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A MODAL SHIFT, BUT HOW?

Summary. In this paper, we investigate the conditions that must be met for modal shift (i.e., the transfer of freight transport from road to rail). In addition to describing the competitiveness conditions, the paper makes technical and organizational proposals for rail freight traffic management. One of the most important conditions is that rail-road intermodal freight transport must be competitive in time and price with unimodal road freight transport. The freight transport model presented in this article provides a solution to this problem and an approach to estimating the additional intermodal freight traffic. Another important criterion is the relatively dense network of road-rail links, known as intermodal transshipment points (ITPs) along main railway lines. The proposed model can be compared to the freight transport model described in the term Physical Internet, with the addition that the objective is to minimize road haulage when locating ITPs (or hubs). ITPs are rail-road terminals or, more precisely, transshipment points, which differ substantially from the commonly used continental terminals. The third condition to be met is a horizontal container handling procedure that can be applied efficiently (i.e., at low cost) under the railway catenary and is capable of handling intermodal units used in continental traffic and maritime freight. Finally, an example for the Visegrád countries is presented. The essence of the example is the potential additional freight traffic or modal shift that could be included in the proposed ITP network. We believe that a modal shift could occur for up to 50% of the indicated heavy goods vehicle (HGV) traffic if the offer is competitive.

1. INTRODUCTION

An important purpose of the current European Union (EU) transport policy is to promote a modal shift from road to rail for freight transport and to significantly reduce carbon dioxide (CO_2) emissions from the freight sector. HGV traffic accounts for 4 to 4.5% of total CO_2 emissions [16] in EU member states. Studies on the subject have generally identified electric rail freight transport as the solution to this problem. [6, 13, 17] Electric trucks support environmentally friendly road transport or unimodal road transport, but their mass introduction is still a distant prospect, so a more realistic goal is a modal shift (i.e., the transfer of freight transport from road to rail). But what will make the modal shift from road to rail today? After all, unimodal road transport is much more flexible and sometimes even cheaper. The EU targets of "30 % of road freight over 300 km should shift to other modes, such as rail or waterborne transport, by 2030, and more than 50 % by 2050" [6, 13] may not be achievable. Research and professional proposals generally contain little concrete information on how to achieve this.

The industry is interested in technically feasible and commercially viable solutions. For a modal shift to be successful, customers must be offered a rail-road intermodal freight service that is competitive in

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terms of time and price with current unimodal road freight transport. Competitiveness in time and price is necessary because the EU freight transport market is fully liberalized—that is, the behavior of customers is essentially determined by the quality (competitiveness in time, predictability) and price of the service offered. We believe that a modal shift could occur for up to 50% of the indicated HGV traffic if the offer is competitive.

The proposal on competitiveness is presented in Section 2. In Section 3, the proposed intermodal transshipment point (ITP) scheme and the proposed container handling technology are presented. In Section 4, an intermodal freight network is presented with possible traffic and revenue estimation using the example of Visegrád countries. In our findings and analysis, we draw heavily on research [2] that comprehensively assessed the situation of intermodal freight transport in the EU.

2. COMPETITIVENESS

2.1. Competitiveness in time

The current daily transit distance for road freight is around 700 to 800 km/day (nine hours driving time per day). The average daily transit distance for rail freight is significantly lower. The requirement for Hungarian Magyar Államvasutak (MÁV) is 200 km/day [23]. Another important characteristic of freight transport is flexibility. This generally refers to the time when transport can start after an order has been placed and the minimum volume that can be transported. Current intermodal freight transport is terminal-to-terminal, and the smallest transport unit is a train (30 to 40 pcs containers or 1 pc freight wagon). Transport can start two to three days after an order is placed. In the case of unimodal road freight transport, the delivery can start on the day of the order, and the delivery unit is 1 pc intermodal transport unit (ITU) or 1 pc truck. For lorries, the groupage technique makes the price competitive but reduces the daily transport distance.

A study commissioned by the EU Directorate General Mobility & Transport (DG MOVE) [2, p.154] shows the time spent by the ITU in the intermodal transport chain (see Table 1). We use ITU to refer to ISO standard containers and stackable and non-stackable vehicle swap bodies. The data in Table 1 assume the time for 75-75 km pre- and post-haulage and does not take into account the time between the dispatch of the order and its transport from the ITU customer's premises.

A comparison of the data in Table 1 with the data for unimodal road freight transport shows that the daily transit distance is lower for intermodal solutions with known technology, and therefore, they are not competitive.

Table 1

Time spent on ITU in a supply chain by transshipment technology and transport distance [2]

Transshipment technology and ITU size	600 km	1,000 km
Gantry Crane – 20'	19.24 h	29.24 h
Gantry Crane – 40'	19.10 h	29.10 h
Reach Stacker – 20'	22.84 h	32.84 h
Reach Stacker – 40'	21.96 h	31.96 h
ContainerMover – 20'	27.23 h	37.23 h
ContainerMover – 40'	23.62 h	33.62 h

Research findings and industrial practice should be examined. A well-known variant of intermodal freight modeling is known in the literature as the Physical Internet. The Physical Internet is a graph without loop edges, with points as hubs and edges as transport routes between hubs. Parallel transport is possible between each hub, which in graph theory is called multiple edges. The authors of the study [7] examined intermodal freight transport based on graph theory and found that decentralization helps to manage dynamic logistics networks. This leads to the practical conclusion that elements of the logistics network, namely terminals or ITPs, should be deconcentrated rather than concentrated. The intermodal freight transport solution proposed in this paper is a deconcentrated ITP network comparable to the overhead conveyor or roller table freight transport used in industry, with innumerable branching points (nodes), like real rail networks.

The following are examples of in-plant material handling solutions from logistics industry practice. Roller conveyor and overhead trolley conveyor track systems are widely used for internal material handling and sorting. An examination of the prevalent indoor logistics solutions can explain why the proposed intermodal freight transport may be more efficient than currently used intermodal freight transport variants.

Fig. 1. Overhead trolley conveyor line [Source: conveyco.com]

Fig. 2. Roller conveyor sorting system [Source: ssi-schaefer.com]

Fig. 1 shows an overhead conveyor system for moving medium-weight objects, most commonly used in painting shops and assembly lines. Fig. 2 shows a sorting system with two-dimensional roller conveyors. The material handling systems shown in Figs. 1 and 2 are widely used in industrial plants, warehouses, and package distribution centers. The intermodal freight transport system presented later is a material handling system where the overhead conveyor track and the roller track are similar to the railway track, but the transport unit is a standard ITU. The common characteristic of the indoor logistics solutions shown in Figs. 1 and 2 and the intermodal rail-road freight transport system proposed by the authors is that the availability in time of the transport types (conveyer track, railway train) is significantly better than the availability of the transport means of the currently used intermodal freight transport variants.

In the nodes (HUBs) of the Physical Internet material flow systems, other logistics services (repackaging, sorting) are provided in addition to the transshipment function. In the ITP nodes of the intermodal freight transport system described below, goods are not repackaged or sorted by default. The ITP handles ITU from rail to road and vice versa or from rail to rail.

The roundabout intermodal freight transport model, shown in Fig. 3, results in an efficient door-to-door (D2D) freight transport. Efficient D2D rail-road intermodal freight transport can be profitable and sustainable for distances below 300 km [5]. Fig. 3 does not show the stations of departure and destination of the freight. Trains can run with relatively short tracking times in both directions. The advantage of the model is that it is possible to calculate exactly when the goods will arrive at the destination station after dispatching, and the ITU spends significantly less time in the transport chain than in known solutions for ISO containers. It is a competitive solution with the flexibility and predictability of current road transport, as a container picked up from the dispatch point can be on a train within one to two hours. As there is no compulsory rest period in rail transport, a train traveling between ITPs can travel significantly longer than a truck in 24 hours—around 1,200 to 1,400 km/day. The model in Fig. 3 has the properties described in the Physical Internet theories [22]. The city names and distances are only examples.

The use of rail container trains with short tracking times is partly based on the fact that the share of fixed costs in the cost structure of rail transport is about 2/3, while the share of variable costs is about 1/3. This also means that, although capacity utilization has an impact on profitability, building flexibility and predictability that is comparable to road transport is a more important factor in facilitating the modal shift. Thus, it has priority.

Table 2 shows the time 1 pc ITU spends in the transport chain when using the intermodal freight transport by model in Fig. 3 based on the model calculation data. The table also shows the number of

ITP stops per container train within the transport distance. The calculations are based on a freight train speed of 70 km/h, a 20-20 km pre- and post-road haulage, and a maximum stopping time of 20 minutes at each ITP.

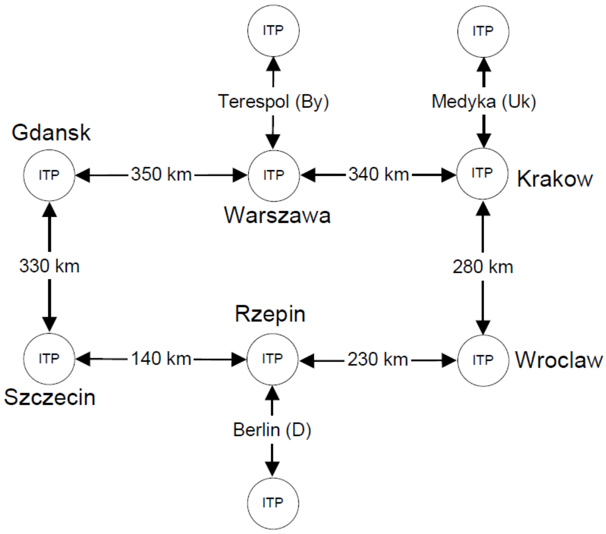

Fig. 3. Freight rail roundabout model for Poland (Source: own editing)

Table 2

Time spent by ITU in a transport chain and transport distance
with the proposed transshipment technology (Source: own calculation)

Transshipment technology	600 km	1,000 km
ITP – Loxodon-HCT (see 3. chapter and [24])	10.5 hours	17 hours
Number of ITP stops	4 pcs	6 pcs

The authors calculated the values in Table 2 using the methodology presented in [2] pages 200-203. The main feature of the transshipment technology implemented with Loxodon-HCT is that the diesel locomotive and the train marshaling are not necessary due to the horizontal transshipment under the catenary. A comparison of the data of Tables 1 and 2 clarifies that the proposed intermodal freight solution has a significant time competitive advantage over known intermodal transport solutions. A prerequisite for applying the model is to run container trains with a tracking time of 1 to 2 hours (i.e., a significant improvement in the availability and accessibility of rail transport means).

2.2. Competitiveness in price

Rail-road intermodal freight transport, as shown in Fig. 3, can lead to market success if it offers competitive prices compared to unimodal road freight transport. As the freight market is fully liberalized, the price is determined by agreement between the participants. The price of both domestic and foreign intermodal and unimodal road freight transport is determined by the following main factors, which have been partly highlighted by the authors of [5]:

- the unit price per kilometer of road transport,
- unit price of rail transport per train-km,
- the distance of road and rail transport,
- the numbers and unit price of ITU transshipments.

Research shows that the unit cost of rail freight transport is lower than road transport due to better energy use and less labor. A lower price is an important prerequisite for competitiveness, as underlined by the authors [8]. It is also well known that rail freight transport can be generated in an environmentally friendly way based on electricity (i.e., it is sustainable). In contrast, unimodal road freight transport generates significant CO_2 emissions and, therefore, cannot be considered sustainable. Given the inflexibility of current rail freight transport and the existing transshipment technology, intermodal transport is only used in terminal-to-terminal transport. Rail freight is typically used for the transport of large bulk commodities, dangerous materials, and piece goods for which there is no competitive advantage in terms of the shortest possible time in the supply chain.

Taking into account all cost factors, the cost of intermodal freight transport can be calculated using equation (1). An intermodal transport offer can be price competitive if it costs less than unimodal road transport. In our example, we show a unit price of € 0.718/km, which is a constantly changing value due to market and cost conditions.

$$K = \sum_{i=1}^{n} K_{Ri} + \sum_{j=1}^{m} K_{Sj} + K_{\text{ü}} + \sum_{i=1}^{n} K_{Ti} + \sum_{j=1}^{m} K_{Ej} - K_{v} \leq 0{,}718 \frac{€}{km} \tag{1}$$

where

K_{Ri} – total transshipment costs per terminal;
K_{Ti} – storage cost per terminal;
n – number of ITP points;
K_{Sj} – total transport costs per route section (road, rail, externalities);
K_{Ej} – other costs per route section (road, rail, externalities);
m – number of route sections;
$K_{\text{ü}}$ – unloaded running cost;
K_{v} – return freight income;
€0.718/km – data from [2], summarized in Table 3, which is the lowest cost per 1,000 km transport distance as a competitive target price.

According to the authors of [10], the intermodal price can be competitive if it is 10 to 20% lower than the unimodal road price. Our proposed rail-road intermodal freight transport can achieve a competitive price. A study commissioned by DG MOVE [2] also analyzed the different container management procedures. The analysis was carried out to determine the cost of each transshipment and the cost of each mode of transport for 600 km and 1,000 km transport distances, 85% occupancy, and different transshipment technologies.

Table 3 shows the data from [2] for the transport cost for the investigated transport distance, the most common vertical container transshipment technologies, and one horizontal transshipment technology.

Table 3

Intermodal cost depends on transshipment technology and transport distance [2]

Transshipment technology and ITU size	600 km	1,000 km
Gantry Crane – 20'	664 €	718 €
Gantry Crane – 40'	715 €	870 €
Reach Stacker – 20'	709 €	826 €
Reach Stacker – 40'	777 €	933 €
ContainerMover – 20'	692 €	788 €
ContainerMover – 40'	772 €	918 €

The cost of designing and building the different terminals according to [2] and the estimated construction cost of the ITP proposed is given in Table 4. The data clearly show that the cost of setting up an ITP based on Loxodon-HCT container handling technology is significantly lower than other known container handling technologies. This implies that a higher density of ITP networks can be established. We estimate that the required ITP density depends on many factors. For a population proportional approach, 500,000 to 600,000 persons/ITP may be desirable.

In Table 4, the value for IPT is calculated using the methodology presented in [2], pages 190-191. In this table, as shown in Fig. 4, we calculate with 2 pcs Loxodon-HCT units counted to ensure reliability and train service within 15 to 20 minutes. The 15- to 20-minute time is sufficient for 3 to 4 pcs ITUs to "land" or "board" a train at a given ITP during the stopping time. As the number of ITP network elements increases or the distance between ITPs decreases to 40 to 60 km, 1 pc Loxodon-HCT may be sufficient to serve the traffic. In this case, reliability should be ensured by design solutions and IT service availability at all times. Rail transport is provided by scheduled container trains with one- to two-hour tracking times. There may also be busy sections where the tracking time of container trains is significantly shorter. Research [14] concludes that the scarcity of intermodal interchanges significantly impacts the demand for the service. In agreement with this finding, we believe that the ITP distance along main rail lines should be between 40 to 60 km. Of course, the area's population and industrial potential and the density of the rail network can significantly impact ITP density.

Table 4

Cost of setting up terminals

	Construction + Design	Machine + Design	Total
Terminal + Gantry crane [2]	15.7 m€	8.3 m€	24 m€
Terminal + Reach Stacker [2]	9.5 m€	1.5 m€	11 m€
IPT + 2 pcs Loxodon-HCT [own calculation]	3.1 m€	1.7 m€	4.8 m€

In order to achieve a modal shift, it is necessary that the solution to equation (1) results in a competitive price. This is possible for the ITP-based intermodal freight network shown in Fig. 3 for the following reasons:

- low ITP investment costs,
- lower road pre- and post-haulage distance,
- competitively priced horizontal transshipment technology,
- lower cost of rail inspection due to the continuous traffic and absence of diesel traction,
- lower labor costs by automating the container handling process.

In [11], the authors also examined the cost range of unimodal road and rail-road intermodal freight transport at the mathematical model level. For rail transport costs, the cost less government subsidies was considered. It is common practice for EU governments to subsidize rail freight. We propose defining the intermodal price based on the unimodal road transport distance at 10 to 15% lower and not increasing it by the pre- and post-road haulage and terminal costs, as these cost elements are already included in the unit price. The following factors may allow for this:

- Because of the high fixed-cost ratio of rail transport, profits are less affected by utilization (the saturation of the train).
- In the EU, industrial hubs and rail hubs overlap so that the road pre- and post-haulage rarely exceeds 20 km, and therefore, its real cost within the overall transport chain is not decisive.
- Electric energy produced in an environmentally friendly way is cheaper than fossil automotive fuels.
- Due to the low cost of container handling compared to known solutions, the cost per transshipment is not significant.

3. ITP CONSTRUCTION AND CONTAINER HANDLING TECHNOLOGY

In [12], the authors investigated widely used container handling procedures. It can be concluded that these procedures have not been able to increase the rail freight transport rate above 18 to 19%. Significant innovation is needed in both terminal design and container handling to increase rail freight transport rates.

Research on modal shift shows that when a container train stops along a route where it is possible to take off and take on containers, the utilization of that route (i.e., container traffic) increases [1]. Another condition to be met, as identified by research, is low-cost of container handling technology [1]. In this section, we present an ITP layout with the following main characteristics:

- small area with a road surface with a load capacity adapted to the axle load of the trucks,
- through railway track, the overhead line is separated from the main line,
- parallel layout to the main railway line,
- absence of rail wagon marshaling and diesel traction,

- minimal rail car inspection due to a lack of wagon marshaling,
- standard gauge (1,435 mm) HCT [24] rail track.

These features represent a significant departure from the design of current continental terminals. Fig. 4 shows an ITP layout that corresponds with the characteristics listed above. Since the transshipment track has a catenary, vertical container handling procedures are not possible. The layout includes the installation of a 2-pc container transshipment machine to ensure the transshipment capacity, which is also considered important by the authors of [9], and reliability.

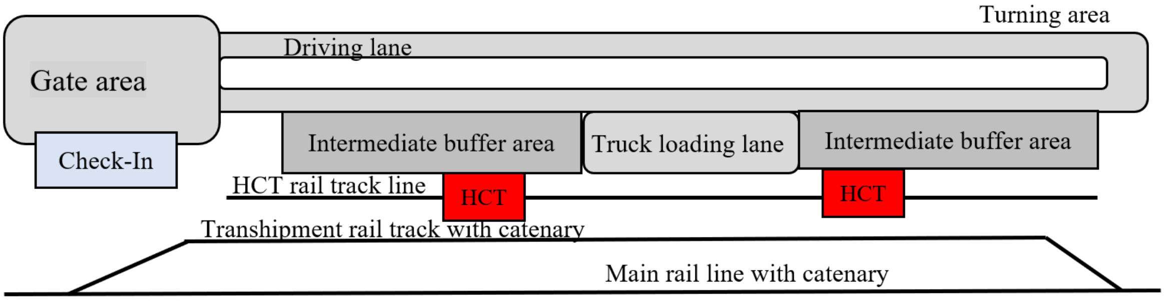

Fig. 4. ITP layout (Source: own editing)

Known horizontal container handling procedures are not adequate to meet the competitiveness in time. Fig. 5 shows a new design of container transshipment equipment that is sufficiently efficient that the cost per transfer is significantly lower than the existing technologies. The cost per transshipment of the different container handling technologies is shown in Table 5. In Table 5, the value for Loxodon-HCT is calculated using the methodology described in [2], pages 185-193.

Table 5

Cost of a transshipment using different technologies

Transshipment technology	Calculation (€/transshipment)	EU coast range (€/transshipment)
Gantry Crane [2]	32.33	16.91 - 45.36
Reach Stackers [2]	49.05	23.65 - 70.56
Loxodon-HCT [own calculation]	15.29	--

Fig. 5. Loxodon-HCT horizontal container transshipment machine (Source: own editing)

The designed load capacity of the Loxodon-HCT with dynamic counterweight shown in Fig. 5 is 40 tonnes. The actual load capacity is determined by the maximum weight of the ISO container, which is 34 tons. The proposed design is a 16 degrees of freedom container transshipment robot, which is also suitable for unattended operation. If dynamic counterweights are used, the construction of a supporting track is not necessary. It is environmentally friendly due to its electrical operation. As the ITP shown in

Fig. 4 has a relatively low traffic volume compared to known continental terminals, it can be set up in the existing rail freight yard and goods station areas of larger cities. The ITP does not generate road traffic, and therefore, the environmental impact is low.

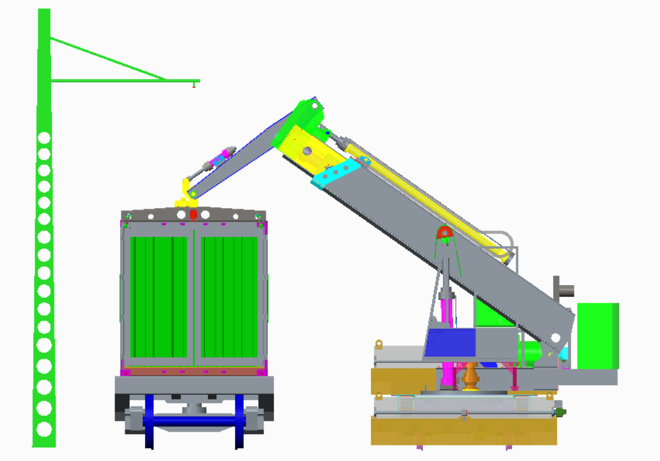

Fig. 6. ITP cross section (Source: own editing)

Fig. 6 shows the ITP cross-section for the case where the Loxodon-HCT serves the transshipment track. The design of the machine is such that the structural elements subjected to the higher loads are kept at a safe distance from the catenary, the height of which is 6,000 mm from the rail crown. The catenary section concerned is de-energized for the duration of the transshipment to meet railway safety requirements.

4. INTERMODAL FREIGHT ITP NETWORKS

In this section, we examine the modal shift potential of four Central European countries based on their HGV road traffic. The additional modal shift traffic can be estimated based on HGV traffic data on main roads and motorways if a competitive service is offered in terms of time and price. Goods can enter and exit the freight transport system at the ITP. The modal shift of HGV traffic shown on each line cannot be exactly calculated, and not all types of freight are suitable for ITU transport. However, we believe that a modal shift could occur for up to 50% of the indicated HGV traffic if the offer is competitive. This, of course, raises a number of other issues. Is the necessary amount of rolling stock available? Is there sufficient rail capacity? These questions should be considered separately for each country and each railway line, which are beyond the scope of this article.

The average transshipment capacity of ITPs equipped with Loxodon-HCT can be up to 12 pcs ITUs per hour. If the ITP is open for 14 hours and there are 250 working days per year, [2] the annual transshipment capacity is 42,000 units per transshipment machine. The actual number of transshipments is influenced by the priority of the train service, which means that when there is a train on the ITP, the HGV service is interrupted. If there are no trains on the ITP, ITUs can be sorted and HGVs can be served. The transport performance and the economic results of the rail-road intermodal freight network shown in Figs. 7-10 can only be estimated, as it is not a market service. We used the following data for the calculation:

- In Table 3, the unit cost for a 1,000 km transport distance is €0.718/km/ITU.
- If the capacity of the trains in one direction is 68 ITU/train and there are 14 trains per day in one direction, this gives a capacity of 952 ITU/day per direction. On the outward and return directions, this gives a capacity of 1 904 ITU/day.
- The average net ITU load is 14 tonnes.
- If the HGV traffic on a route is less than twice the value of 1,904 units/day (i.e., less than 3,808 HGV/day) (Figs. 7-10), only half of the actual traffic value is considered.

The results of the calculations are shown in Table 6. In reality, both economic and freight transport performance may be higher as more transport routes cross the borders.

Some simplification calculations have been applied to the ITP network deployment costs shown in Figs. 7-10. We have calculated that the cost of installing 1 pc ITP is 4.8 m€. The investment cost of any additional rolling stock that may be needed has not been taken into account.

Table 6

Possible result of modal shift (own calculation)

Country	ITU transport (pcs/year)	Income (m€/year)	Transport performance (billion t.km/year)
Poland	4,793,000	728	14.2
Czech Republic	4,501,750	355	6.9
Slovak Republic	1,662,000	167	3.2
Hungary	4,735,000	287	5.6
Total:	**15,691,750**	**1,537**	**29.9**

4.1. Poland intermodal ITP network

A network of 9 pcs ITPs For Poland is shown in Fig. 7. The deployment of a country-wide ITP - Loxodon-HCT-based intermodal freight network could include 60 to 70 intermodal nodes.

In Fig. 7, the HGV traffic on the connecting lines between the elements of the ITP network at the major railway interchanges in Poland is marked with a red number, corresponding to the data of the Polish National Road and Motorway Directorate General [21]. This is the portion of traffic that can be modally shifted from road to rail in case of a competitive offer. The links between ITPs coincide with the main railway lines in Poland. The investment cost of the network shown in Fig. 7 is €43.2 million.

According to [15] rail transport data, the average train speed in 2019 was 22.8 km/h, while the average transport distance was 236.6 km. Rail capacity utilization in the regions ranged from 1.9% to 24.8% in 2018. In other words, even in the most heavily used region, there was significant spare rail capacity available for a modal shift.

4.2. Intermodal ITP network in the Czech Republic

An intermodal network of 10 pcs ITPs in the Czech Republic is shown in Fig. 8. The figure also shows three additional cross-border ITPs. A country-wide ITP - Loxodon-HCT-based intermodal freight network could include 25 to 28 pcs intermodal nodes.

In Fig. 8, the HGV traffic on the connecting lines between ITPs at major railway interchanges in the Czech Republic is marked with a red number based on data from the Road and Motorway Directorate of the Czech Republic (ŘSD) [20]. This is the portion of the traffic that can be shifted from road to rail in a competitive offer. The links between ITPs coincide with the main railway lines in the Czech Republic. The investment cost of the network shown in Fig. 8 is € 48 million.

4.3. Intermodal ITP network in Slovakia

A network of 7 pcs ITPs in Slovakia is shown in Fig. 9. Due to the topography of Slovakia, the main road lines and rail network are different than those of the other countries of the region. As a consequence, the coverage of the country by the ITP network can be ensured with a smaller number of ITPs. A country-wide ITP - Loxodon-HCT-based intermodal freight network could include 14 to 16 pcs intermodal hubs.

Fig. 9 shows the HGV road traffic on the proposed interconnection line between the ITPs in the Slovak Republic based on data from the Slovak Road Administration (Slovenská Správa Ciest) [19]. Part of this traffic can be shifted from road to rail in case of a sufficiently competitive offer. The indicated connections between ITPs coincide with the main railway lines in Slovakia. The investment cost of the network shown in Fig. 9 is 33.6 m€.

4.4. Intermodal ITP network in Hungary

A network of 12 pcs ITPs in Hungary is shown in Fig. 10. One ITP could be established across the border in Austria. The deployment of a country-wide ITP - Loxodon-HCT-based intermodal freight network could include 22 to 24 pcs ITPs. The Hungarian rail network is Budapest-centric. Thus, container rail roundabouts could be developed in the eastern and western parts of the country.

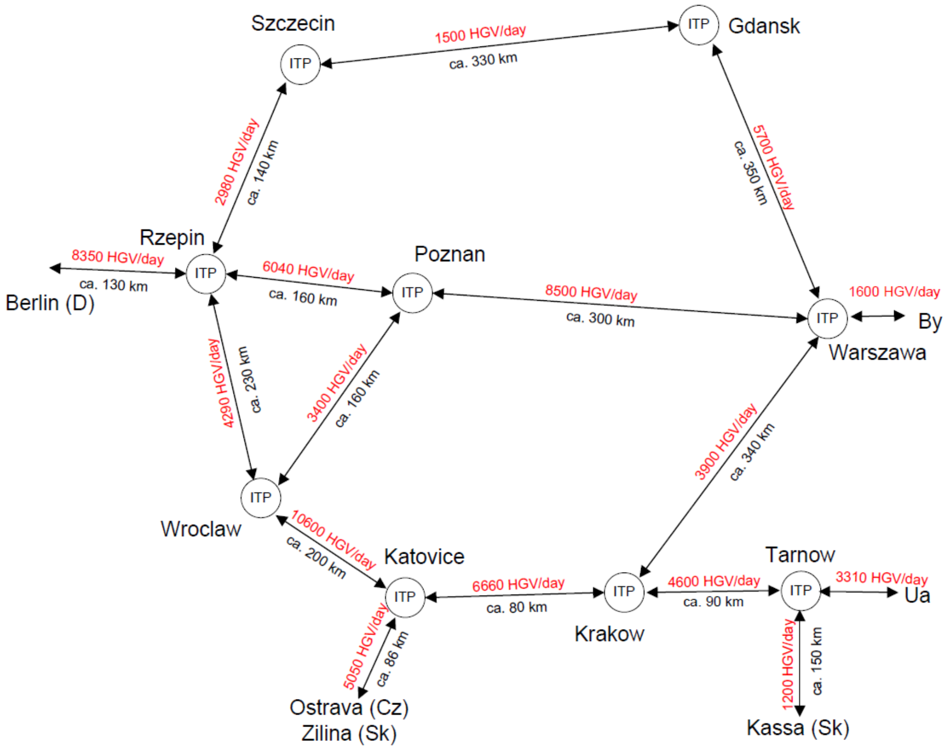

Fig. 7. ITP network in Poland (own edition)

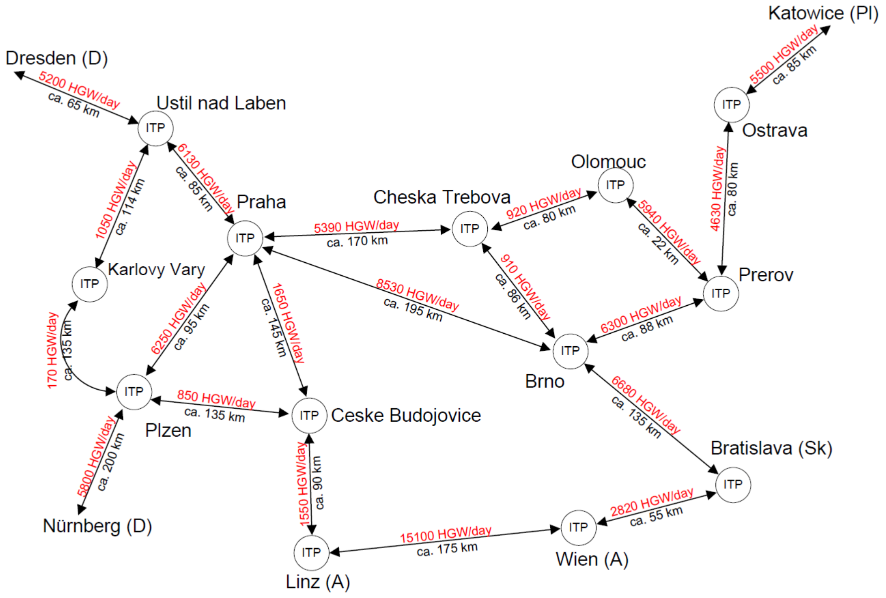

Fig. 8. ITP network in the Czech Republic (own edition)

Fig. 10 shows a possible ITP layout for Hungary covering the eastern and western parts of the country. The numbers in red are based on data from the Hungarian Public Road Nonprofit Ltd [18] and represent the HGV traffic on the road for the given road section. The links between ITPs coincide with the main railway lines in Hungary. The ITP nodes of the country-wide intermodal freight network should be located in agricultural and industrial nodes. The investment cost of the network shown in Fig. 10 is 57.6 m€.

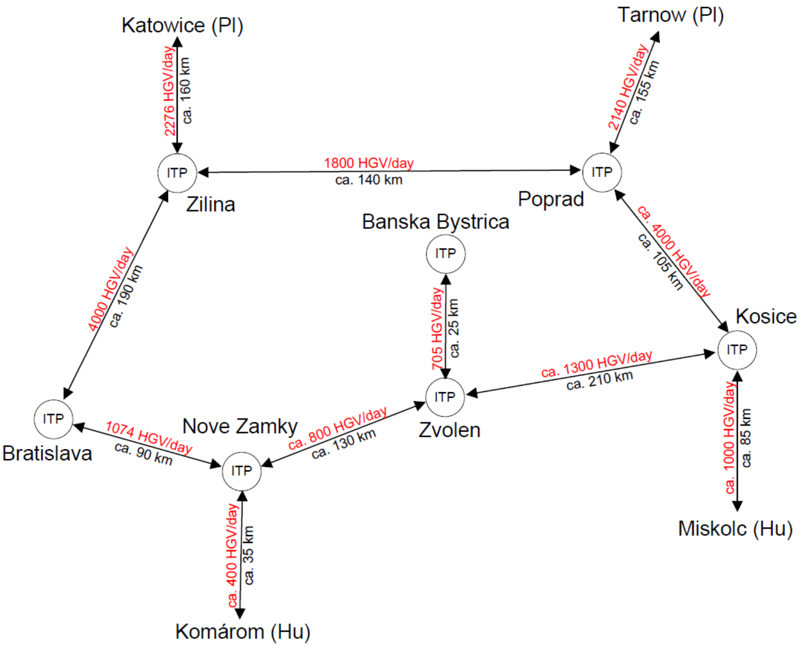

Fig. 9. ITP network in Slovakia (own edition)

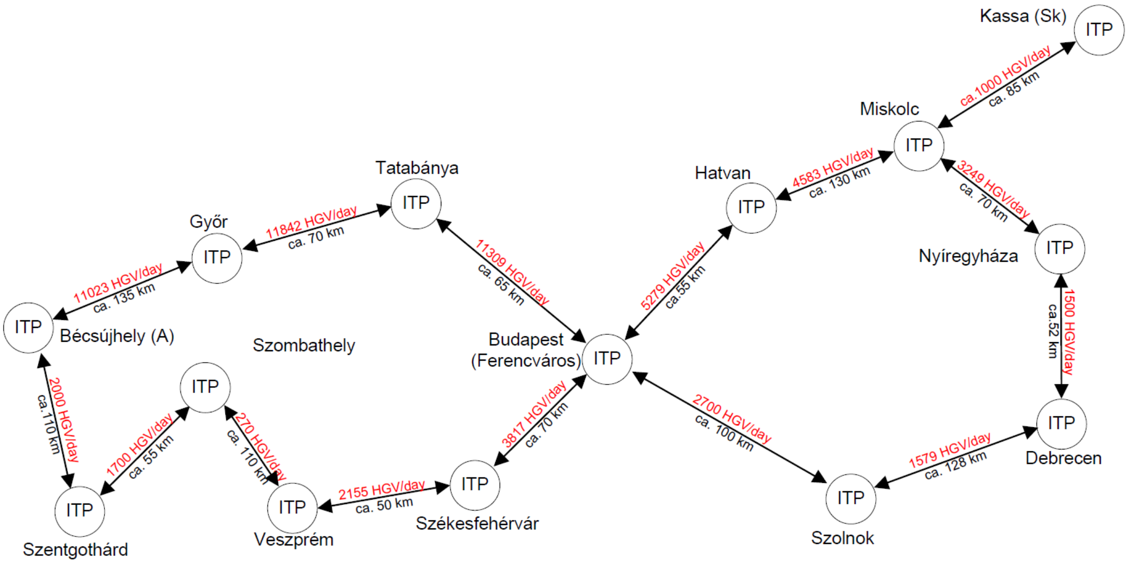

Fig. 10. ITP network in Hungary (own edition)

5. CONCLUSIONS

For modal shift, there is a technical (Loxodon-HCT) and organizational (ITP network, rail freight train traffic) solution that allows a competitive freight offer in terms of time and price compared to unimodal road transport. This solution can lead to even more ambitious freight modal shifts and CO_2

reduction targets. Unlike electric self-driving HGVs for road transport, the state-of-the-art horizontal container handling technology is feasible today. A crucial aspect is that professionals need to develop technical solutions that can benefit potential users and financial investors in the foreseeable future. In order to meet environmental requirements, technical solutions should be developed that do not increase the ecological footprint of the freight transport sector while allowing the EU economy to operate without CO_2 emissions. We are convinced that the rail-road intermodal freight transport solution described in this paper meets these requirements.

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