

Sustainable and connected infrastructure networks and
urban regions – transition towards integrated planning
of urban nodes on TEN-T corridors
- WORK IN PROGRESS -

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Abstract: Achieving a smart, green and integrated transport system is essential for the (social)-economic and environmental vitality of European urban regions. In order to better integrate urban nodes into TEN-T corridors, the challenges of multimodal connections between long-distance and last-mile transport have to be tackled from both freight and passengers' perspective. Different spatial scales, modalities, sectors and stakeholders have to be taken into account when improving mobility, infrastructure and spatial development in both urban nodes and corridors. To tackle these challenges a research programme has been developed, supported by EU's Horizon2020 (Vital Nodes), which analyses best practices, experiences and opportunities in various urban nodes in Europe. This paper addresses the approach deployed by the Vital Nodes-project to integrate investments in mobility, infrastructure and urban development from (inter)national/corridor, regional and local perspectives. To this end, the paper discusses results from case studies in urban nodes as Gothenburg, Vienna, Rotterdam, Genova, Strasbourg, Turku, Hamburg, Budapest and Mannheim and related TEN-T corridors, including an analysis addressing their main challenges. The paper concludes by exploring the main elements of such transition that will improve the integration of urban areas into the TEN-T corridors and the vitality of the urban regions of tomorrow.

Keywords: integrated spatial and infrastructure planning, multi-modal infrastructure, multi-level governance, urban nodes

1. Introduction

The worlds of transport and spatial planning are in a major transition, coping with a large number of changes and (the need for) related innovations. This relates to global challenges related to climate change, energy transition, environmental pollution, globalisation, ageing infrastructures as well as densification, urban growth, liveability and growing passenger transport and freight volumes. Transport and logistics provides vital functions to the European society, enabling economic growth and access to jobs and services, but also create issues of CO₂ emissions, environmental pollution, fragmentation and land-take. *Urban nodes* are crucial for the effectiveness of the core network of Trans-European Transport Network (TEN-T), as they are the origin and/or destination of most long-distance transport flows, for both passengers and freight. Several trends and major developments can be seen that influence the relation between the TEN-T (core) network and the urban nodes – e.g. changing freight flows via the New Silk Route between China and Europe. Developments that (may)

affect spatial-economic growth, mobility and freight flows in and between metropolitan areas, thereby impacting infrastructure networks and liveability, especially in urban areas. Important trends and transitions in the field of transport include (Linden and Linssen, 2018b):

- Growing urbanization and densification;
- E-Commerce, 24/7 delivery and access to multiple distribution channels;
- Urban and logistical sprawl and development of micro and midi hubs;
- Agglomeration, e.g. development of XXL warehouses (economics of scales);
- Growing demand of flexibility in freight transport and logistics;
- Increasing number of cities with low-emission transport policies and sustainable transport modes (related to Sustainable Urban Mobility Plans, SUMP);
- Conflicting transport flows between freight and logistics, and person transport.

These trends are coinciding with a transformation in Europe's transport system as discussed in the Transport White Paper by the European Commission (COM, 2011) focusing on e.g. limiting transport emissions and contributing to accessibility and liveability in cities. In this regard urban nodes specifically are major areas in which public and private parties and society should join forces to cope with transitions and related challenges. The local context and characteristics of a specific place are however making an effective integration of a node in the TEN-T network more complex. As urban logistics and freight transport grow, innovate and increasingly impact socio-economic development in urban areas, accessibility and spatial-environmental quality of urban regions, there is need for a transition towards integrated planning approaches. An integrated planning of spatial, mobility and infrastructure that takes into account different spatial scales, sectors, modalities and stakeholders.

Currently infrastructure development, mobility and spatial planning are mainly separate worlds, which have not yet been integrated although the many challenges which call for an integrated and innovative approach. For an integrated approach of effective and sustainable incorporating urban nodes on the European transport corridors, a variety of actors need to collaborate early on in the decision making process, such as urban planners, freight and logistic operators, infrastructure operators and coordinators and financiers. This allows not only integrated perspectives and solutions, but also integrated investments in mobility, passenger transport, freight and logistics and infrastructure from local, regional and (inter)national/corridor perspectives. Funding is key when implementing integrated solutions and improvements. However, the conventional shaped worlds of infrastructure, urban mobility and spatial planning are often funded within their own sector. An integrated approach needs integrated funding. A (sustainable) integration of urban nodes into the TEN-T network requires coordination in public funding at European, national and/or local level but also with private funding.

This paper aims to explore how the transition towards an (sustainable) integration of urban nodes into the European TEN-T corridors can be stimulated. To this end, we build upon the results of the European Horizon 2020 project *Vital Nodes* (<https://vitalnodes.eu>). First, the paper discusses the approach of the Vital Nodes project, which has been applied during workshops in a series of urban nodes in 2018-2019, including Vienna, Rotterdam, Gothenburg, Budapest, Hamburg, Genoa, Turku, Strasbourg, Mannheim. Next, we discuss a specific case – the urban node Vienna – addressing good practices and tools that support tackling the occurring challenges. The paper concludes with a discussion of the Vital Nodes' project results and recommendations for integrated planning of urban nodes on the TEN-T corridors.

2. Integration of the worlds of spatial and infrastructure planning

To cope with current challenges, a focus on innovative technical solutions alone, will not be enough. There is need for a transition in planning connecting between the worlds of infrastructure, mobility, freight and logistics, and the world of urban and spatial development. An approach in which there is attention for soft innovations, addressing the multiplicity of the challenges by integrating different spatial scales, sectors, modalities, stakeholders, funds and levels of governance. This need for integration has been acknowledged by key stakeholders such as National and Regional Infrastructure Authorities and DG MOVE, as well as the Coordinators of the TEN-T corridors, who stress the importance of integrated strategies, platforms for exchanging experiences and multi-level governance approaches (Philips et al., 2016). Meaning a need to combine policy objectives as promoted by the Commission in the 2013 Urban Mobility Package (UMP) of the TEN-T regulations and the Sustainable Urban Mobility Plans (SUMP) (EC 2013, COM 2012, 2013). This asks for forward-looking practices and integrated approaches, which both enhance transport solutions and stimulate synergies with other urban functions (Balázs et al., 2016). Viewing the complexity of the current and future challenges, there are no ‘silver bullets’ (CEDR et al., 2018; Broesi et al., 2018).

The Vital Nodes project is funded as part of the EU Horizon 2020 programme, to investigate integrated planning approaches. The main objectives of the Vital Nodes project are (Vital Nodes Consortium, 2017; <https://vitalnodes.eu>): to deliver validated recommendations for a more effective and sustainable integration of all 88 urban nodes into the TEN-T corridors, focusing on freight and logistics; and, to establish a long-lasting European expert network for safeguarding long-term continuity in knowledge and implementation. As part of the Vital Nodes project challenges, drivers and barriers, good practices and opportunities are analysed in various urban nodes and TEN-T corridors. To this end, Vital Nodes has brought existing networks together and has been working on ensuring long-term engagement and recommendations for research and funding needs as well as input to adapt the TEN-T and CEF (Connecting Europe Facility) guidelines.

3. Approach: analysis of multiple dimensions of practical cases

The approach applied in Vital Nodes is based on the Networking for Urban Vitality (NUVit) concept (see Arts et al., 2015, 2016; www.nuvit.eu) that comprises various dimensions (see Figure 1). The spatial and network dimensions regard the linkages between transport infrastructure, freight logistics and land-use. This includes innovative solutions for freight logistics. Combining spatial and network dimensions results in potential synergies that have to be considered, at which the time and value dimensions are important to analyse and discuss. Finally, to become effective integrative planning, it is needed to develop an adequate institutional approach and dealing with implementation issues. Subsequently, transport infrastructure can be carefully coordinated with spatial developments resulting in tailor-made solutions to the local situation (landscaping, context sensitive design), enhanced vitality of regions (at the level of a Daily Urban System) and well-functioning (inter)national transport corridors and networks.

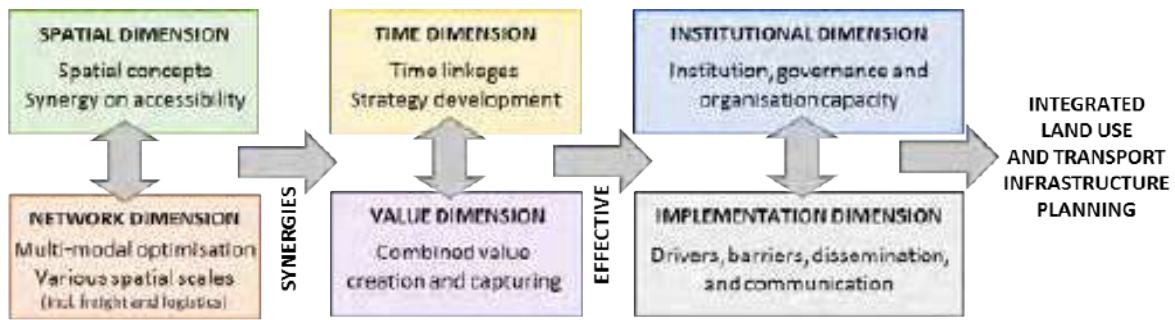


Figure 1: Linkages between different dimensions (based on Arts et al., 2016).

During 2018 and 2019 the Vital Nodes project has conducted numerous workshops throughout Europe in urban nodes such as: Vienna, Rotterdam, Gothenburg, Budapest, Hamburg, Genoa, Turku, Strasbourg, Mannheim, Ljubljana, Munich, Duisburg, Venlo, Tallinn, Bilbao, Antwerp Cologne, Piraeus and Gdynia. Within these workshops, (local) challenges have been identified, drivers and barriers discussed and good practices with potential impact presented (Poppeliers et al., 2018a; Linden and Linssen, 2018a). By bringing together results of the workshops, knowledge and information and make them available for European stakeholders, infrastructure providers, investors and urban nodes a solid basis has been developed to formulate recommendations to the European Commission for stimulating an sustainable and efficient integration of the transport network in Europe.

An important aspect of to the Vital Nodes project for planning practice proved to be bringing together stakeholders from different disciplines and backgrounds to discuss challenges of the specific urban nodes. Stakeholders present at the workshops included a variety of stakeholders: national government representatives, road and waterway authorities, railway infrastructure managers, environmental agencies, representatives of the airport, provinces/regions, service providers, urban/spatial planners, city representatives regarding spatial planning, mobility and environment, port authorities, hub operators, public transport operators, representatives of the chamber of commerce, company representatives and research institutes. In addition, external experts were also participating in the discussion to share good practices from elsewhere in Europe and to reflect on the discussions. While widening their own knowledge the participants in the workshop often came to a real understanding of each other's issues and worked together towards integrated solutions (see Figure 2).



Figure 2: Vital Nodes workshop in Gothenburg, April 2018, participants discussing the challenges of the urban node Gothenburg, while using maps.

An important issue proved to be raising awareness amongst stakeholders on the role of the urban node in the European TEN-T network and the role of freight, logistics for the urban region. In order to create this understanding a set of tools was used and developed (van der Linden and Linssen, 2019) – such as the use of ‘research by design’ and mapping the functional urban area – which proved helpful in developing possible solutions addressing the specific circumstances of an urban node.

During the discussions, participants showed their interest in the linkages between the different geographical scale levels (of (inter)national corridor, urban region and local neighbourhood) and the role of ‘their’ urban node in the context of the TEN-T corridors. Based on the objectives of the participating stakeholders and the Vital Nodes project, the data and information provided, the Vital Nodes appraisal methodology and urban node typology (Poppeliers et al., 2018b), discussions focused on the specific challenges of the urban node regarding infrastructure, freight and logistics and spatial planning. The data and information collected on forehand in a so called ‘Fingerprint’ (Linden and Linssen, 2018b; Poppeliers et al., 2018b) provided insights in – and common understanding about – the characteristics of the node, similarities and differences between nodes that might specify drivers or barriers for challenges, impacts and solutions, and good practices usable for other nodes.

The introduction of one or more European good practices, to help the stakeholders in the urban node to make a mind shift from thinking in barriers and obstacles towards (potential) solutions and options, has shown to be an effective method. Besides, several good practices connect local, regional and corridor level, so stakeholders will get concrete input and inspiration from other European cities and regions on how the relation between the urban node (local, regional) and the corridor level might be improved (Poppeliers et al., 2018c). Cases across Europe show that coordinated optimisation of infrastructure and spatial development at the level of the Dialy Urban System (DUS) can be key to safeguard corridor interests while solving local spatial conflicts. Moreover, the other way around, small measures at local scale may help to solve bottlenecks at the DUS level and the corridor level. For instance, at urban ringroads often up to 30% of the traffic is local. ‘Shaving off’ some of this share by relatively small local mobility measures (which may regard other modalities; e.g. public transport, biking) may reduce traffic sufficiently to (partly) solve congestion bottlenecks at the urban ringroad. If such a ringroad is part of the an (inter)national corridor such ‘acupuncture’ measures can be of importance to the (inter)national transport network (see also Arts et al. 2016).

Following a discussion on solutions, drivers and barriers, the different scale levels are again related to each other while discussing the added value for the local, regional and European level. The added value for Europe relates to the integration of the urban node in the TEN-T network. Special attention is given to drafting business cases with potential win-wins for both the urban node (local, regional scale) and the corridor (European scale). Identifying this (potential) European added value that can be realized in the urban node (city and region) will be direct input for the recommendations of the Vital Nodes project to the urban node and the European Commission.

4. Case study urban node Vienna

As an example of the urban nodes workshops conducted in the Vital Nodes project, the case of Vienna is described in more detail below. Among the participants were a variety of representatives of the national and regional government, municipality, railway infrastructure manager, road administration, waterway administration, airport, chamber of commerce, research institutes and the

private sector. Thereby knowledge was brought together from the fields of infrastructure, freight and logistics, spatial planning, environment, economy and finance.

The Austrian capital of Vienna with around 2.6 million inhabitants is located on three core network TEN-T corridors – the Baltic Adriatic, Orient/East-Mediterranean and Rhine-Danube corridor – including road, rail, aviation and waterways for both freight and passengers (see Figure 3).

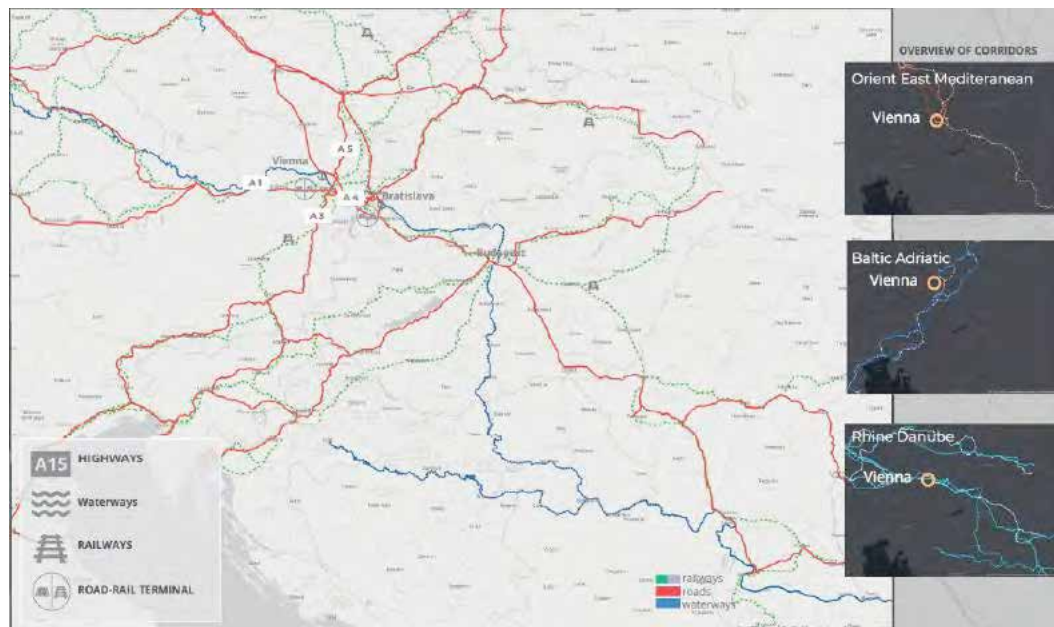


Figure 3: Vienna's location on three TEN-T corridors (van der Linden and Linssen, 2018b).

On each of the corridors Vienna is located mid-way, heightening the urban node's importance to enable well performing transit flows. It is noted that the Baltic-Adriatic flows by road are mostly transferred along Bratislava, with which Vienna has a strong relation. As a border cohesion region future investments in road and rail infrastructure are foreseen between Vienna and the Czech border, which might draw the North-South flows over Vienna instead of via Bratislava (van der Linden and Linssen, 2018b; Poppeliers et al., 2018a).

The urban region of Vienna is fast growing and major urban developments are planned (Vienna City Administration, 2014; van der Linden and Linssen, 2018b, 2018c) on Vienna's East in Aspern, Vienna's Urban Lakeside (Aspern Seestadt) and through various mixed-use urban development zones like the inner city housing projects such as the Sonnwendviertel in the central station district and the development of the Nordwestbahnhof. Impacting the regional level are: a railway connection between Hütteldorf (western side of the city) and Meidling (southwest), and the development of an additional runway of the airport. Also cross-border links are discussed such as the link between the airport and Budapest via the Eastern Rail line, an upgrade of the Pressburgerbahn between Hainburg (on the border with Slovakia) and Bratislava. At a higher spatial scale many investments are done in improving the TEN-T links at the corridors. All these developments are undeniably influencing the transport flows of passengers and freight on different levels, having its effects on the needs for consolidations centres, and hubs at different scale levels as part of logistics oriented development.

With these developments issues of multi-level governance and integrated planning becomes pressing related to the scattered responsibilities of the surrounding municipalities (local planning), the Vienna city administration with coinciding borders of the Bundesland Vienna, the neighbouring Bundesland Lower Austria, and the nearby national borders.

5. Challenges of urban nodes

Through discussions amongst all participating representatives, challenges related to the urban regions have been discussed, using maps on local, regional and (inter)national/corridor level as tools to guide the discussion and clarify specifically mentioned aspects. From the discussions in the urban node Vienna, three challenges were identified that proved to be exemplary for the urban nodes in general (van der Linden and Linssen, 2018c; see also Figure 4):

- (Lack of) logistics oriented development;
- Spatial planning at functional urban area level;
- Robustness and vulnerability of the network.

5.1. (Lack of) logistics oriented development

Vienna is centrally positioned on TEN-T corridors. However awareness of this position amongst the stakeholders in the region proves to be rather limited. However, the position on the TEN-T corridors shows the importance of the urban area for neighbouring areas and countries regarding freight flows. Multiple corridors (road, rail and waterway) are crossing the Austrian capital, meaning that the impact is substantial. Therefore the urban region has to deal with logistics in its development to be a vital node in the European network accommodating liveable housing areas and facilitating freight transport. Rethinking ‘functions’ of urban areas is essential.

5.2. Spatial planning at functional urban area level

Because of growing population, urbanization and increasing transport flows of persons and freight/logistics, a real challenge of space occurs. Many different functions are fighting for space and their place in the city. There is need for mixed land uses and attention for socio-economic relations to maintain a liveable city. This relates to both central city and peri-urban areas, urging for multi-level governance and integrated planning at the level of the Daily Urban System (DUS, for persons transport) and the Functional Urban Area (FUA, for freight transport). In other urban nodes such as Budapest similar challenges have been identified. NB: the workshop results indicate that the FUA is larger than the DUS which is usually the focus of attention in policy-making.

5.3. Robustness and vulnerability of the network

One of the main challenges discussed during the workshops is that persons and freight transport compete for limited infrastructure capacity at national, regional and local level. In Vienna the network proves to be vulnerable, especially the crossings of the Danube via road and rail. This asks for alternative routes, e.g. via a South-East bypass. Optimizing the use of the network and looking for opportunities to use the river Danube for inland waterway transport could be possibilities to find multimodal solutions. This vulnerability and robustness of the network is also a major challenge in the urban region of Mannheim in Germany.

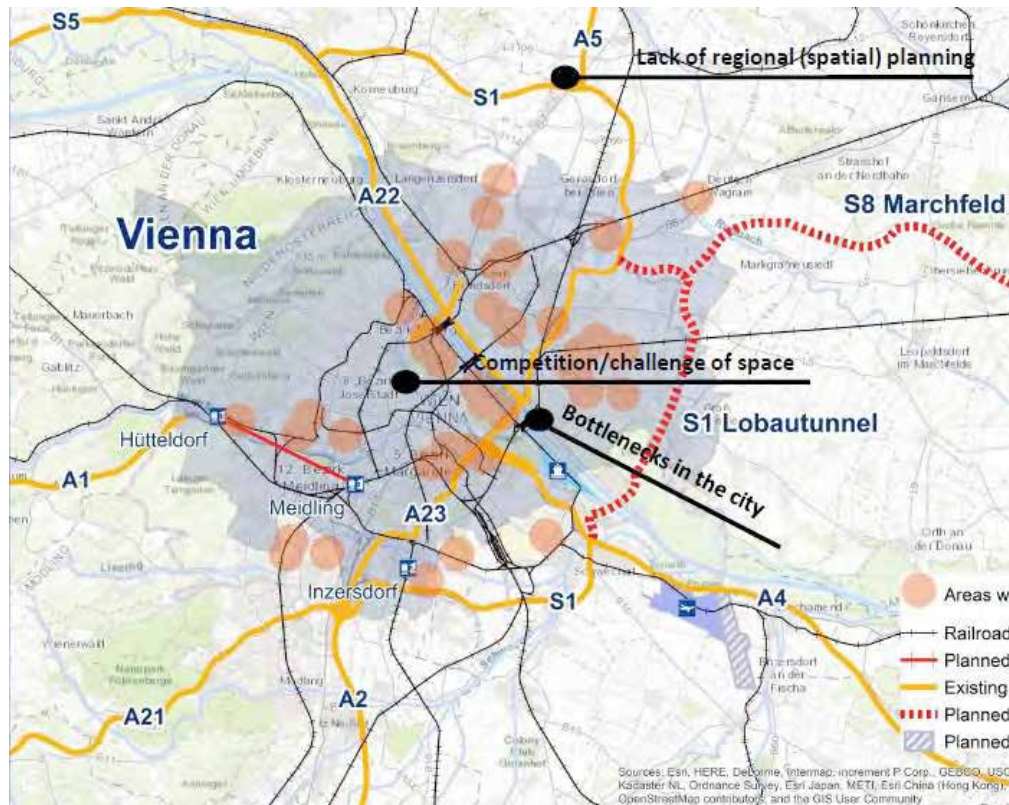


Figure 4: Challenges within and around the urban node Vienna.

6. Good practices for creating impact

Much effort has already been done in Vienna and other urban nodes to tackle the challenges identified, resulting in some *good practices* with (potential) impact that might even be of inspiration for other urban nodes throughout the (European) network (Poppeliers et al., 2018c). A few examples, related to the challenges mentioned are discussed hereafter.

6.1 (Lack) of logistics oriented development

Dealing with the (lack of) logistics oriented development has led to the search for hubs on different scale levels, including the development micro and midi hubs in the city centre of cities, accommodating supplies for last-mile logistics. An example of such approach is Vienna's HUBERT project (<http://hubert.stadtlogistik.at>). Another example can be found in Budapest where empty buildings within the city are used as micro and midi hubs for last- last-mile logistics and distribution.

6.2 Spatial planning at FUA level

To face the complexity of multi-level spatial planning, including the peri-urban areas, the city of Vienna together with other stakeholders, thought about the claim of space already in an early phase and developed a vision named the 'Produktive Stadt' (Stadt Wien, 2017) as part of its long-term strategic vision STEP2025 (Vienna City Administration, 2014). Within this vision interesting and innovative directions are introduced such as the reservation of brownfield spaces within the city centre for possible future development – not only for housing, but also for logistics, transport, industrial development. In this way authorities aims to make preservations of these areas for e.g. handling goods and prevent huge increase of land value causing future impossibilities.

The discussions during the Vital Nodes workshops in Vienna made clear to the participants that multi-level governance and cooperation in their urban region is needed to address the planning issues resulting from the highly dynamic transport and spatial developments such as urban growth and logistic sprawl in the Functional urban Area that go beyond administrative borders.

6.3 Robustness and vulnerability of the network

Developments at corridor level, focusing on multimodality could stimulate the robustness of the network and decrease the vulnerability. This is currently done in the Netherlands in the *East/South-East Freight Corridor programme in the Netherlands* that regards the corridor between Rotterdam and the Rhein-Ruhr area (Germany) consisting of a highly developed network main highway, railway and waterway (and pipeline) connections (see Faith Ell et al., 2019). This cross-national corridor is not only vital to the Netherlands' transport system and economy but also to the EC (being part of the TEN-T Rhine-Alpine Corridor). The Freight Corridor programme currently investigates what is needed to maintain and optimize this highly important multimodal corridor with the ambition of being a "topcorridor in 2030", which should result in a coherent package of measures at which national, regional and cities collaborate together with private companies. The programme focuses explicitly on the optimization of 6 major nodes. The programme strives for new economic development with specialisation in the major nodes in order to prevent unwanted competition between nodes and cities. This proves to be a complex multi-level governance issue, as it requires on the one hand that local and regional government think at corridor / network level (as many local terminals and hubs were developed, competing with each other) and on the other hand that national government reaches out to local and regional spatial-economic development issues. The programme has increased the awareness of being on a corridor, and the importance of the corridor to the country, regions and cities. Attention points for the programmatic approach prove to be issues of: multi-level governance, creating multimodality, balancing freight and persons transport, and developing a scope for cross-border issues and measures – to Germany and Flanders (Faith-Ell et al., 2019).

Another interesting development is in the Swedish city of Norrköping (130.000 inhabitants) situated 165 km southwest of Stockholm, which is transforming fast due to the building of a new high-speed rail line linking the Swedish capital with Gothenburg and Malmö including a new railway station in or nearby Norrköping (CEDR et al, 2018). At this moment the existing rail link is heavily used by both passenger and freight transport. The new high-speed railway connection will create conditions for improving freight transport and activities at both the corridor and the local level. At corridor level the new high-speed rail link will leave extra capacity at the existing rail link for freight trains (also causing less mixing of freight and passengers traffic). At local level, harbour and logistics activities will be concentrated on a 'Harbour Island' that will be developed North of the city at the former harbour area, while a new harbour extension is created to the east in seaward direction. Several smaller distribution centres that are currently scattered in the city and thereby disturbing the city life will be relocated to the Harbour Island. A new, consolidated logistic centre will be developed in the new harbour area as well (Broesi et al 2018).

7. Recommendations

Based on two years of bringing together knowledge throughout Europe – such as the Vienna experiences – recommendations can be drawn from the Vital Nodes project. Within this paper we focus on recommendations regarding the network, spatial and implementation dimension (Linden and Linssen, 2018b; Böhler et al., 2019). As In addition, some first directions are provided regarding funding mechanisms and needs (Van der Werf, and Smit, 2018).

7.1. Network dimension

Explore Functional Urban Areas (FUA), such as Vienna-Bratislava, Rotterdam-Venlo. Possible solutions for bottlenecks within urban nodes can be found elsewhere on the wider TEN-T corridor, including the comprehensive network. E.g. multimodal terminals in Venlo (NL) and Lauterbourg (FR) to relieve pressure in the urban regions of respectively Rotterdam and Strasbourg (“second order effects”).

Stimulate network resilience and infrastructure fitness. Currently local, regional and long-distance people and freight flows come together on two Danube bridges in Vienna. Realizing a new link across the Danube can free the city from the long-distance transport flows. This is also true for other nodes such as Mannheim.

Renovation and renewal of infrastructure. For instance, bridges across the Rhine is a major challenge in Germany, as has been discussed in Mannheim. This task should be organized in a broader regional perspective to prevent cutting off communities west and east of the Rhine and to offer alternative transport options for inhabitants and companies. Renovation and renewal need a more prominent position on the TEN-T agenda.

Develop the potential of urban nodes, as the main hubs for connecting the local and regional network to the TEN-T core network corridors, as *forerunner for distributing and deploying alternative fuels and other innovative technologies*. They can be centres for new inter- and multimodal logistics concepts and structures along the corridors.

7.2. Spatial dimension

Combine Transit Oriented Development (TOD) and Logistics Oriented Development (LOD) concepts (Vienna, Budapest, Hamburg, Strasbourg). Policies for densifying cities should not only relate to housing and offices but also to ‘blue collar’ production and logistics activities.

Midi and mini hubs should be implemented to stimulate sustainable inner-city freight flows and modal shift to cargo bikes and other cleaner vehicles for the last mile delivery and construction-related freight flows.

Careful design of interfaces (via integrated planning) of trans-national network and local transport. For instance, in Vienna two major Urban Consolidation Centres (Wien-Süd and Port of Vienna) are the main entrance and exit points between the corridor (rail, road, waterborne) and the city.

7.3. Institutional dimension

Development of regional SUMP including strategy on freight and logistics for preventing ‘Logistics Sprawl’ regions across city borders. E.g. in Vienna the Logistics Oriented Development strategy ideally comprises surrounding municipalities.

Stimulate regional collaboration beyond classical government borders, multi-level governance and cooperation should be required when applying for EU funding for infrastructure/regional development. Develop TEN-T related *cross-border strategies and operations* for urban nodes. For example, there is a strong connection between Vienna and Bratislava in terms of freight and logistics. The Port of Rotterdam has an important link with Duisburg and Strasbourg with the port of Kehl. These cross-border collaborations have many economic benefits for both urban nodes, but because of differences in legislation, permits, etc., the economic possibilities are often not fully utilised and can be strengthened.. To this end, cross-border collaboration is to be established.

Raising awareness for freight/logistics issues in urban, regional, and infrastructure planning. Increase the involvement of the urban nodes into the coordination of the nine TEN-T core network corridors under the lead of the European Coordinator. This could include actively involving the (main) urban nodes in the core network corridors coordination, for example by having a dedicated urban node working group, closely linked to corridor coordination. And in addition, assigning a dedicated urban node European Coordinator (in addition to the already existing ‘horizontal’ coordinators on European Rail Traffic Management System (ERTMS) and Motorways of the Sea (MoS). Establish an urban node information exchange and lobbying network, playing an active role in integrating urban nodes in the TEN-T corridors, lobbying for the urban nodes interests regarding the interface between the FUA and the TEN-T corridors.

Other recommendations relate to the focus of current TEN-T policies which focuses heavily on the core network. *Smaller nodes are also important to the functioning of the (core) TEN-T network corridors* (e.g. Venlo and Lauterbourg), this is especially true in poly-nuclear urban regions such as The Netherlands, Rhein/Ruhr and Rhein/Neckar. Include incentives for *public-private and private-private cooperation schemes* on the regional ("transit regions") and node level. Support cooperation between the public and the private sector to develop innovative logistic concepts for e.g. capacity sharing in terminals.

7.4. Funding

The current TEN-T guidelines (article 30) recognise and formalise the important role of urban nodes on the TEN-T network to connect and facilitate flows of people and goods while mitigating the negative effects. Funding of integrated solutions is complex, but also might provide ways forward to deal with this multi-level governance situation.

Awareness of complexity and importance of urban nodes. TEN-T Funding policies should be more aware of the complexity and liveability issues of urban nodes in TEN-T project development. As discussed before, urban nodes are the places where many different networks, actors and demands come together and interconnect. One stretch of TEN-T infrastructure might for example be used by both passenger- and freight transport, for different modalities, for both long- and short distance. For one single type of transport the network might seem robust, if transport grows at all these types at the

same time. Bottlenecks in the overall transport network as well as the urban spatial fabric might quickly occur (as has been observed for Vienna in the (near) future). TEN-T policy and investments should be aware of this. Sectoral, uni-modal investments along TEN-T corridors may create (especially) new bottlenecks in urban nodes, not only regarding transportation issues but also environmental issues, spatial and socio-economic development. To realize sustainable integration of the urban nodes on the TEN-T networks and increase liveability of these urban nodes at the same time, in TEN-T policy more awareness is needed of these complex environments and environmental challenges for the success of CEF and TEN-T investments in cities and regions. Sufficient funding should be set apart for mitigating measures or even alternative investments that might give the same results as the planned TEN-T investment, e.g. measures to reduce transport needs.

Integrated (metropolitan) governance and funding as key element for successful urban nodes. Given the complexity in urban nodes, the quality and architecture of metropolitan governance has a major impact on the sustainable development of urban nodes. Here awareness that the functional-spatial relationships of the DUS and FUA spread beyond (municipal) administrative borders is crucial. Through its funding, the EC has a leverage to stimulate integrated metropolitan governance. In the European Cohesion policy a certain budget is reserved for sustainable urban development. Cities can only have access to this funding if they have integrated sustainable urban development strategies (such as a SUMP). Some Member States have added the requirement for their cities that such a strategy is designed at metropolitan level. If such a requirement would become European policy, this could be an important incentive for cooperation at urban-regional scale. In practice, however, urban nodes (regions and cities) are often consulted at a late stage, when critical planning decisions have already been taken. A stronger involvement of the various governmental levels in urban nodes can significantly improve the coordination, the added value of investments, liveability and development of TEN-T projects, maximizing the potential benefits of the projects implemented on the ground.

Better integration of different types of EU funding. CEF grants are a vital part in the realization of the TEN-T networks and the TEN-T objectives. While maintaining the CEF funding for urban nodes, added value could be created by a better integration of different types of EU-Funding. Sustainable integration of urban nodes is not only a matter of increasing the capacity of infrastructure but also a matter of lowering environmental impact of logistics and transport in and around an urban node. An integrated approach of spatial and mobility planning seems the only way to make infrastructure investments acceptable to citizens and local authorities and to capture added value, e.g. for environment, liveability and property. But such an approach is expensive. Here European funding can contribute to achieving a business case for integrated infrastructure and spatial development. The European Fund for Strategic Investments (EFSI) may offer alternative means and instruments to invest in high-risk (infrastructure) projects. While national, regional and city authorities recognize and make use of the potential of Public Private Partnerships (PPPs) to support many essential urban transport projects, there are fundamental infrastructure projects that are relevant to the overall transport network structure but that cannot attract private finance because of their low financial returns. Nevertheless, these projects have a high European added value and a wide socio-economic return, bringing benefit to overall society. In order to be able to facilitate an integrated approach, proper use of financial instruments is important. A sound mix of public and private investors and long-term commitment are critical factors. Long-term commitment is a challenge for both the public and private investors and focus is often on the short and medium term. When using financial

instruments for an integrated approach, a wide range of private investors should benefit from the investment. Private investors not only include banks and pension funds, but could also include real estate companies and logistic and transport companies.

On basis of the experiences gained in the Vital Nodes project some first indications of funding needs might be given. As discussed, funding for integrating urban nodes on TEN-T corridors is financial more challenging because of the complex nature as it regards: multiple transport modes, multiple and connected infrastructure networks, multiple sectors, multiple geographical scales and multiple governance layers – see also above. As a consequence of this multiplicity nature, a first step could be that different funding sources (e.g. CEF, EFSI, ERDF, Horizon2020/Horizon Europe), are combined in order to create a shift towards integrated infrastructure and spatial development in practice. Regarding the absolute magnitude of funding needs: a comparable amount of budgets as the current funds comprise can be considered to be needed. To create a fundamental shift towards integrated planning, that at least 20% of these budgets should be combined and devoted for integrated development – and ensure that only proposals that address integrated development are eligible for this. In a stepwise approach, the percentage of funds devoted to integrated development could be raised (e.g., 50% in the subsequent period). NB: In various member states (such as the Netherlands) infrastructure and spatial development funding has already been combined over the last years (currently, in the Netherlands national infrastructure funding is in effect for some 80% devoted to integrated infrastructural and spatial development). The results of the Vital Nodes project suggest that such 20% of CEF-funding should be reserved for:

- investments in infrastructure, mobility, spatial and environmental measures enhancing the integration of urban nodes on the TEN-T Network;
- investments that focus on the peri-urban networks (the interface of long-distance, inter-urban, and short distance intra-urban mobility), on intra-urban networks in economic core areas (strengthen agglomeration effects, conform ‘borrowed size’), and on coordination with spatial development to strengthen socio-economic benefits (creating multiplier effects) of EU funding;
- investments that enhance integrated spatial and multimodal transport development and that increase coherent development of innovation, sustainability and liveability.

On basis of earlier experiences with integrated planning, it can be expected that such integrated investments in urban nodes and the peri-urban networks in economic core areas may lead to less costly planning processes (as development is directly coordinated between governance levels), less costs of mitigation and compensation measures (because of integrated spatial and environmental design), and less societal costs related to noise, air pollution (health effects) and safety (because of combined planning of (multimodal) infrastructure and spatial development).

In addition, the Vital Nodes project results suggest that more focus could be given on measures with a smaller investment volume (around EUR 50 million), which can be invested in coherence with other small initiatives and deliver an interesting proposition. And, that more funding is needed to invest in infrastructures and urban nodes that are resilient against climate change, natural disasters and catastrophes. This could include such measures as the construction of bypasses in the network, in multi-modal connections, or investments in innovative and green shipping logistics.

6. Conclusions

The Vital Nodes project discussed in this paper shows that urban nodes are often not yet an integral part of the TEN-T and comprehensive network. On the one hand, urban nodes are often important transport bottlenecks on the TEN-T network corridors, while increasing traffic at corridors is causing much environmental and spatial pressure in urban nodes. On the other hand, urban nodes profit socio-economically from their central position in the transport network, while the importance of urban nodes in terms of logistics and passengers transport at the TEN-T network will increase in the future. Urban nodes (and urban areas in general) seem to change faster than the network can keep up. To cope with these developments, a focus on innovative technical and sustainable solutions alone, will not be enough, as the challenges in integrating urban nodes into network corridors have a multi-dimensional character. Therefore, a transition towards sustainable integration of urban nodes into the TEN-T network requires an integrated a planning approach as has been discussed in the previous sections. This need for integration has been acknowledged by key stakeholders (see Philips et al., 2016) such as National, Regional Infrastructure Authorities and DG MOVE, as well as the Coordinators of the TEN-T corridors, who stress the importance of integrated strategies, platforms for exchanging experiences and multi-level governance approaches. A careful mix of interventions – regarding network, spatial, institutional and funding dimensions – seems to be the way forward to strengthen the connections between urban nodes and TEN-T corridors, and to achieve an efficient and sustainable transport system and vital urban regions.

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