COMBINED TRANSPORT TERMINALS BENCHMARK ANALYSIS

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CONTENT

1 INTRODUCTION

The COMBINE Project aims at enhancing the combined transport (CT) in the Baltic Sea Region (BSR). Pathways towards this goal lead by different areas of CT organisation, including: technology, economic, legal and environmental as well as all phases of cargo unit carriage (i.e., loading unit by shipper, pre-haulage by road or sea, trans-shipment in terminals, main haulage by rail or waterways and last mile delivery to the receiver. The whole of the carriage process engages many different entities, including consignor/shipper, consignee, forwarder, carrier (i.e., road, rail, inland waterway or shipping owner), terminal operator, infrastructure manager, custom administration and government. At every stage, by every process, participants appear in a number of different aspects subject to improving (and developing) transportation efficiency. CT as a complex service (i.e., especially when compared to direct shipping) implies a number of aspects in terms of efficiency enhancement and improvement.

This report aims at analysing existing terminals in the BSR to create a benchmark for the region and for the overall transportation process. The primary data analysed is based on the BSR CT terminals. The structure of the report breaks down the methodology and data collection process in chapter two. In chapter three, the main goals of the benchmark analysis are pieced together and examined. Due to the adopted methodological structuring, the self analysis is divided into two stages – reflecting the data collection process. In chapter four, a basic analysis of the main CT terminals parameters is presented (i.e., separated into four groups), including: spatial distribution, operational models, range of provided services and terminal infrastructure and equipment). Moreover, a forward-thinking process is presented via four specific areas of CT terminal operation (i.e., special infrastructure assessment for efficiency improvement, energy consumption, terminal efficiency and digitalisation). In these four areas, based on individual case studies met in the BSR and outside the region are presented solutions moving CT terminal towards improvement in operation efficiency. In chaper five, conclusions concerning the specificity of BSR CT terminals, average parameters, deviations and efficiency measures are presented as well as an elabortive list of reccomendations for future development. Overall, the report paints a realistic picture of a typical BSR CT terminal and introduces potential benchmarks and expectiations of terminal development region-wide.

2 METHODOLOGY AND DATA COLLECTION

By way of internal project meetings and teleconferences a common methodology of data collection and benchmark analysis was selected and adopted. Based on experience and expertise, full CT terminal data for all BSR countries was difficult to achieve. As a result, a list of the "most important" parameters were necessary to select. The parameters needed to be available to the public as well as readily available. Data collection was divided into two stages. Data collection for both stages was conducted over a number of months concluding in March 2020.

Stage 1 is a list of all BSR CT terminals with basic data from each. Data collection from this stage included 39 parameters made up of the following:

Facility type
Facility name
Seaport
Inland port
Rail Freight Corridor
TEN-T
Volumes handled in 2018
wherein: Containers
wherein: Swap bodies
wherein: Semi trailers
wherein: RoLa
Freight village
Model for operation and maintenance
Facility operator (name)
Type of operator
Fax
Email
Website
Facility owner (name)
Timetable for service trains

Loading/unloading/trans-shipment
Storage of containers/ general cargo
Storage of dangerous goods
Storage and handling of Reefers
Weighing of wagons/Loading units
Street, house number
ZIP-Code
Town
Country
All facility tracks: number
Number of (gantry) cranes
Number of mobile cranes
Public accessibility
Max. permitted train length
Clearance gauge
Trailer size limit
Trailer weight limit
Truck + trailer (Rola) acceptance
Storage area [m^2]
Storage area [TEU]

In terms of benchmark analysis among all BSR CT terminals, "most important" data for the market analysis, comprised of: number of terminals in specific countries and for the whole region, spatial distribution of them in the BSR (i.e., including TEN-T network and Rail Freight Corridors), determine operations models used in the BSR, specifics of terminals including differences for seaport terminals and land terminals, range of services provided in terminals including type of cargo units to be serviced, transport modes to be crossed and additional services for the cargo and/or for the shipper. Finally, the main infrastructure and trans-shipment capacity (i.e., the amount of existing equipment) was looked at for the first stage.

Assuming not all types of data would be feasible for collect, a detailed benchmark analysis in other areas of terminal operation was proposed based on case study methods. Methodology on terminal (cases) selection for the detailed benchmark analysis per country included the following five criteria:

1. Different type/mode of terminal (i.e., tri-modal port, bi-modal rail-road, bi-modal inland waterways- road etc.) reflecting the distribution of the types in the complete list of terminals, but at least one seaport terminal and one inland terminal (dry port);
2. Balanced geographical distribution of the selected terminals among the TEN-T Core Network or Comprehensive Network, but at least one terminal located on the Rail Freight Corridor(s) (RFC);
3. Different terminal handling technology, but at least one terminal with horizontal handling technologies as main (or exclusive) trans-shipment solution or, alternatively, when no one existing can be found, other terminal suitable for horizontal technologies or predestinated for it;
4. Terminals with different operating model (i.e., fully in-house, concession, operating contract, rental agreement for commercial operation), but at least one open access terminal and one privately owned, dedicated terminal, if available; and
5. Different size terminals based on the throughput in TEU p.a.

In addition to the above criteria, due to not dichotomic purposes that can be case-specific, all Project Partners were asked to select 2-3 terminals from their country for Stage 2 analysis. The Stage 2 analysis used the following 56 parameters:

Other type of operator
Contact person
Phone
Type of owner
Other type of owner
Customs clearance
Connection of facility to public rail network
Conditions for road access
Facility operation status
Platform tracks: thereof electrified
Platform tracks: max. usable length
Trans-shipment tracks: number
Trans-shipment tracks: max. usable length
Horizontal trans-shipment system
Number of reefer connections
Empty container depot
Legal requirements
Electrified rail access possible

Max. permitted axle load
Min. track radius
Container acceptance
Container size limit
Container weight limit
Swap body acceptance
Swap body size limit
Swap body weight limit
Trailer acceptance
Conventional cargo acceptance
Palletised goods
Bulk
Fluids and gas
Dangerous goods
Heavy loads
Reefer cargo
Other cargo types
IT systems
Total facility area (ha)
Berths length (m)
No. Of berthing places
No. of STS
No. of RTG
No. of Reach stackers
No. of straddle carriers
No. of lift trucks
No. Of tractors
Total facility yearly turover
Average tonnage of 1 ILU
Yearly electric power consumption
Yearly fuel (diesel) consumption
Yearly fuel (gasoline) consumption
Handling fee per semi-trailer
Handling time per semi-trailer

Parking space dedicated to semi-trailer
Indirect terminal operating organisation (process)
Infrastructure investment cost per semi-trailer
Costs of wagons for semi-trailer

The Stage 2 parameters allow for the analysis of infrastructure elements and trans-shipment capacity as well as a performance analysis on energy consumption. In addition, an initial attempt on the digitalisation process in CT terminals was possible.

It should be pointed out that one fundamental problem was encountered during the data collection and research. A widespread lack of data included not only detailed issues of terminal technology and equipment, but basic information ranging from terminal working hours, train schedules, range of available services or ownership and management issues were common. Data collection was not limited to desk research alone but went well beyond the initial adopted model. The following sources were used to fill in the gaps: telephone interviews, expert interviews with practitioners from the CT industry, actual measurements in the terrain and the use of Google Maps service (i.e., via its street view) as well as applied statistical estimation modeling.

As a result, it was not possible to collect 100% of the data. The largest deficiencies were observed in the German terminals which are related to the largest number of terminals (for this country), but also their dispersement and diverse form of ownership. In such cases, data were taken for analysis after prior cleaning for estimation purposes. In the results, however, this is manifested in the form of an abbreviation “n.a.” (i.e., not applicable) which often caused a slight distortion of the actual picture of the Baltic CT terminal services market.

In this context, the very first conclusion and recommendation from the analysis is the neccessity of implementation of a common statistical reporting system which should be developed for best practices stakeholders, decision makers and researchers alike in the area of reporting and parameters development for any future reporting rules.

3 BASIC CT TERMINALS BENCHMARK ANALYSIS

3.1. Spatial distribution of CT terminals in the BSR

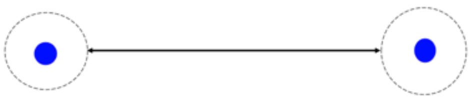
From the dynamic development of unitised cargo transport technologies at the turn of the twenty-first century, intermodal/CT of containers, semi-trailers and swap bodies developed very intensively in Europe. These technologies are based on two relative types of CT – sea-land transport of containers and ro-ro units, as well as land (i.e., rail-road) transport of containers and other cargo units (i.e., semi-trailers, swap bodies and trucks).

Maritime transport is based on regular shipping – i.e., container, ro-ro and ro-pax lines. Appropriate, deeply specialised vessels carry containers and ro-ro cargo (i.e., semi-trailers, roll-trailers and trucks) between ports. These ports can be divided into three basic types. The first consists of numerous ports where final cargo arrives (i.e., final destination ports). The second consists of large terminals and trans-shipment ports (i.e., gateways, hubs), which are gates linking smaller ports and local/regional shipping lines network with overseas shipping lines. The third consists of ports supplementing of road systems through connections by passenger-car ferries, passenger-car-rail and ro-pax or ro-ro units.

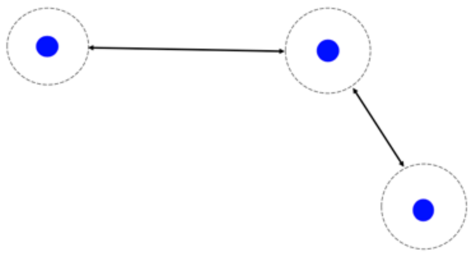
The BSR is one of the most intense sea areas in terms of navigation. There are approximately 4,000 ships operating at one time with more than 350 of these are ro-ro or ro-pax vessels operating exclusively in the Baltic ferry market. Another 350 are container ships sailing in this area as feeder ships or in the short sea shipping scheme.

The second part of the market – rail-road combined transport serves by way of two forms. First, the sea-land network can be described as hinterland services for shipping based on regular rail services or inland waterways shipping lines. The road section plays the role of the last mile delivery phase. The second part consists of a multi-liner rail service network acorss the whole of Europe. These services can work as national or international rail connections. Analysing these types of services, six illustrative examples are derived:

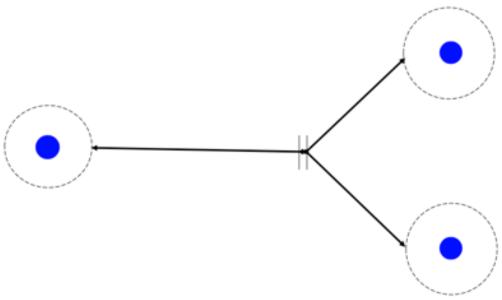
1. Shuttle service



2. Antenne-shuttle service

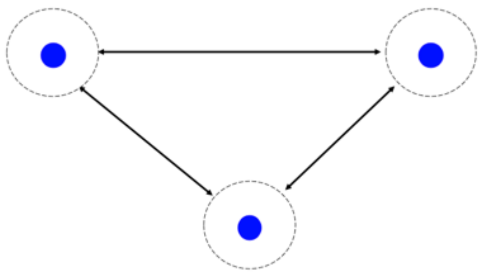


3. Y-shuttle service

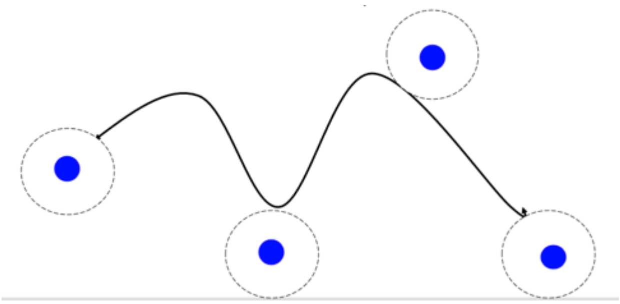


4. Liner service

5. Round service

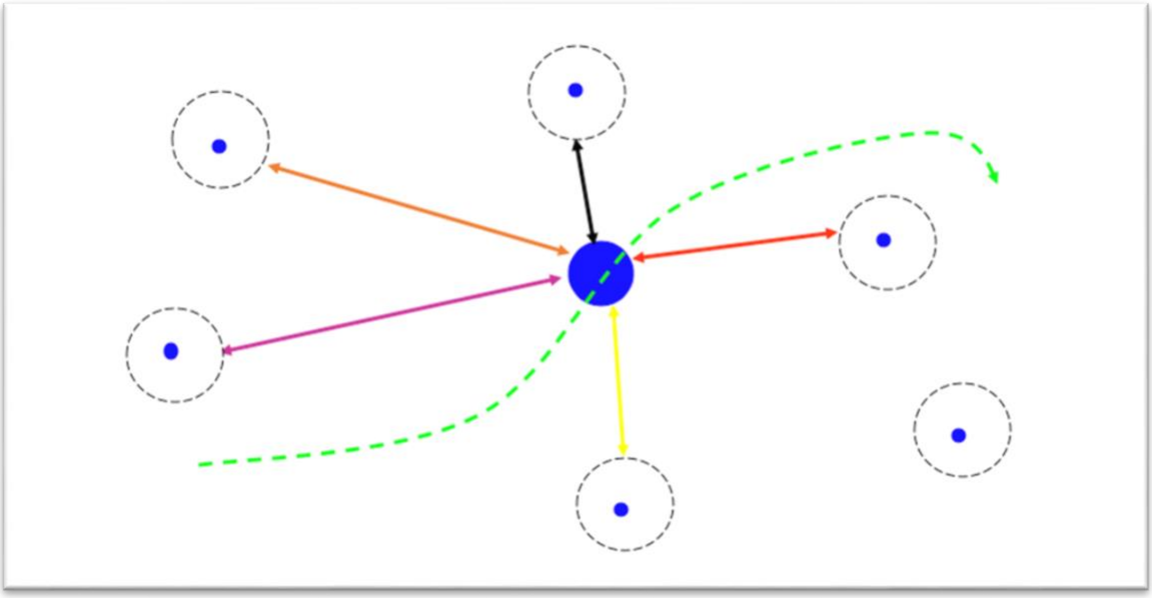


6. Aggregating service

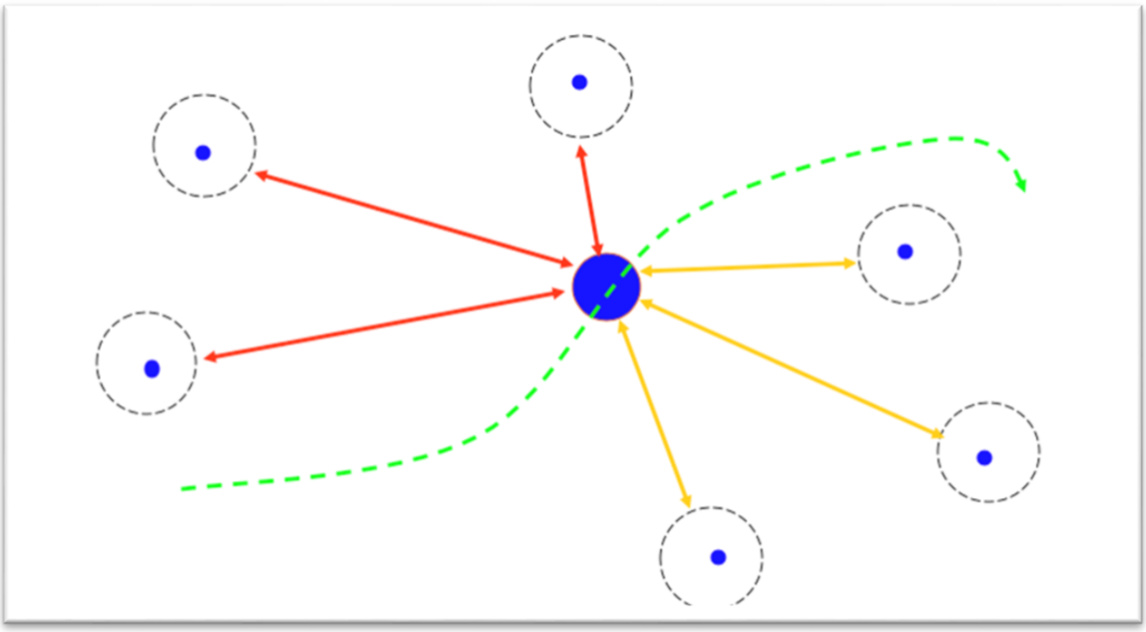


The above types of CT services are flexible and easely replaced by another type due to the cargo volume at par with specific shipments. A set of such services creates a CT network, i.e., where CT terminals are crucial infrastructural elements that play different roles for the market and for the carrier. Depending on hinterland borders and services, three relational types of CT network can be selected:

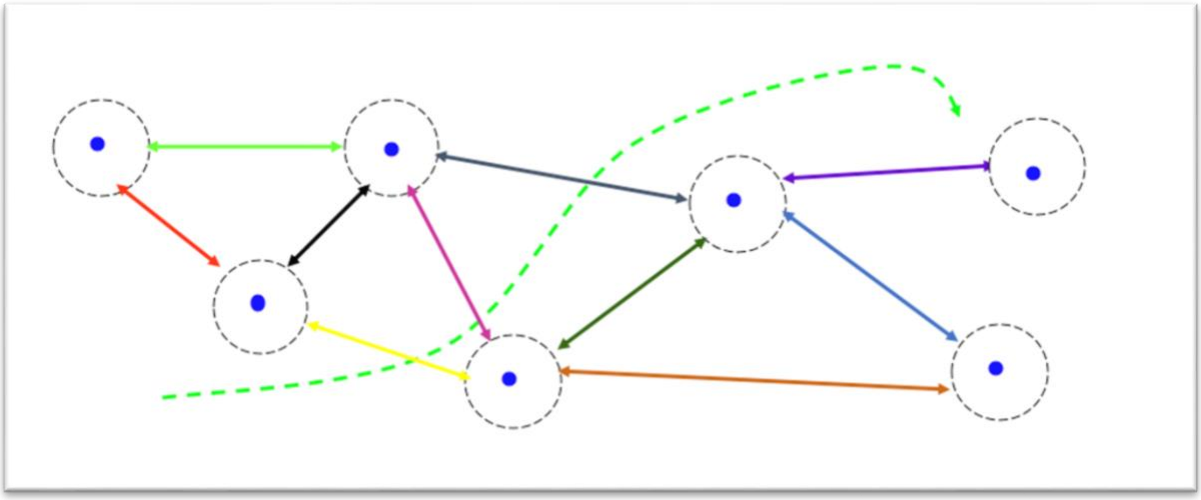
1. Hub-and-spoke network



2. Gateway network



3. Shuttle network



In the EU's economic development policy, the BSR is seen as an area of increasing socioeconomic importance in Europe. A number of land and sea intermodal transport chains, connecting the highly developed economies of Scandinavia with the countries of Central and South Europe, run through the Baltic Sea. Maritime transport in the Baltic Sea is provided by ocean and short-sea shipping.

The basic form of general cargo transportation in the Baltic Sea shipping is by rolling stock. Hence, the Baltic Sea concentrates a significant part of global ferry traffic in its area and intermodal road – sea and rail – sea transport techniques are widely used in the transport processes of Scandinavia – Central and South Europe.

This arrangement is directly reflected in the CT network and location of the terminals. Spatial distribution of CT terminals in the BSR are presented on map (Figure 3.1.1). Analysing the geographical distribution of CT terminals, a large number of them are found in the region of the Jutland peninsula. In the north-eastern of Baltic Sea (i.e., Lithuania, Latvia, Estonia and Russia) there are fewer of them. The situation is similar in the north of the Baltic area. A list of terminals taken for benchmark analysis is provided in Table 3.1.1.

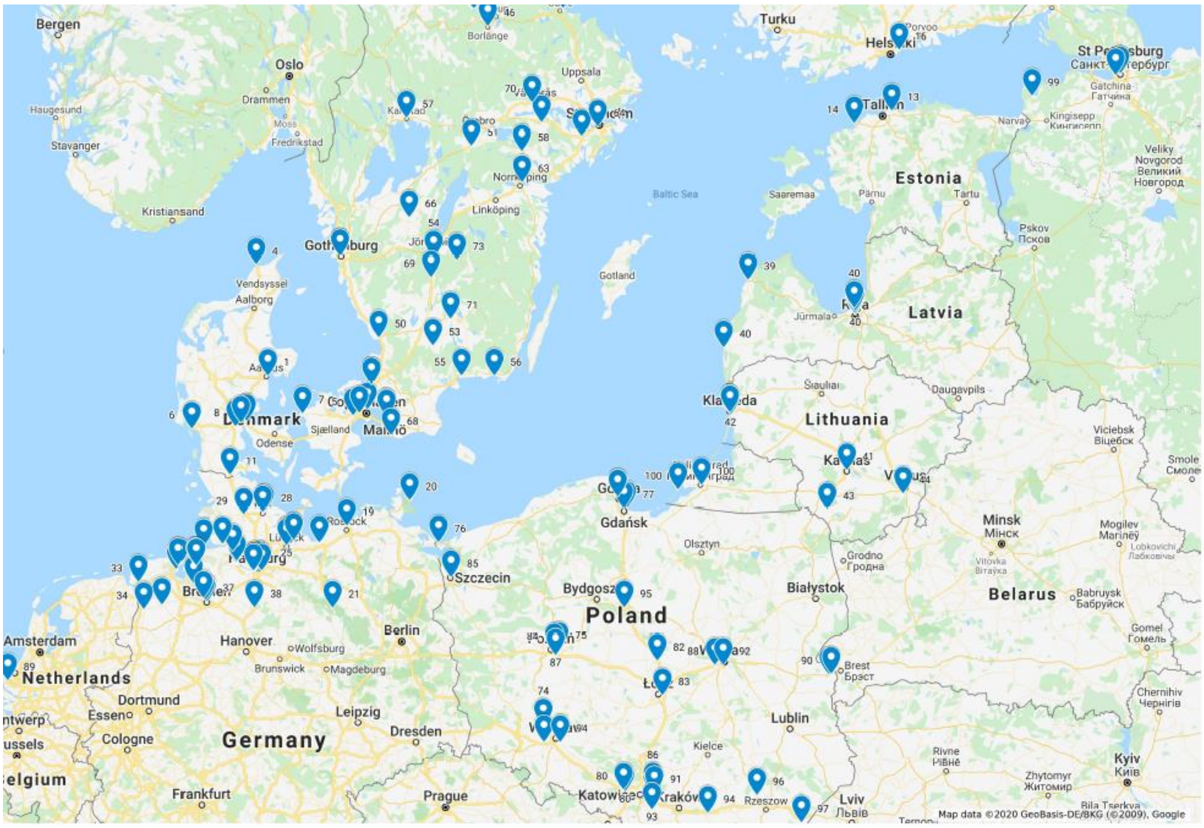


Figure 3.1.1. Spatial distribution of CT terminals in the BSR.

Source: www.googlemaps.com.

Table 3.1.1. List of CT terminals in the BSR included in the analysis.

No.	Country	Terminal
1	Denmark	APM Terminal Aarhus
2	Denmark	Copenhagen Malmö Port AB
3	Denmark	Taulov Container and Rail Terminal
4	Denmark	Kombiterminal Hirtshals
5	Denmark	Høje Taastrup Combiterminal
6	Denmark	Jutlandia Terminal
7	Denmark	Port of Kalundborg
8	Denmark	H. Daugaard
9	Denmark	Railport Glostrup
10	Denmark	Ro-Ro Terminal Fredericia
11	Denmark	TX Logistik Combi Terminal Padborg
12	Denmark	Kombiterminal Taulov
13	Estonia	HHLA TK Estonia
14	Estonia	Esteve
15	Finland	Kouvola RRT
16	Finland	Vuosaari Harbour
17	Finland	Port of Hamina-Kotka
18	Finland	Rauman Satama Port of Rafuma
19	Germany	Rostock Trimodal RTM

20	Germany	Mukran Port
21	Germany	Elbe Port Wittenberge
22	Germany	Container Terminal Burchardkai -CTB
23	Germany	Container Terminal Tollerort -CTT
24	Germany	Hamburg BUSS Hansa Terminal
25	Germany	Hamburg O'Swaldkai
26	Germany	Hamburg Süd-West-Terminal
27	Germany	Cotac Depot Hamburg
28	Germany	Hamburg Dradenau
29	Germany	CST Hamburg
30	Germany	Wallmann & Co.
31	Germany	WCS Santangelo GmbH
32	Germany	EUROGATE Container Terminal Hamburg -CTH
33	Germany	Hamburg Altenwerder CTA
34	Germany	Ernst Logistik Depot
35	Germany	EUROKOMBI Terminal GmbH
36	Germany	Remain Container-Depot Hamburg
37	Germany	Industriebahnhof Stade-Brunshausen
38	Germany	Stade BUSS Terminal
39	Germany	DUSS-Terminal Hamburg-Billwerder
40	Germany	Lübeck Nordlandkai
41	Germany	Schlutup Lübeck
42	Germany	Cargo-Terminal Lehmann -CTL
43	Germany	Lübecker Hafen-Gesellschaft mbH
44	Germany	Baltic Rail Gate
45	Germany	Seehafen Wismar
46	Germany	Kiel Schwedenkai
47	Germany	Kiel Ostuferhafen -KombiPort
48	Germany	Terminal Neumünster
49	Germany	Rendsburg Port
50	Germany	Glückstadt Port
51	Germany	Brunsbüttel Ports
52	Germany	Container Terminal Wilhelmshaven -CTW
53	Germany	NORDFROST Seehafen-Terminal
54	Germany	Rail Terminal Wilhelmshaven
55	Germany	c-Port cargo & industrie am küstenkanal
56	Germany	Terminal Nordkai Emden
57	Germany	Dörpen
58	Germany	Brake J. MÜLLER BBT
59	Germany	Cuxport Terminal
60	Germany	Bremerhaven MSC Gate
61	Germany	Bremerhaven NTB
62	Germany	Container Terminal Bremerhaven
63	Germany	Rail Terminal Bremerhaven RTB
64	Germany	Bremerhaven Addicks + Kreye Containerservice
65	Germany	Bremen Roland
66	Germany	Remain Container Depot Bremen
67	Germany	Hansakai Bremen
68	Germany	Containerdepot Griepe
69	Germany	Soltau Logistic Center
70	Latvia	Noord Natie Ventspils Terminals
71	Latvia	Railport Riga
72	Latvia	Riga Container Terminal
73	Latvia	Baltic Container Terminal

74	Latvia	Riga Universal Terminal
75	Latvia	Terrabalt
76	Lithuania	Kaunas Intermodal Terminal
77	Lithuania	Klaipėda Container Terminal
78	Lithuania	Central Klaipėda Terminal
79	Lithuania	Šeštokai Railway Station
80	Lithuania	Klaipėdos Smeltė
81	Lithuania	Vilnius Intermodal Terminal
82	Sweden	Arken Kombiterminal
83	Sweden	Borlänge Kombiterminal
84	Sweden	Södertälje hamn
85	Sweden	Eskilstuna Logistikpark
86	Sweden	Gävle Hamn Kombiterminal
87	Sweden	Skandiahamnen
88	Sweden	Hallsbergsterminalen
89	Sweden	Hallands hamnar - Halmstads kombiterminal
90	Sweden	Helsingsborgs kombiterminal
91	Sweden	Helsingborgs hamn - Combiterminal
92	Sweden	Terminalen i Insjön
93	Sweden	Älmhults Terminal AB
94	Sweden	Jönköpings Kombiterminal
95	Sweden	Karlshamns Hamn
96	Sweden	Karlskrona Hamn
97	Sweden	Karlstads kombiterminal
98	Sweden	Katrineholms Kombiterminal
99	Sweden	Kiruna Cargo
100	Sweden	Luleå Kombiterminal
101	Sweden	CMP Combi Terminal
102	Sweden	Malmö Kombiterminal
103	Sweden	Pampusterminalen
104	Sweden	NLC Terminal
105	Sweden	Dryport Skaraborg
106	Sweden	Årsta Kombiterminal
107	Sweden	Sundsvalls kombiterminal
108	Sweden	Trelleborgs kombiterminal
109	Sweden	Båramo kombiterminal
110	Sweden	Västerås Kombiterminal
111	Sweden	Alvesta kombiterminal
112	Sweden	NLC Storumanterminalen
113	Sweden	Nässjö kombiterminal
114	Poland	PCC Intermodal Brzeg Dolny
115	Poland	Brzeski Terminal Kontenerowy
116	Poland	CLIP Intermodal Container Terminal
117	Poland	OT Port Świnoujście Container Terminal
118	Poland	DCT Gdansk
119	Poland	Euro Terminal Slawków
120	Poland	Nabrzeże Szczecinskie
121	Poland	BCT Gdynia
122	Poland	Hutchison Ports Gdynia (GCT)
123	Poland	PKP Gliwice
124	Poland	PCC Intermodal Gliwice
125	Poland	Terminal Kontenerowy Schavemaker Kąty Wrocławskie
126	Poland	PCC INTERMODAL Kutno
127	Poland	Centrum Logistyki LAUDE SMART INTERMODAL

128	Poland	Terminal Kontenerowy Spedcont Łódź
129	Poland	PCC INTERMODAL Kolbuszowa
130	Poland	Terminal Kontenerowy Poznań Franowo
131	Poland	DB Port Szczecin
132	Poland	Metrans Terminal Dąbrowa Górnicza
133	Poland	Metrans RAIL HUB TERMINAL GADKI
134	Poland	Metrans Terminal Pruszków
135	Poland	PKP CARGO CL Małaszewicze
136	Poland	PKP Cargo CL Medyka-Żurawica
137	Poland	Terminal Przeladunkowy Zaborze
138	Poland	Terminal Sławków DB Spedkol
139	Poland	PKP CARTO TERMINAL WARSZAWA
140	Poland	EUROPORT
141	Poland	Katowice Wlosienica Terminal
142	Poland	Wroclaw Siechnice Terminal
143	Poland	Adampol Terminals
144	Russia	Container Terminal Saint-Petersburg
145	Russia	First Container Terminal
146	Russia	Petrolesport
147	Russia	Ust-Luga Container Terminal
148	Russia	Baltiysk Container Terminal
149	Russia	Kaliningrad Sea Commercial Port
150	Russia	Seaport of Saint-Petersburg

Source: own elaboration.

A CT terminal is basically defined as a place with access to at least two transport modes (i.e., rail and road, or sea and rail, etc.), where trans-shipment of a unitised cargo take place and where other services related to the cargo units and/or transport means can be offered (Table 3.1.2).

Table 3.1.2. Division criteria of CT terminals by size.

Criteria	Small	Medium	Large
Number of handled units per year	< 25 000 UTIs or 50 000 TEUs	25 000 – 50 000 UTIs or 50 000 – 100 000 TEUs	> 50 000 UTIs or 100 000 TEUs
Surface area (in m2)	0 – 40 000	40 000 – 70 000	> 70 000
Equipment	Mobile crane / forklifts / reachstackers	3-4 gantry cranes	More than 4 gantry cranes

Source: COMBINE internal agreement.

The benchmark analysis includes 150 CT terminals in nine countries. The analysis of the CT terminals is broken down and presented by country.

Data analysis by country

Germany

The largest number of the analysed terminals is located in Germany. Table 3.1.3 shows that there are 51 CT terminals in Germany. This applies only to terminals located in the BSR regions according to the Interreg BSR framework. In terms of the number of CT terminals, Germany ranks first in the BSR. The national average number of terminals including per 100,000 km^2 is 43.1 for the Baltic part of Germany. The average number of terminals per 1,000,000 inhabitants is 2.4.

Table 3.1.3. Basic country data for Germany.

Number of CT terminals	51
Country area	357,340 km^2
Area belongin to the BSR*	118 152 km^2
Population	83,000,000
Population living in the BSR area*	21 181 482
Average number of CT terminals (pcs) per 100,000 km^2	43.1
Average number of CT terminals per 1,000,000 inhabitants	2.4

* refers to the following states: Bremen, Niedersachsen, Hamburg, Schleswig-Holstein, Meklemburg-Vorpommern, Berlin, Brandenburg (www.interreg-baltic.eu).

Source: own elaboration based on data analysis.

Taking the type of terminals as a criterion, the following graphs show that most of them (75%) are intermodal terminals. The next in terms of share are storage siding (19%) and maintenance facility (2%). More than half of them (63%) are located in seaports and 32% are inland terminals. Furthermore, 60% of the CT terminals are located in the TEN-T corridors whereas 30 CT terminals are located in the RFC (Figure 3.1.2).

It should be mentioned that there are five German commercial ports in the Baltic Sea, the largest ones being Lübeck (with Travemünde) and Rostock (with Warnemünde), followed by Kiel and Sassnitz/Mukran and Wismar. In addition, terminals in the ports of Hamburg and Bremen/Bremerhaven were also included in the analyses.

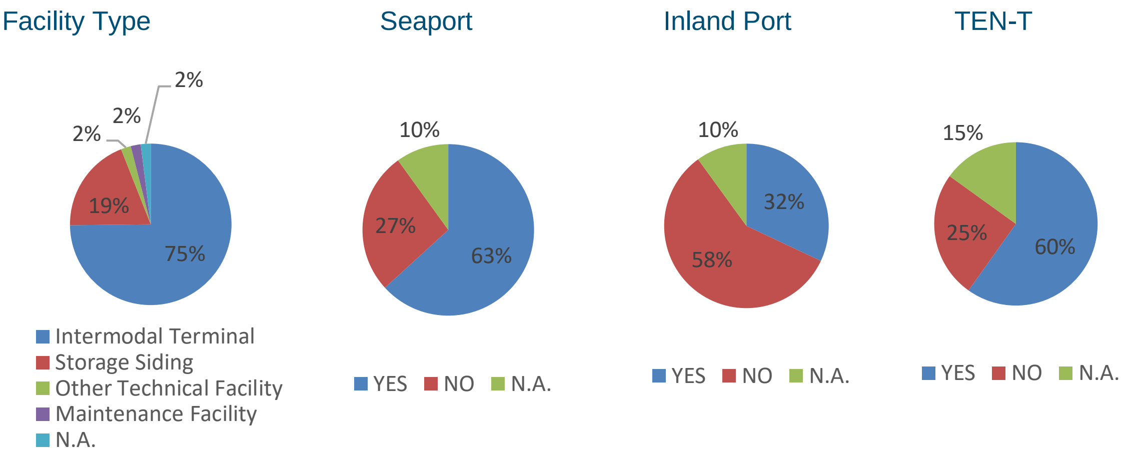


Figure 3.1.2. Structure of German CT terminals by types.

Source: own elaboration based on data analysis.

The port in Lübeck is currently the largest German commercial port in the Baltic Sea. It is a typical general cargo port with four terminals (i.e., with a receiving total of 24-ship stations) adapted to handle ro-ro and container cargo and non-containerised cargo. Investments in the port environment were aimed at changing the structure of goods transport between the port and the hinterland. Federal and national funds were allocated for the modernisation of the canal, electrification of the railway track and increase of the A1 capacity from Lübeck to Hamburg and A20 to Rostock and Szczecin. Rostock is the second German port in the Baltic Sea in terms of cargo handling and the first in terms of passenger traffic. The port of Rostock plays an important role among German Baltic ports. It has a well-developed infrastructure and good sea connection with Scandinavian and land ports and industrial centres of Germany. The logistics centre of the GVZ Rostock is located on the peripheral industrial area of the city adjacent to the seaport. This location provides very good access to transport infrastructure. Its excellent location in the south-western bend of the Warnow Lower River offers good rail and road connections to the A19 and A20 motorways allowing for fast transport of goods to and from Scandinavia, Eastern Europe and the Baltic States (Die Küste, 2008).

Another seaport is located in Wismar. As the largest port on the southern coast of the Baltic Sea in Germany, Wismar''s seaport is an ideal import and export hub for many streams of goods. North-south traffic between Central Europe and Scandinavia, the Baltic States and Russia is combined and distributed in Wismar. In addition to the geographical location of the port, its economic availability and thus its attractiveness to potential forwarding customers depends primarily on the quality of its connections with the hinterland. With the expansion of the A14 motorway (Wismar-Schwerin) and the connection to this motorway, the coastal motorway A20 (Lübeck-Szczecin) and the newly electrified railway line, the port provides excellent transport links.

As far as land terminals are concerned, it is worth mentioning Berlin's transport system, in which three large logistics centres (Güterverkehrszentren - GVZ) located on the outskirts of the city, Wustermark, Grossbeern and Freienbrink, play an important role. The GVZ Wustermark is located to the west, GVZ Grossbeern to the south and GVZ Freinbrink to the southeast of the centre, all outside the urban area. This location corresponds to the three most important directions of cargo flow to and from the Berlin-Brandenburg region. Each logistics centre provides a multimodal platform with access to road and rail transport infrastructure and, in the case of the GVZ Wustermark, also to inland waterway transport. The centres are characterised by their location close to the intersection of the Berlin bypass motorway with important railway lines entering and leaving the city:

1) the high-speed line Berlin-Hannover,
2) the high-speed line Berlin-South Germany (Anhalter Bahn), and
3) the east-west Berlin-Warsaw-Moscow transit line.

Another Iinland waterways) port terminal is located in Anklam, which is today the largest port of its kind in Mecklenburg-Vorpommern. The goods trans-shipped here are mainly fertilizer, scrap metal, building materials, grain, rapeseed and wood. The favourable geographical location makes Anklam's port attractive for the trans-shipment of goods. The town on the Peene River is crossed by federal roads B109, B110 and B197. The coastal motorway A20 runs about 25 km southwards. There is a connection to the main railway line between Stralsund and Berlin via a railway siding. Binnenhafen Anklam GmbH also operates the ports of Jarmen and Demmin. The harbour of Jarmen is very close to the federal roads B96 and B11 0 and the A20 motorway. The trading port of Demmin is located directly on the B110 and has a good connection to the B194 (Die Küste, 2008).

Sweden

The second largest number of terminals in the Baltic Sea Region can be found in Sweden. Table 3.1.4 shows there are 32 terminals suitable for handling unitised cargo in Sweden. The national average number of terminals per 100,000 km^2 is 7.3 while the average number of terminals per 1,000,000 inhabitants is 3.1.

Table 3.1.4. Basic country data for Sweden.

Number of CT terminals	32
Country area	438,574 km^2
Population	10,230,000
Average number of CT terminals (pcs) per 100,000 km^2	7.3
Average number of CT terminals per 1,000,000 inhabitants	3.1

Source: own elaboration based on data analysis.

Figure 3.1.3 illustrate that more than half of the analysed terminals (58%) are intermodal, while (42%) are multifunctional rail terminals. Less than half of them (42%) are seaports, over 1/4 (27%) are inland terminals. A total of 64% of CT terminals are located in the TEN-T area and 21 of the CT terminals are located in the RFC area.

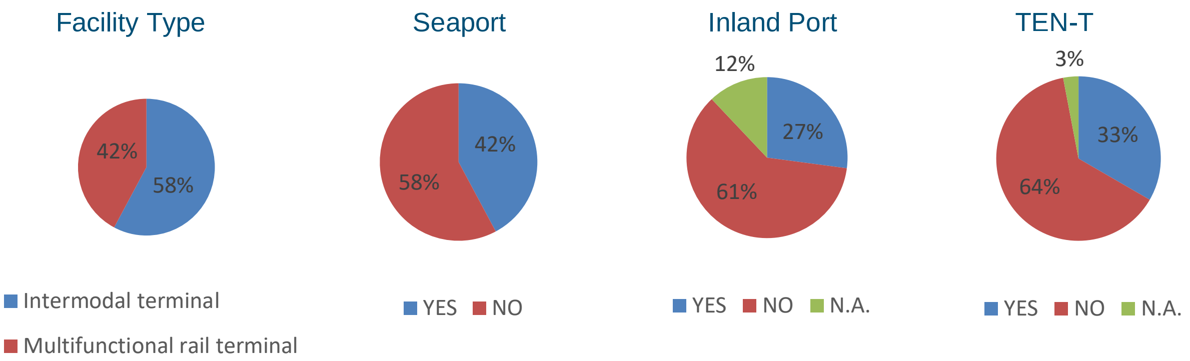


Figure 3.1.3. Structure of Swedish CT terminals by types.

Source: own elaboration based on data analysis.

The port complex of Copenhagen-Malmö and the city of Malmö have built a new terminal and a new Northern Harbour logistics centre. The North Terminal has paid special attention to the possibility of using intermodal connections. The railway siding allows containers to be loaded onto wagons from or to trains or vessels. The rail network is connected to the latest control systems. The terminal has also paid attention to environmental aspects, including its location in order to reduce noise emissions. It is important that the new port and logistics centre is listed as a planned and key element of the TransEuropean Network - Transport (TEN-T). The 11.5 million EUR investment in Gothenburg is expected to eliminate bottlenecks in the port infrastructure including double-tracks on the main line connecting the port to the national rail infrastructure, dredging of fairways and the refurbishment of berth to accommodate larger vessels. In excess, the construction of a fourth terminal is ongoing to handle unitised cargo (Arendal 2). The infrastructure projects are part of the European Commission's strategy for the development of the European transport networks (TEN-T). The projects are focused on the development of economical, ecological transport in the Scandinavian countries and the southern Baltic Sea.

The Port of Gothenburg is the largest port in Scandinavia, serving about 11 thousand of ships per year. It has conditions for receiving and handling deep-sea vessels. In this part of Europe, it is the best organised port in terms of intermodal transport management having abt. 60% of the hinterland transport carried by intermodal rail shuttles. Logistics land is a special designated investment area at the interface with the port. The area on land and sea is separated. The plan to expand the port requires the creation of logistic space in areas that are not yet fully utilised. As a result of the construction of the new areas to the sea, a new terminal Arendal 2 is currently under construction. On land, 250,000 m^2 have been set aside for a logistics park in the Tankgatan area near the thoroughfare. On the other side of the road, a 400,000 m^2 logistics centre is planned in Halvorsäng. A 565,000 m^2 Logistics Centre near Hisingsleden is already completed. It has been intentionally located between the Volvo factory and Björlandavägen (Grzybowski, 2015). The investments in the ports of Gothenburg and Århus are intended to contribute to their transformation into trans-shipment ports for the entire Baltic Sea. As a result of the investments in the Danish Straits, these ports are to become Baltic hubs which will take over part of the cargo handled at the Hamburg and Rotterdam terminals (Grzybowski, 2011).

There are several intermodal terminals in mid-south Sweden where most of the unitised cargo are being handled and stored prior distribution. Mainly in the vicinity of Jönköping and in the areas of Örebro/Hallsberg, Västerås and Eskilstuna, larger distribution centres are established. These logistics centres serve the main consumer markets in Sweden, Norway and Finland. Overseas cargo mainly arrives by train-shuttles from the port of Gothenburg and the Port of Helsingborg. European trailer volumes arrive by road having used the ferry terminals on the southcoast including the main terminal in Trelleborg or via the fixed linked (Öresund connection) between Danmark and Sweden. These logistics centres in the mid-south of Sweden are also important trans-shipment points for bulk cargo and forestry produce mainly arriving from the northern parts of Sweden. The terminals in the are suitable to unitise these types of cargo making them suitable for further intermodal transportation relieving the southern infrastructure of Sweden from return transportation of conventional train waggons used for bulk and forestry produce.

Main terminals between Sweden and the eastern Baltic States are in Karlskrona (connection to Poland), Karlshamn (connection to Lithuania), Ystad (connection to Poland) and in the Stockholm region (connections to Finland and Estonia). Almost all cargo handled in the ports for the trans-baltic transports are carried by trailers using roro-connections

Swedish road investments are targeted at ports on the Swedish eastern coast in connection with anticipating the development of ferry traffic to Poland and the CIS and connecting to the Trans-Siberian railway line and the Trans-European North-South Highway (TEM). The fixed link through the Öresund Strait (i.e., the rail-road link between Copenhagen and Malmö), are an important investment for European transport links, and are included by the European Community among its 14 priority projects in the Trans-European Transport Network Programme. The Öresund Bridge, 7845 m long, connects by a tunnel between the Danish island of Amager to the artificial island and the Lernacken bridgehead on the Swedish coast. After exiting the bridge, the motorway connects to the Malmö bypass and the motorways (E4/E20) towards Stockholm or Gothenburg. A railway line (from Copenhagen) has been connected to the line connecting Malmö with the Swedish mainlines and to the cities of Trelleborg and Ystad. The transport network of Zeeland (road and rail) is linked to the Danish (on the Jutland

Peninsula), German and Swedish transport systems by numerous ferry connections. There is one rail and eight passenger-car ferry lines connecting Zeeland with Funen and the Jutland Peninsula (Pacuk, 2004).

Poland

Poland is third in terms of the number of terminals located in the country. The information contained in Table 3.1.5 shows that there are 30 CT terminals in the country. The national average number of terminals per 100,000 km^2 is 9.6 while the average number of terminals per 1,000,000 inhabitants is 0.8 for Poland.

Table 3.1.5. Basic country data for Poland.

Number of CT terminals	30
Country area	312 679 km^2
Population	37.9 m
Average number of CT terminals (pcs) per 100,000 km^2	9.6
Average number of CT terminals per 1,000,000 inhabitants	0.8

Source: own elaboration based on data analysis.

The graphs in Figure 3.1.4 show that the vast majority of the terminals analysed (75%) are intermodal terminals, while (25%) are multifunctional rail terminals. Only 19% are seaports and 3% are land terminals. A total of 84% of the CT terminals are located in the TEN-T area and 28 of the CT terminals are located in the RFC area.

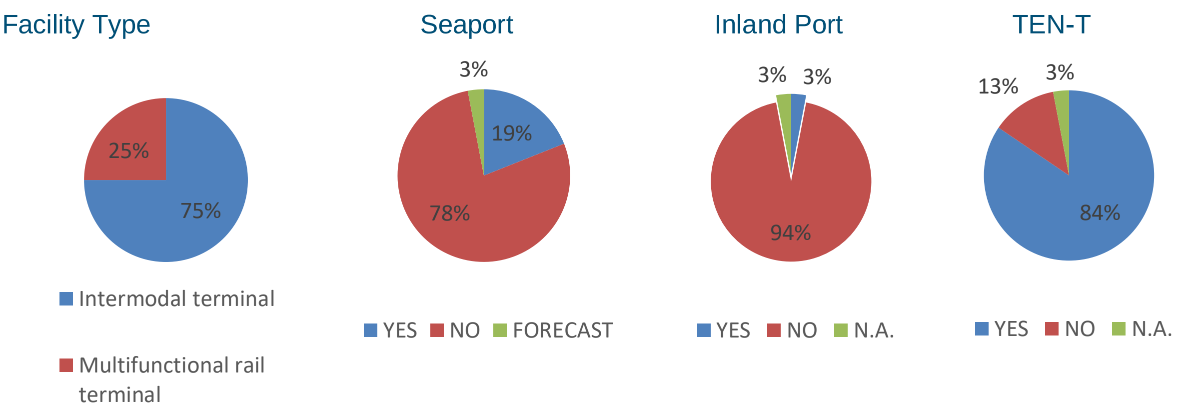


Figure 3.1.4. Structure of Polish CT terminals by types.

Source: own elaboration based on data analysis.

The port of Gdansk is currently the largest port in the Baltic Sea capable of handling "Baltimax" class ships, i.e., the largest vessels crossing the Danish Straits. The port consists of two parts: the inner part, i.e., the traditional port lying at the mouth of the Dead Vistula River, and the outer part – the modern North Port. Most of the solid cargo reaches the port by rail. In order to improve the transport accessibility of the port of Gdansk, a collision-free route is planned to connect the port with the planned Trans-European North-South Highway (TEM). The port in Gdynia is a universal port that specialises in reloading general cargo, especially containers, and grain. Baltic Container Terminal is the only port terminal for trans-shipment of containers in various transport relations (i.e., ro-ro, lo-lo, road and rail transport).

The ports of Gdansk-Gdynia are centrally located on the North-South route. These ports are crossed by the main central Baltic communication axis, opening a land and sea transport corridor for the development of ferry, ro-ro and container traffic between the Scandinavian countries – Poland and Central and Eastern Europe. However, this transport axis, which is of fundamental importance for the activation of both ports, is so far not sufficiently filled with an extensive network of land transport connections as well as an adequate number of liner shipping connections with other Baltic seaports.
The analysis shows that 84% of CT terminals are located in the TEN-T area. This is the largest percentage of all of the countries analysed, therefore it is worthwhile to approximate the distribution of these corridors, especially as they also concern the other countries. The corridors whose routes pass through Poland were established as follows:

- The Baltic – Adriatic Corridor (running as the former Corridor VI with ports in Gdańsk and Gdynia, including the second line Świnoujście/Szczecin - Poznań - Wrocław - Ostrava, with seaports in Szczecin and Świnoujście). The A1 Motorway marked out in this corridor was designed as a toll road within the international road E75. It is also called the Amber Highway; and
- The North Sea – Baltic Sea Corridor (running as the former corridors I: Helsinki-Tallinn-Riga-Kaunas-Warsaw and II: Berlin-Warsaw-Minsk-Moscow-Nizhnyi Novgorod).

The Baltic Sea - North Sea corridor connects Poland with the Baltic countries: Finland, Estonia, Latvia and Lithuania. Its route in Poland is not long (i.e., the shortest of all corridors is about 300 km) – it runs from the border with Lithuania to Warsaw and as a second branch from Kaliningrad to Gdansk. The road section Świecko-Terespol runs through the Euroregion Bug, which is part of a pan-European corridor running through Germany, Poland, Belarus and Russia. In Poland, in the Świecko-Terespol corridor, there is the A-2 motorway (called the Freedom Motorway – 626 km), which is to connect the United Kingdom via the land route through the Netherlands and Germany with Belarus and Russia. It currently reaches Warsaw and its eastern section from Warsaw to the border with Belarus is only partially completed. The Polish section runs along the Świecko-Poznań-Łódź-Warszawa-Kukuryki route. At the border crossing in Świecko it connects with the German motorway A12 and in Kukuryki with the Belarusian main road M1. In Stryków junction it intersects the A1 motorway, so both corridors presented above are crossed.

- Corridor II:

A number of transport links leading through the ports of Gdansk and Gdynia are particularly important for the transport routes of the EU. They include:

⇒ Trans-European roads (TEN roads);

⇒ A1 motorway (Gdansk/Gdynia - Łódź - Katowice) with branches;

⇒ Grudziądz - Poznań, Toruń - Warsaw and Łódź - Wrocław;

⇒ Trans-European Railways (TEN railways);

⇒ Gdansk/Gdynia-Warsaw-Katowice - Zebrzydowice railway line, with a branch Warsaw - Dorohusk; Gdansk/Gdynia-Bydgoszcz-Katowice railway line with connections to the line: Inowrocław - Poznań, Zduńska Wola - Wrocław; and

⇒ Gdansk/Gdynia - Elbląg - Braniewo - Kaliningrad railway line.

An important element of the logistics system in Szczecin, as well as in other cities, is road transport, which is used to handle passenger and freight traffic. The road system of Szczecin is connected with the road system of the country through national roads, which run through the central area of the city. Szczecin's road system consists of the following national roads: A6 motorway (E28), S3 expressway (E65), national road no. 3 (E65), national road no. 3 (E65), national road no. 10, national road no. 13, national road no. 31 and provincial road no. 115. Sea and inland navigation also play an important role in servicing cargo streams, which is due to the fact that Szczecin has a seaport. This port, together with the port in Świnoujście, is situated on the shortest road connecting Scandinavia with Central and South Europe. In addition, these ports are the closest seaports for western and south-western Poland, bringing together such industrial areas of the country as: Upper Silesia, Wroclaw and Poznan. The port in Szczecin is situated 65 km inland. For the ports in Szczecin and Świnoujście, the Szczecin Declaration recently signed by ministers from Scandinavian and Central European countries is of great importance. It is an agreement on the establishment of the Central European Transport Corridor CETC-ROUTE65. The Central European Transport Corridor runs along the E65 road, which starts in Malmö and ends in Chaniá, Crete. In Poland, it is road no. 3 Świnoujście - Lubawka, which is being rebuilt into the express S3. It is worth mentioning that the port plays a very important role in the logistics system of Szczecin, as well as the whole region, as it is conveniently connected by highway to Berlin and further to West Europe. As a result, it is a service point for cargo transported from north to south of Europe. Moreover, the port is connected with the national road E65, the railway line E59 and EC59, as well as the water system of the Oder River. Through the Oder and the Oder-Havel canal, direct inland connections are made to Berlin and further to the entire European inland waterway system. This route can reach Hamburg, Bremen, Bremerhaven, Rotterdam and Antwerp. The stock of warehouse space in the Szczecin region belongs mainly to Prologis Park Szczecin, North-West Logistic and several smaller investors. Warehouse facilities belonging to companies operating in the Szczecin Port area also play an important role. In addition to the above-mentioned cargo streams, the West Pomeranian Logistics Centre together with the container terminal, located within the Szczecin Port area, plays an important role. Prologis Park Szczecin was established in 2008 and has 41,600 sqm of warehouse space. It is located near Goleniów, on the S3 expressway, and 20 km from the national road No. 10 between Szczecin and Toruń. Another warehouse complex in Szczecin is North-West Logistic Park. It is located in the right-bank part of Szczecin (10 km from the city centre), in Dąbie district. The complex is under construction and will ultimately have 64,000 m^2 of modern warehouse space (Witkowska-Jsik, 2014).

There are several logistics centres within the Berlin-Warsaw transport axis. Wielkopolskie Centrum Logistyczne Konin-Stare Miasto S.A. was established in 2001. The centre addresses logistic companies, importers who carry out distribution throughout the country and supply platforms for retail chains. The centre has an attractive geographical location at the junction of the A2 motorway with the national road 25, a container terminal at the E20 railway route is being prepared (http://www.wcl.pl). The Gądki logistics centre is owned by Panattoni. The facility has a very good location by the S11 expressway connecting Poznań with Silesia, near the A2 motorway. The centre has a very good infrastructure consisting of six modern warehouse buildings, which can also be adapted to production activities (http://warehouse-poland.com.pl). There is a container terminal of POLZUG Polska Sp. z o.o., which provides multimodal transport services. The centre plays an overriding role in both regional and international logistics. In western Poland, in the area of influence of Rail Baltica, there are several potential locations of logistic centres and terminals (e.g., Poznań-Franowo). They are prepared for investments in transport and storage infrastructure, but are currently not used (Jordan et al., 2007). The north-eastern part of Poland is underdeveloped in economic terms. Despite a significant share of cross-border freight traffic along the West-East (as well as North-East) transport corridor, no logistics centre of national or international importance has been established in the region. Due to its geographical location in relation to European transport corridors, the region has considerable potential, but so far it has not been used. Kaunas Public Logistics Centre in Kaunas, Lithuania should be considered the only logistics centre on the Lithuanian-Polish border with a strong impact on Rail Baltica. In the Kaunas region, it should be noted that a concentration of logistics and transport infrastructure (i.e., railway connections to Tallinn, Vilnius, Kaliningrad Oblast and Klaipeda, motorway network, airport and inland waterway route from Nemunas to Klaipeda). The implementation of the centre is at an early stage, but the potential of the project is significant (Dobrzyńska, 2014).

Kutno is a new, extremely attractive point on the Polish warehouse map. The Hillwood logistics centre is located in the immediate vicinity of the A1 motorway, and the junction of the A1 and A2 motorways is only a 20-minute drive away. The central location of the investment allows for quick distribution of goods throughout the country. Whereas Małaszewicze, 10 km away from the Polish-Belarusian border, is one of the largest PKP dry docks in Poland and Europe. The investment in this region is part of the concept of building a new silk route connecting Europe with the Far East. The connection through the continent is to be an alternative to the sea trade route and Poland is an important element of the new route.

Another logistics centre in Sławków is being developed to serve the freight traffic between the Far East and West Europe in the future. Rail transport from Asia to Europe takes almost twice as long as the sea. It may be profitable, for example, for companies transporting specialised cargo, which is exposed to damage in maritime transport or which is more expensive to transport by ship. For several years, efforts have been made to transport some of the cargo to Europe by rail instead of by ship. Then, among others, the role of the logistics centre in Sławków would increase.

Denmark

In Denmark there are 12 CT terminals that were analysed. The national average number of terminals, of which per 100,000 km^2 is 28.0 and the average number of terminals per 1,000,000 inhabitants is 5.5 (Table 3.1.6).

Table 3.1.6. Basic country data for Denmark.

Number of CT terminals	12
Country area	42 921 km^2
Population	5.8 m
Average number of CT terminals (pcs) per 100,000 km^2	28.0
Average number of CT terminals per 1,000,000 inhabitants	5.5

Source: own elaboration based on data analysis.

The graphs from Figure 3.1.5 show that most of the terminals (74%) are intermodal. More than half of them (74%) are seaports, none of them is an onshore terminal. Moreover, 95% of the CT terminals are located in the TEN-T area and four CT terminals are located in the RFC area.

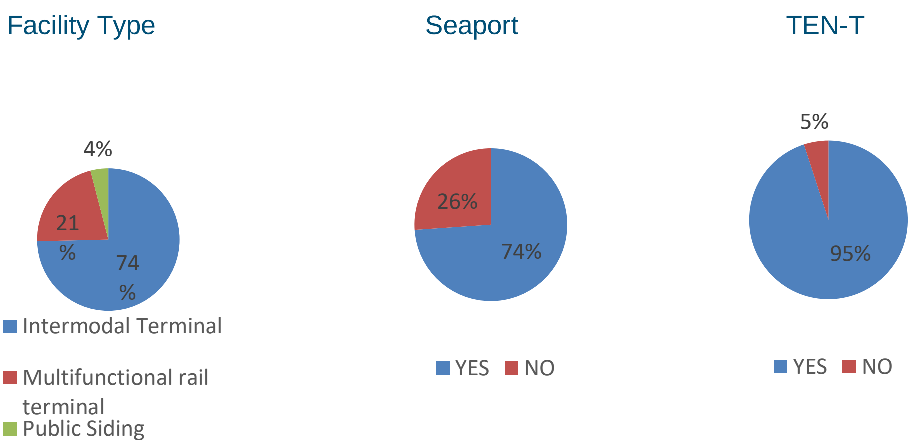


Figure 3.1.5. Structure of Danish CT terminals by types.

Source: own elaboration based on data analysis.

The road system in Denmark consists of motorways, forming the so-called 'Great H', which extend in western Denmark from north to south – from Hirthals and Frederkshavn to Padborg, from north to south in the eastern part of Denmark – from Elsinore to Rodba and from Esbjerg to Copenhagen – connecting east to west. Similarly, the railway line runs from Aalborg in northern Jutland to Padborg and from Esbjerg to Copenhagen. It consists of motorways:

- E 20 – running from east to west from Copenhagen to Esbjerg,
- E 39 – running from north to south from Hirtshals to Aalborg,
- E 45 – running from north to south from Frederikshavn to Padborg,
- E 47 – running from north to south from Helsingør to Rødby, and
- E 55 – running from north to south from Helsingør to Nykøbing Falster.

The European corridors are the most important for Danish transport. The national roads also play a major role, as they interconnect large agglomerations and interweave the whole country. Among the most important national roads we can count:

- road No. 9 – Odense - Ringe,
- road No. 16 – Copenhagen - Hillerød, and
- road No. 21 – Copenhagen - Roskilde - Holbæk.

DB Cargo operates two connected terminals in Denmark, located in two central distribution hubs: Taulov in the Triangle region (i.e., Kolding, Vejle and Fredericia) and Høje Taastrup in Greater Copenhagen. These terminals handle containers, trailers and swap bodies that are loaded on and off the many trains that pass daily, connecting Scandinavia with the rest of Europe via the vast DB Cargo rail network, with hubs across the continent.

The central location of the municipality of Middelfart with access to several modes of transport is the driving force behind the development. Deep inside the port of Fredericia, the Dry Port Taulov is being developed, which is an area of 887,325 m^2, where modern storage and logistics facilities and the possibility of trans-shipment of goods between ports, rail and highways create efficient and flexible transport and logistics solutions for customers. ADP thus not only provides the port infrastructure, but is also a partner who thinks 360 degrees around the transport and logistics challenges of customers.

Russia

Russia has 7 CT terminals located in the BSR. The information in Table 3.1.7 shows that it covers a total area of 17 075 400 km^2. The national average number of terminals per 100,000 km^2 is 0.04 while the average number of terminals per 1,000,000 inhabitants is 0.2.

Table 3.1.7. Basic country data for Russia.

Number of CT terminals	7
Country Area	17 075 400 km^2
Area belonging to the BSR*	1 677 900 km^2
Population	146.9 m
Population living in the BSR country area*	13 974 486
Average number of CT terminals (pcs) per 100,000 km^2	0.4
Average number of CT terminals per 1,000,000 inhabitants	1.7

* these are: St. Petersburg, Arkhangielsk Oblast, Vologda Oblast, Kaliningrad Oblast, Republic of Karelia, Komi Republic, Leningrad Oblast, Murmansk Oblast, Nenetsky Autonomous Okrug, Novogorod Oblast and Pskov Oblast (www.interreg-baltic.eu).

Source: own elaboration based on data analysis.

The following graphs show that most of the CT terminals in Russia (71%) are multifunctional railway terminals. A total of 86% of them are seaports, none of them is a land port. None of the CT terminals are located in the TEN-T area, and all six CT terminals are located in the RFC area (Figure 3.1.6).

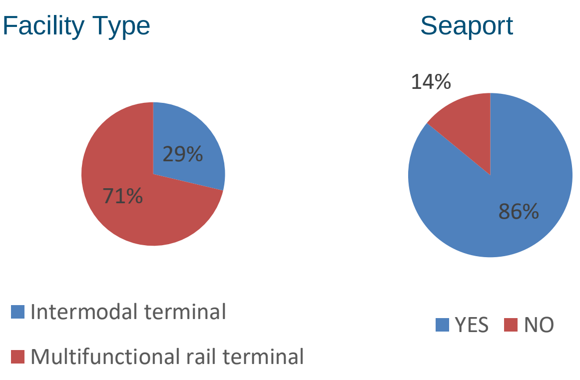


Figure 3.1.6. Structure of Russian CT terminals by types.

Source: own elaboration based on data analysis.

A pan-European transport corridor passes through the territory of six countries: Finland, Estonia, Latvia, Lithuania, Russia and Poland. Its total length is 3285 km (including 1,655 km on motorways and 1,630 km via rail). Pan-European ITC No. 1 connects the main European capitals among themselves: Helsinki, Tallinn, Riga, Kaunas and Warsaw. Within this transport corridor there are six airports and 11 ports. Part of it runs through Russia, within the Kaliningrad region and includes a large Baltic port with the city of Kaliningrad. The Pan-European International Transport Corridor 2 connects Central Europe with the European part of Russia. It passes through the territory of four states, i.e., Germany, Poland, Belarus and Russian. The transport corridor connects large cities, including: Berlin, Poznan, Warsaw, Brest, Minsk, Moscow and Nizhny Novgorod.

The port of St. Petersburg considered to be the "European gateway to Russia" is the most important Baltic port for Russia. It is located in the Neva delta, on the Gulf of Neva, at the western end of the Gulf of Finland. It is one of the oldest ports in Russia. St. Petersburg is a dynamically developing multi-purpose port, visited also by passenger ships, which moor for up to three days. Through this port, Russia has the most important connections with the countries of West and North Europe and North and Central America. Through St. Petersburg there are transport routes from West Europe and Scandinavia to Japan and South-East Asian countries. It is not only a commercial port of global importance, but also a large international class passenger port. St. Petersburg is connected by international passenger lines to New York, Montreal and Le Havre, among others, and by a passenger car ferry also to Stockholm. St. Petersburg is a universal port. However, it has separate sections specialised in specific cargo groups such as containers and ro-ro cargo, trans-shipment of wood (i.e., wood port), coal (i.e., coal port), grain, fish (i.e., fishing port). The second most important Russian seaport in the Baltic is Kaliningrad. The port is located on the shore of the Kaliningrad Lagoon, 40 km from the sea. Kaliningrad together with the neighbouring Baltic Sea are already practically open ports and are perceived by shipowners and investors as places worth increasing their activity (Palmowski, 1999). The port of St. Petersburg covers an area of 629.9 km^2 and has about 200 quays along 31 km, most of which are managed by private entities. There are about 30 large logistic and trans-shipment organisations. There are about 20 large logistics centres and about 200 smaller units. (Grzybowski, 2015)

The seaport of Viipuri consists of two trans-shipment areas. The first one is located within the city limits of Viipuri, the second one is located at the port station Wysock, 30 km south-west of Viipuri and 150 km north-west of St. Petersburg. The port of Viipuri is located in the bay of the same name.

As part of the expansion of the harbour complex around St. Petersburg, several new trans-shipment ports are being built. The most important of these are: Ust-Ługa, Batarejnaja, Primorsk, Lomonosov and Kronstadt. Ports of minor importance are Bronka, Gorskaya and Otradno. Numerous logistics centres are built around St. Petersburg. Itella Logistics St. Petersburg with an area of 10,000 km^2 is located in the Utkina plant. The centre has a good rail connection to Moscow and offers all basic logistics services such as cargo picking, storage and transport services.

Lithuania

Lithuania is intensively developing transport and logistics infrastructure, creating conditions for stable development of TSL industry in the country. There are six CT terminals located in Lithuania with a total area of 65 300 km^2 (Table 3.1.8). The national average number of terminals, of which per 100,000 km^2 is 9.2 while the average number of terminals per 1,000,000 inhabitants is 2.1.

Table 3.1.8. Basic country data for Lithuania.

Number of CT terminals	6
Country Area	65 300 km^2
Population	2.8 m
Average number of CT terminals (pcs) per 100,000 km^2	9.2
Average number of CT terminals per 1,000,000 inhabitants	2.1

Source: own elaboration based on data analysis.

Lithuania's location favours the development of various modes of transport. Two pan-European corridors run through the country: (1) North-South direction – corridor I with branch IA and (2) East-West direction – corridor IX with branches IXB and IXD. Lithuania's trans-European transport network comprises 1,617 km of roads, 1,100 km of railways, 278 km of inland waterways, Vilnius, Kaunas, Palanga and Klaipeda seaport. As can be seen from Figure 3.1.7, most of the analysed terminals (67%) are multifunctional railway terminals. In all, 50% of them are seaports and 50% are land terminals. All CT terminals are located in the TEN-T and RFC area.

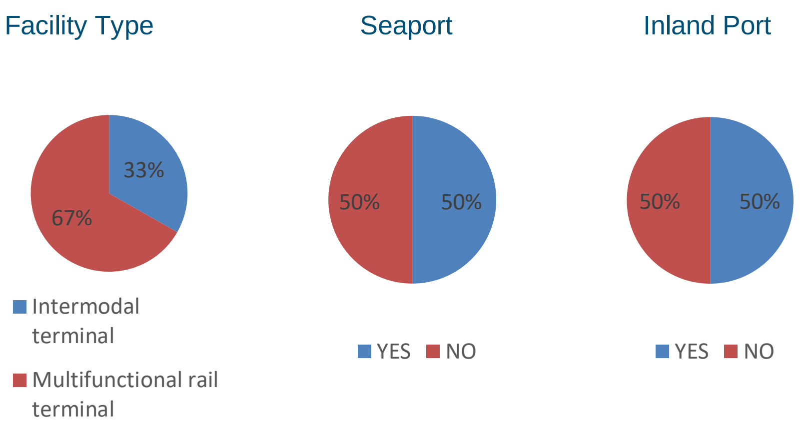


Figure 3.1.7. Structure of Lithuanian CT terminals by types.

Source: own elaboration based on data analysis.

Two projects which are related to the use of the transit function of the state in the movement of goods in east-west and north-south directions play a strategic role for the Lithuanian economy in the area of transport, namely: East-West Transport Corridor II (EWTC II) and Rail Baltica Growth Corridor (RBGC). The EWTC Corridor is a good example of how transport development activates areas around its infrastructure. Of course, the centrepiece of the east-west connection in Lithuania is the frost-free port of Klaipeda, which is able to adapt to the growing demands for increased accessibility from the sea and land. The inflow of investments into the port allows to stay on the list of dynamically developing ports in the Baltic Sea area, which is extremely important, especially as the expected RMB trans-shipments increase (Ginc, 2015). The largest and non-freezing port of Lithuania – Klaipeda – is located at the entrance from the Baltic Sea to the Curonian Sea on both sides of the mouth of the river Data. Klaipėda is the country's largest transport hub. It has sea, inland waterway, road, rail and air connections, and is where the Klaipeda-Kaunas-Vilnius Minsk-Kyivu transport corridor begins. In Kaunas, it intersects with the north-south Tallinn-Riga-Kaunas-Warsaw transport route (i.e., "Via Baltica"). The Klaipeda-Kaunas Corridor also intersects with the Riga-Kaliningrad-Gdansk route (i.e., "Via Hanseatica"). Klaipeda seaport has good road, rail and water connections with the country's hinterland. The share of transit in trans-shipments of this port is estimated at 80%. Klaipeda is improving its multimodal connections. As much as 78% of the cargo is transported to and from the port by trains. It is one of the highest rates in Europe. In all, Lithuanians are building new tracks and stations and are modernising the existing ones: Klaipėda, Perkėla, Pauostis and Draugystė.

It should be stressed that investment activity in Lithuania is also high in the case of point-to-point infrastructure, which are nodes for several transport modes. Public logistics centres are being established along the main transport routes, covering the entire service facilities serving the transport, logistics and storage sectors. In Vilnius and Kaunas at the end of 2014 and in Klaipeda and Šiauliai at the end of 2016, modern logistics centres have started operating.

The RBGC project aims at relieving saturated road traffic on the Via Baltica corridor and thus reducing external costs generated by road transport in the form of environmental pollution, noise, accidents, etc. It is worth noting that Kaunas Rail Baltica is to intersect with the transnational East-West corridor. As a result, construction of a modern trans-shipment terminal will mean that transported goods will be directed from Kaunas to Klaipeda and onward to the Scandinavian countries or to the East. This network complements the already existing railway connection of the Baltic and Black Sea. The Viking container train running on this route has the possibility to directly deliver cargo from Klaipeda to the Black Seaports and further join the TRACECA corridor (Ginc, 2015).

Latvia

Latvia has six CT terminals. From the information in Table 3.1.9 it appears that they cover a total area of 64 573 km^2. The national average number of terminals per 100,000 km^2 is 9.3 while the average number of terminals per 1,000,000 inhabitants is 3.2.

Table 3.1.9. Basic country data for Latvia.

Number of CT terminals	6
Country Area	64 573 km^2
Population	1.9 m
Average number of CT terminals (pcs) per 100,000 km^2	9.3
Average number of CT terminals per 1,000,000 inhabitants	3.2

Source: own elaboration based on data analysis.

All analysed CT terminals in Latvia are seaports, none of which are land-based. All CT terminals are in the TEN-T area, none of them is in an RFC. Latvia has three important ports and four smaller ones. Their advantage is their availability all year round – inclusive of winter. Ventspils specialises in trans-shipment of oil and oil products. Riga uses quays for the trans-shipment of containers, coal and general cargo, and Liepaja is used for the transit of Russian oil wood for export and ro-ro trans-shipment. The three ports have duty-free zones. The Latvian ports have good rail connections with Russia. In 2005, Ventspils High Technology Park was established, which has an area of 30 hectares at its disposal and which concentrates new technologies (e.g., ICT, electronics and space technologies) not directly related to the port and logistics but relevant for the port from a marketing viewpoint.

Finland

Finland has four CT terminals. From the information in Table 3.1.10 it appears that they cover a total area of 338 435 km^2. The national average number of terminals per 100,000 km^2 is 1.2 and the average number of terminals per 1,000,000 inhabitants is 0.7.

Table 3.1.10. Basic country data for Finland.

Number of CT terminals	4
Country Area	338 435 km^2
Population	5.5 m
Average number of CT terminals (pcs) per 100,000 km^2	1.2
Average number of CT terminals per 1,000,000 inhabitants	0.7

Source: own elaboration based on data analysis.

As can be seen from Figure 3.1.8, three of the analysed CT terminals (75%) are multifunctional railway terminals, three of them (75%) are seaports – not land terminals and 75% of the CT terminals (3) are located in the TEN-T area.

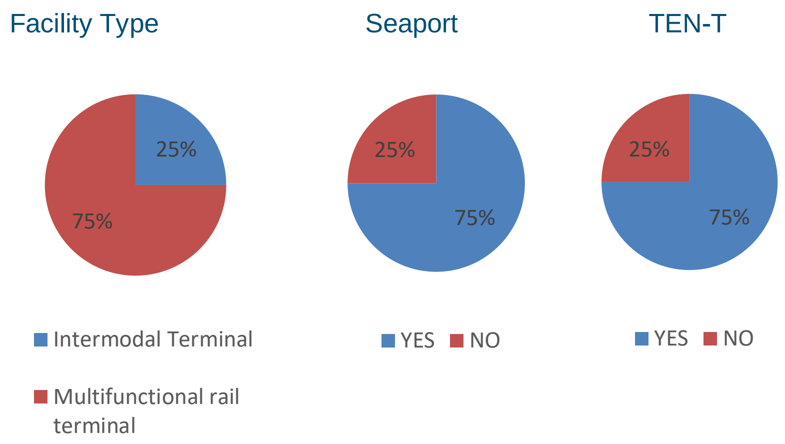


Figure 3.1.8. Structure of Finnish CT terminals by types.

Source: own elaboration based on data analysis.

As part of the New Silk Road between Finland and Asia, Kouvola RRT's rail and road terminal project introduces a new concept to international logistics. The intermodal terminal, which is being built in the Tehola-Kullasvaara area of Kouvola, will open a competitive rail transport corridor for container transport between Europe and Asia. Once completed, the Kouvola Rail and Road Terminal (Kouvola RRT) will be an efficient and competitive terminal area for intermodal transport. It will respond to the growing demands of national and international traffic. The modern intermodal terminal is under construction in Kullasvaara, Kouvola. The terminal will operate on the basis of the open access principle and allows for the operation of trains with a length of more than one kilometre. Kouvola RRT is the only rail and road terminal in Finland that is part of the Trans-European Transport Network (TEN-T). In terms of international importance, the terminal can be compared to the main ports and airports in Finland.

HaminaKotka Port is a comprehensive Finnish seaport serving commercial and industrial functions. Our location on the border between the European Union and Russia provides a unique route to Central Asia and China. This creates an excellent operational environment for international trade and industry. Regular liner connections to seaports in continental Europe, identical track gauge with Russia and the CIS countries, well-functioning road transport links, the E18 motorway, complete infrastructure and a comprehensive range of logistics services have turned the port of HaminaKotka into a significant logistics hub.

Estonia

Estonia has the smallest number of CT terminals with only two making up a total area of 45 339 km^2. The national average number of terminals of which per 100,000 km^2 is 4.4 and the average number of terminals per 1,000,000 inhabitants is 1.5. Both terminals are seaports and are not land-based. The CT terminals are located in the TEN-T area (Table 3.1.11).

Table 3.1.11. Basic country data for Estonia.

Number of CT terminals	2
Country Area	45 339 km^2
Population	1.3 m
Average number of CT terminals (pcs) per 100,000 km^2	4.4
Average number of CT terminals per 1,000,000 inhabitants	1.5

Source: own elaboration based on data analysis.

The port of Tallinn is the largest port complex in Estonia as well as, if we consider the combined passenger and cargo traffic, the largest in the Baltic Sea. The Tallinn Harbour Complex consists of six ports: Vanasadam, which is located in the centre of Tallinn and is the largest passenger port in the Baltic Sea. It serves international connections with Finland, Sweden and Russia. Another one is the old town marina in the centre of Tallinn, serving recreational craft. The third is Muuga Port – the largest cargo port in Estonia, located in the village of Muuga, about 13 km north-east of Tallinn. The other port complexes include: South Port of Paldiski – the second largest cargo port in the Tallinn Port complex (i.e., located in Paldiski, 45 km west of Tallinn), the port complex is Paljassaare Port (i.e., another cargo port located on the Paljassaare Peninsula about 6 km from the centre of Tallinn) and Saaremaa Port (i.e., a passenger harbour in the village of Ninase on the island of Sarema.

Conclusions

These connections are important parts of the land and sea transport corridors connecting the Scandinavian countries with Central and South Europe, as well as part of the network of transport links connecting North-Western European countries with Central and South-Eastern Europe. The analysis shows that terminals are an integral part of large logistics centres. They are located on the outskirts of large cities, at a considerable distance from residential areas. Access to transport infrastructure is a priority. The largest number of CT terminals are located in Germany (51), Sweden (32) and Poland (30). The smallest number of CT terminals are located in Estonia (2), Finland (4), Latvia (6) and Lithuania (6). CT terminals are mainly located close to international traffic routes. This has meant that land terminals are mostly located within the TEN-T corridors and near large agglomerations (i.e., at the crossroads of major roads – for example Kutno - A2 and A1 motorway). CT terminals located outside the TEN-T network are located on national trade routes. The preferred solution is to locate the terminals at the intersection of the urban road ring road with the main railway line. In port cities, a large part of the turnover of terminals is made up of sea transport loads, hence their location is as close as possible to the port area. Port terminals are most often served by lines connecting Baltic ports (e.g., Gdynia - Karlskrona, Helsinki - Tallinn, Lubek - Malmo, Rostock - Hamina / Kotka, etc.) and are located in the largest Baltic seaports, thus having a close correlation with other port cargo turnover. The analysis also shows that large urban agglomerations have several terminals – logistics centres or a network of sub-centres located closer to the final recipients of goods (Table 3.1.12). The average number of CT terminals per 1,000,000 inhabitants for the region is 1.0 (with Russia at 0.6), while the average number of CT terminals (units) region-wide per 100,000 km^2 is 8.59 (with Russia at 0.08).

Table 3.1.12. Spatial intensity factors of CT terminals location in BSR countries.

Country	Average number of CT terminals (pcs) per 100,000 km^2	Average number of CT terminals per 1,000,000 inhabitants
Germany	43.1	2.4
Sweden	7.3	3.1
Poland	9.6	0.8
Danmark	28.0	5.5
Russia	0.4	1.7
Lithuania	9.2	2.1
Latvia	9.3	3.2
Finland	1.2	0.7
Estonia	4.4	1.5

Source: own elaboration.

3.2. Operation models and ownership relations of CT terminals

The operation of CT terminals results from the ownership structure of the terminal itself as well as the operator company operating the terminal. Both of these issues are not always combined in one, many countries in their legal systems separate ownership and operator functions. The most common sector where such separation occurs is port activity and therefore all terminals located there. It is also less common on land. In this section the ownership and management of terminals is analysed.

At the outset, it should be explained that the basic issue in this respect is the ownership of the property on which the terminal is located. Depending on the country in question, this may be land owned by the government, regional or local authorities, or private property, or the ownership of a railway company that owns the tracks and associated point facilities. The ownership title determines who is also the investor in new terminal investments and who is obliged to bear the maintenance costs of existing infrastructure. In special cases, however, the investor's responsibility can be transferred to the operator by placing the land itself at the disposal of the operator, who builds the land according to his own needs on the basis of a contract or lease agreement (usually for a long period of even 25-30 years). There may also be situations in which local or central authorities invest in a finished terminal and entrust the operation to private entities on the basis of a bidding or tender or concession.

The issue of ownership of land and infrastructure elements in the BSR states is extremely difficult to collect, as there are no publicly available real estate databases with their owners, which have simply answered the question of ownership. This issue is the subject of a separate study within the COMBINE project.

The research shows that we cannot speak on the BSR scale of one, exclusive or the most common model of terminal ownership. In the following section this issue is analysed in detail by country.

The second area of analysis concerns the issue of the operational model of the terminal. This model is only partly due to the adopted ownership model, hence the necessity to separate it. The role of a terminal operator can be played by the following entities: state enterprises, private enterprises and public transport service providers (i.e., rail, road or sea). Such an operator may also be a combined or intermodal transport operator, which, within the framework of its network of connections, based on public access to line infrastructure, creates its own terminal network (i.e., regardless of whether it owns the land underneath). It can also be a specialised operator which, thanks to its experience, locates its terminals in optimal locations and makes its potential available to all those willing to do so on a public access basis. It is then in the interest of such an operator to spread its offer as widely as possible among all railway undertakings, freight forwarders and intermodal operators. The opposite is the case when an intermodal operator creates a network of terminals exclusively for its own needs without making them available to other entities. In this case, the model adopted is an element of competitive advantage over other operators who do not have the possibility of trans-shipment in a given terminal, and thus in its nearest region. It is rare for several terminals to be very close to each other.

To sum up this thread, four basic operational models of a terminal can be distinguished:

1) Fully in-house,
2) Concession,
3) Operating contract, and
4) Rental agreement for commercial operation.

The above options were adopted in the benchmark analysis for the BSR.

The issue of public availability of terminals is an important element of the whole market, as it shows the extent to which new and independent operators can develop their activities.

Table 3.2.1 presents the summary results of the correlation analysis between the adopted operational model of the terminal and the extent of terminal availability for public entities.

As one can observe, the most popular among the above four models is the model based on the full ownership formula, i.e., a situation in which the terminal operator is also its owner. About 64% of terminals in the BSR have adopted such a model. The vast majority of them operate on the principle of public access (almost 82%). Only 15 terminals managed in this way operate for the exclusive needs of the operator itself. It should be emphasised that this may indicate that the operators still want to maximise the level of utilisation of their trans-shipment capacity by making it available to other entities. It also means that existing terminals are much larger (in terms of turnover capacity) than would be required by the operator himself. The largest number of such publicly accessible terminals are located in Germany (32) and Sweden (15). In Poland, on the other hand, they number 10 which almost equals the number of terminals closed to other operators (9).

The second most popular operator model is rental agreement for commercial operation. This means that the ownership function of the terminal is separated from the operational sphere. In total, there are 24 terminals of this type in the BSR, which constitutes 19% of all analysed. Interestingly, most of them operate in a closed formula, without public access. This means that if a given operator has undertaken operations on a leased terminal, it is mainly for its own needs. Serving other entities may interfere with their own work and distract them. This is the case in all analysed terminals in Latvia, which is 100% operating in the presented formula. Also 10 Polish terminals use this model, where the issue of public availability is equally divided into half – half of the terminals offer services for all, the other half do not.

The third most common operating model is the operating contract. It operates on the basis of an order given to an operator selected through a competition or from a free hand. Its task is to provide reloading services for the region or city, i.e. in the public access formula. This is the case in Sweden, where 13 terminals implement this model and in Denmark (four terminals). A total of 19 terminals operate in this way, which is 15 % of all analysed terminals in the BSR. Of these only three operate in a closed formula, the rest are public. From the accompanying circumstances it can be concluded that such contracts are awarded by municipalities in a situation of market shortages and low interest in this type of activity in a given region, i.e. where the volumes of cargo weight do not justify market interest in this industry.

Table 3.2.1. Correlation between operation model and public accessibility of a BSR CT terminal.

Operation model	**BSR country**	**Publicly accessible**	**Not publicly accessible**
Fully in-house (1)	Denmark	5	1
	Estonia	0	0
	Finland	0	1
	Germany	32	4
	Latvia	0	0
	Lithuania	6	0
	Poland	10	9
	Russia	7	0
	Sweden	15	0
Total model 1	**BSR**	**68**	**15**
Concession (2)	Denmark	0	0
	Estonia	0	0
	Finland	0	0
	Germany	0	0
	Latvia	0	0
	Lithuania	0	0
	Poland	0	0
	Russia	0	0
	Sweden	3	0
Total model 2	**BSR**	**3**	**0**
Operating contract (3)	Denmark	3	1
	Estonia	0	0
	Finland	0	0
	Germany	0	1
	Latvia	0	0
	Lithuania	0	0
	Poland	0	1
	Russia	0	0
	Sweden	13	0
Total model 3	**BSR**	**16**	**3**
Rental agreement for commercial operation (4)	Denmark	0	1
	Estonia	0	2

	Finland	3	0
	Germany	0	1
	Latvia	0	6
	Lithuania	0	0
	Poland	5	5
	Russia	0	0
	Sweden	1	0
Total model 4	**BSR**	**9**	**15**
Grand Total	**BSR**	**96**	**33**

Remark: data has been cleaned off the missing data (for 21 terminals was impossible to indicate approved operating model).

Source: own elaboration based on data analysis.

The last operational model – based on a concession – works only in three terminals, which constitutes 2% of the analysed market. This model is only used in Sweden and takes the form of public access. This applies to two terminals in the port of Gothenburg and one in Gavle. This can be interpreted as a more far-reaching formula than an operating contract to commission specific handling work for a region or city at a specific location on a specific infrastructure. This model, in turn, is more likely to be used in situations where the loading weight of a terminal is so high that many people want to handle it, although only one can physically do so.

To sum up the issue of accessibility, it should be stressed that almost three-fourths of them operate in an open formula. Only 25.6% of the terminals in the BSR are not publicly accessible. Almost half of them (15) operate in Poland while for the remaining countries they are sporadic cases.

Data analysis by country

Germany

According to the analyses, the largest number of CT terminals is located in Nimiec. Assuming the ownership structure as the criterion, it follows from Figure 3.2.1 that shows 29% are fully in-house terminals while 2% are rental agreements for commercial operation and operating contact. As far as public accessibility is concerned, 31% of German terminals have this possibility.

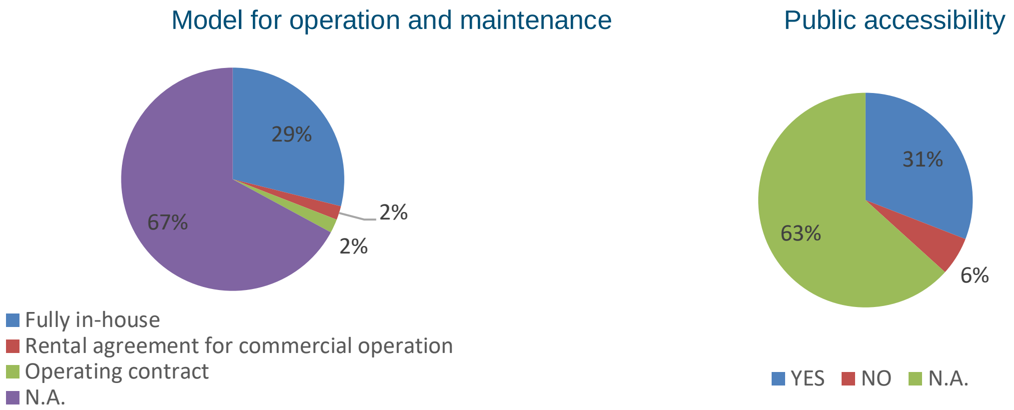


Figure 3.2.1. Operation model and public accessibility of CT terminals structure in Germany.

Source: own elaboration based on data analysis.

Sweden

Another country in terms of the number of terminals is Sweden. Figure 3.2.2 shows that 45% of terminals are fully in-house, 36% operating contract, 9% concession and 3% rental agreement for commercial operation. Moreover, 97% of terminals have public accessibility.

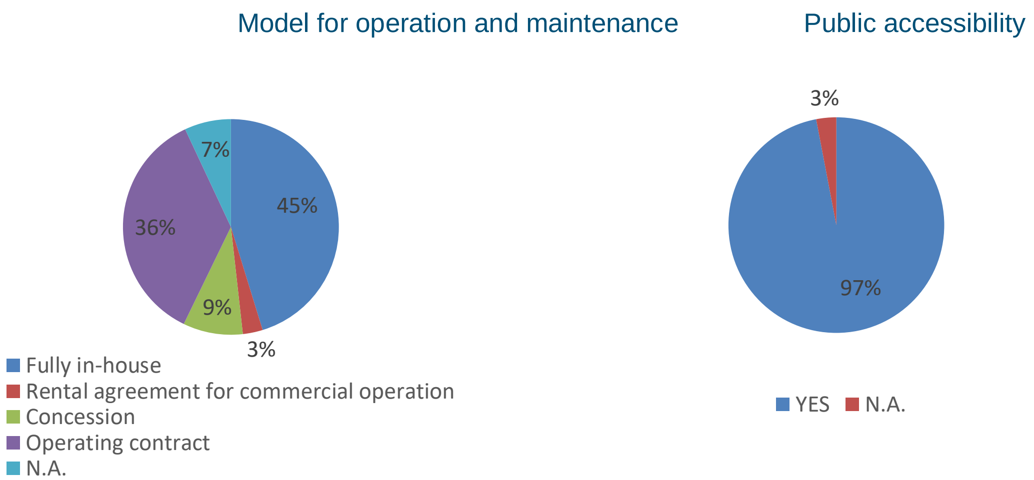


Figure 3.2.2. Operation model and public accessibility of CT terminals structure in Sweden.

Source: own elaboration based on data analysis.

Poland

In Poland, 59% of terminals are fully in-house, 31% rental agreement for commercial operation and 3% operating contract. In terms of public accessibility, 47% of terminals have this possibility (Figure 3.2.3).

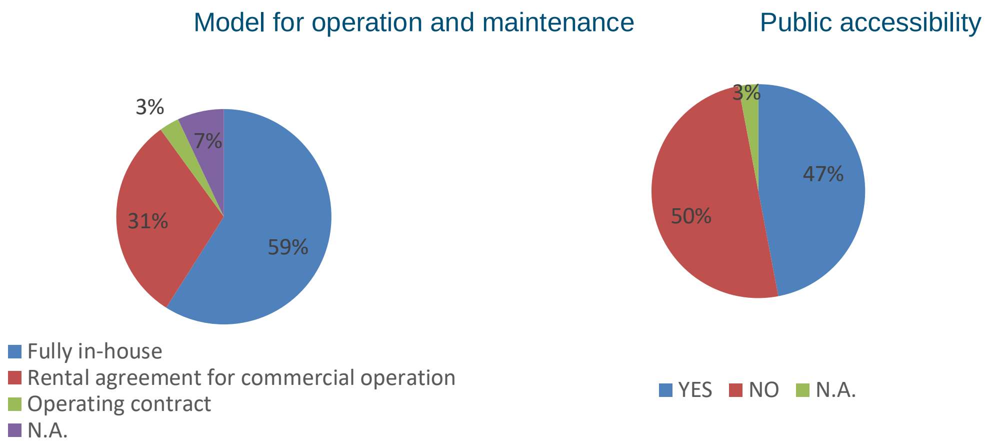


Figure 3.2.3. Operation model and public accessibility of CT terminals structure in Poland.

Source: own elaboration based on data analysis.

Denmark

In Denmark, as shown in Figure 3.2.4, 53% of terminals have a fully in-house ownership model, 26% operating contract and 11% rental agreement for commercial operation. Furthermore, 53% of terminals are characterised as publicly accessible.

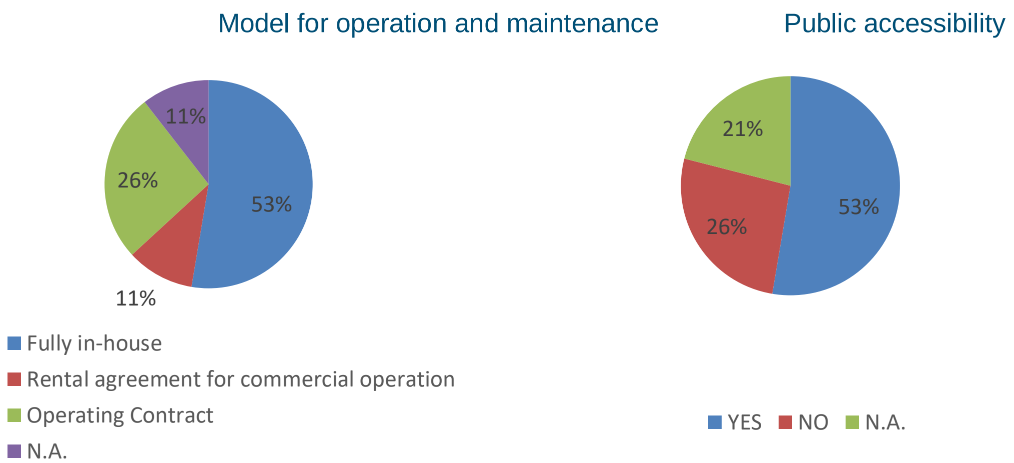


Figure 3.2.4. Operation model and public accessibility of CT terminals structure in Denmark.

Source: own elaboration based on data analysis.

Finland

In Finland, which has only 4 CT terminals, 75% work based on rental agreement for commercial operation and in 25% are fully in-house. Of these, 75% have public accessibility (Figure 3.2.5).

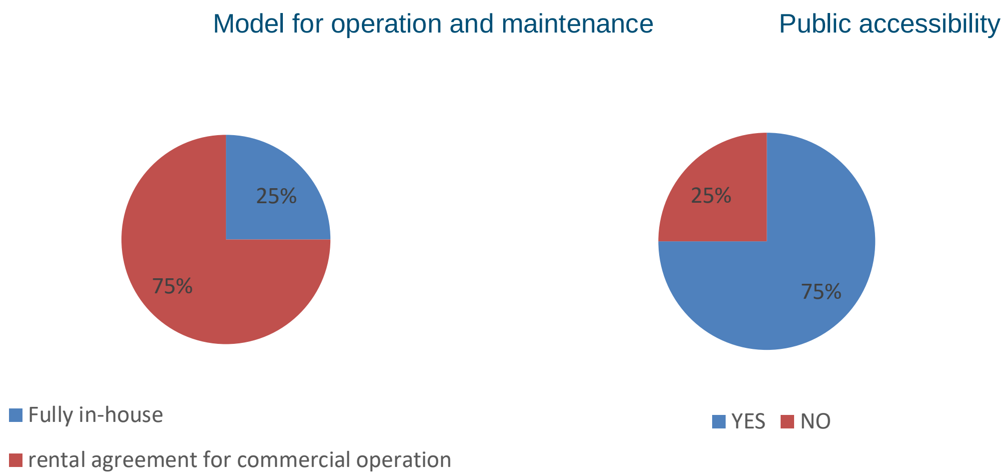


Figure 3.2.5. Operation model and public accessibility of CT terminals structure in Finland.

Source: own elaboration based on data analysis.

Russia, Estonia, Latvia and Lithuania

In Russia (7 CT terminals) and Lithuania (6 CT terminals), all located CT terminals are fully in-house and public accessibility. In Latvia (6 CT terminals) and Estonia (2 CT terminals), all the terminals available there are rental agreements for commercial operation, but they are not publicly accessible.

Key findings:

- most popular is fully in-house (64%, 83 CT terminals);
- second popular is rental agreement for commercial operation (19%, 24 CT terminals);
- third popular is operating contract (15%, 19 CT terminals);
- concessionj very rarely used, actually only in Sweden (2%, 3 CT terminals);
- 100% operation model as rental agreement for commercial operation in Estonia and Latvia.;
- 100% operation model as fully in-house in Russia and Lithuania;
- dominant operating model as fully in-house in Germany, Poland and Sweden;
- high share of rental agreement for commercial operation in Poland (12 of 30 CT terminals);
- high share of operating contract in Sweden (12 of 32 CT terminals); and
- no public accessibility in Estonia and Latvia.

CT terminals are often owned by the operator:

- six CT terminals in Denmark;
- one CT terminals in Estonia;
- three CT terminals in Finland;
- 32 of CT terminals in Germany;
- one CT terminals in Latvia;
- six CT terminals in Lithuania;
- 12 of CT terminals in Sweden;
- 22 of CT terminals in Poland; and
- three CT terminals in Russia.

3.3. Range of terminal operations

The scope of services offered in the terminal's CT constitutes the basic area of competitive advantage of each operator. It can be concluded that the primary reason for the location and construction of the terminal is the transport need, which usually results from the vicinity of a large agglomeration or industrial centre, or a large seaport. However, as the operational activity develops, the terminal should expand the scope of its service offer, apart from strictly reloading and storage (and of course cargo handling of means of transport). Additional activities may be related:

1) a wider range of cargo units (ro-ro, RoLa, Modalohr, CargoBeamer);
2) non-standard loading units and non-standard loads (reefers, dangeres cargo, oversized cargo);
3) new (in relation to the originally operated) modes of transport;
4) services on the goods (LCL/FCL formation, packing, picking, packing, etc.);
5) services for the shipper and/or forwarder (customs, phytosanitary and customs agency); and
6) services to loading units, means of transport and packaging (weighing, repair, servicing, refuelling, certification, etc.).

All the above-mentioned groups of ancillary services are referred to as value-added services and are increasingly common in all types of terminals in the BSR. This often determines the further activity of the terminal especially in case of close proximity to other terminals (e.g., near Poznan/Poland, where we have four terminals located within 60 km radius).

The general conclusions of the conducted analyses allow to determine the typical features that CT terminals in BSRs show and these are:

- 91% of BSR CT terminals are ready to storage of containers and general cargo;
- 77% of BSR CT terminals are ready to storage and handling of reefers;
- 100% of BSR CT terminals are ready to storage of dangerous goods;
- no correlation observed between the service of weighing of wagons/loading units and TEN-T network;
- no correlation observed between the service of weighing of wagons/loading units and RFC;
- correlation between storage of containers / general cargo service and TEN-T network observed;
- none RoLa units/services in volumes handled in 2018 in BSR CT terminals;
- RoLa not accepted in Latvia at all;
- no correlation observed between RoLa acceptance and TEN-T network nor RFC;
- Loading /unloading / trans-shipment: 100% basic service in Estonia and Latvia; and
- Loading /unloading / trans-shipment: 100% basic + additional + ancillary service in Lithuania, Finland and Russia.

The direct result of the range of services provided is the terminal's turnover. It can be measured in units of cargo corresponding to 1 TEU, 1 UTI or in tonnes. The choice of the statistics is up to the terminal operator. However, the biggest problem encountered during the research is the availability of data in any form. It turns out that the operational results of a terminal are usually strictly confidential information covered by trade secrets. Therefore, it was impossible to present and analyze this turnover for the whole BSR. Most of such cases occur in Germany. Full results, in turn, are given by Scandinavian terminals and Baltic States and Russia. Therefore, in the absence of data for some terminals, an estimation method based on data from previous years (rather than 2018) and available trans-shipment infrastructure and equipment was used. This made it possible to determine the total national turnover and average turnover figures for the terminal by country with the exception of Germany, where the number of unknown turnovers was significantly higher than the number of known results. These are summarised in Table 3.3.1.

Table 3.3.1. Volumes handled in BSR CT terminals by country (except Germany) in 2018.

	Total terminals turnover	*Average turnover per terminal*
Denmark	880 940	97 882
Estonia	22 540	11 268
Finland	919 112	229 778
Latvia	586 538	97 756
Lithuania	390 700	195 350
Poland	3 655 000	243 667
**without DCT*	1 729 000	123 500
***without seaports*	916 000	76 333
Russia	1 333 000	669 500
Sweden	896 040	35 842
TOTAL	7 856 669	52 378
**without DCT*	5 930 669	39 800
****without DCT and Russia*	4 597 669	32 152

Source: own elaboration based on data analysis.

The following general conclusions could be drawn on this basis:

- total BSR CT terminals yearly turnover exceeds 7,5 million of TEU (equivalent number for all cargo units);

- highest share for Poland, where one terminal – DCT Gdańsk – represents 1.9 million TEU volume a year. The sum of the Polish seaport terminals container turnover exceeds 2.7 million TEU;
- if calculations were to include Russian terminals, which all are located in seaports and service yearly ca. 1.3 million TEU;
- in other BSR countries the volumes handled are influenced by seaports;
- the highest average turnover per terminal is in Russia (669 500 TEU);
- the lowest average turnover per terminal is in Estonia (11 268 TEU);
- an average result per terminal for the whole BSR equals to 52 thous. TEU, and when corrected by eliminated DCT high score, the value falls to 39.8 thous. TEU. Further on, corrected by DCT and Russian terminals, the average BSR volume handled is reduced to 32 152 TEU a year; and
- 100% containers at CT terminals (2018) in Lithuania, Estonia and Russia. In other countries the structure of units serviced includes also trailers and swap bodies, but in a very limited dimension.

Table 3.3.2. Average volumes handled in 2018 per CT terminal by country (except Germany).

	average (1 000 TEU)	*median (1 000 TEU)*	*minimum (1 000 TEU)*	*maximum (1 000 TEU)*	*wherein: Containers (%)*
Denmark	97.9	161.0	29.93	494.0	72.0
Estonia	11.3	11.26	7.33	15.2	100.0
Finland	229.8	653.0	265.0	1 112.0	67.0
Latvia	97.8	80.53	40.0	280.0	87.0
Lithuania	195.4	202.5	0.6	386.7	100.0
Poland	243.7	85.0	21.0	1 926.0	85.0
Russia	669.5	198.9	27.1	722.0	100.0
Sweden	35.8	20.0	5.0	90.0	99.9

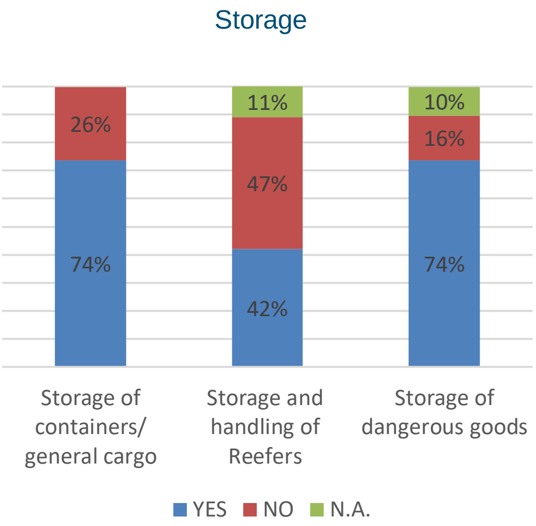
Source: own elaboration based on data analysis.

Country analysis (in alphabetic order)

Denmark

12 CT terminals

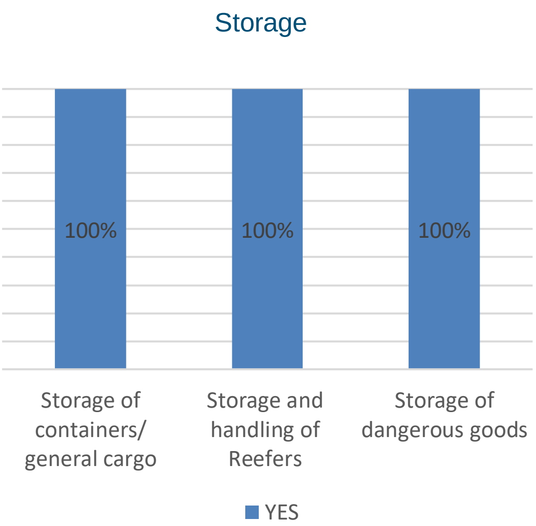
- CT terminals are weighing of wagons/loading units
- 74% CT terminals are ready to storage of containers / general cargo
- 42% CT terminals are ready to storage and handling of reefers
- 74% CT terminals are ready to storage of dangerous goods



Estonia

2 CT terminals

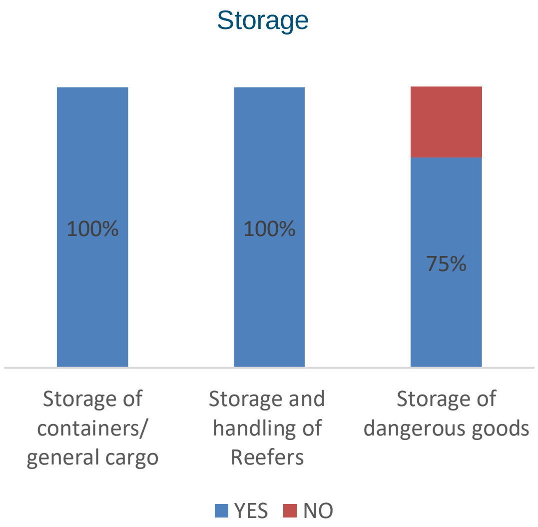
- all CT terminals are weighing of wagons/loading units
- 100% CT terminals are ready to storage of containers / general cargo
- 100% CT terminals are ready to storage and handling of reefers
- 100% CT terminals are ready to storage of dangerous goods



Finland

4 CT terminals

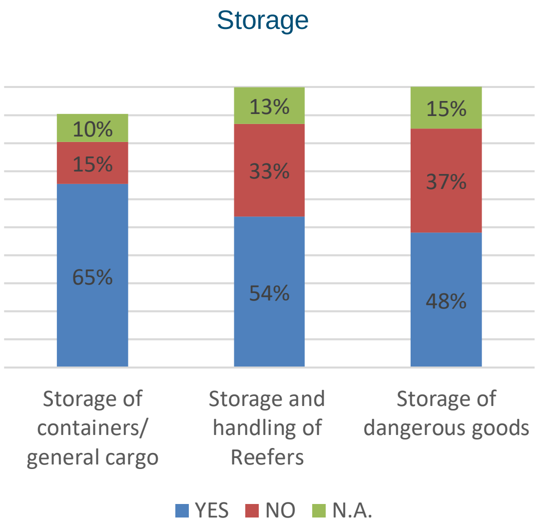
- all CT terminals are weighing of wagons/loading units
- 100% CT terminals are ready to storage of containers / general cargo
- 100% CT terminals are ready to storage and handling of reefers
- 75% CT terminals are ready to storage of dangerous goods



Germany

51 CT terminals

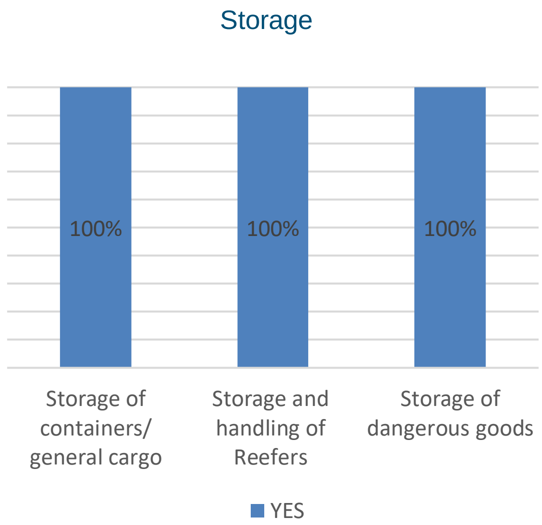
- CT terminals are weighing of wagons/loading units
- 65% CT terminals are ready to storage of containers / general cargo
- 54% CT terminals are ready to storage and handling of reefers
- 48% CT terminals are ready to storage of dangerous goods



Latvia

6 CT terminals

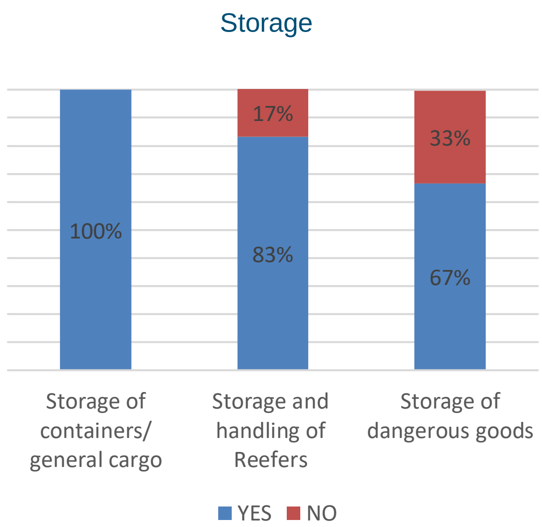
- none CT terminals are weighing of wagons/loading units
- 100% CT terminals are ready to storage of containers / general cargo
- 100% CT terminals are ready to storage and handling of reefers
- 100% CT terminals are ready to storage of dangerous goods



Lithuania

6 CT terminals

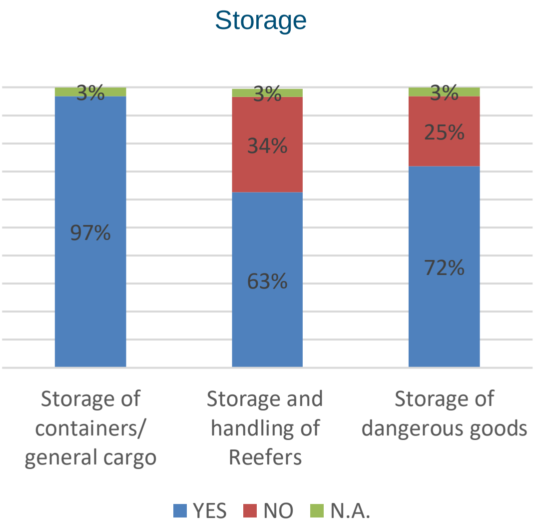
- CT terminals are weighing of wagons/loading units
- 100% CT terminals are ready to storage of containers / general cargo
- 83% CT terminals are ready to storage and handling of reefers
- 67% CT terminals are ready to storage of dangerous goods



Poland

32 CT terminals

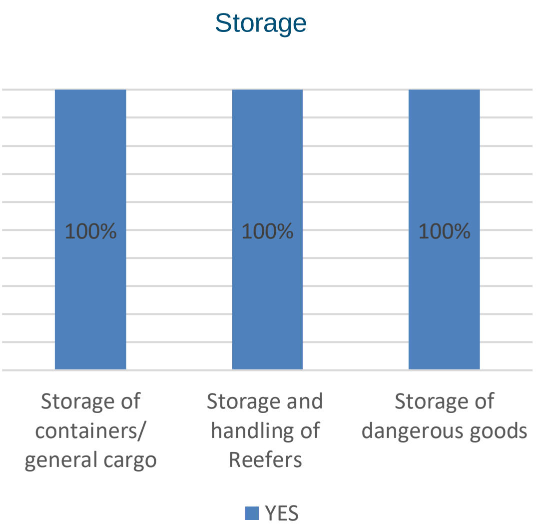
- 22 CT terminals are weighing of wagons/loading units
- 97% CT terminals are ready to storage of containers / general cargo
- 63% CT terminals are ready to storage and handling of reefers
- 72% CT terminals are ready to storage of dangerous goods



Russia

7 CT terminals

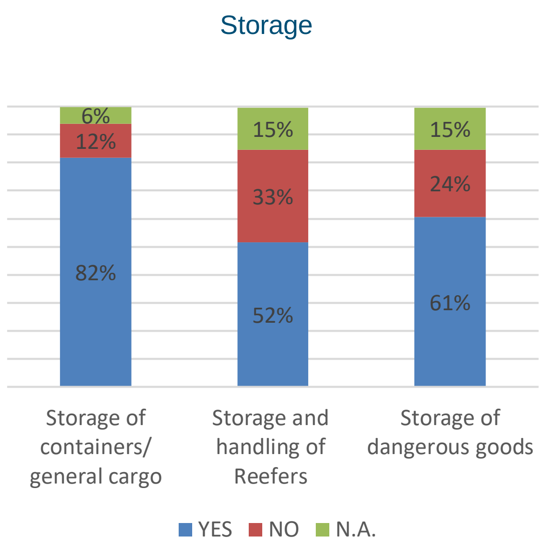
- all CT terminals are weighing of wagons/loading units
- 100% CT terminals are ready to storage of containers / general cargo
- 100% CT terminals are ready to storage and handling of reefers
- 100% CT terminals are ready to storage of dangerous goods



Sweden

32 CT terminals

- 12 CT terminals are weighing of wagons/loading units
- 82% CT terminals are ready to storage of containers / general cargo
- 52% CT terminals are ready to storage and handling of reefers
- 61% CT terminals are ready to storage of dangerous goods



Key findings

- BSR CT network bases on large number of terminals, basicaly distinctively twofold: seaport terminals for sea-land CT, and inland terminals, serving rail-road relations and, additionaly also seaport hinterland services;
- Althought most common size of BSR CT terminal is large and small at the secon place, the median volume handled is between 80,000 and 200,000 TEU per year;
- Large number of terminals in Sweden results in broad spatial distribution between specific terminals and relatively small average yearly turnover in this country;
- The results obtained are overstated by seaport terminals turnover – specially in Poland (due to the largest Baltic container hub) and Russia (a large number of container terminals and no inland terminals);
- Vast majority of BSR CT terminals are servicing containers. Servicing semi-trailers is quite common, unlike swap bodies, which are serviced rarely;
- Type of cargo unit is strongly correlated to trades relation: seaport hinterland services are dedicated to container traffic, also Euro-Asia trade line generates container flow. Semi-trailers are the result of intra-Baltic and intra-European trade exchange, appearing in ro-ro and ro-pax shipping lines and their hinterland flows, as well as horizontal transport on East-West corridor;

Conclusions:

- BSR CT statistics system is subject to significant imporove and public accessibility dissemination;
- BSR CT market analysis should accommodate clear difference between sea-land chains and rail-road combined transport flows;
- Rail infrastrucutre capacity development needs in terms of container traffic, while for semi-trailers popularisation – terminal equipment and horizontal etchnologies implementation necessity;
- Supporting terminal infrastructure and innovative trans-shipment equipment would result in expanding the scope of terminals' activity, and improve the quality of provided services and CT as whole; and
- Container rail services for seaport terminals can deal as good starting base for launching semi-trailers carriage (firstly as accompaniayng waggons, then possible separate trains implemented in the operator's schedules).

3.4. Terminal infrastructure and trans-shipment equipment

The spatial location of the terminal is a strategic issue. The operational issue is its reloading capacity. This depends on two basic components of each terminal – infrastructure and reloading equipment (i.e., suprastructure). Both of these elements are crucial for determining the capacity of each terminal. It can be measured both dynamically and statically.

Dynamic measures relate to the rate at which the trans-shipment of loading units in the terminal is or can be performed, e.g., the number of TEUs trans-shipped per hour, per shift, per month or per year or the maximum number of loading units that can be handled in the terminal within a given time. As such, the first example shows the reloading work performed and the second example shows potential reloading capacity. The difference between the two is important and tells us how much the terminal uses its capacity. The ratio of the first meter to the second is between zero and unity. In this group of meters, you can also find retail indicators that tell you about the speed of operation of individual handling equipment or the acceptable speed of movement within the terminal by different means of transport. However, these are individual meters for each device and for each manufacturer, which makes a more general comparative analysis impossible. Therefore, within the framework of data collection, the number of the main handling equipment has been limited, without going into details about its brand and model.

Static meters speak of the number of loading units that may be present in the terminal at any given time, distinguishing between location and nature. This can be distinguished by the capacity of the storage yards, the storage area, including covered storage, the number of rack stands, parking spaces for trucks, the number of siding tracks and loading tracks.

Next, the results of benchmarking analysis will be presented according to particular parameters: storage area, number of tracks, number of cranes, number of mobile handling equipment and weight limits of handled units as the most important parameters speaking about CT handling capacity of terminals.

Parametres related on terminal area

This parameter determines the one-time amount of cargo units that a terminal is able to absorb at one time. For seaport terminals this is crucial in terms of the capacity to accommodate the largest container cessels (22,000 TEU and more). For inland terminals this is important in terms of the capacity to handle a certain number of trains per shift or day in the knowledge that stripping and forming a train composition requires an average of three to seven days to deposit the cargo unit at the terminal (in some standards it can be 14 days). This parameter may be supplemented by additional information. For example, the number of places for refrigerated containers for which a power supply system is prepared (for the connection of refrigeration units) is additionally given. Under special conditions, this allows for the handling of reefers on long distances (e.g., Italy - Scandinavia, for fruit, vegetables, fish and meat). A lack of mention of such a service in the official data of the terminal, which was met very often during the research, may indicate a lack of such service, although not necessarily. Often terminal operators forget to provide such data, which has been confirmed many times during research. Another type of detail is the information about the covered area of warehouses available in the terminal. This means that not only the forming services of FCL/LCL load units can be performed in the terminal, but also value-added services on the cargo themselves.

Based on the analysis results, it can be determined that:

- the average size of the CT terminal in the BSR is 183,743 m^2 (18,4 ha);
- this corresponds to a storage capacity of approximately 7,900 TEU, but in reality, this capacity measured in container slots is much lower;
- this average is overestimated by port terminals, which are approximately 3 to 4 times larger than the land terminals in the BSR;
- the smallest average terminal areas are in Finland, Lithuania and Sweden;
- the highest average terminal areas are in Denmark and Russia (with only seaport terminals analysed in Russia);
- the average storage area needed for a storage capacity equivalent to 1 TEU is 23.3 m^2, with two important correlations: port terminals, despite storing containers in a larger number of layers (which underestimates the consumption rate of m^2 per 1 TEU), require more space per balance for the movement of larger cargo handling equipment and thus overestimate this rate, while land terminals, despite their smaller size, make better use of available storage areas for cargo units;
- the average size of a terminal in the BSR is between 50,000 and 70,000 m^2, while in TEU units it is 2,000 - 3,000;
- this average does not reflect the reality well enough and it is necessary to analyse the size of the terminals according to the initial division into three types: small, medium and large (see Table 3.4.1), where small size terminal means area below 40,000 m^2, medium size terminal means area between 40,000 and 70,000 m^2 and large size terminal means area above 70,000 m^2;
- of the three types of terminal size, the most common one is large (69 units), followed by small (48 units) and than medium (34 units); these values include a total of 90 port terminals, including 35 very large port terminals; and
- interesting are average values of terminals areas for all BSR terminals, where only Lithuania terminals oscillate around 50,000 m^2 and all other exceeds 100,000 m^2 (except Sweden with average area of 93 thous. m^2).

Table 3.4.1. BSR CT terminals structure by size.

	Small	Medium	Large	Total	Where in: Seaport terminals	Large seaport terminals
Denmark	7	2	3	12	7	4
Estonia	0	0	2	2	2	2
Finland	0	2	2	4	2	2
Germany	6	12	32	50	43	6
Latvia	1	1	4	6	6	4
Lithuania	3	1	2	6	3	2
Poland	11	12	8	31	6	5
Russia	1	0	6	7	7	7
Sweden	19	4	10	33	14	3
Total	48	34	69	151	90	35

Source: own elaboration based on data analysis.

Parametres related on rail infrastructure

The basic transport mode for inland terminals is rail. It is also crucial for all port terminals with high container turnover in terms of hinterland services. Hence, not only the availability of international terminal rail services (i.e., whether the terminal is part of the TEN-T network and the RFC, as discussed in section 3.1) is important, but also the number of tracks inside the terminal on which wagon loading can be carried out. This issue is not clear, as there may be tracks inside the terminal for warehouses waiting to be handled, in transit, but mainly for the handling itself – unloading and loading. There may also be tracks for the train marshalling, especially when the length of these tracks within the terminal is less than 400 m, which makes it impossible to place the entire train on a single track, and makes it necessary to disconnect the wagons into two or three groups and dismantle them into two or three tracks respectively, and then, after loading, form them again into one depot. The most common train length limits in Europe are 650 - 700 m. As practice shows, however, most often the tracks located in the terminal are used first of all for cargo handling, and in addition, they also serve for parking or forming trainsets.

On the basis of analysed data, BSR CT terminals are characterised by the following features:

- the average number of tracks in one terminal for the whole BSR equals to four;
- the most common number of tracks (dominant feature) is two;

- the average is overstated by large land terminals and port terminals; the highest ratio was recorded in one ternminal in the port of Hamburg - 14;
- the lowest value of this parameter was recorded for Estonia (2), while the highest for Finland (6) and Russia (5.7);
- high number of rail tracks plays important role for seaport terminals, especially the largest ones, which export to the hinterland up to 35-40% of containers by rail;
- the average small inland terminal is served by two tracks, with a fairly short length of up to 450 m;
- the longest trains are allowed in Sweden – up to 950 m;
- the smallest discrepancies are found in the German terminals, where it is standard to be able to handle freight trains up to 700 m long. Terminals in other countries show very big differences, both spatially and generically and allow handling sets from 300 to 650 m long; and
- an exception in the region is the Kouvola terminal, where it is possible to handle trains up to 1,100 m long - however, this is the result of specialisation in handling empty containers from Finland to China, which was until recently the case at this terminal.

Summarised detailed data is shown in the Table 3.4.2.

Parametres related on transshipment equipment

Equipping the terminals with gantry cranes determines its role in the national and international transport system. At the beginning, however, it is necessary to distinguish very clearly between seaport terminals, where STS (ship-to-shore) gantries are the basis of activity. Their quay outrich and lifting height are proof of the gantry generation. Currently, the most modern ones handle up to 28 containers from the quayside and up to a height of about 73,5 m above the ground. Their capacity is counted in 30 - 35 operations per hour for single crane trolleys, and it is also possible to operate sets of two or more containers at the same time. However, such types of cranes are not yet available on the Baltic Sea.

The basic equipment of large land terminals is RMG (rail moulded gantry cranes, which cover up to four railway tracks and up to four vehicle lanes. RMGs with a width of 3+3 (3 tracks + 3 lanes for lorries) are standard. Importantly, RMG's equipment of the terminal demonstrates its high level of infrastructural development, as this type of gantry requires larger areas with a paved surface and is also equipped with mobile cranes (RTG – rubber tyred gantry crane). Therefore, RMG does not meet in small terminals, while in medium-sized ones it is sporadic. They are mainly used in border terminals, especially when there is a change in track width (1435/1520 mm).

From the analysis it can be concluded that:

- n the BSR the average number of gantries per one terminal is 4.4;

- the extreme values of this parameter for individual countries range from 0.3 (in Sweden) to almost 25 (in Russia, but only port terminals were included in the analysis, with the largest ones in St. Petersburg, which significantly disturbs the region's average);
- in Poland, the average values of the index are overstated by the three largest container terminals, with 56 cranes self in DCT Gdansk. Excluding these three port terminals, this parameter reaches 1.2 with a simultaneous number of 16 terminals in Poland that do not have this type of gantries at all;
- in Sweden, only 9 terminals have any type of gantry at all, with a maximum of two per terminal; similarly, in Denmark, where half of the total number of gantries are STS, the rest are located in five land terminals;
- as many as 61 terminals in the BSR do not have any gantry and are mostly small or medium sie CT terminals;
- a typical arrangement for a small inland terminal is one crane or one or two reachstackers instead;
- in inland terminals equipped with gantries, there is an average of 1,000 - 2,000 TEU of storage capacity per one gantry, with a maximum of 50,000 TEU in extreme cases; and
- port terminals equipped with cranes have an average storage capacity of 3,000 - 3,500 TEU per crane station, with a maximum of 75,000 TEU (Ventspils) in extreme cases.

Parametres related on mobile equipment

Terminal mobile cranes are used in two ways. The first one – as the basic and only handling equipment. This is especially the case in small or medium size terminals, where there are no gantries, or accompanied by one RMG. Mobile cranes are most effective in this type of terminal due to their high flexibility of application, both in terms of the type of units they serve (i.e., universal spreaders make it possible to pick up both containers and cranable trailers or swap bodies) and spatially (i.e., anywhere in the terminal the handling in a truck-truck or trick-train or truck-barge relation). From this point of view, mobile cranes constitute the basis of operational activity. The second way of using them is as complementary devices, mainly for back-up activities or short movements within the terminal. This is the case in large terminals, which are based on the operation of STS or RMG railway gantry cranes and cooperation with RTG's on storage yards.

Both ways lead to a similar scale of application, as the small terminals require two or three such devices, while the large terminals still support the handling work on the gantries, while the mobile cranes are treated as peripheral or complementary equipment.

The following conclusions can be drawn from the data analysis:

- the average number of mobile cranes in BSR terminals is 3.1;
- this value is very significantly influenced by 440 devices in Germany alone and 100 in Poland; in the other BSR countries the total number of these devices oscillates between 13 and 19; only Estonia shows a total of three such devices;
- the national averages also show large disparities, ranging from 1.3 (Sweden) to 11.9 (Germany); and
- these are mainly reachstackers, less mobile cranes or straddle carrier - these are very rarely used in terminals of universal character or with the lowest infrastructure development threshold.

Parametres related on weight limits for cargo units

From the point of view of accessibility, the terminal is also determined by the maximum permissible weight of the cargo units to be handled. This is important in the case of heavy containers and semi-trailers, especially in relation to imports from China and in the conditions of cross-border transport of heavy units.

In general, similar standards can be observed in the BSR, which have their origin in the cooperation within the EU of all countries. This standard is defined by the weight of 40 tonnes per unit of cargo. Of the analysed countries, only Poland shows a lower value of this parameter (38.85 tonnes on average). On the other hand, there are two countries – Lithuania and Russia, in which there are no such limits at all. Sweden deserves to be mentioned as well, as it allows for a maximum weight of 60 tons as standard, and there is a discussion on the introduction of 80 tons in road traffic in this country.

As an exception for CT, the permissible increase of the limit to 60 tonnes of a lorry in Germany on certain roads can be regarded as an exception, which also results in increased limits for the units handled at terminals. In the case of the MPs, it is permissible to increase the limit by one tonne provided that the transport is carried out using the last mile technology, which is defined as a section of up to 150 km between the last terminal where the unit left the railway and the destination of the transport.

Table 3.4.2. Key infrastructural elements of CT terminals.

	Total terminals area (m²)	Total number of gantry cranes	Total number of mobile cranes	Average					
				Terminal area (m²)	Area use per 1 TEU (m²)	Trailer weight limit (T)	Number of mobile cranes	Number of (gantry) cranes	All facility tracks: number
Denamrk	1 523 500	16	17	126 958	25,19	41	1,4	1,3	2,7
Estonia	305 000	10	3	152 500	43.02	40	1,5	5,0	2
Finland	1 689 600	19	16	422 400	7.19	40	4,0	4,8	6
Germany	-*	66	440	192 357	-	-	11,9	2,0	4,8
Latvia	1 171 100	18	19	105 183	16.48	40	3,2	3,0	3,8
Lithuania	305 800	16	13	50 967	11.25	no limit	2,2	6,0	5
Poland	3 524 800**	135	100	117 493**	29.24	38,85	3,2	4,4	3,1
Russia	2 749 660	172	15	392 809	22,57	no limit	2,1	24,6	5,7
Sweden	2 976 732	11	39	93 023	31.41	60	1,3	0,3	3
TOTAL	14 246 192	463	662	183 743	23,3	-	3,1	4,4	3,9

*- due to lack of data of majority terminals, this parameter is unfeasable to sum up.

**- value without one seaport terminal - DCT Gdańsk – with area of 700 ha, which would introduce incorrect values diffrenciating from other countries.

Source: own elaboration based on data analysis.

Key findings:

- The highest average of storage area is in Russia and Denmark;
- The lowest average of storage area is Lithuania and Finland;
- The highest average number of gantry cranes is in Russia and Poland, the lowest in Sweden and Denmark;
- The highest average number of mobile cranes is in Germany and Finland, the lowest in Estonia and Denmark; and
- A typical BSR inland terminal bases on maximum 1 gantry crane or without gantries, but equiped with at least one reachstacker.

4 CASE STUDY ON TERMINAL OPERATION ASPECTS

4.1. Special infrastructure elements supporting terminal operation

Modern inland CT terminal besides having basic, typical handlings equipment as reach stacker and gantry cranes, which are using to move containers or other cargo units at the terminal, trans-shipment from one mode of transport ot another, needs also additional valuable assets, tools and solutions which help inland terminals to develop, increase effectivness, save costs, time, generall improve quality in transport supply chain plus provide new additioanl services to customers. It concerns installed infrastructure for increase scope of services, particular solutions in IT system management or special techniqual equipment. All this become group of special infrastructures and organiziational elements supporting standard, regular terminal operations relate to loading full and empty containers in transport process.

One of the most important issue in today’s perception of inland CT terminal is wider analysis, not only from point of view of the part that supports transport of trains and truck but also integrated terminal with logistics and distribution facilities, comprehensive and advanced services as inland intermodal hub combined spread services. Infrastructure might include **warehouse** for consolidation and de-consolidation containers. It requires another type of machinery park, fork-lifts with different tonnage capacity which can enter to the container to pull out or put in (palletised) goods – also heavy cargo up to 10 ton per unit. Warehouse allows to load cargo from containers to trailor truck (or in opposite way) for palletized cargo or to arange manual loading, cartons, boxes, rolls. It might be very usefull when terminal is connected in international network and deliveries are arranged for long distance what is cheaper solution for final clients. Deliveries full container is profitable only for short distance from initial terminal up to 150 km. Warehouse allows also to serve more type of services, palettizing of cargo, which simplifiy delivery in road network, segregation, inspections and storage. It is very relevant that the entire terminal and warehouse is recognised by customs office as a Temporary Storage Warehouse. It allows to storage cargo by 90 days under customs procedure

One of the most significant attitudes of each container terminal is the largest **storage capacity** for full and empty containers. Storage of hazardous goods specially in long-term framework, requires special zone on surface of terminal and permision for local authorities and proper status of infrastructure facility. Number of electrical connections for refrigerated container (reefer) is used in intermodal freight transport that is refrigerated for the transportation of temperature-sensitive cargo. Reefer has an integral refrigeration unit, they rely on external power, from electrical power grids – specially created for this type of boxes. When being transported over the road on a trailer or over rail wagon, they can be powered from diesel powered generators which attach to the container whilst on road transport. Refrigerated containers are capable of controlling temperature ranging from -65 °C up to 40 °C.

Next services transfered to many inland terminal outisde the port is **Verified Gross Mass** (VGM), which says that responsible for checking real mass of cargo before loading container on vessel rely on the shipper. It automatically passed to semi-station or port terminals what was needed to install car scale. Alternative solution is to install weight directly on reach stacker when weight of container is display during trans-shipment process. It shortens time of verifing mass of containers due to limit operations. Implementation of weight can be done also on track, then terminal gains access to verified weight of whole block train which can be used for rail carrier or another stakeholder in transport chain

Flow of empty containers needs additional services for shipowners and forwarders or even for the terminal itself when it carries out the transport process:

- Removal of dunnage;
- Electric cooling and heating;
- Assembly/disassembly, utilisation of flexi tank;
- Container cleaning and sweeping;
- Container repairs and sealing;
- Application and removal of labels RID/ADR; and
- Container washing.

The common **staff for re-loading** containers but also semi-trailers or swap bodies is reach stacker, gantry crane or terminal tractor – used for moving ready cotnainers from the crane arena to indicated sectors in terminal to aviod driving by reach stacker what is less effective slower and takes more fuel resources. For similar reasons, terminal diversifies the choice of equipment – using empty handler which are cheaper, costs less fuel. Nowadays, besides economical values, very important is eco aproach and focus to decrease used level of fuel and noise reduction. Social effects are one of the most important factors. Solutions using modern technology and data transmission are used. Technical solutions for handling equipment that minimise the impact of their work on the environment. Reconstruction and modernisation consist in replacement diesel engines for electrical or hybrid drive system. This allowes up to 40% reduction of fuel consumption. For gantry cranes, full electrical propulsion is cheaper by around 13-14 times than diesel cranes (www.kalmarglobal.com). Additional advanced systems which support working of operator via a fully automatic process is when one person can control work of few cranes at the same time.

To be more friendly to the environment, each terminal should have **own independent seperate infrastructure** with proper length and amount of track. Effectivness of rail transport and loading operations depends not only on internal terminal conditions, but also on outside process and infrastructure on nearest rail station, rail network, acces to platforms and marshalling locomotives. The problem illustrating this lack of policy is the shortage of shunting capacity. If terminals are more efficient and therefore faster, the big problem is shunting wagons. Indeed, the shunting capacity is crucial for the functioning of intermodal terminals, but unfortunately does not meet the demand in many cases. It is not only about shunting capacity in terms of space. Shunting requires locomotives and people, both of which can be scarce. This is very difficult to manage, but it affects the terminal efficiency significantly. Even the most efficient terminal, if shunting capacity is not up to the required level process it is not working well and is the weakest link in the chain (www.railfreight.com). Crucial key of speed up CT inland operations using the rail service is gate in/out of wagons to terminal. To reach that, the largest and upgraded terminals dispose own locomotives or outsource the special carrier dedicated only for that kind of operation. Receiving block trains from the station is done by seperate locomotive which is prepared in advance to take over the platforms, divide the trains according with schedule the priority. Particularly on big serving station where is a lot of trains and cargo for one terminal, this method is practiced avoiding congestions.

Together with efficient shunting, an important check includes incoming containers/wagons. Normally this work is done manually by taking pictures of all the elements that need to be registered. It is one of the innovations that embraces a fully digitalised facility. It helps by positioning rail **OCR** (Optical Character Recognition) that is installed especially for big port container terminals. OCR system equipped with camera systems and OCR engines, and further extended with various sensors. When a train drives through the camera portal, the linescans generate high-quality images of each container’s left, right and top side, while optional area scans take images of the container’s front and back. Collected OCR data are container number, ISO code, non-ISO container number, railcar and chassis number, IMDG and seal presence and door direction. Using a sophisticated railcar detection and identification system, the rail OCR system is able to return the exact position of every container on an identified railcar. OCR solution supports running trains, stops and shunting without delaying or hindering the operational processes in any way (www.camco.be).

4.2. Energy consumption in CT terminals

4.2.1. Energy consumption structure

Electricity and fuels that are consumed by the combined terminal have very large impact on operating costs and the amount of harmful emissions. Both parameters are of key importance today for assessing the terminal's operational efficiency and it seems that this importance will grow in the future. Hence, terminals use a monitoring system of energy consumed, which is often part of the Environmental Management System (EMS) implemented by terminal operator. Available publications on this subject relate mostly to terminals in seaports but may also be used in the analysis of combined terminals. The same container handling equipment is used in port container terminals and combined terminals, and the same trans-shipment technologies for handling land and river transport means are used.

In research carried out in 2016 in a group of 91 European ports, as many as 80% of them implemented a system of continuous energy monitoring, which means an increase of 9% compared to 2013. Moreover, the reduction of fuel and electricity consumption belong to the three top environmental priority areas in terminal management next to the air quality and noise reduction activities. Appropriate tools for monitoring, reporting and optimisation of energy consumption, often integrated with Terminal Operating Systems (TOS), are used in both seaport and inland terminals.

The starting point for any analysis and optimisation is the knowledge of the volume and structure of electricity and fuel consumption generated by the terminal. Based on data from seaport container terminals, we can distinguish the following basic areas of energy consumption at the combined terminal:

1. electricity for:

a) handling equipment (Rail Mounted Gantries - RMGs, Ship-To-Shore crane - STS, Rubber Tired Gantries – RTGs, Empty Container Handlers – ECHs, Terminal Tractors -TTs,),

b) storage yard lighting,

c) offices, and

d) container reefers;

2. liquid fuels (diesel oil, LNG, LPG) for:

a) handling equipment (Reach Stackers - RSTs, RTGs, ECHs, TTs),

b) locomotives,

c) terminal staff cars, and

d) client trucks.

In the group of terminal handling equipment, replacement of classic diesel engines with electrically assisted drives, i.e., hybrid (diesel-electric) or fully electric (Figure 4.2.1 – 4.2.3) is observed. Another trend is the use of dual-fuel (diesel-gas) engines or powered exclusively with alternative fuels (LNG, CNG, LPG, Hydrogen). This applies in particular to RTGs, ECHs and TTs handling units. The biggest challenge in this respect seems to be changing the Reach Stacker (RST) diesel engine, which is characterised by an extremely demanding work regime. This challenge was taken up as part of the H2Ports project that aims to develop a zero-emission eRST featuring a hydrogen fuel cell on board. The new Reach Stacker is expected to enter operation in 2021 at the MSC Terminal Valencia (MSCTV) in Spain.[1]

Figure 4.2.1. Hybrid RTG with rechargeable power pack.

Source: www.moveitmagazine.com/2019/03/22.

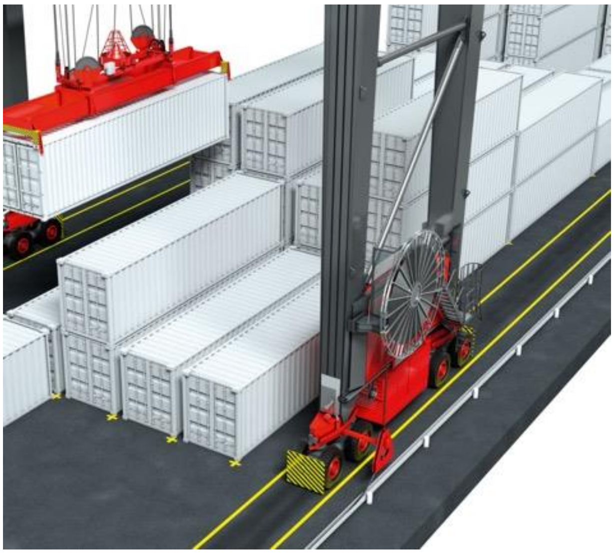


Figure 4.2.2. eRTG with cable reel.

Source: www.moveitmagazine.com/2019/03/22.

[1] Hyster begins development of electric reachstacker for Port of Valencia, https://moveitmagazine.com/2019/03/22/

There is a huge capacity of energy transition from fossil fuels to alternative fuels and electric power for all handling equipment. Creates a simple way to achieve the strategic goal, which is 'zero emission CT terminal' which would be completely neutral for the environment and society. This goal can be achieved by 2025.

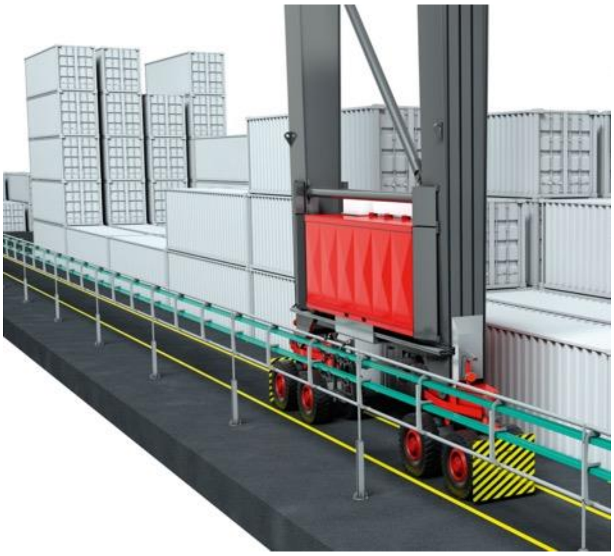


Figure 4.2.3. eRTG with busbar.

Source: www.moveitmagazine.com/2019/03/22.

The structure of electric energy and fuel consumption is always related to the specificity of the terminal infrastructure and equipment as well as the volume of trans-shipments. The differences would be large even within the terminals of the same operator similarly equipped. The available data on energy management of seaport container terminals shows that two container terminals at the Port of Gdansk have completely different approaches to the energy sources used. The larger Deepwater Container Terminal (DCT) has a 54% share of electrically powered trans-shipment facilities, and at the smaller Gdansk Container Terminal (GTK) this share is equal to zero. The average number of electrical trans-shipment devices in five Polish container terminals is 41% (Blue Baltics, 2020; Go LNG, 2020; ICF, 2020). Data for container terminals in other countries show that this share has similar values, i.e., 34% for Rotterdam and 53% for ports in Finland.

4.2.2. Energy balance for model CT terminal

The energy balance for a typical rail-road terminal will be presented below (Figure 4.2.4). The assumption is that this is a new terminal with a reloading capacity of 130,000 ITU equipped with: one eRTG, two RSTs and two TTs with semitrailers (adapted for the transport of containers and semitrailers). The infrastructure of the terminal with a total area of 6 ha includes: load tracks with a length of 650 m, storage yards of about 30,000 m^2, seven power supply points for refrigerated containers, an office and social building with a usable area of about 250 m2, a workshop of 3,000 m^3 space area, parking lots, a covered shed and washing point.

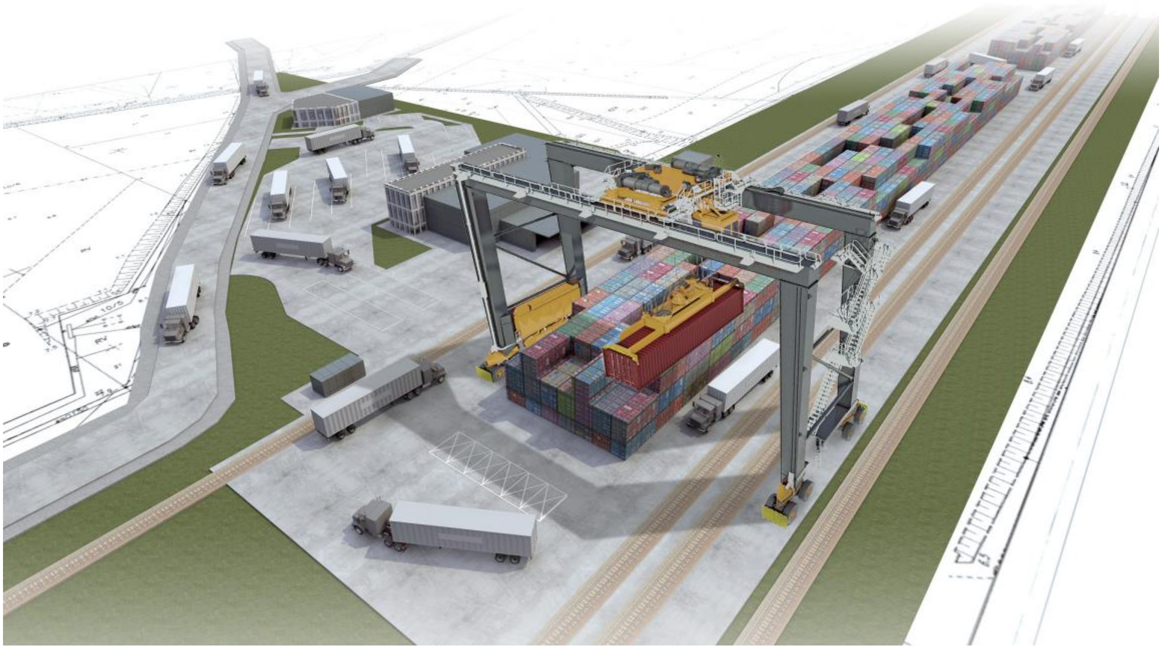


Figure 4.2.4. Visualisation of a model rail-road CT terminal.

Source: CCIC Intermodal Depo Dunikowo, http://serwer1847329.home.pl/autoinstalator/wordpress1/

Table 4.2.1 presents basic data determining the energy demand of basic infrastructure elements and handling devices of the model combined terminal. Based on these data, you can calculate the daily, monthly or annual energy demand including fixed and variable consumption. For example, for the adopted model of rail-road combined terminal, the estimated total fixed annual energy demand is equal to 390,000 kWh/year. This figure considers seasonal fluctuations in energy demand during one year of operation, e.g., no heating and shorter daily lighting time during the summer.

Table 4.2.1. Estimated energy demand for infrastructure elements and handling equipment of the model combined terminal.

Facility/ device	Key parameter	Demand for diesel oil	Demand for gas	Demand for electric power
eRTG	electric, power 400-500 kW 30 moves/hour	-	-	2.5-3.0 kWh/move
RST	diesel, 45 t 20 moves/hour	20 litres/hour	-	-
TT (tug+semitrailer)	diesel, 90 t 20 moves/hour	10 litres/hour	-	-
Office and social building	250 m^2 usable area	-	32 kW	13 kW
Workshop	600 m^2 usable area	-	60 kW	11 kW
Washing point	160 m^2 usable area	-	35 kW	6 kW
Terminal lighting (LED)	30,000 m^2 storage yards	-	-	300 kW
Other electrical equipment	n/a	-	-	50 kW

Source: own elaboration.

Variable demand is proportional to the volume of trans-shipments. We will calculate them by multiplying the unit energy consumption by the number of intermodal units handled or by the number of movements performed by the primary handling equipment of the terminal (Table 4.2.2).[2]

[2] The relationships between the trans-shipment volume and the number of movements of primary handling equipment were adopted on the basis of publication: S. D. Stoilova, S. V. Martinov, Choosing the container handling equipment in a rail-road intermodal terminal through multi-criteria methods, Materials Science and Engineering 664 (2019)

Table 4.2.2. The annual energy demand of the model combined terminal depending on the trans-shipment volume.

Parameter	Unit	Result		
Terminal trans-shipment volume	ITU	50,000	90,000	130,000
eRTG moves	moves	50,000	90,000	130,000
eRTG time	hours	1,667	3,000	4,333
eRTG energy consumption	kWh	137,500	247,500	357,500
TT moves	moves	50,000	90,000	130,000
TT time	hours	2,500	4,500	6,500
TT energy consumption	diesel oil litres	75,000	283,500	409,500
RST moves	moves	50,000	189,000	273,000
RST time	hours	2,500	9,450	13,650
RST energy consumption	diesel oil litres	50,000	189,000	273,000
RTS+TT energy consumption	diesel oil litres	75,000	234,000	338,000
RS+TT energy consumption[3]	kWh	750,000	2,340,000	3,380,000
eRTG+RS+TT energy consumption	kWh	887,500	2,587,500	3,737,500

Source: own elaboration.

The obtained results show that the variable energy demand of the model terminal ranges from 887,500 kWh to 3,747,500 kWh depending on the trans-shipment volume. Hence the total fixed and variable energy demand of this terminal ranges from 1.28 MWh to 4.13 MWh (Table 4.2.3). On this basis, a marginal consumption can be calculated, which in the case of the model terminal is 25.6 ÷ 31.8 kWh per ITU. It should be remembered that only part of this demand relates to pure electricity, i.e., 5.8 ÷ 10.6 kWh per ITU. Importantly, the structure of unit electricity is less favourable when trans-shipment

[3] Calculations based on the estimated energy value of diesel oil (1 litre of diesel = 36 MJ = 10KWh)

volume increases and the share of handling movements done with diesel-powered devices, i.e., RSTs and TTs, increases. This last parameter is consistent with research studies related to energy consumption of seaport container terminals. They indicate average electric energy consumption values 5.00 ÷ 7.25 kWh/move (Delft, 2014).

Table 4.2.3. The structure of the annual energy demand of the model combined terminal.

Parameter	Unit	Result		
Terminal trans-shipment volume	ITU	50,000	90,000	130,000
fixed energy consumption	kWh	390,000	390,000	390,000
variable energy consumption	kWh	887,500	2,587,500	3,737,500
Total energy consumption	kWh	1.277,500	2,977,500	4,127,500
Energy consumption per ITU	kWh/ITU	25.6	33.1	31.8
Electricity consumption per ITU	kWh/ITU	10.6	7.1	5.8

Source: own elaboration.

4.2.3. Trends in power supply technology of CT terminals

In conclusion, it should be emphasised vast potential for energy efficiency measures existing in the area of terminal infrastructure and handling equipment. The main trends in the energy management of terminals are identified below.

1. Most significant potential for energy saving in infrastructure include low-energy yard lighting, passive/low energy office buildings, efficient heating systems;
2. Handling equipment should be powered by electricity, alternative fuels and hybrid systems in drives,
3. Terminals possess favourable conditions for operating Renewable Energy Sources (RES) technologies including producing renewable energy in the terminal area;
4. Terminal area can be used for provision LNG/CNG/electrical charging infrastructure;

5. Conditions (e.g., terminal gate systems, TOS) for efficient train and trucks servicing and handling (e.g., slot system) should be applied;
6. Incentive scheme rewarding carriers and operators that uses less energy and/or alternative energy sources should be applied; and
7. Energy consumption and efficiency criteria and good operational practices should be incorporated in tendering procedures associated with terminal investments.

4.3. Cargo turnover – terminal capacity correlation

Each CT terminal can be described by a set of performance indicators – technical and economic. Maximum turnover capacity is one of the most important to describe the status and performance of terminal. It is defined by the lowest value among throughput of terminal gate, throughput of storage yard and trans-shipment capacity of handling equipment. All of those factors are calculated by selected aspects of terminal operations.

4.3.1. Throughput of terminal entrance gate

The throughput of terminal entrance gate determines the number of intermodal loading units that can be checked at the entrance gate of the terminal during the year.

$$C_g = n_g \cdot \frac{1440}{T_g} \cdot b \cdot 360$$

where:

C_g – throughput of terminal entrance gate [ITU/year]

n_g – number of entrance traffic lines

T_g – average time at gate [min] (T_g=5÷15 min)

b – ITUs per vehicle coefficient (b=1,75 for standard semi-trailer)

Main aspect which effects on gate capacity are the terminal opening days in year and the average time at gate. Concerning two similar terminals in Poland, one with installed semi-automatic gates (PCC) and one with manual – Spedcont Lodz. As the reference DCT Gdansk with installed fully automatic gates with LPR system and 4-5 (one for oversize loads) lane gates complex operating 24/7 (Table 4.3.1).

Table 4.3.1. Terminal gate capacity in selected BSR terminals.

Terminal	*PCC KUTNO*	*SPEDCONT*	*DCT Gdansk*
Trailer capacity factor	1.75	1.75	1.75
Average gate-in time [min]	2	3	1
Gate lanes number	2	2	4
Working days / year	312	312	360
Gate Throughput capacity	786,240	524,160	3,628,800

Source: own elaboration.

In practice, gate complex throughput should be more effective than other terminal parties. The reason for this is connected with fluctuation of last mile operations during daytime. As per below chart, DCT Gdansk gains almost 100% usage of gate slots in the afternoon, whereas in the morning it does not exceed 60%. Such construction allows to avoid congestion and extended waiting time for truckers (Figure 4.3.1).

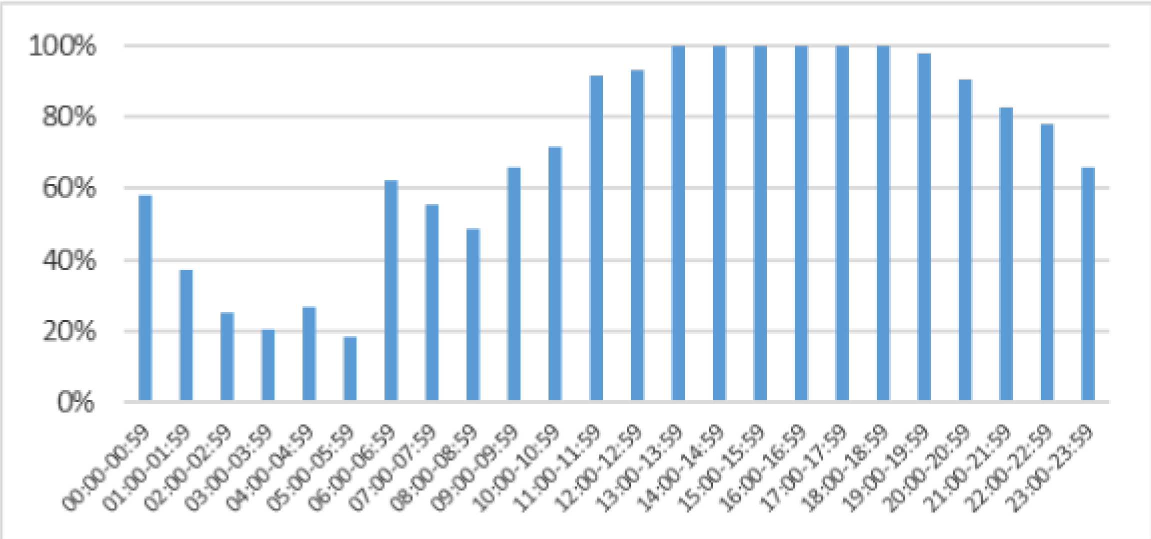


Figure 4.3.1. DCT Gdansk gate slots usage during day.

Source: DCT internal sources.

4.3.2. Throughput of storage yard

Throughput of the storage yard determines the number of intermodal loading units that can be stored on the terminal's storage yards during the year.

$$C_y = V_y \cdot r$$

where:

C_y – throughput of storage yard [ITU/year]

V_y – capacity of storage yard [ITU]

Efficiency of storage yard is connected mainly with its area and the equipment used for handling. RMG cranes allows to store the containers in tight blocks, whereas reach stackers usage requires to limit block storage to void restacking containers to get access to second and subsequent rows.

A second aspect of yard storage efficiency is the average time of container storage. Depending on supply chain models, containers are stored on terminals starting from 2-3 days up to even 14 days. Parallel storage days are limited by the terminal tariffs. Tariff is the instrument which can easily steer the maximum storage capacity. Table 4.3.2 shows how tariff storage free days may affect terminal storage capacity.

Table 4.3.2. Comparision of storage yard in PCC Kutno and Railport Riga.

Terminal	*PCC KUTNO*	*Railport Riga*
Storage capacity [ILU]	4,000.00	4,000.00
Storage period	4.00	7.00
Storage throughput	360,000.00	205,714.29

Source: own elaboration.

Thus, the terminals located in Germany or Denmark gain their efficiency by shortening storage free time. Standards for Western BSR is to settle the free time max 2-5 days. Eastern BSR terminals offers longer time for storage to attract the shippers or operators. Standard for Poland is between 5-10 days free of storage placed in terminal's tariff, terminals in Lithuania offers even 14 days free of storage charges.

4.3.3. Trans-shipment capacity of handling equipment

The trans-shipment capacity of handling equipment determines the number of intermodal loading units that can be trans-shipped by the terminal's primary handling equipment during the year. Primary handling equipment on combined terminals include: RTG gantry cranes, RMG gantry cranes and reach stackers RST.

$$C_h = n_h \cdot \frac{(P_h \cdot T_h \cdot 360 \cdot R_h)}{a}$$

where:

C_h – trans-shipment capacity of handling equipment [ITU/year]

n_h – number of handling facilities

P_h – productivity of one handling facility [ITU/h] (P_h= 20÷30 ITU/h for gantry crane RTG or RMG, P_h= 12 ITU/h for reachstacker RST)

T_h – average daily working time of handling facility [h] (T_h=12 h for two shifts, T_h=18 h for three shifts)

R_h – technical availability of handling equipment (R_h= 0.80÷0.95)

a – coefficient of simultaneous work of handling equipment (a= 1.00÷1.25)

Most of the CT terminals conducting their handling operations using reach stackers, mainly due to its relatively low investment cost, availability and requirements on the infrastructure. RMG's are approx. 2x more efficient than reach stackers offering handling 20-30 ILUs per hour comparing to RTS with 12 ITUs per hour. On the other hand, investment on RMGs requires proper constant flow of cargo. Table 4.3.3 shows the comparisons of equipment throughput for two terminals. Kuvola, which works three shifts with two reach stackers and Taulov, DK working two shifts with two RMG.

Table 4.3.1. Comparisons of equipment throughput for terminals in Kuvola and Taulov.

	Finland	*Denmark*
	Kuvola Cargo	Taulov DK
Number of handling devices	2	2
effciency ILUs / hours	12	25
Work time 2 or 3 shifts	18	12
Handlig equipment throughput	91 898,18	127 636,36

Source: own elaboration.

If one of the mentioned parameters is significantly lower, it should be considered as one the bottleneck of the terminal. This should lead for further investments in particular business areas: gate throughput, storage area or handling equipment. In selected terminals may indicate bottlenecks in storage capacity in terminal Sestokai or PCC Kutno, but further analysis of ILUs flow (i.e., direct trans-shipments train-train, average ILU storage time etc.) should indicate real requirements for storage capacity in those locations. Every field of CT operation requires to find a way to capacity improvement for bottleneck avoidance (Table 4.3.4).

Table 4.3.2. Solutions for bottlenecks avoidance.

Bottleneck	Possible solutions
Gate	Imprementation OCR/LPR systems
	Adding additional traffic lane
	Truck arrival pre-notification requirement
Storage yard	Expanding storage area
	Handling equipment replacement (increasing number of container layers on yard)
	Free storage time decrease in terminal tariff
	Digital tools implementation for efficiency improvement
Handling equipment	Expanding the fleet of handling equipement - additional RMG or RS
	Replacement of Reachstackers with the RMGs
	Digital tools for better investment planning and current terminal logistic

Source: own elaboration.

4.3.4. Terminal utilisation rate

Combining the terminal capacity with yearly turnovers allows to indicate terminal utilisation rate. This correlation describes following formula:

$$e_t = \frac{T_t}{C_t}$$

where:

e_t – terminal capacity utilisation rate

T_t – actual terminal trans-shipments [ITU/year]

C_t – terminal trans-shipment capacity [ITU/year]

Depending on received rate terminals can be in one of four stages:

e < 0.3 – terminal still have free workflow, additional;

0,3 < e < 0.5 – terminal has proper throughput;

0.5 < e <1.0 – terminal requires investments to increase throughput; and

e > 1.0 – terminal handle more cargo than it's nominal throughput.

The **e** factor at the level below 0.3 means, that the terminal is not sufficiently used, and further network development should be conducted. It is possible by adding additional trains, barges or shorsea vessels into the timetable to increase the turnovers. Such status in longer horizon may lead to terminal closure or merge with other terminal to build the effects of scale.

Utilisation rate between 0.3 and 0.5 means, that the terminal is at its' optimum workflow and throughput.

Exceeding **e** factor above 0.5 requires from terminal management steps for terminal development. Depending on the bottleneck to remove it may concern handling equipment purchase (i.e., short time, low cost), storage yard expanding (i.e., long time, high costs) or gate complex development (i.e., medium cost, medium time).

If **e** factor exceeds the 1.0, terminal works in a congestion mode. It means that the cargo flows exceed terminal efficiency. It may affect only one of the aspects, i.e., yard capacity – when the containers are stored, i.e., in traffic lanes, or only in gate efficiency – when gate-in process generates truck queues in front of the terminal gate. Such situations require radical reaction from terminal management, as it affects terminal stakeholders – last mile operators, rail carriers, customers or investors.

4.3.5. Utilisation rate in selected BSR CT terminals

Average gate yearly capacity in mentioned terminals exceed 500,000 TEU. The biggest capacity is noticed in KTL Ludwigshafen, mainly due to its operations six days a week 24/7 but also due to efficient automated gate lanes. The lowest efficiency of gate is noted in Railport Riga, not more than 130,000 TEU per year.

Storage capacity can be managed by expanding the space or limiting available days free of storage to speed up the containers flow. Average storage throughput of selected CT terminals exceeds 300,000 TEU per year with the lowest number in Lithuanian terminals (approx. 30,000 TEU) and the biggest in Germany (above 600,000 TEU).

Handling equipment throughput value depends mainly on terminal working hours (two or three shifts) and on the type of equipment. Terminals equipped in RMGs are achieving higher utilisation rates (KTL, Taulov CK, PCC Kutno). Terminals which base on reach stackers (Kuvola cargo, Malmo Kombi) have limited handling capacity.

Table 4.3.5. Capacity parameters of selected BSR CT terminals – summary.

Country	*Terminal*	*Gate throughput capacity*	*Storage trroughput*	*Handling equipment throughput*	*Yearly handling capacity*	*TEU Handled*	*Termianl handling utilisation rate*
Poland	PCC Kutno	786 240	360 000	583 553	360 000	210 000	0,58
Poland	SPEDCONT Lodz	524 160	576 000	528 414	524 160	200 000	0,38
Sweden	MALMO Combi Terminal	218 400	113 241	250 167	113 241	68 000	0,60
Sweden	Arken Norra Gothenburg	218 400	221 400	214 429	214 429	65 000	0,30
Germany	Tricon Nurnberg	393 120	360 000	459 490	360 000	185 000	0,51
Germany	Hamburg Eurokombi	655 200	648 000	765 818	700 000	510 000	0,73
Germany	KTL Ludwigshafen	1 572 480	576 000	918 981	576 000	354 414	0,62
Lithuania	Šeštokai Railway Station	218 400	54 000	191 454	54 000	33 700	0,62
Lithuania	Vilnius Intermodal Terminal	604 800	36 514	88 363	36 514	12 000	0,33
Latvia	Railport Riga	131 040	205 714	63 818	63 818	30 000	0,47
Finland	Kuvola Cargo	327 600	514 285	91 898	91 898	55 000	0,60
Denmark	Taulov DK	436 800	162 000	127 636	127 636	52 000	0,41
	Average	507 220	317 430	357 002	266 975	147 926	0,54

Source: own elaboration based on data analysis.

Average utilisation factor for selected terminals shows 54% of maximum throughput, by average handling of almost 150,000 TEU and above 260,000 TEU capacity. It means that the terminals in BSR might be on their last moment to build a common, sustainable strategy of infrastructure development. From the angle of particular counties, most congested terminals are located in Western Europe.

In Germany all selected terminals show the utilisation rate between 0.5 to 0.73. On the other hand, some terminals in Central Eastern Europe (Lithuania, Poland) may face not sufficient utilisation level. It can be caused by relatively young, fragmented market. As the example, only in Poznan area there are four CT terminals owned mainly by rail operators to serve their block trains.

The issue of two-poles market is much clearly visible on below table. Terminals in Germany, Denmark, Sweden provide average utilisation factor above 0.5 whereas Central-East BSR countries utilise their terminals between 30 – 48%.

4.4. Digitalisation in CT terminals

Digitaliisation is the originally understood process of transforming information from an analog (paper) form into a digital version for the subsequent processing on electronic devices (Ober, 2005). By implementing it, it seeks to change business models, improve the efficiency of supply chains, and increase the turnover in enterprises and create value-added products and services. The general objectives of digitalisation are the protection of collections, their preservation, processing and sharing. Many times, you can hear about innovations such as Internet of Things (IoT), blockchain technology, cyber-physical systems or data storage in the cloud (CS - cloud solutions). These concepts are very often discussed, analysed and used in various ways in many industries, including transport. Digitalisation, therefore, is a kind of binder of the traditional form of doing business with its digital equivalent**.**

Big data analysis is an element related to digitalisation. This involves collecting and subsequently calculating huge sizes of data sets over time (Jaworowska, Piątek, 2019). Its use increases the likelihood of efficient, safe and sustainable transport in both economic, environmental and social terms for the transport sector. It can also be used as a tool for forecasting expected events in the delivery process, e.g., the time of arrival of a ship to the seaport or its departure from the seaport. In light of this, the terminal superstructure can be used more efficiently. Intelligent seaports (the so-called Smart Port) and intelligent terminals (smart terminals) connected to each other having mutual access to huge amounts of data allow the development of new products and services. Consequently, the attractiveness and competitiveness of all the ports involved are increasing, giving them a significant advantage over ports and terminals outside the network. The problem that the whole world is struggling with is the phenomenon of congestion (congestion), which is the most serious bottleneck of connections inland. It concerns the formation of congestion in road, rail, sea and air traffic. Big Data analysis can be used to improve responsiveness to communication delays and congestion, which will increase the efficiency of the resources used, reduce financial and time losses. An example of such use can be a digital platform based on common data, enabling the assignment of cargo to different types of transport and facilitating the planning of synchromodal transport.

In today's reality, the best cooperation between links in the transport chain is sought, and even synergy is achieved in order to achieve competitive advantage on the market. The phenomenon of integration within and between chains is increasingly being observed. Various technologies and IT systems that have transformed production efficiency and profitability are useful for the mentioned phenomenon. Transforming the supply chain using digitalisation technology minimises losses and also improves the entire organisational structure.

Digitalisation allows numerous benefits to be achieved in the combined transport industry. The most important of them include better decision making thanks to the transparency of processes, increased flexibility, reduction of inventory costs and reduction of the level of business risk. As a last benefit, surprisingly, the reduction of costs of transport itself is indicated. This may indicate that entities carrying out transports, especially unitised loads in international relations, with a high level of complexity particularly value the support provided by digitalisation in the supply chain management process itself, and not necessarily by reducing their costs. Stability and transparency of the work environment are more important, which in turn gives much greater benefits, including financial ones, than the mere reduction of the costs of clean transport operations.

Like all aspects, digitalisation also has its drawbacks. The implementation of technology and information requires the loss of business entity autonomy. This applies to both the IT sphere of the entity (the need to buy SCM systems from external suppliers) and the dependence of its clients on IT and information enterprises. The digital transformation of logistics, e.g. maritime, is effective only when the subjects of personal data protection and data security play a key role in the implementation strategy. Support for digital applications and technologies requires not only competent users who are familiar with digital innovations, but also secure operating systems to protect against cyberattacks. Digitalisation creates the risk of inadequate use of data, cyberattacks and job losses in some industrial positions (Fruth, Teuberg, 2017). Computers using algorithms may also be exposed to unnecessary errors. It is artificial intelligence, and, in some situations, human intervention may be needed. Real-time data transmission, e.g. of an intelligent container equipped with RFID systems, makes the container location, its content and condition of goods transparent, but it should be considered that many precise data may fall victim to cyberattacks or unwanted data leaks. Another example is autonomous container ships, fully dependent on digital navigation systems that could be manipulated to disembark. A single power failure can also have far-reaching consequences in a digital and networked environment (www.munichre.com).

Information security issues are becoming key, so a separate issue that each entity must develop in the digitalisation process is to ensure an appropriate level of security along with threat analysis and instructions in the event of any of them occurring. This, of course, involves additional costs, which, however, must be incurred.

In view of the complexity of the discussed digitalisation process, it is difficult to clearly demonstrate its profitability in terms of numbers, especially in relation to the expenditure to be incurred on this occasion. Nevertheless, it can be objectively considered that without this process further development of transport, and especially the desire to increase business efficiency, cannot go without it.

An element supporting digitalisation in ports and combined terminals (CT terminals) is the Internet of Things (IoT). It is a communication technology based on the idea of wireless communication between M2M (Machine-To-Machine) devices. It enables the exchange of information, data collection and processing between wireless devices only via a computer network (Kwiatkowska, 2019) or sensory technologies, the computer can receive and identify even incomplete information entered into the network. In cooperation with technologies such as RFID radio identification systems. It is expected that at the end of 2020, with a global population of 7.6 billion, it will amount to about 50 billion devices connected to the Internet. It is expected that at the end of 2020, with a global population of 7.6 billion, it will amount to about 50 billion devices connected to the Internet (Evans, 2019). IoT, together with other technologies, enables you to monitor and control the processes that make up the supply chain in a very accurate manner. Sensors that work with the Internet of Things allow you to create specialised predictions and preventive operations against potential faults. Nowadays, the Internet of Things is considered a compulsory technological concept that will completely change the world and is necessary in the current reality. The development of digital technologies has an indescribable impact on the control and improvement of the supply chain. Coping with the problems of integrity of activities and comprehensive management are among the most common problems of enterprises that they have to deal with. The implementation of an intelligent digital supply chain will significantly facilitate the functioning of the entire transport process. All information received will be transmitted in real time, with full E2E (End-to-End) visibility, and the entire process will be comprehensively integrated from suppliers to final recipients. It is also possible to control traffic in a given part of the supply chain by embedding special control towers in its points, operating as relays. They collect information and then send data in real time, which allows later analysis of the chain.

A network of connected, intelligent seaports and intermodal/combined inland terminals provides significant added value for customers. This can be an overall cost reduction due to factors such as reduced safety inventory (due to increased reliability of supply chains and predictability of delivery dates), reduced transport costs (due to reduced transport time and lower human labor in monitoring delivery). Timeliness and speed of delivery are factors determining competitiveness on the market in the transport industry. Real-time cargo tracking and monitoring of ship systems in the cloud is no longer a future issue, as the remote-controlled or fully automatic ship operation that will become a reality in the near future (Furth, Teuberg, 2019). Currently, the biggest challenge for digital integration of the intermodal chain is to use combined capacity for all modes of transport. Operators compete with each other, and system optimisation seems unrealistic. Data is collected at specific points in the transport chain and can only be exchanged within previously defined entities. Synchromodality or simultaneous use of the full capacity of each transport mode can only be achieved if information exchange barriers are overcome. In pursuit of sustainable development and achieving economic and environmental efficiency of transport and logistics, it is necessary to use assets and resources efficiently and fully. This means completely accessible, transparent intermodal transport services. The long-term goal is the physical internet as a truly integrated transport system. In this respect, a common broadband network will be a factor facilitating the connection of a logistics system that allows the seamless sharing of resources and flow consolidation.

Global seaports, and thus most often global container hubs are of key importance for the global economy. Since 1990, the world container exchange has consistently increased by an average of 8-10% per year. There is also a steady increase in the size of ships, which is a growing number of logistical and technical problems around the world, forcing them to master more and more information each time. Taking this into account, shipping, maritime logistics and generally intermodal supply chains must be subject to the process of digitalisation, and decisions taken by managers must be based on the analysis of data collected in Big Data technology, especially since over 90% of global freight is transported by sea. In quantitative terms, it is over 8 billion tons of goods transported across the sea by container ships, tankers and bulk carriers. Maritime logistics is therefore one of the key sectors of digital transformation.

All participants of maritime transport, thanks to the use of ICT communication technology (e.g., GPS navigation, ECDIS, RFID, AIS and Big Data) have the ability to react early enough in any situation. Moreover, the parties may be informed about activities performed before mooring the ship. Containers are increasingly equipped with RFID radio frequency identification systems, which makes them intelligent (smart boxes). They are fully in line with the created and developed global digitalised transport system. A container equipped with RFID contributes to the sustainable development of maritime transport and significantly improves the transparency and security of international intermodal container traffic. Each terminal vehicle, machinery and equipment involved in the transport, loading and unloading of goods are connected with each other and communicate with each other. This is possible thanks to appropriate information and communication technologies. In back-up relationships, intermodal transport participants receive a synchromodality service, i.e. external and internal integration. External integration boils down to cooperation with systems covering other stages of transport (e.g., sea section). The internal integration covers activities and tasks carried out as part of the container back-up / drop-off process, including the possibility of choosing individual variants for this section. Synchromodality therefore allows for a significant reduction in transport costs and optimal use of transport means while complying with the relevant delivery conditions (Furth and Teuberg, 2019). Based on the concept of the Internet of Things, machines and equipment on board ships can be equipped with sensors and transmitters transmitting data to the computer about the ship's performance, as well as sensors that detect errors before their symptoms occur. As a result, this leads to a consistent repair or replacement of defective systems in the port. The advantage of this is a great saving of time as well as costs that would have to be covered for the arriving technicians and parts for the location of the ship in transit (www.munichre.com).

Another digital innovation is Blockchain technology, i.e. deleting data on the Internet without centralised computers, which stores and transmits information about transactions made on the internet. This information is collected in the form of successive data blocks. Blockchain is a decentralised database storing information and events or contracts between stakeholders in a way more resistant to hackers and more secure in a distributed network infrastructure. It is also considered an indestructible digital book of business transactions that can be programmed to record not only financial transactions, but virtually anything of value. All data can be distributed in a very secure way thanks to the built-in digital encryption. Each transaction in the network is recorded in efficient and scalable blocks, each of which connects to the previous and next to form a chain. However, there is no single or "centralised" copy of the book, but there are many located in a large Blockchain network, with each node performing a cryptographic algorithm in each block. Blockchain's biggest advantage is the transparency of the record, and its transactions are irreversible.

The VGM (Verified Gross Mass) portal was created on the basis of the Blockchain technology, whose originator was the global operator Kuehne + Nagel. The purpose of implementing this concept was to increase the convenience of freight forwarders in completing the VGM declaration, which is required for sea shipments based on the International Convention for the Safety of Life at Sea (SOLAS). All data entered by the portal is accumulated in the supply chain, which makes it possible to use internal Blockchain interfaces in the context of data exchange with third parties (Jurczak, 2019). VGM verification is done before shipment and the load will not be loaded if the VGM document is not checked. A new concept based on Blockchain technology are sea waybills (bills of lading) encrypted in the cloud, the so-called Smart Bill of Lading (SB / L). Enterprises can issue and maintain original waybills on the Ethereum Blockhain network (ie, "a decentralised cloud platform supporting" intelligent "contracts based on applications operating exactly as programmed and without external interference". This is the first fully digital, secure solution created to handle the sea bill of lading (Wisniewska, 2018). In addition, it is effective in terms of labor time and costs.

An interesting example of cooperation based on Blockchain is the case of cooperation between the world leader in container shipping, the Danish company Maersk and one of the oldest IT companies in the world - IBM, in the form of the "TradeLens" platform. The idea of this platform is to increase the efficiency of shipping and throughout the entire supply chain, covering all activities related to the transport of goods and all processes of refining these goods. The intention of the platform creators was to implement digitalisation technology for each stage of global trade and transform it into a tool for communication between chain participants. Thanks to visual data sharing and real-time monitoring, the platform is expected to improve transport management and process control from start to finish. The TradeLens platform is to enable tracking of tens of millions of containers around the world. Information exchange communication and cooperation via digital means is also to operate smoothly between supply chain participants, thus enabling the creation of a transparent and secure transaction record. Platform updates and verifications are to take place on an ongoing basis and any network user can participate in this. CMA CGM, MSC, Hapag Lloyd and One joined the platform in 2019, i.e., most of the world's leading global container shipowners. Ports in Singapore, Hong Kong, Rotterdam have also joined the platform, and from the administrative authorities – Customs Offices in the Netherlands, Singapore, Australia. This clearly demonstrates the high value of this initiative.

Another example of a decentralised transaction platform based on Blockchain is the Deliver system - the fruit of cooperation between three partners: Samsung SDS, ABN AMRO and the Port of Rotterdam. This system is responsible for concentrating all movements in logistics – from booking, monitoring, to waybills and financial issues. It brings great opportunities to digitise the supply chain and full electronic integration of physical, administrative and financial streams to the TSL industry (ABN AMRO, 2019). It reduces the risk of errors and also reduces stagnation and delays in intermodal/combined transport. Deliver is practical and working already on the one hand, a very transparent solution, on the other hand, equipped with many safeguards to protect information.

Another example of digital technology for combined transport support is the Uber Freight application, which was implemented through the port of Rotterdam and which aims to carry out transport without the participation of traditional forwarders. Its essence is to merge carriers and shippers and enable them to contact each other. This is to significantly increase the flexibility and efficiency of the process while reducing costs (even by omitting the participation of freight forwarders) due to the use of spare capacity existing at various service providers by the entity currently having surplus labor. Its operation is based on a specialised algorithm that, after submitting electronic information about the transport service by the shipper, adjusts the appropriate company offering the appropriate service at a given moment. Stages of transport organised in this way can be followed in real time. The main advantages are certainly high efficiency, low commission for the Uber Freight 'digital forwarder', short payment terms (Kulikowska-Wielgus, 2019) and reduction of unnecessary costs for additional delays.

Another example of the strong development of the intermodal/combined transport digitalisation process is the Portchain start-up (2017). It is a digital platform launched in February 2019 to optimise and coordinate connections between seaports and carriers (www.portchains.com), based on the beginnings of artificial intelligence. The platform's founders estimated that as much as 8.5 billion EUR could be saved by optimising port connections using digital communications between shipowners, ports, agents and port authorities around the world. The use of the power of artificial intelligence will dramatically change and improve the operational efficiency of all forwarding companies in the world. The developers of the platform believe in the rapid increase in computing power and efficiency of algorithms that will facilitate planning and searching for optimal solutions. Over the next 6-12 months, Portchain is to conduct pilot projects in several of Europe's largest ports (www.portchain.com).

Strong development of communication, robotics, automation or artificial intelligence technologies has led to the creation of new and better tools supporting production, logistics and transport processes. The binder connecting these areas in combined transport has long been observed in the process of automating transport operations and consists in replacing human work with machines and robots at virtually every stage of the chain. Therefore, we can talk about the automation of loading, trans-shipment, unloading, transport, customs clearance and other formal and legal activities, as well as, as already shown, the sphere of transaction settlement. The main impulses for the development of the automation process in intermodal/combined transport include:

- pressuring to reduce labor costs in order to increase the competitiveness of the operator's and carrier's offer,
- striving to stabilise chain performance by eliminating adverse events resulting from human errors,
- striving to increase the productivity of given resources in the company, and
- improving security.

Automation in terminals is defined as the use of integrated technology to develop intelligent solutions for effective control of traffic and cargo flows in the terminal, while increasing their capacity and efficiency. Automated terminals implement cloud solutions-based software in their operations to support the creation of operational flows that enable smooth operation of seaports. The increase in the volume of maritime trade has forced a new approach to the development of seaports towards the so-called Smart Ports, i.e., smart ports. This term is understood as the organisational level of the entire port as an economic entity in which its individual elements function in an integrated, automatic and learning manner in order to constantly improve the quality and adaptation of services provided at the port. The degree of their automation varies depending on many factors, e.g. location, transport accessibility from the back, infrastructure quality, capacity, load structure, and finally economic value (www.shmgroup.com). The basic principle of automation is process orientation requiring integration in the entire chain of terminal systems and key interfaces. The idea of automation should not be based solely on running old processes with new automated equipment. The first step towards change should be the redesign of the operational model.

Automation processes in intermodal/combined transport, apart from the advantages mentioned above, are characterised by a significant threat in the area of cybersecurity. This is particularly important in seaports and trans-shipment terminals as well as in the aspect of dangerous goods turnover. Automated systems controlled by IT & ICT are susceptible to software attacks and the loss of confidential data. Processes implemented may also be modified in undesirable directions in order to e.g., carry out a terrorist attack. The violation of security can cause interruptions in supply, destruction of cargo or even contamination of the environment, as well as damage to the health and life of people. Potential losses can be large. In addition to this risk, the disadvantages of the automation process include the relatively high cost of capital investment, which can be a barrier, especially for entities located in underdeveloped or developing countries. Automation, by eliminating the human factor involved in all work processes, significantly reduces the number of jobs, which in turn negatively affects local labor markets and generates negative social effects. Automation also means high maintenance costs, and automated systems must be updated at regular intervals. Ignorance of software updates can lead to serious security breaches. Due to the development of automation and the implementation of its technology in transport systems, the demand for specialists in the fields of IT, mechatronics and automation is also growing significantly.

Despite these drawbacks, it is becoming increasingly common to invest in technologies that automate the handling of loads and means of transport, especially in the field of containerisation. Over the next five years, as many as 60 automated container terminals are to be built, with handling potential of approximately 90 million TEU / year (Frankowski, 2019). Rotterdam port seems to be a pioneer in this area, where as early as in the 1990s a container terminal with a high degree of work automation was put into operation (Matczak, 2019). Both automated and semi-automated container terminals commonly use AGV (automated guided vehicles), i.e. automatically controlled vehicles to and off containers for cranes, and ALVs (automated lifting vehicles), which are automatically controlled lifting vehicles; A-RMG, i.e., automatic lifting devices and AShC which are automatic backhoe trucks.

In the same port in 2008, the Euromax container terminal was launched, considered one of the most advanced and environmentally friendly container terminals in the world, designed for fast, safe and efficient handling of large container ships. The fully automated process of reloading, container handling, control and directing the movement of vehicles at the gates, as well as a modern and fully automated truck service system fulfill the definition of a smart port. Truck drivers are equipped with appropriate electronic cards that enable them to enter the terminal without leaving the vehicle unnecessarily. The whole service process - from the moment the container is taken from the ship by the STS container crane and its automatic transport to an automatically controlled AGV trolley, to a storage yard served by A-RMG rail gantry cranes, which transport it to the appropriate sector and storage location - is automated. Each container is automatically adapted to its sector, through the most modern terminal operating system, transmitting relevant information to the crane. It is also possible to automatically transfer the container to railway wagons using a crane (Kaup, Chmielewska-Przybysz, 2014). Efficiency and error-free operation are supported by automated measuring systems equipped with sensors detecting any obstacles, determining the exact position of the load during transport by an overhead crane, as well as the target container location. The crane spreaders are equipped with cameras equipped with infrared sensory transmitters and operating with great precision up to several millimeters.

An interesting case in this respect is the Container Terminal Altenwerder - CTA (Hamburg), the first automated container facility in Germany, where manned operations are limited to the safe minimum (only STS operators). Loading containers to AGV's, moving them to the yard and storage is fully automated. In 2018 CTA ordered 90 electric AGV (eAGV) to substitute old ones and finally move towards CO_2-neutrality. Only this investment is expected to save CO_2 emissions by 15.000 tonnes annually and NO_x by 118 tonnes. PM's, SO_x, noise and other pollutants are not measured but also expected to be reduced significantly. In the energy dimension It means an increase in demand for electric power of up to 4 MW, which will be delivered by dedicated plugging stations. A single charge should take only 1,5 h. This project is co-financed by the EU with 8 million EUR of ERDF.

One of the innovative methods of automation is the RCMS (Robotic Container Management System) system created by the Israeli company Israel Aerospace Industries. This system is responsible for a modern, automated method of container storage. With the increase in container traffic, each participant involved in the movement of containers faces challenges related to the increasing number of operations and decreasing free storage space. Its basic element is the skeleton structure of the building, located parallel to the waterfront line, with a maximum height of up to 15 floors. Thanks to this spacing, the system reduces the storage area in container terminals by up to 50%, increasing the capacity of the terminal, guaranteeing a higher speed of unloading containers with optimal use of all available storage places (www.iai.co.il). This concept is based on handling only 20’ and 40’ containers (currently no space is allocated for containers of unusual dimensions) in properly adapted sockets, which minimises the process of unification of operations. Separate operations are performed for empty containers. The extreme sides of the RCMS construction are intended for the storage of refrigerated containers. The mechanism of placing containers in the appropriate nests is done by means of robotic AGV trolleys, which move in two axes (X, Y). This design also has special elevators for vertical movement of motor vehicles. An advanced, state-of-the-art command and control centre using algorithms developed by IAI provides constant, autonomous process supervision by operators. Loading stations for trucks and trains operated by OHBC (Overhead Bridge Crane) have also been improved. Investment costs regarding the construction of the structure itself as well as the entire technical facilities in the form of vehicles, elevators and OHBC are a significant obstacle to the implementation of RCMS (Matczak, 2019).

According to the CEE Transport and Logistics Trend Book 2019 report presented by PwC, the next five years for the entire part of Central and Eastern Europe will be a period of enormous changes. The report presents five leading forces that are to have the greatest impact on TSL industries. Digitalisation is considered the most influential, the other four are: shifts in international trade, software solutions, internal changes in trade and solutions in the field of machinery and equipment (www.dlahandlu.pl).

Current digitalisation solutions are mainly inspired by consumer behavior, the scope of access to technology and the economic potential of the implementing entity. Access to the broadband internet enabling technology development is considered as basic. The survey conducted in 2017 (Digital IQ Survey) shows that for 54% of respondents recorded an increase in revenues from digitalisation, and 16% expect a digitalisation of increased profits. For 11%, digitalisation also means greater opportunities to meet customer requirements (PWC, 2019). Therefore, investments are important here - in order to reap later economic benefits, enterprises must allocate larger sums of capital to the implementation and development of digitalisation.

The global intelligent transport system (ITS) market on roads is expected to reach over USD 72.3 billion by 2022. By 2021, the global market for process automation is expected to reach over USD 1.2 billion. Solutions in the area of machinery and equipment will bring business benefits in the form of better control of processes and human behavior, ultimately leading to the improvement of service quality.

Thanks to them, unnecessary maintenance costs and errors in routine processes will be removed. Development of Robotic Process Automation (South Africa) is expected will have a big impact on transport and logistics. For example, it can be used as a tool to automate and support companies operating in various branches of transport and logistics. Every company is under great pressure to digitise and automate all aspects of its business. South Africa is the simplest, fastest and most efficient way to provide and improve information from any sources (e.g., systems and applications). South Africa is able to work in parallel with employees, eliminate the risk of errors and the need for continuous, manual updating of data (www.kofax.com). South Africa's operation is based on machine learning and artificial intelligence to be able to correctly understand contexts and automate processes. Also uses natural language processing (NLP – neurolinguistic programming) for better interaction. South Africa is also very popular in SCM supply chain management. Chain participants can adapt to consumer requirements faster and increase the scale of their operations thanks to automated systems. It is also a great financial burden for enterprises, which employees carrying out repetitive tasks of low value can be transferred to positions requiring improvement and strategic activities. South Africa eliminates errors and duplication in the supply chain, resulting in higher quality of service and streamlined processes. Thanks to the previously reported identification of warehouse needs, you can replenish your inventory faster, which translates into timely performance of services along the entire chain (www.blumeglobal.com).

5 SUMMARY AND RECOMMENDATIONS

Summary

The report consists of two general parts – a basic benchmark analysis and in-depth analysis of selected issues related tot he terminal operation.

As mentioned at the beginning, the most important problem was to collect appropirate data for all terminals to ensure coherent and complex analysis.

The analysis shows that terminals are an integral part of general transport system. In BSR, including nine countries, there are 150 terminals in operation. The largest number of CT terminals are located in Germany (51), Sweden (32) and Poland (30). The smallest number of CT terminals are located in Estonia (2), Finland (4), Latvia and Lithuania (6). It follows that the terminals are mainly located close to international traffic routes. This means that land terminals are mostly located in the TEN-T corridors and near large agglomerations, at the crossroads of major roads. CT terminals located outside the TEN-T network are located on national trade routes. It follows that the preferred solution is to locate the terminals at the intersection of the urban road ring road with the main railway line. In port cities, a large part of the turnover of terminals is made up of sea transport loads, hence their location as close as possible to the port area. Port terminals are most often served by lines connecting Baltic ports and are located in the largest Baltic seaports, thus having a close correlation with other port cargo turnover. The analysis also shows that large urban agglomerations have several terminals - logistics centres and/or a network of sub-centres located closer to the final recipients of goods. The average number of CT terminals per 1,000,000 inhabitants for the region is 1.0, while the average number of CT terminals (units) per 100,000 km^2 for the region is 8.59.

There is a clear divission between seaport terminals, which serve another trade relation and inland (rail-road) terminals serving rather horizontal trade relations. Further conclussions can be formed in the following list:

- Public accessibility of CT terminals is not obvious and there are 25,6% terminals with restriced access;
- Small share of publicly accessible terminals is in Germany (31%), while in Poland 50% The most restrictive countries in this case are Estonia and Latvia. 100% of ports are not available for public.
- Most popular operation model is fully in-house (64%, 83 CT terminals);
- Second popular is rental agreement for commercial operation (19%, 24 CT terminals);
- Third popular is operating contract (15%, 19 CT terminals);
- Concessionj very rarely used, actually only in Sweden (2%, 3 CT terminals);
- 100% operation model as rental agreement for commercial operation in Estonia and Latvia.;

- 100% operation model as fully in-house in Russia and Lithuania;
- Dominant operating model as fully in-house in Germany, Poland and Sweden;
  High share of rental agreement for commercial operation in Poland (12 of 30 CT terminals);
- High share of operating contract in Sweden (12 of 32 CT terminals);
- 91% of BSR CT terminals are ready to storage of containers and general cargo;
- 77% of BSR CT terminals are ready to storage and handling of reefers;
- 100% of BSR CT terminals are ready to storage of dangerous goods;
- No correlation observed between the service of weighing of wagons/loading units and TEN-T network;
- No correlation observed between the service of weighing of wagons/loading units and RFC;
- Correlation between storage of containers / general cargo service and TEN-T network observed;
- None RoLa units/services in volumes handled in 2018 in BSR CT terminals;
- RoLa not accepted in Latvia at all;
- No correlation observed between RoLa acceptance and TEN-T network nor RFC;
- Loading /unloading / trans-shipment: 100% basic service in Estonia and Latvia;
- Loading /unloading / trans-shipment: 100% basic + additional + ancillary service in Lithuania, Finland and Russia
- Total BSR CT terminals yearly turnover exceeds 7,5 million of TEU (equivalent number for all cargo units);
- Highest share for Poland, where one terminal – DCT Gdańsk – represents 1.9 million TEU volume a year. Sum of Polish seaport terminals container turnover exceeds 2,.7 million TEU;
- In calculations were included also Russian terminals, which all are located in seaports and service yearly ca. 1.3 million TEU;
- Also, in other BSR countries the volumes handled are influenced by seaports;
- The highest average turnover per terminal is in Russia (669 500 TEU);
- The lowest average turnover per terminal is in Estonia (11 268 TEU);
- An average result per terminal for the whole BSR equals to 52 thous. TEU, and when corrected by eliminated DCT high score, the value falls to 39.8 thous. TEU. Further on, corrected by DCT and Russian terminals, the average BSR volume handled is reduced to 32 152 TEU a year;
- 100% containers at CT terminals (2018) in Lithuania, Estonia and Russia. In other countries the structure of units serviced includes also trailers and swap bodies, but in a very limited dimmension;
- BSR CT network bases on large number of terminals, basicaly distinctively twofold: seaport terminals for sea-land CT, and inland terminals, serving rail-road relations and, additionaly also seaport hinterland services;

- Althought most common size of BSR CT terminal is large and small at the secon place, the median volume handled is between 80,000 and 200,000 TEU per year;
- Large number of terminals in Sweden results in broad spatial distribution between specific terminals and relatively small average yearly turnover in this country;
- The results obtained are overstated by seaport terminals turnover – specially in Poland (due tot he biggest Baltic container hub) and Russia (a large number of container terminals and no inland terminals);
- Vast majority of BSR CT terminals are servicing containers. Servicing semi-trailers is quite common, unlike swap bodies, which are serviced rarely;
- Type of cargo unit is strongly correlated to the trade's relation: seaport hinterland services are dedicated to container traffic, also Euro-Asia trade line generates container flow. Semi-trailers are the result of intra-Baltic and intra-European trade exchange, appearing in ro-ro and ro-pax shipping lines and their hinterland flows, as well as horizontal transport on East-West corridor;
- The average size of the CT terminal in the BSR is 183,743 m^2 (18,4 ha);
- This corresponds to a storage capacity of approximately 7,900 TEU, but in reality, this capacity measured in container slots is much lower;
- This average is overestimated by port terminals, which are approximately 3 to 4 times larger than the land terminals in the BSR;
- The smallest average terminal areas are in Finland, Lithuania and Sweden;
- The highest average terminal areas are in Denmark and Russia (with only seaport terminals analysed in Russia);
- The average storage area needed for a storage capacity equivalent to 1 TEU is 23.3 m^2, with two important correlations: port terminals, despite storing containers in a larger number of layers (which underestimates the consumption rate of m^2 per 1 TEU), require more space per balance for the movement of larger cargo handling equipment and thus overestimate this rate, while land terminals, despite their smaller size, make better use of available storage areas for cargo units;
- The average size of a terminal in the BSR is between 50,000 and 70,000 m^2, while in TEU units it is 2,000 - 3,000;
- Interesting are average values of terminals areas for all BSR terminals, where only Lithuania terminals oscillate around 50,000 m^2 and all other exceeds 100,000 m^2 (except Sweden with average area of 93 thous. m^2);
- The average number of tracks in one terminal for the whole BSR equals to four;
- The most common number of tracks (dominant feature) is two;
- high number of rail tracks plays important role for seaport terminals, especially the largest ones, which export to the hinterland up to 35-40% of containers by rail;

- The average small inland terminal is served by two tracks, with a fairly short length of up to 450 m;
- The longest trains are allowed in Sweden – up to 950 m;
- The smallest discrepancies are found in the German terminals, where it is standard to be able to handle freight trains up to 700 m long. Terminals in other countries show very big differences, both spatially and generically and allow handling sets from 300 to 650 m long;
- In the BSR the average number of gantries per one terminal is 4.4;
- The extreme values of this parameter for individual countries range from 0.3 (in Sweden) to almost 25 (in Russia, but only port terminals were included in the analysis, with the largest ones in St. Petersburg, which significantly disturbs the region's average);
- As many as 61 terminals in the BSR do not have any gantry and are mostly small or medium sie CT terminals;
- A typical arrangement for a small inland terminal is one crane or one or two reachstackers instead;
- In inland terminals equipped with gantries, there is an average of 1,000 - 2,000 TEU of storage capacity per one gantry, with a maximum of 50,000 TEU in extreme cases;
- Port terminals equipped with cranes have an average storage capacity of 3,000 - 3,500 TEU per crane station, with a maximum of 75,000 TEU (Ventspils) in extreme cases;
- The average number of mobile cranes in BSR terminals is 3.1;
- This value is very significantly influenced by 440 devices in Germany alone and 100 in Poland; in the other BSR countries the total number of these devices oscillates between 13 and 19; only Estonia shows a total of 3 such devices;
- The national averages also show large disparities, ranging from 1.3 (Sweden) to 11.9 (Germany);
- These are mainly reachstackers, less mobile cranes or straddle carrier - these are very rarely used in terminals of universal character or with the lowest infrastructure development threshold;
- The highest average of storage area is in Russia and Denmark;
- The lowest average of storage area are Lithuania and Finland;
- The highest average number of gantry cranes are in Russia and Poland, the lowest in Sweden and Denmark;
- The highest average number of mobile cranes are in Germany and Finland, the lowest in Estonia and Denmark; and
- A typical BSR inland terminal bases on maximum one gantry crane or without gantries, but equiped with at least one reachstacker.

Recommendations

As announced in June 2020, on the North Sea – Baltic Corridor in the enxt future will be derived a huge budget for railway projects of ca. 44 billion EUR. Another 39.5 billion of EUR will be dedicated to orad investment and 11.6 billion EUR for maritime related infrastructure development (www.railfreight.com). And this is only fort he NSB Corridor. BSR bases also on the Baltic – Adriatic Corridor, which is of smaller scale, but still needs to be developed too. Generally, TEN-T network hast o be compliance to the TEN-T technical regulation and meets strategic goals (i.e., whole network should be coveraged by 83% of ERTMS, electrification, track gauge and train length and by 96% in terms oft rain speed).

From the market point of view, the demographic and economic growth will lead to increase of trade and, consequently, to transport demand. In the context of the White Paper 2011 goals, including The New Green Deal 2019, future shape oft he European and BSR transport system it cannot be realised on the cost oft he publicity and environment and should strongly intense the rail and waterborne transport modes.

The combined transport system needs to be developed as the best way to combine between rail and waterbourne transport capacity and road transport flexibility by the lowest external effects.

This report should help to understand the importancy of combined transport terminals in the BSR transport system. It indicates a lot of technical and legal details characterizing regional specifity and standards. And this should also help by the decission process of investing funds not only for the rail tracks, but also for combined terminals, which actually are at most important for the CT effciency (according tot he rule – the whole chain is as strong (efficient) as ist weakest link. And the weakest link mighth be a terminal or the number of CT terminals located in specific corridor.

Basing on conclussions from the current benchmark analysis there are some few important recommendations fort he future CT development in the BSR:

1) Supporting research and development by implementation of propper statistical reporting system as an accurate source of data;
2) Including trade relation specifity, more focus on inland terminals should be given rather than on seaports terminals;
3) Including specifity of the BSR, more small and medium size CT terminals should be located, instead of large or very large ones;
4) The ownership of the terminal should not be limited to the operator – national or regional interests arguing for public participation in the infrastructure development;
5) The operation model for the CT terminal should be free to select for the operator in terms of local, national and international competition and market conditions;
6) Public accessibility of the rail network should be ensured in terms of tracks but can not be forced on private owned terminals. But, allthought, some incentives can be introduced to the operator for opening his capacity to the others;
7) To support CT terminal operators, a general fund should be diverted to the research and development of new, innovative and green technologies in terms of energy consumption (supporting electrification of terminals' equipment, implementing energy-saving propulssions, alternative fuels and RES implementation for energy production on site); and

8) To support differntation of cargo units and related technologis, especially horizontal ones on those relations, where the traffic is not sufficient for commercial implementation. Additionally, also expanding the scope of terminal activity, and improve the quality of provided services.

6 LIST OF TABLES AND FIGURES

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