Analysis of multimodal terminal costs

Introduction

After dynamic growth of multimodal traffic in Europe last decade of XX century, multimodal transport encounters a number of barriers in development. These difficulties concern to a large degree a rail-road transport, which loses competition with pure road freight transport. Reasons are placed in various fields and were investigated in detail in many research projects. One of them described main decisive factors in the modal choice between multimodal and road transport. Surveys concluded in 2000 proved that price is the most important reason for choosing multimodal transport. Its role in modal choice is equal to or considerably greater than any of the quality aspects. The second most important reason for choosing multimodal transport is ability to match customer’s logistic structure. All other reasons, flexibility in particular, score low, in some exceptions of reliability. The conclusion out of this and other surveys seems obvious: cost-effective solutions will have the greatest meaning in revitalisation of European multimodal transport.

Multimodal traffic is concentrated on chosen corridors. These are: Alpine crossing, feeder service to Northern Range Ports and short-sea shipping all around the continent. The rest of potential routes are still dominated by road transport. In spite of all efforts, politicians have not managed to improve attractiveness of multimodal alternatives on European cost-oriented market. Cheaper and faster road carriers dominate especially East-West continental corridors. Even if all multimodal subcontractors, including trains, terminals and pre- and end-haulages offer their lowest prices, total price for multimodal chain is higher than customers want to pay.

The solution, which is crucial, is budgetary and fiscal policy aiming at internalisation of external costs of transport. White book of 2001 defines this solution and Marco Polo Programme as main tools making possible shifting the cargo from road to multimodal transport in the perspective of 2010. Experience of the last three years proves that these tools may be insufficient. There is strong need to evaluate new solutions helping to increase price attractiveness of multimodal transport. Two methodological approaches should be put into practice. First one aiming to minimise the cost of trains,

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1 EU Project Intermodal Quality, Final report, 2000, p. 22
2 White Paper European transport policy for 2010: time to decide, European Communities 2001
terminals and pre-and-end-haulage operators whereas second one aiming to minimise the
cost of the whole multimodal chain. Taking the first one into consideration, the terminals
seem to be the weakest link in the most cases of multimodal chains. Following analysis is
narrowed to inland terminals, which offer mainly rail-road transhipments; however
conclusions to a large extent can be useful for port terminals (maritime or inland
shipping).

**Costs of a multimodal chain**

The main problem encountered is that no detailed cost accounting data is publicly
available, with reference to costs of a multimodal chain. As a consequence, only cost
estimation for separate links or a complete door-to-door multimodal chain can be applied.
Cost of terminal operations per loading unit as an element of total costs depends on
following factors:

1) number of terminals serving loading unit from consigner to consignee (minimum 2),
2) type of transhipment (direct, indirect, rail-rail, rail-road, …)
3) terminal technology (lo-lo, ro-ro, …),
4) additional logistic services (sorting, consolidating for storage, distribution-
   processing, e-logistic …).

Figure 1 present the breakdown of multimodal chain cost per loading unit analysing three European routes: Genoa-Manchester, Barcelona-Warsaw, Athens-
Gothenburg. The terminal cost shares in total multimodal costs are 32%, 8% and 4%
respectively. Of course, it does not mean that the percentage share is inversely
proportional to the distance. The number of terminals is not decisive in this case either as
it equals 6 or 7 for all studied routes. The most important factor is the differenciation in
used types of transhipment. The high cost (166 EUR) of transhipment between inland
water barge and ship in Rotterdam contributed to a high share of terminal cost on the
Genoa-Manchester route (table 1). Much lower costly (36 EUR on average) are rail-road
transfers and the lowest costly (27 EUR on average) are rail-rail transfers.

![Figure 1. Breakdown of costs per loading unit for three European intermodal chains](image)

*Source: Based on EU Project RECORDIT, Final report, 2003, p. 40*
Table 1.
Internal costs of terminal transhipments of 40 ft loading unit

<table>
<thead>
<tr>
<th>Transhipment</th>
<th>Terminal costs [EUR/transhipment]</th>
<th>Average [EUR/Transhipment]</th>
</tr>
</thead>
<tbody>
<tr>
<td>road-barge</td>
<td>Basel – 50</td>
<td>50</td>
</tr>
<tr>
<td>rail-ship</td>
<td>Genoa – 80, Felixstowe – 40</td>
<td>60</td>
</tr>
<tr>
<td>road-ship</td>
<td>Patras – 25, Brindisi – 101</td>
<td>63</td>
</tr>
<tr>
<td>ship-barge</td>
<td>Rotterdam – 166</td>
<td>166</td>
</tr>
</tbody>
</table>

Source: EU Project RECORDIT, Final report, 2003, p. 41

Figure 2 presents similar breakdown of costs assuming constant distance of main haulage and changing distance of pre-and-end-haulage. In all three variants the rail-road terminal cost is constant in monetary value, but its share in total multimodal costs is decreasing from 24% down to 18% as a result of stretching pre-and-end-haulage distance. Quite importantly for this analysis, a great part of pre-and-end-haulage costs are time-based costs. It can be assumed that part of these costs are costs of terminal’s gate queuing. Additionally, time and distance of pre-and-end-haulage operations depends to a large extent on location of begin and end terminal. It can be stated that most important criterion of choosing terminal location should be minimisation of pre-and-end-haulage costs. Level of terminal capital costs is of lower importance.

Figure 2. Breakdown of costs per loading unit for multimodal transport chain, assuming constant distance of main haulage

Source: Ruesch M., Research Initiatives and other Developments related to Intermodal Terminals in Switzerland, EUPT Steering Committee Meeting 9.03.2004, DG TREN Offices, Brussels 2004, foil 29
Infrastructure costs

Terminal operations are often described as non-profitable. In great degree, the infrastructure costs are blamed for commercial ineffectiveness. The problem seems to be more complicated. The infrastructure costs allocation constitutes the main difficulty because, generally, railway companies are responsible for rail infrastructure investment (trucks lines, sidings, shunting area, cranes, etc.) and should invoice operators for the use of this infrastructure. But the infrastructure costs are allocated mostly to operation accounts at the rail freight cost amount. Thus, it is difficult to evaluate the portion of total rail infrastructure costs to allocate to the rail-road multimodal terminal.

The analysis revealed that the fixed infrastructure costs for the construction of a new inland terminal is very often more than 50% of the total investment costs. The rest is shared between superstructure cost and variable costs, mainly wages. The superstructure cost and variable costs are proportionally greater for large terminals. Average investment costs of a new inland terminal vary from 20 millions EUR in case of a national-size terminal (tracks length of 1000 m) to 80 millions EUR in case of a European-size terminal (track length of 3000 m). Business plan of such an investment should include the Net Present Value, which decide on its economical effectiveness.

Providing that terminal’s income is based on current tariffs of European rail-road terminals, it is hardly ever possible to cover the total cost of such a terminal in a perspective of 20 years. Only entirely or partly subsidising of infrastructure costs can make this investment profitable. In case of covering minimum of 50% infrastructure costs by public funds Net Present Value could be positive. Of course, a minimal traffic volume is required to generate terminal’s income. The traffic should be no lower than 20,000 loading units a year for a national-size terminal and 40,000 loading units a year for a European-size terminal. Generally, the investment payback period becomes shorter as the traffic increases.

The other solution is a rise of terminal’s tariffs. The current tariffs per loading unit do not cover the real costs of terminal’s transhipment. Taking into account all the difficulties in identification of costs, the difference between actual cost and price for conventional inland terminal is up to 50%. The various levels of subsidy could be substituted in a common rise of terminal’s tariffs on European market.

External costs

The idea of internalisation of external costs is a key argument in the design and execution of transport policy in Europe. European providers of transport services do not suffer from all the additional costs their activity generates. There are some achievements in internalisation of infrastructure wear and tear costs and air pollution costs, but there are difficulties in terms of accidents, noise and congestion costs. The policy based on ‘user pays’ principles encounters strong resistance of road transport operators.

The calculation of external costs of a transport activity is based on three factors: scale of the initial production of emissions (including noise, injuries, etc.), physical impact of these emissions and finally validation of these impacts. The conversion into monetary value should allow evaluation of total level of external costs per

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3 EU Project Intermodal Quality, Final report, 2000, p. 37
vehiclekilometre or transhipment. Through deducting obligatory charges including taxes (fuel taxes, road taxes, registration taxes, circulation taxes minus subsidies) and infrastructure net payments (tolls, road charges and vignettes minus infrastructure wear and tear costs) the extra charge required can be calculated.

\[ \text{Extra Charge} = \text{External Cost} - (\text{Taxes} + \text{Infrastructure Net Payments}) \]

\[ \text{Infrastructure Net Payments} = \text{Infrastructure Payments} - \text{Infrastructure Costs} \]

Table 2 shows calculations of extra charge per vehiclekilometre for road and rail transport. The data vary through European countries with weighted average of 0,21 EUR/vkm for road and 0,09 EUR/vkm for rail transport. Strict application of external costs pricing principles would therefore require transport taxes to be raised on average by these two figures on the two modes.

Researches on terminal’s external costs are carried out as well. It is proven that crane movements and storage yard operations cause air pollution and global warming. Calculations for several European countries show that total terminal’s external costs ranges from 0,02 EUR up to 0,36 EUR per transhipment of loading unit (table 3). The national energy mix of the countries heavily influences the cost’s level. In case of coal-generated thermal plants at low stage of used technology the external costs are the highest. However, comparing above-mentioned rates of terminal’s external costs to the level of its internal costs, first ones turn out to be low enough to be ignored.

### Table 2.

<table>
<thead>
<tr>
<th>Country</th>
<th>Road Transport [EUR/vehiclekilometres]</th>
<th>Rail Transport [EUR/vehiclekilometres]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Taxes</td>
<td>Infrastructure Net Payment</td>
</tr>
<tr>
<td>France</td>
<td>0.14</td>
<td>0.00</td>
</tr>
<tr>
<td>Germany</td>
<td>0.13</td>
<td>-0.05</td>
</tr>
<tr>
<td>Hungary</td>
<td>0.11</td>
<td>-0.06</td>
</tr>
<tr>
<td>Italy</td>
<td>0.09</td>
<td>-0.01</td>
</tr>
<tr>
<td>Poland</td>
<td>0.14</td>
<td>-0.06</td>
</tr>
<tr>
<td>Spain</td>
<td>0.12</td>
<td>0.00</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.09</td>
<td>-0.04</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.16</td>
<td>-0.15</td>
</tr>
<tr>
<td>UK</td>
<td>0.34</td>
<td>-0.18</td>
</tr>
<tr>
<td>Weighted average</td>
<td>0.15</td>
<td>-0.05</td>
</tr>
</tbody>
</table>

Remark: Some rows may not add due to rounding

Source: EU Project RECORDIT, Final report, 2003, p. 119-120
Table 3.

External costs of transhipments

[EUR/40 ft loading unit]

<table>
<thead>
<tr>
<th>Country</th>
<th>Air pollution</th>
<th>Global warming</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>0.04</td>
<td>0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>Germany</td>
<td>0.07</td>
<td>0.10</td>
<td>0.17</td>
</tr>
<tr>
<td>Hungary</td>
<td>0.19</td>
<td>0.07</td>
<td>0.26</td>
</tr>
<tr>
<td>Italy</td>
<td>0.08</td>
<td>0.09</td>
<td>0.16</td>
</tr>
<tr>
<td>Poland</td>
<td>0.20</td>
<td>0.16</td>
<td>0.36</td>
</tr>
<tr>
<td>Spain</td>
<td>0.07</td>
<td>0.08</td>
<td>0.15</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>UK</td>
<td>0.08</td>
<td>0.07</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Source: EU Project RECORDIT, Final report, 2003, p. 71

Gate operations

A number and the speed of movements of multimodal units through the gates are the key factors determining productivity of the multimodal terminal. Gates are controlling and regulating movement of vehicles to and from a terminal, therefore they are not necessary in case of pure sea-rail or barge-rail terminals. Examining the costs of gate operations one should take into consideration the vehicles waiting costs. The time a vehicle spends at the gate includes following time components:

1) queuing,
2) vehicle/unit identification,
3) checking the physical condition of the unit,
4) entering the information of vehicle/unit to the terminal’s computer system,
5) issuing the terminal documents (spot ticket, routing slip).

The costs of labour, fuel, amortisation of the vehicles as well as external costs can determine total waiting costs of a vehicle. In some cases the percentage value of cargo unit should be added. Therefore it can be evaluated an hour rate of waiting cost for every combination of truck, driver and cargo unit.

There are two solutions helping to eliminate needless waiting costs. One of them is optimisation of queuing time as effect of opening additional gate lines. The number of gate lines in service should be calculated as an objective of balance between cost of waiting and cost of service (see figure 3). The number of lines in service should be adjusted to a changing flow of serviced vehicles during the day. What is as well important, the changing flow of vehicles should determine opening and closing hours of the terminal’s gate. Optimum opening hours should be calculated basing on the rule of achieving minimum of total social costs. A two- or three-shift system could significantly increase gate capacity.
Second solution aims at speeding up gate processing through adopting modern information technology. Up-to-date technologies make possible:
1) fully automatic recognition and identification of driver, vehicle licence plate, chassis number and cargo unit number and type,
2) automatic generation of terminal documents for a driver,
3) storing and processing of all electronic data providing real-time gate traffic information,
4) remote system operation performed by the gate personnel in a secured and comfortable way.
All these technologies reduce gate-processing time dramatically, such that thereby expanding gate capacity without building more lines and adding personnel. Therefore additional costs of adaptation of modern information technology can be balanced by infrastructural and personnel savings. Cost-benefit analysis of every solution should decide.

Figure 3. Gate queuing cost analysis

Concept of Compactterminal
A new cost-effective solution in multimodal terminal outlay is named Compactterminal. This concept can be applied to inland road-rail terminals. Up till now it was only a theoretical model proposed by Swiss company Tuchschmid AG. In 2004 first terminal based on this model is under construction. The terminal named Cargodrome, placed 35 km from Berne, was planned as conventional terminal with gantry cranes but factors such as lower handling costs, greater handling capacity and faster transhipment
times influenced the consortium of investors to build modern terminal using Compactterminal technology.  

Figure 4. Compactterminal  
Source: EU Project SAIL, Final report, 2002, p. 65

Compactterminal has modular construction including (see figure 4):  
1) transhipment module – equipped with semi-automatic loading crane enabling direct transfer rail-rail, rail-road and indirect transfer rail-storage with usage of AGV7,  
2) storage module – equipped with AGV short-term-storage yard where cargo units are held between road and rail moves,  
3) road module – equipped with crane similar to that used in transhipment module enables indirect transfer road-rail and road-storage with usage of AGV,  
4) distribution module – adjoining the road module offers full pallet of logistic services for vehicles and cargo.  

A break-through in cost and efficiency results from an idea, that terminal service can be realised in all situations, in all size ranges. From minimal and economical installations of transhipment module for small throughputs to reach infrastructure of logistic centre, including all modules, in case of high market demands. In all cases Compactterminal proves to be cheaper in terms of investment and exploitation costs comparing to conventional terminal (see table 4 and figure 5). Altogether, Compactterminal’s cost per lift can be almost by 30% lower compared to conventional terminal. Decisive factors are:  
1) much lower cost of salaries,  
2) lower cost of cranes installed in transhipment and rail modules,  
3) smaller area needed for storage module,  
4) high productivity of AGV as a cost-effective alternative to traditional terminal vehicles.

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5 Cargodrome, press information on website: www.intermodallogistics.co.uk  
6 EU Project SAIL, Final report, 2002, p. 67-68  
7 AGV – automatic guided vehicle
5) lower cost of services and maintenance.

Full module size of Compactterminal is mostly effective. What is important in competition with road transport, terminal services are much more flexible, comparing to conventional, in handling peak demand situations by road and rail.

Table 4.

| Terminal type | Yearly transhipments | Total investment costs \[x1000 EUR\] | Yearly exploitation costs \[x1000 EUR\] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Interest costs | Depreciation costs | Amortisation of land & track | Operational costs | Service/maintenance costs | Salaries |
| Compact-terminal 1** | 30 000 | 4 458.2 | 111.4 | 128.2 | 110.2 | 150.6 | 83.6 | 392.0 | 32.5 |
| Reach Stacker | 30 000 | 4 306.5 | 107.7 | 119.2 | 85.4 | 262.3 | 122.3 | 672.0 | 45.6 |
| Compact-terminal 2*** | 100 000 | 9 891.0 | 247.3 | 435.4 | 164.0 | 423.8 | 259.3 | 952.0 | 24.8 |
| Gantry Crane | 100 000 | 12 503.5 | 312.6 | 472.6 | 195.4 | 657.5 | 400.6 | 1 344.0 | 33.8 |

* Interest costs = 0.5*(5%*Total investment costs)
** Compactterminal 1 – consist of only transhipment module equipped with 2 rail tracks and buffer area for cargo units (without AGV)
*** Compactterminal 2 – consist of transhipment and storage module with AGV

Source: Based on EU Project SAIL, Final report, 2002, p. 73-76

Figure 5. Comparison of costs of transhipment at four types of terminals
Source: Based on EU Project SAIL, Final report, 2002, p. 76
Conclusions

Basing on analysis of the terminal operational costs the following thesis can be established.

1) The most important factor determining the terminal costs is the transhipment technology. There are great differences in costs between inland and port terminal. The latter generates higher level of costs of cargo unit transhipment compared to rail-road transhipments. Therefore ship or barge based multimodal chains can be less competitive due to high cost of port terminal operations.

2) Among criteria of choosing terminal location, capital costs are of lower importance comparing to costs of pre-and-end haulage. First ones influence on terminal’s cash flow only in first 10-20 years and can be covered by subsidies. The second ones determine economic effectiveness of every multimodal chain passing through begin and end terminals.

3) Business plan of multimodal terminal should assume subsidising of minimum 50% of infrastructure costs. Actual terminal’s tariffs don’t allow covering real infrastructure costs without public aid. This aid is necessary only at the investment stage, no future subsidy should be allowed.

4) The common rise of terminal’s tariffs is essential. Basing on minimisation of terminal’s profit the rest of price should cover 100% of terminal fixed and variable costs. Because the costs per transhipment can be reduced by increase of cargo traffic, some small and not properly situated terminals will loose their clients.

5) The key solution to increase terminal efficiency is implementation of modern technology and management. In one case building a new terminal is necessary in other some organisational and infrastructural changes are sufficient. New generation terminals are cost-effective due to much lower exploitation costs comparing to conventional costs. Costs are reduced by usage of information technologies, better utilization and reliability of infrastructure and superstructure.

6) The new generation terminals are profitable for the whole network thanks to:
   — higher load factors of wagons/barges/ships,
   — higher transport frequencies,
   — shorter circulation time for wagons/barges/ships and load units.
This implies a relocation of costs and profits within the transport chain. In practice this mean that profits from network could compensate the multimodal transport operator for increased terminal tariffs. The implementation of the new terminals results in the lower total chain costs (figure 5).

7) The internalisation of external costs in all transport services will not be as profitable for multimodal transport as it’s commonly assumed. The tariffs will increase:
   — for rail operations by about 10% (0,90 + 0,09 EUR/km),
   — for road operations by about 17% (1,20 + 0,21 EUR/km),
   — for terminal’s operations by about 1% (36 + 0,15 EUR/transhipment).
External costs of terminal’s operations may be disregarded. The rise based on above-mentioned figures will imply an incensement of multimodal traffic but at a very limited extent.
Figure 5. Changes in the multimodal chain cost due to implementation of new-generation terminals (dotted line)

Source: EU Project TERMINET, Final report, 2000, p. 65

Literature
1. Cargodrome, press information on website: www.intermodallogistics.co.uk
2. EU Project IQ - Intermodal Quality, Final report, 2000
4. EU Project SAIL, Final report, 2002
5. EU Project TERMINET, Final report, 2000
6. Ruesch M., Research Initiatives and other Developments related to Intermodal Terminals in Switzerland, EUPT Steering Committee Meeting 9.03.2004, DG TREN Offices, Brussels 2004