CORRIDORS FOR CUSTOMERS: ANALYSING BOTTLENECKS IN INTERMODAL FREIGHT TRANSPORT

Patrick Witte[1] and Bart Wiegmans[2]

[1] Utrecht University, the Netherlands, p.a.witte@uu.nl
[2] TU Delft, the Netherlands, b.wiegmans@tudelft.nl
Keywords: inter-sectoral coordination, European transport infrastructure, bottlenecks

ABSTRACT

The present understanding of bottlenecks in intermodal freight transport fails to grasp the cumulating and culminating effects of bottlenecks, for the scope of the research is in most cases limited to a one-sided (logistics) perspective. A theoretical framework has been created, which argues that bottlenecks should be interpreted as integrative, complex problems, operating on the cutting edge between transportation, spatial planning, environmental issues, economic development and transnational governance. The aim of this paper[i] is to provide empirical evidence to support this framework, in a context of European transport corridor development. The theoretical framework has been preliminary tested in an empirical setting by zooming in on the European transport Corridor 24 (ranging from the Netherlands to Italy), using mixed-scanning methodology. In a first step, both general (macro-level) and specific (micro-level) bottlenecks have been identified by interviewing logistics experts. In a next step, these first results will be further used to perform an in-depth, qualitative analysis of bottlenecks in case-study areas along Corridor 24. One of the key findings is that a customer perspective, which stresses to perceive bottlenecks from the perspective of the direct users of transport infrastructure, is the most prominent aspect lacking in the present understanding of bottlenecks. The findings furthermore suggest that bottlenecks emerge from different, sectoral perspectives. Moreover, these perspectives appear to be highly interrelated. In other words, more attention should be paid to the cumulating and culminating effects of bottlenecks, operating as comprehensive problem areas. The most important implication for research and policy is that, when using a limited, sectoral perspective on bottlenecks, one loses track of the possible added value of sector-transcendent analyses. This will ultimately lead to inefficient use of transport networks. This paper provides the present body of knowledge with a new conception of the possibilities of inter-sectoral coordination in dealing with bottlenecks in intermodal freight transport.

1 INTRODUCTION

The existence of bottlenecks in the European transport network is a persistent issue in European (spatial) policy. Therefore, the possibility of upgrading the existing transport infrastructure to help remove bottlenecks has been extensively studied in recent years. However, the upgrading of existing infrastructure is only part of the solution. And a lack of capacity in the infrastructure network – the reason for upgrading the infrastructures – is only part of the problem. This paper argues that a lack of understanding of the scope, complexity and cumulative effects of bottlenecks is the most prominent aspect currently missing in the analysis of bottlenecks in the European transportation network.

The traditional understanding of transport bottlenecks is predominantly limited to a (technical or managerial) sectoral perspective. Of particular concern within this understanding are the capacity constraints of transport infrastructure. The technical capacity of transport infrastructure can be defined as follows, adapting Rothengatter's (1996) definition of the theoretical capacity of a rail network: '*The maximum quantity of freight which can be operated on a link, depending on a number of factors such as the type of vehicles, the speeds, the mix of transport modes as well as the operation and scheduling systems*' (p. 51).

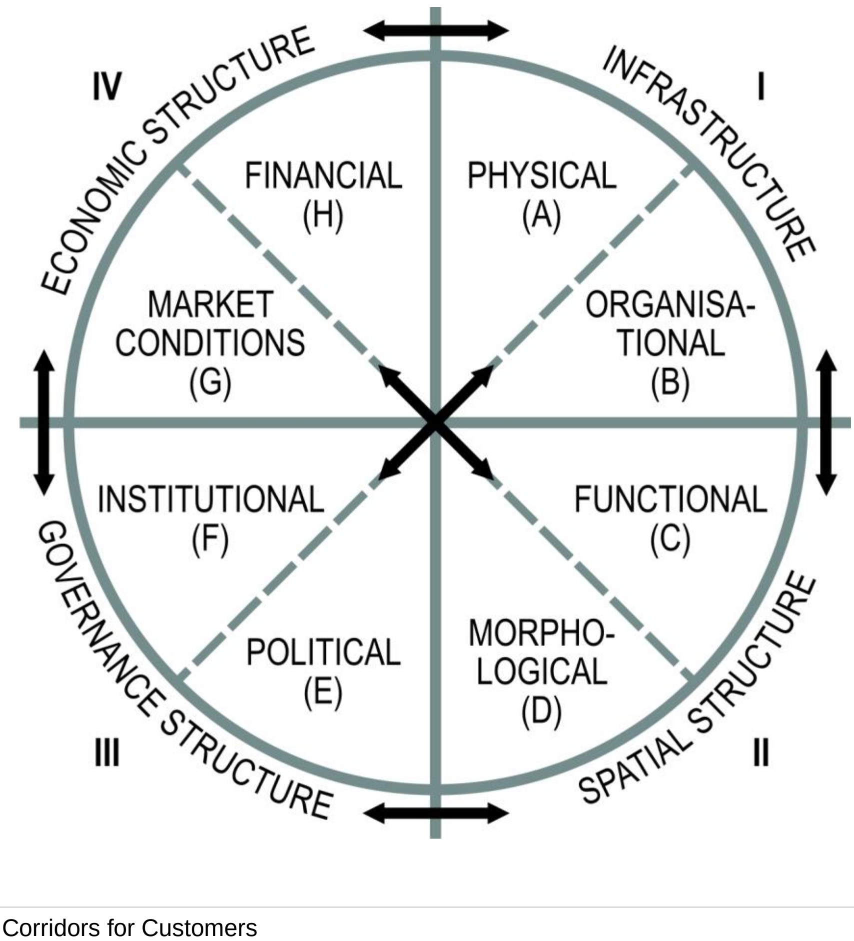
This closely relates to a literal definition of a bottleneck as a narrow section of road or a junction that impedes traffic flow.

Despite the attention to transport bottlenecks, academic research thus far has largely failed to develop a comprehensive, consistent and especially an integrative framework to analyse and evaluate bottlenecks in transport networks. The urgency of resolving bottlenecks in European transport networks has heightened the need for innovative solutions. However, as will be pointed out here, this is easier said than done, since transport bottlenecks have become so much interrelated with a multitude of economic, spatial and governance issues. This has thus far only been partly understood. The aim of this paper is therefore to shed more light on the complexity of the sectoral bottlenecks and their development into comprehensive problem areas in which the problematic characteristics of old (sectoral) and new (comprehensive) bottlenecks cumulate and culminate.

2. CONCEPTUAL FRAMEWORK

This section will discuss different perspectives on transport bottlenecks. An extensive literature review has been performed, especially covering the most recent period from 1995 onwards. This has generated a conceptualisation consisting of four common, distinctive perspectives on bottlenecks (Figure 1). The first is infrastructure (I), including the physical (A) and organisational (B) dimension. The second is spatial structure (II), consisting of the functional (C) and morphological (D) structure. The third is governance structure (III), dealing with the political (E) and institutional (F) structure. The fourth is economic structure (IV), taking into account the market conditions (G) and financial aspects (H). Within each perspective and type, numerous bottlenecks can be found. This paper will highlight the most important ones.

Figure 1. Conceptual framework



2.1 Infrastructure (I)

In this paper, the subdivision in physical and organisational structure which is common in definitions of infrastructure will be used to explain the different bottlenecks involved in the infrastructure perspective.

First, physical bottlenecks (A) will be discussed. The most common bottleneck within this category is congestion. Congestion involves many dimensions, various spatial scales and multiple transport modes (Chapman et al., 2003, p. 185; Rodrigue, 2004, pp. 158-159). Congestion should not be confused with another important type of bottleneck in the physical transport infrastructure: capacity constraints. Capacity constraints amount to the mere technical capacity of a certain piece of infrastructure (Rothengatter, 1996), whereas congestion also originates from other issues besides capacity constraints, such as accidents and bad weather.

Closely related to physical bottlenecks are organisational bottlenecks (B), relating to the organisational *facilities* of infrastructure. Apparently, there is a frequent call for harmonisation and standardisation, originating from, for instance, policymakers who try to implement innovative concepts such as 'integrated supply chain management'. However, as Maes et al. (2009, p. 1, 15) point out, there is hardly any cooperation between logistics and industrial companies. It proves hard to break with institutional structures. The problems with harmonisation and standardisation reinforce other bottlenecks related to the organisational infrastructure, which all influence the efficiency of transport networks: for instance, the adaptation of freight loads to regulatory constraints (Rodrigue et al., 2010, pp. 521-522). It goes without saying that a more holistic approach is desired to overcome these problems.

2.2 Spatial structure (II)

The second perspective concerns the spatial structure of transport networks, consisting of the functional and morphological structure. The functional structure covers aspects related to land use, plus the planning processes underlying the actual land use. The morphological structure covers the unplanned, external conditions or surroundings, especially those in which people live or work.

First, bottlenecks related to the functional structure (C) will be discussed. Actual land-use bottlenecks can be summarised as 'pressure of space on the transport network' (Hesse and Rodrigue, 2004, p. 181). One of the main issues is the lack of land for expansion in traditional port areas. This leads to changing port–city relations and expansion of ports towards the coast (Wiegmans and Louw, 2011, p. 581). Bottlenecks related to the planning process are especially difficulties of involving private parties in the financing of transport infrastructure. Issues in this case are the diversity of actors and the risk-avoiding behaviour of private parties. Other constraints relate to multiple ownership of land or fragmented land ownership (e.g. Louw, 2008, p. 69). Issues in this case are the behavioural characteristics of land owners and the institutional context of land ownership.

With regard to the morphological structure (D), two types of bottlenecks emerge. The first type can be characterised as traffic externalities, in most cases implying environmental effects. The externalities consist of the degradation of urban landscapes, use of space by traffic, road safety (i.e. accidents), air pollution and other types of environmental pollution, traffic noise, etc. (Banister, 2000, pp. 116-117). The second type of morphological bottleneck concerns 'inescapable' physical barriers, in which path-dependent development has a crucial part to play. An example is the passage through the Alps to reach the seaport of Genoa in Italy, by means of the hinterland connections of the Port of Rotterdam; tunnels are still being constructed and the topography does not allow for very high speeds (Van Klink and Van den Berg, 1998, pp. 6-7).

2.3 Governance structure (III)

The third perspective is related to the governance structure. Governance structure can be divided into political structure and institutional structure.

With regard to the political structure (E), different bottlenecks emerge. A first issue is the lack of knowledge of politicians and the subsequent use of planning methodology in practice. As Peters (2003, p. 317) suggests, European Union (EU) transport investments lack consistency and sustainability owing to the existence of partially complementary, partially competing development objectives. Furthermore, planning processes especially in transport corridors are often characterised by a narrow focus on bottlenecks and a rather defensive attitude taken by regional and local governments (Romein et al., 2003, p. 211).

The second dimension of the governance structure is the institutional structure (F). This type closely relates to the organisational bottlenecks mentioned before. In this paper, organisational bottlenecks concern friction factors with regard to the organisational *facilities* in infrastructure (formal, hard structures). Institutional bottlenecks are defined broader and thus cover also the way people (or firms, public bodies, etc.) *make use* of these facilities (informal, soft structures). Institutional fragmentation can be regarded as an example of a serious institutional bottleneck. Institutional fragmentation occurs in situations where different procedures do not fit with each other. This is the case in the European rail system, for instance, where a host of different technical systems is used by national rail companies simultaneously (Priemus and Zonneveld, 2003, p. 169). A related issue of fragmentation is the transnational nature of transport corridors, cutting through regional and national administrative borders (Romein et al., 2003, p. 207).

2.4 Economic structure (IV)

The final perspective is the economic structure. The definition of economic structure is the availability, quality, spatial distribution and cohesion of production functions, including infrastructures. To be more specific, economic structure will be divided into market factors (i.e. conditions) and financial factors (i.e. availability and allocation of resources).

Bottlenecks related to market conditions (G) can be characterised as the influence of competition and market principles on the one hand, and the effects of agglomeration externalities on the other. In the first case, one can point to operational and commercial barriers obstructing access to infrastructure. Another example is the existence of monopolistic structures in transportation networks. Regarding agglomeration externalities, bottlenecks that can be identified are to be found at the 'break-even point' where positive agglomeration effects turn into negative agglomeration effects. There are limits on the degree to which agglomeration contributes to economic growth, particularly in metropolitan areas, where congestion and environmental degradation can become important problems when this 'turning point' is reached (Farole et al., 2009, p. 8).

Bottlenecks related to financial factors (H) consist of both the basic availability of financial resources and the costs and effects of the actual allocation of these resources. Concerning the availability of financial resources, one should not be surprised that the recent economic downturn is regarded by some researchers as an external factor which is disturbing and damaging the already declining funding activities of governmental bodies. If investing in transport infrastructure occurs nevertheless, there are oftentimes many problems. Examples include the costs of investments (Marvin and Guy, 1997, p. 2026), diverse effects of over- or under-building of infrastructure (McCann and Shefer, 2004, p. 179) and the unlikelihood of short-term returns on infrastructure investments (Van Klink and Van den Berg, 1998, p. 3).

2.5 Cumulative effects of bottlenecks

In many cases bottlenecks appear to be interrelated, leading to cumulative effects. This links closely to the concept of logistical friction as a multidimensional concept (Hesse and Rodrigue, 2004, p. 179). Friction factors can be understood as factors impeding the (most efficient) circulation of freight. The different perspectives of bottlenecks therefore essentially are friction factors which cumulate to create a bottleneck.

The strongest relations can be found between the infrastructural perspective on bottlenecks and any of the additional perspectives on bottlenecks. Infrastructure and spatial structure are connected for instance by the integration of transport infrastructure in the urban fabric and local environments. The negative external effects created by traffic externalities are another example. The pressure of space on transport, for example through the effects that the operation of real estate markets has, is also illustrative. Finally, the negative impacts of environmental protection on the transportation network can be mentioned.

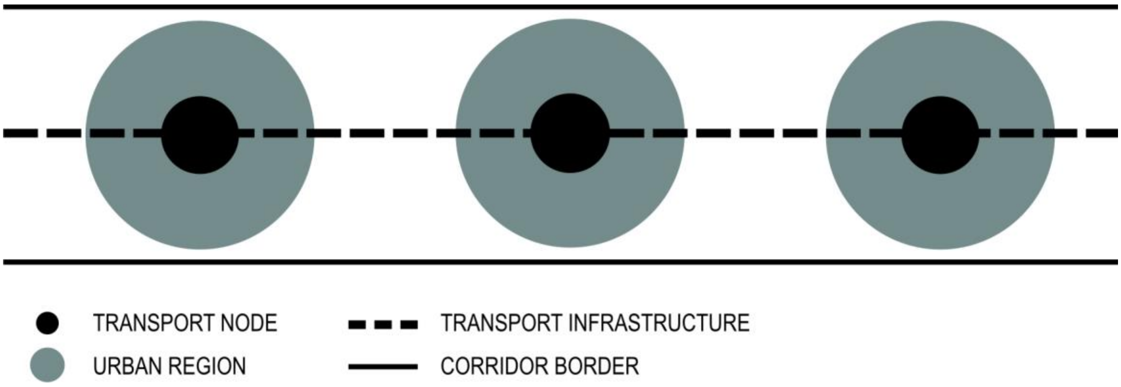
The relation between infrastructure and economic structure has also been pointed to before. One can think of the friction between policy documents aiming at the introduction of new concepts such as integrated supply chain management, the competitive considerations of logistics companies and the financial consequences that could possibly follow a decision to implement such concepts. This also links closely to the relations existing between infrastructure and governance structure. In this case, the correlation between technical and organisational chokepoints (electric power compatibility, waiting times, interoperability) and the political and institutional embeddedness of these chokepoints comes to the fore.

On basis of the foregoing, an integrative conceptual framework is designed (Figure 1). This conceptual framework can be understood as a wheel, which consists of a number of different spokes. The wheel consists of four quadrants (i.e. the perspectives), and each quadrant of two types (i.e. the dimensions). Returning to the concept of logistical friction, it should be stressed that there are many different friction factors hampering the most efficient movement of freight. Each spoke in the wheel can therefore be understood as a friction factor cumulating to create a bottleneck. The main argument here is that in attempting to solve a bottleneck, it is not sufficient to consider only one dimension. Because of the cumulative effects of bottlenecks, all types of friction factors should be considered. The arrows in the model represent the connectedness of all the different perspectives involved. There is no specific order in arranging the quadrants in the model, nor in the length or magnitude of the arrows. The model is used merely as a visualisation of the complex overlaps of bottlenecks.

3. METHODOLOGY

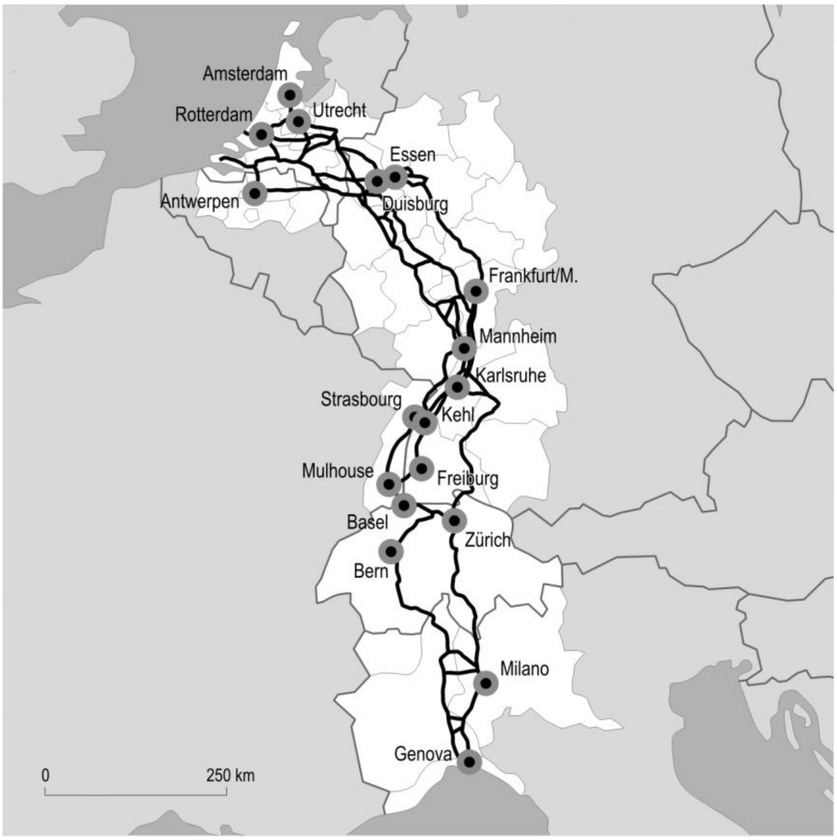
The conceptual framework will be tested in an empirical setting by zooming in on the TEN-T Corridor 24 transportation network. Corridor 24 is one of the major transport corridors in north-western Europe, stretching from Rotterdam to Genoa. Transport corridors can be defined, following Priemus and Zonneveld (2003), as bundles of infrastructure (roads, railways, waterways) connecting two or more urban regions (p. 167). Transport corridors are concerned with connections (i.e. transport nodes) that use different modes (road, rail, barge or intermodal) and include both passenger and freight transport (Figure 2).

Figure 2. Transport corridor conceptualisation



This empirical application deals with the European area interested in the development of the intermodal transport corridor linking the transport nodes of Rotterdam and Genoa. This space hosts a number of the most densely populated urban regions in Europe (Figure 3). What becomes evident is that different spatial scales are at stake on the Corridor 24 transport network. The transnational transport corridor scale (macro), as well as the urban region and the local transport node scale (micro), are of importance. Therefore this paper needs a methodology that is suitable for both the macro and the micro level of analysis at the same time, since neither of the two levels is able to capture the full complexity of the transport bottlenecks occurring on transport corridors.

Figure 3. Corridor 24 and its environment



This paper will use mixed scanning methodology, since the requirements mentioned above especially coincide with the overall principle of this type of methodology: a broad, strategic analysis of the main bottlenecks on the transport corridor will provide a definition of specific problem areas which require a more detailed examination. Mixed scanning methodology was originally introduced by Etzioni (1967, 1986) and is still often used in decision-making and planning. Etzioni used the metaphor of a weather observation system to explain the logic and relevance of his framework. Where a rationalist would examine the entire sky and an incrementalist would focus on certain, specific areas, the mixed scanning approach uses two cameras: a broad angle to cover all parts of the sky, but not in great detail, and a second camera to focus on those areas revealed by the first camera to require a more in-depth examination (Etzioni, 1967).

When applying the mixed scanning framework to this paper, one could argue that a broad, strategic analysis of the transport capacity of the transport corridor will fail to take into account specific, interrelated chokepoints at the local level. For example, the impact of noise protection measures resulting from national legal structures. At the same time, a regional strategy for a certain transport node will neglect the impacts of border-crossing problems on the transport corridor at the transnational level. Mixed scanning is able to tackle these problems.

The identification of general (macro) bottlenecks for the Corridor 24 regions has already been described extensively in Witte et al. (2012) and will therefore not be repeated at this point. This paper only makes use of data derived from the Regional Workshops, which provided this paper with a selection of problems in specific locations (micro) along the Corridor 24 transport network[ii]. The aim of these workshops is to be open to all the institutions and citizens interested in the Corridor 24 transportation network by activating a network of strategic decision makers and stakeholders and starting up a series of workshops to share information and collect expectations on a regional (micro) scale. In this way nine Regional Workshops have been carried out[iii]. About three hundred people, including regional and local planning authorities, transport authorities, logistic and transport entrepreneurs, research institutes and experts, local companies and global corporations, associations of citizens, port authorities and political decision makers, participated.

In addition, this paper will highlight some findings from an informal test planning procedure, which was undertaken in the region of Wesel, Germany. These results can be viewed as a first attempt to perform an in-depth, qualitative analysis of bottlenecks in case-study areas along Corridor 24. It needs to be stressed that these results can only be used to gain a first, indicative impression of the empirical validity of the conceptual framework. Follow-up case study evidence will be the topic of debate in another, forthcoming paper[iv].

4. FINDINGS AND DISCUSSION

This section will first summarise the micro-level findings of Witte et al. (2012). These findings have resulted from the Regional Workshop in Rotterdam, complemented with follow-up in-depth interviews with logistics experts from the Port of Rotterdam Authority. Nine experts participated in the Regional Workshop, including representatives of the Dutch Ministry of Transport, the Port of Rotterdam Authority, public and private institutions in the management of Dutch railway systems and universities. Afterwards, the indicative case study evidence from the Wesel region in Germany will be presented.

4.1 Micro-level analysis

One of the key findings of the micro-level analysis is that a customer perspective, which stresses the need to perceive bottlenecks from the point of view of direct users of transport infrastructure, is the most prominent aspect lacking in the present understanding of bottlenecks. This is reflected in a number of technical and managerial bottlenecks (Table 1). The lack of a customer perspective plays a key role in the discussion of all the bottlenecks identified in the micro-level analysis.

Table 1. Technical and managerial bottlenecks in the Netherlands

Technical	*Managerial*
Track length	Needless stops
Track capacity	Travel time
Train length	Circulation time
Security systems	Estimated Time of Arrival
Voltage systems	Knowledge of trains' priorities
Slot incompatibility	Traffic management
Free access to ports	Cross border slot reassignment
Connections to terminals	Language barriers engine's drivers

Source: Authors' own table based on expert interviewing

In the Dutch context, a number of issues related to infrastructure (I) were identified. With regard to the physical (A) point of view, issues identified were a lack of long tracks at the starting points of freight routes, a lack of sufficient capacity along the way (i.e. too many trains are operating on the same tracks), a lack of long tracks at the train stops along the way and too many different systems. From a customer point of view, the previous physical problems result in several organisational (B) problems: transporters cannot operate trains with a length of over seven hundred metres, they need very expensive engines regardless of the distance travelled, they have to make needless stops and they cannot make ideal circulations because of timetables and working conditions of engine drivers.

Related to bottlenecks in infrastructure are bottlenecks in spatial structure (II). The morphological structure (D) is of especial interest in this case. It appears that many present-day bottlenecks result from past path-dependent choices that are reflected in the present spatial, morphological structure. Examples of specific bottlenecks in the Netherlands include different security systems along the A15 highway, 1.500-volt 'islands' (compared to 25 kV continuous-flow electricity systems), too short tracks on Maasvlakte–Oost and Waalhaven (Rotterdam), limited transport capacity 'at the doorstep' and a lack of tuning between limited slot-capacity and the ideal of an accurate 'estimated time of arrival'. In part these bottlenecks can be considered as 'accessibility problems' in traditional port areas. A lack of accessibility can also be characterised as a bottleneck in the functional structure (C).

When extending the analysis to include a cross-border corridor perspective, bottlenecks in infrastructure are complemented by bottlenecks in governance structure (III). Some experts mentioned the problems identified in the NewOpera report. Those include insufficient cross-border coordination for slot reassignment; a lack of harmonisation in train numbering, tracing and handling; a lack of supporting tools to manage traffic; a lack of knowledge of trains' priorities; and a lack of punctuality (Castagnetti, 2007, p. 62). The key finding of this research report is that technical improvements on the corridors will be nullified if driving rules, working patterns and safety regulations are not standardised.

Of course, there are many programmes and actions going on to tackle these problems. However, as the experts have repeatedly stressed, as long as 'the customer' does not take part in these projects, effects will be small. A promising solution would be to classify and deliver programmes and actions according to the customer's preferences. This is, however, easier said than done; projects often diverge and there are no strict deadlines for realisation of such projects. This issue is closely related to the political (E) and institutional (F) bottlenecks.

The different perspectives (*in brackets*) again seem highly interrelated, leading to the cumulative effects of bottlenecks. For example, to upgrade the present level of service in railway freight transport operations (*organisational*), several measures are needed (e.g. improvement of reliability, shorter travel times). What is required to achieve these improvements is, for instance, an attitude shift from reactive to proactive on the part of the infrastructure managers, railway undertakings and terminal operators (*institutional*) and a close cooperation between various traffic managers (*market conditions*). Besides, heavy investments are required (*financial*) to further improve the functioning of the present transport infrastructure network (*physical*). Examples include the implementation of the ERTMS security system at the Kijfhoek shunting yard (near Rotterdam, Netherlands) or near the Zevenaar border (close to Emmerich, Germany).

But who will pay? The experts have agreed that there is a need for an 'integral corridor director' to mediate in such issues. Ideally, 'the market' should initiate such a director, but in certain cases, the experts concluded, 'the market' also profits from suboptimal solutions. There appears to be a lack of involvement; no one is willing to invest. This is a clear example of the effects of economic structure (IV) on the Corridor 24 transport network. In sum, one can state that 'the customer' is often lacking in discussions on bottlenecks, especially in corridors, and that an integral corridor director is suggested as a promising way forward.

4.2 Informal test planning procedure: the case of Kreis Wesel

A recent example of the integrative nature of bottlenecks along corridors is the discussion with respect to the creation of a third track in Germany between Emmerich and Oberhausen to better connect the dedicated Dutch freight transport railway line 'Betuweroute' to the German hinterland. The line has a strategic importance as freight corridor connecting the system of inland ports and logistic centres of the Ruhr region in Germany to the dedicated line linking the region to the Port of Rotterdam. Whereas the Dutch government has speeded up the procedure for implementation of this project, the German procedure is running parallel, but without strict deadlines for implementation, owing to political reasons. This is likely to hamper the implementation of fluent cross-border freight transport in the short term.

At first sight, this seems to be merely a physical bottleneck; there is lacking capacity on the German part of the network following the Betuweroute, so an additional track is needed at one specific section of the network. However, closer examination also reveals problems in the governance structure: political resistance to the project, and differences in institutional structures and procedures which hamper efficient cross-border cooperation. Moreover, the German section of the line presents several additional problems that need to be solved: some fifty level crossing along the line, insufficient capacity of the stations (e.g. Oberhausen) or sub-optimal employment of the nodes and disturbances to the surrounding settlements (e.g. noise, dangerous materials, fragmentation of the communities).

The German rail operator 'Deutsche Bahn' has therefore developed a project to upgrade the line to three tracks and eliminate most of the crossings. According to the German law the new development should provide the necessary compensations to the communities, including noise reduction measures (i.e. noise walls). However, due to the topographical structure of the area and the type of settlements these walls need to be high (often between two and six metres). This has encountered the opposition of the communities that see the proposed solution as a further disturbance to their living condition rather than a betterment.

First of all, it should be noted that many bottlenecks are interrelated in this case. What at first sight seems to be a mere physical bottleneck, also appears to have a clear functional, morphological, political and institutional dimension. In addition, the bottlenecks occur on both a micro and a macro scale. On a local level, the project of the Deutsche Bahn is facing heavy local resistance because of the visual impact of the noise walls. On the other hand, from a transnational corridor perspective, this area is of crucial importance to achieve efficient goods travel from the Betuweroute to the German hinterland. Thus, different types of bottleneck interfere at different spatial scales, which calls for a strategic set of measures.

A second point of concern is the modal competition this area is facing. On the one hand, the creation of a third track to solve the bottleneck should be measured against the alternative costs of expanding the German motorway network. The recent policy attitude towards achieving modal shift from transport by road to rail and inland navigation is helpful and strategic in this respect, to strengthen the insufficient and difficult links between the railway and the inland ports in this region. On the other hand, inland navigation itself via the river Rhine can also be seen as a competitor to rail transport for this area. Moreover, this line is in competition with other corridor routes that also show high rates of ton/km and with other projects that also opt for German federal funding. In this way, market conditions and financial factors can also be included as bottlenecks, to add to the complexity of this area.

To contribute to a solution, an informal planning procedure called 'Ideenwerkstatt Fortsetzung der Betuweroute' has been promoted by the regional association Ruhr together with the municipalities along the German part of the Betuweroute. The aim of this informal procedure is to elaborate alternatives to high noise barriers that separates entire settlements as a foreign body structure and to find alternative, innovative and original solutions. Three cities in the region 'Kreis Wesel', Dinslaken, Wesel and Hamminkeln (Mehrhoog), were selected as pilot areas where these attempts should take place (Figure 4).

Figure 4. Betuweroute and German hinterland

Source: GIS-Works, RegionalVerband Ruhr

Our contribution to this workshop resulted in a set of strategic questions or alternatives:

- Should this project concentrate only on the creation of a third track and the realisation of noise protection on a local scale to solve the bottlenecks, or are there more strategic interventions to be implemented in this region?
- Is noise protection the only way to tackle the existing morphological bottlenecks, or can the upgrading of the railway station areas and their surroundings lead to synergies on a regional scale, which can be seen as a form of compensation?
- Would the establishment of an efficient railway link between the Wesel region and a logistics hub near the river Rhine contribute to a routing shift, so the construction of a third track can be postponed or abolished?

In the first question, the negative external effects which tend to aggregate on a low spatial scale (i.e. noise nuisance, safety and visual quality of the localities involved) are measured against possible positive spill-over effects which tend to aggregate on a higher spatial scale (e.g. corridor development and related regional economic growth). The second and third question make use of a growth management perspective: in this case compensating noise nuisance with the creation of synergies at railway station areas, or investing in another part of the region to shift the freight from the overloaded existing network. In this way, physical, functional and morphological bottlenecks on a local scale are tried to be solved by seeking economic potential on a regional to transnational (corridor) scale.

Although the regional authorities present at the workshop stressed the lack of available financial means to implement such investments, the strategic questions allowed for a reconsideration of the problem. Instead of asking: 'How to design the most efficient noise protection measures?', the question becomes: 'How should this region perform twenty to fifty years from now?'. The bottleneck problem thus evolves from a short-term technical problem to a problem of long-term economic development and possible planning interventions. This has been visualised in a grid of cases (Table 2). The grid displays two alternatives on each axis: no investments versus investments (i.e. third track), and stagnation versus growth.

Table 2. Towards a regional strategy in the region of Wesel

	No investments	*Investments*
Stagnation	Worst case scenario: - Selective improvements - Low-cost solutions - Other financial resources	Negotiation scenario: - Innovative, privately funded noise protection - Node development optional
Growth	Self-help scenario: - Self-funded noise protection measures	Integrated node & location development scenario

Source: Authors' own table based on informal test planning workshop

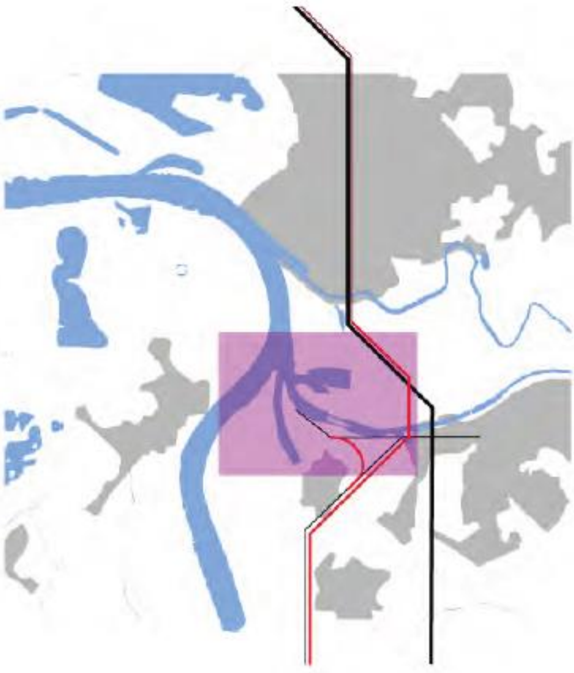
As an example, two possible strategies were developed in further detail. The first strategy concerns a robust strategy for municipal development in case of the integrated node and location development scenario. In this case, noise protection is integrated in the build environment, by creating residential units near the railway station area, which function as high quality metropolitan living areas and noise protection walls at the same time (Figure 5). These new residential units might also trigger related investments in the surroundings (e.g. shopping facilities, office space, etc.). The urban design, as well as the planning process are of critical success factors in this scenario.

Figure 5. Visualisation of residential noise protection in Wesel

Source: Stefano Pensa, Politecnico di Torino

The second scenario also involves investments, but in this case investments elsewhere. The focus in this case is on inland ports development in vicinity of the region of Wesel, as a means to shift some of the freight traffic from the existing lines towards a newly build logistics hub near to the river Rhine. Because this hub might function as an alternative to the Port of Duisburg, investments in this inland port might initiate related logistics activity and attract new businesses to the region of Wesel. The physical link to the existing network can be established by renovating an existing section of unused track, instead of building an additional third track (Figure 6).

Figure 6. Linking the logistics hub to the existing network in Wesel



Source: Markus Nollert, ETH Zürich

In sum, the integrative analysis of bottlenecks in the region of Wesel and the strategic questions posed to deal with those issues have contributed to the development of a regional perspective on the future development of the region. Whereas other workshop teams focussed strongly on (audio-)technical and architectural measures to be taken to reduce the negative impacts of noise nuisance and visual quality, the integrative analysis of bottlenecks provided a new, regional outlook on the problems in Kreis Wesel. By focussing so strongly on the local noise problem, the regional development perspective had been lost. This is not to say that technical solutions to technical bottlenecks are therefore irrelevant, but by adopting this integrative perspective new opportunities and development alternatives have come to the fore.

5. CONCLUSION

Intermodal transportation is often hampered by bottlenecks in transportation networks. So far, the understanding of these problems has remained largely incomplete. Policy documentation is often limited to include only sectoral perspectives on bottlenecks. Especially in times of economic downturn, a sectoral perspective is often favoured over a holistic approach towards bottlenecks, for reasons of efficiency. One can think here of the traditional emphasis on the literal definition of bottlenecks, that is, the mere capacity constraints and congestion occurring in the infrastructural networks.

What has become clear, however, is that bottlenecks can no longer be viewed as mere capacity constraints of infrastructure networks. Instead, they should be interpreted as being integrative, complex problems, operating on the cutting edge between transportation, spatial planning, environmental issues, economic development and transnational governance. In other words, more attention should be paid – both in scholarship and in practice – to the cumulating and culminating (friction) effects of bottlenecks, operating as comprehensive problem areas.

This paper suggests that bottlenecks emerge from different sectoral perspectives. Moreover, these perspectives are highly interrelated. Based on these suggestions, a conceptual framework has been developed to identify and analyse bottlenecks in a more holistic way. This can be considered a useful tool to the further development of planning education on this topic. The most important insight for practitioners in applying this framework is that when using a limited, sectoral perspective on bottlenecks one loses track of the possible added value of sector-transcendent analyses. This will ultimately lead to inefficient use of transportation networks, as the case of Wesel has demonstrated.

One of the key findings is that a customer perspective, which stresses to perceive bottlenecks from the perspective of the direct users of transport infrastructure, is the most prominent aspect lacking in the present understanding of bottlenecks, especially in the case of corridors. An integral corridor director is suggested as a promising way forward, to mediate in such issues. The framework presented in this paper in this respect allows for a new conception of the possibilities of inter-sectoral coordination. This provides interesting opportunities for reconsidering the position of spatial planning in future policy regarding European transportation networks.

A suggestion to enrich the planning education on bottlenecks might be to rate the (lack of) importance of different types of bottlenecks as perceived by the direct users of transport infrastructure (logistics companies, port authorities, other relevant stakeholders, etc.). In this way it would be possible to arrive at a better understanding of the relative value of bottlenecks (i.e. the distribution of the fields in the model and the direction and magnitude of the arrows). This would also be an interesting way of asking private companies valuable information on bottlenecks without having to ask them for sensitive data or information. This method could result in a clear and easily interpretable framework for practitioners to deal with comprehensive bottlenecks in the European transportation network.

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[i] This paper is an adaptation of a research paper by the same authors, originally published in Research in Transportation Business and Management (2012, volume 5, pp. 57-66). This paper aims to summarise the main argument of that paper, and add some new empirical insights obtained since the original publication.

[ii] The research has been carried out in the context of the INTERREG IV-B co-funded project 'CODE24'.

[iii] The workshops took place in Rotterdam (Netherlands), Antwerp (Belgium), Essen, Frankfurt, Mannheim & Karlsruhe (Germany), Zurich (Switzerland) and Milan & Genoa (Italy), thus covering the entire space belonging to Corridor 24. The authors participated in the workshop in Rotterdam.

[iv] This paper will deal with bottlenecks in a context of inland ports development.