IN SEARCH OF A DUTCH LOGISTIC CORE ROAD NETWORK

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Abstract
This paper is elaborating on why there is a need for a logistic core road network within the Dutch context and how such a network can be obtained. The ultimate goal is an optimal organization of the transport 'flow' of goods through a better interaction between the 'supply' of infrastructure and the demand on freight transport. This paper provides a framework of thought for the stakeholders to further identify the characteristics of a logistic core road network.

Keywords: logistic core road network, maintenance, quality of the living environment, robustness and reliability, safety, competitive strength, dialogue, dialectic

1. Introduction

The performance of the freight sector is driven by the interaction amongst three key elements (Punte and Bollee 2017):

- Transport system (infrastructure) and policies
- Freight movement – this entails the organization of the supply chain and the decisions made by shippers, customers, Logistic Service Providers etc.
- Freight equipment – this includes all vehicles and vessels.

The creation of a qualitative transport system is a prerequisite to optimize routing and scheduling of freight flows. Furthermore it is believed that effective regulations with regard to the use of infrastructure will have a positive effect on the greenification of vehicles. The Dutch government has defined (Ministerie van Infrastructuur en Waterstaat, 2017), as one of their ambitions concerning freight transport, to identify a **logistic core road network**.

Given this information research has been started to investigate the characteristics and consequences of a **national logistic core road network** within the Dutch context and the process to get towards such a defined network. Road freight transport was the focus of this research since road freight holds almost 70% of the total weight of goods transported within the Netherlands (Bakker et al., 2017) and is therefore the biggest aspect to relate to. This focus does not mean that the other modalities are neglected. Measures with regard to the optimization and greenification of road freight transport have an effect on the other modalities. It possibly leads to a modal shift from road to other modalities for instance.

This research followed a so called design approach (see attachment I – research approach). Visualizations have been made and interviews performed in order to get a better grasp on the idea of a core road network. The outcome is a framework which helps the different stakeholders to discuss upon the topic and to further elaborate the actual network. The framework is a guide towards the future. A future which promises a comprehensive system for the goods to be transported efficiently and clean from origin to destination. Individual measures meant to further green and optimize the logistics sector should be grafted onto the idea of a **logistic core road network** in order to achieve this comprehensive system.

2. The need for a national logistic core road network

The task to define a **national logistic core road network** is rooted in a strong demand for the logistics sector to operate more sustainable and more efficient. This demand is based upon urgent matters with regard to several topics:

- Maintenance – The relation between road freight transport and the ageing of infrastructure is strong. Regularly upkeep is needed. However financial means are scarce hence choices need to be made on where to invest. This is affiliated with how the transport system is used.
- Quality of the living environment – This includes the reduction of emissions of air pollutants, greenhouse gases and the production of noise. The share of the logistics sector in the total amount of emissions is significant (Bakker et al., 2017). Furthermore the quality of the living environment is defined by the interaction of the living environment, its characteristics and the way how the transport system (road infrastructure, waterways and rail infrastructure) is used. This requires adequate

sustainability measures and a closer relationship between spatial planning and the traffic system.

- Robustness and reliability – the demand for freight is increasing (Bakker et al., 2017), leading to an increase of the amount of traffic making use of the transport system. Negative results as congestion are imminent. This has financial consequences for the logistics sector. Adequate traffic management and optimization of the transport system (optimal interaction between different modalities) is required.
- Safety – The nature of freight becomes more costly this leads to increased vandalism. Furthermore casualties due to accidents with freight related vehicles are still being faced. The external costs related to traffic accidents in general is significant. In the Netherlands these costs are higher than costs related to congestion and expenses related to environmental issues (emission of air pollutants and greenhouse gases) (Swov.nl, 2017).

  Though the transportation of goods are not often involved in accidents they tend to be involved in severe and fatal accidents (Road Freight Transport Services Reform; Guiding Principles for Practitioners and Policy Makers, 2017/ Swov.nl, 2016).
- Competitive strength - The Logistics Perfomance index (LPI indicator) published by the world bank (Lpi.worldbank.org, 2017) shows a fourth position for the Netherlands. Logistics and logistic related activities account for almost 9% of the Dutch Gross Domestic Product (GDP) (Monitor logistiek en goederenvervoer voor Nederland 2016, 2017). The sector is therefore of real economic value for the Netherlands. The Dutch government is inclined to preserve or improve the position with regard to the LPI indicator.

The issues depicted above are intertwined with each other and cannot be approached and solved individually. An integral answer is needed; a comprehensive system which cuts through different geographical scales and which is of help to reconcile seemingly conflicting goals. Long heavy vehicles for instance have a larger effect on roads than regular vehicles - the lifespan of the pavement decreases due to extra load exerted onto it (Schroten et al., 2014). At the same time a higher load factor potentially saves transport which is better for the living environment. In these cases choices have to be made on where to allow these heavy vehicles and on where to abolish the use of these trucks. On which locations and routes is it beneficial and where does it harm? A **national logistic core road network** guides these choices on priority and hierarchy.

3. What is a logistic core road network ?

As described in the former two chapters the idea of establishing a **logistic core road network** derives from the identification of different urgent matters. It is believed that the transport system has a strong potential to positively influence the logistic system by stimulating or enforcing a certain use of the network. The ultimate goal is an optimal (safe, smooth and sustainable) organization of the transport 'flow' of goods through a better interaction between the 'supply' of infrastructure and the demand on freight transport. This goal holds three basic design rules:

- the right truck on the right road
- the right infrastructure on the right location
- the right logistic activities on the right location

These design rules will be the starting point to define this **core road network** and its concurring aspects as hubs and terminals, facilities (parking facilities for trucks) and the surroundings. In order to ultimately provide the extra quality to freight transport. **This qualification calls for intervention within the fields of the different urgent matters identified:**

Maintenance
A transport system of high quality entails smart and appropriate maintenance and management of the network. Investments in order to upkeep the infrastructure should be done 'just in time' and on the right location.
This also concerns differentiating in maintenance levels. Some parts of the network require other types of maintenance than others assuming the current and the future use of the network by the logistic sector and the characteristics and the economic value of the flow goods at a particular location. These characteristics are related to the different kind of sub-markets and its subsequent type of vehicles, loading factors, type of trips, appearance of freight etc.
In short the WHY aspect of the reason why goods are transported needs to be connected to the amount of infrastructure available . The 'dialogue' between the two leads to a useful hierarchy.

Quality of the living environment
A living environment of high quality is about the right balance between accessibility and livability. Hotspots for the logistics sector need to be accessible. Livability is related to the amount of emissions and noise produced by the logistics sector. It also concerns the amount of freight movements through sensitive areas as areas which are densely populated. This asks for integral development; synergy and strengthening of the spatial quality of the surroundings with the organization and design of hubs and facilities along the network. A more intimate relation between spatial design and logistics saves unnecessary movements and raises efficiency. For instance through the concentration of logistic activities along the network. The interaction with other modalities will become more successful at these particular spots of concentration. A concentration of activities opens up the possibility to strategically focus investments. Also a stimulation to make better use or a limitation of certain use of the transport system during the day based on the (sensitive) characteristics of the surroundings (differentiation in use), can have positive effects for the environment.

Robustness and reliability
A robust and reliable transport system asks for optimal use of a limited amount of infrastructure. ensuring the accessibility of hubs and other facilities. Robustness is about providing the opportunity to use alternative routes in cases necessary. This requires a complementary system of main infrastructure and the secondary infrastructural system; an ongoing hierarchical network.

Robustness is also about being adaptive. It is most likely that the characteristics of freight and transport flows will change over time. It is for instance very well possible that in the future less fossils will be transported due to the increase of the use of sustainable energy. A single development, as for example reshoring (production of goods closer to the final customer and therefore more local transport) will have an effect on the total system endowed with the transport of goods. Also the rise of new technologies like self-driving vehicles will have an

impact on the use of the infrastructure. This requires an adaptive transport system; a flexibly designed and constructed network. Dedicated lanes for freight transport which are physically detached from other lanes might not fit a futureproof adaptive transport system. This inflexible design will lead to a sub optimal use of the transport system by all traffic. The use of electronic signage to flexibly assign a lane to a certain target group in situations needed probably fits better. The use of intelligent access systems to allow or to stop the use of certain parts of the network by road freight transport is another example which meets the ideas of an adaptive infrastructural network. The requirements of these systems can be altered easily when circumstances ask for it. Extensive monitoring is required to keep track on emerging mismatches.
Furthermore it is of utter importance to make sure that road users do have the chance to have access to up-to-date and reliable traffic information. This is of great help for logistic companies to make informed decisions on when to transport their goods.
Another aspect of reliability is about adequately managing transport flows in times of scarcity. This is about finding the right balance between the demand for mobility in general and the total amount of infrastructure available in times when the demand is relatively high compared to the capacity available. The smart logistics movement, the interaction between traffic management and management on logistics in order to better organize flows of goods, is a promising concept to better shape the right equilibrium (Rijkswaterstaat, n.d.).
Reliability is also related to climate change. A higher frequency of extreme weather circumstances, as storms and floods, requires infrastructure which is able to meet these circumstances.

Safety and security
A **logistic core road network** should provide extra quality with regard to topics as safety and security. Having a network of main routes might already help to improve road safety. Another important aspect to ensure road safety is to have a sufficient maintenance level of the transport system. Furthermore having clear procedures in place such as restrictions on traffic and parking and adequate incident management will possibly lead to improved road safety (Road Freight Transport Services Reform; Guiding Principles for Practitioners and Policy Makers, 2017). From the interviews performed during this research one asked for a more prominent place for the user perspective with regard to the design of hubs, facilities and also regulations. Secured and clear parking places which are illuminated overnight could help to decrease theft of freight for instance.

Competitive strength
An attractive, good maintained and continuous robust network, with the right facilities, giving access to strategically positioned clusters of industry is highly beneficial for efficient and sustainable road freight transport. It minimizes external costs caused by the issues identified. These circumstances lead to a competitive advantage; a positive climate for a company to settle oneself. Increased attractiveness will at the end lead to increased economic vitality; one of the key objectives of a government. A vital ground to intervene on aspects concerning the other urgent matters (maintenance, qualitative living environment, robustness and reliability, safety and security).

4. How to get to a logistic core road network?

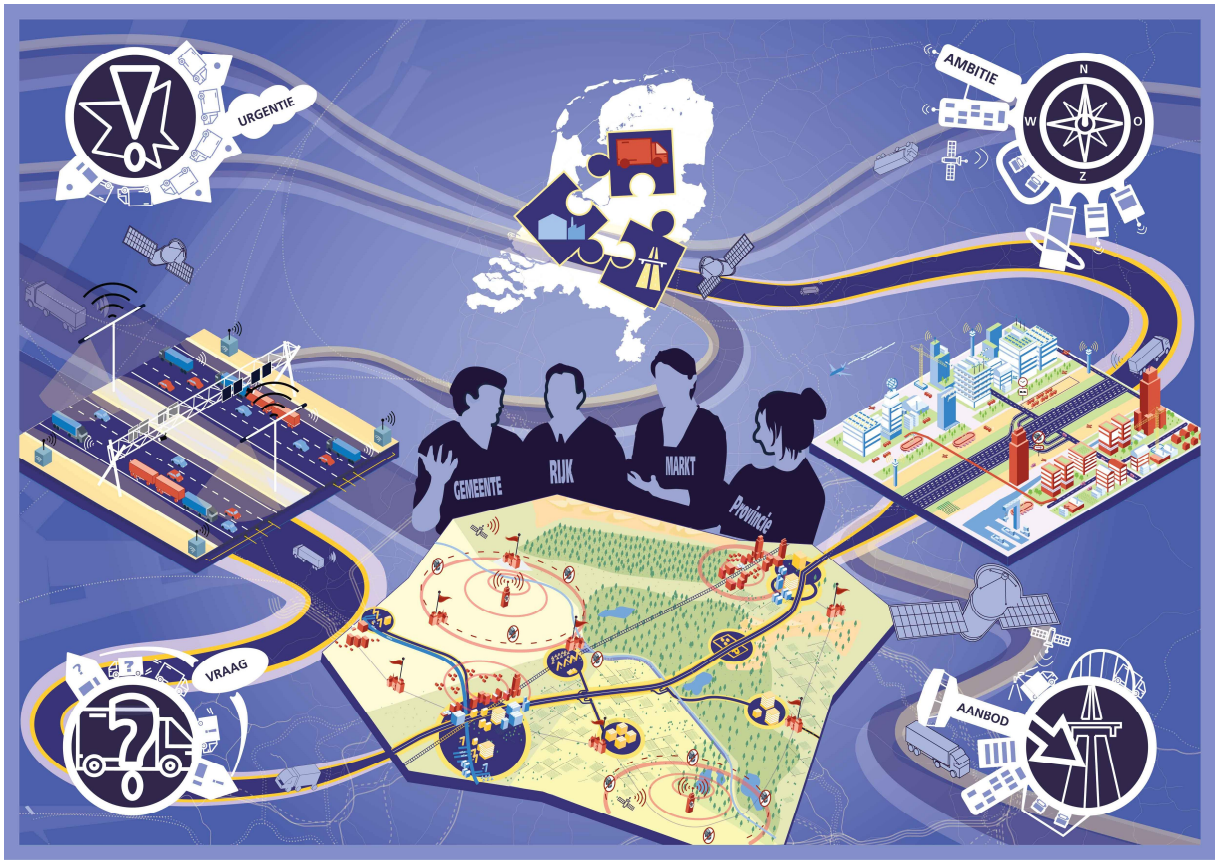

Figure 1 – defining a logistic core road network is about entering into a dialogue

In chapter three a **core road network** has been described as a system which provides extra quality to hubs and terminals, the transport network, facilities (parking facilities for trucks) and the surroundings. Defining a **logistic core road network** is about entering into a dialogue and finding the right balance between different aspects.
The dialogue has to lead to rigorous choices on where to invest to provide extra quality, on where flows of goods will be fully accommodated and on where restrictions for heavy traffic will be introduced. This **core road network** incorporates parts of the network and excludes other parts based on the dialogue. The research performed has defined four dialectic fields which describes the arena on where choices should be made in order to get to this network.

Dialectic between urgency and ambition
One of the important aspects of coming to priorities in a network or a new infrastructural project is through the inventory and analysis of bottlenecks in the infrastructural network. In the Netherlands the – Nationale Markt- en Capaciteitsanalyse – is the analysis of these bottlenecks (Ministerie van Infrastructuur en Waterstaat, 2017) . From there the national and regional agenda for infrastructural and accessibility projects and investments is created. This procedure is based on and starting with problems or urgencies. The problems of today have a central position within the project definition. The consequent projects are meant to be the answers to these problems.

However recent developments are characterized by a lot of uncertainties; developments are disruptive. We don't know what the effects will be of the self-driving vehicle on safety and the flow of traffic for example. Also climate change and its compelling effects for society concurs with a lot of uncertainties. Therefore it is important to move beyond the problem and its solution. It is time to define an ambition. These ambitions cannot be predicted they need to be designed. All stakeholders involved need to think carefully on their goals and ambitions for the future. The interaction between the problems of today and the (different) ambitions will lead to the design of a possible prospective situation.
The central question in defining a **logistic core road network** is about how one thinks future transport can be organized most efficient, safe and sustainable. It holds different issues, described in chapter 2 and at the same time moves beyond these problems by formulating a joint ambition for the future. An exclusive focus on problems leads to symptom management and is on the long run not the answer to the optimal organization of the transport of goods. The logistic core road network is the ambition and promises to offer a framework for decisions to prioritize the ongoing flow of issues with regard to the transport system.

Dialectic between demand and supply
The demand for freight is increasing (Bakker et al., 2017). If the definition of a core road network was only depending on the demand for freight extra quality could be provided to hubs, facilities and the network on every spot the 'demand for freight' asked for it. Examples of the extra quality are: dedicated lanes for heavy road freight, secured parking lots for truckers to have a break and full access during the day to all places of loading and unloading also within the confines of a city.
However this logistic core road network is not only depending upon freight demand it is also building upon the 'supply' of infrastructure. The amount of infrastructure requires a certain use matching its characteristics and the characteristics of the environment for instance through providing access to city centres during limited times of the day, refraining from using the network during peak hours or to only allow trucks to pass the bridge when they do not exceed a certain deadweight.
It is all about the differentiation of the use of the network with regard to time, intensity, environmental impact and load bearing capacity of the transport system.
When demand and supply conflict on a certain location, a 'dialogue' between the two is required in order to come to a harmonious situation. This leads to a situation the demand for freight transport is met and the infrastructure is used most efficiently and sustainably; the right balance between providing extra quality and differentiated use of the network. This leaves several possibilities such as a better management of road freight transport by combining data on logistics and on traffic, making use of alternative routes or upgrading the transport system. One of the key aspects of a logistic core road network is to influence the demand for freight by clustering of industries. The assumption is that unnecessary movements in between companies can be prevented and loading factors of trucks can be increased by organizing the supply chain as efficient as possible, from a spatial point of view, and to claim space as sensible as possible.
One of the most challenging aspects here is that demand for freight transport is quicker to change than the supply and location of infrastructure. This asks for a robust transport system which is able to adapt to changing circumstances. Robustness in terms of having different alternatives to get from origin to destination but also with regard to the design of infrastructure.

Connection between different geographical scales
The **logistic core road network** is a network which contains all different geographical scales; the cross border, the national, the regional, the city and the object (road, bridges, tunnels). This **logistic core road network** holds the promise of a good functioning system. It is of utter most importance to realize that every single spatial scale is holding unique challenges.
The municipality of the city for instance wields timeframes for trucks to be allowed to deliver their goods within the city center. This is an important regulation to provide the city dweller and stroller with a pleasant (living) environment. This might be positive on a micro scale on a macro scale however this sometimes yields inefficiency. Due to the different timeframes cities are using truckers have to drive inefficient and longer routes.

Goods should be able to move smoothly throughout the transport system. This requires good understanding of the different challenges related to the spatial scales for at the end to realize a perfectly intertwined network.

Every single national network has an international component. Important question is how the national regimes are reconciled with international regimes. Especially the corridors of national importance need to have an equivalent corridor across the border. Equivalency in terms of physical characteristics and regulations with regard to use.
At the national scale the selection of complementary national hubs and the identification of the most relevant corridors concerning freight transport based on use and size of scale is important. This selection implies a hierarchy and a clustering of activities which enables the way to synchro modal transport. A lack of clustering will only lead to less efficient dispersed intermodal transport (Onlinemagazine.logistiek.nl, 2018).
At the regional scale the selection of complementary regional hubs and the definition of a robust network consisting of main corridors and secondary roads plays a role. Furthermore the definition of how transport is best integrated with the surroundings to provide a qualitative living environment is a key factor.
On a city scale the task to design the interface between the city network and the surrounding network and last but not least to optimally organize city logistics, is being faced. These aspects require special attention since the amount of inhabitants in cities increases (Centraal Planbureau, Planbureau voor de Leefomgeving, 2015). As a result space and infrastructure are going to be used more heavy and intensive. At the same time cities are aiming for a healthy environment for their inhabitants. The unification of the two is challenging. What kind of services (transport management) and facilities (parking, Logistic handling points) are needed to shape this relation?
On the scale of the object, ‘use’ needs to match with the characteristics of the assets. This requires both knowledge and data on the location and size of the current and future flow of goods, information on the design criteria which were the basis of the actual construction of the different assets and the current state of the assets. These details need to be combined with the information and strategies of logistic related activities concerning the specific location. Altogether this will lead to a **logistic core road network** differentiated in how it is used.

Dialogue between different stakeholders
A national network is used by many and maintained by several. The different stakeholders all have their own goals, responsibilities and ideas concerning the transport of goods and the transport system itself.

It is in the interest of shippers, transport companies and logistic service providers to have freight moved via a good working transport system; this entails accessible locations and services and a minimum of road congestion.
Governments and road authorities have similar goals in order to assure the flourishing of the logistic sector. On top of that one wants to save money with regard to the upkeep of roads, bridges and tunnels and have the urge to provide livable and sustainable living environments for their inhabitants. Regional governments have a specific focus concerning the (economic) vitality of the region they are responsible for.
The input of all different stakeholders and consequently the dialogue between the different parties involved is needed in order to get towards a widely supported **logistic core road network**. This common goal will smoothen the cooperation between the different parties involved. Regional governmental bodies will be more willing to collectively utilize one, strategically positioned, industrial plot instead of utilizing an industrial plot of their own. The latter will lead to more fragmentation and inefficiency. Also the alignment of maintenance policies of national and regional governments becomes easier since the framework of a **logistic core road network** comes with certain prerequisites which will be the basis for these maintenance policies.

5. Discussion

The 'dialogues' between the different aspects described in chapter three lead will lead to a joint image on what a core road network should be. The logistical network, based upon the design principals; the right truck on the right road, the right infrastructure on the right location and the right logistic activities on the right location, can be projected onto a map. It preferably shows an image of an hierarchical network together with the nodes of consolidation. Every category comes with dominant outlines concerning the use by freight related transport, which is translated into signing and (virtual) guidance (the digital maps shows routes available for the different kinds of transport depending on their weight, dimensions, emissions etc.) and standards with regard to performance (fuel types, weight and dimensions, noise production etc.).These outlines are subject to structural changes within the field of logistics. The outlines will also be a guiding mechanism on how the network functionally should be designed, shaped and maintained. This map will be a guiding mechanism which has its effect on the exchange between different modalities. Based on this hierarchical network shippers will make their decisions on when and how freight is being transported. Which routes have to be taken, at which time of the day can a certain good best be transported and what kind of vehicle is going to be used for the shipment.

Having a strong vision on how to adequately organize a logistic transport system leaves also possibilities for developments with regard to regulations (internalization of transport by means of pricing), transitions (energy transitions, circular economy) and technological developments (automated driving) to be grafted onto this. In this respect the transport system serves as a main guardian to provide coherence between different technological and sustainability measures.

From a policy maker point of view the definition of a national **logistic core road network** is very promising. It provides a framework which defines the boundaries of its use and from there helps to target financial investments. Within that framework the other components of the

freight sector (vehicles and freight movement) have room to develop as desired. Hence such a defined network is also beneficial to them, the selected network provides quality and clarity.

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Attachment I - Research approach

The nature of the research topic is very complex. A so called ill-defined problem. Many aspects do have an effect on how the ideal transport system should be organized. These are the transport flows, location of logistic activities, sustainability goals, characteristics of the living environment, social aspects, education, technical and logistic innovations etc. A design approach has been deployed in order to design the possible future. This approach holds a few crucial elements:

Problem framing

What designers do is to define the limits of a problem and the suggestion of a possible solution. Schön suggests that in order to formulate a design problem to be solved, the designer must frame a problematic design situation. That is to name the things which will be attended by setting boundaries and selecting particular aspects for attention. From there a coherence (ordering principle) will be imposed on the situation that will guide subsequent moves (Schön cited in Cross, 2006). The act of problem framing is one of the key features of design research since it provides a solid starting point to solve an ill-defined problem. Road freight was the focus or frame of the problem of the research on a logistic core road network. As has been written in the introduction; road freight holds almost 70% of the total weight of goods transported within the Netherlands (Bakker et al., 2017) and is therefore the biggest aspect to relate to. This focus does not mean that the other modalities are neglected. Measures with regard to the optimization and greenification of road freight transport have an effect on the other modalities. It possibly leads to a modal shift from road to other modalities for instance

Connection making

It needs a creative process to bridge problem and solution. The making of connections is at the heart of this creative process. A creative process has a natural rhythm which is usually being iterated several times. The first 'phase' is about the generation of several possibilities and the later 'phase' is about narrowing down the solutions. Psychologist J.P. Guilford called this phenomenon 'divergent' and 'convergent' thinking (Nielsen and Thurber, 2016). Both phases of the process include the involvement of different stakeholders to generate ideas and to check upon the validity and feasibility of solutions.

During the course of the research performed several workshops had been organized and interviews performed. Attendees from different backgrounds and organisations such as spatial designers, policy makers from various backgrounds, researchers and logistic lobbyists, were present in order to give their input. This led to a big 'web' of aspects on what a logistic core road network could possibly entail. From there the entirety of possible applications and meanings of a logistic core road network were narrowed down to a workable framework.

Visualizing

The act of visualizing is a very powerful tool in design thinking. Purcell and Gero (cited in Cross, 2006) suggested that visualizations serve as:

- an external memory in which ideas can be left as visual tokens. These visual tokens give cues and help us to recognize emergent features and properties.
- a physical setting in which design thoughts and possible solutions are constructed in a type of situated action.

But there is more to it, a visualization is a mean to reflect for both the individual as the collective. For instance to reflect upon which aspects can be reconciled with each other and which don't. A visualization is also an effective mean to communicate the idea to others. An image tells more than a 1000 words.

During the analysis phase – the phase of diverging - it was figured out that different strategies and visions have ideas on a logistic core road network. These ideas were projected onto a map of the Netherlands – (figure 2). It was striking to discover, through these illustrations, that the embodiment of the different visions do not accord with each other. These visualizations have helped to illustrate the complexity of the subject matter and the need of a constructive dialogue to come to a commonly shared idea on what a logistic core road network should entail.

Figure 2 – Different visions on a core road network projected on a map