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Concept of Quattro Modal Freight Hubs

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Abstract

Currently, the linkage of the four transportation modes, namely, road, rail, water and air on a quattro-modal freight hub is a low-priority issue with many uncertainties. The Austrian research project "Q4" focuses on this knowledge gap and on both potentials and limits of quattro-modal freight hubs. Therefore, the results of the Austrian research project outline in an exemplary manner the implementation opportunities for a quattro-modal freight hub within the central region of Linz-Wels-Steyr and the metropolitan region of Vienna.

1. Current situation

The reduction of negative environmental effects achieved by multimodal transport solutions is referred in previous studies [12, 13, 10].

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Particularly considered are those multimodal transport solutions that use an eco-friendlier transportation mode for the main arm of their supply chain, such as rail or inland waterways.

Motivated by the efforts to reduce negative environmental effects, strategy papers on transport policy – like the European Commission's Transport White Paper [11], the Green Paper of sustainable logistics [5] and the Green Paper of sustainable logistics in urban space [2] – demand a transport organization that covers all freight transport modes and frequently takes up the concept of "multi-modality" in this context. However, a precise consideration shows that these strategy papers on transport policy mostly refer to bi-, sometimes tri- and seldom to quattro-modal logistics. Currently, this requirement is found in logistical practice mainly in the provision of tri-modal hubs of freight transport. The peculiarity of these widespread types of hubs is the integration of three different modes of transport. This is especially apparent with the three transportation modes, namely, road, rail and waterway, which are coordinated by technological and/or organizational measures concerning traffic engineering, in order to achieve an uncomplicated and fast exchange of goods and load units. An analogy to this is the idea to integrate four types of transport modes into a quattro-modal freight transportation hub. Such approach will require an adjustment within traffic engineering and technological and/or organizational systems. Although the concept of quattro-modal hubs can be interpreted in different ways - pipeline, regular and broad gauge, as well as inland and sea waterways are respectively understood as an own transportation mode for combination – a macroeconomic approach offering the combination of the four transportation modes road, rail, waterway and air seems appropriate. On one hand, this is based on their differences regarding their system properties, which does not make a clear distinction between regular and broad gauge. On the other hand, this combination of transportation modes allows the changing of loading units unlike a combination with a pipeline as a transportation mode.

2. Implementation prospects of quattro-modal hubs

At the moment, quattro-modal hubs are seen as a low-priority issue, which meet the interests of several but not the majority of the stakeholders involved in freight transport. In the future, quattro-modal hubs will dramatically gain importance, especially because trends like synchro-modality and the physical internet will need a suitable option for transitioning [7]. A deep analysis of the currently rare case examples points to the more frequent application of this concept in the context of the description of regions instead of logistics centers. The German federal state Bremen [6] and North Rhine-Westphalia [8], the Austrian region Linz [15] and the port of Vienna, with its geographical position [1] can be referred as examples in this field. Some scientific articles [18] describe possible models and their impacts on regional and/or organizational combinations of different types of transportation modes, under special consideration of the transportation mode air, but prospects for implementation hardly play any part at all.

The Austrian research project “Q4”, which is supported by the Austrian Ministry for Transport, Innovation and Technology, is developing a contribution to the estimation of theoretical potentials and limits of the concept of quattro-modal hubs. Since there are only a few hubs where the four modes of transport (road, rail, waterway and air) are locally bundled and technologically, organizationally so as infrastructurally linked an iterative approach for the estimation of the potentials of this concept is required. Therefore, within the research project “Q4”, action prospects for quattro-modal hubs were identified for the central region of Austria Linz-Wels-Styria and the metropolitan region of Vienna. To estimate the theoretical potential of the concept of quattro-modal freight hubs, bi-modal (e.g. Vienna International Airport, Linz Airport) as well as tri-modal examples (e.g. Port of Hamburg, Port of Constanta) were analyzed and interviews with experts from logistics service providers, infrastructure operators, researchers and representatives of interests were held. Special focus was put on aspects for the integration of air cargo traffic into a freight transport system (operability), potentials/limits of the extended options for transportation (diversity) and possible synergies/barriers due the linkage of the four modes of transport (opportunity). Due to the analytic consideration of the concept, theoretical potentials and limits can be derived from spatial planning (e.g. land use, emitting uses), traffic engineering (e.g. infra- and suprastructures), macroeconomic (e.g. competition, resilience) as well as economic (e.g. cooperation, efficiency) perspectives.

2.1. Potentials of quattro-modal hubs

To draw up a potential of quattro-modal hubs the improvement of transport safety by integrating the air freight traffic in a freight transport system (***operability***) could be given as an example. For instance, the linkage of the freight transport system could lead to a reduction of traffic in sensitive/urban spaces due to peripheral position (e.g. airports) of the quattro-modal hubs on one hand, and helps to implement appropriately measures to enhance traffic safety or to make the shifting of freight onto "safer" carriers (like e.g. rail, ship or aircraft) more attractive on the other hand.

Regarding the aspect of the ***diversity*** of transport offers and, in this context, also the concept of synchro-modality, there are potentials regarding traffic engineering, macroeconomic and economic perspectives conceivable. The subject of diversity in a technical way is often associated with increasing reliability or resilience. For the concept of synchro-modality, this means:

- booking of transport services without predefined modal restrictions,
- common planning and coordination of a network of supply chains,
- bundling of good flows and services,
- flexible shift between different transportation modes and a
- transparent – according to the situation – choice of transport modes with exchange of information [9].

For this concept to work in a transportation-economic practice, at least tri-modal, if not quattro-modal hubs would be needed. Consequently, regarding the macroeconomic perspectives, quattro-modal hubs could increase the attractiveness and the resilience of an economic region, primarily if this characteristic represents an exclusive feature. This would be caused by the expansion of the opportunities for choosing different transport modes (and means of transportation). The positive effects are, for example, industrial location or shipping activities, which are primarily caused by the expansion capabilities of the product portfolios of the haulers and forwarding agents.

Furthermore, quattro-modal hubs could increase the level of utilization of the transport modes, whereby eco-friendlier transports become possible, even for air cargo with comparatively low additional costs. Goods could be flexibly assigned to a mean of transport that still has corresponding free capacities. Besides the business report of the Lufthansa Group indicates a potential for the integration of air cargo into the existing freight transportation system. According to the internal statistics of the Lufthansa Group, it recorded a worldwide average level of utilization of their cargo planes of almost 70% in the year 2014 [3] and a Europe-wide decline of the capacity utilization rate between the years 2013 and 2014 by 3,2% to 50% [3].

Depending on the ***opportunity***, quattro-modal hubs without spatial concentration of the transport modes could benefit from the strategy and process level. Hubs that create synergy effects with a common and coordinated land use as a result of bundling processes with higher-level functions (like customs clearance), special requirements (like dangerous goods and cold storage facilities, infrastructure for the handling of living animal transports) or with high emissions (like gravel handling, docking processes or maneuvering of trains) can be given as an example. Moreover, hubs characterized by communal use can profit from the system advantages of the other hub and thereby enlarge their range of services. In this case, it would not be the individual hubs, but the whole region that make up quattro-modality.

2.2. Limits of quattro-modal hubs

Referring to the aspect of opportunity, the concept of quattro-modal hubs has less potential for improvement. One reason is the restricted application of common loading units used in air freight traffic. Presently, different types of containers are optimized for transportation use on road, rail or cargo ships, but shifting freight to air cargo is still limited in terms of operability. Additional handlings will be necessary for commissioning and shifting the freight, which are accompanied by additional costs and loss of time. Currently, there are only occasional applications of the quattro-modal concept and, therefore, there is no requirement for such handling. This results in non-existing attempts in improving this concept. Examples of requirements for integrating air cargo into a whole concept of freight transport with technological innovations are the coordination between tracking and tracing systems of different transport modes [17] and also the development of special handling technologies and information gathering, such as RFID-systems.

Limits regarding the expansion of transport options (***diversity***) could be caused by the high grade of coordination and data integrity of different companies involved. The requirements for cooperation between all types of transport

modes are not only the alignment of management system, information system and processes, but also the determination of assessment, an amplified internal quality management and the determination of professional skills (primarily of those, that are between customer appeal of the transport supply and the cost recovery). Just-in-time-production and outsourcing has caused processes of suburbanization (establishing required areas outside a city), which has changed the logistic requirements of the different transportation modes. Also Schubert, A. [16] noticed that in contrast to railway transportation, road, water and air cargo transportation systems can adapt (particularly due to the high net density) more flexible to changed conditions, primarily due to their system characteristics. These transportation modes meet the high requirements on the part of the customers with regard to speed, networking and flexibility and can complete the transportation offer of logistics service providers well. Due to their system characteristics positive effects regarding resilience of transport systems can be expected in order to compensate delays, as for an example, heavy delays at border crossings. In this context, the option of "air cargo" needs to be considered critically, especially regarding possible amounts of transported volume from financial and resource efficient perspective. Depending on the ***opportunity***, concepts of quattro-modal hubs can create a specific danger of increasing transportation vehicles due to the relieved access to four transportation modes; this can be seen as undesirable from transport policy perspective. This is particularly valid if the transfer to another transportation mode causes additional, induced ("home-made") traffic.

3. Practical relevance of quattro-modal hubs

For the assessment of the practical relevance of the concept of quattro-modal hubs regarding to freight transport beside organizational and technological, spatial aspects play an important role. Different understanding of quattro-modality (see Chapter 1) in regard to the spatial levels (region vs. location) aggravates this assessment. In the context of the research project Q4, action recommendations for implementation for concrete Austrian regions are evaluated using the concept of quattro-modal hubs. The issue of practical application of quattro-modal hubs brings the question whether spatial concentration of the infrastructures of different transport modes is necessary for planning and implementation of freight transport, or (maybe intuitively) too much importance is given to it. To answer this question, possible synergies or barriers caused by spatial concentration regarding following aspects are taken into account:

- Efficiency in the transport-/logistic sector (business and macroeconomic consideration)
- Optimized traffic organization (coordination, cooperation, reliability, safety, …)
- Interaction of traffic, spatial structures and environment (multidirectional interconnections, sustainable implementation of transport and logistics services)

Although Dubai is internationally known as an example of the integration of air cargo, a critical analysis of the background and framework conditions is needed in order to assess the economy of this hub. Political intentions and geopolitical motives represent an essential factor because the air cargo is promoted by low landing and air traffic control charges [14].

Particularly, questioning which kind of good and freight would be suitable for processing via a quattro-modal hub is very interesting. On one hand, every transportation mode has its own load with special affinity (e.g. piece goods, bulk goods, heavy burden goods heavy burden goods) and the possible combination of certain transportation modes under simplified conditions (like shifting without changing the transport container). On the other hand, transportation currents, which seem atypical or really unrealistic for the time being, can arise out of historical processes of urban development or special production-/distribution situations. For example, Hamburg has developed to "a hub of German and European carpet trade" [4]. The hand-knotted carpets which have a value up to 4.000 Euro per square meter are frequently transported by trucks, but also by freight flights [4].

The advantages and disadvantages of a spatial concentrated quattro-modal hub are assessed by the respective stakeholders very differently. Operators of hubs consider the spatial concentration of the transportation modes as substantial, logistic service providers and other stakeholder which are not tied to a certain location are more focused on organizational and technological linkage.

Moreover, under consideration of spatial aspects, the outsourcing of storage areas (which was already mentioned in point 2.1.) from port (ports feel confronted with space problems such as Hamburg due to the increasing ship sizes) to airport locations is not always possible. Not only the opportunity of expansion at a location, but also the local infra-

and suprastructural equipment, as well as the spatial structural context (e.g. the location of an airport compared to that of a port) play an essential role. Theoretically, outsourcing storage areas of a port is possible – Vienna is given as an example; but Hamburg´s port does not have such an opportunity for outsourcing freight due to its direct neighborhood to the city center. For the estimate of the relevance of implementation of quattro-modal hubs, the integration of the potential transportation mode "air" in the Supply Chain (pre-carriage and onward carriage) plays a role from the organizational point of view. If air cargo is used for pre-carriage in the Supply Chain, it will cause a high amount of different stakeholders and irregular transportation of comparatively low quantity of goods. Among other issues, the comparatively high costs, which incur for transportation via air traffic has to be mentioned as a reason. It can be assumed that for onward carriage of the transportation arriving by a plane, a shift from road to, for example, rail is rather improbable; this is due to the distribution function of this transportation (burden Mile). This assessment tries to estimate the potential relevance of quattro-modal hubs for those cases, where air cargo is actually carried out with a flight number but physically moved by truck (trucking). Although this assumes not relevant at the first sight, trucking is quite common. As a requirement for displacing transportations by trucking to rail, first of all, the organization of individual truck traffic (e.g. spatial proximity to a marshalling yard) needs to be checked.

Particularly in regard to the ***technological coordination*** of the transportation modes, a great potential for the integration of air cargo could lay hidden. Technological innovations, which enable an uncomplicated cooperation between a variety of stakeholders due to simplification and accelerating of processes, conventional models can be revolutionized (e.g. Physical Internet) and introduce a reconsideration of this topic.

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