INTEGRATING AIR CARGO INTO MULTIMODAL TRANSPORTATION NETWORKS: VISION AND PRACTICAL RELEVANCE OF QUATTROMODAL FREIGHT HUBS

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1 ABSTRACT

One crux of intermodal freight transportation is the ability to tranship goods from one mode of transport (MOT) towards another one. Typically, this is realised in bi- or trimodal hubs, i.e. hubs connecting two or three different MOT with each other. Talking of intermodal freight transportation these connected MOT are road, rail and/or (inland) navigation. Including air cargo into the range leads to an advancement of hubs towards quattromodal hubs, i.e. hubs combining all four so far mentioned MOT, which – to our best knowledge – literature addresses only poorly so far.

In this paper, we start with a definition of quattromodality with a special focus on the integration of air cargo. It turned out, also based on site visits at best practices identified in Europe where integration of air cargo is already done or at least started, that in contrast to classical trimodal hubs quattromodal hubs are rather defined on a regional (and not local) level, i.e. that proximity is realised through mile-in-the-middle concepts. We finally focus on the Vienna region (in Austria) where a trimodal hub (road, rail, inland navigation) and a bimodal hub (road, air) are relatively close located to each other. We present four different mile-in-the-middle concepts for this region.

2 INTRODUCTION AND MOTIVATION

Recent works suggest intermodal freight transport to have a promising potential of reducing negative effects such as emissions caused by the transport sector (e.g. Kreutzberger et al., 2003; Hanaoka/Regmi, 2011; Bauer et al., 2009, European Commission, 2011). Policymakers therefore promote multimodal transport through various channels and set the legislative background in the form of strategy papers on transport policy (BVL, 2014; Gregori/Wimmer, 2011; KOM, 2011). Tapping the full potential of multimodal transport requires an eco-friendly multimodal supply chain, where environmentally friendly modes of transport (MOT) such as rail or inland waterways cover significant parts, i.e. the main run, of the distance.

Multimodal integration of different MOT at single hubs currently focusses on bi- and trimodality. Common MOT for multimodality are road, rail and waterways (inland navigation, short sea shipping, and/or deep-sea shipping). In contrast, airfreight transport is only regarded in an isolated manner. Consequently, there is only very limited scientific and empirical evidence for the local, hub-related integration of air cargo into multimodal transport chains.

Nevertheless, the local bundling of four different MOT might entail specific advantages due to the additional mode option: Among others, such a concept allows for more robust transportation networks. E.g., individual MOT are backups for other MOT in case of breakdowns. In addition, quattromodal hubs support more sustainable transport decision (e.g. shift from air towards rail or inland navigation). The aim of this paper is to examine the potential and practical relevance of quattromodal hubs in freight traffic.

This paper reports on the outcome of a nationally funded Austrian research project focusing on the integration of air cargo into "classical" intermodal transport infrastructure (i.e. bi- and trimodal hubs and transport networks relying on road, rail and inland navigation) and is structured as follows: First, we give an introduction into quattromodality, quattromodal transports and quattromodal hubs. In the subsequent section, we report on site visits at best practices with respect to air cargo and quattromodal hubs. Finally, we focus on potentials and possibilities in the Vienna region (Vienna, Austria). Conclusions and outlook finalise the paper.

3 QUATTROMODALITY, QUATTROMODAL HUBS AND QUATTROMODAL TRANSPORT

For this research, quattromodal hubs are defined as logistic pivots where the four MOT road, rail, waterways and air cargo come together. Even though, other MOT (such as pipeline, regular gauge, broad gauge, inland waterways and sea waterways, cf. also (Kummer, 2008)) can be understood as alternative modes for combination, they do not seem appropriate from a macroeconomic perspective due to their differences regarding system properties and incompatibility when it comes to changing units between modes (Hauger et al., 2016).

Quattromodal transports are transports incorporating four different MOT along the supply chain, i.e., at least three transhipments from one MOT to another one have to occur. Analogously, quattromodality transport refers to a transport network incorporating four different MOT.

3.1 Relations between Quattromodal Networks, Hubs and Transports

Based on the above definitions, a quattromodal transport network is a necessary condition for a quattromodal transport as well as for a quattromodal hub. However, neither quattromodal hubs nor quattromodal transports are prerequisites for the other. This means that quattromodal transport might occur even if there is no quattromodal hub and quattromodal hubs can exist although no quattromodal transports are performed. For bi-, tri- and quattromodal transports it is sufficient that each hub incorporated in the transport chain is bimodal, which is obvious as in one hub the transhipment from one MOT to only one other MOT occurs.

3.2 Potential of Quattromodal Hubs with respect to Regional Development

While bi- and trimodal hubs are taken for granted with respect to meaningfulness, we encountered resentment towards quattromodal hubs during expert interviews, which were conducted with stakeholders and researchers in the field of transportation. Two main arguments were stated against quattromodal hubs. The first one addresses the combination of airfreight and inland navigation. The second one refers to possible negative impacts on the modal split.

Although a direct combination of airfreight and inland navigation might not be straightforward, we refer to the results presented in Section 4. Nevertheless, it is important to keep in mind that a quattromodal hub not only combines air cargo and inland waterways but all other combinations represented at the hub are available as well. This implies the real potential of quattromodal hubs: E.g., instead of constructing two trimodal hubs – one for air cargo, road and rail as well as the other for waterways, road and rail – it is more convenient to install only one hub combining all four MOT. Besides a reduction of the construction costs, other positive effects can be gained such as spatial concentration of noise pollution at only one location.

With respect to the second argument against quattromodal hubs, we want to highlight that the goal of quattromodality is not to achieve a modal shift from waterways towards air cargo but vice versa. I.e., instead of transhipping goods from one plane to another one, one might utilise the ship for the next leg in the transport chain. In addition, we have to emphasise that currently there is virtually no hub combining air cargo and inland navigation. Therefore, installing a quattromodal hub could almost be called a “disruptive” development.

3.3 Installation of Quattromodal Hubs

Although the concept of quattromodal hubs is promising (e.g. concentration of noise pollution at one location, competitive advantage, reduced required space, etc.), the installation of such a hub poses many challenges. First, in most cities/regions there are already existing hubs/terminals. Second, the adaption of existing terminals is not that easy as including a port at an airport is virtually as impossible as constructing a runway at (already existing) ports. One approach might be the conjunction of two existing hubs – one equipped with a port, the other with a runway. This might be possible as in most cases spatial proximity is not as important as cooperation and organisational coordination. Nevertheless, the distance between the two hubs should be limited to a regional understanding which is hard to determine and therefore was part of stakeholder interviews described in Section 4. Furthermore, according capable infrastructure needs to be available (or installed) between these two hubs. Two predestined examples in Austria for such an integration are the Vienna region (port and airport Vienna) as well as the Linz region (port Enns and airport Hörsching). We refer to Section 5 for a detailed description of the Vienna case study.

4 EXPERT INTERVIEWS AND SITE VISITS

The requirements of relevant user groups for quattromodal hubs and quattromodal transport can be very different depending on access, background, field of activity and area of responsibility. To cover the whole range, expert interviews were conducted with representatives from different domains such as logistic service provision, infrastructure operation, politics and research. In order to assess the concept in different geographical settings, we not only contacted local stakeholders but we also performed site visits in Hamburg, Germany, and Constanta, Romania, based on the results of a global best practices analysis.

In order to ensure the identification of factors leading to success or failure as well as to review potential system strengths and weaknesses, we conducted expert interviews based on a semi-standardised questionnaire. The content of the questionnaire ranged from questions on the state of knowledge on quattromodal nodes to properties of quattromodal nodes, assessment of strengths and weaknesses of quattromodal nodes and concluding questions.

4.1 Interviews with local experts

Since it was regarded as important to light on various practical aspects, stakeholders with different backgrounds and key areas were chosen to be questioned about the concept of quattromodality. Finally, representatives from 14 different organisations participated in an interview: ACS Logistics, Air Cargo Center Airport Hörsching, Quehenberger Logistics, Lufthansa Cargo, Cargo Center Graz, Port of Linz, viadonau, Vienna International Airport, Port of Vienna, Port of Hamburg Marketing e.V, Container Terminal Ennshafen, City of Vienna (MA 18), Fraunhofer and Vienna University of Economics and Business.

Asked about the spatial distribution of the envisaged four MOTs, all interviewees confirmed the importance of physical proximity but at the same time had different opinions on the maximum distance between them. Some considered the distance Frankfurt-Hamburg as feasible, some even Bayern-Baden Wuertemberg. It was further mentioned, that the unused potential of trimodal hubs should be the starting point for considerations regarding the concept of quattromodality and that different regional understanding of the term (and therefore the role of the pipelines) has to be considered.

Serious doubts were mentioned regarding the feasibility of quattromodality when it comes to organisational and technological aspects. Carrier compatibility, safety aspects and IT were mentioned as barriers for connecting the MOT since these elements are not standardised and therefore varying. Some of the interviewees would even go one step further by suggesting pipelines as a fourth mode instead of aviation since they regard air cargo as completely different compared to other options and therefore very hard to integrate into the overall system.

Finally, technological coordination was pointed out as the basis for organisational coordination and the functioning of the entire system of quattromodality. According to the experts, the concept of quattromodality strongly relies on the technological embedding of the different MOT. Only three interviewees regard technical aligning as little or not important. In this context, not only the technological differences between the airport and the container terminal (in the port of Vienna) were pointed out but also the low level of interconnectedness of the two sites. On the other hand, most of the experts did not regard organisational embedding as equally important since they pointed out that it is already closely linked to the technological embedding.

4.2 Site visit in Hamburg, Germany

Hamburg in Germany has a harbour in the South and an airport in the North of the city combined with a well-connected rail and road system. The site was chosen due to its importance as a port in Europe. Since it has its own company for data communication and is a hub for logistic providers one of the research questions referred to the clarification of the feasibility of technological integration and another one to the current state of quattromodality in this area.

During the site visit, representatives from six organisations were interviewed: HPA Hamburg Port Authority, KLU Kühne Logistics University, DAKOSY Datenkommunikationssystem AG, Harburg University of Technology, LHU Luft-Hafen-Umschlag (Air Cargo) and Kühne+Nagel.

The interviews revealed that air cargo in Hamburg is mainly chosen as transport mode for accelerations due to delivery commitments (e.g. error response, response to late runners) and historical reasons (strong connection to Teheran because of the Iranian community living in Hamburg, transfer of goods such as crabs, fruits, individual shipment and carpets (Fruendt 2014)). As fall-back solutions for air cargo railway and the road network are used. Since air traffic in the current horizon needs a lot of space, drones for lighter parts were mentioned as suitable alternative, especially for rural areas.

Questioned on the combination of airfreight and waterways, interviewees stated that the combination is only used for specific goods such as luxury goods (Ferrari, breeding stock), parts with high importance (for plant operations or production processes), perishables, time-sensitive goods, medicines/drugs and economically perishable goods (magazines). Furthermore, a common hazardous material warehouse of the port and airport was regarded as interesting niche. For passenger transport the port and airport in Hamburg already work together and established a subsidiary in the form of a cruise terminal.

From an organisational perspective, some interviewees put the compatibility of the change carriers with containers and the provision of the necessary transport volume for the relation airfreight-railway into question. Some also doubt whether the prices can be lowered by quattromodal nodes since the cost/benefit ratio is currently not in favour of aircrafts. On the other hand, the interviewees widely agreed that it is not essential that the four modes are on one site since extra costs hardly arise from a regional allocation (in air cargo distance is of no consequence for expenses).

A representative stated that all four MOTs are currently used by a logistic provider but not necessarily in combination. As main reasons for not using all modes, arising costs were mentioned. From a technological point of view, according to the interview partner from the field of data communication systems, the exchange between four volumes can be arranged without much effort even though it is not established yet.

4.3 Site visit in Constanta, Romania

The second site visit took place in Constanta in Romania which is situated at the Danube – Black Sea Canal. Constanta has an airport and a port which comprises the transport modes maritime waterway, inland waterway, rail, road and pipeline, i.e. under strict review, this port is already pentamodal (connecting five MOT) without including air cargo. Since the airport is currently not used for air cargo, the main research question was to find out about the reasons and to reveal potentials and barriers that arise from connecting different MOT with each other.

Therefore, interviews with representatives from three different organisations took place: Maritime Ports Administration Constanta, Romanian Logistics Association, and a local terminal operator. Apart from the interviews, a technical site visit of the port gave insight into the current situation in Constanta as well as opportunities for quattromodality.

Since the port in Constanta mostly handles bulk products, interviewees stated that the integration of air freight is currently not in focus. On the other side, they agreed that the utilisation of the port is currently low and therefore a new, innovative business such as the development of a quattromodal hub would be desirable.

For now, the connection between the port and the airport is limited. According to the experts, there is no cooperation between them due to historically developed structures and the proximity to and accessibility of Bucharest airport. This development did not take place on purpose and cooperation is therefore not ruled out by any party but at the same time one has to keep in mind that the airport is used by military, which could be hindering.

As major barrier for the development of logistics in Romania, the experts mentioned bureaucracy and shortage of qualified personnel. This also affects the concept of quattromodality since the concept needs political approval and qualified staff.

5 CASE STUDY: VIENNA, AUSTRIA

The Hafen Wien (port of Vienna) as well as the Vienna International Airport build a very interesting setting for a quattromodal hub. The Hafen Wien is a fully equipped trimodal hub with access to the Danube River, a rail terminal with momentum access without shunting locomotive (also referred to "Schwungeinfahrt" in German) and almost direct access to the highway. Beside the runway, the airport has only access to the highway and tracks reserved for passenger traffic only. Both hubs are, however, almost neighbours to each other: driving distance is – dependent on the route chosen – between 11km and 14km; the beeline is even shorter. Furthermore, the airport is only about 3km beeline from the Danube River; separated by the highway and a nature reserve. The current air cargo centre is even closer to the Danube River at the North-Eastern corner of the airport area. We refer to Figure 1 for a geographical overview.

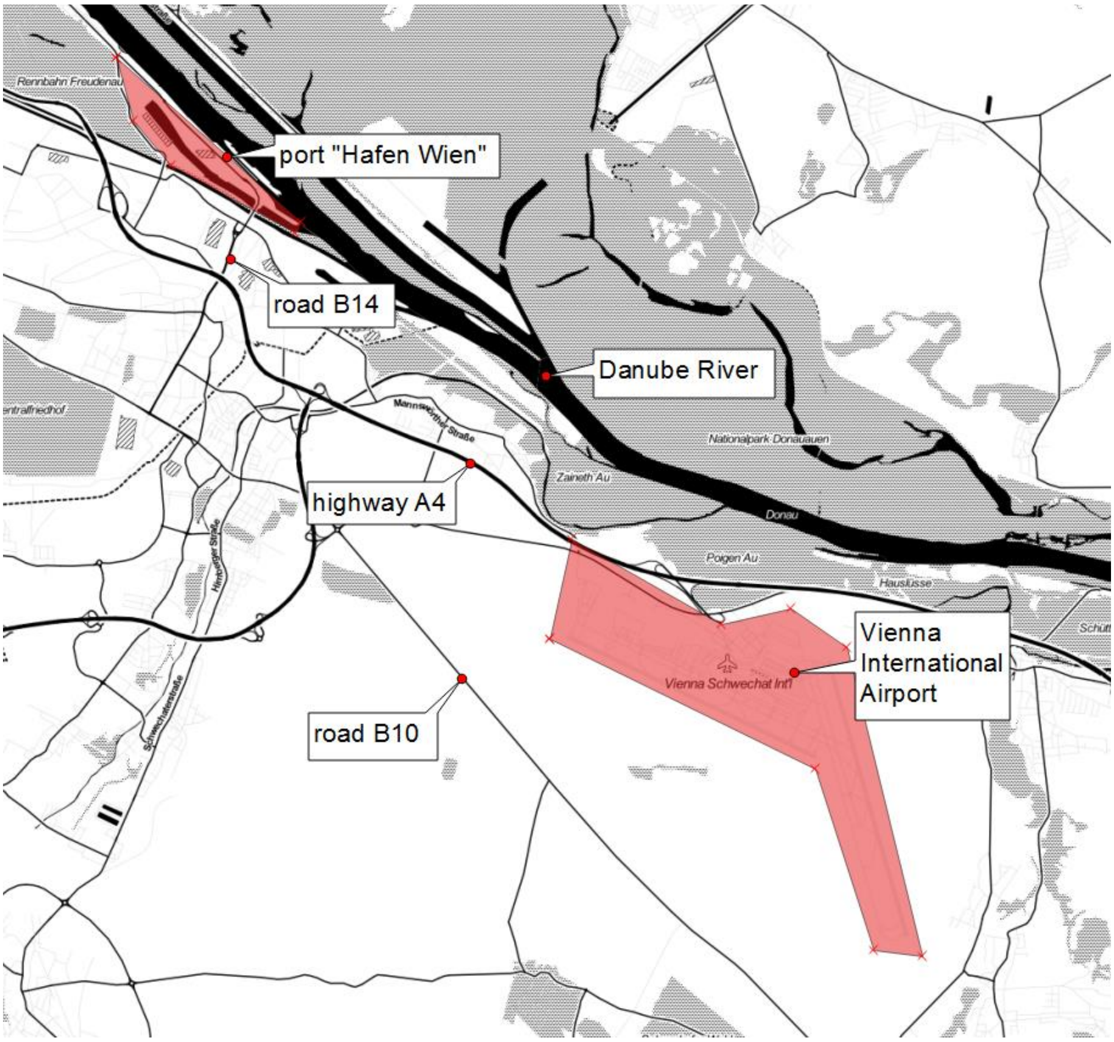

Figure 1: geographical overview of the situation in the Vienna region. Both, the port and airport, are located south-east of Vienna.

Even though both sites are well connected, there is no convenient conjunction between the airport and the port apart from the road. The airport is equipped for passenger transport but does not have freight rail tracks even though most of the surrounding companies do have their own rail connection.

5.1 Existing road link

Since the Vienna International Airport does not have freight rail tracks, the only existing connection between the airport and the port is the road. Vienna International Airport has a direct connection to the A4 Ost Autobahn (East Highway) and the B9 Pressburger Straße (Pressburger Road). The airport is already connected to the port of Vienna via A4 Ost Autobahn, B228 Simmeringer Straße (Simmeringer Road) and B14 Klosterneuburger Straße (Klosterneuburger Road).

The advantages of this connection comprise no extra costs by using the stock and the current cargo centre at the Vienna International Airport. The main disadvantage of the road connection besides the environmental aspect is the use of the heavily loaded highway where congestion is already a problem during peak hours.

In order to improve the connectivity of the two sites, avoiding peak hour traffic and minimising environmental pollution, three other options to connect the airport with the port were developed, including railway, circulating cable car combined with inland waterways and freight-zeppelin.

5.2 Alternative 1: Rail connection

To cope with the increasing demand for international flights, the airport is to be expanded by 2025 in the form of a third airstrip in the South of the area. Due to the expansion, the B10 Brucker Bundesstraße (Brucker Federal Road) in the South of the airport has to be relocated which gives a hint that bigger changes regarding the existing infrastructure cannot be ruled out.

The first alternative to the connection via road is based on the planned airport expansion which makes a relocation of the cargo centre to the South feasible. The new cargo centre can be integrated in the existing railway network through the railway siding of the Petrochemie Danubia around 4km North-West of the airport and only needs connecting tracks for this section (see Figure 2).

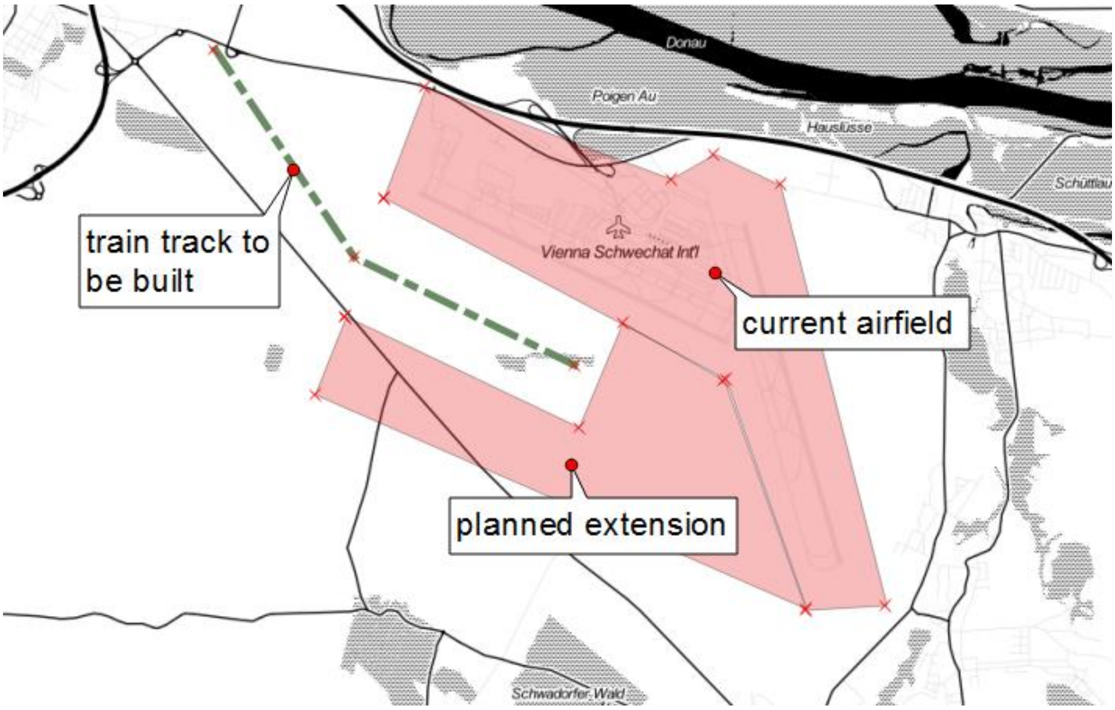

Figure 2: potential train track integrated in the extension plans of the Vienna Interational Airport.

The existing rail network allows connecting the airport with the port only with a detour. The most cost efficient solution is the conjunction Petrochemie Danubia – Kledering – Hauptbahnhof (central train station) – Meidling – Donauländebahn – Kaiserebersdorf – Hafen Wien, which is a travel distance of about 33km. Using this route is not only cheaper than building a connecting link but also has the advantage of connecting airport and port with the freight yard Inzersdorf giving the opportunity to transfer train sets directly to both destinations.

5.3 Alternative 2: Connection via circulating cable car and inland waterway

For the second alternative, the closeness to the Danube can be used since the distance of the current cargo centre to the riverbank can be bridged by a 1.5km circulating cable car (see Figure 3). Since the circulating cable car can be automated it is very efficient and only needs a minimum additional staff (De Decker, 2011). An agricultural area on the Danube river bank North-East of the airport site could be used as transhipment area before loading the goods on the barge going directly to the port.

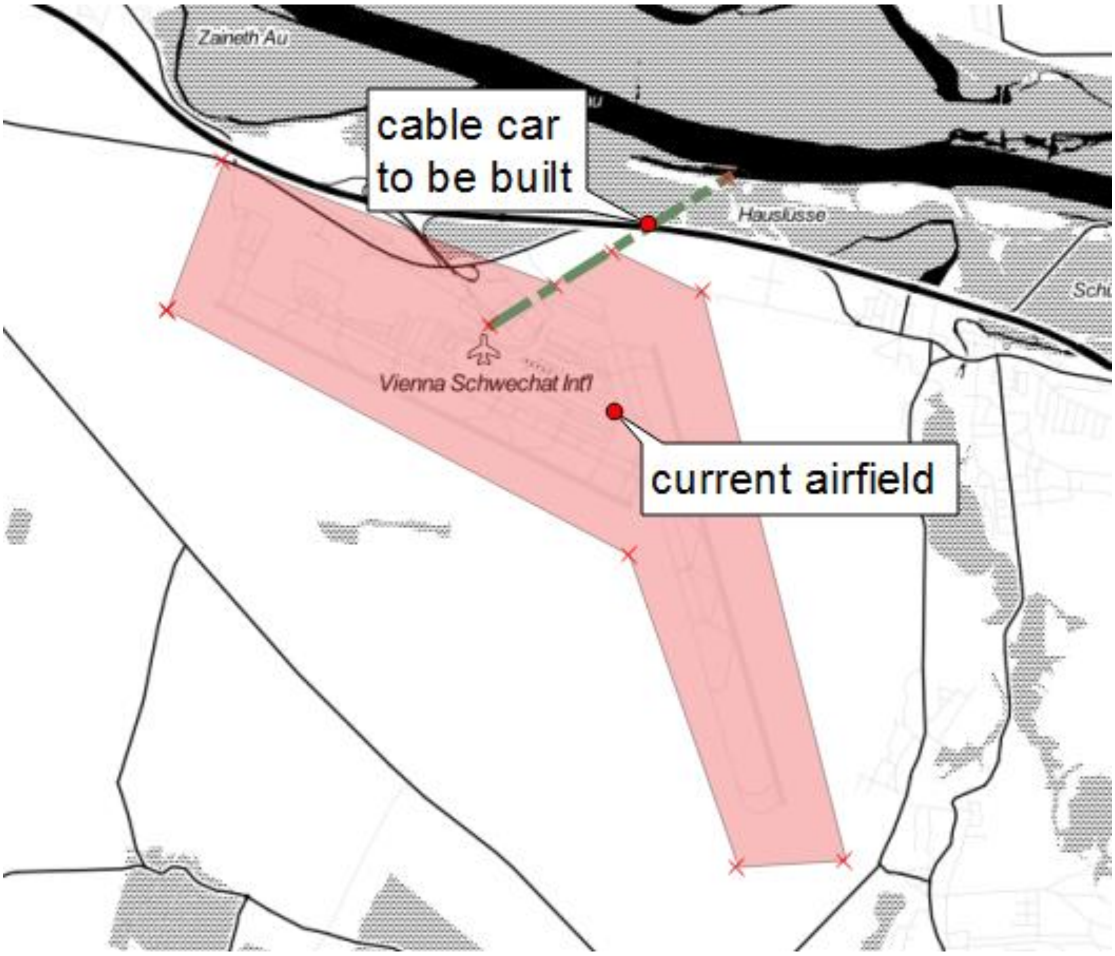

Figure 3: Possible construction of a cable car connecting the Danube River and the airport cargo centre with each other.

The main advantages of this alternative are the sole use of the infrastructure for freight purposes, the retention of the cargo centre at the current location and a simple implementation of an automatic reloading of the transport containers between the circulating cable car and barge. Still, there is a critical point since the connection affects the territory of the national park. Not to forget the investment costs for the construction of the cable car.

5.4 Alternative 3: Connection via freight-zeppelin

The third option would be the application of a freight-zeppelin (Baker, 2014; Hegmann, 2013). The freight-zeppelin operates on its own line/trace which could run parallel to the existing infrastructure (e.g. the highway). It therefore resembles a circulating cable car with the advantage of being less noisy and space-consuming.

Using a freight-zeppelin would be the best alternative with regards to noise and space savings but the system is not used in Austria so far and therefore implies some legal (e.g. crossing property of railway company) and technological aspects (construction details) that have to be figured out.

6 CONCLUSIONS AND OUTLOOK

The interviews with stakeholders and site visits revealed that there is potential for quattromodal freight hubs combining road, rail, waterways and air cargo even though there are some aspects that require special attention.

According to the findings from expert interviews and site visits we define quattromodal hubs as logistics pivots where four modes of transport (road, rail, waterway and air) are either locally bundled or at least technologically and organisationally integrated. This implies that the concept of quattromodality is not limited to a specific site where all four modes meet (e.g. an airport). It can also refer to a region or a district where all four modes are available and integrated in an intelligent way. Technological integration means that there is the possibility to overcome physical interfaces, e.g. through cargo-handling technology and appropriate IT systems. Organisational integration means cooperation in terms of transport organisation, e.g. exchange of information and cooperation in processing.

Although a data communication expert questioned technological integration as a barrier, there are still obstacles. Especially when it comes to organisational matters such as different containers or cost-related issues such as the price ratio between air cargo and transportation by ship. However, this does not indicate that the concept is not feasible but rather shows that a direct transfer from air cargo to ship is only interesting for specific goods at the moment as long as the pricing does not change. It might be even worth considering using common storage areas, which was regarded as good idea for a niche among the experts when it comes to dangerous goods.

Anyways, the connection of hubs with each other in order to bring the four different MOTs together has advantages regarding flexibility and cost efficiency, not to mention prestige for the region and an advantage in the competition between cities. As already pointed out, the creation of a quattromodal hub does not mean that all transport modes have to be used for one transport chain. Quattromodal transport, on the other hand, would imply that four different MOTs are used but was more or less ruled out by the stakeholders since it is hardly ever practical.

An aspect not sufficiently examined was the effect for regions that would arise from not only better connecting the four MOTs but also using technologies, which reduce transport time. Shorter and/or faster transport routes would not only enable to increase the transport volume but also bring the region closer together affecting municipal budget, employment, housing etc. In our future work, we will set a focus on these aspects as well.

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