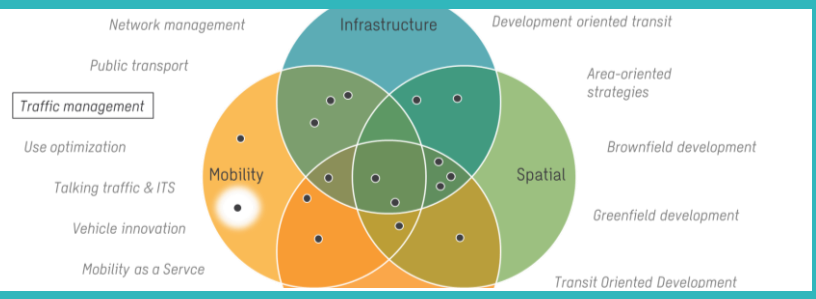
Active traffic and demand management/Dynamic Traffic Management: A Variable Message Sign (VMS) (also called Traffic Information Sign) is a programmable electronic panel capable of displaying different types of messages. Depending on the type of technology employed, the panel is capable of displaying messages composed of text, pictograms or a combination of them. Visualization technologies employed in VMS, e.g. LCD screens, include dynamic features such as the use of animation, flashing, scrolling, etc. This leads to a great flexibility in the content and type of information that can be displayed. In addition, it poses several questions on the information to be displayed in order to provide understandable and effective messages.As an important part of ATIS, Variable Message Sign (VMS) plays an important part in improving transportation efficiency, reducing traffic accidents and relieving traffic pollution by providing drivers with dynamic traffic information.

Concept Overview

Concept Details

	Short	Medium	Long
Time Frame	✓	✓	
	Local	Regional	Transit/National
Geographical Scale	✓	✓	
	Person	Freight	
Traffic Type	✓		

Concept Categories



Concept Assessment (5I Approach)

	Linked Measures
Innovation	
Information	✓
maintain (in stand)	✓
shape (inrichten)	✓
infrastructure	✓

- Congestion Charge – Stockholm

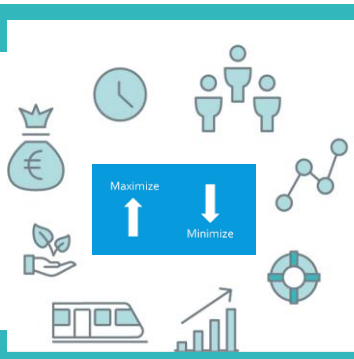
SPINTRENDS WP3 Exploring innovative concepts

Use Optimization

Concept Description

The use of optimisation methods can help to make traffic, transport & fleet management and route planning more efficient, reduce costs, and also contribute to climate protection. Passenger, Transport and logistics service providers, freight forwarders as well as Transport Agencies can benefit from traffic optimisation. (Further more: concept of system-aware optimisation)

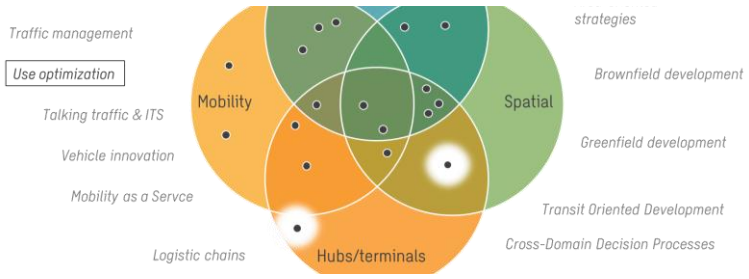
Concept Overview



Concept Details

	Short	Medium	Long
Time Frame	✓	✓	
	Local	Regional	Transit/National
Geographical Scale	✓	✓	✓
	Person	Freight	
Traffic Type	✓	✓	

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation	✓	• Produktive Stadt Wien • ELP Strasbourg
Information	✓	
maintain (in stand)		
shape (inrichten)		
infrastructure		

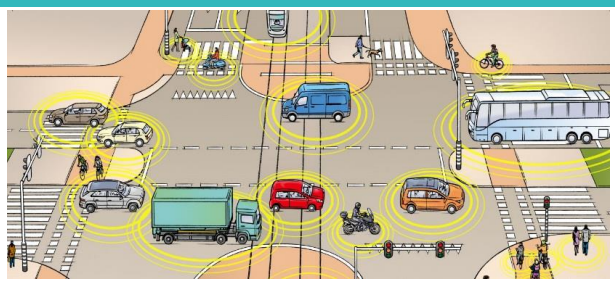
SPINTRENDS WP3 Exploring innovative concepts

Talking traffic & ITS (C-IST)

Concept Description

The Talking Traffic project (cooperative ITS) permits road users, traffic lights, traffic control centers, and roadside systems to communicate with each other. This yields valuable data which makes it possible to provide every road user with travel information and advice, both before and during the journey, on the basis of his or her final destination. The final goal is to make journeys as quick and smooth as possible.

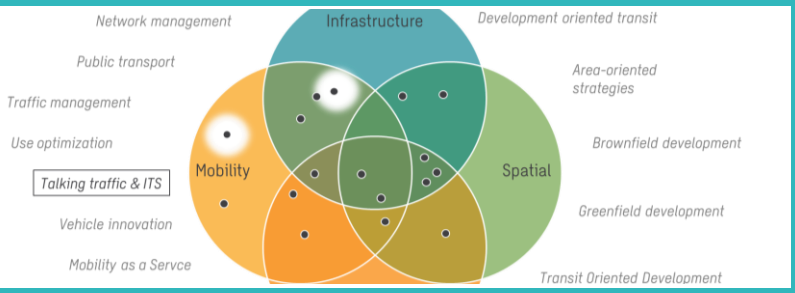
Concept Overview



Concept Details

	Short	Medium	Long
Time Frame	✓	✓	
	Local	Regional	Transit/National
Geographical Scale	✓	✓	
	Person	Freight	
Traffic Type	✓		

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation	✓	• Inter-city Cycling Route • Mobility as a Service – Helsinki
Information	✓	
maintain (in stand)		
shape (inrichten)		
infrastructure		

SPINTRENDS WP3 Exploring innovative concepts

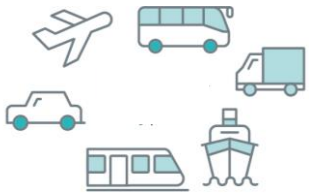
Vehicle Innovation

Concept Description

A concept may foster the use of vehicle innovations towards a more efficient and sustainable mobility. Vehicle innovations are e.g. electric vehicles, cooperative systems, shared vehicles, cargo bikes and more. The introduction and usage of such vehicle innovations (or green vehicles) can be achieved by:

- driving restrictions for unwanted vehicle types or technologies. The intention is to ban certain vehicles from roads (or regions) to achieve an improved level of service for not restricted vehicles or reduce local emissions,
- or by incentives for new vehicle technologies e.g. by appropriate subsidies.

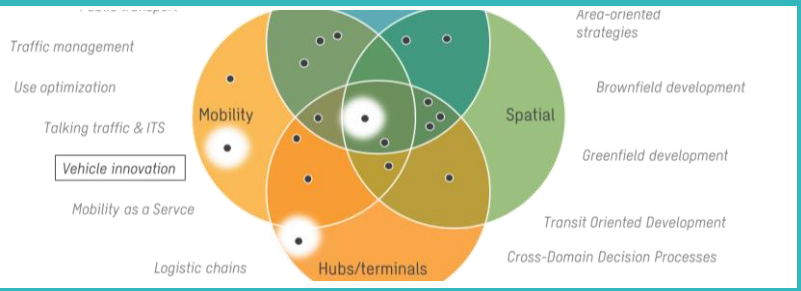
Concept Overview



Concept Details

	Short	Medium	Long
Time Frame	✓	✓	
	Local	Regional	Transit/National
Geographical Scale	✓	✓	✓
	Person	Freight	
Traffic Type	✓	✓	

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation	✓	• ELP Strasbourg • Congestion Charge – Stockholm • Bijlmeer Arena – Amsterdam
Information	✓	
maintain (in stand)	✓	
shape (inrichten)		
infrastructure		

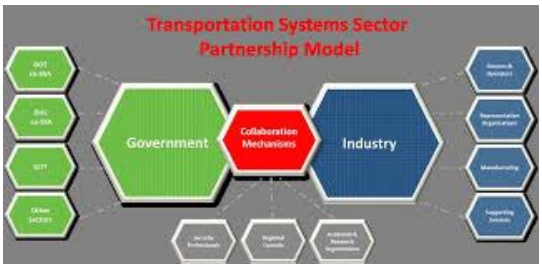
SPINTRENDS WP3 Exploring innovative concepts

Cross-Domain Decision Processes

Concept Description

Implementation of cooperative land-use strategies that include the competencies and processes for regional, national and other invovled domains. For example, the design of a joint planning and decision process for a road transport network or infrastructure by different actors from differnt domains including public and private sectors.

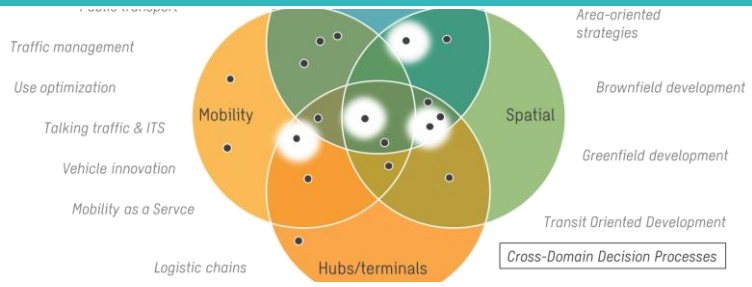
Concept Overview



Concept Details

	Short	Medium	Long
Time Frame		✓	
	Local	Regional	Transit/National
Geographical Scale	✓	✓	
	Person	Freight	
Traffic Type	✓	✓	

Concept Categories



Concept Assessment (5I Approach)

		Linked Measures
Innovation		
Information	✓	• Ardrie – Bathgate Rail Link • Ring Road – Antwerp • Bijlmeer Arena – Amsterdam • Railport Scandinavia
maintain (in stand)		
shape (inrichten)		
infrastructure		

3.3 Overview of concept categorization

At the time of preparing this report, 19 generic concepts from different areas of transportation were summarized and listed in the catalogue.

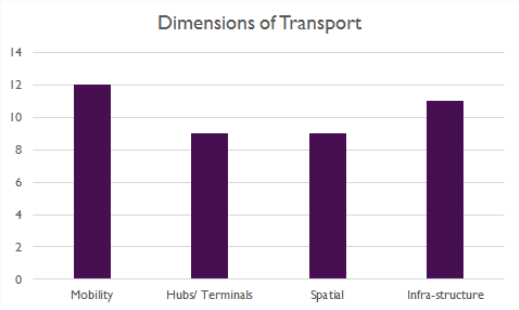


Figure 5: Number of listed concepts per Dimension of Transport (incl. multiple nominations)

The following illustrations show some aggregated views, based on the concept characteristics.

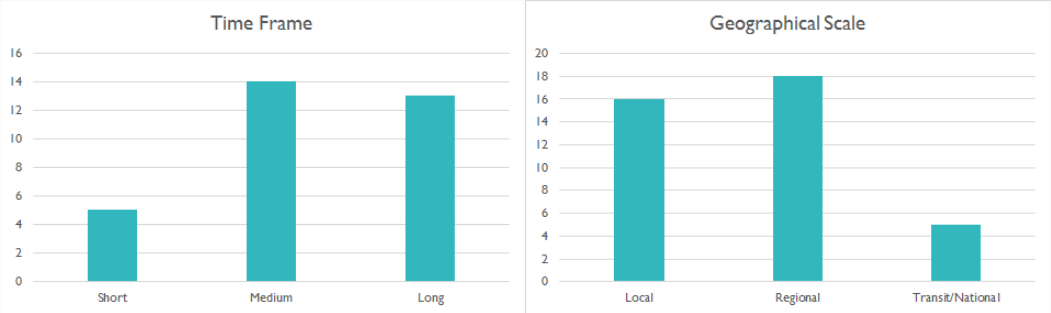


Figure 6: Number of concepts assigned per Time Frame (left) and Geographical Scale (right) (inlc. multiple nominations)

The assignment to time frames shows, that the most concepts are addressing medium- and long-term developments. The diagram in geographic scale shows, that only 5 concepts are focussing (or at least including) transit traffic;. Interesting here is, that these 5 concepts were rated as relevant for all geographic scales (e.g. multimodal nodes, public transport or new infrastructure).

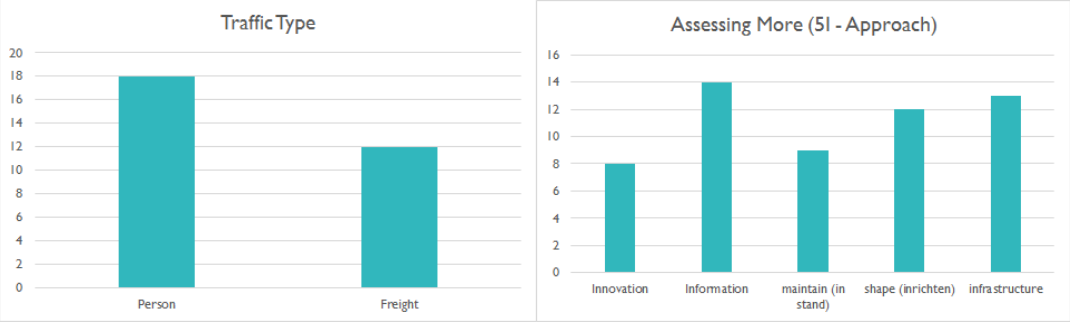


Figure 7: Number of Concepts per Traffic Type (left) and the 5I Approach (right) (inlc. multiple nominations)

11 out of 19 concepts are relevant for both traffic types: the mobility of person and freight. These concepts are related to area-development strategies and infrastructure related projects. From the 5I Approach we can see, that *Information* and *Infrastructure* are the most prominent I's here. Less than the half were rated as Innovation, because the list also includes concepts based on best practices, existing knowledge and decision processes.

4 MEASURES

The focus of the measures study was to explore and analyze examples from planning practice across Europe and summarize them in the catalogue of good practices. This study was performed in cooperation with the project SPINDESIGN.

Therefore, this chapter refers to the report "Transportation at the co-last mile interface: an inventory of good practices", a output of work package 2 from the SPINDESIGN project.

4.1 Correlation between concepts and measures

In SPINTRENDS, the correlation between the identified generic concepts as described in chapter 3 and the measures from the inventory of good practices from SPINDESIGN was analyzed. This correlation is shown in Figure 8 and Figure 9 below.

	Concept \ Measure	Inter-city Cycling Route	Airdrie - Bathgate Rail Link	A2 Tunnel - Maastricht	Nordhavn Copenhagen	Gate - Genoa	Ring Road - Antwerp	Produktive Stadt - Wien	Zaanstad Corridor	Science Park - Turku	Bijlmer Arena - Amsterdam	ELP Strasbourg	Mobipoints	Railport Scandinavia	Congestion Charge – Stockholm	Mobility as a Service	Ringrail - Helsinki	Better Use of Inland Waterways – Noord-Brabant	Baana - Helsinki
1	Mobility as a Service												■			■			
2	Logistic Chains							■				■							
3	Park and Bike								■		■		■		■		■		■
4	Multimodal Nodes	▒	▒			■			▒	■	■		■				■		▒
5	Park and Ride		▒						▒		■				■		■		
6	Transit Oriented Development				■			■	■	■							■		
7	Greenfield Development				■														
8	Brownfield Development				■														■
9	Area-oriented Strategies			■	■		■	■	■	■	■			■			■		■
10	Development Oriented Transit					▒		■			■						■		

Figure 8: Correlation between concepts and measures (part 1)

	Concept \ Measure	Inter-city Cycling Route	Airdrie - Bathgate Rail Link	A2 Tunnel - Maastricht	Nordhavn Copenhagen	Gate - Genoa	Ring Road - Antwerp	Produktive Stadt - Wien	Zaanstad Corridor	Science Park - Turku	Bijlmer Arena - Amsterdam	ELP Strasbourg	Mobipoints	Railport Scandinavia	Congestion Charge – Stockholm	Mobility as a Service	Ringrail - Helsinki	Better Use of Inland Waterways – Noord-Brabant	Baana - Helsinki
11	Expanding Infrastructure			main								must		main				main	
12	New Infrastructure (Cycling/walking/PT)	main	must			main		could	must	must	could				must		main	must	main
13	Network Management						must											must	
14	Public Transport		main			must		must	must	must	must		could			main	must		
15	Traffic Management						could								main				
16	Use Optimization							must				must							
17	Talking traffic & ITS	must														main			
18	Vehicle Innovation										could	main			could				
19	Organizational Competences		must				must		could		must			must		could			

Figure 9: Correlation between concepts and measures (part 2)

main	main: the measure includes all main aspects of concept
must	must: the measure includes essential aspects of the concept
could	could: the measure could include some aspects of the concept

Figure 10: color coding for the correlation between concepts and measurements

5 CONCLUDING REMARKS AND OUTLOOK

The project SPINTRENDS is dealing with exploring effective approaches for future-proof road networks based on trends in mobility and spatial development.

Therefore, in a first phase future trends in mobility and spatial development as well as of innovative measures/concepts to deal with growing mobility demand were analyzed and documented. This resulted in the following subelements

- Catalogue of trends
- Catalogue of concepts
- Inventory of good practices (in cooperation with SPINDESIGN)
- Correlation between Concepts and Measures

The combination of all these items represents the first two proposed key results of SPINTRENDS:

- **KR1: Overview of future trends** in mobility and spatial development
- **KR2: Overview of innovative measures/concepts** to deal with growing mobility demand

The next steps within SPINTRENDS are the development of a vision document and a roadmap for CEDR members toward a collaborative planning approach to ensure effective and future-proof road networks.
Therefore, the identified concepts will be assessed by experts via an online survey based on simplified ratings. With this approach, successfully proved concepts and approaches will be identified and highlighted. The results of this survey together with the outcome of this report will serve as basis for the vision and roadmap development.
The proposed approach to develop this vision as well as the roadmap includes five steps:

- Development of a framework to consider differences in European NRA's
- Analysis on the results of WP 2 and WP3 in order to fill the framework
- Compile a draft vision/roadmap document and discuss the draft vision with PEB
- Update the draft vision/roadmap and present the final draft in the PEB
- Finalize the vision/roadmap document on collaborative planning

The development of the vision and the roadmap document has to be done in close cooperation between the SPINTRENDS consortium and the CEDR members (especially PEB members) to ensure that it is in a format to support NRA's in the future work.

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