ANALYSIS OF THE TECHNOLOGICAL AND SPATIAL NEEDS OF THE MULTIMODAL FREIGHT TERMINAL RAIL BALTICA AT MUUGA HARBOUR (MCTRB)

Work Packages 2-4

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Report

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1. WP 2.1 Identification of terminal functions and technological needs

1.1. Identification of terminal functions

The aim of WP 2.1.1 is to clarify the functionality of the multi-modal cargo terminal by studying following areas of questions:

- Existing traffic analysis
- Existing expectations
- Transport modelling results
- Limitations and restrictions

The analysis of the existing traffic (inbound and outbound transport flows by transport modes) at Muuga harbor allows to get the picture to the current transport situation (volumes, exchange flows) and to reveal the utilization level of the existing facilities. The key question here is to understand, whether the capacity of the current facilities (liquid bulk, dry bulk, general cargo, container terminal, RoRo) will be able to handle the forecasted demand.

The existing expectations towards terminal functions' of different stakeholders (logistics service providers, shippers, existing terminals' operators, port authority) provide the direct customer' wishes and enable to control, whether all of the planned functions are covered.

Based on the results of WP1 (forecasting), a decision can be made, which service functions are desired and required. Finally, possible spatial and functional limitations (e.g. free zone, spatial distances, crossing opportunities, 1435-1520 transshipment) in the investigated potential locations of the port area enable to get the first insights into the feasibility of service offering.

In following, the main results of the work package 2.1.1 "Identification of the terminal functions" are presented.

1.1.1. As-Is situation of the terminal operators in Muuga harbour

The aim of the As-Is analysis is to analyse the current situation in Muuga harbor based on the information from Operators located in the port while taking into account results of WP1. To reach this goal, an accordant questionnaire was prepared and sent to the Operators. Based both on the operators' replies and on statistics from Port of Tallinn the facilities in port of Muuga were analyzed.

The structure of this section is as following: firstly, the overall situation with the flows dynamics from 2003 till 2016 is presented; secondly, commodity groups are analyzed through the prism of transportation modes distribution and facility utilization rate; finally, the results of the analysis are presented with the help of figures which demonstrate the structure of inbound and outbound flows. The structure of in-/outbound flows is presented in comparison to the forecasted in WP1 freight volumes in 2055. Please note, however, that figures in this report differs from WP1 in years 2050-2055, because it does not assume the construction of Helsinki-Tallinn tunnel, unlike WP1.

Moreover, in this section analysis of potential information and management systems is conducted. The main requirements for information systems are determined.

To the moment 19 operators manage material flows in Muuga harbor. The main operators participated in the questionnaire and provided data regarding their business activities. That is, more than 80% of the total volume was covered. For some commodities groups, because of data absence, some assumptions were made. Table 1 demonstrates the key information about the operators (managed freight type and commodity group).

Table 1 Key information about Operators

Operator	Freight type	Commodity group
Vesta Terminal	Liquid bulk	Crude petroleum, petroleum products and gas

Operator	Freight type	Commodity group
VOPAK EOS AS	Liquid bulk	Crude petroleum, petroleum products and gas
AS Coal Terminal	Dry bulk	Solid mineral fuels
AS Inflot	Container	Foodstuffs, Animal food and Foodstuff waste, Oil seeds and Oleaginous fruit and Fats
		Miscellaneous articles
	Dry bulk	Natural and Chemical fertilizers
AS DBT	Dry bulk	Natural and Chemical fertilizers
	Break bulk	No data
Alekon Cargo	Break bulk	No data
	Mixed freight	Metal product
	Container	No data
AS Komerk	Break bulk	Wood and cork
	Dry bulk	No data
	Mixed freight	Metal product
	Container	No data
AS MGT	Dry bulk	Cereals, fruit and Vegetables, Live animals, Textiles, Other raw materials
AS Nynas	Liquid bulk	Oil and oil products
ITT Baltic OÜ	Break bulk	No data
	Mixed freight	Metal product
Transiidikeskuse AS	Container	Miscellaneous articles
	Mixed freight	Metal products
	Break bulk	Wood and Cork
	Dry bulk	Natural and Chemical fertilizers
	Dry bulk	Cereals, fruit and Vegetables, Live animals, Textiles, Other raw materials
AS Oiltanking Tallinn	Liquid bulk	Oil and oil products
AS Stivis	Dry bulk	Crude and Manufactured minerals, Cement, Lime and Manufactured building materials
ArcelorMittal Tallinn OÜ	Heavy cargo	Metal products
AS Sankotrans	Container	Foodstuffs, Animal food and Foodstuff waste, Oil seeds and Oleaginous fruit and Fats
Katoen Natie Eesti AS	Container	Foodstuffs, Animal food and Foodstuff waste, Oil seeds and Oleaginous fruit and Fats
Neste Eesti AS	Liquid bulk	Oil and oil products
Hoidla tee OÜ	No data	No data
ExpoGroup OÜ	No data	No data

There are six freight types which are handled in Muuga harbor. The main type is liquid bulk type (56% of total cargo turnover in 2016). Other types have much less shares – dry bulk (26%), containers (15%), general cargo (2%), non-marine (0,1%) and Ro-Ro (the activity has stopped since 2011).

Reviewing the statistics for previous period, Muuga harbor's freight turnover fell year by year. In comparison to 2010 in 2016 Muuga harbor freight turnover decreased by 61% or by 18.333.499 tons[1]. The Figure 1 and the **Table 2** demonstrate this negative trend through the lens of freight types.

[1] Statistics from Muuga turnover dynamics 2010-2016 from Port of Tallinn

Figure 1. Dynamics of material flow of Muuga harbour from 2010 to 2016

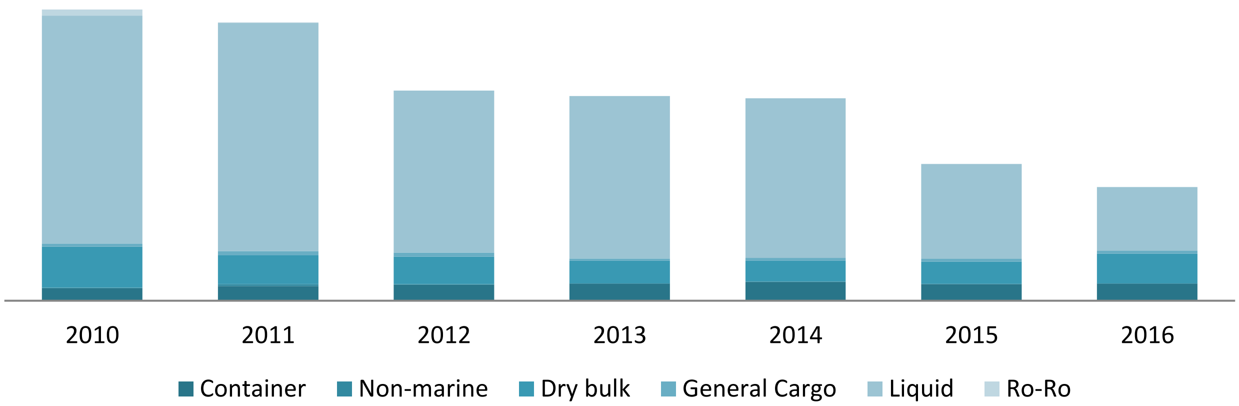


Table 2 The Muuga's freight turnover within 2010-2016 in thous.tonns

	2010	2011	2012	2013	2014	2015	2016
Container	1.290	1.515	1.629	1.764	1.945	1.715	1.762
Non-marine	48	194	66	12	17	18	8
Dry bulk	4.241	2.971	2.875	2.347	2.155	2.285	3.100
General cargo	311	439	368	241	294	318	280
Liquid	23.545	23.552	16.749	16.773	16.502	9.789	6.592
Ro-Ro	641	63	0	0	0	0	0
Total	**30.076**	**28.736**	**21.687**	**21.137**	**20.911**	**14.124**	**11.742**

The only one freight type demonstrated positive tendency was container freight flow which increased steadily (excepted the drop in 2014). The more detailed information for different freight types is presented in the **Table 3**[2].

Table 3 The absolute and relative changes in Muuga's freight turnover within 2010-2016

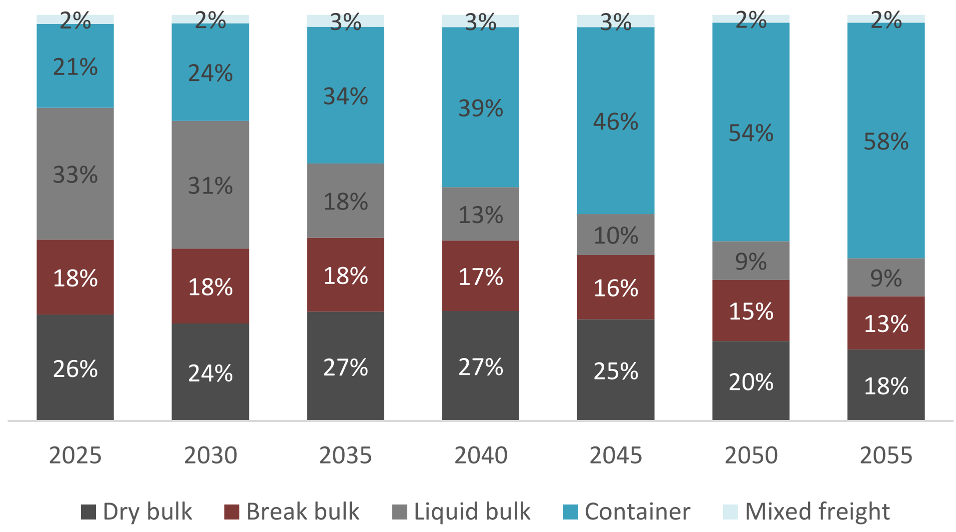
Freight type	Absolute change in 2016 vs. 2010, tons	Relative change 2016 vs.2010, %
Container	**+ 471.654**	**+ 36.56 %**
Non-marine	**-39.610**	**- 82.85 %**
Dry bulk	**-1.140.851**	**- 26.90 %**
General Cargo	**-30.930**	**- 9.94 %**
Liquid	**-16.952.864**	**- 72.00 %**
Ro-Ro	N/A	N/A

[2] Statistics from Muuga turnover dynamics 2010-2016 from Port of Tallinn

It should be pointed out that the main freight type – liquid bulk freight type – has decreased by 72% in comparison to 2010. During the reviewed period the annual average decline of liquid bulk was 17%.

According to the results of WP1 the structure of handled freight types is going to change significantly (see the Figure 2).

Figure 2. Dynamics of freight types shares from 2025 to 2055



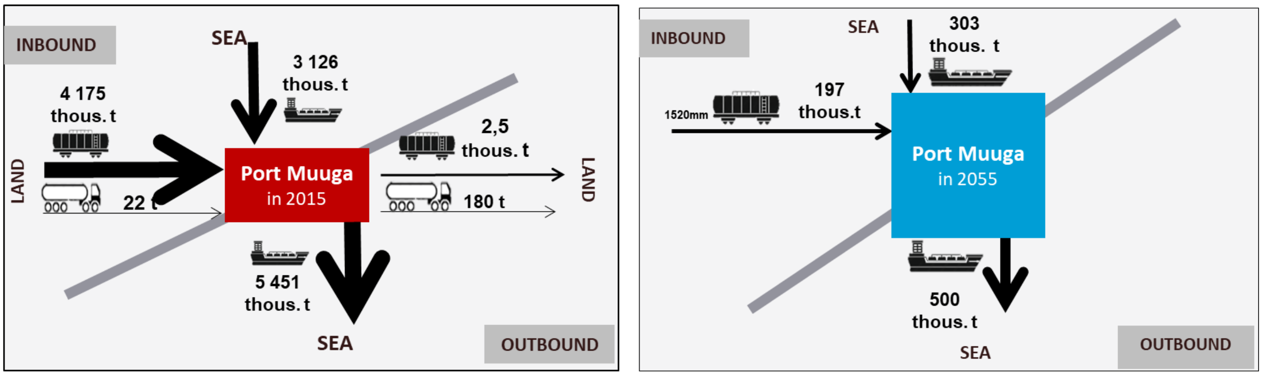
The structure of handling freight flow in 2025 is going to be the following: dry bulk (26% of total freight volume), break bulk (18%), liquid bulk (33%), container (21%), mixed freight (2%). It is important to mention that the structure is going to change within the forecasted period (till 2055). The share of mixed cargo freight type will be quite stable (2%); container freight type is going to increase steadily (from 21% of total volume share in 2025 to 58% in 2055); share of liquid bulk is going to decrease (from 33% in 2025 to 9% in 2055); the decrease in freight volume share is expected for break bulk/general cargo freight type (from 18% in 2025 to 13% in 2055); as forecasted in WP1, the share of dry bulk will decrease (from 26% in 2025 to 18% in 2055).

The further analysis of the internal Muuga flows is based both on operators' answers and assumptions which were made where necessary. In addition, the results of WP1 are also used to point out the forecasted development of commodity groups.

Before presenting the results of freight flows' analysis it is necessary to clarify the used term "facility utilization". The utilization rate presents an average utilized capacity of the storage facility per year. For example, if the average utilization rate is 10% this means that during reviewed year the storage facility was full on average by 10%. Thus, in other words this is the average inventory level of the reviewed facility.

The first reviewed commodity group is Crude petroleum, petroleum products and gas. This commodity group accounted 69,4% of total Muuga harbor's cargo turnover in 2015. Four operators handle this type of the cargo – AS Oiltanking Tallinn, Vesta Terminal, Vopak EOS AS, AS Nynas, Neste Eesti AS. AS Oiltanking (5% of total storage capacity of the reviewed commodity group) did not provide the information regarding flows distribution, thus, only four operators were analyzed. Data from the operators (Vesta Terminal, Vopak EOS AS) is for 2015 due to the reason that one of the main operators is not allowed to provide information for 2016 due to confidentiality reasons. Thus, the analysis was conducted for 2015. The resume of in-/outbound flows structure is presented in the Figure 3.

Figure 3. The structure of material flow for Crude petroleum, petroleum products and gas



Transport modes distribution. Oil and oil products during 2015 were delivered by rail (57%) and by sea (43%). The polar opposite situation is with outbound flow which is mainly handled by sea (more than 95%).

Facility utilization. Based on received answers from operators and own analysis it should be mentioned that the demonstrated utilization rate of facilities was very high during the reviewed period (from 83% till 94% for different years). In addition to this notice, it should be pointed out that Muuga harbor increased the facilities' capacity year by year. In 2006 the increase of m^3 was 65% in comparison to 2003. In 2008 the increase of m^3 was 76% in comparison to 2006. When evaluating answers of Operators it is possible to see the significant increase of facility capacity during the reviewed period by 211% (from 414 thous. m^3 to 1.558 thous. m^3). Instead of this positive trend (increase in capacity and high utilization rate) it should be beared in mind that the flow decrease took place after 2008 because of the drop of the oil and oil products from Russia. The reason why the utilization was still high is the increase in storing days, which also explains the business model of the terminals – storage of oil due to speculation purposes.

Further development. Based on WP1, this commodity group will decrease its absolute volume by 25% in 2025 in comparison to 2015. After such significant drop the increase till 2030 is expected (by 27% in comparison to 2025). After 2035 the significant drop year by year is forecasted (annual average drop is 10%). As a result, the absolute volume of handled commodity group will reach 500 thous. tons (vs. 7.323 thous. tons in 2015). Thus, there are sufficient facilities at Muuga's disposal to handle the decreased number of the reviewed commodity group (Muuga can handle now annually 40.000.000 tons of the reviewed commodity group). The inbound flow is going to change and be delivered mainly by sea (61%). Structure of the outbound will also change –sea (100%).

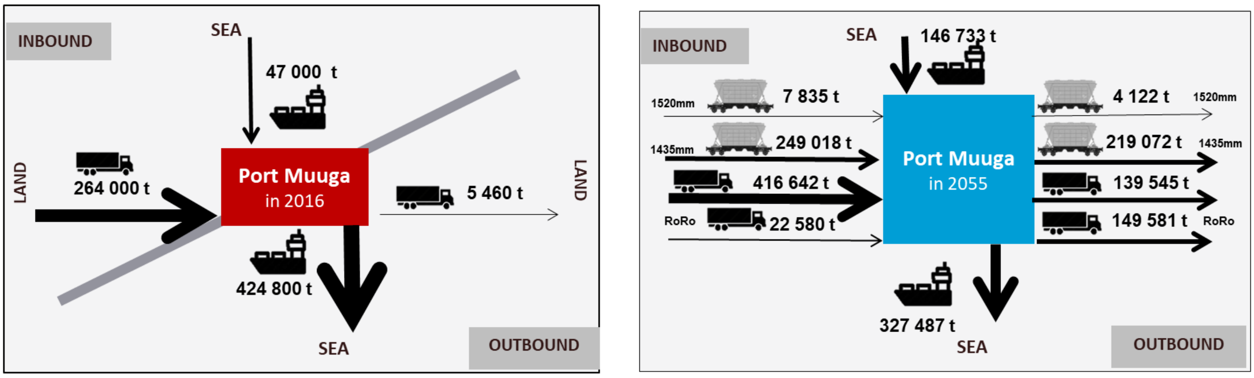
The second reviewed group is **Cereals, Fruit and Vegetables, Live animals, Textiles, Other raw materials**. This commodity group (grain and other seeds) accounted 2,7% of total Muuga harbor's cargo turnover in 2015. Two operators manage this type of commodity - AS MGT and Transiidikeskuse AS. The resume of in-/outbound flows structure is presented by the Figure 4.

Transport modes distribution. The distribution of transports modes used for this commodity group differed year by year. In the beginning of the reviewed period (2003-2006) transportation of inbound flow was mainly by rail (at least 85%) and outbound flow – by sea (more than 95%). After 2003 the continuous fall in the flows was demonstrated. This decrease was till 2016 (annual average decrease was 35%). In 2016 the increase in the flow was demonstrated (+77% vs. 2012). The structure of used transportation mode was changed. In 2016 the majority of inbound flow (approx. 85%) was handled by road, outbound flow saved the tendency – sea predominated (more than 95%).

According to information provided by AS MGT until 2008-2009 about 80-90% of Estonian grain has been delivered by rail. The rest – by road. Since then approximately 100% is delivered by road. The reason of switching from rail transport mode to road was the increase in rates of Estonian Rail.

In 2055, 840 thousand tonnes of cereals, fruit and vegetables, live animals, textiles and other raw materials are forecasted to move through Muuga Harbor. Regarding RoRo part, 22.6 thousand tonnes of it is forecasted to arrive to Muuga Harbor in 2055 on RoRo. 47.5% of this amount will be transported away from Muuga on RB, while the remaining 52.5% will be carried away on road. In terms of outbound RoRo, the total flow for this commodity group is 149.6 thousand tons. Outbound RoRo is significantly bigger than inbound RoRo for this commodity group, because the goods that are transported away from Muuga on RoRo come predominantly on RB (73.5%) and road (26.5%).

Figure 4. The structure of material flow for Cereals, Fruit and Vegetables, Live animals, Textiles, Other raw materials commodity group



Facility utilization. The capacity of facilities did not change during the reviewed period. The utilization rate reached the maximum in 2003 (55%) and minimum in 2012 (12%). In 2016 the average utilization rate was 26%.

Further development. Based on results of WP1, the share of this commodity group is going to increase. The biggest increase is forecasted in 2035 (by 17% in comparison to 2030). The share of this commodity will increase and remain relatively stable during the reviewed period (from 1% in 2015 to 3,3% in 2055). The absolute amount will reach 840 thous. tons in 2055 (vs. 182 thous. tons in 2015). Based on the information from open sources, the main Operator (AS MGT) is able to handle 5.000 thous. tons annually. Thus, there is sufficient capacity at disposal. As presented by the Figure 4, for inbound flow the road mode will prevail as it was in 2015. In addition, the structure of outbound flow will stay relatively the same – the main share will be transported by sea (39%).

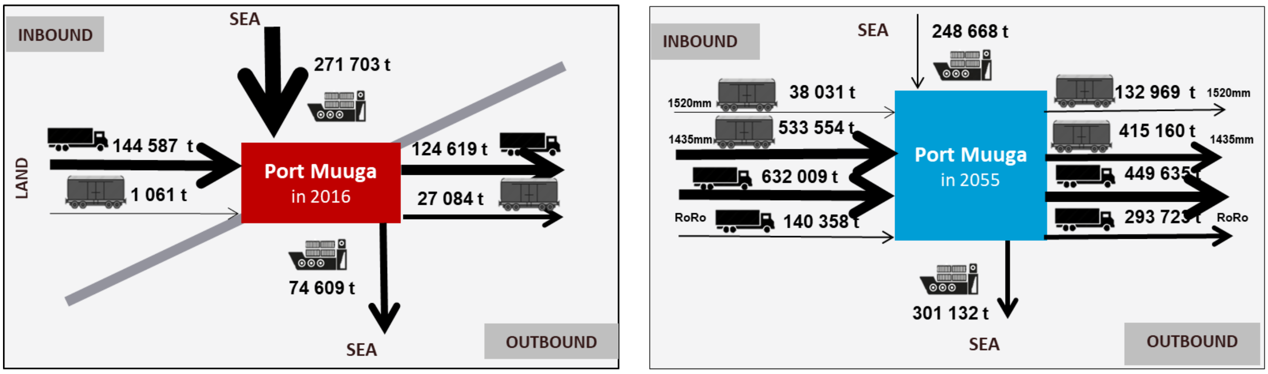
The next reviewed commodity group is **Foodstuffs, Animal food and Foodstuff waste, Oil seeds and Oleaginous fruit and Fats.** This group amounted 0,2% of total Muuga harbor's cargo turnover in 2015. Three operators indicated this commodity group as their business activity - AS Inflot, Sankotrans AS and Katoen Natie Eesti AS.

The food and beverages are delivered in containers. The main food commodities are cocoa beans and cocoa products which are transported in bags.

Transport modes distribution. The only one Operator handles containers - Transiidikeskuse AS. Other Operators begin manage their material flow from the container terminal (in most cases containers are delivered to other Operators from the container terminal by road). Based on information from Transiidikeskuse AS, 65% of total inbound flow was handled in 2016 by sea, remain part – by road. Meanwhile, by road was handled more than half of outbound material flow (55%), by sea - 33%, by rail – 12%. The transport modes distribution is presented by the **Figure 5**.

In 2055, 1.59 million tonnes of foodstuffs, animal food and foodstuff waste, oil seeds and oleaginous fruit and fats are forecasted to move through Muuga Harbor. Regarding RoRo part, 140.4 thousand tonnes of it is forecasted to arrive to Muuga Harbor in 2055 on RoRo. 47.5% of this amount will be transported away from Muuga on RB, while the remaining 52.5% will be carried away on road. In terms of outbound RoRo, the total flow for this commodity group is 293.7 thousand tons. Outbound RoRo is significantly bigger than inbound RoRo for this commodity group, because the goods that are transported away from Muuga on RoRo come predominantly on RB (58.8%) and road (41.2%).

Figure 5. The structure of material flow for Foodstuffs, Animal food and Foodstuff waste, Oil seeds and Oleaginous fruit and Fats



Facility utilization. Katoen Natie Eesti AS is facing with a need to increase the warehousing area. As stated in the opened sources, the reviewed Operator has increased its capacity since 2012. In the future extension in facility capacities is planned by the Operator.

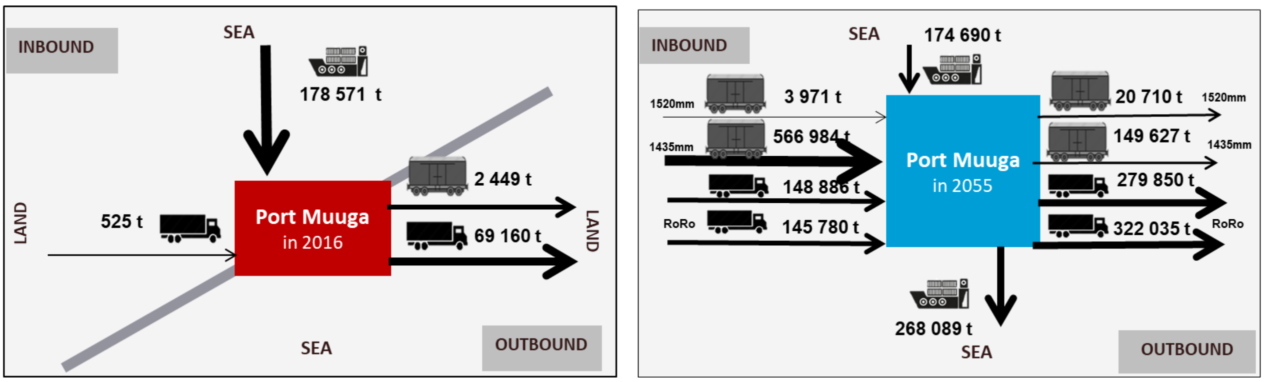
Future development. Based on results of WP1, the reviewed commodity group will reach 6,2% of freight flow share in 2055. The reviewed commodity group is going to reach 1.593 thous. tons in 2055 (vs. 24 thous. tons in 2015). The forecasted increase can lead to the necessity to provide storage capacities, especially for storing containers. The distribution of the used modes of transport is going to change. The role of rail 1435 mm for inbound flows is going to increase significantly (34% of total volume in 2055). For the outbound flow road (28%) prevails.

The next reviewed commodity group is **Metal products.** Consists of Pig iron and crude steel (NSTR51), Semi finished rolled steel products (NSTR52), Steel sheet plates hoop and strip (NSTR54) and Non-ferrous metals (NSTR 56). Also this group includes copper and articles (CN72), Nickel and articles (CN75), Aluminium and articles (CN76). This group amounted 0,6% of total Muuga harbor's cargo turnover in 2015. Several operators can be assigned to this commodity group - Transiidikeskuse AS, Inflot AS, Aekon Cargo, ITT Baltic OÜ and Arcelor Mittal Tallinn OÜ.

Transport modes distribution. Based on statistics from Port of Tallinn it can be indicated that the main inbound flow is handled by sea (from Belgium and Denmark), outbound – by land transport. Several years ago rail transport prevailed, now – road transport is used more frequently for this commodity group (see Figure 6).

In 2055, 1.04 million tonnes of metal products are forecasted to move through Muuga Harbor. Regarding RoRo part, 145.8 thousand tonnes of it is forecasted to arrive to Muuga Harbor in 2055 on RoRo. 47.5% of this amount will be transported away from Muuga on RB, while the remaining 52.5% will be carried away on road. In terms of outbound RoRo, the total flow for this commodity group is 322.0 thousand tons. Outbound RoRo is significantly bigger than inbound RoRo for this commodity group, because the goods that are transported away from Muuga on RoRo come predominantly on RB (74.8%) and road (25.2%).

Figure 6. The structure of material flow for Metal products



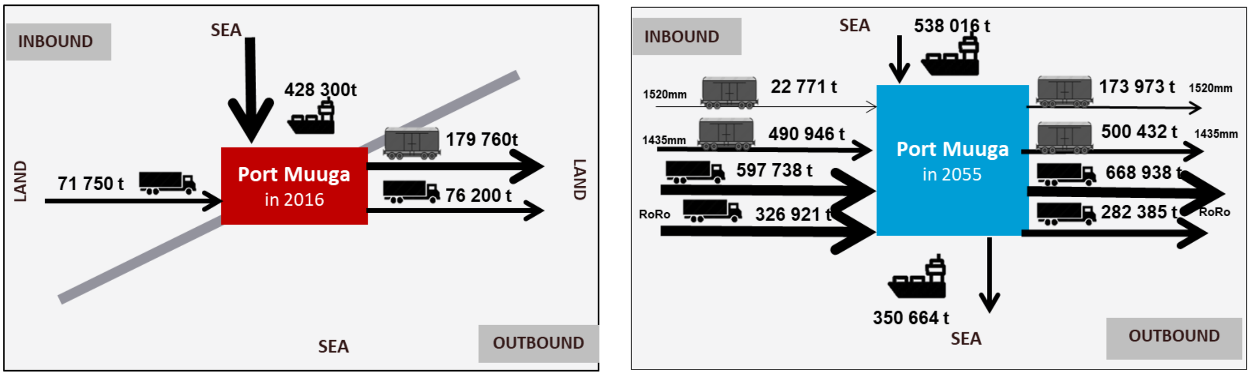
Facility utilization. The main operator of this commodity group (Arcelor Mittal Tallinn OÜ) is going to sell its facilities. Due to the selling plans of Arcelor Mittal the low level of business activities, and, in consequence, a low utilization level can be assumed.

Future development. Based on results of WP1, the reviewed commodity group will increase its freight volume share (5,7 % in 2055). The most significant increases are predicted in 2050 and 2055. The absolute freight volume is going to reach 1.040 thous. Tons in 2055 (vs. 172 thous. tons in 2015). This increase can lead to necessity to handle heavy cargo and have enough storage capacity. The inbound flow will mainly be handled by rail 1435 mm (55%). Meanwhile the outbound flow, the main role have sea (26%) and road (27%).

The next reviewed commodity group is **Crude and Manufactured minerals, Cement, Lime and Manufactured building materials.** The several operators handle this commodity group - AS Stivis, Transiidikeskuse AS. It should be mentioned that AS Stivis also handled coal (0,3% of total Muuga harbor's cargo turnover in 2015, but in 2016 no business activity was on this commodity type (**Solid mineral fuels** which consists of coal , lignite, peat)). Based on answers from AS Stivis questionnaire, the summary of in-/outbound flows structure, is presented by the **Figure 7**.

In 2055, 1.98 million tonnes of crude and manufactured minerals, cement, lime and manufactured building materials are forecasted to move through Muuga Harbor. Regarding RoRo part, 326.9 thousand tonnes of it is forecasted to arrive to Muuga Harbor in 2055 on RoRo. All of this amount will be transported away from Muuga on road. In terms of outbound RoRo, the total flow for this commodity group is 282.4 thousand tons. Inbound RoRo is bigger than outbound RoRo for this commodity group, because of road transportation (100%).

Figure 7. The structure of material flow for Crude and Manufactured minerals, Cement, Lime and Manufactured building materials



Transport modes distribution. The main transport mode which is used for inbound flow is the transportation by sea. The small share of inbound flow (less than 15%) belongs to transportation by road. For outbound flow it should be highlighted that the main outbound flow is managed by rail. Approximately 30% of all outbound flow of this commodity group is handled by road.

Facility utilization. AS Stivis has indicated that the average facility utilization rate in 2016 was 20%. In 2006 this parameter reached the mark of 86% because the business activities in the field of coal.

Future development. Based on results of WP1, the reviewed commodity group will demonstrate increase. In 2055 this commodity group is going to reach 7.7% of total freight volume. The reviewed commodity group will reach 1.976 thous. tons in 2055 (vs. 514 thous. tons in 2015). The significant amount of rail 1435 mm usage is predicted for both directions. However, the road mode of transport will prevail. Essential to point out that RoRo will be actively used for this commodity group (17% of total inbound flow; 14% total outbound flow in 2055)

The next reviewed commodity group is **Natural and Chemical fertilizers.** This group is amounted 11,1% of total Muuga harbor's cargo turnover in 2015. Several operators indicated this commodity group as their business activity - Transiidikeskuse AS, AS DBT and AS Inflot. The main operator (AS DBT) did not provide the information about its activities. From the open sources the facility capacity was identified – more than 2 mln tons annually can be handled, the facility maximum capacity is more than 190.000 tons.

Transport modes distribution. Without data from the main Operator it is not possible to present the transportation distribution of in-/outbound flows but it can be pointed out that the main share of cargo to terminals is transported by rail (1520mm) from Russia. Based on the statistics from Port of Tallinn, from the terminal this commodity group is mainly delivered by sea to South America, Asia and Africa.

Facility utilization. Based on the information from Port of Tallinn in 2015 the total amount of handled fertilizers was 1.567.232 tons. Part of the fertilizers was handled by another operators (471.800 tons), thus, 1.095.432 tons (or approx. 70% of total handled commodity group volume) was handled by DBT. The maximum capacity of AS DBT was

2.025.000 tons. Taking into account the maximum storage capacity (165.000 tons) the average utilization rate was 55% in 2015.

Future development. The future development of this commodity group is seen through lens of two commodity groups - Natural and Chemical fertilizers and Coal chemicals, Tar, Other chemicals, Paper pulp and Waste paper. Based on results of WP1, the reviewed two commodity groups will demonstrate the increase and reach 17% of total freight volume share. In the absolute amount these groups will reach 2.765 thous. tons in 2055. Taking into account annual possible freight turnover of the main Operator (AS DBT) – 4.290 thous. tons, there is no necessity in additional storage capacities. As presented by the Figure 8, Natural and Chemical fertilizers group is mainly delivered in 2055 by rail 1520 mm (79% of inbound flow) and sea (79% of outbound flow). Coal chemicals, Tar, Other chemicals, Paper pulp and Waste paper group (see the) will be mainly delivered into Muuga harbor by sea and road (31% each) and transported out of the port facilities by rail 1435 mm (42%)

In 2055, 2.22 million tonnes of natural and chemical fertilizers are forecasted to move through Muuga Harbor. Regarding RoRo part, 234.7 thousand tonnes of it is forecasted to arrive to Muuga Harbor in 2055 on RoRo. All of this amount will be transported away from Muuga on road. In terms of outbound RoRo, the total flow for this commodity group is 47.4 thousand tons. Inbound RoRo is bigger than outbound RoRo for this commodity group, because of road transportation (100%).

Figure 8. The structure of material flow for Natural and Chemical fertilizers

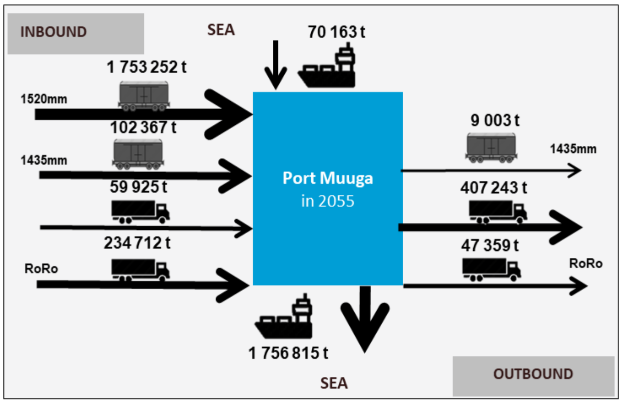
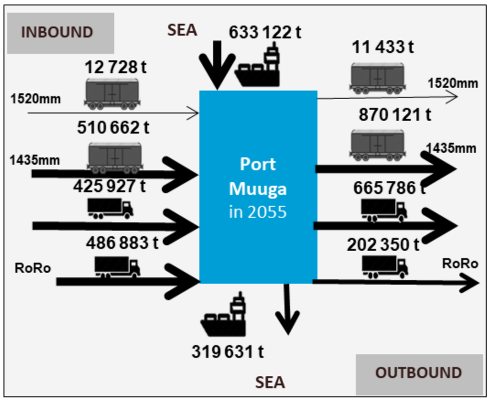


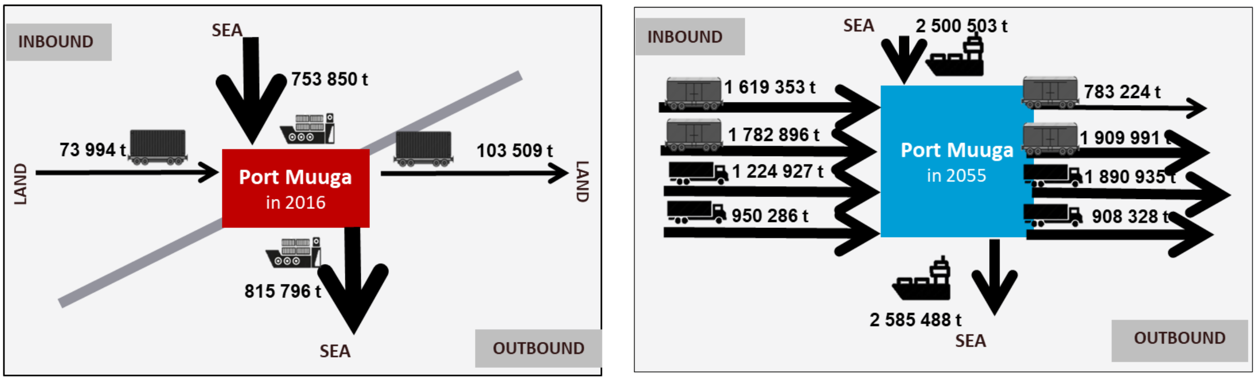
Figure 9. The structure for Coal chemicals, Tar, Other chemicals, Paper pulp and Waste paper



The next reviewed commodity group is **Miscellaneous articles.** Consists of electronics, transport equipment, electrical machinery, articles of clothing, knitted fabrics, footwear, clocks and watches, paper and paperboard, furniture and toys. Part of this commodity group is named in Muuga harbor's statistics as "Products in containers" category which was 12,2% of total Muuga harbor's cargo turnover in 2015. The operators handle containers are Alekon Cargo (3.500 TEU per year), AS Komerk (1.500 TEU per year), AS Inflot (10.400 TEU per year), AS Sankotrans and Katoen Natie Eesti AS. The main and exclusive operator which handles this type of commodity group is Transiidikeskuse AS (600.000 TEU per year). The other Operators work with Transiidikeskuse AS. The cargo is transported mainly by FEU (77% of amount of inbound containers, 92% of amount of outbound containers). The resume of in-/outbound flows structure is presented by the Figure 10.

In 2055, 8.08 million tonnes of miscellaneous articles are forecasted to move through Muuga Harbor. Regarding RoRo part, 950.3 thousand tonnes of it is forecasted to arrive to Muuga Harbor in 2055 on RoRo. 47.5% of this amount will be transported away from Muuga on RB, while the remaining 52.5% will be carried away on road. In terms of outbound RoRo, the total flow for this commodity group is 908.3 thousand tons. Outbound RoRo is bigger than inbound RoRo for this commodity group, because the goods that are transported away from Muuga on RoRo come predominantly on RB (70.9%) and road (29.1%).

Figure 10. The structure of material flow for Miscellaneous articles



Transport modes distribution. Freight is mainly transported in containers by sea. The distribution has not been changed since the beginning of the reviewed period.

Facility utilization. The container operator increased the facilities year by year to handle more containers. Based on statistics, provided by Transiidikeskuse AS, in 2016 handled container volume was 317.479 TEU (full ones) or 462.612 TEU (full and empty ones) in comparison to the capacity to handle 600.000 TEU annually. Important to point out that until 2014 Transiidikeskuse AS sent 16 container trains per week. From 2014 only 7 container trains are dispatched. Transiidikeskuse AS has 404 slots for reefer containers at its disposal and only 7-10 are used (this, the average annual utilization rate is quite low – 5%).

Future development. Based on results of WP1, the reviewed commodity group will demonstrate the increase in freight volume share – 31.6% in 2055. In absolute figures the reviewed commodity group will reach 8.078 thsd. tons in 2055 (vs. 145 thous. tons in 2015) Thus, the required storage area should be calculated very carefully and precisely. As presented by the **Figure 10**, all modes of transport have relatively equal shares in managing flows. Thus, the ability to handle containers by all modes of transport is crucial.

The last reviewed group is **Wood and Cork.** This group was determined because of the prospected high relevance to Muuga harbor. Several operators handle this commodity group - Transiidikeskuse AS, AS Komerk. In 2015 this group amounted 0,1% of total Muuga harbor's cargo turnover.

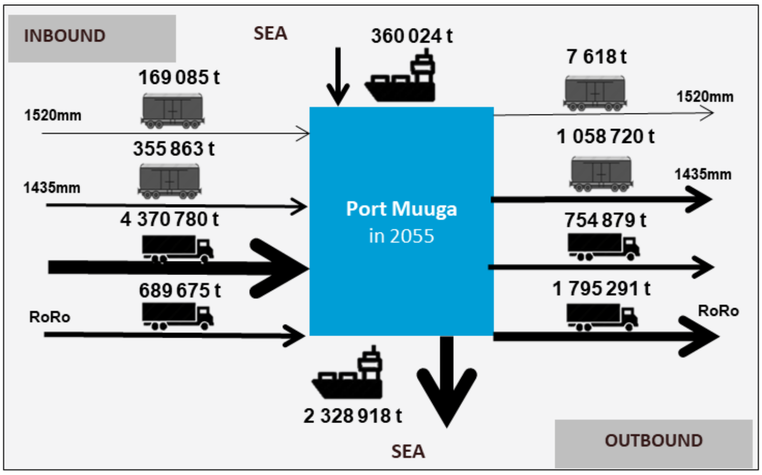
Transport modes distribution. Based on the information from Port of Tallinn it could be indicated that all freight is delivered by road from Estonian plants. According to the information from Transiidikeskuse AS the inbound flow is handled by road (95%) mainly. After that this commodity group is transported by sea to the UK and Iceland.

Facility utilization. Wood and cork are handled in the General Cargo Area of Transiidikeskuse AS today.

Future development. Based on results of WP1, the reviewed commodity group will demonstrate the intensive increase till 2035. The freight volume share will reach 23.2% in 2055 and in the absolute volume the group will reach 5.945 thous. tons in 2055 (vs. 1.059 thous. tons in 2015). The distribution of transportation modes in 2055 is presented by Figure 11.

In 2055, 5.95 million tonnes of wood and cork are forecasted to move through Muuga Harbor. Regarding RoRo part, 689.7 thousand tonnes of it is forecasted to arrive to Muuga Harbor in 2055 on RoRo. All of this amount will be transported away from Muuga on road. In terms of outbound RoRo, the total flow for this commodity group is 1.795 million tons. Outbound RoRo is bigger than outbound RoRo for this commodity group, because of road transportation (100%).

Figure 11. The structure of material flow for Wood and cork



The main used modes for inbound flow are road (73%) and for outbound flow are sea (44%) and RoRo (30%)

Additionally future development of not mentioned by Operators commodity groups is presented – future development of Solid mineral fuels group (consists of coal, lignite and peat) and of Iron ore, Iron and Steel, Non-ferrous Ore and Waste commodity group.

As presented by the Figure 12, Solid mineral fuels group is going to be handled mainly by road (64%) and sea (33%). Regarding to the outbound flow, for this group rail 1435 mm (51%) and sea (45%) play the dominant role.

As presented by the Figure 123, Iron ore, Iron and Steel, Non-ferrous Ore and Waste commodity group is going to be handled mainly by road (37% of inbound flow, 38% of outbound flow), followed by RoRo (31% of inbound flow and 17% outbound flow).

In 2055, 103.3 thousand tonnes of solid mineral fuels are forecasted to move through Muuga Harbor. Regarding RoRo part, 31.3 thousand tonnes of it is forecasted to arrive to Muuga Harbor in 2055 on RoRo. All of this amount will be transported away from Muuga on road. In terms of outbound RoRo, the total low for this commodity group is 17.2 thousand tons. Inbound RoRo is bigger than outbound RoRo for this commodity group, because of road transportation (100%).

Figure 12. The structure of material flow for Solid mineral fuels

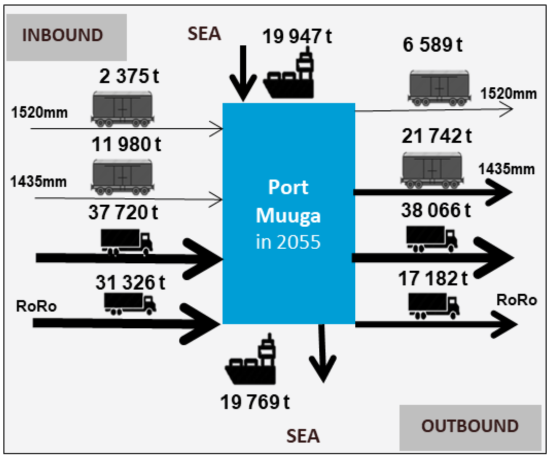
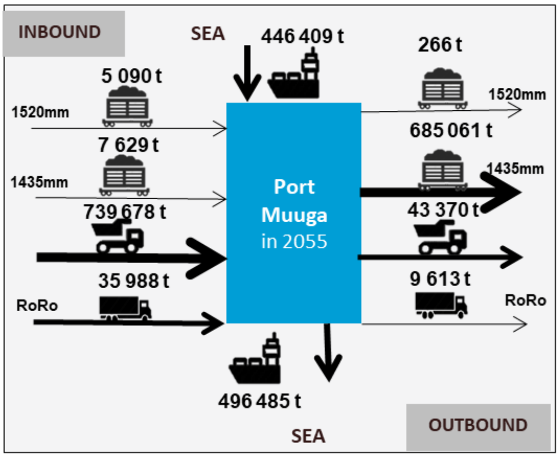


Figure 13. The structure of material flow for Iron ore, Iron and Steel, Non-ferrous Ore and Waste



Further details to port' statistics which were gathered in the context of the questionnaires (e.g. transport volumes development by commodities 2003-2015, breakdown by modes of transport) can be found in Annex 1.

According to information from Port of Tallinn, the maximum capacity of the Muuga harbor is the following: for containers is 600.000 TEU per year (only for the container terminal), for liquid bulk – 40 mln tons, for dry bulk – 15,5 mln tons, for break bulk – 4 mln tons. The actually handled material flows was the following: for containers bound sea was 200.235 TEU per year (31% out of the maximum capacity), for liquid bulk – 6,6 mln tons (17% out of the maximum capacity), for dry bulk – 3 mln tons (20% out of the maximum capacity), for break bulk – 0,3 mln tons (8% out of the maximum capacity). It is clear from the provided figures that Muuga harbor has sufficient additional storage capacity for majority reviewed freight types.

To conclude there is the main information in the Table 4 regarding the current status of facilities availability.

Table 4 Current facilities to manage material flows

Fre-ight type	Operator	Commmodity group	Maximum freight turnover capacity per year		Stock capacity		Capacity utiliza-tion	Site	
Dry bulk	AS Coal terminal	Solid mineral fuels	5.000.000	t	233.000	t	0%	61	ha
	AS Inflot	Fertilizers	N/A	t	48.000	t	30%	14.335	m^2
	AS DBT	Fertilizers	2.300.000	t	165.000	t	55%	64.000	m^2
	AS Komerk	No specialization	N/A	t	N/A	t	N/A	45.000	m^2
	AS MGT	Cereals	5.000.000	t	300.000	t	26%	11.400	m^2
	Transiidikeskuse AS	Fertilizers	N/A	t	N/A	t	N/A	N/A	
		Cereals	N/A	t	N/A	t	N/A	N/A	
	AS Stivis	Construct	2.500.000	t	117.000	t	20%	49.700	m^2
		TOTAL for Muuga	**15.500.000**	**t**					
General cargo	AS DBT	No specialization	N/A		N/A		N/A	18.400	m^2
	Alekon Cargo	No specialization	N/A		N/A		N/A	16.000	m^2
	AS Komerk	No specialization	N/A		N/A		N/A	55.000	m^2
	Katoen Natie	Foodstaff	N/A		N/A		N/A	34.590	m^2
	ITT Baltic OÜ	No specialization	N/A		N/A		N/A	15.565	m^2
	Transiidikeskuse AS	Wood and cork	N/A		N/A		N/A	N/A	
	ArcelorMittal Tallinn OÜ		N/A		N/A		N/A	32.400	m^2
	TK Muuga		N/A		N/A		N/A	N/A	
		TOTAL for Muuga	**4.000.000**	**t**	**TOTAL for Muuga**			**436.900**	m^2
Liquid	Vesta Terminal	Crude petroleum, petroleum products and gas	30.000.000	t	405.600	m^3	60%	N/A	
	Vopak EOS AS		N/A	t	1.026.000	m^3	100%	N/A	
	AS Nynas		N/A	t	21.700	m^3	75%	N/A	
	AS Oiltanking Tallinn		N/A	t	78.550	m^3	N/A	N/A	
	Neste Eesti AS		N/A	t	25.900	m^3	N/A	N/A	
		TOTAL for Muuga	**40.000.000**	**t**	**1.557.750**	m^3			
Containers	Transiidikeskuse AS		600.000	TEU	N/A		33%	38	ha
	Alekon Cargo		3.500	TEU	N/A		N/A	N/A	
	AS Komerk		1.500	TEU	N/A		N/A	N/A	
	AS Inflot		10.400	TEU	N/A		N/A	10.780	m^2
	AS Sankotrans		N/A	TEU	N/A		N/A	160.000	m^2
		TOTAL for Muuga	**600.000**	**TEU**					
RoRo	Transiidikeskuse AS		N/A		100	parking slots	0%	N/A	

Transhipment

The also project also analyses two relevant transhipments between different forms of rail in Muuga harbour. The modelling results show that transhipment from RB 1435 mm to existing 1520 mm rail will be much more significant in terms of volume than transhipment in the opposite direction. Significant transhipment volumes are expected to start immediately in 2025, steadily increase until 2035 and remain stable until 2055.

Table 5 show the total forecasted transhipment flows for 2025-2055.

Table 5. Transhipment flows between RB 1435 mm and existing 1520 mm rail (thousand t, realistic scenario)

RB section	2025	2030	2035	2040	2045	2050	2055
Transhipment from existing rail to RB	95	114	211	159	147	162	162
Transhipment from RB to existing rail	265	320	499	456	439	493	493

In the forthcoming Table (see Table 6) the forecasted transport volume development along with the existing capacity level in Muuga harbor is presented. The figures demonstrate the capacity shortage for the existing container terminal facilities, which will start to take place between 2030 and 2035. Due to the very significant RORO volumes, the existing 100 parking places for trucks might also not be sufficient to handle the predicted demand. The detailed calculation of technical needs for all terminal zones along with the accordant consequences is presented in the section 1.2.2. As it will be presented in the mentioned section, apart of container and RORO area, no further terminal zones will face space shortages in the forthcoming years.

Undoubtedly, there are seasonal peaks for different commodity groups. For instance, for cereals during the harvesting period the intensity of the freight flow increase intensively. But based on interviews with operators and predicted volumes (WP1) there are sufficient capacity to handle this volume (see also Table below – "Dry Bulk").

Table 6 Matching of the forecasted transport volumes with the existing capacity in Muuga harbour (in tonnes)

Freight type	Commodities	2025	2030	2035	2040	2045	2050	2055	Existing annual capacity in Muuga (t)
Dry bulk	Solid mineral fuels, Fertilizers, Cereals, Construction materials	5,116,891	6,227,124	6,773,994	6,722,752	6,257,994	5,033,090	4,520,301	**15.500.000**
General cargo* (Mixed freight + Break Bulk)	Iron and Steel, Metal products, paper pulp, miscellaneous articles, wood and cork	4,047,244	5,319,838	5,336,842	5,054,366	4,703,146	4,324,874	3,829,281	**4.000.000**
Liquid	Crude petroleum, petroleum products and gas	6,354,610	8,160,133	4,607,084	3,265,109	2,521,490	2,424,909	2,411,831	**40.000.000**
Containers	Foodstuffs, cereals, iron and steel, metal products, cement, fertilizers, paper pulp	4,029,884	6,239,324	8,468,628	9,783,137	11,502,812	13,762,842	14,838,994	**600.000 TEU or 6.600.000 tons**
RORO	Foodstuffs, cereals, iron and steel, metal products, cement, fertilizers, paper pulp	3,387,692	5,726,947	6,117,256	6,451,714	6,718,117	6,986,804	7,092,357	**100 parking slots for heavy trucks on the birth 14**

* The term „General Cargo“ is used, which unites Break Bulk and Mixed Freight. General Cargo is a freight type, which is more widely used in the categorization of goods (see e.g. Muuga harbour)

Analysis of potential information and management systems

The described functionalities can be used as a part of the tender documentation aimed at the search for the appropriate Traffic Organization System (TOS)

All interviewed operators indicated that they have their own developed IT which are able to provide such functions as, for example, 24/7 online logistics planning, automated data transfer between railway, customs authorities and independent inspection companies with a link to visualization and accounting software.

The main aim of the information system is to provide all involved parties with the essential information – importer/exporter, freight forwarder customs agent, shipping agent, shipping company, container terminal, container depot, transport agent, customs, port authority, and other authorities.

Based on best practices cases, the Traffic Organization System (TOS) should be able to support several activities, which are:

- Berth zone & vessel loading/unloading management:
    - Editing calling schedules which come from contracts with shipping lines
    - Assigning vessels to berths
    - Supporting berth allocation considering traffic flow of transporters and yard positions
    - Estimating berthing and departure time of each vessel
    - Supporting ad-hoc vessel calls which are not included in the regular calling schedule
- Yard management:
    - Defining automatic stacking rules for import, export, and transshipment freight
    - Covering inbound freight from vessels and outbound freight from the gate and the rail
    - Selecting storage slots considering the efficiency during retrieval operations
    - Considering workload distribution over yard areas during vessel loading process
    - Forecasting future freight inflow, outflow, and inventory for each vessel
    - Supporting the space reservation for each vessel at each bay in each block
    - Shared reservation of the same space for multiple vessels
    - Visualizing the yard map showing stacks by container groups
- Rail operations management:
    - Collecting handling order information including the loading list from rail operation companies or shippers
    - Rail crane split & rail crane work scheduling considering crane specifications
    - Slot sequencing for loading and unloading
    - Wagon composition for each ingoing/outgoing train considering wagon specifications
    - Planning operations considering schedules in the port terminal
    - Ability to support transshipment between 1435 mm and 1520 mm gauges
- Truck operations management:
    - Collecting handling order information including the loading list from road operation companies or shippers
    - Road crane split & road crane work scheduling considering crane specifications
    - Slot sequencing for loading and unloading

- Screening zone management;
- Repair zone management where support the planning and operation of housekeeping of containers is provided;
- Gate & Electronic driver Queue management:
    - Assess gate carrying capacity
    - Planning gate operations
    - Scheduling in/outcomming trucks
    - Support of truck electronic queue
- Container Freight Station (stuffing/restuffing) management :
    - Supply and delivery by truck/wagon/vessel
    - Packing, unpacking and direct loading of containers and flats with goods of all types
    - Storage of all goods, including storage in security zone (providing the IMO class permits intermediate storage), order picking, marking, labelling, scanning, tallying, container stowing advice
    - Supply and delivery of breakbulk by truck/wagon/vessel
    - Handling with reach stackers or container gantries
    - Breakbulk intermediate storage
    - Transport service trailer from/to riverside quay
- Empty container depot management;
- Automatic refer monitoring;
- Data capture terminals;
- Crane systems. The used TOS should allocate cargo properly and use the cranes capacity effectively;
- EDI (electronic data interchange) should be supported between the involved parties;
- KPI. Used TOS should create highly detailed terminal planning with the link to assign key performance indicators and with the possibility to assess the efficiency of the processes;
- Web interfaces for involved parties with Internet access;
- Customs systems. The used TOS should provide data interchange and support customs functions in port;
- Global positioning systems;
- External ERP systems. Used TOS should create a link with external IT systems for smooth data exchange;
- OCR-systems which provide an opportunity to recognize printed or written text documents and transfer this information into computers.

The additional attention should be paid on the possibility to support transshipment between different rail tracks (1435 mm and 1520 mm).

1.1.2. Access to the terminal area by types of transport modes and commodities – Limitations and restrictions

There are six sites under evaluation which are presented in the Figure 14. It shall be pointed out that several locations in parallel have to be used to meet requirements and needs of MCTRB. That means functions of MCTRB will be spread in the harbor territory. Each of the potential locations has advantages and disadvantages for overtaking of accordant function which will be reviewed further.

Figure 14. Options for MCTRB locations

The first plot is situated close to the marshalling yard and can be used as a marshalling yard also for 1435mm. The distance to the port is medium.

The second plot is located on the existing container terminal and has the nearest proximity to the berths. This area is good to handle container flow (inbound/outbound) and has additional development areas (120.000 m²). In addition, on that site RO-RO terminal is located.

The third plot is situated near to oil and fertilizers terminals which might lead to the additional risks and hazardous. Moreover, based on the feedback from port of Tallinn, the road access is complicated – through gate with considerable circle and across 1520 mm infrastructure. As the last disadvantage the high distance to the berths can be named which will lead to the additional internal transportation costs.

The fourth plot is the furthest from port facilities, which causes additional reloading costs for the sea bound cargo. This piece of land can be used for handling continental goods (not requiring sea connection), ro-ro trucks and 1435 and 1520 mm rail tracks. The theoretical advantage of this plot is the the possibility to handle full trains directly from the Maardu station.

The fifth plot is situated closer than the forth plot. The distance to the port is medium. Currently, this plot is under investigation by the Chinse investors for the purpose of its usage as an industrial zone. As an advantage of this plot the good extension capabilities can be named. This plot might be used as a dry port. Installment of 1050 m tracks to this plot are somewhat problematic due the size and shape of the plot.

The sixth plot is situated in the area of coal terminal. This plot can be reviewed as an alternative to plot 2 or as an extension option for setting up of a next stages of container terminal and RORO terminal.

After preliminary sites analysis the first proposal can be made:

1) TK container terminal could be used for RB container handling due to sufficient capacity especially in the first years (up to 2030)
2) RO-RO terminal can be created at the plot 6 (existing coal terminal). The coal terminal is considered as an appropriate location for the extension of container and RORO handling.
3) Plot 4 and 5 might be used as an industrial zone and for 1435-1520 transshipment
4) Plot 1 might be used as a marshalling yard for 1435 mm

5) Plot 3 also might be used for fertilizers, grain and oil terminals

The detailed analysis (SWOT analysis and follow-up ranking) is conducted in the section 2.

For the first evaluation of locations, the main restrictions should be also taken into account – minimization of transportation costs (which can occur due to long distances), minimization of time for transportation semi-trailers from the point of unloading to the point of loading into ferries (which is close to the berths). In this connection, for location 4 the highest internal transportation costs (delivery to berths) might be expected.

However plot 4 and 5 should be further studied if the incoming inflow of semitrailers would substantially increase or if the expansion of the terminal areas (for example the coal terminal area) cannot be developed as suggested by the current study. In that case plots 4 and 5 could be used as buffer areas for either 1435/1520 reloading or for transshipment of semitrailers on rail.

Based on information from Port of Tallinn the existing free zone has no negative influence on RB related cargo. Within the free zone EU cargo is separated from non-EU cargo and all cargo movements will be controlled electronically.

1.1.3. Functions of the Railway Facilities of Rail Baltica

The most advantageous conditions for the functional design of railway facilities appear, when the railway transport is organized homogenously using block trains that directly access the loading terminals. However, considering the expected structures and volumes of railway freight flows handled in Muuga port and the resulting demand to access the existing freight terminals, such conditions are not to be expected.

Therefore, conventional railway harbor facilities have to be envisioned within the port of Muuga. These facilities basically need to consist of:

- Main railway line to the railway terminal (station)
- Railway terminal (station), including
  - Arrival tracks
  - Turnout track(s)
  - Sorting tracks
  - Departure tracks
- Connecting tracks between railway station and freight terminals
- Tracks within the freight terminals (loading, buffer, turnout tracks according to the loading technology)
- Tracks for auxiliary functions, like
  - Stabling of locomotives (long and short term)
  - Stabling of wagons (long and short term)
  - Depot functions for locomotives and wagons (technical inspections and repairs)

Within the functional design, the focus has to be on the facilities needed for the major functions, i.e. the railway line, station and connecting tracks to the freight terminals. Within the terminals, the existing facilities play a decisive role, while the allocation of facilities for the auxiliary functions is much more flexible and of less influence on the operation costs. Therefore the auxiliary facilities are regarded as space that needs to be provided with a suitable connection to the track network, but subordinated to the core functions of the facilities within the port area. Generally, empty space for such auxiliary facilities is available in the proximity of the 1435 mm station in all considered alternatives, as shown in chapter Chapter 2.2.2.

1.1.4. Functions of the Customs Board

Based on the interviews with the port's representatives in Germany two types of functions of Customs Board in ports can be identified – functions for EU cargo (transported within EU, the shipper and cargo receiver are situated in EU) and functions for non-EU cargo (transported not only within EU, the shipper and/or cargo receiver are situated not in EU). The common ground for both types of cargo is the obligatory presence of the special area where the visual inspection and quantity check can be made on demand. Moreover, the special area should be provided for the shipments if the cargo is rejected by customs clearance authority. Based on the German ports' best practices, the customs area should be enough to contain simultaneously 15 trucks. Additionally, the area for 5 semi-trailers in each terminal area was considered in Technical needs calculation

The difference for these two types of cargo is mainly in the required documents and the obligation to customs clearance (customs duty, VAT, and, where applicable, any special excise duties).

Customs Board executes the risk analysis in order to identify the necessity of the control of the shipment quality and quantity. The decision depends on several factors: the amount of the shipment, country of origin, previous shipments from this shipper, the authority of the freight forwarder. Hereby, the random inspection check also take place.

A successful case of TK terminal in terms of separation between EU-goods and Non-EU-goods can be applied for the terminals' infrastructure in Muuga harbour. Cargo from the third countries (e.g. transit 1520-1435) is handled (transshipped) within free economic zone. For EU-cargo (cargo is transported within the boundaries of the European Union) a separate corridor shall be installed (which is already a case on the territory of TK terminal for RORO traffic between Estonia and Finland). The governmental permission for the establishment of such a corridor (excluded from the Free Economic Zone) requires 2-3 months in Estonia.

1.1.5. Analysis of the service functions

The analysis was conducted for different freight types and directions of in-/outbound flows. The foundation of the analysis is the forecast from WP1 and the stated expectations of stakeholders (see WP1). It should be indicated that the increase or decrease in the forecasted freight type will not change significantly the list of necessary functions.

The additional value added and special services will increase the competitiveness of MCTRB and will attract new customers to the port. All of the envisaged services which we named by the potential users of MCTRB during the interviews in the WP1 were being integrated into the present section.

Freight types defined with the scope of this report are the following:

- Liquid bulk
- Containers
- Ro-Ro
- Break bulk
- Dry bulk
- Mixed freight (consists of products like nuclear reactors, boilers and electrical machinery and equipment)

The first reviewed freight type is **Liquid bulk** (7% of future freight flow in 2055). The inbound flow can be delivered by rail (1520mm), by sea The outbound flow is anticipated to be transported by sea or by rail (1520mm and 1435mm). Thus, for this type of freight the facilities should provide an opportunity to manage the following functions:

- (Un)Loading from/to 1520 mm gauge
- (Un)Loading containers from/to 1435mm gauge
- (Un)Loading from/to tank vessels
- Storage in tankers

No additional value added services are required for new customers attracting.

The second reviewed freight type is **Containers** (56% of future freight flow in 2055). Two commodity groups are assigned to this freight type – miscellaneous articles and foodstuff which are transported in containers. Containers are delivered by sea, rail (1520mm and 1435mm) or road.

This flow has to be managed close to the berths to minimize transportation distances from container terminal to the rail yard. The required set of functions is the following:

- (Un)Loading containers from/to 1520mm gauge
- (Un)Loading containers from/to 1435mm gauge
- Store containers /swap bodies/tractors
- (Un)Loading from/to trucks
- (Un)Loading containers from/to the vessels

Additional value added services for new customers attracting:

- Labelling

- Weighing
- Sorting
- Transhipment from 1435mm gauge to the 1520mm gauge

To operate the transshipment the terminal shall possess reachstackers or cranes. Depending on the transport volume handled in the container terminal the first or the second alternative hat to be chosen.

Apart of container traffic, container terminal will also handle the cranable semi-trailers, where a significant amount of this loading unit is anticipated. In following a reference to the statistics of Germany is given, which verifies the assumption to concentrate on cranable semi-trailers in Muuga harbour. Similar development is anticipated for Muuga. German statistics for road transportation was taken as a case for the investigation of the development of the types of semi-trailers transportation over years. Data from Germany can also be considered as applicable for the whole European Union, since the semi-trailers transportation is not bounded within one country but also happens cross-national in the longer distances. In addition, the statistics covers the development in the continental combined transport, including several countries in the transport chain. Finally, as it is shown below, the handling of both types of semi-trailers – cranable and non-cranable – is foreseen on Muuga harbour."

Continental combined transport in Germany demonstrates a continuous positive dynamics. In 2010 71,695 ths tonnes were transported via combined transport. In 2015 the amount of transport volume has reached 89,358 ths tonnes. Hereby, the breakdown of the loading units has changed significantly. In 2010, 84% of the above mentioned transport volume was executed by containers and swap-bodies. Accordingly, 16% was operated by semi-trailers, of which 14% were cranable (compatible for vertical transshipment by gantry crane) and 2% were non-cranable (transportation via rolling motorway, RoLa). Five years later the share of containers has decreased to 72%, whereas more cargo has shifted to semi-trailers, 28% respectively. Out of 28% semi-trailers, 24% were cranable and 4% were non-cranable. Taking the latest data for January 2017, a further decrease of containers' share to 71% can be registered. The share of semi-trailers amounted to 29%, of which 26% were cranable and 3% were non cranable (Statistisches Bundesamt). In other words, a significant increase of cranable semi-trailers in the continental combined transport can be registered. This is also corresponding with an increase of the cranable semi-trailers in the total fleet of the semi-trailers. The current share of cranable semi-trailers is estimated to be 15% in 2016 (compared to 5% in 2010). This development can be explained by the increasing service level of the combined transport and by the competitive prices compared to road transportation in the long distances (800 km onwards).

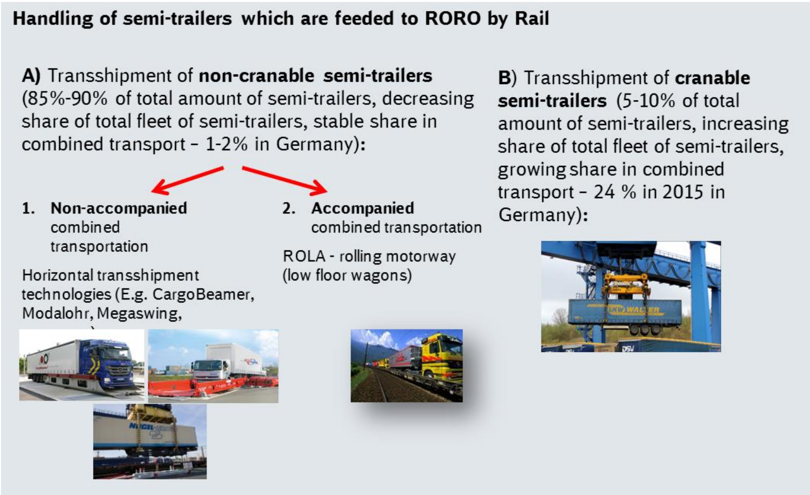
At this point, port of Rostock can be named as an example, where a modern EU-financed terminal for transshipment of cranable semi-trailers is settled (see **Figure 15**). From the opening of the terminal in 2011 the transport volume is steadily increasing. Today, the terminal handles between 4-6 trains per day with 36 semi-trailers per train in 24/7.

Figure 15. RTM terminal (Rostock Trimodal) for transshipment of cranable semi-trailers

One of the reasons for shippers and forwarders to switch from containers to semi-trailers are the lower transshipment costs. That is, a container (in case of oversea transport) should be transshipped two times (from rail and to sea) and a semi-trailer only once (from rail). Besides cranable semi-trailers, also the segment of non-cranable semi-trailers can be handled in Muuga, by for example such technologies as Nikrasa[3] . This technology provides an opportunity to use the existing infrastructure with the minimum investments and also handle the non-cranable semi-trailers. This is a major benefit of this technology that differs from Modalohr, CargoBeamer which require significant investment and space. In addition, a dense network of terminals of the horizontal transshipment technologies shall be in presence, which additionally increases the attractiveness of the combined transport for the decision maker. This is however not the case for Modalohr and CargoBeamer. No positive dynamics can be also registered in terms of market diffusion of the mentioned technologies, which today serve more as a niche solutions (e.g. for Alps –crossing transports).

The summary of the possible ways to handle cranable and non-cranable semi-trailers is presented in the **Figure 16**.

Figure 16. Transshipment options for semi-trailers



For incoming trucks or semi-trailers following set of functions has to be provided at the RORO-Terminal:

- Quick check-in of semi-trailers (check-in-facility)
- Adequate number of parking slots for semi-trailers in the check- in area and in the waiting/sorting area on the berth
- Adequate number of gates to waiting/sorting area

The forth reviewed material flow is **break bulk** freight type (13% of future freight flow in 2055). This freight type is anticipated to be managed by sea, rail, road. The proposed functions for this freight type shall be the following:

- (Un)Loading from/to 1520mm gauge
- (Un)Loading from/to 1435mm gauge
- (Un)Loading from/to vessel
- (Un)Loading from/to truck
- Storage
- Customs clearance

Additional value added services for new customers attracting:

- Sorting
- Packaging
- Weighting

The next reviewed freight type is **dry bulk** (21% of future freight flow in 2055). This freight type mostly consists of grain, fertilizers and minerals. The required services are the following:

[3] http://www.nikrasa.eu/home.html

- (Un)Loading from/to 1520mm gauge
- (Un)Loading from/to 1435mm gauge
- (Un)Loading from/to vessel
- (Un)Loading from/to truck
- Customs clearance
- Storage

Additional value added services for new customers attracting:

- Labelling
- Weighting

The last reviewed freight type is **mixed cargo** (3% of future freight flow in 2055) which, based on the used classification, mainly consists of heavy cargo (the commodity group is metal products) such as nuclear reactors, boilers and electrical machinery and equipment. This freight type is oversized and lengthy or goes in special coils for which the special equipment is needed.

- (Un)Loading from/to 1520mm gauge
- (Un)Loading from/to 1435mm gauge
- (Un)Loading from/to vessel
- (Un)Loading from/to trucks
- Storage

Additional value added services for new customers attracting:

- Sorting
- Packaging
- Weighting

During storage the freight should be saved from corrosion and impurity. This freight type should be stored in enclosed warehouses, storage in open warehouse areas even under canvas is not allowed. In addition, the separate wagon storage should be provided. As the interviewed companies have pointed out the there is need for technical equipment suitable for handling large and heavy products. In addition, the employees managed cargo in Muuga harbor must have experience in handling those kind of products.

1.1.6. Summary to the scope of functions of MCTRB

To sum up the list of functions the Table 7 is created where functions are broken up into categories: obligatory services (OS), value added services (VAS) and not required (NR).

Table 7 Required provided functions depend on the freight type

Name of the function	Freight type				
	Liquid bulk	Containers/ Semi-trailers	Ro-Ro	General cargo	Dry bulk
(Un)Loading from/to 1520mm gauge	OS	OS	NR	OS	OS
(Un)Loading from/to 1435mm gauge	OS	OS	NR	OS	OS
(Un)Loading from/to track/semi-trailer	OS	OS	NR	OS	OS
(Un)Loading from/to vessel	OS	OS	OS	OS	OS
Storage in tanks	OS	NR	NR	NR	NR
Storage in enclosed warehouse areas	NR	OS	NR	OS	OS

Name of the function	Freight type				
	Liquid bulk	Containers/ Semi-trailers	Ro-Ro	General cargo	Dry bulk
Storage in open warehouse areas	NR	OS	OS	OS	NR
Parking of semi-trailers	NR	OS	OS	NR	NR
Vertical transshipment	NR	OS	NR	OS	OS
Horizontal transshipment	NR	NR	NR	OS	OS
Sorting	NR	VAS	NR	VAS	NR
Packaging	NR	VAS	NR	VAS	OS
Labelling	NR	VAS	NR	NR	VAS
Weighting	NR	VAS	VAS	VAS	VAS
Electricity provision / temperature controlled warehouse	NR	VAS	VAS	NR	OS

Special services should be provided regardless of the freight type. These services are the following:

- Customs clearance
- Maintenance services for wagons, locomotives and trucks (e.g. inspection, repair, cleaning, handling empty wagons)
- Energy supply and fitting (e.g. fuel, water, sand, maintenance of electrical and communication equipment, maintenance, etc.)
- Parking opportunities/stabling tracks for locomotives, wagons, trucks (long- and short-term options)
- Handling of containers inbound road (port logistics)
- Technical support services (servicing of wagons, break checks)
- Maintenance of fire standards and provision of safety related and emergency equipment (such as fire fighting, first aid, security, environmental protection, surveillance, fence surrounding, application of code of ISPS etc.)
- Radiation control
- Paper free data collection
- Provision of maintenance equipment
- Utility rooms and facilities installation

1.2. Identification of terminal technical needs

In the current section the description on technologies, design standards and specifications are provided based on the functions and transport demand forecast identified in previous sections. The section starts with the detailed description of the potential crossing solutions 1435/152 which is followed by the derivation of the technical needs by terminal' zones. In the last part the potential alternative location settings of MCTRB are evaluated with a recommendation of two alternatives as a result.

1.2.1. Compatibility of 1435/1520 – potential usable crossing solutions

General

The port territory in Muuga and a number of the terminals in it are connected to the railway network of Eesti Raudtee. Since the lines of "Rail Baltica" are considered as additional hinterland connection and the area around the port in Muuga is supposed to become an important source and destination for freight transport on "rail baltica", a connection to the 1435 mm railway infrastructure is considered as key success factor for the new railway line.

To achieve this, there are 3 principal solutions:

(1) Establishing a separate port and industrial area to be connected to 1435 mm railway infrastructure

(2) Transhipment of freights to and from 1435 mm gauge trains to 1520 mm trains and using the existing railway connection

(3) Establishing of new 1435mm railway infrastructure in the territory of Muuga port and industrial area

Regarding the development of the area within the recent years, option (1) is obviously not realistic and therefore beyond the scope of this analysis. Since the time demand and costs of additional transhipments endanger the competitiveness of a transport chain, also option (2) is not supposed to become the preferred option for the regular connection of the port area with the “rail baltica”. However, for special cases and smaller amounts it may become a reasonable alternative to the costly construction of new railway infrastructure. Consequentially the main focus of the analysis will be option (3). This implies that railway infrastructure of both gauges has to be located in the same area, resulting in interference of both systems. With the historical decision of the Russian Empire to separate its railway system using a differing track gauge, the further development in the expanding systems grew apart. Consequentially, today a number of technical aspects differs in both systems, even when the functionality is regularly rather equal. The relevant technical aspects to be considered within this analysis are:

- Alignment parameter
- Trackworks
- Traction power supply systems
- Signalling and telecommunications

They are discussed in the following sections.

Alignment parameters

The detailed final alignment parameters of the rail baltica infrastructure are not developed yet, an according consultancy project is currently (March 2017) in the tendering stage. For the current analysis, it is assumed that for the alignment of the 1520 mm infrastructure the applicable Estonian standards are used, while the regular values of the German standards are used for the layout of the 1435 mm tracks. In case of ambiguity, the more challenging values apply. This ensures full compatibility with the UIC guidelines, and makes sure that no solutions are suggested that do not comply with currently used relevant standards. However, not all parameters are to be applied on the level of this analysis. The following parameters are assumed to be applicable for the purpose of this analysis.

Table 8 Alignment parameters for both gauges

Parameter	Value 1520 mm	Value 1435 mm	Comment
Minimum track distance open line	4,60 m	4,00 m	
Minimum track distance stations	4,00 m	4,50 m	
Minimum curve radius line track		300 m	
Minimum curve radius station track		180 m	
Maximum gradient		12,5 ‰	
Usable track length	1050 m	1000 m	
Smallest turnout geometry		190 1:9	

In any case, the elaborations within this analysis cannot substitute an accurate planning to be made when the applicable parameters are developed and can be applied. Additionally, the dominant shunting operation in the port area allows for several exemptions from standard values due to the low speeds.

Trackworks

The most prominent difference in track construction is the gauge. This necessarily results in a different sleeper construction. Due to the higher axle loads, the 1520 mm system is regularly using smaller spacing between sleepers.

With the most common types of rail fastenings and several versions of it available for both, 1435 mm and 1520 mm gauge, no technical problems are expected with them.

The rails itself are produced according to differing standards. However, the often used UIC 60 rail for the 1435 mm system and the P65 of the 1520 mm system have rather similar characteristics. The use of P65 rails on the main lines of former East German railways demonstrates their compatibility to UIC – wheelsets.

The substructures do not principally differ in both systems, but particular parameters vary without contradicting each other. Therefore it is possible to construct substructures matching to both systems with no or very little additional costs.

Traction power supply systems

Currently, the electrified network (3kV AC) of Eesti Raudtee serves commuter transport around Tallinn but does not include the line(s) to Muuga. In case of a main line electrification for freight transport that is not excluded for the long term, it is most likely that a 25 kV AC system will be installed, since it provides significantly better performance and is the standard solution for new electrifications. The “rail baltica” lines will be equipped with the 25 kV AC system, too. There is no supposed negative impact on the 1520 mm system.

Additionally, especially the tracks connecting the terminals (which are supposed to have the closest interaction with the existing 1520 mm system) are likely not to be electrified. Lower speeds and partly reduced train weights require for less traction power, and a catenary system is often obstructing loading and unloading processes. Therefore it is common practise to leave the terminal access tracks without catenary and to start the line electrification at the train departure/ arrival tracks of the related shunting station.

In case that electric traction shall be provided on these tracks to minimise noise and air pollution, battery driven shunting locomotives may be an option.

Signalling and telecommunications

The 1435 mm infrastructure of “rail baltica” will be equipped with the latest version of the ETCS signalling and train protection system, most likely on level 2. At the same time, it is likely that the 1520 mm railway infrastructure will stay with the established signalling technology or an respectively enhanced system.

In all cases, where a constructive separation of the track infrastructure of both systems is given, there is no need of interaction between both signalling and train protection systems.

However, whenever a physical interaction between the track infrastructure of both systems appears (crossing or “gauntlet”), this section has to be secured by appropriate signalling equipment. The basic requirement is that the track occupancy detection provides an interface to the respective other system. This allows each signalling system for blocking a train of one system to enter a section that is occupied from another train, even if it belongs to the respective other system. But also the installation of a new common traffic control system for both infrastructures (1435 mm and 1520 mm) is an option. This mainly depends on the condition of the existing system. If it is old enough that a renewal has to be made in the nearer future or if the necessary adaptations create more effort than the installation of a new joint system, it is obviously preferable to install a new system. Neither the development of a common system nor of interfaces between 2 systems is a significant technical problem.

Special solutions are required, if road level crossings include tracks of both systems with their technical security equipment. If such equipment needs to be integrated into the train protection systems of the 1435 mm and the 1520 mm system, it is most likely that the installation of new level crossing security equipment on the 1520 mm system that allows for the integration in both train protection systems is the best option, rather than adapting the old equipment for the ETCS system of the new line and the new level crossing equipment to the old train protection system.

Applicable solutions

The following potential solutions are promising enough to be considered further:

- Parallel connection and rail crossings
- Multiple gauge tracks – turnouts
- Railway trucks etc
- Transhipment (road trucks)

Parallel connection and rail crossings

Description:

Terminals to be connected to the 1435 mm system will have separate feeder and loading tracks. Since the principal conditions are nearly the same for tracks of both gauges, a parallel alignment to the existing 1520 mm tracks is most likely to be the best option.

However, the number of facilities and their various track connetions will not allow to completely avoid crossings between the tracks of both systems. Preferably, such crossings use multilevel solutions, but with the long development of necessary ramps for heavy freight trains and a topography of the area not providing suitable natural opportunities for level segregation, such solutions become costly and space consuming. Therefore, it is most likely that a multilevel solution can be established only in a very small number of occasions.

Figure 17. Crossing of 1520 mm and 1435 mm track in Sestokai, Lithuania

Crossings between 1520 mm and 1435 mm tracks on the same level are supposed to become the standard solution. For the construction of such crossings the conditions are not much different from those for crossings of the same gauge, as illustrated by Figure 17. Differing rail profiles may cause little higher effort, but the actual challenge is the train protection. In the 1520 mm system, such crossings are not often used, but in the 1435 mm system they are a common element of the track construction. Their incorporation into the signalling and train protection system is a standard solution.

Advantages:

- Reduction of interferences between 1435 mm and 1520 mm to the unavoidable minimum
- Smallest extend of capacity reductions in 1435 mm and 1520 mm system
- Interfaces in both, trackwork and signalling/train protection system, are tried and tested, reliable standard solutions

Disadvantages:

- space consumption for railway infrastructure is nearly doubled
- extension of loading and unloading facilities becomes necessary
- several objects (buildings, structures, roads and other communications) close to the existing 1520 mm tracks need to be relocated
- occasionally, space restrictions may not allow for this solution at reasonable costs.

Conditions and field of application:

The solution is recommended as standard, wherever the available space allows for its application.

Multiple gauge tracks

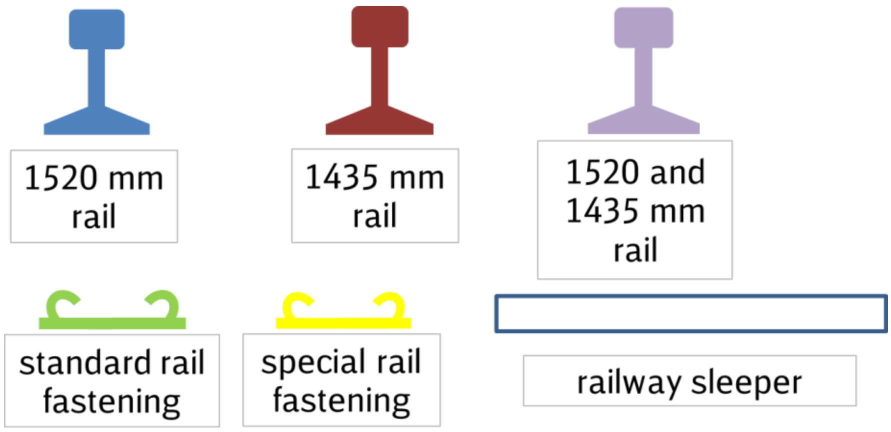
Description:

In many places where railway lines of different gauges coexist, tracks with double gauge are a common practice. Today they are less prominent than in the past, mainly as a result of the reduced extend of narrow gauge railway networks. This is not due to technical insufficiency, but mostly because they used to serve less developed areas were railway transport could not compete with road transport.

The particular construction depends mostly on the gauge difference. There are 4 principal types of construction for a multigauge track, which are described in the following sections and illustrated with schemes. The first scheme (Figure 18) is the legend to the used symbols.

The particular advantages and disadvantages of each construction are given with its description, while the general advantages and disadvantages of multiple gauge tracks are summarised in the respective chapter.

Figure 18. Legend to symbols for Figure 19 to Figure 22



Type 1: Three-rail track within one structural gauge

The most simple way to combine 2 track gauges is to add an additional rail for the narrower gauge on the sleepers of the wider gauge (Figure 19). It is the cheapest solution and was widely used, wherever narrow gauge (mostly 750, 900 or 1000mm) lines needed to use European standard tracks of the 1435 mm system. At that time, when rail the construction was easily to build, when rail fastenings where nails driven into wooden sleepers. Using concrete sleepers would need a special sleeper construction. The main disadvantage is that the gauge difference between 1435 and 1520 mm is too little to apply the solution. The bases of the separate 1520 and 1435 mm rail would overlap. Constructing special rail fastenings of a completely new type and/or a special rail profile would become necessary. Besides this, also the gap between the rail heads would be too small to allow for a regular operation in curves.

Therefore, this solution is not applicable in the facilities of the Muuga terminal.

Figure 19. Three-rail track, using the same structural clearance

Type 2: Four-rail track within one structural gauge

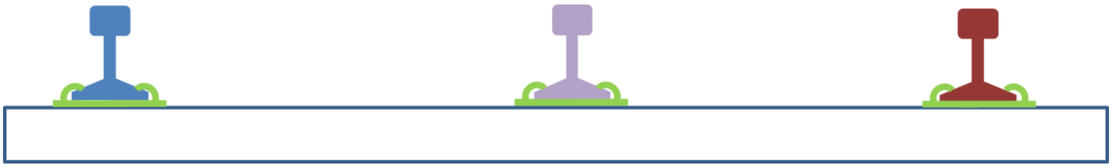
Figure 20. Four-rail track with identical track centre

In cases, where it is desirable to have an identical track center for the tracks of the different gauges, a solution using four rails is used as pictured in Figure 20. It allows for the better utilisation e.g. of loading/unloading facilities, platforms or maintenance equipment in depots. The problems of the Three- rail solution remain and appear on both sides of the track and in larger extend, because the space from the gauge difference has to be used now twice to facilitate the wheelsets. Therefore, this solution is not constructable with any standard parts of railway trackwork and is not applicable in the Muuga port territory.

Type 3: Three-rail track with differing structural clearance gauge

A solution using 3 rails only, but avoiding the obstacles of type 1 could be to establish the additional rail not inside the broader gauge, but in parallel on the outer side of abroad gauge track by extending the sleepers (Figure 21). This allows for application with any gauge difference using standard rails and fastenings. Sleepers need to be of a special type. For railways, the rails are normally tilted to the inside to promote the smooth running of the wheelsets. Obviously, the central rail in this construction has two inner sides and cannot be tilted. This makes this solution applicable only for low speeds as they are typical for shunting operations within terminals.

Figure 21: Three-rail track with differing structural clearance



The solution requires an approximately 1,5 m wider space than a normal single track construction, but still considerably less than 2 separate tracks.

Type 4: Four-rail gauntlet track

Only slightly wider than a single track construction is the gauntlet track. The four rails form enlaced tracks, using the same sleeper as shown in Figure 22. Rails and rail fastenings are of standard type, and there is no relevant limitation of application[4]. The sleepers are of special type.

The main disadvantage is that there is a very little saving of material compared with 2 separate tracks.

Figure 22. Four- rail gauntlet track

<u>Advantages</u>

Originally, multigauge tracks were developed to save permanent way material and equipment. There were applied later also to avoid additional land use. In any case, the condition is a traffic density that can be fully handled with a single track line. Basically, these are the advantages still today, emerging in differing extend with the particular type of construction described above.

[4] The dynamics of the construction at high speed operation would still need to be tested, but this is not relevant for the Muuga area.

Disadvantages

The main disadvantage is that the construction is more complicated than single gauge track, resulting in higher costs for investment and maintenance. Furthermore, the two differing systems (1435 mm and 1520 mm) cannot be operated separately and have to be integrated into a common train protection system. If concrete sleepers are used, always a special construction is required which pays off only with a large number of sleepers to be produced, i.e. a certain length of tracks to be equipped. Wooden sleepers are much easier produced in the required length and can be easier adapted to the particularly needed position of the rail fastenings. Turnouts for multi gauge tracks are much more complicated than standard turnouts and are usually avoided, as shown in Figure 23.

Figure 23. To avoid the very complicated multi-gauge turnouts, the gauntlet track between Mockava and Sestokai in Lithuania separates both gauges before the stations

Conditions

In cases where space restrictions apply or special cranes, bunkers or other equipment need to be connected to tracks of both gauges, multi-gauge tracks can help to cope with the situation. Since this is supposed to regard short track sections only, the four-rail gauntlet track on wooden sleepers seems to be the most promising option. Whenever possible, multi-gauge turnouts have to be avoided.

Railway trucks (transporter trailers or transporter wagons)

Description

The basic idea of this solution is to use transport vehicles of one gauge to carry the vehicles of the other gauge. Solutions, where broader gauge vehicles were transported on trailers or wagons of the narrower gauge were historically more common, but this is no condition. There are 2 basic types:

- Transporter trailers are similar to auxiliary bogies and consist of at least 2 wheelsets connected by a frame that carries an adapter to hold the axle of one wheelset of the wagon to be transported. To carry a wagon with bogies, the trailers have to be adjustable to the wheelbase of the bogie or 2 trailers have to be used, which need to be respectively short. Usually, the loaded wagons are coupled with each other and the locomotive
- Transporter wagons are basically wagons providing a track-like facility as loading platform. Usually, the construction tries to be as low as possible, and the loaded wagons have to be secured by drag shoes. Transport wagons usually are coupled with each other using special coupler beams. The loaded wagons are not coupled with each other.

The wagons are loaded on both types of trucks using special ramps. Both types are available with braking equipment.

Advantages

Wagons of a differing rail gauge loaded on railway trucks can use the existing infrastructure to go to a facility connected by a different gauge track. No additional track infrastructure to connect loadingand unloading facilities is necessary. The method is applicable for all regular railway vehicles, special machinery for loading wagons on the trucks is not necessary. The required ramps are easy to construct and do not require extraordinary maintenance. Especially transport trailers are constructed rather simple and not expensive.

Disadvantages

Although the construction of transport trailers and wagons aims in low construction height, the loaded wagon is in any case in a higher position above the rail surface as before, making an extended structural gauge necessary. This may result in lacking accessibility to a number of loading and unloading facilities which are not adoptable to the differing structural gauge. Also gravity discharge may be incompatible, if transport wagons are used.

The more simple and easier to handle the construction of the transport trailer or wagon is, the less stable it becomes at higher speeds. Therefore, speed restrictions apply. The permissible speed depends on the particular construction and a number of other conditions (brakes, couplers, wheel diameter), but it is expected that the permissible speed will not exceed 20 -60 km/h with higher values for transport wagons and lower ones for transport trailers.

Since only trailing vehicles may use the trucks, traction has to be provided by a locomotive of the used gauge system. The regular couplers of locomotive and loaded wagons do usually not match, and the low construction height of transporter wagons often requires special couplers, too. Therefore adapters have to be used to connect locomotive and wagons.

Other restrictions occur from the geometry of both, the transported wagons and the transport wagons or trailers. While transport wagons carry a whole wagon[5], the length of the transported wagon is limited according to the length of the transport wagon and the used couplers. Transport trailers are rather flexible regarding the length of the carried wagon, but have restrictions regarding the axle distance and sequence.

Although the loading of wagons to the transport trucks is not complicated, it takes a certain amount of time, extending the duration of the freight handling process in the railway terminal.

Conditions

The usage of rail-rail trucking solutions requires little additional infrastructure, but causes significant restrictions to handling and operation. Therefore it is not considered as a standard solution to connect terminals to a railway system. However, if there are facilities that possess track connection to one system (most likely 1520 mm) and only occasionally demand for delivery of wagons of the other system, it may be an option. In this case the interested parties (terminal operators) should contribute to the investment and maintenance for the necessary equipment (railway trucks, adapters etc), since they save the expenses for additional connecting tracks.

For the conditions in Muuga terminal (low speeds, short distances), transport trailers seem to be the preferable option against transport wagons.

Transhipment

Description

Premising that the aim of railway transport is the delivery of freight, not of freight wagons, it seems to make sense not to bring the freight in its wagons to facilities that are not connected to a suitable railway system, but the freight only. This means a transhipment into a suitable mean of transport. In case of Muuga port area, this can be only 1520 mm rail or road. Freight that arrives on a 1435 mm gauge train and is not bound for a terminal that is connected to that system, needs to be unloaded and loaded again either on a road truck or on 1520mm gauge wagons. To do so, a separate transhipment terminal is necessary. Virtually, this is the concept of a dry port discussed in the report to WP1.

Advantages

All additional loading and unloading facilities are concentrated in one spot, most likely in close proximity of the operational infrastructure of the railway station. Freights that do not need to go to the port area do not need to enter it.

Disadvantages

[5] Under certain conditions it is possible to carry long wagons on 2 or more transport wagons. However, this is subject to permission by the relevant authority and restrictions for speed, length etc.

The number of additional necessary transshipping equipment is rather high, causing a respectively high investment. Additional transport vessels (road trucks or trains) have to be provided, too.

The additional transshipment operation increases time demand and costs within the transport chain.

Conditions

This solution is applicable only for freight, where the costs of the additional transshipment are not decisive. The investment in the transshipment facilities is supposed to pay off only, if the dry port solution is implemented anyhow for other reasons. Even in this case, it is recommendable not to use it as connection for those terminals that have high transport volumes to or from Rail Baltica.

With the principal design solutions available in WP 4, final recommendations for 1435 and 1520 crossing solutions can be given there (chapter 8: WP 4 addendum).

1.2.2. Calculation of technical needs for MCTRB

In following, the calculation of the technical needs for MCTRB is presented. At this point it is again important to underline the understanding of MCTRB concept, which is not considered as a one separate terminal, but rather as a concept of the technical set up of the Muuga harbor, which has to be deployed, in order to cope with the predicted transport demand in a period 2025-2055. The components of the technical set up are: 1520 and 1435 infrastructure, technical equipment for loading/unloading of different types of commodities, warehousing options, service facilities, where existing and planned infrastructure and facilities of terminal operators are taken into consideration when planning the concept of MCTRB.

The table below (see Table 9) provides an overview of the different zones of MCTRB, where the accordant loading units, required unloading and loading technologies for each zone are presented. The zones are assigned based on freight type allocation – container terminal zone, general cargo zone, liquid bulk zone, dry bulk zone and RoRo zone. That is, the same classification of the zones like the existing in Muuga harbor, is used.

Table 9 Overview of required equipment for different zones

	Area	Used loading units	Technology for unloading	Loading technology
G	Warehouses for general cargo (break bulk)	Individually loaded cargo without container (eg., in bags), incl. heavy cargo	(Heavy) duty forklift truck/ reachstacker with forks and other attachments, at least 10 t load capacity and harbor cranes	The same as for unloading technology
C	Container	Different types of ISO containers (20 TEU, 40 TEU, High-cube)	Gantry crane	The same as for unloading technology
L	Liquid bulk	Transported in tank wagons	Oil and oil products are loaded via special pipelines, connected directly to rail tanks / tankers	The same as for unloading technology
D	Dry bulk	Unpackaged commodities such without packaging	▪ Mobile excavator with grab dredge (for open wagons) ▪ Belt conveyor for grain ▪ Front loaders (for goods wagons with gravity discharge)	Front loaders with bucket capacity> 6 m^3
R	RORO	Semi-trailers with the length up to 15,65 m with/without tractors	▪ By tractor (for semi-trailers feeded by ferries) ▪ RMG (for cranable semi-trailers)	The same as for unloading technology

Based on results of WP1, the wagons specification was determined (see Table 10). Here, transport volume of RailBaltica is presented separately. The decreasing role of 1520 and increasing role of 1435 becomes obvious. In addition, one can see following trends: increasing amount of pocket wagons (cranable semi-trailers), flat wagons (containers and timber) and the decreasing amount of wagons for bulk cargo (tank wagons, hopper wagons). That means, Muuga port will strengthen its position in terms of container and RORO transportation, first of all due to RB transport flows whereas role of bulk cargo will weaken over the next decades (except of timber).

Table 10. Specification on wagons at MCTB

	2025	2035	2055
Total amount	19,55 Mio. t 53.558 t per day	25,19 Mio. t 69.004 t per day	25,6 Mio. t 70.138 t per day
Rail 1435mm handled volume	4,62 Mio. t annually	8.68 Mio. t annually	10,45 Mio. t annually
In-/outbound wagons per day	**2025**	**2035**	**2055**
Pocket wagon	70	183	436
of which 1435	69	180	431
of which 1520	1	3	5
Flat wagon	297	668	988
of which 1435	183	377	554
of which 1520	114	291	434
Semi-wagon	94	123	96
of which 1435	87	113	87
of which 1520	7	10	9
Tank wagon	257	167	42
of which 1435	19	30	32
of which 1520	238	137	10
Hopper wagon	80	75	61
of which 1435	12	14	8
of which 1520	68	61	53
Universal wagon	43	46	53
of which 1435	43	43	27
of which 1520	0	3	27
Total handling trains per day	**26**	**36**	**37**
of which 1435	**10**	**18**	**21**
of which 1520	**16**	**18**	**16**

Table 11 presents the assumed configuration of conventional and container trains, where the maximum train length of 700 meters (incl. locomotives) is assumed.

Table 11 Assumed configuration of in-/outbound trains

Train type	Max. length	Number and type of wagons	Number of locos	Max. payload	Train weight
Container train	700 m	43 x 15m container wagon	2 x 25m	87 TEU	~ 2 400 t
Conventional train	700 m	46 x 14m semi-wagons	2 x 25 m	2 760 t	~4 200 t

It has to be noted, that the proposed train lengths are introduced based on the maximum train lengths of in Europe. The introduction of the long trains in Europe struggles on the existing intermodal terminals' infrastructure which is designed to handle max. 700 meters trains' length. In addition, due to the spatial constraints both on the existing container terminal, but also on the existing coal terminal (both terminals have the nearest proximity to the sea and are therefore designated to handle the incoming and outcoming container trains), maximum loading track length is 650 meters. However, to be able to handle the longer trains in the future, the railway station in Muuga will be designed with tracks of 1.050 meters length. According to the calculation results, the length of loading tracks of 200 meters (average length in the general cargo warehouses) is enough to handle the daily trains' operations. Only in case of container transports, longer loading tracks – 650 meters – are required.

Main infrastructure assumptions with regard to infrastructure with focus on the lengths of the tracks are summarized below:

- The plot boundaries of MCTRB is not only limited with the existing area. Also different sites outside MCTRB are reviewed to handle in-/outbound material flow
- Length of tracks in the shunting yard is 1.050 meters
- Length of loading tracks in the container terminal is 650 meters
- Length of loading tracks in the general cargo and dry bulk zone each 200 meters
- Length of loading tracks in the liquid bulk zone 650 meters for 1520 and 200 meters for 1435
- Rail network consists of tracks 1435 mm and 1520 mm gauge, non-electrified, minimum horizontal curve radius of station tracks is 1500m, maximum gradient of line tracks 1,5‰

It is proposed that railway operations are done 24 hours a day, MCTRB can operate in 2 shifts (16h) a day for the forecasted throughput. Regular operating times of MCTRB should be 16 hours a day, since it is sufficient to handle the annual demand. Total number of working days per year is assumed to be 365 days, like in the current case of Muuga harbor.

In Table 12 the proposed operating and trains' handling times are presented.

Table 12 Proposed train handling timer and operating time for different business areas

Business area	Train handling time		Operating time
A – Railway reception, departure	2,8	h / incoming train 1435 or 1520	24 hours 365 days/year
	1,5	h / outcoming train 1435 or 1520	
B – Road	121	min / truck	16 hours 365 days/year
C – Container cargo	4,5	h / train 1435	16 hours 365 days/year
	4,5	h / train 1520	
G – General cargo	5,7	h / train 1435	16 hours 365 days/year
	5,7	h / train 1520	
L – Liquid bullk	4,5	h / train 1435	16 hours 365 days/year
	4,5	h / train 1520	
D – Dry bulk	3,7	h / train 1435	16 hours 365 days/year
	3,7	h / train 1520	

Further functions, operational facilities and capacity calculations for each zone are presented in following. The detailed calculation for each zone of MCTRB is provided in the Annex 1.

The first reviewed zone is **rail infrastructure area – marshalling yard (A)**

Rail access of MCTRB is organized along the new planned rail track 1435 mm and existing 1520 mm. Nowadays the rail access is operated by 1520 mm infrastructure. On the rail terminal/station (reception and departure) the locomotive is decoupled and the parts of the train (bulk cargo) or the whole train (container) are shunted to the accordant terminals. It is also possible to reach the terminals (e.g. oil) directly, without processing over the marshalling yard. Operational procedures and required logistics infrastructure is described in the Table 13. The working principle of 1435 station is the same as in case of the existing 1520 station.

Table 13 Operational process and required logistics infrastructure for rail infrastructure zone

	Operational procedures	Construction facilities
(1)	Train arrival in reception/departure tracks (for both 1435 and 1520)	Train-length reception/departure tracks
(2)	Locomotive change (shunting locomotive takes over)	
(3)	Shunting by means of pull-out track in loading track	Appropriate track length
(4)	After (un) loading brakes test without locomotive	Brakes test
(5)	Coupling of the shunting locomotive, transfer to the departure tracks, locomotive change, brakes test, train departure	Departure tracks

During capacity calculations several assumptions were taking into account:

- Train arrival and departure evenly spread over 24 hours
- The utilization of wagons (average payload) is 85%, except containers where the payload for 1 TEU is assumed to be 10,75 tonnes (current state in the Muuga harbor)
- The separate wagon storage (Reception&Departure sidings are considered as an interim storage place)

The main results of capacity calculation are presented in the **Figure 24**. Based on the total number of incoming and outgoing trains (differed by loaden and empty trains) for each terminal zone as well as on the assumptions for the trains' handling time in the station, a total number of reception/departure tracks is calculated.

Figure 24. Capacity calculation for rail infrastructure zone

A – Reception/departure sidings	2025	2035	2055	
Loaden trains inbound (1435)	5	9	10	Trains/d
Loaden trains inbound (1520)	8	9	8	Trains/d
Loaden trains outbound (1435)	5	9	10	Trains/d
Loaden trains outbound (1520)	1	2	3	Trains/d
Empty trains inbound + outbound (1435)	0	0	1	Trains/d
Empty trains inbound + outbound (1520)	7	7	5	Trains/d
Number of trains per day Inbound + Outbound	**26**	**36**	**37**	**Trains/d**
Required number reception/departure sidings (1435)	**4,0**	**6,0**	**7,0**	
Required number reception/departure sidings (1520)	**6,0**	**6,0**	**6,0**	

Activities Reception/Departure	Duration	Measurement unit
For inbound train (1435, 1520)	**165**	**min/per train**
Train arrival	15	min/per train
Removing the locomotive	15	min/per train
Vehicle registration, customs inspection	90	min/per train
Provision of shunting locomotive	15	min/per train
Waiting time	15	min/per train
Shunting to the waiting track	15	min/per train
For outbound train (1435, 1520)	**90**	**min/per train**
Arrival to the train configuration	15	min/per train
Removing the shunting locomotive	15	min/per train
Providing the locomotive	15	min/per train
Station brakes test	15	min/per train
Handling the necessary documents package	5	min/per train
Waiting time	10	min/per train
Train departure	15	min/per train
Dimensioning R/D tracks		
Occupancy time per train (1435)	255	min/per train
Occupancy time per train (1520)	255	min/per train
Selected risk of overrun for occupied tracks	10%	All trains

The second reviewed zone is **road infrastructure area (B)**

Road infrastructure defines the required total number of gates and parking slots for incoming and outgoing trucks which are distributed over the investigated zones of MCTRB.

Operational procedures and required logistics infrastructure for trucks handling are described in the Table 14.

Table 14 Operational process and required logistics infrastructure for road infrastructure zone

	Operational procedures	Construction facilities
(1)	Truck arrival to the terminal	Road access
(2)	Leaving the truck, the driver continues registration procedure in the special administrative facility	Parking place for truck
(3)	Registration in terminal, customs clearance	Administrative building
(4)	Control of the container / truck (control of the condition and weight) by terminal employees	Area or portal for manual "pre-check" and truck weighting
(5)	Truck enters the terminal	Gatehouse with access barrier
(6)	Loading / Unloading of truck	Accordant transshipment technology
(7)	Truck leaves the terminal	Gatehouse with access barrier

The main results of capacity calculation are presented in the Figure 25. Both loaden and empty trucks are considered in the calculation of the road infrastructure.

Figure 25. Capacity calculation for road infrastructure zone

B - Truck gates and parking lots	2025	2035	2055	
Container terminal: Container	181	271	361	trucks/d
Container terminal: Semi-trailer	49	128	214	trucks/d
General Cargo: Paper & Chemicals & Food	81	90	101	semi-trailers/d
General Cargo: Heavy Cargo	35	37	46	semi-trailers/d
General Cargo: Timber handling	252	375	448	semi-trailers/d
Dry Bulk	184	244	275	semi-trailers/d
Liquid Bulk	97	112	107	trucks/d
RORO terminal	575	1121	1215	semi-trailers/d
Total number check-in gates for inbound flow	**16**	**25**	**29**	
Total number check-out gates outbound flow	**4**	**5**	**6**	
Total number of parking slots for inbound flow	**174**	**291**	**349**	
Total number of parking slots for outbound flow	**115**	**206**	**244**	

Dimensioning assumptions	Value	Measurement unit
Operational time	16	h/d
Peak factor	2.0	
Average handling time Inbound (waiting)	5	min/truck
Average handling time Outbound (waiting)	1	min/truck
Parking at the entarance gate	60	min/truck
Waiting for the exit	10	min/truck

Truck dwell times	B	C	D	G	R	
parking at entrance gate	60					min.
waiting at entrance gate	5					min.
drive to transhipment area	5					min.
loading of truck		10	30	30	30	min.
load securing		10	10	10	10	min.
drive to exit gate	5					min.
parking at exit gate	10					min.
waiting at exit gate	1					min.
Total dwell time	86	20	40	40	40	min.
Average dwell time of trucks					**121**	**minutes**

The third reviewed zone is **container terminal area (C)**

Container handling equipment was selected based on both operational and economic considerations that suit best MCTRB’s terminal design requirements. The used criteria and options are presented in the Table 15.

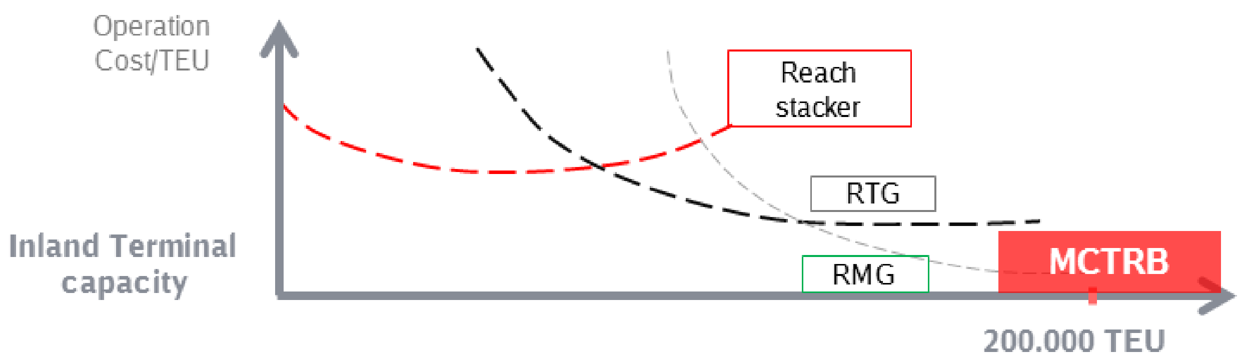
Table 15 Different handling equipment comparison

🟢 Good 🟡 Fair 🔴 Poor

Criteria	Reachstacker	RTG	RMG
Description	Mobile container lifting equipment on wheels	Gantry crane on wheels	Gantry crane on rails
Flexibility	🟢 Very high (no restrictions)	🟡 High	🔴 Low (place bound)
Speed	🔴 18 moves / hour	🟢 30 Moves / hour	🟢 30 Moves / hour
Storage width	🔴 3 lanes	🟡 up to 7 lanes	🟢 up to 16 lanes
Storage height (full / empty)	🟡 3 / 7	🟢 6 / 6	🟡 4 / 4
Span	n.a.	🟡 Up to 27m	🟢 Up to 100m
Required operating space	🔴 High (20m operating width required)	🟢 Low (only two lanes) 2x2m	🟢 Low (only two rails) 2x2m
Prerequisites of surface	🔴 High: Surface pressure	🟡 Medium: Surface pressure	🟢 Medium: crane rail
Safety	🔴 Medium (mobile equipment without guidance)	🟡 Medium (mobile equipment, automation possible)	🟢 High (rail guided)
Environment / Energy	🟡 Diesel	🟡 Diesel or electric	🟢 Electric
Market for used equipment	🟢 Yes	🟢 yes	🟡 Yes, but complicated
Investment per unit	🟢 500,000 €	🟡 1,000,000 €	🔴 4,000,000 €
Operative costs per year (maintenance, repair, energy)	🟡 3.5% of investment	🟡 3.5% of investment	🟢 2.0% of investment
Depreciation period (years)	🔴 10	🟢 15	🟢 20
Operative energy consumption	🟢 16 l / operating hour	🟢 6 kWh per move or 20 l per operating hour	🟢 5,5 kWh per move
Invest for 650 m of operatives lanes	🟡 Operative Area: 650m * 20m * 100 €/m² =1.3 million €	🟢 Wheel lanes: 650m * 4m * 100 €/m² =0,26 million €	🔴 Crane rails 650m*2500 €rails =1,625 million €
Summary	• **Slow, space consuming** • **Not feasible for large terminals**	• **Compromising economy and efficiency** • **Sufficient for medium terminals**	• **Best choice for rail-rail and road-rail transshipment** • **High reliability in cold conditions** • **Sufficient for large terminals**

Based on determined criteria Rail mounted gantry cranes (RMG) is recommended to be used for loading and unloading of containers and cranable semi-trailers. RMG cranes are fully electrified and pursue the aim to handle in-/outbound container and semi-trailers executing transshipment from road to rail and from rail to rail. The economic comparison of different transshipment technologies is provided below (see **Figure 26**). The graph shows the correlation between operational costs and handled TEU. It becomes obvious, that for large terminals with a significant amount of handling volumes, RMG becomes the most cost-efficient alternative.

Figure 26. Economic comparison of transshipment technologies



As demonstrated below (see Figure 27) the annual throughput capacity of the existing container terminal (600 ths TEU) will not be sufficient to cover the additional demand starting from 2035. In addition, significant amount of RORO traffic is anticipated. As it will become obvious from the further description, a set up of a second container terminal is proposed. It shall also be underlined, the total numbers of TEUs in the table refer to the total volume of containers handled by all transport modes (sea, rail, road), whereas the calculated technical needs are based on the inbound and outbound rail transport flows (see the Figure 29).

Figure 27. Technical needs required for the handling of the forecasted container flows

C - Container Terminal	2025	2035	2045	2055
Transport volume per year [TEU/year]	300.070	825.889	1.131.893	1.546.708
Transport volume rail based only [TEU/year]	177.992	442.661	551.071	686.631
Number loading tracks 1435 + 1520*	2 + 2 * 650 m	5 + 3 * 650 m	7 + 3 * 650 m	10 + 4 * 650 m

There are two types of containers to be handled: maritime containers and inland containers. Following figure provides a breakdown of the required TGS (20-foot container ground slot) by the directions and the derivation of the accordant container storage blocks for sea-bound and land-bound containers.

Figure 28. Differentiation of the required container slots (TGS) by directions

C - Container	2025	2035	2045	2055
TGS required transit	239	350	269	217
TGS required local	600	983	1.079	1.148
TGS required export	645	1.811	2.474	3.027
TGS required import	242	1.236	1.796	2.728
Number of container storage blocks total	5	11	15	18
..Of which storage blocks for sea-bound' container yard	**2**	**8**	**11**	**14**
..Of which storage blocks for local + transit (under RMG area)	**3**	**3**	**4**	**4**

The main results of technical requirement calculation for the railway container terminal zone along with the assumptions are presented in the Figure 29. As can be seen, the calculation was made with a contingency – peak factor – of 130%. The same peak factor assumption also applies for all zones of MCTRB.

Figure 29. Capacity calculation for railway container terminal zone

C - Container	2025	2035	2045	2055
Inbound TEU rail based total [TEU/year]	99.366	226.635	277.764	358.029
Outbound TEU rail based total [TEU/year]	59.179	183.023	227.759	279.994
Inbound cranable semi-trailers [nr/year]	12.726	37.132	55.185	86.122
Outbound cranable semi-trailers [nr/year]	9.733	23.171	39.954	61.617
Peak-volume for Inbound + Outbound TEU [TEU/day]	565	1459	1800	2272
Peak-volume for Inbound + Outbound cranable semi-trailers [nr/day]	80	215	339	526
Amount of RMG (cranes)	2.0	4.0	6.0	7.0
Number loading tracks 1435	2 * 650m	5 * 650m	7 * 650m	10 * 650m
Number loading tracks 1520	2 * 650m	3 * 650m	3 * 650m	4* 650m
TGS required transit	197	298	219	349
TGS required local	525	900	980	1087
TGS required export	627	1752	2375	3082
TGS required import	202	1129	1609	1950
Number of container storage blocks	5	11	15	18
Number of parking places for semi-trailers	3	37	58	85

Design assumptions	Value
Working days	365
Maximum amount of TEU per container plattform [TEU]	2.00
Maximum amount of cranable semi-trailers per pocket wagon [semi-trailers]	1.00
Average length of 40' flat wagon[m]	15.00
Average length of pocket wagon (cranable semi-trailers) [m]	18.00
Maximum length of train without locomotive [m]	650.00
Peak factor transport volume fluctuation	130%
Share of FEU	60%
Number of moves per hour per crane	30
Number of movements per container transshipment (30% non-productive)	1.3
Effective operating hours [h/day] incl. maintenance. out-of-order time	14
TEU factor	1.6
Width per TEU-Slot [m]	3.3
Nr of stacking levels [TEU]	4
Storage duration container [days]	6
Length per TEU-Slot [m]	6.5
Length per semi-trailer-slot [m]	14

The above estimated infrastructure demand clearly demonstrates a significant area has to be reserved for the further development stages of the container terminal. That is, to handle the estimated transport volumes in 2055, the width of container terminal shall be approx. 175 meters. Along with the estimated amount of ca. 600 parking slots for RORO, it becomes obvious, that in the current setting of Muuga harbor, it is not possible to handle the depicted demand at one location. In other words, for the forthcoming development stages, a creation of a second container terminal, which shall be specialized on 1435 handling (containers and semi-trailers) shall be constructed.

At this point it is also important to highlight the exchange flows as well as the relevant role of 1435 and 1520 in the transport flows at the container terminal. The accordant data are shown in the Figure 30. As for container traffic, the minor role of rail-rail transshipment becomes obvious. There is a peak of 117 TEU per day (approx. one train) in 2035. Together with further land-bound flows (domestic collection and distrubition) the land-bound segment will reach approx. 30% of the total container flows in 2035. To handle these flows, separate infrastructure outside the port can be settled (dry port). The solution is especially reasonable in combination with further types of flows which might be handled outside (e.g. RORO, General Cargo, Dry Bulk – in case of missing 1435 access tracks), but also in case of placement of industrial zone outside of the port, allowing to use the synergy effect by utilizing the dry port infrastructure. If, however, all transport flows can be handled inside the harbor, it's not recommended to set up a separate infrastructure outside (double investments), but to handle this amount of TEUs and semi-trailers at the container terminal in the port.

Figure 30. Exchange flows development at the container terminal MCTRB

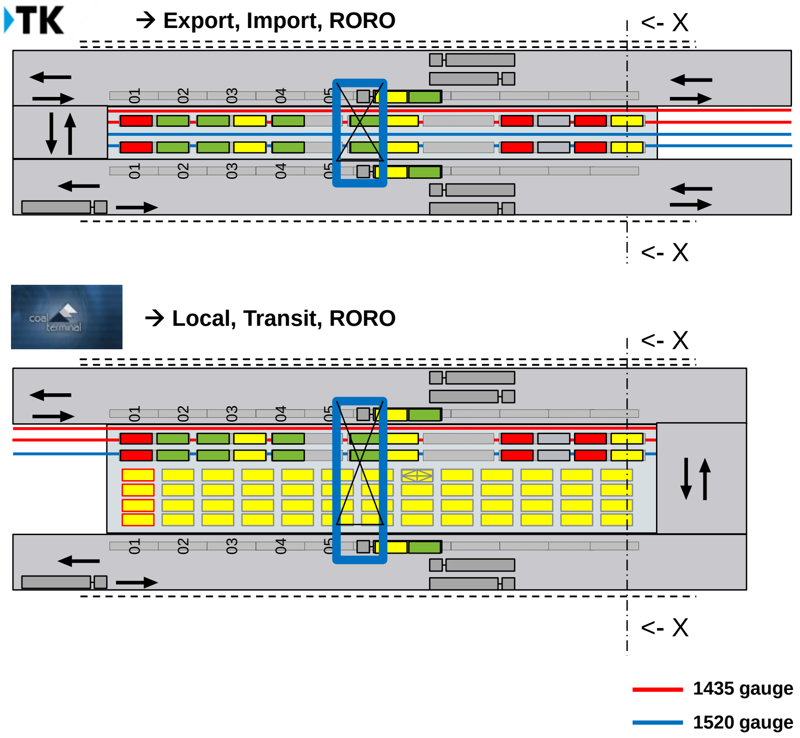
C - Container	2025	2035	2045	2055
Inbound Rail 1435[TEU/year]	53.606	103.892	120.378	140.769
Inbound Rail 1520 [TEU/year]	54.976	137.353	176.468	203.436
Inbound cranable semi-trailers 1435 [nr/year]	14.297	39.943	61.979	90.828
Inbound cranable semi-trailers 1520 [nr/year]	373	1.242	1.591	1.812
Outbound Rail 1435[TEU/year]	54.849	142.261	187.182	240.583
Outbound Rail 1520 [TEU/year]	14.561	59.156	67.043	101.842
Outbound cranable semi-trailers 1435 [nr/year]	10.854	25.649	44.546	66.430
Outbound cranable semi-trailers 1520 [nr/year]	0	0	0	0

C - Container	2025	2035	2045	2055
Transit flow rail-rail [TEU/day]	80	117	90	72
Local flow rail-road, road-rail [TEU/day[	200	328	360	383
Export flow rail-sea [TEU/day]	215	604	825	1.009
Import flow sea-rail [TEU/day]	81	412	599	909
Transit flow rail-rail [semi-trailers/day]	5	15	20	25
Local flow rail-road, road-rail [semi-trailers/day[	11	42	79	131
Export flow rail-sea [semi-trailers/day]	42	114	175	256
Import flow sea-rail [semi-trailers/day]	33	73	111	155

Duration of the dwell time in the loading track	Value
Train arrival [h]	0,5
Preparation for loading/unloading [h]	0,5
Loading/unloading [h]	2
Waiting time [h]	0,5
Loading follow-up activities incl. Station brakes test [h]	0,5
Train departure [h]	0,5
Total dwell time for the loading track [h]	**4,5**

To handle the volumes, four development stages are proposed. For the first stage, following configuration is proposed (see the **Figure 31**).

Figure 31. Top view of container terminal zone with four 1435 and three 1520 tracks – First Stage of MCTRB (year 2025)



The used layout principles are the following:

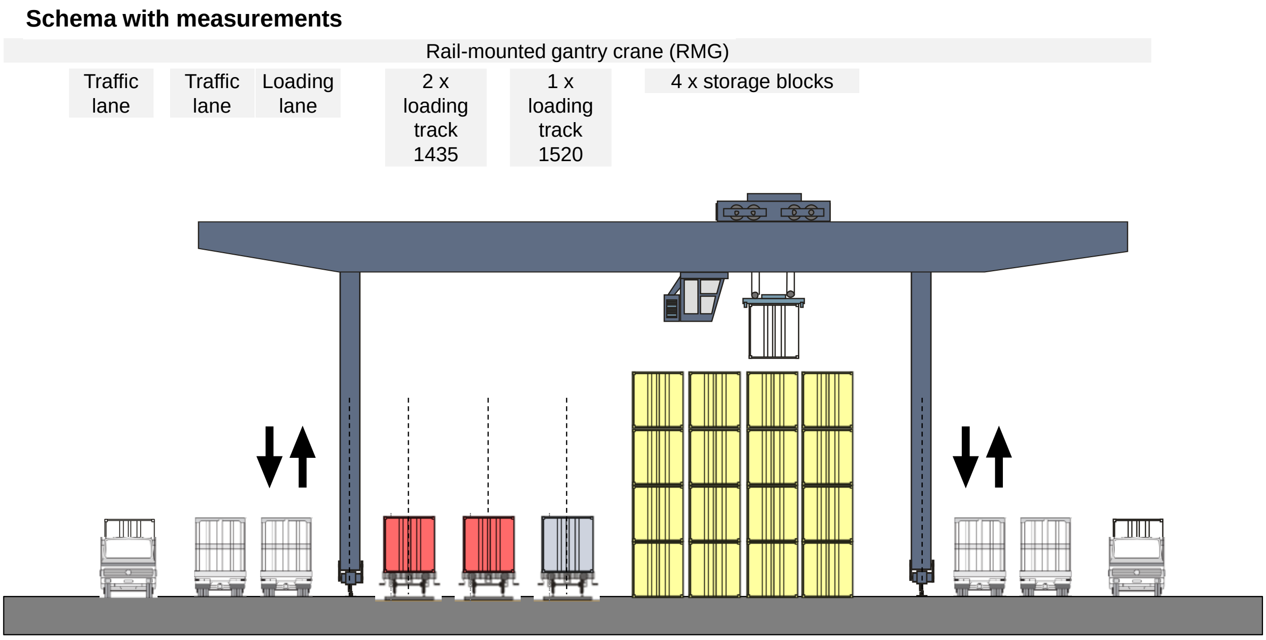
- Usable loading track length is 650 m
- The first module of container terminal consists of:
  - TK: 2 gauges (2x 1520mm, 2x 1435mm)
  - Coal: 2 gauges (1x 1520mm, 2x 1435mm)
  - 2 RMG cranes
  - No locomotive bypass track required, since trains will be pushed
  - 4 storage blocks for Containers at former coal terminal (Stage I) , each Container-Slot is 6,50m length und 3,30m width
  - TK: 2 loading lanes for trucks, 2 traffic lanes for trucks
  - “Coal”: 2 loading lanes for trucks, 2 traffic lanes for trucks
  - Containers with dangerous goods are stored at the ends of the crane runway to enable rapid fire service access
  - Electrics for the supply of electrically operated Reefer containers is provided

The distribution of roles is as follows: the existing container terminal positions itself in its current role and is dedicated to the handling of sea-bound containers (both 1520 and 1435). The role of the second container terminal (located at the former “coal terminal”) at this stage is to handle the land-bound transport. In the forthcoming stages the role will be extended to handle both export and import sea-bound transport flows.

From 2025 onwards the amount of container and semi-trailer is increasing annually, that makes necessary an extension of the container terminal infrastructure. Hereby the development of 1520 and 1435 infrastructure demand will not be similar. Due to higher RB transport volumes, there will be a need to increase the number of 1435 loading tracks from 2 in 2025 to 10 in 2055. That means, during the next three stages starting in 2035, 8 additional 1435 tracks of each 650 meters length have to be installed at MCTRB. The number of 1520 tracks shall be doubled from 2 to 4.

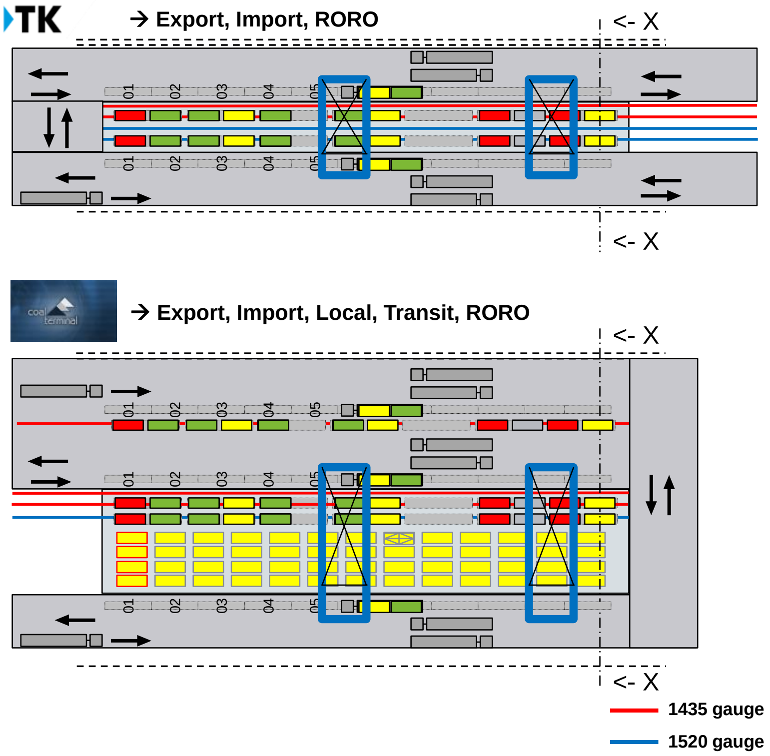
Figure 32 presents a front view of the first stage of container terminal of MCTRB which has to be settled at the former coal terminal. The container terminal can be separated into three zones – road area, container depot and the railway loading tracks (in addition – terminal gate, administrative building, parking slots for trucks and semi-trailers). The road area consists of traffic lanes for incoming and outgoing trucks and of the loading line, where the container is being transshipped to rail or to container yard. In the storage blocks export/import/transit containers are stored. The loading tracks each of 650 m length are used for loading, unloading and rail-rail transshipment of containers and semi-trailers. The same layout also applies to the container module settled on the TK area with the exception, that no container storage under the RMG is required (here, there are also two 1520 tracks).

Figure 32. Front view of container terminal module with two 1435 and one 1520 tracks – First Stage of MCTRB (year 2025) (former Coal Terminal area)



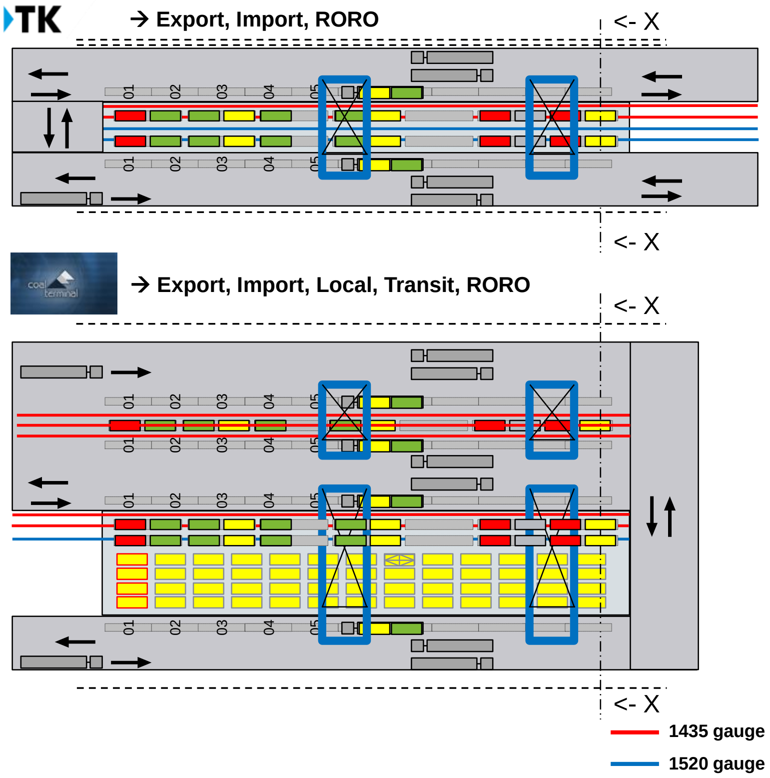
The second development stage which has to be operational in 2035 is presented in the following figure. The difference to the first stage is an additional 1435 track where loading & unloading is operated by reachstackers. This track is mainly focused on the sea-bound cargo.

Figure 33. Top view of container terminal zone with four 1435 and three 1520 tracks – Second Stage of MCTRB (year 2035)



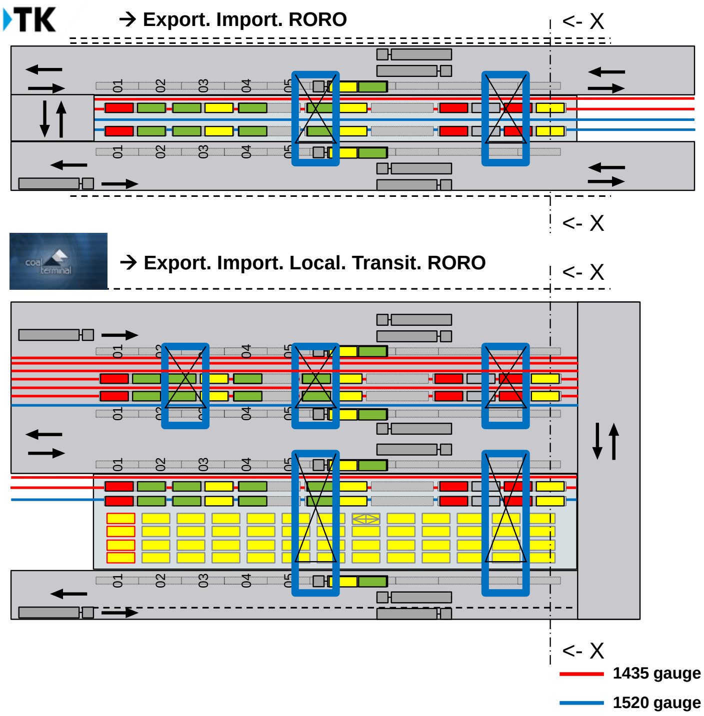
The third development stage which has to be operational in 2045 is presented in the following figure (see Figure 34). The difference to the second stage are two additional 1435 tracks where loading & unloading is operated by RMGs. These tracks are mainly focused on the sea-bound cargo. The sea-bound containers are transshipped from the rail to the sea-bound container yard (equal to the current operations of existing container terminal in Muuga).

Figure 34. Top view of container terminal zone with seven 1435 and three 1520 tracks – Third Stage of MCTRB (year 2045)



The fourth development stage which has to be operational in 2055 is presented in the following figure (see Figure 35). The difference to the third stage are three additional 1435 tracks and one additional 1520 track where loading & unloading is operated by RMGs (also one additional RMG compared to previous stage). These tracks are mainly focused on the sea-bound cargo. The sea-bound containers are transshipped from the rail to the sea-bound container yard (equal to the current operations of existing container terminal in Muuga).

Figure 35. Top view of container terminal zone with ten 1435 and four 1520 tracks – fourth Stage of MCTRB (year 2055)



Functions and operational requirements for the reviewed zone are the following:

- Transshipment of intermodal loading units (Container 20‘,40‘, semi-trailers)
- Transshipment between rail and road (vica versa) and rail-rail
- Intermediate storage for customs inspection, electrical connections for Reefers

Operational procedures and required logistics infrastructure are described in the Table 16.

Table 16 Operational unloading process and required logistics infrastructure for container terminal zone

	Operational procedures	Construction facilities
(1)	Shunting from reception track to loading track	Reception tracks, loading tracks
(2)	Truck arrival and Check-In	Gate area, parking spaces, check-in building
(3)	Preparation the wagon for unloading	Availability train-length tracks (for both gauges – 1435 and 1520)
(4)	Unloading the loading units	RMG with efficient loading capacity (40t)
(5)	Intermediate storage before loading to the platform of truck	Container storage under the crane, Electricity for reefer
(6)	Loading to the truck	1 loading track for trucks, 1 passing track for trucks
(7)	Shunting from loading track to departure track	Loading tracks, departure tracks

The forth reviewed zone is **general cargo business area**

The reviewed freight type consists of Iron and steel and Metal products (in other words, heavy cargo); Coal chemicals, paper pulp and waste paper, wood and cork. The mentioned commodity groups will be reviewed separately.

First sub-zone of General Cargo is named as Paper & Chemicals & Food.

Functions and operational requirements for the reviewed zone of the first commodity group of general cargo freight type are the following:

- Unloading of cocoa beans, paper, chemicals
- Storage of cocoa beans, paper, chemicals
- Loading of cocoa beans, paper, chemicals

Operational procedures and required logistics infrastructure can be found in the Table 17.

Table 17 Operational process and required logistics infrastructure for general bulk zone (Paper & Chemicals & Food)

	Operational procedures	Construction facilities
(1)	Train arrival	Access for both gauges
(2)	Allocation of wagons in the gauge	Appropriate length of both tracks to handle wagons
(3)	Unoading of the wagon	Handling equipment (lift truck with multiple paper roll clamps) and forklift trucks for other commodities
(4)	Interim storage	Asphalted storage area, closed storage
(5)	Freight loading to the truck or wagon	Handling equipment (lift truck with multiple paper roll clamps) and forklift trucks for other commodities
(6)	Shunting from loading track to departure track	Loading tracks, departure tracks

The main results of capacity calculation are presented in the Figure 36

Figure 36. Capacity calculation for general cargo zone (Paper & Chemicals & Food)

G – Paper & Chemicals & Food	2025	2035	2055
Loaded wagons inbound 1435 [Wg/d]	11	16	13
Loaded wagons inbound 1520 [Wg/d]	0	2	1
Loaded wagons outbound 1435 [Wg/d]	17	27	23
Loaded wagons outbound 1520 [Wg/d]	0	1	1
Number Loading Tracks (1435)	1 * 200 m	1 * 200 m	1 * 200 m
Number Loading Tracks (1520)	0 * 200 m	0 * 200 m	0 * 200 m
Required number of forklifts per day (inbound / outbound)	5 / 7	7 / 7	7 / 7
Total required storage area [m²]	12.234	16.697	16.853

Duration of the dwell time in the loading track	Value
Train arrival [h]	0.25
Preparation for unloading [h]	0.25
Unloading/Loading [h]	2
Waiting time [h]	1
Loading follow-up activities incl. Station brakes test [h]	0.25
Total dwell time for the loading track [h]	**3.75**

G – Paper & Chemicals & Food	Value
Working days per year	365
Daily operational hours [h]	16
Average length of wagen	14
Average amount of wagens per train	7
Effective payload per truck [t]	25
Average length of the truck [m]	21
Peak factor transport volume fluctuation	1.3
Length loading track 1435 mm [m]	200
Length loading track 1520 mm [m]	200
Unloading performance per forklift [pallet/h]	20
Average storage period [d]	6

Second sub-zone in the General Cargo is named as Heavy cargo.

The main function and operational requirement for the reviewed zone of the second commodity group of general cargo freight type is the following: Transshipment and interim storage of heavy cargo like steel and (agricultural) machinery between rail (1435), rail (1520) and road

Operational procedures and required logistics infrastructure are presented in the Table 18.

Table 18 Operational process and required logistics infrastructure for general bulk zone (Heavy cargo)

Operational procedures		Construction facilities
(1)	Train arrival	Access for both gauges
(2)	Allocation of wagons in the gauge	Appropriate length of both tracks to handle wagons
(3)	Unoading of the wagon	Heavy lift truck
(4)	Interim storage	Asphalted storage area, closed storage
(5)	Freight loading to the truck or wagon	Heavy lift truck
(6)	Shunting from loading track to departure track	Loading tracks, departure tracks

The main results of capacity calculation are presented in the Figure 37.

Figure 37. Capacity calculation for general cargo zone (Heavy cargo)

G - Heavy Cargo	2025	2035	2055
Loaded wagons inbound 1435 [Wg/d]	21	21	13
Loaded wagons inbound 1520 [Wg/d]	0	0	13
Loaded wagon outbound 1435 [Wg/d]	3	4	3
Loaded wagon outbound 1520 [Wg/d]	0	1	1
Number Loading Tracks (1435)	2 * 200 m	2 * 200 m	1 * 200 m
Number Loading Tracks (1520)	0 * 200 m	0 * 200 m	1 * 200 m
Required number of heavy-lift trucks	1.0	1.0	1.0
Required total storage space [m²]	1.844	2.198	3.651

Duration of the dwell time in the loading track	Value
Train arrival [min]	15
Preparation time for loading / unloading [min]	30
Loading/unloading (25 min/wagen) [min]	296
Waiting time [min]	15
Brakes test [min]	15
Train departure [min]	15
Total dwell time for the loading track [h]	6.5

G - Heavy Cargo	Value
Working days per year	365
Peak factor transport volume fluctuation	1.3
Effective payload per wagon [t/wagon]	60
Average length of wagen	14
Average number wagen per train	12
Operational hours [h/day]	16
Length of loading track [m]	200
Specific gross space requirement [t/m²]	5.0
Average storage duration [d]	6

Third sub-zone of General Cargo is named as Wood and Cork.

Functions and operational requirements for the reviewed zone of the third commodity group of general cargo freight type are the following:

- Unloading of timber
- Storage of timber
- Loading of timber

Operational procedures and required logistics infrastructure are presented in the Table 19.

Table 19 Operational process and required logistics infrastructure for general bulk zone (Wood and cork)

	Operational procedures	Construction facilities
(1)	Train arrival	Access for both gauges
(2)	Allocation of wagons in the gauge	Appropriate length of both tracks to handle wagons
(3)	Unoading of the wagon	Handling equipment (timber wheel loader)
(4)	Interim storage	Asphalted storage area, closed storage
(5)	Freight loading to the truck or wagon	Handling equipment (timber wheel loader)
(6)	Shunting from loading track to departure track	Loading tracks, departure tracks

The main results of capacity calculation are presented in the Figure 38.

Figure 38. Capacity calculation for general cargo zone (Wood and cork)

G – Timber handling	2025	2035	2055
Loaded wagons inbound 1435 [Wg/d]	12	19	22
Loaded wagons inbound 1520 [Wg/d]	10	11	10
Loaded wagons outbound 1435 [Wg/d]	0	1	0
Loaded wagons outbound 1520 [Wg/d]	0	1	0
Number Loading Tracks (1435)	1 * 200 m	1 * 200 m	1 * 200 m
Number Loading Tracks (1520)	1 * 200 m	1 * 200 m	1 * 200 m
Required number of timber wheel loaders	2	3	3
Total required storage area [m²]	29.661	44.626	52.200

Duration of the dwell time in the loading track	Value
Train arrival [min]	30
Preparation for loading/unloading [min]	30
Loading/unloading [min]	257
Waiting time [min]	20
Loading follow-up activities incl. Station brakes test [min]	30
Train departure [min]	15
Total dwell time for the loading track [h]	6.5

G – Timber handling	Value
Working days per year	365
Daily operational hours [h]	16
40' flat wagon (containers or wood)	68
Effective payload [t/flat wagen]	58
Average length of flat wagen	15
Average amount of wagens per train	7
Effective payload per truck [t]	25
Average length of the truck [m]	18
Peak factor transport volume fluctuation	1.3
Length loading track 1435 mm [m]	200
Length loading track 1520 mm [m]	200
Time required for loading / unloading with 1 piece of equipment [min/Wg]	39
Bulk density roundwood. woody pine. beech. etc. [t / m³]	0.85
Specific space requirements [cubic meters per tonne]	1.18
Average storage heigth [m]	2.0
Specific net area requirement [m³ / t]	1.18
Additional area for traffic	20%
Specific brutto area requirement [m³ / t]	1.4
Average storage period [d]	3

The fifth reviewed zone is **dry bulk business area**

Dry bulk consists of the several commodities groups which are Cereals, Fruit and vegetables, Live animals, Textiles, Other raw materials; Solid mineral fuels; Iron ore, Iron and Steel, Non-ferrous Ore and Waste; Crude and Manufactured minerals, Cement, Lime and Manufactured building materials; and Natural and Chemical fertilizers.

The main function and operational requirements for the reviewed zone is the following - Transhipment and temporary storage of grain, fertilizers in bulk form, iron ore, building materials in bulk form such as cement , solid mineral fuels

Operational procedures and required logistics infrastructure are described in the Table 20.

Table 20 Operational process and required logistics infrastructure for dry bulk zone

	Operational procedures	Construction facilities
(1)	Train arrival	Appropriate access to the both gauges
(2)	Allocation of wagons in the track	Appropriate length of both track types to handle wagons
(3)	Wagon unloading	Mobile excavator with grab dredge, belt conveyor and front loaders
(4)	Interim storage	Dedicated storage area
(5)	Loading freight into wagon or truck	Wheel loader
(6)	Truck leaves the terminal	Road for trucks, weighing machine, gatehaus

The main results of capacity calculations are presented in the Figure 39.

Figure 39. Capacity calculation for dry bulk zone

D – Dry bulk	2025	2035	2055
Number of loaden trains 1435 inbound [nr/ day]	1.3	2.4	2.5
Number of loaden trains 1435 outbound [nr / day]	2.7	4.7	4.6
Number of loaden trains 1520 inbound [nr/ day]	5.2	5.2	6.1
Number of loaden trains 1520 outbound [nr / day]	0.4	0.5	0.6
Storage capacity for "Cereals. Fruit and vegetables. Live animals. Textiles. Other raw materials" [t/day]	18.279	26.653	27.438
Storage capacity for "Solid mineral fuels"[t/day]	16.424	23.851	25.413
Storage capacity for "Iron ore. Iron and Steel. Non-ferrous Ore and Waste"[t/day]	743	1.098	1.172
Storage capacity for "Crude and Manufactured minerals. Cement. Lime and Manufactured building materials"[t/day]	17.681	27.271	29.214
Storage capacity for "Natural and Chemical fertilizers"[t/day]	36.008	35.466	41.422
Number Loading Tracks (1435)	3 * 200 m	4 * 200 m	3 * 200 m
Number Loading Tracks (1520)	2 * 200 m	2 * 200 m	2 * 200 m

D – Dry bulk	Value
Working days per year	365
Daily operational hours [h]	16
Effective payload [t/hopper wagen]	60
Effective payload [t/semi-wagen]	60
Effective payload [t/semi-trailer]	21
Average length of hopper wagen[m]	15
Average length of semi-wagen [m]	14
Amount of hopper wagons in train	10
Amount of semi-wagons in train	11
Average length of train without locomotive [m]	160
Maximum length of train without locomotive [m]	200
Peak factor transport volume fluctuation	130%

Duration of the dwell time in the loading track	Value
Train arrival [h]	0.5
Preparation for loading/unloading [h]	0.5
Loading/unloading [h]	1.2 *
Waiting time [h]	0.5
Loading follow-up activities incl. Station brakes test [h]	0.5
Train departure [h]	0.5
Total dwell time for the loading track [h]	3.7

* Average loading/unloading time for several commodities which are included in dry bulk freight type

The sixth reviewed zone is **liquid bulk business area**

Liquid bulk freight type consists of commodity group “Crude petroleum, petroleum products and gas”. The main functions and operational requirements are the following:

- Transshipment of oil and oil products from different modes of transport
- Storage of the liquid bulk

Operational procedures and required logistics infrastructure are described in the Table 21.

Table 21 Operational process and required logistics infrastructure for liquid bulk zone

	Operational procedures	Construction facilities
(1)	Tank wagon arrival	Appropriate access to the both gauges

	Operational procedures	Construction facilities
(2)	Allocation of wagons in the gauge	Appropriate length of both gauges to handle wagons (main focus on 1520 mm)
(3)	Wagon unloading	Special pipelines are used
(4)	Interim storage	Special storage tankers
(5)	Loading freight into wagon/truck/tanker	Special pipelines
(6)	Loaded truck leaves the terminal	Road for trucks, weighing machine, gatehaus

The main results of capacity calculations are presented in the Figure 40.

Figure 40. Capacity calculation for liquid bulk zone

L – Liquid bulk	2025	2035	2055
Number of loaden trains 1435 inbound [nr/ day]	0.2	0.4	0.4
Number of loaden trains 1435 outbound [nr / day]	0.16	0.20	0.72
Number of loaden trains 1520 inbound [nr/ day]	4.4	2.5	0.2
Number of loaden trains 1520 outbound [nr / day]	0.0	0.0	0.0
Number Loading Tracks (1435)	1 * 200 m	1 * 200 m	1 * 200 m
Number Loading Tracks (1520)	2 * 650 m	1 * 650 m	1 * 650 m
Required space [t/day]	176.100	115.110	52.079

L – Liquid bulk	Value
Working days per year	365
Daily operational hours [h]	16
Average length of tank wagon [m]	12.00
Average length of train without locomotive [m]	480.00
Maximum length of train without locomotive [m]	650.00
Peak factor transport volume fluctuation	130%
Effective payload [t/tank wagen]	56
Effective papayload [t/oil tank truck]	14
Average storage days [d]	8

Duration of the dwell time in the loading track	Value
Train arrival [h]	0.5
Preparation for loading/unloading [h]	0.5
Loading/unloading [h]	2
Waiting time [h]	0.5
Loading follow-up activities incl. Station brakes test [h]	0.5
Train departure [h]	0.5
Total dwell time for the loading track [h]	4.5

The last reviewed zone is **RoRo business area.**

Due to the intensive growth the additional stage (2045) is reviewed. **Based on the forecasted freight flow all investments for the phase 2035 should be done before 2030.**

The main functions are the following:

- Handling in-/outcoming semi-trailers from/to ferries, from/to rail/road
- Interim Storage of semi-trailers with tractors

Operational procedures and required logistics infrastructure are described in the Table 22.

Table 22 Operational process and required logistics infrastructure for RoRo zone

	Operational procedures	Construction facilities
(1)	Semi-trailer arrival (by road or rail)	Appropriate number of gates for semi-trailers, check-in facility
(2)	Parking the semi-trailer in the sorting area on the berth	Marked space to park semi-trailers in the appropriate sequence
(3)	Loading/unloading semi-trailers to the ferry	Special ferry ramp

(4)	Semi-trailer leaves the terminal (by road or rail)	Appropriate number of gates for semi-trailers

The main results of capacity calculation are presented in the Figure 41.

Figure 41. Capacity calculations for RoRo zone

R- RORO	2025	2035	2045	2055
Inbound trucks Road-RORO [t / year]	1.642.262	2.802.219	2.840.684	2.717.744
Inbound trucks Rail-RORO [t / year]	218.597	611.274	903.293	1.310.103
Outbound trucks RORO-Road [t / year]	1.354.514	2.312.229	2.396.485	2.235.214
Outbound trucks RORO-Rail [t/ year]	172.319	391.534	577.655	829.296
Inbound trucks Road-RORO [semi-trailers / day]	278,53	475	482	461
Inbound trucks Rail-RORO [semi-trailers / day]	37	104	153	222
Outbound trucks RORO-Road [semi-trailers / day]	230	392	406	379
Outbound trucks RORO-Rail [semi-trailers/ day]	29	66	98	141
Inbound + outboud trucks RORO per day	**575**	**1.037**	**1.139**	**1.203**
Number of parking slots RORO	**224**	**405**	**445**	**470**
Required space [m2]	**16.384**	**29.585**	**32.491**	**34.301**

In the Table 23 and Table 24 a summary to the technical needs per zone is presented.

Table 23 Overview of the calculated technical needs

A – Internal Rail Infrastructure	**2025**	**2035**	**2055**
Transport volume per year [t/year] (max. capacity)	12.194.766	15.630.841	15.423.655
Number of loaden trains In + Out per day (700m)	26	36	38
Number of trucks Reception-/Departure sidings 1435 + 1520	4 + 6	6 + 6	7 + 6
B – Internal Road Infrastructure	**2025**	**2035**	**2055**
Number of trucks per day (max. capacity)	1.453	2.378	2.766
Truck Gates Entrance / Exit	21	33	36
Parking slots for trucks Entrance / Exit	334	565	663
L – Liquid bulk (oil and oil products, gas)	**2025**	**2035**	**2055**
Transport volume per year [t / year] (max. capacity)	6.354.610	4.607.084	2.411.831
Number of loading tracks 1435 + 1520	1*200 m + 2 * 650 m	1*200 m + 1 * 650 m	1*200 m + 1 * 650 m
Terminal capacity [m³]	205.232	133.555	47.122
G - General Cargo	**2025**	**2035**	**2055**
Transport volume per year [t/year] (max. capacity)	4.047.244	5.336.842	3.829.281
Number loading tracks 1435 + 1520	3 + 1 * 200 m	4 + 2 * 200 m	2 + 1 * 200 m
Warehouse area [m²]	50.813	60.814	53.772
D - Dry Bulk (fertilizers, minerals, grain)	**2025**	**2035**	**2055**
Transport volume per year [t/year] (max. capacity)	5.116.891	6.773.994	4.520.301
Number loading tracks 1435 + 1520	3 + 2 * 200 m	4 + 2 * 200 m	3 + 2 * 200 m

Terminal capacity [t/day]	91.034	96.671	81.806

Table 24 Overview of the calculated needs for containers and RoRo

C - Container Terminal	2025	2035	2045	2055
Transport volume per year [TEU/year]	300.070	825.889	1. 131.893	1.546.708
Transport volume rail based only [TEU/year]	177.992	442.661	551.071	686.631
Number loading tracks 1435 + 1520	2 + 2 * 650 m	5 + 3 * 650 m	7 + 3 * 650 m	10 + 4 * 650 m
Number of gantry cranes	2	4	6	7
G- RoRo	**2025**	**2035**	**2045**	**2055**
Number of parking RoRo slots	224	405	445	470
RoRo terminal area m²	16.384	29.585	32.491	34.301

2. WP 2.2 Examination of potential location

In this section, different settings of MCTRB – combinations of the locations' (see Figure 14) – are discussed. The goal of this section is to identify the best suitable locations for parts of MCTRB and, based on the criteria ranking, to present two alternatives which are compared in a follow-up CBA.

2.1. Freight terminals

As already shown in the previous chapter (see 1.1.1 and 1.2) it becomes visible that for most of the commodities the turnover will not exceed the capacity of the existing freight terminals within the forecast horizon (2055). Therefore, it is basically assumed that the freight volumes are handled within the existing terminals which need to be connected to the new 1435 mm railway infrastructure.

Additional capacity will be needed for the handling of Container and RoRo traffic. Besides this, there are concerns within "PoT" (Port of Tallinn) to hamper the future development by focusing on the current terminal operators. Therefore, also potential development sites have to be connected to the new railway infrastructure. The allocation of particular terminals is one of the challenges of the general development of the port. In this connection a number of potential development sites and their possibilities of connection to the RB infrastructure is regarded without defining the particular use of these sites. Apart of the already identified land plots (plot 1, plot 4, plot 5, plot 6 – see Figure 14.) this regards also a stripe of land between the existing 1520 mm railway station and the shore line of Muuga bay, further referred to as "new beach".

2.2. Railway terminal (Rail Baltica station)

Besides the freight terminals with their loading and unloading facilities, a separate railway terminal becomes necessary to receive the arriving and to prepare the departing trains. Also a number of related activities will be performed in this terminal as described before. To avoid confusion with the description of the freight terminals, this railway terminal will be referred to as "station" in following.

2.2.1. Criteria for site selection

Several targets are to be met by the choice of location for the Rail Baltica station (railway terminal):

- Low investment costs
- Low operation costs

- Short distance to freight (loading/unloading) terminals
- Little interference with the existing railway infrastructure and operation
- Minimized adaptation of the existing freight terminal infrastructure
- Minimized use of land in private ownership
- Railway crossings on shunting tracks only, not line tracks
- Ample alignment parameter (low gradients, big radii)
- Attractive to facilitate transport
- Low negative impact on environment
- Facilitates 1050 m trains
- Sufficient handling capacity

All these targets have different levels of abstraction, are interdepending and partly contradicting. The higher the level of abstraction, the more general are the targets. Targets on a lower level are often derived from the targets of higher level. Therefore, conflicting targets on different levels of abstraction are usually not critical and actually rather common[6]. Compromises are required mainly between conflicting targets at the same level.

Consequentially, a target hierarchy has to be applied to allow for a systematic assessment and solution finding. To reduce the complexity of assessment processes, the number of levels should be as little as possible. For the site selection, the distinction of 2 levels, level A and level B, was applied as seen in Table 25.

Table 25 Targets ad allocated levels for the site selection of the Rail Baltica station in Muuga.

Target Nr	Description	Level	Potential conflict
A1	Low investment costs	1	A2, A3, A4, A5
A2	Low operation costs	1	A1, A3, A4, A5
A3	Little interference with the existing railway	1	A1, A2, A4, A5
A4	Attractive to facilitate transport	1	A1, A2, A3, A5
A5	Low negative impact on environment	1	A1, A2, A3, A4
B1	Minimised adaptation of existing freight terminals	2	B2, B3, B4, B5, B7
B2	Minimised use of land in private ownership	2	B1, B3, B4, B5, B6
B3	Short distance to freight terminals	2	B1, B2, B4, B5, B6
B4	Railway crossings on shunting tracks only, not line tracks	2	B1, B2, B3, B5
B5	Ample alignment parameter	2	B1, B2, B3, B4, B6

[6] The target to minimize investment and operation costs as well as the negative environmental impact, not constructing a terminal at all would achieve these targets, but is obviously not a reasonable solution. Therefore they have to be compromised anyway and cannot influence the solution finding on the same level as, e.g. land use and distance topics.

Target Nr	Description	Level	Potential conflict
B6	Tracks for 1050 m long trains	2	B2, B3, B5
B7	Sufficient handling capacity	2	B1, B2, B3

2.2.2. Description of alternatives

A total of 6 alternatives was developed reflecting the differing opportunities to host the Rail Baltica station and to serve the adjacent freight terminals by accordant gauges' solutions. They will be described one by one in the following sections supported by a principal scheme. These schemes are simplified to avoid the impression of more detailed planning. That occurred when the actual working sketches were presented to stakeholders, creating discussions about problems and opportunities that could not be specified in this planning stage yet.

It also has to be recognized that there is no solution identified that allows the smoothless integration of the new 1435 mm railway facilities into the existing situation without compromising the established infrastructure. This regards to the 1520 mm railway objects as well as roads and structures within the port territory.

Initially, the legend for the marks in the schemes is shown below:

Legend:

- Water
- 1520 mm railway line track
- 1520 mm railway connecting track
- 1520 mm railway station
- existing freight terminal, interested in RB connection
- existing freight terminal, not interested in RB connection
- potential site for future terminal development to be connected to RB
- 1435 mm railway line track
- 1435 mm railway connecting track
- 1435 mm railway station
- multiple gauge (1520 +1435 mm) loading track
- new to build 1520 mm track
- other objects (bridges, road relocation etc.)

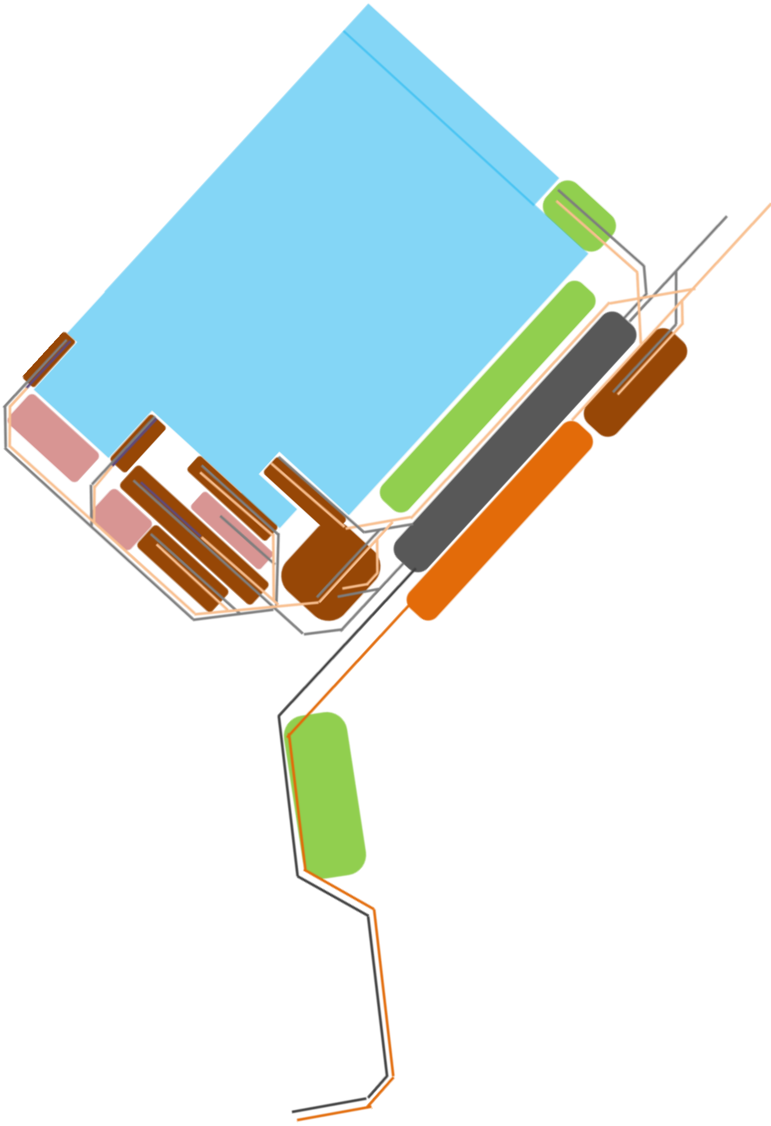
Alternative I

Figure 42. Rail Baltica station Muuga location, Alternative I

Description:

The Rail Baltica line runs parallel on the eastside of the existing 1520 mm railway line. The station is located at the so called “plot 1”. A long turnout track on the North-Western end connects the existing terminals, crossing the 1520 mm turnout tracks, but avoiding the major station tracks of the 1520 mm station Muuga.

A principal scheme to illustrate the alternative is shown as **Figure 42**.



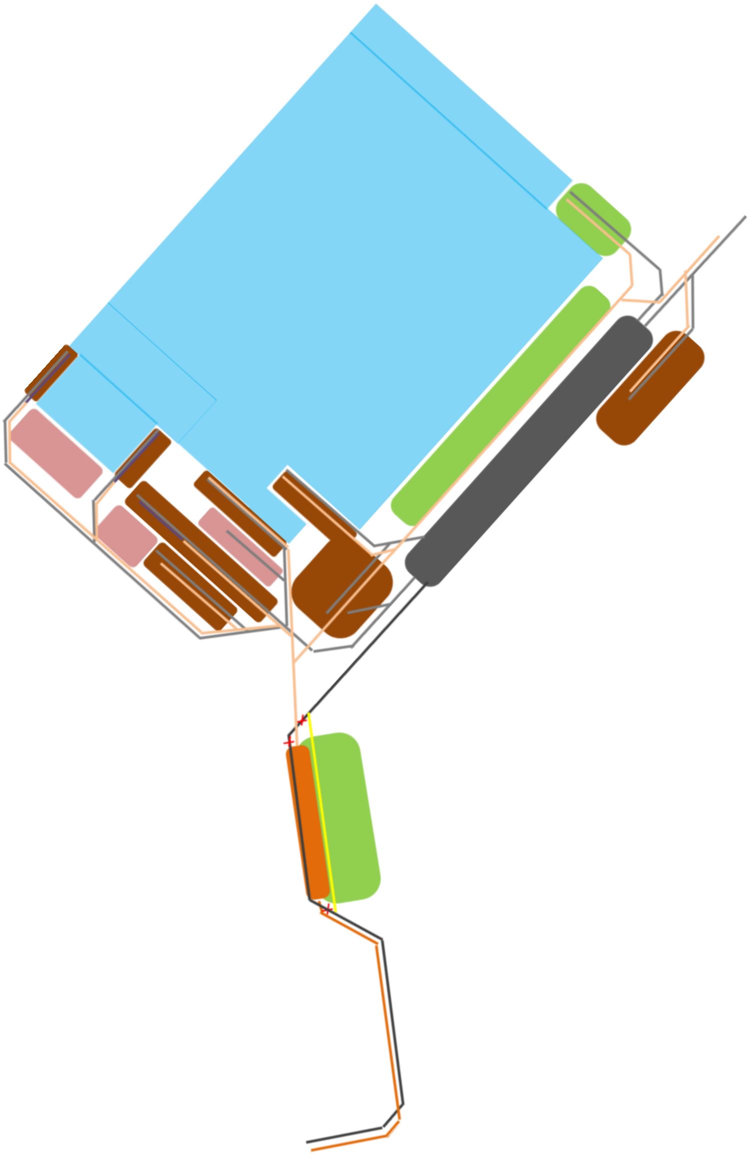
The arrangement would allow to utilise the existing depot for the depot functions of the 1435 mm railway as well. This of course requires the adaptation of the track geometry as well as of the maintenance equipment. This applies for both, locomotives and freight wagons.

Additional tracks for locomotive stabling are best located close to the depot area. Stabling of wagons usually requires longer track groups that may be found parallel to the arrival/departure tracks or on the opposite side of the 1520 mm station.

Alternative II

Figure 43. Rail Baltica station Muuga location, Alternative II

Description:



The Rail Baltica line runs parallel on the westside of the existing 1520 mm railway line, which has to be relocated by approximately 5m to the East, crossing it near the intersection of the roads 1 (Peterburi tee) and 94 (Põhjaranna tee). The station is built on the Western edge of plot 5. The freight terminals are connected to the Northern head of the station. The connection track uses the alignment of the abandoned direct access track (1520 mm) to the oil terminals.

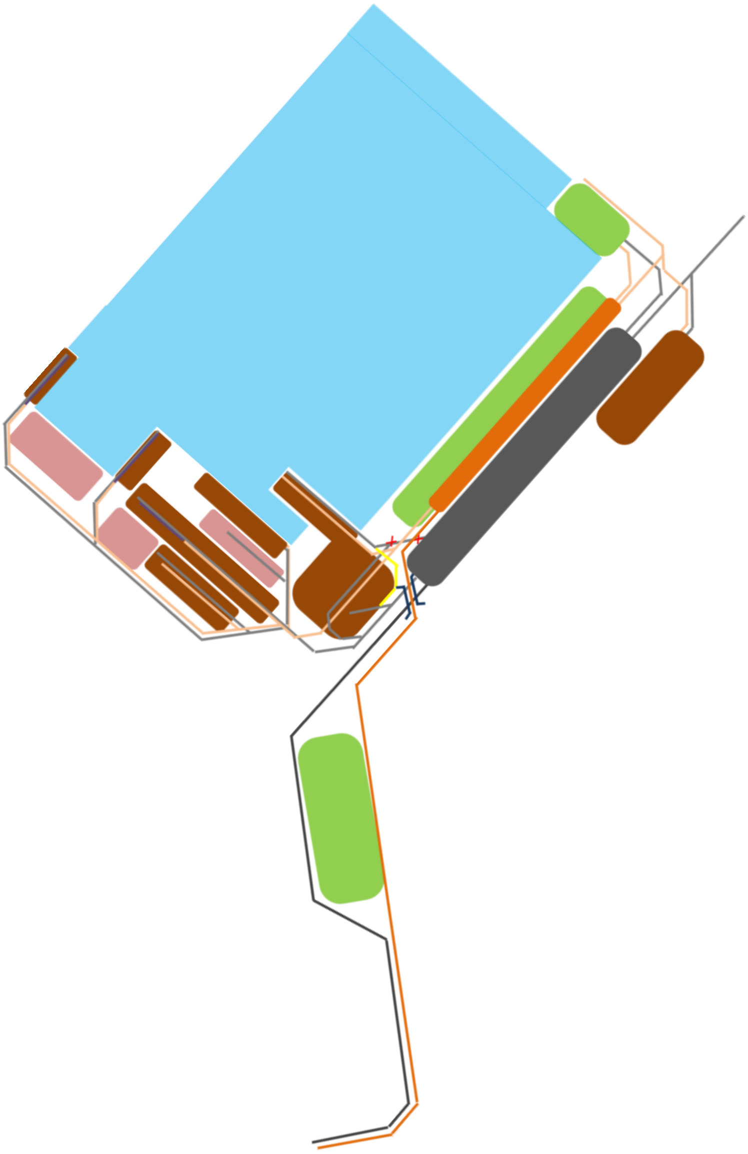
The scheme of the alternative is shown as Figure 43.

Facilities for technical services and depot functions are best to be situated North of the 1435 mm railway station. Additional tracks for short and /or long time stabling of wagons may be located parallel to the station tracks or, if necessary on the plot 3 parallel to Lasti tee.

Since the new alignment of the 1520 mm line will be slightly shorter than today, a small increase of the gradient has to be accepted.

Alternative III

Figure 44. Rail Baltica station Muuga location, Alternative III



Description:

The Rail Baltica line runs on the eastside of the existing 1520 mm railway line parallel to the road Nr 94 (Põhjaranna tee). It elevates on the Eastern edge of plot 5, to bridge the intersection Põhjaranna tee and Maardu tee. It stays elevated to pass the existing harbor road gate in the East, than bridging the Western station head of the 1520 mm station. A ramp lowers the elevation to reach the station on the Northwestern side of the existing 1520 mm station. The turnout track has to be constructed parallel to the existing 1520 mm access track to plot 6 (coal terminal).

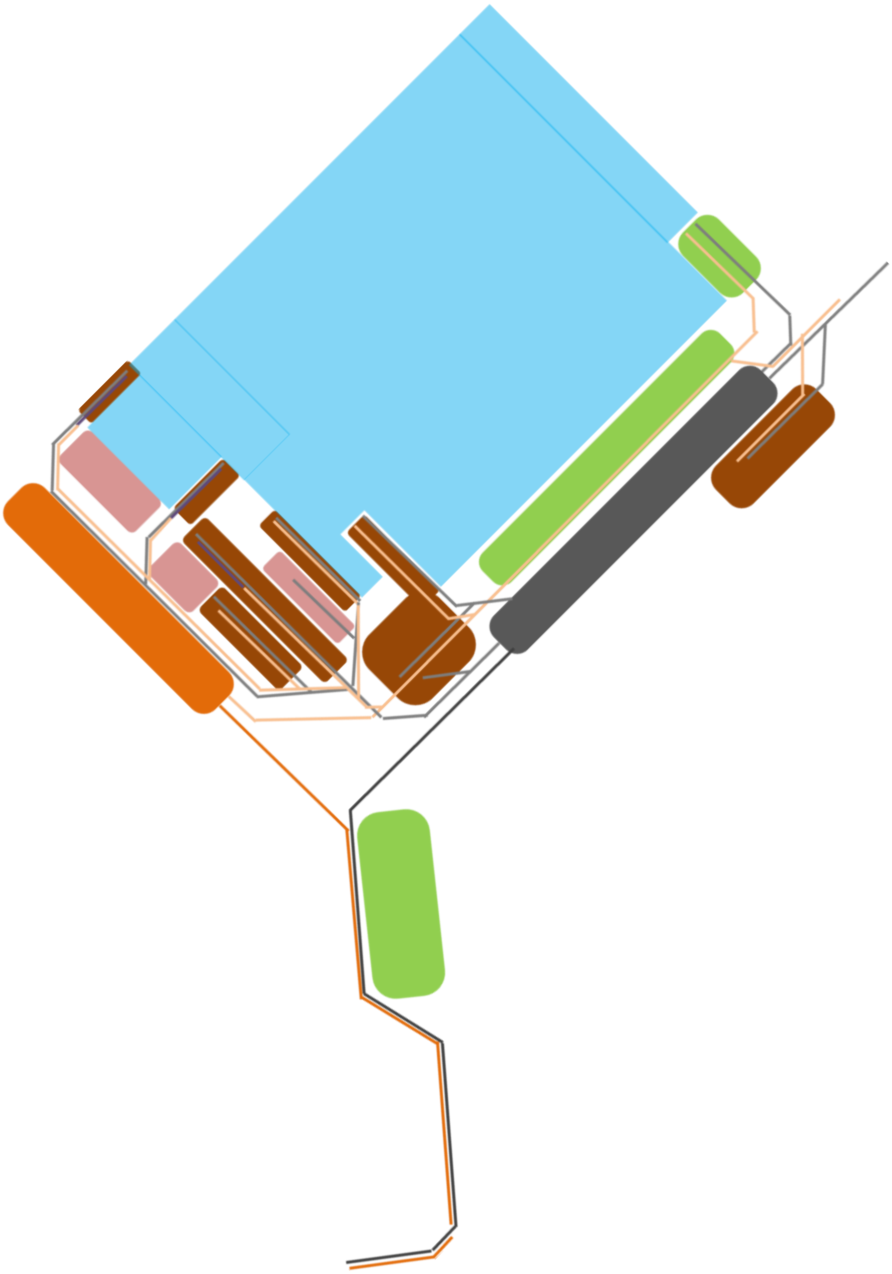
To avoid further implications with spatial planning, the Rail Baltica line could as well follow the alignment of the 1520 mm line, parallel to it on an embankment on the Western side of plot 5. This alignment would be slightly longer, but staying within the envisioned planning corridor. This alternative (III b) is not sketched in the scheme (**Figure 44**).

While additional tracks for wagon stabling are most useful parallel to the station tracks, the depot facilities for technical services of wagons and locomotives may be best located inside the curve that connects the station and plot 6 (coal terminal).

Alternative IV

Figure 45. Rail Baltica station Muuga location, Alternative IV

Description:

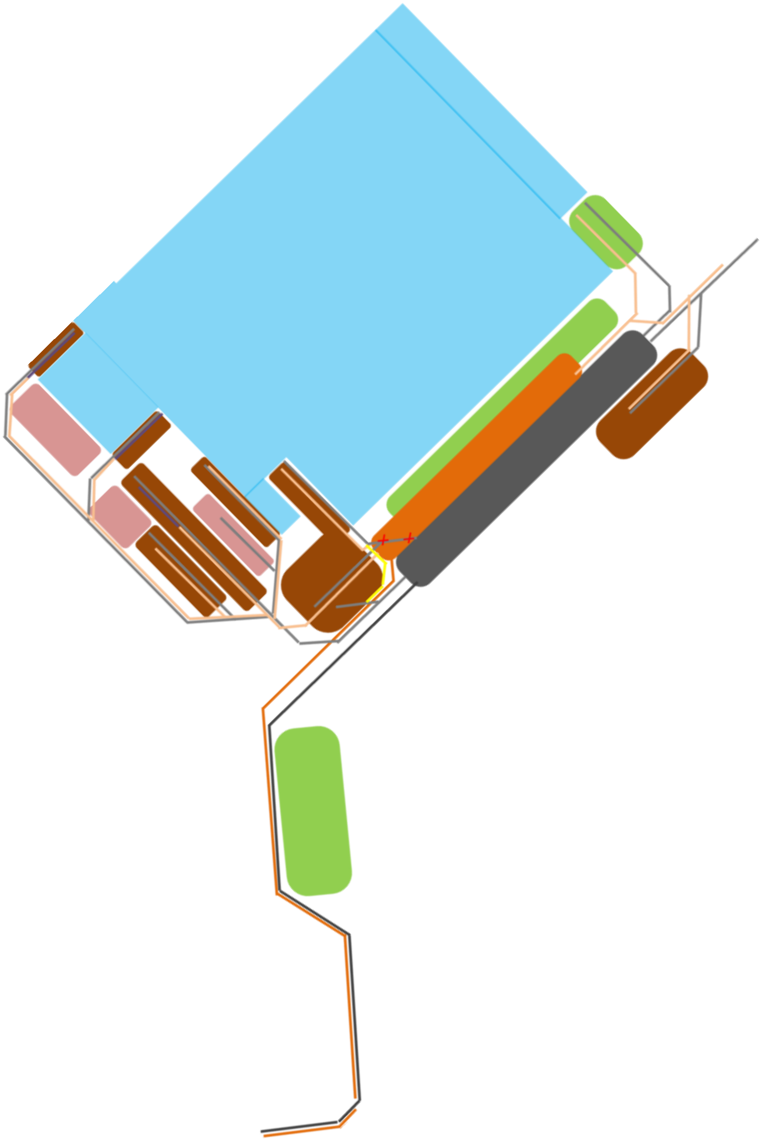


The Rail Baltica line runs parallel on the Western side of the existing 1520 mm railway line, which has to be relocated by approximately 5m to the East, crossing it near the intersection of the roads 1 (Peterburi tee) and 94 (Põhjaranna tee). It passes plot 5 on its Western edge. After crossing Maardu tee it is situated parallel to Veoste and Lasti tee, arriving at plot 3, where the station is constructed. The terminals connect to Southern station head via a turnout track south of the existing container terminal (Transidikeskus).

Depot facilities for technical services and additional stabling tracks for rolling stock are best located parallel to the station facilities on its Western side.

Alternative V

Figure 46. Rail Baltica station Muuga location, Alternative V

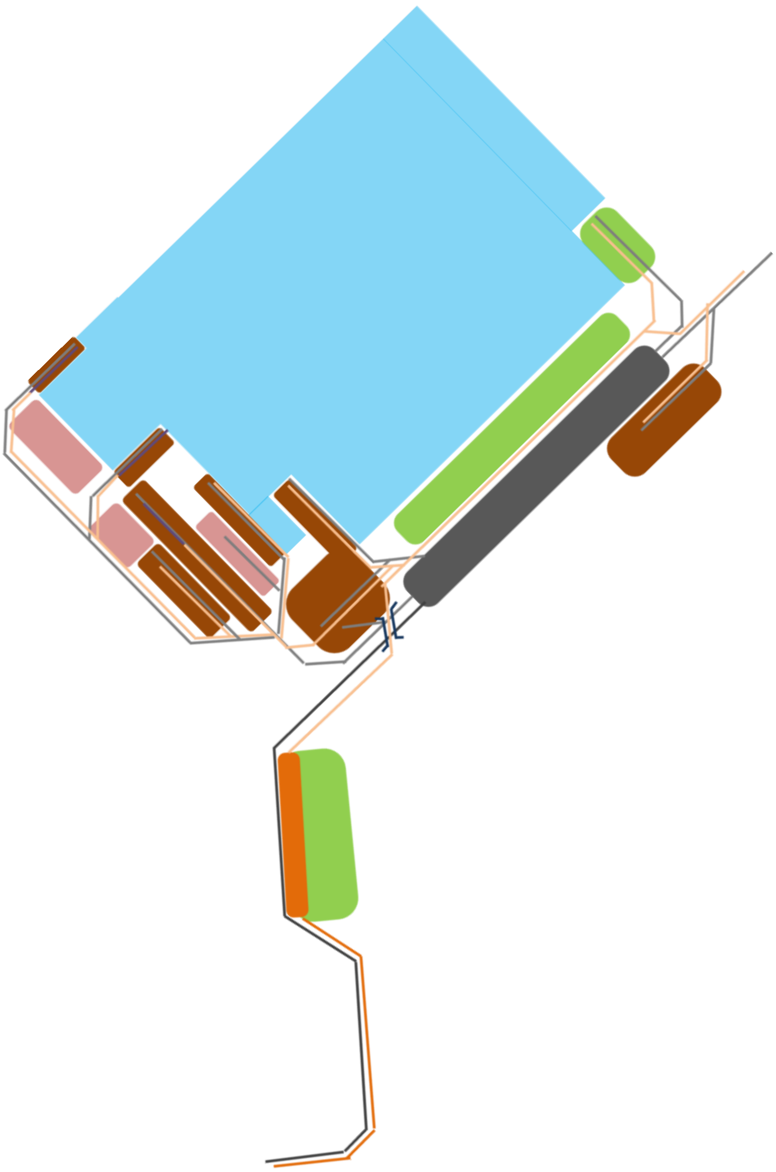


Description:

The Rail Baltica line runs parallel on the westside of the existing 1520 mm railway line, which has to be relocated by approximately 5m to the East, crossing it near the intersection of the roads 1 (Peterburi tee) and 94 (Põhjaranna tee). It passes plot 5 on its Western edge, still following the 1520 mm line after crossing Maardu tee and the 1520 mm terminal access tracks near the station head of the 1520 mm terminal. The rail baltica station is situated parallel to the 1520 mm station. The terminals are connected more or less in parallel to the 1520 mm facilities. The existing 1520 mm access track to the container terminal (Transidikeskus) needs to be relocated, since it would cross the station tracks. An existing inner harbor road needs to be relocated, too, for approximately 1,5 km. While additional tracks for wagon stabling are most useful parallel to the station tracks, the depot facilities for technical services of wagons and locomotives may be best located on the Northeastern end of the station or inside the curve that connects the station and plot 6 (coal terminal).

Alternative VI

Figure 47. Rail Baltica station Muuga location, Alternative VI



Description:

The Rail Baltica line runs parallel on the eastside of the existing 1520 mm railway line to plot 5, where the station is constructed on the Western part. The freight terminals are connected via a turnout track North of the existing 1520 mm station, requiring ramps and bridge (~50m) to cross the 1520 mm tracks near the Southwestern station head.

Facilities for technical services and depot functions are best to be situated North of the 1435 mm railway station. Additional tracks for short and /or long time stabling of wagons may be located parallel to the station tracks or, if necessary on the plot parallel to turnout track and 1520 mm station.

2.2.3. Selection of alternatives

In this section, a pre-selection of 2 most promising alternatives, mostly on a qualitative basis, is conducted. In a follow-up analysis the detailed assessment (CBA) of the both alternatives is executed. Applying of the criteria is defined in chapter 2.2.1, the assessment is shown in the Table 26.

Table 26 Comparison of MCTRB options

Target				MCTRB Options					
Nr	Description	Level	Details	I	II	III	IV	V	VI
A1	Low investment costs	1		+	+	--	++	++	-
A2	Low operation costs	1	IS	++	++	+	++	++	+
			Movements	-	+	+	+	+	-
A3	Little interference with the existing railway	1		++	+	+	++	+	+
A4	Attractive to facilitate transport	1		++	++	++	++	++	++
A5	Low negative impact on environment	1		++	++	++	+	++	++
B1	Minimised adaptation of existing freight terminals	2		++	+	+	++	++	+
B2	Minimised use of land in private ownership	2		+	-	++	+	++	-
B3	Short distance to freight terminals	2	TK Container	+	++	++	+	++	-
			Grain	-	++	+	+	+	-
			BreakBulk1	--	+	+	++	+	-
			BreakBulk2	-	++	+	+	+	-
			BreakBulk3	-	++	+	+	+	-
			Oil	-	+	-	++	-	-
			Plot 1	++	--	--	--	--	+
			Plot 4	--	++	--	-	-	-
			Ex Coal (6)	++	--	++	-	++	+
			Plot 5	++	-	+	-	-	++
			New Beach	+	+	++	+	++	+
B4	No line track crossings	2		++	++	++	++	-	++

Target				MCTRB Options					
B5	Ample alignment parameter	2		++	+	++	++	++	+
B6	Tracks for 1050 m long trains	2		+	+	++	++	++	+
B7	Sufficient handling capacity	2		++	++	++	++	++	++
	Comments			no 1520 connection to plot 5	plot 1 hard to connect to RB plot 5 access with 1520 line crossing only new long road bridge for Maardu tee relocation of 1520 line on plot 5	relocation of inner harbor road (~1 km) elevated alignment (~800m) including 2 large bridges (~100m each) and ramps (~2 km) new 1520 access to TK plot 1 hard to connect to RB	plot 1 hard to connect to RB plot 5 access with 1520 line crossing only relocation of 1520 line on plot 5 road reconstructions	new 1520 access to TK plot 1 hard to connect to RB plot 5 access with 1520 line crossing only plot 4 accessible with long (3000 m) connection track or separate station relocation of 1520 line on plot 5 road relocations	new 1520 access to TK plot 4 access with 1520 line crossing only ramp and bridge (~50 m) between station and turnout track realignment of road access near port gate due to height limitations

Giving the planning stage and the corresponding scope of this study, the qualitative assessment as made in Table 26 is a reasonable approach to identify the best option. However, in some aspects a quantitative analysis is very helpful. This regards especially the aspects of distances between the freight terminals and the railway station, which have an immediate effect to the shunting efforts and the related operating costs. Accepting certain generalization, such an analysis is manageable, but it has to be regarded that the input data base on estimations and forecasts. Therefore the results may be compared in relation with each other, but are not sufficient to assume them as absolute figures.

To conduct the analysis of the estimated shunting effort, the following data input is necessary:

- the expected mode of shunting operations
- an estimation of the approximate travelling distance from the Rail Baltica station to the particular terminals

- the share of each terminal in the forecasted Rail Baltica related transport volume for each commodity
- the share of empty wagons for each commodity has to be estimated to regard the necessary return of wagons to the railway station

The following assumptions are used:

- Terminals are served with wagon groups of the complete length of the loading tracks only
- Only the situation 2035 is considered, when the overall peak load is forecasted
- The additional container and semi-trailer terminal is constructed in the current coal terminal (plot 6)

The following generalisations have to be considered, when interpreting the results:

- Shunting effort in the 1520 mm system is not estimated, although in some alternatives it will change due to necessary track relocations
- The reduced shunting effort of some alternatives is on expense of longer train run distance, which is not accounted as total effort

The resulting estimation of shunting effort is shown in Table 27.

Table 27: Comparison of estimated shunting efforts in 2035 for the developed alternatives

facility	max. demand [t/a]	empty wagon factor	approximate shunting distance						estimated shunting effort [tkm/a]					
			I	II	III	IV	V	VI	**I**	**II**	**III**	**IV**	**V**	**VI**
TK Container	1759072	1.05	4680	2730	1850	3300	1560	4550	8644082	5042381	3416998	6095186	2881361	8403968
Grain	156,292	1.95	5610	2170	2910	3570	2510	5380	1709760	661351	886881	1088029	764973	1639663
BreakBulk1	602,239	1.8	7020	3900	4480	5070	4080	6920	7609896	4227720	4856458	5496036	4422845	7501493
BreakBulk2	2,179,933	1.8	5790	2350	3210	3800	2670	5560	22719257	9221115	12595650	14910739	10476756	21816765
BreakBulk3	914,351	1.8	5330	2200	2960	3430	2400	5220	8772285	3620831	4871663	5645204	3949997	8591244
Oil	613,018	1.9	7310	4130	4910	1800	4510	7080	8514213	4810356	5718849	2096523	5252955	8246324
Plot 1	0		0	0	0	0	0	0	0	0	0	0	0	0
Plot 4	0		0	0	0	0	0	0	0	0	0	0	0	0
Ex Coal (6)	1,744,004	1.05	2750	4970	1830	5330	2580	3100	5035810	9101082	3351103	9760316	4724506	5676731
Plot 5	0		0	0	0	0	0	0	0	0	0	0	0	0
New Beach	0		0	0	0	0	0	0	0	0	0	0	0	0
TK 2	1,005,964	1.8	4160	2150	1790	2060	1310	3920	7532658	3893080	3241216	3730114	2372063	7098081
GC 1	405,287	1.8	3020	5410	2330	6080	3100	5530	2203137	3946680	1699772	4435456	2261499	4034222
Total:									**72,741,099**	**44,524,596**	**40,638,589**	**53,257,602**	**37,106,954**	**73,008,492**

3. WP 3.1 – Terminal functions and business model

3.1. Functional description

In the current section a functional description of the terminal zones - different handling processes in MCTRB - is described in detail.

Both shortlisted alternatives have following components in common (in terms of geographical location): Container zone, General Cargo zone, Liquid bulk zone, Dry bulk and RORO zone. The difference between the both alternatives lies in the placement of the marshalling yard and in the Rail Baltic routing at the harbor area.

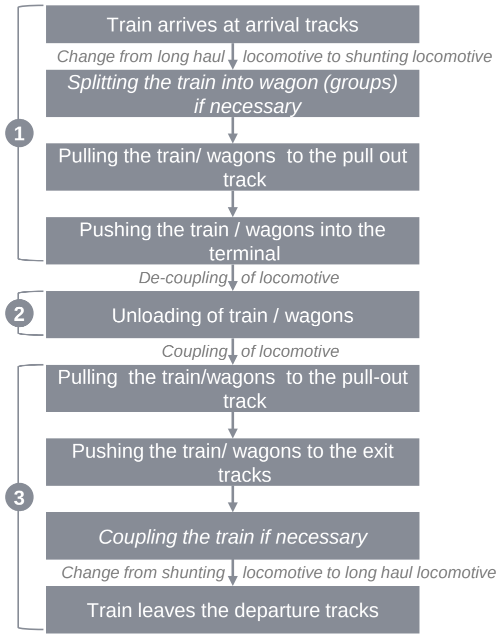
As already demonstrated above, current storage facilities in Muuga – except Container and RORO areas – will be sufficient to cover the forecasted transport demand. The connection of the existing terminals to 1435 does not change in dependence on the chosen alternative. The connection solutions are thoroughly presented in the forthcoming section 1.3.

Summarizing the above, it can be concluded, that from the process-perspective there is no difference between the two alternative options.

3.1.1. Train handling on 1435 or 1520 mm tracks

Handling of trains (independent on the type of gauge) can be separated into three main steps: Train arrives at the reception tracks of the marshalling yard, unloading/loading, train departures from the departure tracks of the marshalling yard. Figure 48 describes the general process of the train handling in detail.

Figure 48. Process of train handling on 1435 and 1520 mm tracks



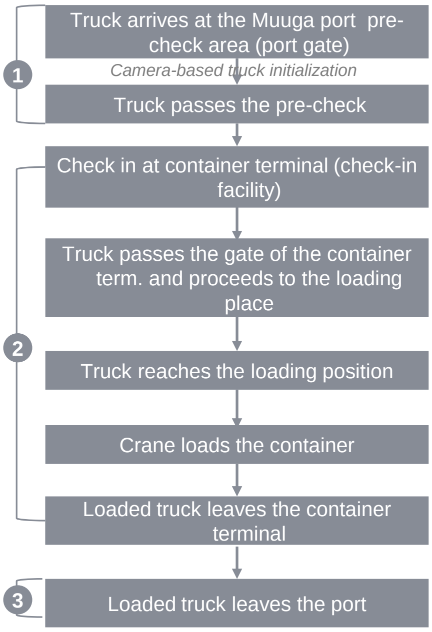
The loading track length for 1435 mm differs among the types of terminals – 650 meters in container terminal and 200 meters in other MCTRB' zones. The customs activities will be done separately inside the terminals and warehouses after unloading/loading of cargo (for export and import). For incoming mixed trains, the train sections will be decoupled in the marshalling yard, from where they are pushed to the accordant terminals by the shunting locomotives.

3.1.2. Container handling via road

The process applies both on the delivery or pick up of local containers (domestic) but also export/import containers. In a first step, truck goes through the video registration gate of the port of Muuga (pre-check), which recognizes the number plate of the truck and the container number and allows driver to save time during the later data input in a follow-up check-in. In a second step, truck driver executes the registration formalities at the operators' check-in facility. Alternatively, the truck can be checked in advance (pre-registration) which is coupled with the following benefits: a) Easy handling on separate truck consoles without leaving the truck and b) No waiting time by personal registration in container handling.

With the issued routing ticket, driver passes the central entrance gate and proceeds to the loading place where the chassis is being loaded or unloaded by the RMG (for local) or by RTG (export/import). Before leaving the terminal through the exit gate, the customs clearance is executed on the area of the container terminal and the port (for import). The accordant process structure is presented in Figure 49.

Figure 49. Process of container handling by truck at the container terminal



3.1.3. Containers' and semi-trailers' handling via rail

For container handling via rail following options have to be differentiated:

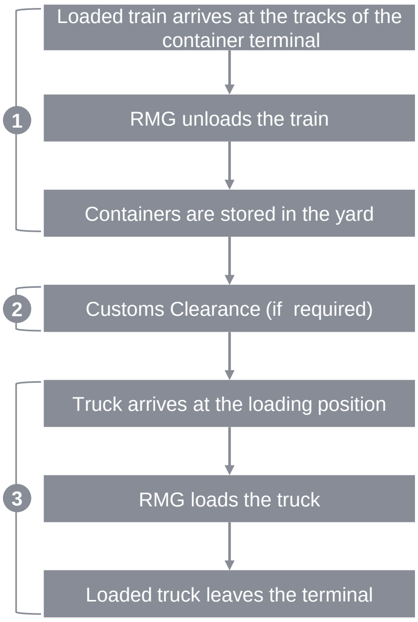
1) Import and export containers or semi-trailers (rail delivers or picks up sea-bound containers or semi-trailers)
2) Domestic containers or semi-trailers (rails delivers or picks up containers or semi-trailers which are dedicated to domestic market or neighboring countries).
3) Transit containers or semi-trailers (transshipment of containers or semi-trailers from 1435 to 1520 gauge and vice versa)

The first two options are described in the Figure 50.

In opposite to the second option, within the first option no container's storage takes place in the container year under the RMG crane. The incoming containers are transshipped to trucks and are transported directly to the sea-bound container yard on the berth, where the RTG is used for the transshipment from the truck to the yard. For the first option, internal trucking within the terminal is executed by tug masters. The second option – pick up or delivery of domestic containers – is thoroughly described in the previous sub-chapter (see 3.1.2).

Within the last option, containers can be either directly transshipped from rail to rail or, alternatively, interim storage of containers in the container yard under RMG cranes can be provided.

Figure 50. Process of rail-road transshipment



The non-cranable semi-trailers (not equipped with grapping devices) in Muuga can be handled in two ways:

- Accompanied combined transport: Delivery of non-cranable semi-trailers via Rolling Motorway (RoLa), where drivers may travel on the same train in the additional wagon. In case, RoLa (Rolling Motorway) trains with low-floor wagon arrive in Muuga, the tracks in the container terminals can be constructed as an open-end tracks (with no dead-locks). A special ramp can be moved on the wagon, the semi-trailers can then be unloaded by self-driving from the train (see Figure 51).

Figure 51. Unloading of RoLa trains via ramp

- Non-accompanied combined transport: Handling of non-cranable semi-trailers with Nikrasa technology, which allows to use the gantry cranes for loading/unloading of the semi-trailers which are not equipped with the grapping devices (see Figure 52).

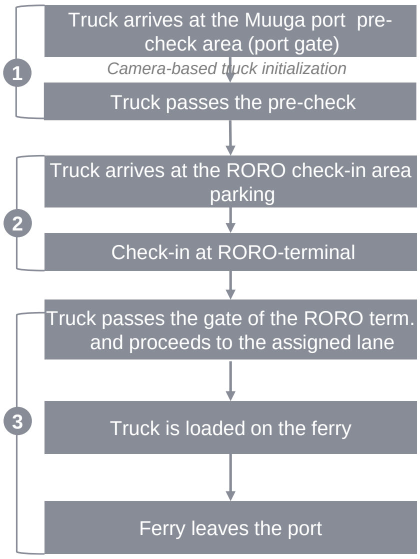
Figure 52. Handling of the non-cranable semi-trailer via NiKRASA technology

3.1.4. RORO handling

RORO flows are feeded either by road or rail. In the first case, the semi-trailer passes the pre-check area (video registration) and moves to the check-in area of the ferry line. In the check-in area, the driver fills out the check-in form, entering such data like e.g. destination, booking number, consigner, type of vehicle, length of vehicle, description of goods, electricity requirement. In the next step, truck proceeds to the entry gate of the RORO area. After passing the entry gate, the truck is guided to the accordant waiting lanes on the berth (i.e. special lanes for trailers with dangerous goods, trailers which require electricity supply). Additionally, EU vehicles have to be separated from non EU cargo. In the next step, the trucks roll on the ferry.

In case, semi-trailer arrives per rail, the terminal operator provides the accordant trailer data to the ferry operator. The tug muster picks up the semi-trailer at the container terminal and brings it to the accordant waiting lane on the berth, and, in the next step, from the lane to the ferry ship. The RORO handling process is presented in the Figure 53.

Figure 53. RORO handling process



3.1.5. General cargo handling

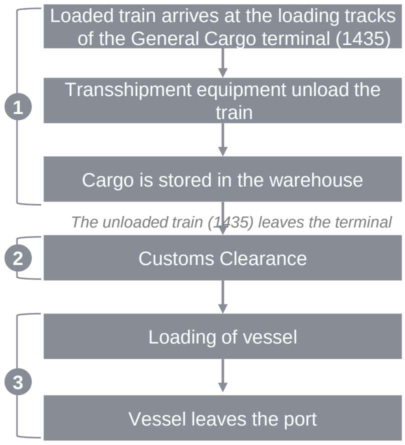
General cargo zone is divided in three sub-zones: heavy cargo, paper&chemicals&food and wood&cork. In opposite to container handling, general cargo demonstrates a higher imbalance of inbound and outbound transport flows. That means dominance of inbound flows (full trains in, empty trains out) for heavy cargo, wood and cork sub-zones. For paper& chemicals&food sub-zone, mainly served by 1435, outbound flows prevail. Here, almost double amount of outbound wagons leave the terminal on 1435 gauge (For the detailed analysis one is referred to the report to WP 2.1.2 "Identification of terminal technical needs").

In the Figure 48 an example of the handling for 1435 inbound trains is shown. In a first step, train arrives at the accordant sub-zone of General Cargo (from the shunting yard, see 3.1.1). In a follow up step, train is unloaded by accordant equipment, which differs among the general cargo terminals:

- Heavy: Heavy-Lift Trucks
- Paper and Chemicals: Fork-Lifts
- Wood&Cork: Timber Wheel Loaders

In the general cargo warehouses, the cargo is stored until its departure via vessels. Additional value added services (e.g. sorting, packaging, weighing) can be executed on demand. Customs clearance service is provided within the terminals. Figure 54 demonstrates the general cargo handling process.

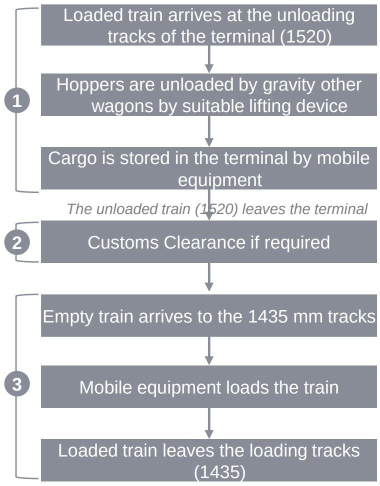
Figure 54. General cargo handling process



3.1.6. Dry bulk handling

The supply of Muuga port with the dry bulk is operated mostly by 1520 gauge. Full trains from Eastern Europe loaded with cereals, solid mineral fuels, iron ore or fertilzers are unloaded by the specific mobile equipment (e.g. wheel loader, or excavator) or by the gravity (hoppers). After unloading, empty wagen are shunted to the marshalling yard, where they are coupled to the trains. The outbound rail flow is mostly carried on the 1435. That is, a certain share of Eastern European dry bulk commodities is temporarily stored in Muuga, before being delivered to Western Europe per Rail Baltica. Figure 55 demonstrates the above mentioned process.

Figure 55. Dry bulk handling process



3.2. Business model of MCTRB

The project can be divided into three stages which are planning, building and operation. During the first stage (planning) developer company plays main role. The developer should plan, design, receive permissions and raise investments. Rail Baltic Estonia can be considered in this role. During the stage two (construction) site development company plays a pivotal role by managing marketing, holding land rental activities and conducting settlers search. Port Of Tallinn is considered as a major stakeholder in this role. During the last stage (operation) the operator should on continuous basis manage transshipment operations, logistics units, support maintenance and manage infrastructure. The tasks of the operator can be executed by the private companies (current case in Muuga) or by the establishment of the state-owned operators' company. Table 28 presents different stakeholders which are involved into the terminal's project.

Table 28: Tasks managed by different parties

Involved party	Tasks
Site development company	Marketing and area management at planning and construction stages Investors search and business model development
Infrastructure Operator	Marketing of the area for potential settlers and managing of the infrastructure during the operation phase
Planning company	Planning of different technical buildings and processes at the planning phase, supervision during the construction phase
Construction company	Construction of different objects which are roads, railways, buildings, underground utilities, electricity and water supply
Logistics company	Depending on Business model - independent construction and operation of transshipment and storage facilities
Railway company	Shunting services, technical checks
Infrastructure company	Operation and maintenance of existing infrastructure and engineering networks, security
Customs clearance company	Customs inspection Samples gathering and their analysis conducting Utilization or return of defective goods

In following four different business models are presented – Project developer model, Landlord model, Build-own-operate (BOO) model and Management fee model. Hereby the models are applied on the perspective of Port of Tallinn, which is a key stakeholder and developer of the Muuga port. For each model, its scope of functions along with its advantages/disadvantages are presented.

The first reviewed model is the Project developer model. The project developer is responsible for attracting investors on the site (see Figure 56). The main tasks are the following: management, marketing and planning. Other tasks are managed by external parties under lease contracts.

Figure 56. Functions distribution of the Project developer model

	Project developer			*Out of the management scope*	
Scope	Site development	Infrastructure and equipment	Logistics structure	Railway	Customs clearance
ToDos	Management	Social media	Containers	Shunting	Documents
	Marketing	Roads	Dry bulk	Pick-up services	Samples
	Planning	Gates	General cargo	Transport	
		Security provision	Heavy cargo	Technical checks	
		Property	Ro-Ro		

The reviewed model has its advantages and disadvantages. One of the major advantages of the model are the considerable low investments and the independence from the freight volume. The revenue is generated from the site sales. Thus, if the port authority is interested only in site development without managing infrastructure and logistics operations than this model is applicable. Task of the project developer is also to find company, which will overtake the construction, operation and management of the basic infrastructure (roads, gates, water supply, energy supply etc.). However, in reality this business model will not be considered by Port of Tallinn since it contradicts with its core business. More detailed assessment of the model is presented by the Figure 57.

Figure 57. Project developer model assessment

	Assessment	**Revenue**
+	**Advantages** ▪ Independence from freight volume ▪ There are low coordination requirements and, thus, there is an easy decision-making process ▪ Low investments are necessary ▪ No logistics know-how is necessary	▪ Revenue is from sites sales and intermediation in the sites sale ▪ Consulting services for the interested parties ▪ There is no income from transshipment, transportation and storage activities
−	**Disadvantages** ▪ Discreet sales volume/revenues that can be spread over a long time horizon ▪ No sustainable sales and, thus, revenue ▪ After planning there is only indirect influence on object development ▪ Planning and infrastructure construction require advance payment ▪ After the last area sale, no more sales are possible, thus, no revenue	**Summary** ▪ Project developer is responsible only for attracting investors on the site. ▪ Revenues are received irregularly (after the sale of individual site) and almost impossible to be planned

To sum up, this model creates small revenues from the sites sale and intermediation in the sites sale. The main task of the site development company is to provide a settlement friendly environment and to promote this logistics site.

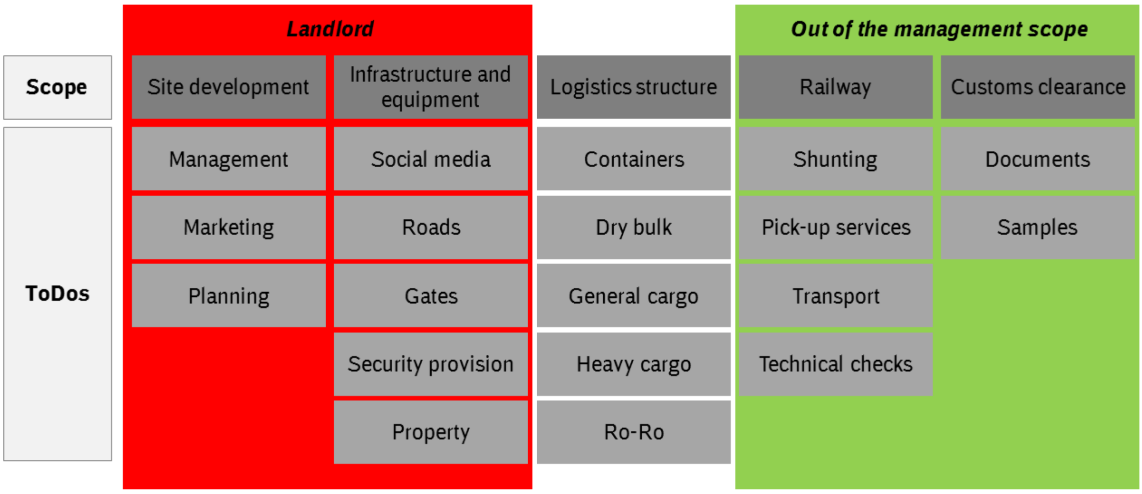
The second reviewed model is the Landlord model which is currently employed by the port authority. Based on The Intergovernmental Commission (IGC) TRACECA report [7], this model is the dominant port model for European ports.

[7] http://www.traceca-org.org/uploads/media/04_Module_C_PPP_Francois_Marc_Turpin_new.pdf

For example, port of Rotterdam, port of Antwerp realize this model. According to the World Bank report [8], this model is dominant for large and medium sized ports all over the world (for example, port of New York and New Jersey and port of Singapore)

Within this model, the port authority owns the basic infrastructure which is leased to Operators on a long-term concession basis and the port authority also carries out all regulatory functions such as management, marketing and planning (see the Figure 58 Figure 58).

Figure 58. Functions distribution of the Landlord model



It should be pointed out that the port authority provides the basic infrastructure (for instance, roads, energy and water supply) while the private operators create their logistics systems by building offices, warehouses, workshops and other infrastructure which is required to support their business activities. Moreover, the private operators install the equipment (RMG's, RTG's, reachstackers). In this context World Bank's[9] recommendation to the Land Lord is to conclude long-term contracts (at least for 20 years) with operators.

The reviewed model has its advantages and disadvantages. For instance, this model provides the port with stable revenue flow which has no correlation with intensity of freight flow. However, the investments are relatively high (to build and maintain the infrastructure). Thus, if the port authority is interested in owning and managing the port infrastructure without carrying activities on owned facilities and is ready to take risks of high investments than this model is applicable. More detailed assessment of the model is presented by the Figure 59.

[8] http://siteresources.worldbank.org/INTPRAL/Resources/338897-1117197012403/mod3.pdf
[9] http://siteresources.worldbank.org/INTPRAL/Resources/338897-1117197012403/mod3.pdf

Figure 59. Landlord model assessment

	Assessment	Revenue
+	**Advantages** ■ Independence from freight volume ■ Stable and continuous revenues ■ No logistics know-how is necessary ■ There are low coordination requirements and, thus, there is an easy decision-making process	■ Revenue is from sites sales and intermediation in the sites sale ■ Rent payments from settles ■ Payments for the infrastructure usage ■ Consulting services for the interested parties ■ There is no income from transshipment, transportation and storage activities
−	**Disadvantages** ■ High investments in infrastructure are necessary ■ Landlord is responsible for settles and users security	**Summary** ■ As a landlord there is a responsibility to ensure perfect conditions for all settlers ■ Sales are steady and relatively independent from the fluctuating capacity utilization

To sum up this model, it is necessary to point out that the main tasks of the Landlord company are to provide a settlement friendly environment for operators and to run the infrastructure in other words to balance public interests (port authority interests) and private interests (clients of the port and terminal operators).

The third reviewed model is build-operate-own (BOO) model. Within this business model, the port authority is responsible for site development, infrastructure and logistics operations carrying, in other words, for the whole spectrum of functions in the harbor area (see Figure 60).

Figure 60. Functions distribution of BOO-Model

	Build-Operate-Own			*Out of the management scope*	
Scope	Site development	Infrastructure and equipment	Logistics structure	Railway	Customs clearance
ToDos	Management	Social media	Containers	Shunting	Documents
	Marketing	Roads	Dry bulk	Pick-up services	Samples
	Planning	Gates	General cargo	Transport	
		Security provision	Heavy cargo	Technical checks	
		Property	Ro-Ro		

That is, the port authority builds and owns the assets and manages these assets. This operation model is rarely used for logistics projects management but mainly used for industry projects (for instance, plants building, nuclear stations development). However, according to the recent EY report, sometimes this model can be implemented for logistics infrastructure objects [10].

The reviewed model has its advantages and disadvantages. For instance, employing this model will give the port authority an opportunity to influence on all decisions of MCTRB. However, high investments are needed to implement this model successfully. More detailed assessment of the model is presented by the Figure 61 Figure 61.

Figure 61. BOO-Model assessment

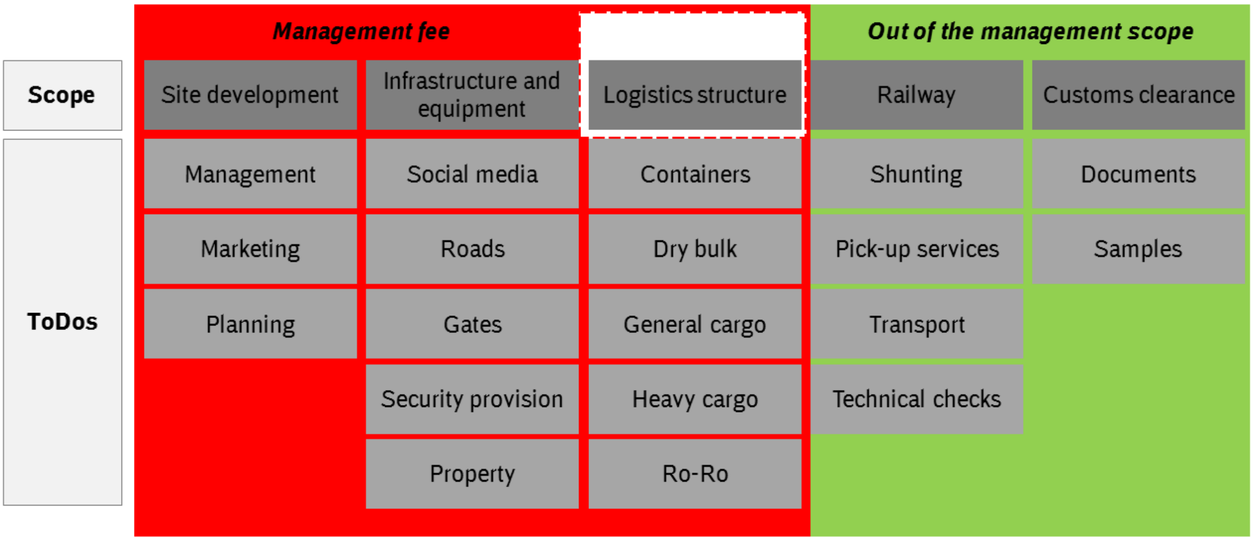
	Assessment	Revenue
+	**Advantages** ■ Independence from freight volume ■ Stable and continuous high revenues ■ Influence on all decisions within MCTRB	■ Revenue is from sites sales and intermediation in the sites sale ■ Rent payments from settles ■ Payments for the infrastructure usage ■ Consulting services for the interested parties ■ Income from transshipment, transportation and storage activities
–	**Disadvantages** ■ High dependency on economic development of MCTRB ■ High investments in infrastructure and assets are required ■ There is a need in logistics know-how ■ Operator is responsible for settles and users security ■ Comprehensive approval process which leads to long decision-making process	**Summary** ■ The operator in the BOO model is responsible for all processes and satisfaction of all involved parties ■ The Operator regularly receives a variety of income types ■ There are high entrepreneurial risks ■ In case of this model implementation it is recommended to have an experienced partner

To sum up this model description, it should be pointed out BOO – model provides sales (thus, revenue) for investors who are willing to take risks.

The last reviewed model is the Management Fee model. The main idea of this model is functions distribution between the port authority and operator (see the Figure 62). The logistics management is conducted by operator using the port authority‘s assets on the fee basis. Thus, this model is close to the third one (BOO-Model) with the difference in that two entities manage logistics structure department instead of one as it is in the BOO-Model.

[10] http://www.ey.com/publication/vwluassets/ey-public-private-partnership-the-next-continuum/%24file/ey-public-private-partnership-the-next-continuum.pdf

Figure 62. Functions distribution of Management fee



Port authority is responsible for equipment and infrastructure provision. Operator is responsible for attraction investors and operations management. Because of two parties presence the advantages/disadvantages for both are separately reviewed by the Figure 63.

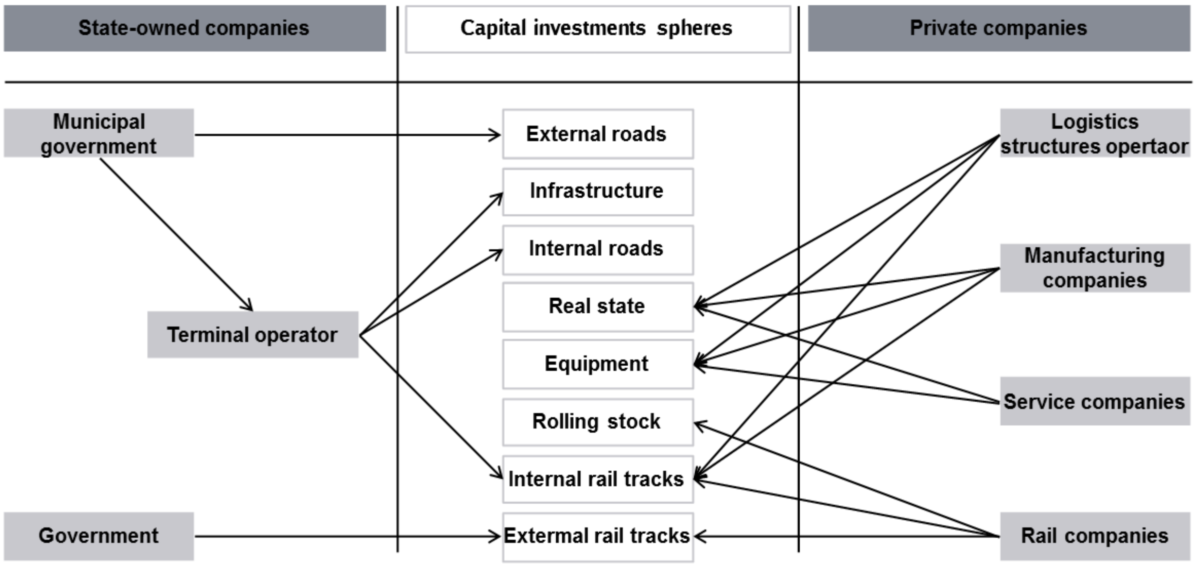
Figure 63. Management fee model assessment

	Assessment for Operator	Assessment for Developer
+	**Advantages** ▪ Operator does not own assets but carries overall responsibility for operation management (thus, there are no fixed costs ▪ Unstable sales volume does not have the direct influence on profitability	**Advantages** ▪ Operations and sales are managed by the expert in logistics field ▪ There is no necessity to own assets
−	**Disadvantages** ▪ There is no possibillity to influnce on decisions concerned infrastructure and equipment	**Disadvantages** ▪ Sales volume variability has a direct impact on the profitability ▪ An infrastructure company is a joint venture in which the developer owns a bigger share

To sum up this model description, it is important to point out that infrastructure and equipment are leased by the third-parties and these third-parties provide logistics services.

In following, a distribution of investments is presented. It should be pointed out that separation of capital investments is a key for successful project. Based on the most common practices implemented in Europe model, the distribution of capital investments spheres is presented by the Figure 64.

Figure 64. Investments distribution



Governmental authorities should invest in building/maintaining external roads, infrastructure, internal roads, internal rail tracks (with the support from railway companies, manufacturing companies and logistics operator) and external rail tracks (with the support from railway companies). Private companies in turn are solely responsible for investing in real estate, equipment purchase and rolling stocks purchase/maintenance.

Conclusion of the business model

Our view is that the long-term business model of the Muuga multimodal terminal is largely determined by the current operation model of Tallinn Port. In the mid 1990s Port of Tallinn was restructured from a service port (used to be the dominant model of the 1980s) into a landlord type of port. In 1999, the last cargo handling operations were finally given into the hands of private companies. Currently, Port of Tallinn operates as a landlord type of port with no cargo handling operations of its own. It is maintaining and developing the infrastructure of the port and leasing territories to terminal operators through building titles giving the operators an incentive to invest into superstructure and technology.

As it was established in WP1 and WP2 of the current work, there is no business logic in establishing RB multimodal terminal outside the port area due to the diminished cargo flows in comparison to the port option. The analysis determined that all cargo operations that involve transshipment over the quay line should be done close to the quay line of Muuga port or in the immediate vicinity of the port area to minimize the transshipment costs. This is crucial for maintaining the competitive advantage over competing RB terminals and for attracting the price sensitive Finnish export towards Europe. Every additional lift and additional mile would mean the loss of competitiveness.

For the cargo that does not need to cross the quay line (for example hinterland RORO or Chinese rail container exchange), the dry port option could be considered in the immediate vicinity of the port area. In WP2 plot no 4 and 5 were identified as potential dry port terminals. Both plots are owned by private operations who have confirmed readiness to invest to respective terminal infrastructure, provided that the public entity would make available 1435 mm connection to the border of their territories. This example also confirms that the developer should focus on providing the 1435 mm railway connecting infrastructure rather involve itself to actual terminal development. The connecting infrastructure is defined as marshalling yard of 1435 mm, connection railways to the terminals and other supporting technical infrastructure. This means that the investment burden of development of different cargo terminals would be left to market oriented and competition driven private companies.

Should the developer decide to develop beyond railway and road infrastructure the preferred business model would still be the Landlord model. In that case the public sector would attract EU financing, develop the functionalities and ultimately contracts out the operation in accordance to the Landlord model.

3.3. Functional SWOT Analysis

3.3.1. General

The general conditions for establishing the Rail Baltica infrastructure in the port territory in Muuga and its proximity are discussed before in WP 2, with the fundamental technical conditions described in chapter 1.2.

6 Alternatives were developed and compared with the results shown in chapter 2.2. Within this WP 3, 2 Alternatives are required to be further outlined to assess technical and economical feasibility in more detail.

Therefore, these alternatives are shown in drawings (approximate scale: 1:25000) based on orthophotos from Estonian Land Board 2014 that allow for the addressing of the relevant information for the assessment of feasibility. However, these drawings are not full scaled designs yet, which would require a much higher effort than is justified at the current planning stage.

The drawings focus on the provision of correct parameter for technical and economic feasibility. Therefore they allow for an adequate accuracy determining:

- dimensions of particular objects (length of tracks and bridges)
- Curve radii
- Gradients
- Occupation of territory
- Necessary relocation of objects

On the other hand, a number of compromises result from the simplified alignment used:

- no transition curves are regarded
- turnout geometry is not considered
- S-shaped curves between parallel straight tracks with minor deflection are shown without radii and curve shape
- Width of tracks is not regarded
- In terminals the number of tracks is not shown, but one line represents all terminal tracks
- The station shows the 2 siding groups only, but not the number of tracks in it
- necessary ancilliary elements like bypass tracks, depot connections and protection sidings are not shown.
- Track arrangement within terminals is only exemplarily to show an option for connection.

For reasons of clarity of the map, not all curves are shown with their respective radius, this regards especially parallel curves.

3.3.2. Selection of preferred Alternatives

Basing on the 6 alternatives developed within WP 2, the Client selected 2 preferable alternatives to be further elaborated. The decision is based on the comparative estimations and involved also the major public stakeholders (Port of Tallinn , Eesti Raudtee and Tehnilise Järelevalve Amet). Since all 6 developed alternatives apply the solution of parallel connection and rail crossings (see chapter 1.2 of the WP 2 report) as much as possible, also the selected preferable alternatives use this solution dominantly. Multiple gauge tracks are used only, when loading facilities do not allow for the construction of parallel tracks.

The alternatives to be further elaborated are Alternative I and Alternative III. Additionally, a version as described as Alternative III b in chapter 2.2.2. of the WP 2 report was requested to be considered.

Within the elaboration of the maps the higher level of itemization figured out that some of the original ideas of the respective alternative could not be implemented in the intended way. Therefore the description of the alternative as given in WP 2 is repeated and supplemented by some details and the changes from the original intention.

Due to concerns of some stakeholders regarding capacity restrictions arising from the necessary crossings of 1435 mmm and 1520 mm tracks, the amount of traffic is briefly analysed by estimating the number s of daily train rides for the commodity groups. Since the commodities are handled in particular terminals, which are located in defined port areas, this estimation also allows for the assessment of the internal traffic in the particular areas of the port. For this purpose, the analysis starts for the time horizon 2055. Since no critical issues are identified, no other situations need to be considered.

The basic assumptions used for the estimation are summarized in Table 29. Another important assumption is that for each arriving wagon after loading/unloading there is a wagon move in the other direction as loaded or empty wagon respectively. This applies to all commodities except containers and trailers, where the wagons arrive loaded and leave with return freight again. Consequentially, the number of train pairs is:

- Equal to the respectively higher number of either arriving or departing loaded trains
- Equal to the total number of loaded trains (arriving or departing) for all other commodities

The numbers of train pairs per day are summarized into reasonable local groups and rounded up to half train pairs.

Table 29: Basic assumptions used for the estimation of port internal railway traffic

Value	unit	amount
day/year	d	300
TEU/train 1435	pcs	85
TEU/train 1520	Pcs	110
Trailer/train 1435	pcs	39
payload/trailer	t	20
payload/train 1435	t	2200
payload/train 1520	t	4500

Table 30: Number of train pairs per day for commodity groups and system as envisioned in 2055.

		2055				day				train/day				pair/day	
Commodity		1435		1520		1435		1520		1435		1520		1435	1520
		in	out	in	out	in	out	in	out	in	out	in	out		
Container	TEU	277729	301863	212888	92304	926	1006	710	308	10.9	11.8	6.5	2.8	13.5	6.5
RoRo	t	528782	926871	0	0	1763	3090	0	0	2.3	4.0	0.0	0.0		
oil	t	0	0	197432	0	0	0	658	0	0.0	0.0	0.1	0.0	1.5	1.5
fertilizer	t	102367	9003	1753252	0	341	30	5844	0	0.2	0.0	1.3	0.0		
wood	t	355863	1058720	169085	7618	1186	3529	564	25	0.5	1.6	0.1	0.0		
metal	t	566984	149627	3971	20710	1890	499	13	69	0.9	0.2	0.0	0.0		
building materials	t	490946	500432	22771	173973	1636	1668	76	580	0.7	0.8	0.0	0.1	2.5	
chemicals + paper	t	510662	870121	12728	11433	1702	2900	42	38	0.8	1.3	0.0	0.0		
coal	t	5641	446839	3648	247	19	1489	12	1	0.0	0.7	0.0	0.0		

Used with the freight volumes of 2055, the numbers of train pairs per day are as shown in Table 30. The figures allow for the following conclusions:

- With less than 1 train pair per hour, a single track feeder line for the connection of the Muuga port territory to the rail baltica main line may be sufficient. However, since the current (preliminary) specifications for rail baltica aim in double track high speed line, this is not further regarded in WP 4 or any other part of this study.

- The railway traffic within the port territory will have a significant density only feeding the container terminals, where more than 75% of the 1435 mm trains and more than 80% of the 1520 mm trains are related to. Therefore, concerns regarding mutual obstructions of the shunting moves on both systems are of certain relevance only for the container (and RoRo/Trailer) transport, while in all other port areas such concerns are not justifiable. This picture does not change, assuming that every train will be split into several wagon groups for shunting. The dominating container (and trailer) trains will not be split into more than 2 groups, since the loading tracks in both terminals offer more than half of the respective train length of both systems.

For the technical realization of the rail-rail crossings, standard solutions exist that can be adapted to the use with differing gauges without compromising the functionality. However, they need to become subject to certification of the responsible technical supervision authority. On Estonian territory, this is Tehnilise Järelvalve Amet (TJA). Even in case that a special, multinational body is introduced for rail baltica's technical supervision, such crossings are also part of the Estonian 1520 mm infrastructure and hence object of acceptance by TJA.

3.3.2.1. Alternative I

The Rail Baltica line runs parallel on the eastside of the existing 1520 mm railway line. Between Maardu station and the bridge of Vana Narva Mantee, it has to be lowered to undergo the 1520 mm tracks branching from the main line to the West. In all other locations, the vertical alignment is the same as for the existing 1520 mm line, which does not need to be adjusted. Therefore, no further description of the vertical elements of the Rail Baltica need to be given for Alternative I. Rail Baltica station is planned parallel to Nuudi road. 1050 meter pull out track is foreseen towards North-East for the decomposition of arrival trains and composition of departing trains. Except the former coal terminal and the general cargo terminal in the Western port territory, all other freight terminal need to be connected using another turnout track. This turnout track does not need to be longer than the shunting tracks in the sorting group of Muuga station (850 m). Even a shorter turnout track according to the maximum length of tracks in the terminals (650 m), may be sufficient. This turnout track is connected to the station with a s-shape curve and is best located between the existing turnout track (1520 mm) and the feeding track to the coal terminal (1520 mm). This connection track crosses the 1520 mm hump, which is currently not in use and need to be removed.

Depending on the particular layout of the assumed new container and RoRo terminal on plot 6 (former coal terminal) the apparently best option to connect it is to align the 1435 mm track parallel to the existing 1520 mm track. The aforementioned general cargo terminal may be connected by a track branching Northeastward from the connecting line between station and turnout track.

Figure 65. Detailed map for the Alternative I

From the turnout track in Southwestern direction, a connection track runs parallel between the 1520 mm station and an internal harbor road. Branch lines connect the TK facilities (container terminal and general cargo sheds), before an s-shaped curve deviates the connecting track further parallel to the 1520 mm connection tracks to access the other terminals (grain, oil, general cargo). This alignment provides better conditions than the originally intended course parallel to Hoidla tee. Details are presented by the Figure 65.

Alternative I allows for the use of the existing, but currently not fully utilized depot facilities for the 1520 mm system in Muuga. Without detailed examination of the state of the depot and with no detailed alignment made yet, it seems to be the most promising option to dedicate the Southwestern side of the locomotive depot to 1435 mm and to construct additional tracks for locomotive stabling there, while the opposite side remains with the 1520 mm system. This applies respectively to the facilities for technical services of freight wagons, too. Since concerns against a joint use of depot by both systems were raised by some stakeholders, in WP 4 a separate depot in the vicinity of the existing one is envisioned.

Assuming a phased construction of the station according to the forecasted traffic demand, it is apparently the best solution to construct more sorting tracks than actually needed and to use them for wagon stabling. The same can be done with the arrival and departure tracks, but to avoid interference with the train traffic, it is recommended to use these tracks for long time stabling only. With increasing demand of sorting tracks (or arrival departure tracks respectively), additional stabling tracks may be constructed parallel to Nuudi tee or, closer to the freight terminals, parallel to the 1520 mm station,on its Northwestern side.

3.3.2.2. Alternative III a

The Rail Baltica line runs on the eastside of the existing 1520 mm railway line parallel to the road Nr 94 (Põhjaranna tee). It elevates on the Eastern edge of plot 5, to bridge the intersection Põhjaranna tee and Maardu tee. It stays elevated to pass the existing harbour road gate in the East, than bridging the Western station head of the 1520 mm station. A ramp lowers the elevation to reach the station on the Northwestern side of the existing 1520 mm station. To allow for limitation of ramp gradient (10 ‰) and establishment of 1050 m long arrival and departure tracks, the whole railway station needs to be elevated by approximately 1 m. However, to facilitate the 1050 m long tracks (which is no requirement for the near future, but is recommendable to prepare for in general), the road bridge on the Eastern end of the station cannot be kept, and the adjacent road section parallel to the railway station has to be moved closer to the shoreline.

Additionally, the 1520 mm access to the former coal and assumed future container and RoRo terminal needs to be realigned and the 1435 mm access track to this terminal will have an alignment that does not allow for an extension of the loading tracks in this terminal beyond its current length.

On the Eastern station head only a short turnout track (approximately 500 m) can be constructed parallel to the existing one, which would be sufficient to connect the general cargo terminal on the Western edge of the port territory. A longer turnout track for the train composition and decomposition from the arrival and departure tracks has to be located either on the Western head between the rail baltica main track and the terminal access tracks or parallel to the 1520 mm access track to the coal terminal and further besides the coal terminal itself.

From the Western end of the shunting group a connecting track heads parallel to the line track. When the line track starts to curve towards the railway bridge, the connection track takes an s-shape curve to run parallel to Hoidla tee. Within the course of this s-shape curve the container and the general cargo terminal of TK are connected with a branch track each. Along Hoidla tee, the connecting track curves to the North further to access the other terminals (grain, oil, general cargo) parallel to the 1520 mm connection tracks.

The ramp from the railway bridge down to the station blocks the current 1520 mm access track to the TK container terminal. Therefore a new one has to be established parallel to the embankment close to the railway bridge, where the space is rather narrow. The details are presented in the Table 31and by Figure 66

Depot facilities for technical services of locomotives and wagons are preferably new constructed, since accessing the existing ones is possible, but requires long approaches. Suitable locations are the areas:

- parallel to the station (Northeast), where also stabling tracks can be constructed.
- North of the Northeastern station head or
- West of the Southwestern station head, which allows for a small number of rather short stabling tracks, too.

Table 31: Elevation for the Alternative III a

Approximate elevation above sea level [m]				
Section	Rail Baltica	1520 mm line	Ground level	1435 access tracks
A-A	23	31	29	--
B-B	20	--	17	--
C-C	16	--	7	--

D-D	13	5	4	5
E-E	10	5	5	5
F-F	6	5	5	6
G-G	6	5	5	6

Figure 66. Detailed map for the Alternative III a

3.3.2.3. Alternative III b

The Rail Baltica line follows the alignment of the 1520 mm line, parallel to it on an embankment on the Western side of plot 5. It elevates to bridge Maardu tee besides the level crossing of the 1520 mm line, It stays elevated to pass between the existing harbor road gate in the East and the adjacent road bridge over the 1520 mm tracks in the West, bridging these tracks before the Western station head of the 1520 mm station. A ramp lowers the elevation to reach the station on the Northwestern side of the existing 1520 mm station. The turnout track has to be constructed parallel to the existing 1520 mm access track to plot 6 (coal terminal).

Generally, the allocation of all facilities is similar to the one described with Alternative III a. The decisive difference is that the railway bridge can be located around 200m more to the West, easing the constraints of the station length on both ends considerably. Therefore, the station does not to be elevated against the existing one anymore, the Eastern road bridge needs only adaptation instead of removal (when the station is dimensioned for 1050 m train length in future). The 1520 mm connection to the former coal and assumed future container and RoRo terminal does not need to be realigned.

The conditions further improve, when the arrangement of arrival / departure and sorting group of the station is changed. The connection track to the Western freight terminals can underpass the railway bridge parallel to the 1520 mm connection tracks to access the other terminals (grain, oil, general cargo). The disadvantage of this solution is the crossing of the 1435 mm container terminal access track with the 1435 mm line track. Alternatively, the access track can be constructed parallel to the relocated 1520 mm access track of the same terminal, requiring a turnout track again. The details are presented in the Table 32and by the Figure 67.

Depot facilities for technical services of locomotives and wagons are preferably new constructed, since accessing the existing ones is possible, but requires long approaches. Suitable locations are the areas:

- parallel to the station (Northeast), where also stabling tracks can be constructed.
- North of the Northeastern station head,
- West of the Southwestern station head between the bridge ramp and the 1520 mm station or

West of the Southwestern station head on the Northside of the beginning bridge ramp.

Table 32: Elevation for the Alternative III b

Approximate elevation above sea level [m]				
Section	Rail Baltica	1520 mm line	Ground Level	1435 access tracks
A-A	23	31	29	--
B-B	20	18	17	--
C-C	16	8	8	--
D-D	16	5	7	--
E-E	13	5	4	5
F-F	5	5	5	5
G-G	5	5	5	5

Figure 67. Detailed map for the Alternative III b

3.3.2.4. Necessary adaptations on 1520 mm infrastructure

For a better overview, the necessary adaptations of the 1520 mm infrastructure are summarized again in Table 33. The listing does not regard the tracks within the freight terminals.

Table 33 Necessary adaptation of existing 1520 mm track infrastructure

Plot	Adaptation of 1520 mm infrastructure		
	Alternative I	Alternative IIIa	Alternative IIIb
Southwestern station head	-	New access track and turnout track to the container terminal need to be incorporated.	New access track and turnout track to the container terminal need to be incorporated.
Connecting curve between station and Western terminal area	The inner track of the double track curve is substituted by the 1435mm connection track using the same alignment. After the road bridge the 1520 mm track moves outward to reach the subgrade of the former direct access from Maardu to the oil terminals	The inner track may be dedicated as turnout track for the new access track for the container terminal, ending before the Hoidla tee level crossing.	The inner track of the double track curve is substituted by the 1435mm connection track using the same alignment. After the road bridge the 1520 mm track moves outward to reach the subgrade of the former direct access from Maardu to the oil terminals
Level crossing Hoidla tee and adjacent turnouts	2 Southwestern tracks remain 1520 mm, 2 Northeastern tracks are substituted by 1435 mm. Branching of both gauges to the terminals starts after level crossing	The track layout needs to be simplified by abandoning the direct access Maardu - oil terminals and reducing the 5 tracks on the level crossing to 2 or 3. Turnouts need to be relocated also to improve the conditions for the new to built crossings with 1435 mm tracks	2 Southwestern tracks remain 1520 mm, 2 Northeastern tracks are substituted by 1435 mm. Branching of both gauges to the terminals starts after level crossing
Feeding track to TK container terminal	Remains, but crosses the 1435 mm main access track for the Western terminals	A new track needs to be constructed from the Southwestern station head to the container terminal. Additionallly, a new turnout track becomes necessary to allow for the utilization.	A new track needs to be constructed from the Southwestern station head to the container terminal. Additionallly, a new turnout track becomes necessary to allow for the utilization.
Feeding track to coal terminal	-	The existing track has to be removed to allow for the construction of the 1435mm access tracks. A New 1520mm access track has to be constructed appr. 100m further to the East.	
Turnout track and hump	The hump has to be abandoned, since the	The turnout track will be crossed by the 1435 mm	The turnout track will be crossed by the 1435 mm

	connection from 1435 mm station to the terminals has to cross it. The dedicated tracks for coal and container terminal parallel to the actual station need to be shortened at the Northeastern end to facilitate the 1435 mm connection tracks from both, station to coal terminal and turnout track to the Western terminals.	access track to the general cargo terminal. Removing the hump would allow to facilitate 650 m turnout length before the crossing point.	access track to the general cargo terminal. Removing the hump would allow to facilitate 650 m turnout length before the crossing point.

Additionally, some adaptations are recommendable, but not necessary for the construction of the 1435 mm facilities. This regards especially:

- Abandoning the direct access from Maardu to the oil terminals to ease the track topology around the Hoidla tee level crossing
- Reducing the number of tracks in the 1520 mm station may allow for better conditions for alignment of the 1435 mm tracks and cost savings. The effect can be achieved, if the most outer (Northwestern) tracks could be removed, which are in ownership of the coal and container terminal operator.
- Reducing the number of 1520 mm tracks in the approaches of the oil terminal creates the necessary space to facilitate 1435 mm tracks there.

At the current planning stage, not all information is available to elaborate the detailed track layouts. To demonstrate the feasibility of the suggested alternatives anyway, for the most decisive plots suggestions were elaborated, how the track infrastructure of both systems can be arranged in the pre-selected Alternatives (I, IIIa and IIIb). This regards the 2 areas where the most difficult conditions exist, which are identified as the Notheastern Station head and the area around the road crossing Veose / Hoidla tee. These suggestions are shown in Figure 69 to Figure 73**, the respective legend in** Figure 68. It has to be noted that the suggestions are not to be considered as designed solutions, but as principal demonstration that a solution can be found, but needs to be elaborated at a later planning stage in the level of itemization that is necessary for the respective stage.

Figure 68: Legend for Figure 69 to Figure 73.

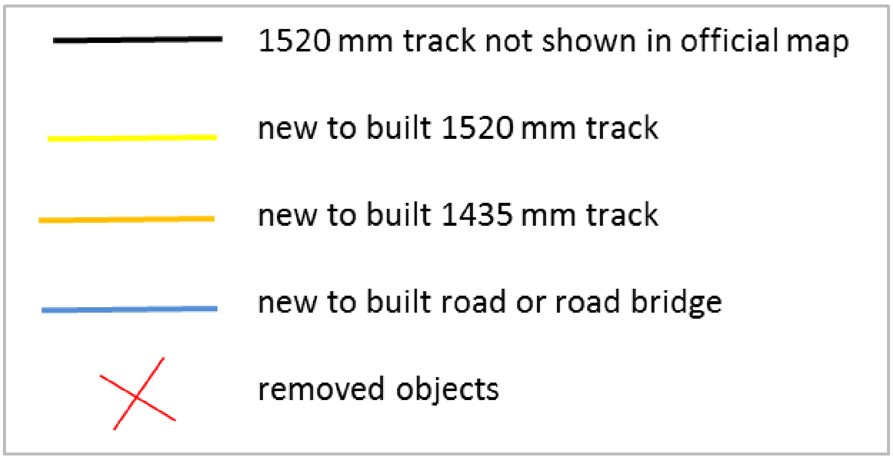


Figure 69: Northeastern Station head and hump area. Possible track layout in Alternative I.

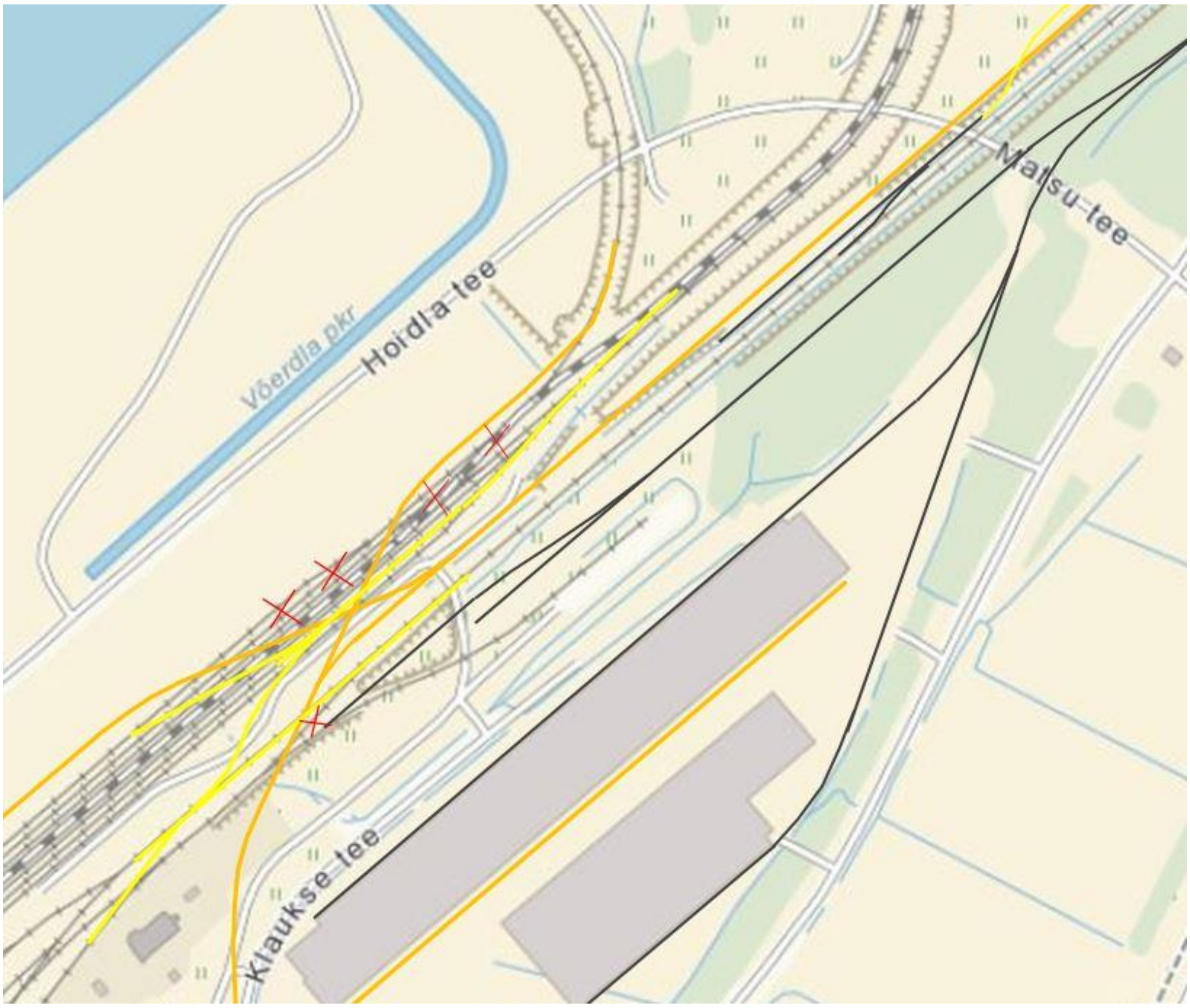


Figure 70: Northeastern Station head and hump area. Possible track layout in Alternative IIIa. Please note that in this figure the access to the concrete plant and the Katoen Natie warehouses is not shown. It would be nearly identical as in Alternative IIIa. The respective solution is shown in Figure 71.

Figure 71: Northeastern Station head and hump area. Possible track layout in Alternative IIIb.

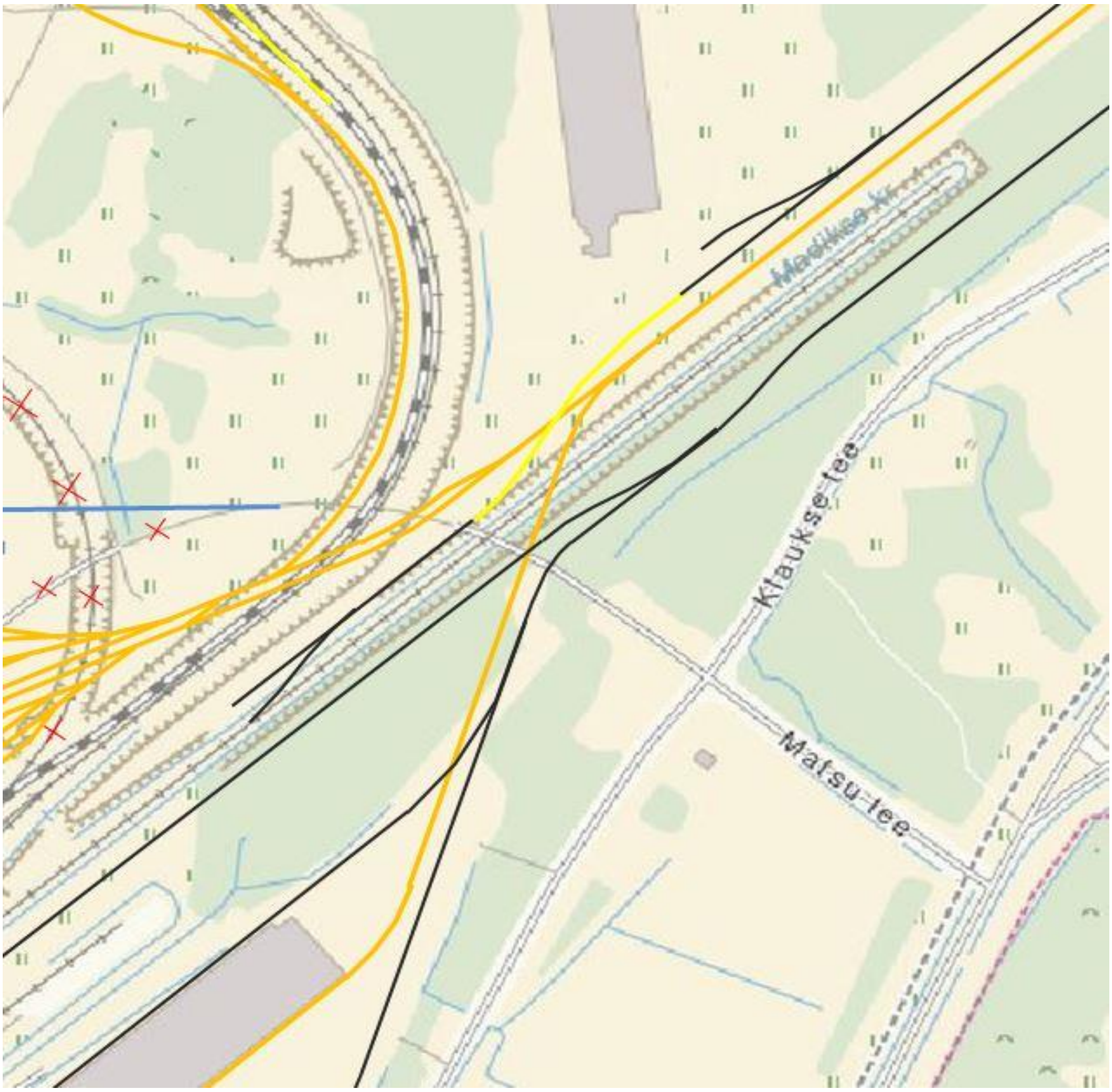


Figure 72: Area around Veose / Hoidla tee. Possible track layout in Alternatives I and IIIb.

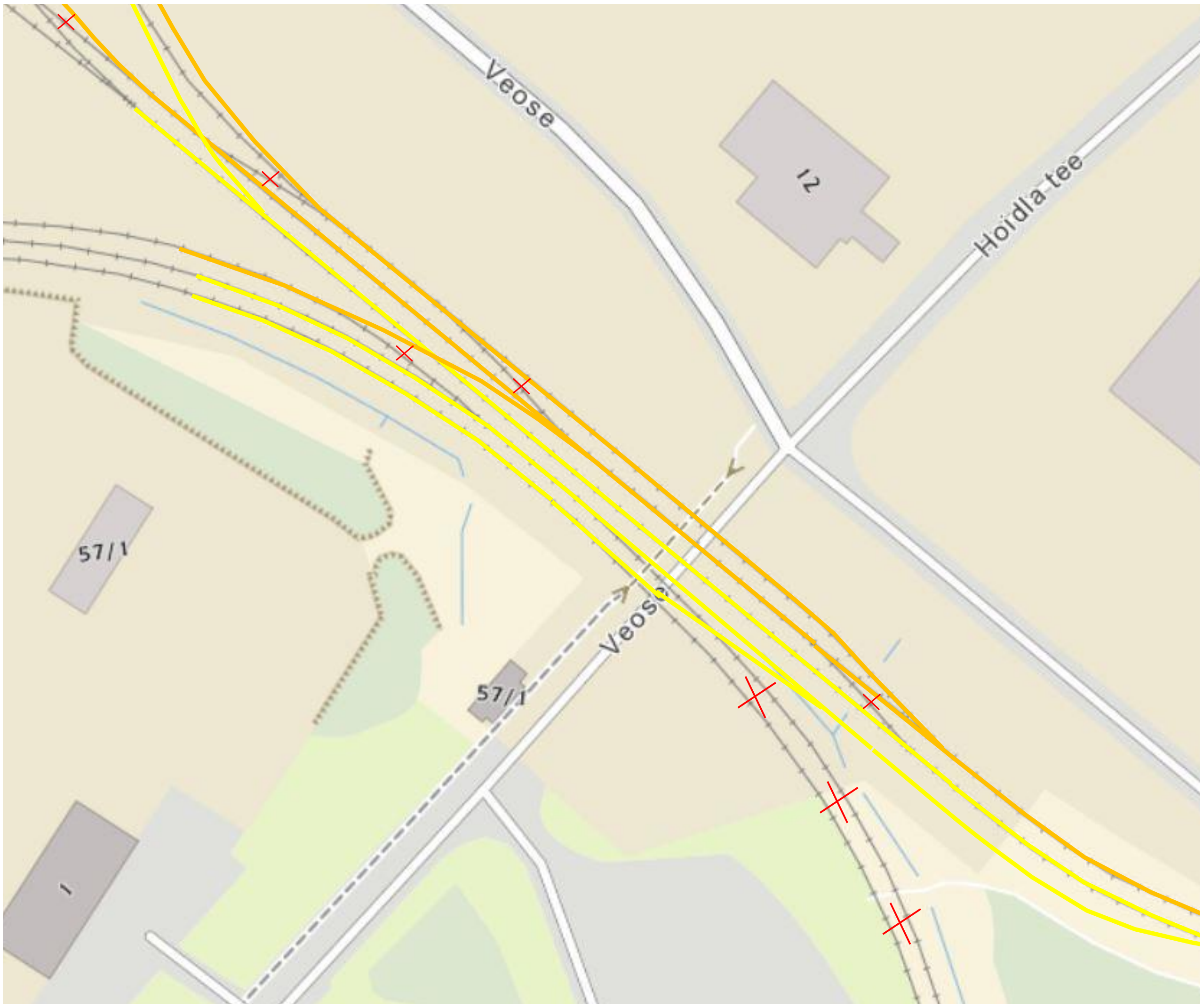


Figure 73: Area around Veose / Hoidla tee. Possible track layout in Alternative IIIa.

4. WP 3.2 – The most important interest groups

The consultant started working with the stakeholders in the first assignment package, where they interviewed more than a hundred companies. Consultations with various stakeholders lasted from January to December 2017.In this section, we cover the immediate stakeholders of RBMMT. This is how we define the companies that operate at Muuga Harbour or in its immediate surroundings and whose interest have the biggest impact on the technical solution of the RBMMT and the handled groups of goods. They are mostly existing terminal operators and possible future terminal operators, land owners, the local government and state agencies.

Private sector stakeholders: Terminal operators at Muuga Harbour

Three main groups of stakeholders can be distinguished among the undertakings operating in the territory of Muuga Harbour in terms of their attitude towards the RBMMT:

a) the stakeholders that see the potential of the RBMMT or are cautiously positive (hereinafter Stakeholder Group 1).

b) the stakeholders that tend to be convinced that the RBMMT will not create any added value for their business or have doubts about the vitality of RB as such (hereinafter Stakeholder Group 2).

c) the stakeholders that are based in the vicinity of Muuga Harbour and are planning additional terminals (hereinafter Stakeholder Group 3).

Stakeholder Group 1

At the positive end of the scale are the companies that are directly or indirectly engaged in handling container goods. These companies agree with the person carrying out the survey that the containerisation of goods will continue in the coming decades. This group includes companies that add value or repackage goods, e.g. repackage goods received from China for the markets of Scandinavia and/or North-western Russia, or reload certain types of foodstuffs. These companies tend to see Rail Baltica as added value and they see possible synergies in the 1435 mm and 1520 mm railway.

Stakeholder Group 1 agrees with the consultant's conclusion that the RBMMT should be established right next to the harbour to minimise the additional expenses of reloading goods. At the same time, these stakeholders emphasise that the 1520 mm track must remain functional when the 1435 mm railway connection is developed. A significant part of the existing 1520 mm railway infrastructure (access roads and waiting tracks) belongs to these stakeholders.

The private property and/or rights of superficies of these companies must be kept in mind upon the construction of the 1435 mm railway infrastructure. Information about the issued building permits and plans is accessible in the environment chapter of this assignment.

Stakeholder Group 2

At the negative end of the scale are companies that handle bulk goods moving east to west, such as oil, fertilisers and grains. Their higher level of scepticism is largely justified by the logic of movement, geographic and/or technical features of bulk goods. The consultant largely agrees with the opinions of these stakeholders. For example, oil goods move in an east-to-west direction and the quantities moving north to south-west are marginal. This group is also more focused on marine transport (as the reloading or bulk goods is expensive and time is not a significant factor, they do not see the benefits of the 1435/1520 reloading possibility). Some of these companies focus exclusively on 1520 transport in an east-to-west direction. A considerable part of today's bulk goods are so-called intercontinental goods and the north-to-south direction therefore has no meaning for these stakeholders. Therefore, these undertakings have no direct interest in disturbing the existing functionality or possible additional investments in the 1435 mm rail network.

There were a few undertakings in this group that suggested that the existing 1520 railway infrastructure is over-dimensioned and could be scaled down.

All in all, the pessimistic undertakings support the technical solution of RBMMT that would be located outside the territory of Muuga Harbour. They prefer the solution of a dry-port that would be located up to 5 km from the harbour.

Stakeholder Group 3

In addition to the terminal and goods operators working at Muuga Harbour, the consultant interviewed stakeholders who would like to build new goods terminals in the vicinity of Muuga Harbour. They include developers who are prepared to build warehouses and production premises as well as multimodal terminals with 1435/1520 reloading possibilities and the possibility to load trailers. These undertakings support the consultant's vision that goods related to the water line should go directly to the harbour. However, the stakeholder groups in question also find that goods sent from or to the inland that have no connection with the sea and wharf line should be loaded outside the territory of the harbour. Such developments should be promoted, as Muuga Harbour is a landlord harbour and maximum competition is in the interests of the end customer. Two companies from the stakeholder group in question have given the consultant their consent for sharing specific development plans with the RB team.

Muuga Dry Port development project

Muuga Dry Port is a private development project with a capacity of 500,000 containers or trailers per year. The terminal is situated between the Tallinn-St Petersburg highway, Maardu railway station and Muuga Harbour. The distance of road transport from Muuga Harbour is 1.8 km. This area of development was also one of the six possible locations of the MCTRB terminal. Muuga Dry Port makes it possible to handle trailers moved by cranes and ordinary trailers by offering alternative loading capacity to variant I or IIIb as well as container goods and RORO buffering capacity. This would mainly concern goods that will not be transhipped to maritime transportation. Muuga Dry Port has also potential of receiving full trains if the technical connection to the 1435 could be reasonably solved. Eight railway spurs for container terminals and two for loading trailers, a 10,000 m^2 warehouse complex with a railway spur for loading directly from rail cars to the warehouse and a maintenance station for containers and other equipment have been planned for the terminal. The planned capacity of the main gate is 1500 vehicles per day, six access lanes and five lanes at the weighing and measuring point. A parking place for 800 trailers and a secure car park for 300 heavy vehicles with washing facilities and food service. The area of the planned terminal is 28.5 ha, which can be extended by 9 ha if necessary. The terminal allows up to 28 trainsets to be served per day. The trainsets would be served via Maardu station, where the trainset of Muuga Dry Port will be hooked to the trainset that arrives from Muuga.

Investments will be made in stages according to actual demand. A warehouse complex with a 1520 mm spur will start operating in 2023. An effective detailed plan exists, a building permit for the railway spurs has been issued, construction notification has been made and the works have started. The construction of a 1435 mm railway spur makes it possible to offer effective reloading from one width to another. The main 1435 mm line should be designed in consideration of the need to connect the given terminal.

Interest group "RRK Muuga Dry Port" – one of the potential partner terminals to Muuga MCTRB

Northshore Terminal & Logistics Park (NTLP)

According to plans, the NTLP will be build on the registered immovable that borders the territory of Muuga Harbour. This area of development was also one of the six possible locations of the MCTRB terminal. According to the business plan of the terminal, a multimodal terminal with a 1520 mm railway connection will be built by 2020. The terminal will mainly specialise in the exchange of goods between the European Union and the People's Republic of China. Initial project capacity is planned at 300,000 containers per year. Considering the geographic location of Estonia and its potential as a distribution centre for Asian goods, guaranteeing a 1435 mm connection is recommended for said terminal. The NTLP plans should be considered at least at the theoretical level during the designing of the main route of Rail Baltica. The implementation of the NTLP business plan calls for the amendment of the effective detailed plan.

In the case of both development projects, it must be kept in mind that investments with EU support cannot be made on registered immovables belonging to private owners. However, EU funds could theoretically be used to cover the expenses that make it possible to connect said development areas with Rail Baltica. This is possible on condition that there are more beneficiaries than one specific company.

Stakeholder Group 4

The fourth stakeholder group consists of public undertakings or state agencies such as the Port of Tallinn, Estonian Railway and the Technical Regulatory Authority. Below we look at the feedback and proposals received from said stakeholder groups.

Port of Tallinn

Muuga Harbour was built and has been developed for the purpose of servicing goods transported by the 1520 mm railway network. Muuga railway station and the roads connecting it to the terminals at the harbour function very well together. The location of the Port of Tallinn is important so that the RBMMT railway network creates additional synergies with existing infrastructure and does not have a negative impact on existing infrastructure and the business interests of operators. Since the Port of Tallinn operates as a landlord port, it would be in its interests to create a business environment that is as favourable as possible for the terminal operators at the port, and not compete directly with its customers.

In the context of the given project, this means taking the 1435 mm railway infrastructure to the terminal operators, but not participating in the investments made in the terminals. Even if the Port of Tallinn were the developer of a capacity related to the RBMMT, this would mean giving the development area on rent by way of a public procurement as set out in the business plan.

As the Port of Tallinn would like to maximise its revenue from the developed land, it tends to support a solution where railway infrastructure is not built on valuable land. The land near the water line is valuable land for the Port of Tallinn. This is why the Port of Tallinn has not expressed its final opinion of the use of the so-called coal terminal area upon the development of container goods and RORO buffering capacity. If the area in question cannot be used, then the companies in Stakeholder Group 3 and their development areas should be considered as the buffer area.In general, the Port of Tallinn supports a hybrid version where the goods related to the water line are handled at the port and goods not related to the water line are handled in the dry port area. The Port of Tallinn is one of the most important partners in the context of the RBMMT and its interests must be accommodated as much as possible in order to not disturb the working business model of the port. The Port of Tallinn is also the largest land owner of Muuga Harbour.

Estonian Railways

Estonian Railway is the owner and operator of the 1520 mm railway infrastructure at Muuga Harbour and the guarantor of the functioning 1520 mm connection. The RBMMT can only function successfully in cooperation with the owner and operators of the 1520 mm railway infrastructure. From the viewpoint of Estonian Railway, investments in 1435 mm railway infrastructure should be made in such a way that they do not weaken the everyday operation of the 1520 mm infrastructure. Level crossings are the biggest risks seen by Estonian Railway. During consultations, Estonian Railway considered the establishment of level crossings possible outside the main tracks, provided that the traffic control system makes operating two different railway systems possible. Unlike the vision of the Port of Tallinn, Estonian Railway does not support the integration of the 1520 and 1435 stations, preferring the separate management of both systems. However, Estonian Railway has mentioned the reduction in the capacity of the marshalling yard as a risk related to level crossing railway systems. In the case of grade-separated crossings, the risks highlighted by Estonian Railway are the issue of transport capacity resulting from the height difference.

Technical Regulatory Authority (TRA)

The TRA is an agency operating in the area of government of the Ministry of Economic Affairs and Communications, which exercises state supervision of railway safety and railway construction (railway infrastructure, rail traffic, transport and vehicles). Since the TRA is the agency that decides on permitting the use of railway facilities, the type-approval of rail vehicles and the engines installed on locomotives, railcars and road-rail vehicles, it is an important stakeholder in this project. The TRA has participated in this project as an independent observer with an independent position in the context of both 1435 and 1520 mm railway infrastructure. As a result, the TRA has given independent opinions about the six shortlisted technical solutions and analysed variants I and IIIb in greater depth. The consultant asked the TRA to investigate whether connecting the development projects mentioned in Stakeholder Group 3 with the Rail Baltica and 1520 railway track would be technically feasible.

Jõelähtme Municipality Government

The economic, spatial and environmental impact of alternatives I and IIIb have been introduced to Jõelähtme Municipality Government. It does not prefer either variant over the other, but pointed out the potential problems that variant I may cause: there are a lot of established detailed plans and private houses in the area covered by the plan. The established plans would have to be annulled in their present format and new plans would have to be established. Agreements with land owners would have to be reached before this could be done. In the case of variant IIIb, the main negotiator in respect of the sale of land is the Port of Tallinn. The municipality government is of the opinion that the Contracting Entity must decide on the variant it wishes to proceed with as soon as possible. Only then will it be possible to analyse the further schedule of the plans in greater detail.

5. WP 3.3 – Technological and operational profile

Table 34 summarizes the technological profile of the terminal's infrastructure in the port of Muuga and also provides an overview of the railway and road infrastructure.

Table 34: Overview of the technical profile of MCTRB zones (Except container and RORO zones)

A – Internal Rail Infrastructure	2025	2035	2055
Transport volume per year [t/year] (max. capacity)	12.194.766	15.630.841	15.423.655
Number of loaden trains In + Out per day (700m)	26	36	38
Number of trucks Reception-/Departure sidings 1435 + 1520	4 + 6	6 + 6	7 + 6
B – Internal Road Infrastructure	**2025**	**2035**	**2055**
Number of trucks per day (max. capacity)	1.437	2.288	2.566
Truck Gates Entrance / Exit	21	33	36
Parking slots for trucks Entrance / Exit	334	565	663
L – Liquid bulk (oil and oil products, gas)	**2025**	**2035**	**2055**
Transport volume per year [t / year] (max. capacity)	6.354.610	4.607.084	2.411.831
Number of loading tracks 1435 + 1520	1*200 m + 2 * 650 m	1*200 m + 1 * 650 m	1*200 m + 1 * 650 m
Terminal capacity [m³]	205.232	133.555	47.122
G - General Cargo	**2025**	**2035**	**2055**
Transport volume per year [t/year] (max. capacity)	4.047.244	5.336.842	3.829.281
Number loading tracks 1435 + 1520	3 + 1 * 200 m	4 + 2 * 200 m	2 + 1 * 200 m
Warehouse area [m²]	50.813	60.814	53.772
D - Dry Bulk (fertilizers, minerals, grain)	**2025**	**2035**	**2055**
Transport volume per year [t/year] (max. capacity)	5.116.891	6.773.994	4.520.301
Number loading tracks 1435 + 1520	3 + 2 * 200 m	4 + 2 * 200 m	3 + 2 * 200 m
Terminal capacity [t/day]	91.034	96.671	81.806

Table 35 summarizes the key technical characteristics of the container and RORO zones. Detailed information to the technical set up of the zone is presented in the section 1.2.2 of the WP2 report. The description of the operational profile per zone is thoroughly described in the section 3.1 of the present report.

Table 35: Overview of the technical profile of container and RORO zones

C - Container Terminal	2025	2035	2045	2055
Transport volume per year [TEU/year]	300.070	825.889	1. 131.893	1.546.708
Transport volume rail based only [TEU/year]	177.992	442.661	551.071	686.631
Number loading tracks 1435 + 1520	2 + 2 * 650 m	5 + 3 * 650 m	7 + 3 * 650 m	10 + 4 * 650 m
Number of gantry cranes	2	4	6	7
G- RoRo	**2025**	**2035**	**2045**	**2055**
Number of parking RoRo slots	224	405	445	470
RoRo terminal area m²	16.384	29.585	32.491	34.301

6. WP 3.4 – A cost-benefit analysis (CBA)

6.1. General Approach and Objective

The analysis of costs and benefits for the multimodal freight terminal Rail Baltic at Muuga Harbour is not straight forward, since Muuga Harbour is an integral part of a bigger project, the Rail Baltic Global Project, for which a CBA has already been conducted[11].

This situation – the need of assessing the effects of a subproject, which is part of a larger project – leads to a number of peculiarities, especially when it comes to the economic analysis. In particular difficult is the determination of the share of the benefits from the Global Project, which are attributable to the Muuga Harbour connection, for the following reason: Usually, according to the CBA guidelines, one needs a business-as-usual (BAU) scenario and a development scenario. An isolated Muuga Harbour CBA would therefore need a BAU-scenario, which assumes that RB is built, but Muuga Harbour stays like it is, while the development scenario would assume that RB is built and Muuga Terminal is developed as well. In such an approach the development of Muuga Harbour, like the other terminals, represents a major removal of a bottleneck which very likely leads to huge benefits. This is always then the case when several subprojects are needed to unlock the inherent network effects. That last unit to be built is then the one that unlocks them but it is not the origin for all the benefits generated.

This is why such an approach would neglect one of the key aspects of a CBA, which is to “focus on the whole project as a self-sufficient unit of analysis”, i.e. the Rail Baltica Global Project as a whole. Such an approach of evaluating a subproject would severely distort the results and furthermore very likely lead to a financial analysis with a positive net present value (which in turn could make the project ineligible for financing assistance by the EU, since the project itself is self-financing). However, the determination of the exact economic benefits is also not the goal of this analysis at hand.

While it has already been cleared, that the whole RB global project, of which the development of Muuga Harbour is one part, is worth proceeding (see Global Study), the main objective of this analysis is to provide assistance in the decision-making with respect to which of the alternatives of connecting Muuga Harbour to Rail Baltic (alternative I or alternative IIIb) is the better option.

What does this mean for the following analysis?

The individual economic impact of the Muuga Harbour connection, as it is an integral part of the Rail Baltic project, is not reliably quantifiable. However, the assumptions regarding the freight flows are the same for both alternatives (see Figure 74 on p. 100). This means that it can safely be assumed that major parts of the economic effects, especially the contribution of the Muuga Harbour connection to the economic benefits of the RB Global Project as a whole, are basically the same for both alternatives as well. Therefore it is possible to calculate only those economic costs and benefits, which are different between alternatives, and use those as decision basis. Other costs and benefits, which are identical for both alternatives, affect the absolute value of the economic net present value, but not the order of the alternatives. So, even though the exact economic value is unknown, because the attribution of the network effects is difficult if not impossible and they cannot simply be distributed over the different parts of the Global Project, it is possible to reach a well-founded decision based on the alternative-dependent differences.

So how then to provide a basis for decision-making regarding the identification of the better alternative?

What matters for decision making is the relative advantage of one alternative over the other. Since the trade flows are assumed to be the same for both alternatives, the absolute value of the economic benefits generated by Muuga Harbour actually does not matter in a relative evaluation. Therefore, the analysis provided here will first conduct a standard financial analysis based on the guidelines of the CBA-guide. Then a partial economic analysis will be carried out, which leaves out major parts of the economic benefit calculation as they are not quantifiable. This is possible, because the omitted values are (practically) identical for both alternatives and would not change the decision-making towards the identification of the better alternative. In the end two Net Present Values simply have to be compared. The one that shows a higher value represents the economically better option.

[11] Rail Baltica Global Project CostBenefit Analysis Final Report (30 April 2017)

Steps towards a partial CBA:

- Standard Financial Analysis
- Economic Analysis:
  - Transformation of the financial analysis through revenue correction and shadow price adjustments
  - Alternative-dependent environmental and social effects

That means that the final Financial and Economic Analysis look like that:

FINANCIAL ANALYIS (Alternative I)			1	2	3	4	5	10	15	20	25	30
Financial discount rate : 4%		in net present value	Construction			Operation						
Revenues	mEUR	A'	0	0	0	a'	a'	a'	a'	a'	a'	a'
Project investment cost	mEUR	B'	b'	b'	b'	0	0	0	0	0	0	0
Project O&M costs	mEUR	C'	0	0	0	c'	c'	c'	c'	c'	c'	c'
Residual value of investments	mEUR	D'	0	0	0	0	0	0	0	0	0	d'
Financial costs and benefits	mEUR	∑A'B'C'D'	b'	b'	b'	∑a'c'	∑a'c'	∑a'c'	∑a'c'	∑a'c'	∑a'c'	∑a'c'd'
FNPV	**mEUR**	**FNPV**										

To derive values from the financial analysis for the economic analyis, conversion factors (for shadow prices) are used:
(the original values in the financial analysis are marked by an apostrophe " ' " in the financial analysis)

ECONOMIC ANALYIS (Alternative I)			1	2	3	4	5	10	15	20	25	30
Social discount rate : 5%		in net present value	Construction			Operation						
Muuga Harbour												
Revenues	mEUR	A	0	0	0	a	a	a	a	a	a	a
Project investment cost	mEUR	B	b	b	b	0	0	0	0	0	0	0
Project O&M costs	mEUR	C	0	0	0	c	c	c	c	c	c	c
Residual value of investments	mEUR	D	0	0	0	0	0	0	0	0	0	d
Externalities (alternative-dependent):												
Noise		E	0	0	0	e	e	e	e	e	e	e
Climate Change		F	0	0	0	f	f	f	f	f	f	f
Air pollution		G	0	0	0	g	g	g	g	g	g	g
Partial economic benefits and costs (alternative dependent)	mEUR	**∑ABCDEFG = NPV1**	b	b	b	∑acefg	∑acefg	∑acefg	∑acefg	∑acefg	∑acefg	∑acefg
From the Global Project: e.g.												
Time savings		x1	0	0	0	These values are generated by the global project. They cannot be determined due to the strong network effects and interdependencies. 'Project demarcation' refers to potential correction of double counting. (Assumed to be identical for both alternatives)						
VOC savings	mEUR	x2	0	0	0							
Accident savings	mEUR	x3	0	0	0							
CO2 savings	mEUR	x4	0	0	0							
Project Demarcation	mEUR	x5										
Impact from Global Project	mEUR	X	x	x	x	x	x	x	x	x	x	x
Total economic benefits and costs	mEUR	**∑ABCDEFG +X**	b+x	b+x	b+x	∑acefg+x	∑acefg+x	∑acefg+x	∑acefg+x	∑acefg+x	∑acefg+x	∑acefg+x
ENPV	**mEUR**	**NPV1 + X**										

This is done for both alternatives I and IIIb. Then: comparison of alternatives:

ALTERNATIVE 1	**NPV1 + X**	**X cancels out. Decision is based on NPV of partial economic benefits and cost:**
ALTERNATIVE 3	**NPV3 + X**	**NPV1 > or < NPV3 ?**

Bottom line:

When comparing the two alternatives, the unknown amount of economic benefits mathematically cancel each other out. So that alternative should be chosen, which generates the higher NPV.

On the implication for local politicians and decision-makers:

When providing assistance for decision making in bigger or international projects, it is very often the case that local politicians and decision-makers seek justification for their decisions, in form of a positive contribution of a certain project towards their specific regions. But this information is often not generated on regional level, sometimes not even on a national but only on an international (global) level, due to the vast impacts that are derived from network effects.

In a recent discussion at the 2017 OECD International Transport Forum on quantifying the socio-economic benefits of transport[12] this problem is addressed in one of the key findings:

"However, the standard application of transport CBA faces challenges that have attracted the attention of practitioners and researchers. These […] broadly fall into three related themes:

Relevance – There is often a mismatch between the information wanted by decision makers compared to what is supplied by a standard CBA. For instance, CBA supplies measures of resource benefits and social welfare benefits from the perspective of the nation. But decision makers may wish to understand the final (transmitted) impacts on jobs and economic activity in their region […]."

So it is understandable that there is a strong desire to "break down" national or - in the case at hand - global effects to the individual nations or regions. That desire was also met in the "Rail Baltica Global Project Cost Benefit Analysis"[13] (see page 189), although the authors of that study state in a respective disclaimer that the Global CBA has been prepared […] with the consideration of a single united infrastructure across the Baltic States and not as a combination (sum) of national components. Therefore, based on the calculations there is not a single objective criterion or method how to split the results into three separate individual countries." However, keeping in mind the shortcomings of a simple break-down, it provides an idea of the distributional effects.

Summarizing, the effects of the Global Project are difficult to break down to regional or functional units like the Muuga Harbour. There are possibilities of simply breaking-down the benefits given a certain investment-share. For the analysis at hand, these effects are not decisive since they both affect the alternatives in questions in the same way ("plus X"). Thus, they can be cancelled out or neglected when it comes to comparing the two alternatives. So with regard to the above table, the basis for the decision-making is effectively comparing the NPV1 with the NPV3.

6.2. Methodology

Cost-Benefit Analysis (CBA) is an analytical tool for estimating the economic advantages or disadvantages of an investment decision by assessing its costs and benefits in order to assess the welfare change attributable to it.

The cost-benefit analysis of the project (CBA) is based on the European Commission guidelines for cost-benefit analysis of investment projects[14].

The analytical framework of CBA refers to a list of underlying concepts, amongst others:

- **Long-term perspective.** A long-term outlook is adopted, ranging up to the year 2055.
- **Calculation of economic performance indicators expressed in monetary terms.** CBA is based on a set of predetermined project objectives, giving a monetary value to all the positive (benefits) and negative (costs) welfare effects of the intervention. These values are discounted and then totalled in order to calculate a net total benefit. The project overall performance is measured by indicators, namely the Economic Net Present Value (ENPV), expressed in monetary values, and the Economic Rate of Return (ERR), allowing comparability and ranking for competing projects or alternatives.
- **Incremental approach.** The CBA only considers the difference between the cash flows in the with-the-project and the counterfactual scenario without-the-project. In cases where a project consists of a completely new asset, e.g. there is no pre-existing service or infrastructure, the without-the-project scenario is one with no operations. In the case of Muuga harbour area, there is currently no infrastructure to serve freight flows from Rail Baltica. Hence, the CBA will only consist of additional cash flows arising from investments to serve Rail Baltica' freight flows.

Financial analysis

To compute the project's financial performance indicators the financial analysis is included in the CBA. Financial analysis is carried out in order to:

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[12] ITF (2017), Quantifying the Socio-economic Benefits of Transport, ITF Roundtable Reports, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789282108093-en

[13] http://www.railbaltica.org/wp-content/uploads/2017/04/RB_CBA_FINAL_REPORT_0405.pdf

[14] Guide to cost-benefit analysis of investment projects (Economic appraisal tool for Cohesion Policy 2014-2020) http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf

- assess the consolidated project profitability;
- assess the project profitability for the project owner and some key stakeholders;
- outline the cash flows which underpin the calculation of the socio-economic costs and benefits.

The financial analysis methodology used is the **Discounted Cash Flow (DCF) method**. The following principles were observed for the preparation of the financial analysis:

- Only **cash inflows and outflows** are taken into account, i.e. accounting items like depreciation, reserves, price and technical contingencies, which do not represent actual cash flows, are disregarded.
- In general the financial analysis should be carried out from the point of view of the infrastructure owner. Since in the case of MCTRB owner and operator will not be the same entity, therefore a **consolidated financial analysis**, which excludes the cash flows between the owner and the operators, is carried out.
- **4% (real) Financial Discount Rate (FDR)**[15] is adopted in order to calculate the present value of the future cash flows. The financial discount rate reflects the opportunity cost of capital.[16]
- According to the standard benchmark, the project's economically useful life is set at 30 years, therefore the **time horizon (or reference period)**, for which cash flows are forecast, is set reaching up to the year 2055.
- The financial analysis is carried out in constant (real) prices[17], i.e. with prices fixed at a base-year 2017.
- The analysis is carried out **net of VAT**, both on purchase (cost) and sales (revenues), as it is recoverable by the project promoter.

Economic analysis

Following the financial analysis, an economic analysis is carried out to estimate the project's contribution to welfare. The main difference is the use of **shadow prices** to reflect the social opportunity cost of goods and services – both project inputs and outputs -, instead of prices observed in the market, which may be distorted due to non-efficient markets, taxes and other factors.

As suggested in the European Commission guidelines, the economic analysis starts from the financial analysis and moves from to the economic analysis by a series of adjustments, i.e.:

- fiscal corrections;
- conversion from market to shadow prices;
- evaluation of non-market impacts and correction for externalities.

Analogous to the financial analysis the adjusted costs and benefits as well as non-market impacts (e.g. impacts on the environment) occurring at different times are discounted. In accordance with the European Commission recommendation, a **Social Discount Rate (SDR)**[18] of **5%** (in real terms) is used to reflect the social view on how future benefits and costs should be valued against present ones.

The project's **economic performance** is finally measured based on the Economic Net Present Value (ENPV), which is more significant, since only a partial economic CBA can be conducted. The alternative with the higher value of ENPV is the option to proceed with.

6.3. Project identification

The goal of the investment project is to create **Rail Baltic multimodal freight terminal** and **additional service capacity to handle freight flows** passing through Muuga Harbour along the 1435 mm railway.

The investment includes the following infrastructure:

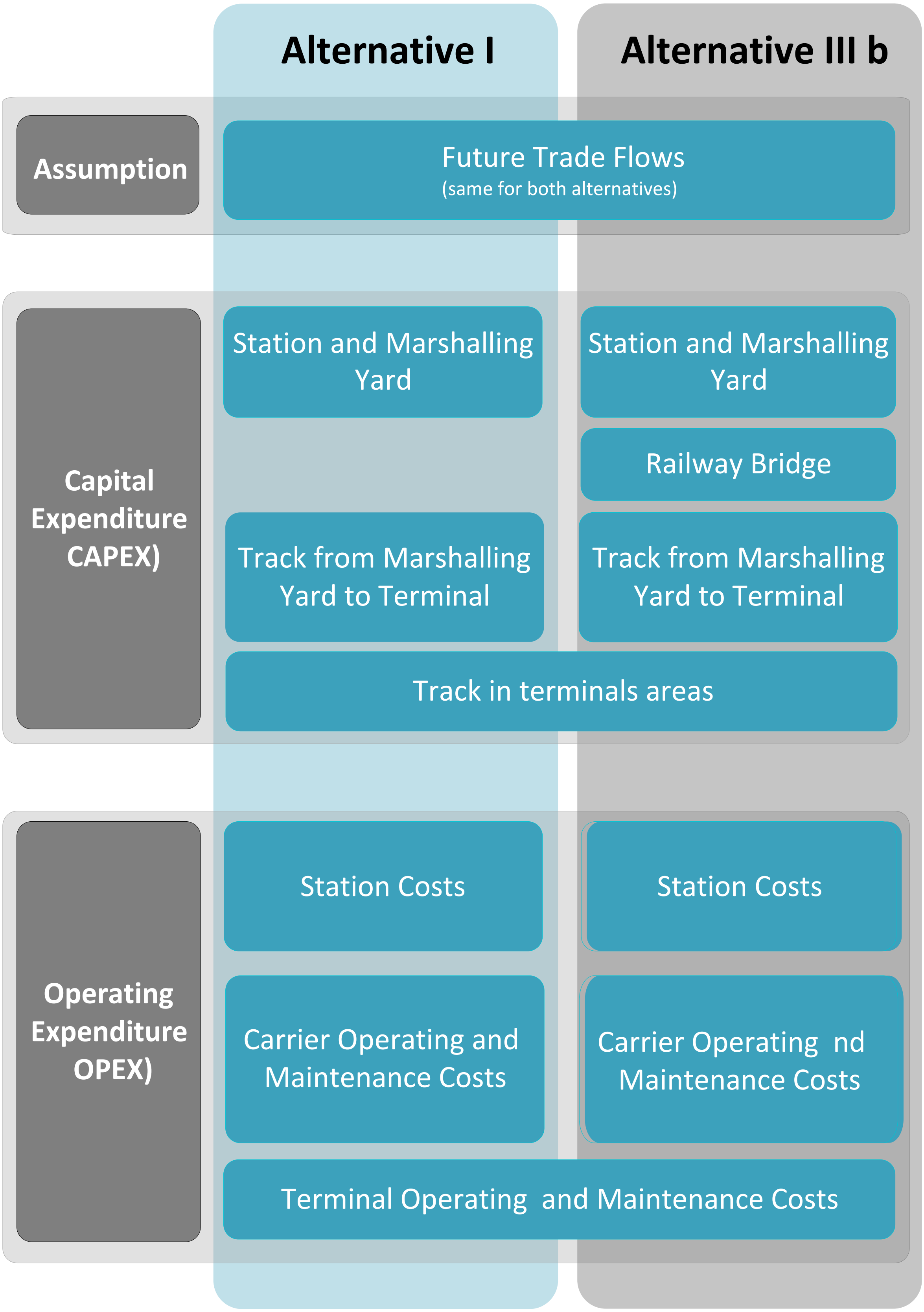
[15] The European Commission's reference parameter suggested for the programming period 2014-2020.
[16] According to Article 19 (Discounting of cash flows) of Commission Delegated Regulation (EU) No 480/2014, for the programming period 2014-2020, the European Commission recommends that a 4 % discount rate in real terms is considered as the reference parameter for the real opportunity cost of capital in the long term.
[17] Based on the European Commission guidelines for cost-benefit analysis of investment projects, p 41. "The fnancial analysis should usually be carried out in constant (real) prices, i.e. with prices fxed at a base-year. The use of current (nominal) prices would involve a forecast of CPI that does not seem always necessary."
[18] For the programming period 2014-2020 the European Commission recommends that for the social discount rate 5 % is used for major projects in Cohesion countries.

- Double track mainline (with overpass bridges for Alternative IIIb)
- Rail Baltica terminal station with marshalling yard
- Signalling and telecommunication
- Depot with equipment
- Road redeployment and new access roads
- Single tracks (1435 mm) from marshalling yard to terminals
- Single tracks (1435 mm & 1520 mm) in terminals areas
- Additional equipment for loading/unloading in terminals areas
- Ro-Ro terminal

Financial analysis will be conducted for 2 most promising pre-selected alternatives[19]: **Alternative I** and **Alternative IIIb**.

[19] Basing on the 6 alternatives developed within WP 2, the Client selected 2 preferable alternatives to be further elaborated: Alternative I and Alternative IIIBb. The decision is based on the comparative estimations and involved also the major public stakeholders (Port of Tallinn , Eesti Raudtee and Tehnilise Järelevalve Amet).

Figure 74. Similarities and differences between alternative scenarios



The freight flows would be identical for both alternatives. The main difference between the two alternatives lies in the location of the train station and in the length of tracks from station to freight terminals. Alternative IIIb also includes a long overpass railway bridge before train station and much more earthworks and retaining walls. But at the same time the station and marshalling yard can be built on a easily purchasable public property, while in the case of Alternative I, a station and marshalling should be built on a much more hard to buy private property. Size of the train station and marshalling yard will be the same for both alternatives. However, the lengths of tracks from marshalling yard to terminals are different for each alternative. Tracks in terminal areas and loading/unloading equipments and Ro-Ro area will be the same for both alternatives.

Railway Station capital expenditure, operation and maintenance cost will be the same for both alternatives. Although in the case of Alternative IIIb, the railway bridge is added, which also increases the maintenance costs for Alternative IIIb. Due to the difference of distances from marshalling yard to terminals, the shunting manoeuvres activity costs will be different for each alternative, hence the operation and maintenance costs will also be different and lead to different freight carrier charges for each alternative. As freight terminals have the same layout and equipment configuration for both alternatives, and the freight flows are the same, the overall operation and maintenance cost will be the same for both alternatives, except the freight carrier charges which differ for each alternative.

Since MCTRB is aimed at the provision of a general interest service and investment owners and operators will not be the same entities, a consolidated financial analysis is carried out to assess the profitability of the investment.

In total, the new rail infrastructure, freight carriers, and terminal owners are consolidated for financial analysis, based on the principle of incremental costs and benefits. The profitability of the investment is measured independently of the internal payments - the cash flows between the owners and the operators are excluded. But for the purposes of later Public Private Partnership analysis, the possible allocation of internal payments among owners and operators is also indicated.

The final analysis is based on the following general assumptions:

- Infrastructure manager should charge users as much as to get the net present value of investments to zero (NPV=0)
- Freight carriers are doing their business, as usual, earning the market's average EBITDA margin and charging freight terminals accordingly to achieve it
- Terminal owners are doing their business, as usual, setting the load handling charges in line with the current situation in the market and earning the market's average EBITDA margin

Figure 75. The structure of the consolidated financial analysis

	Investments	Revenues	O&M costs	EBITDA margin	Net Revenue excluding internal payments
RAILWAY INFRA OWNER	(Railway bridge) Station Marshalling yard Tracks to terminals	Infrastructure access charge	Operating expenses Replacement costs	NPV=0	XXX
CARRIERS	Locomotives	Freight carrier charges	Operating expenses Infrastructure access charge Replacement costs or	≈14,5%	YYY
TERMINALS	Tracks in terminals areas Loading/unloading equipments	Freight handling charges	Operating expenses Freight carrier charges Replacement costs	≈15,4%	ZZZ
	Total Investments				**Total Net Revenue excluding internal payments**

$$NPV = \sum_{t=1}^{T} \frac{\textit{Total Net Revenue excluding internal payments}}{(1+4\%)^t} - \frac{\textit{Total Investments}}{(1+4\%)^t}$$

6.4. Financial analysis

Investment cost, replacement costs and residual value

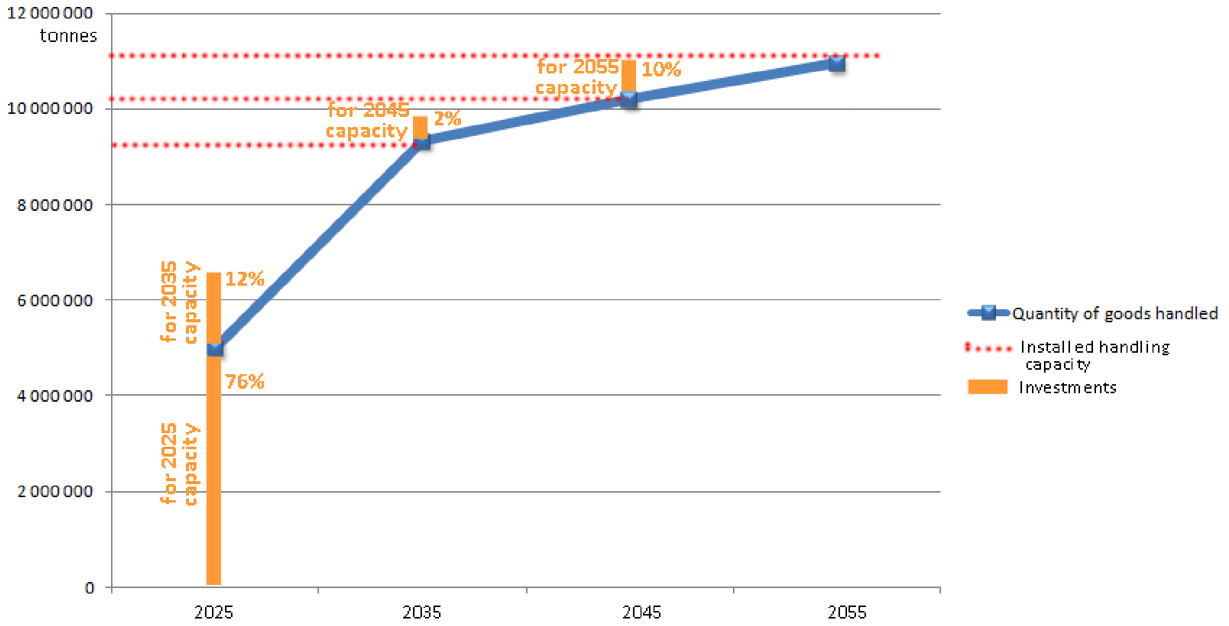
Investment costs are based on Rail Baltic freight flow for the years 2025, 2035, 2045, 2055. In WP2 the technical requirements were determined to handle this freight flow. In WP3 investment costs are calculated on a unit costs basis in relation to various cost elements per segments of the MCTRB area.

Table 36 and Table 37 summarizes the volumes for proposed investment stages for Alternative I (p.104) and for Alternative IIIb (p.105). Investment stages in Table 36 and Table 37 denote the year, in which the capacity is required[20] and match with the excel file worksheets "Investments for I" and " Investments for IIIb" by years.

Table 38 and Table 39 summarizes the total costs for proposed investment stages for Alternative I (p.106) and for Alternative IIIb (p.107). Once again, investment stages denote the year, in which the capacity is required[20] and match with the excel file worksheets "Investments for I" and " Investments for IIIb" by years.

The overall investment plan is set accordingly to provide necessary freight flow handling capacity before the actual need arises, so there won't be any capacity constraint prior. As shown in Figure 76, in the year 2025 sufficient capacity is built to match the freight flow handling demand until 2035. That is, the first and second stages of investments will be made by 2025. In 2035 the capacity is further expanded to match the demand until 2045 and so on. The Y axis represents the quantity of goods handled (in tonnes) and the maximum handling capacity (in tonnes). The x axis is a timeline. The orange bars for investment illustrate the proportional size of investments in each stage (no scale).

Figure 76. Investment strategy for 2025-2055



20 Not the year, in which the investment is actually made

Table 36. Volumes for proposed investment stages (Alternative I)

		Total	Stage 1 (2025)	Stage 2 (2035)	Stage 2.5 (2045)	Stage 3 (2055)
Public investment	**Main line**					
	Double track	1 978 m	1 978 m			
	Turnouts	4 pcs	4 pcs			
	Earthworks	11 868 m³	11 868 m³			
	Retaining walls	0 m²	0 m²			
	Culverts	4 pcs	4 pcs			
	Electrification	1 978 m	1 978 m			
	Railway bridges	0 m	0 m			
	Marshalling yard					
	Track	28 930 m	19 530 m	4 400 m		5 000 m
	Turnouts	52 pcs	38 pcs	8 pcs		6 pcs
	Earthworks	356 600 m³	356 600 m³	0 m³		0 m³
	Culverts	10 pcs	6 pcs	2 pcs		2 pcs
	Electrification	15 600 m	9 600 m	1 200 m		4 800 m
	Drainage	28 930 m	19 530 m	4 400 m		5 000 m
	Fence	3 000 m	3 000 m			
	Signaling and telecommunication	lumpsum	lumpsum			
	Depot					
	Tracks	700 m	700 m			
	Turnouts	12 pcs	12 pcs			
	Equipment	lumpsum	lumpsum			
	Building	1	1			
	Land plot					
	Land plot for mainline, station and turnout track	245 000 m²	245 000 m²			
	Changes to 1520mm tracks					
	Relocation	870 m	870 m			
	Demolition	3 850 m	3 850 m			
	New	1 700 m	1 700 m			
	Roads					
	Relocation	3 450 m	3 450 m			
	New access road to Ex Coal (6)	2 850 m	2 850 m			
	Maardu tee road bridge	36 m	36 m			
	Track (1435) from marshalling yard to terminal					
	Track	14 755 m	14 755 m			
	Turnouts	26 pcs	26 pcs			
	Rail crossings	29 pcs	29 pcs			
	Earthworks	50 992 m³	50 992 m³			
	Culverts	15 pcs	15 pcs			
	Road crossings	25 pcs	25 pcs			
	Drainage	1 770 m	1 770 m			
Private investment	**Locomotives for shunting**					
	Locos (Diesel GE 6000 PS)	5 pcs	3 pcs	1 pcs	pcs	1 pcs
	Terminals areas					
	Track (1435 mm)	18 tracks	11 tracks	4 tracks	1 track	2 tracks
	Track (1520 mm)	2 tracks	1 track			1 track
	RMG	7 pcs	2 pcs	2 pcs	1 pcs	2 pcs
	Forklifts	15 pcs	14 pcs	1 pcs		
	Timber wheel loaders	1 pcs	1 pcs			
	Ro-Ro area	43 326 m²	20 088 m²	16 022 m²	3 750 m²	3 466 m²

** Investment stages denote the year, in which the capacity is required not the year, in which the investment are actually made*

Table 37. Volumes for proposed investment stages (Alternative IIIb)

		Total	Stage 1 (2025)	Stage 2 (2035)	Stage 2.5 (2045)	Stage 3 (2055)
Public investment	**Main line**					
	Double track	3 125 m	3 125 m			
	Turnouts	4 pcs	4 pcs			
	Earthworks	485 000 m³	485 000 m³			
	Retaining walls	5 850 m²	5 850 m²			
	Culverts	5 pcs	5 pcs			
	Electrification	3 125 m	3 125 m			
	Railway bridges	110 m	110 m			
	Marshalling yard					
	Track	29 515 m	20 115 m	4 400 m		5 000 m
	Turnouts	57 pcs	39 pcs	8 pcs		10 pcs
	Earthworks	227 000 m³	227 000 m³	0 m³		0 m³
	Culverts	8 pcs	7 pcs	1 pcs		0 pcs
	Electrification	15 600 m	9 600 m	1 200 m		4 800 m
	Drainage	29 515 m	20 115 m	4 400 m		5 000 m
	Fence	0 m	0 m			
	Signaling and telecommunication	lumpsum	lumpsum	lumpsum		lumpsum
	Depot					
	Tracks	770 m	770 m			
	Turnouts	12 pcs	12 pcs			
	Equipment	lumpsum	lumpsum			
	Building	1 pcs	1 pcs			
	Land plot					
	Land plot for mainline, station and turnout track	253 000 m²	253 000 m²			
	Changes to 1520mm tracks					
	Relocation	450 m	450 m			
	Demolition	6 500 m	6 500 m			
	New	1 350 m	1 350 m			
	Roads					
	Relocation	12 750 m	12 750 m			
	New access road to Ex Coal (6)	2 850 m	2 850 m			
	Track (1435) from marshalling yard to terminal					
	Track	9 885 m	9 885 m			
	Turnouts	19 pcs	19 pcs			
	Rail crossings	23 pcs	23 pcs			
	Earthworks	34 598 m³	34 598 m³			
	Culverts	9 pcs	9 pcs			
	Road crossings	21 pcs	21 pcs			
	Drainage	46 155 m	46 155 m			
Private investment	**Locomotives for shunting**					
	Locos (Diesel GE 6000 PS)	5 pcs	3 pcs	1 pcs	pcs	1 pcs
	Terminals areas					
	Track (1435 mm)	18 traks	11 tracks	4 tracks	1 track	2 tracks
	Track (1520 mm)	2 tracks	1 track			1 track
	RMG	7 pcs	2 pcs	2 pcs	1 pcs	2 pcs
	Forklifts	15 pcs	14 pcs	1 pcs		
	Timber wheel loaders	1 pcs	1 pcs			
	Ro-Ro area	43 326 m²	20 088 m²	16 022 m²	3 750 m²	3 466 m²

** Investment stages denote the year, in which the capacity is required not the year, in which the investment are actually made*

Table 38. Total costs for proposed investment stages (Alternative I, mln euros)

	Unit cost	Total	Stage 1 (2025)	Stage 2 (2035)	Stage 2.5 (2045)	Stage 3 (2055)
Main line						
Double track	1 000 €/m double track	2,0	2,0			
Turnouts	100 000 €/pcs	0,4	0,4			
Earthworks	14 €/m³	0,2	0,2			
Retaining walls						
Culverts	130 000 €/pcs	0,5	0,5			
Electrification	300 €/m single track	1,2	1,2			
Railway bridges						
Marshalling yard						
Track	500 €/m	14,5	9,8	2,2		2,5
Turnouts	90 000 €/pcs	4,7	3,4	0,7		0,5
Earthworks	14 €/m³	5,0	5,0			
Culverts	250 400 €/pcs	2,5	2,2	0,1		0,2
Electrification	250 €/m + 50 000 € turnout	5,4	3,4	0,5		1,5
Land plot	50 €/m²	12,3	12,3			
Drainage	15 €/m	0,4	0,3	0,1		0,1
Fence	80 €/m	0,2	0,2			
Signalling and telecommunication	lumpsum	10,0	8,5	1,0		0,5
Depot						
Tracks	500 €/m	0,4	0,4			
Turnouts	90 000 €/pcs	1,1	1,1			
Equipment	lumpsum	5,0	5,0			
Building	lumpsum	1,0	1,0			
Land plot						
Land plot for mainline, station and turnout track	50 €/m²	12,3	12,3			
Changes to 1520mm tracks						
Relocation	500 €/m	0,4	0,4			
Demolition	30 €/m	0,1	0,1			
New	500 €/m	0,9	0,9			
Roads						
Relocation	300 €/m	1,0				
New access road to Ex Coal (6)	300 €/m	0,9				
Maardu tee road bridge	68 750 €/m	2,5				
Track (1435) from marshalling yard to terminal						
Track	500 €/m	7,4	7,4			
Turnouts	90 000 €/pcs	2,3	2,3			
Rail crossings	175 000 €/pcs	5,1	5,1			
Earthworks	14 €/m³	0,7	0,7			
Culverts	130 800 €/pcs	2,0	2,0			
Road crossings	30 000 €/pcs	0,8	0,8			
Drainage	15 €/m	0,03	0,03			
Locomotives for shunting						
Locos	2,9 mln €/loco	14,5	8,7	2,9		2,9
Terminals areas						
Track	500 €/m (RMG tracks 1000€/m)	6,4	2,4	2,1	0,7	1,3
Track	500 €/m	1,3	0,7			0,7
RMG	1 mln €	7,0	2,0	2,0	1,0	2,0
Forklifts	50 000 €	0,8	0,7	0,1		
Timber wheel loaders	50 000 €	0,2	0,2			
Ro-Ro area	350 €/m²	15,2	7,0	5,6	1,3	1,2

TOTAL CONSTUCTION COSTS		**135,9**	**102,4**	**17,2**	**3,0**	**13,4**
Planning, site supervision	10%	11,4	9,1	1,2	0,2	0,8
Project management costs	3%	4,1	3,1	0,5	0,1	0,4
Administrative approval charges	5%	5,7	4,5	0,6	0,1	0,4
Contingencies	10%	13,6	10,2	1,7	0,3	1,3
TOTAL COSTS		**170,7**	**129,4**	**21,3**	**3,6**	**16,4**

** Investment stages denote the year, in which the capacity is required not the year, in which the investment are actually made*
***Unit costs are based on DB Engineering & Consulting GmbH estimates*

Table 39. Total costs for proposed investment stages (Alternative IIIb, mln euros)

	Unit cost	Total	Stage 1 (2025)	Stage 2 (2035)	Stage 2.5 (2045)	Stage 3 (2055)
Main line						
Double track	1 000 €/m double track	3,1	3,1			
Turnouts	100 000 €/pcs	0,4	0,4			
Earthworks	14 €/m³	6,8	6,8			
Retaining walls	650 €/m³	3,8	3,8			
Culverts	130 000 €/pcs	0,7	0,7			
Electrification	300 €/m	1,9	1,9			
Railway bridges	79 273 €/m	8,7	8,7			
Marshalling yard						
Track	500 €/m	14,8	10,1	2,2		2,5
Turnouts	90 000 €/pcs	5,1	3,5	0,7		0,9
Earthworks	14 €/m³	3,2	3,2			
Culverts	287 625 €/pcs	2,3	2,2	0,1		
Electrification	250 €/m + 50 000 € turnout	5,4	3,4	0,5		1,5
Drainage	15 €/m	0,4	0,3	0,1		0,1
Fence	0 €/m	0,0				
Signalling and telecommunication	lumpsum	10,0	8,5	1,0		0,5
Depot						
Tracks	500 €/m	0,4	0,4			
Turnouts	90 000 €/pcs	1,1	1,1			
Equipment	lumpsum	5,0	5,0			
Building	lumpsum	1,0	1,0			
Land plot						
Land plot for mainline, station and turnout track	50 €/m²	12,7	12,7			
Changes to 1520mm tracks						
Relocation	500 €/m	0,2	0,2			
Demolition	30 €/m	0,2	0,2			
New	500 €/m	0,7	0,7			
Roads						
Relocation	300 €/m	3,8	3,8			
New access road to Ex Coal (6)	300 €/m	0,9	0,9			
Track (1435) from marshalling yard to terminal						
Track	500 €/m	4,9	4,9			
Turnouts	90 000 €/pcs	1,7	1,7			
Rail crossings	175 000 €/pcs	4,0	4,0			
Earthworks	14 €/m³	0,5	0,5			
Culverts	94 000 €/pcs	0,8	0,8			
Road crossings	30 000 €/pcs	0,6	0,6			
Drainage	15 €/m	0,7	0,7			
Locomotives for shunting						
Locos	2,9 mln €/loco	14,5	8,7	2,9		2,9

	Unit cost	Total	Stage 1 (2025)	Stage 2 (2035)	Stage 2.5 (2045)	Stage 3 (2055)
Terminals areas						
Track	500 €/m (RMG tracks 1000€/m)	6,4	2,4	2,1	0,7	1,3
Track	500 €/m	1,3	0,7			0,7
RMG	1 mln €	7,0	2,0	2,0	1,0	2,0
Forklifts	50 000 €	0,8	0,7	0,1		
Timber wheel loaders	50 000 €	0,2	0,2			
Ro-Ro area	350 €/m²	15,2	7,0	5,6	1,3	1,2
TOTAL INVESTMENT COSTS		**151,1**	**117,4**	**17,2**	**3,0**	**13,5**
Planning, site supervision	10%	12,9	10,6	1,2	0,2	0,9
Project management costs	3%	4,5	3,5	0,5	0,1	0,4
Administrative approval charges	5%	6,4	5,3	0,6	0,1	0,4
Contingencies	10%	15,1	11,7	1,7	0,3	1,4
TOTAL COSTS		**190,0**	**148,5**	**21,3**	**3,6**	**16,6**

** Investment stages denote the year, in which the capacity is required not the year, in which the investment are actually made*
*** Unit costs are based on DB Engineering & Consulting GmbH estimates*

Table 42 and Table 43 (109 p.) summarize the yearly breakdown of investment plan for both alternatives. In these tables the years refer to the years in which the investments is actually made. That is, the first and second stages of investments will be made by 2025. In 2035 the capacity is further expanded to match the demand until 2045 and so on.

For both alternatives investment costs are split between the public and private sector as following:

- main line, bridges, station, marshaling yard, depot and tracks to terminals are public investments;
- tracks in terminals areas, loading/unloading equipment, Ro-Ro area and locomotives for shunting are private investments.

To obtain necessary replacement cost and the possible residual value at the end of the reference period the following economically useful lifetimes have been assigned for each investment (see Table 40 and Table 41). Replacement investments are done at the end of the economically useful lifetime. If the economically useful lifetime ends at the end of the reference period, no replacement is made. For those fixed assets, whose economic life is not yet completely exhausted at the end of the reference period, the residual value is calculated using the depreciation formula[21].

Table 40. Replacement costs and residual value of Alternative I (mln euros)

	Economic Life	Replacement costs			Residual value
		2035	2045	2055	
Tracks	30 Years				4,7
Signalling and telecommunication	20 Years		9,5		5,0
Roads	20 Years		4,4		
Depot building	30 Years				0,0
Depot equipment	10 Years	5,0	5,0		0,0
Locos	20 Years		11,6		7,3
RMG	20 Years		4,0		2,5
forklifts & wheel loaders	10 Years	0,9	0,9		0,0
RoRo area	20 Years		12,6		6,6
Total		**5,9**	**48,0**	**0,0**	**26,1**

** In this table the years refer to the years in which the replacements are actually made*

[21] Guide to cost-benefit analysis of investment projects (Economic appraisal tool for Cohesion Policy 2014-2020), p. 45 http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf

Table 41. Replacement costs and residual value of Alternative IIIb (mln euros)

	Economic Life	Replacement costs 2035	2045	2055	Residual value
Railway bridges	50 Years				3,5
Tracks	30 Years				4,8
Signaling and telecommunication	20 Years		9,5		5,0
Roads	20 Years		4,7		
Depot building	30 Years				0,0
Depot equipment	10 Years	5,0	5,0		0,0
Locos	20 Years		11,6		7,3
RMG	20 Years		4,0		2,5
forklifts & wheel loaders	10 Years	0,9	0,9		0,0
RoRo area	20 Years		12,6		6,6
Total		**5,9**	**48,3**	**0,0**	**29,7**

** In this table the years refer to the years in which the replacements are actually made*

Table 42. Yearly breakdown of investment plan for Alternative I (mln euros)

		2019	2020	2021	2022	2023	2024	2025	2035	2045	Total
Public investment	**RAILWAY INFRASTRUCTURE OWNER**										
	Main line						2,1	2,1			**4,3**
	Railway bridges										**0,0**
	Marshalling yard						14,0	14,0		4,8	**32,7**
	Signalling and telecommunication						4,8	4,8		0,5	**10,0**
	Depot						3,7	3,7			**7,4**
	Changes to 1520mm tracks						0,7	0,7			**1,4**
	Track (1435) from marshalling yard to terminal						9,1	9,1			**18,2**
	Roads						2,2	2,2			**4,4**
	Land plot	6,1	6,1								**12,3**
	Planning and administration costs	0,4	0,8	1,2	3,2	3,2	3,2	3,2		1,0	**16,3**
	Contingencies (10%)	0,6	0,6				3,7	3,7		0,5	**9,1**
	Replacement costs								5,0	18,9	**23,9**
	Total for RAILWAY INFRASTRUCTURE OWNER	**7,1**	**7,5**	**1,2**	**3,2**	**3,2**	**43,5**	**43,5**	**5,0**	**25,6**	**139,9**
Private investment	**CARRIERS**										
	Loco							11,6		2,9	14,5
	Project management costs							0,3		0,1	0,4
	Contingencies (10%)							1,2		0,3	1,5
	Replacement costs									11,6	11,6
	Total for CARRIERS	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**13,1**	**0,0**	**14,9**	**28,0**
	TERMINAL OWNERS										
	Track in terminals areas						2,6	2,6	0,7	2,0	7,7
	Equipment for loading/unloading							4,9	1,0	2,0	7,9
	Ro-Ro area						6,3	6,3	1,3	1,2	15,2
	Planning and administration costs				0,8	0,8	0,8	0,8	0,4	0,6	4,4
	Contingencies (10%)						0,9	1,4	0,3	0,5	3,1
	Replacement costs								0,9	17,5	18,4
	Total for TERMINAL OWNERS	**0,0**	**0,0**	**0,0**	**0,8**	**0,8**	**10,6**	**16,0**	**4,5**	**23,8**	**56,7**
	Total CAPEX	**7,1**	**7,5**	**1,2**	**4,1**	**4,1**	**54,1**	**72,6**	**9,5**	**64,4**	**224,6**

** In this table the years refer to the years in which the investments are actually made*

*** Compared to Table 3, Table 7 includes replacement costs as part of total capital expenditures*

Table 43. Yearly breakdown of investment plan for Alternative IIIb (mln euros)

		2019	2020	2021	2022	2023	2024	2025	2035	2045	Total
Public investment	**RAILWAY INFRASTRUCTURE OWNER**										
	Main line					6,2	8,3	2,1			**16,6**
	Railway bridges					3,3	4,4	1,1			**8,7**
	Marshalling yard					9,8	13,1	3,3		5,0	**31,2**
	Signalling and telecommunication					3,6	4,8	1,2		0,5	**10,0**
	Depot						3,7	3,7			7,4
	Changes to 1520mm tracks						0,7	0,7			1,4
	Track (1435) from marshalling yard to terminal						9,1	9,1			18,2
	Roads						2,2	2,2			4,4
	Land plot	12,7									**12,7**
	Planning and administration costs	0,4	0,8	1,2	3,9	3,9	3,9	3,9		1,0	**19,0**
	Contingencies (10%)	1,3				3,3	4,4	1,1		0,5	**10,6**
	Replacement costs								5,0	19,2	**24,2**
	Total for RAILWAY INFRASTRUCTURE OWNER	**14,3**	**0,8**	**1,2**	**3,9**	**40,1**	**52,1**	**16,0**	**5,0**	**26,2**	**159,6**
Private investment	**CARRIERS**										
	Loco							11,6		2,9	14,5
	Project management costs							0,3		0,1	0,4
	Contingencies (10%)							1,2		0,3	1,5
	Replacement costs									11,6	11,6
	Total for CARRIERS	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**13,1**	**0,0**	**14,9**	**28,0**
	TERMINAL OWNERS										
	Track in terminals areas						2,6	2,6	0,7	2,0	7,7
	Equipment for loading/unloading							4,9	1,0	2,0	7,9
	Ro-Ro area						6,3	6,3	1,3	1,2	15,2
	Planning and administration costs				0,8	0,8	0,8	0,8	0,4	0,6	4,4
	Contingencies (10%)						0,9	1,4	0,3	0,5	3,1
	Replacement costs								0,9	17,5	18,4
	Total for TERMINAL OWNERS	**0,0**	**0,0**	**0,0**	**0,8**	**0,8**	**10,6**	**16,0**	**4,5**	**23,8**	**56,7**
	Total CAPEX	**14,3**	**0,8**	**1,2**	**4,8**	**40,9**	**62,7**	**45,1**	**9,5**	**64,9**	**244,2**

** In this table the years refer to the years in which the investments are actually made*

*** Compared to Table 4, Table 8 includes replacement costs as part of total capital expenditures*

Operating costs and revenues

RAILWAY INFRASTRUCTURE OWNER

The main costs for the railway infrastructure owner are related to the maintenance of tracks: from the station through the marshalling yard to the terminals and to the organization of the railway station work.

It is estimated that the cost of railway tracks maintenance for mainline is 44 097 €/km per year, for marshaling yard and tracks to terminals 11 261 €/km per year [22] and the maintenance of the bridge is calculated as 1% of the bridge construction cost per year[23]. It is estimated that at least 16 people are required to operate the railway station[24]: station manager, 5 maneuver dispatchers and 10 station controllers. The level of wages is the average Harjumaa

[22] Rail Baltica Global Project CostBenefit Analysis Final Report (30 April 2017), p 145.
Double-track, electrified: Track 18 747 EUR/km + Interlocking & remote control 3 774 EUR/km + Traction 15 538 EUR/km + Power current Tele & IT, Buildings, etc. 6 038 EUR/km.
Single-track, not electrified: (Track 18 747 EUR/km + Interlocking & remote control 3 774 EUR/km)/2

[23] Rail Baltica Global Project CostBenefit Analysis Final Report (30 April 2017), p 290

[24] The assessment is based on the staffing requirements of the Estonian Railway Muuga Station

county salary[25]. Other infrastructure manager operating expenses are assumed to be at 20% of total maintenance costs[26].

Table 44. Cost and revenue assumptions for railway infrastructure owner

	Alternative I	Alternative IIIb
Maintenance costs		
Tracks maintenance (main line)	44 097 €/km/year	
Tracks maintenance (Marshaling Yard & tracks to terminals)	11 261 €/km/year	
Main line	1,98 km	3,13 km
Marshalling yard	28,93 km	29,52 km
Tracks to terminals	14,75 km	9,89 km
Railway bridges		1% of bridges constriction costs/year
Personnel		
Employees	16	
Average gross monthly salary	1 337 €/month	
Taxes	33,8%	
Labour costs total	1 789 €/month	
Other general expenses		
Other expenses	20% of maintenance costs	
Revenues		
Infrastructure access charge	0,92 €/t	1,09 €/t
Additional services	5%	

The forecast of the revenues is based on the assumption that the infrastructure access charges must cover the investments and future maintenance costs. Given that it involves the use of public money and it is the EU-funded project, the railway infrastructure owner's NPV has to be close to zero (given the 4% financial discount rate). The Infrastructure access charges are calculated in such a way that the NPV of the project would be zero for the railway infrastructure owner. Additional services account for 5% of the basic income.

The results for the financial return on investment for railway infrastructure owner are summarized in **Table 45** and **Table 46** (112 p. and 113).

When interpreting these tables, it must be taken into account that this is an extract from the Rail Baltic Global project. Muuga station is part of the Rail Baltic, and the actual infrastructure access charge for the entire track will be different than calculated it separately for Muuga station alone.

Profitability and funding gap analyses have been carried out within the Rail Baltic Global project. As a result, the Rail Baltic Global project is forecast to have negative 5,48% financial rate of return, and a negative financial net present value and the financial gap rate is forecast to be 94,18%[27].

[25] Statistics Estonia: WS5211: AVERAGE MONTHLY GROSS AND NET WAGES (SALARIES) BY ECONOMIC ACTIVITY (EMTAK 2008)
[26] Rail Baltica Global Project CostBenefit Analysis Final Report (30 April 2017), p 145
[27] Rail Baltica Global Project CostBenefit Analysis Final Report (30 April 2017), p 154

Table 45. Financial return on investment of railway infrastructure owner (Alternative I)

RAILWAY INFRASTRUCTURE OWNER	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2030	2035	2040	2045	2050	2055
Revenues																
Infrastructure access charge										4,9	6,2	8,6	9,1	9,4	9,7	10,1
Additional services										0,2	0,3	0,4	0,5	0,5	0,5	0,5
Total Revenues										**5,2**	**6,5**	**9,0**	**9,5**	**9,9**	**10,2**	**10,6**
Residual value																**8,2**
Total inflows	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**5,2**	**6,5**	**9,0**	**9,5**	**9,9**	**10,2**	**18,8**
CAPEX																
Main line								2,1	2,1							
Railway bridges																
Marshalling yard								14,0	14,0					4,8		
Signalling and telecommunication								4,8	4,8					0,5		
Depot								3,7	3,7							
Changes to 1520mm tracks								0,7	0,7							
Track (1435) from marshalling yard to terminal								9,1	9,1							
Roads								2,2	2,2							
Land plot			6,1	6,1												
Planning and administration costs			0,4	0,8	1,2	3,2	3,2	3,2	3,2					1,0		
Contingencies (10%)			0,6	0,6	0,0	0,0	0,0	3,7	3,7					0,5		
Replacement costs												5,0		18,9		
Total CAPEX	**0,0**	**0,0**	**7,1**	**7,5**	**1,2**	**3,2**	**3,2**	**43,5**	**43,5**	**0,0**	**0,0**	**5,0**	**0,0**	**25,6**	**0,0**	**0,0**
OPEX																
Maintenance costs										0,5	0,5	0,5	0,5	0,6	0,6	0,6
Personnel										0,3	0,3	0,3	0,3	0,3	0,3	0,3
Other expenses										0,1	0,1	0,1	0,1	0,1	0,1	0,1
Total operating expences										**1,0**	**1,0**	**1,0**	**1,0**	**1,0**	**1,0**	**1,0**
Total outflows	**0,0**	**0,0**	**7,1**	**7,5**	**1,2**	**3,2**	**3,2**	**43,5**	**43,5**	**1,0**	**1,0**	**6,0**	**1,0**	**26,7**	**1,0**	**1,0**
Net cash flow	**0,0**	**0,0**	**-7,1**	**-7,5**	**-1,2**	**-3,2**	**-3,2**	**-43,5**	**-43,5**	**4,2**	**5,6**	**3,0**	**8,6**	**-16,8**	**9,2**	**17,7**
FNPV (C)	**0**															
FRR (C)	**4,0%**							Average EBITDA margin	**88,8%**							

Table 46. Financial return on investment of railway infrastructure owner (Alternative IIIb)

RAILWAY INFRASTRUCTURE OWNER	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2030	2035	2040	2045	2050	2055
Revenues																
Infrastructure access charge										5,9	7,4	10,2	10,8	11,2	11,5	12,0
Additional services										0,3	0,4	0,5	0,5	0,6	0,6	0,6
Total Revenues										**6,1**	**7,8**	**10,7**	**11,3**	**11,7**	**12,1**	**12,6**
Residual value																**11,8**
Total inflows	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**6,1**	**7,8**	**10,7**	**11,3**	**11,7**	**12,1**	**24,4**
CAPEX																
Main line							6,2	8,3	2,1							
Railway bridges							3,3	4,4	1,1							
Marshalling yard							9,8	13,1	3,3					5,0		
Signalling and telecommunication							3,6	4,8	1,2					0,5		
Depot							2,8	3,7	0,9							
Changes to 1520mm tracks							1,8	2,3	0,6							
Track (1435) from marshalling yard to terminal							0,4	0,5	0,1							
Roads							5,0	6,7	1,7							
Land plot			12,7													
Planning and administration costs			0,4	0,8	1,2	3,9	3,9	3,9	3,9					1,0		
Contingencies (10%)			1,3	0,0	0,0	0,0	3,3	4,4	1,1					0,5		
Replacement costs												5,0		19,2		
Total CAPEX	**0,0**	**0,0**	**14,3**	**0,8**	**1,2**	**3,9**	**40,1**	**52,1**	**16,0**	**0,0**	**0,0**	**5,0**	**0,0**	**26,2**	**0,0**	**0,0**
OPEX																
Maintenance costs										0,7	0,7	0,8	0,8	0,9	0,9	0,9
Personnel										0,3	0,3	0,3	0,3	0,3	0,3	0,3
Other expenses										0,1	0,1	0,2	0,2	0,2	0,2	0,2
Total operating expences										**1,2**	**1,2**	**1,3**	**1,3**	**1,5**	**1,5**	**1,5**
Total outflows	**0,0**	**0,0**	**14,3**	**0,8**	**1,2**	**3,9**	**40,1**	**52,1**	**16,0**	**1,2**	**1,2**	**6,3**	**1,3**	**27,6**	**1,5**	**1,5**
Net cash flow	**0,0**	**0,0**	**-14,3**	**-0,8**	**-1,2**	**-3,9**	**-40,1**	**-52,1**	**-16,0**	**5,0**	**6,6**	**4,4**	**10,0**	**-15,9**	**10,6**	**22,9**
FNPV (C)	**0**															
FRR (C)	**4,0%**							Average EBITDA margin	**87,5%**							

CARRIERS

In this analysis, the carriers are responsible for delivering wagons from station to terminals and back. The main costs for carriers are related to infrastructure access charges, fuel consumption and maintenance costs for locos and labor costs.

Infrastructure access charges have already been set at the owner's level. The main difference between the two alternatives is the maneuvering mileage, which for the alternative I is 70% higher than for the alternative IIIb. This results in higher fuel consumption and higher maintenance costs for alternative I. The work force consists of train drivers and maintenance staff. It is assumed that the train drivers' salary is 25% higher compared to the average salary. Other carrier operating expenses are assumed to be at 25% of total costs.

The revenue forecast is based on the assumption that rail carriers operate under competitive conditions and earn a market average EBITDA margin and charge freight terminals accordingly to achieve it. For the period 2010-2016 the average EBIDTA margin for the Estonian rail transport sector was 14,5% and average EBIT margin was 7,1%[28]. During the period under review, the margins have decreased and the EBIT margin has been even negative in recent years. This situation is not sustainable in long-term. Compared to 2010, the volume of rail freight traffic in 2015 has decreased about 30%. When Rail Baltic starts to operate, the freight volumes start to grow considerably and with it also the EBIT margin for freight carriers, reaching in long-run up to 7-8% on average. Additional services account for 9,1% of the basic income.

The results for the financial return on investment for carriers are summarized in Table 49 and Table 50 (116 p.-117).

Table 47. Cost and revenue assumptions for carriers

	Alternative I	Alternative IIIb
Manoeuvring mileage		
estimated shunting effort in tkm/a [29]	54 283 642 tkm/year	31 698 497 tkm/year
estimated shunting effort in km/a [29]	91 551 km/years	52 490 km/years
Maintenance costs		
Locos (Diesel GE 6000 PS)	0,65 €/train km	
Fuel consumption	15 litre/km	
Fuel price / diesel	1 €/l	
Personnel		
Employees	18 - 24	
Salary	1 604 €/month	
Taxes	33,8%	
Labour costs total	2 147 €/month	
Other general expenses		
Other expenses	25% of Total costs	
Revenues		
Freight carrier charges	0,16 €/tkm	0,29 €/tkm
	1,32 €/km	1,40 €/km
Additional services	8,4%	
Average EBITDA margin	14,5%	

** Maintenance costs are based on DB Engineering & Consulting GmbH estimates*

[28] This is in line with Rail Baltica Global Project Cost-Benefit Analysis Final Report (30 April 2017), p 114: "Based on ~ 700 comparable European freight and passenger carriers, the following EBIT margins are applied for return on capital calculation purpose: Freight carrier – 8.09%".
[29] Year 2026, values change over years

Table 48. FS001: ENTERPRISES' INCOME STATEMENT by Indicator, Economic activity
(EMTAK 2008: H491-492 Rail transport, thousand euros)

	2010	2011	2012	2013	2014	2015	2016	Average
Number of enterprises	8	7	7	7	6	6	6	
Number of persons employed	1 606	1 691	1 745	.	1 300	1 083	945	
Number of employees	1 604	1 679	1 737	.	1 298	1 080	69 831	781 823
Turnover	155 698	176 547	172 134	.	113 838	93 775	894	65 728
Other revenue	18 711	19 890	21 281	.	1 655	3 297	74 205	
Costs total,	154 078	168 040	175 217	.	115 629	98 719	10 041	63 169
..depreciation	7 702	8 452	12 332	.	13 849	10 794	-3 759	59 783
Operating profit (loss)	20 238	28 360	17 071	.	-302	-1 826	6 282	122 951
EBITDA	27 940	36 811	29 403	.	13 548	8 968	8,9%	**14,5%**
EBITDA margin	16,0%	18,7%	15,2%	.	11,7%	9,2%	-5,3%	7,1%
EBIT margin	11,6%	14,4%	8,8%	.	-0,3%	-1,9%	6	

. Data are confidential.

SOURCE: Statistics Estonia, Last-Updated 2017-02-16

Table 49. Financial return on investment of carriers (Alternative I)

CARRIERS	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2030	2035	2040	2045	2050	2055
Revenues																
Freight carrier charges										9,3	10,9	13,0	12,9	12,7	12,6	12,5
Additional services										0,8	0,9	1,1	1,1	1,1	1,1	1,0
Total Revenues										**10,1**	**11,9**	**14,1**	**14,0**	**13,8**	**13,7**	**13,5**
Residual value																**7,3**
Total inflows	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**10,1**	**11,9**	**14,1**	**14,0**	**13,8**	**13,7**	**20,7**
CAPEX																
Locos (Diesel GE 6000 PS)									11,6			0,0		2,9		
Project management costs									0,3			0,0		0,1		
Contingencies (10%)									1,2			0,0		0,3		
Replacement costs												0,0		11,6		0,0
Total CAPEX	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**13,1**	**0,0**	**0,0**	**0,0**	**0,0**	**14,9**	**0,0**	**0,0**
OPEX																
Infrastructure access charge										4,92	6,21	8,59	9,09	9,39	9,70	10,08
Maintenance costs										0,06	0,06	0,08	0,08	0,08	0,08	0,08
Fuel consumption										1,37	1,37	1,79	1,79	1,79	1,79	1,95
Personnel										0,46	0,46	0,54	0,54	0,54	0,54	0,54
Other expenses										0,47	0,47	0,60	0,60	0,60	0,60	0,64
Total operating expences										**7,29**	**8,58**	**11,60**	**12,10**	**12,40**	**12,72**	**13,30**
Total outflows	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**13,1**	**7,3**	**8,6**	**11,6**	**12,1**	**27,3**	**12,7**	**13,3**
Net cash flow	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**-13,1**	**2,8**	**3,3**	**2,5**	**1,9**	**-13,5**	**0,9**	**7,4**
FNPV (C)	**15**															
FRR (C)	**21,3%**						Average EBITDA margin		**14,5%**							

Table 50. Financial return on investment of carriers (Alternative IIIb)

CARRIERS	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2030	2035	2040	2045	2050	2055
Revenues																
Freight carrier charges										9,6	11,4	13,7	13,6	13,6	13,5	13,5
Additional services										0,8	1,0	1,2	1,1	1,1	1,1	1,1
Total Revenues										**10,4**	**12,4**	**14,9**	**14,8**	**14,7**	**14,7**	**14,6**
Residual value																**7,3**
Total inflows	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**10,4**	**12,4**	**14,9**	**14,8**	**14,7**	**14,7**	**21,8**
CAPEX																
Locos (Diesel GE 6000 PS)									11,6			0,0		2,9		
Project management costs									0,3			0,0		0,1		
Contingencies (10%)									1,2			0,0		0,3		
Replacement costs												0,0		11,6		0,0
Total CAPEX	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**13,1**	**0,0**	**0,0**	**0,0**	**0,0**	**14,9**	**0,0**	**0,0**
OPEX																
Infrastructure access charge										5,85	7,38	10,21	10,80	11,16	11,53	11,98
Maintenance costs										0,03	0,03	0,05	0,05	0,05	0,05	0,05
Fuel consumption										0,79	0,79	1,05	1,05	1,05	1,05	1,19
Personnel										0,46	0,46	0,54	0,54	0,54	0,54	0,54
Other expenses										0,32	0,32	0,41	0,41	0,41	0,41	0,45
Total operating expences										**7,46**	**8,99**	**12,25**	**12,84**	**13,20**	**13,57**	**14,20**
Total outflows	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**13,1**	**7,5**	**9,0**	**12,2**	**12,8**	**28,1**	**13,6**	**14,2**
Net cash flow	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**-13,1**	**3,0**	**3,4**	**2,6**	**2,0**	**-13,4**	**1,1**	**7,6**
FNPV (C)	**17**															
FRR (C)	**22,4%**							Average EBITDA margin	**14,5%**							

TERMINAL OWNERS

Rail Baltic's freight flows will increase the load handling of the terminals. This will result in the addition of direct costs (like freight carrier charges, port charges and fees, track maintenance costs, equipment maintenance costs, energy and personnel costs), but also the inclusion of a number of indirect costs related to the handling of these freight flows (additional transport, sales costs, labor costs, administrative costs etc.)

Freight carrier charges have already been set at the carriers' level. The main difference between the two alternatives is the maneuvering mileage, which for the alternative I is 70% higher than for the alternative IIIb. This results in higher freight carrier charges for alternative I.

Average port charges for the Port of Tallinn at Muuga Harbor are: for containers 10 €/TEU and for Ro-Ro cranable semi-trailers 4,5 €/trailer.

It is estimated that the cost of railway track maintenance is 11 261 €/km per year[30], the maintenance of equipment is calculated as 3% of the purchase price per year[31] and the maintenance of the Ro-Ro area is calculated as 2% of the construction cost per year[32]

The energy consumption of equipment is estimated on the basis of the average energy consumption of the terminals[33] operating at Muuga Harbor per ton treated.

It is estimated that at least 22-25 new job sites will be created to operate the equipment (RMGs, forklifts, timber wheel loaders) and, assuming work in two shifts, it's necessary to hire 66-75 employees. The level of wages is the average Harjumaa county salary[34].

Rail Baltic's freight flows will increase the load handling of the terminals. This will result in the addition of the above mentioned direct costs, but also the inclusion of a number of indirect costs related to the handling of these freight flows (additional transport, sales costs, labor costs, administrative costs, etc.). Based on the statistics of the sector, and the economic results of the terminals operating at Muuga Harbor, this indirect cost is estimated at 56% of revenues.

Table 51. Cost and revenue assumptions for terminals

	Alternative I	Alternative IIIb
Port charges and fees		
Containers	10 €/TEU	
Cranable semi-trailers	4,5 €/trailer	
Maintenance costs		
Tracks	11 261 €/km/year	
Tracks length	5,70 km - 8,30 km	
Equipment	3%/year	
RoRo area	2%/year	
Energy costs		
Energy costs	0,5 €/t	
Personnel		
Job sites	22 - 25	
Employees	66 - 75	
Salary	1 337 €/month	
Taxes	33,8%	
Labour costs total	1 789 €/month	
Indirect costs		
Indirect costs	56%	
Revenues		
Load handling		
Container	75 €/TEU	

30 Rail Baltica Global Project CostBenefit Analysis Final Report (30 April 2017), p 145.
Single-track, not electrified: (Track 18 747 EUR/km + Interlocking & remote control 3 774 EUR/km)/2
31 http://jmst.ntou.edu.tw/marine/12-3/159-170.pdf
32 Rail Baltica Global Project CostBenefit Analysis Final Report (30 April 2017), p 290
33 DBT AS, MGT MUUGA GRAIN TERMINAAL AS, TRANSIIDIKESKUSE AS
34 Statistics Estonia: WS5211: AVERAGE MONTHLY GROSS AND NET WAGES (SALARIES) BY ECONOMIC ACTIVITY (EMTAK 2008)

	Alternative I	Alternative IIIb
Ro-Ro	30 €/unit	
Dry Bulk	7,0 €/t	
General Cargo	5,0 €/t	
Liquid Bulk	7,0 €/t	
Additional services	1,5 €/t	
Average EBITDA margin	15,4%	

Table 52. FS001: ENTERPRISES' INCOME STATEMENT by Indicator, Economic activity
(EMTAK 2008: H52 Warehousing and support activities for transportation, thousand euros)

	2010	2011	2012	2013	2014	2015	2016	Average
Number of enterprises	992	1 079	1 182	1 283	1 333	1 378	1 449	
Number of employees	10 457	10 795	11 445	12 030	12 555	12 613	12 513	
Turnover	2 275 490	2 684 482	3 143 123	2 785 945	2 506 254	2 288 301	2 372 310	18 055 906
Other revenue	50 337	46 340	62 480	46 780	40 306	51 830	76 715	374 788
Costs total	2 062 702	2 421 579	2 867 274	2 517 948	2 272 139	2 108 615	2 289 731	
..depreciation	119 734	123 681	128 195	158 724	160 879	157 812	209 727	1 058 751
Operating profit (loss)	245 132	291 502	322 613	301 809	258 267	216 013	138 035	1 773 370
EBITDA	364 866	415 183	450 808	460 533	419 146	373 825	347 762	2 832 121
EBITDA margin	15,7%	15,2%	14,1%	16,3%	16,5%	16,0%	14,2%	**15,4%**
EBIT margin	10,5%	10,7%	10,1%	10,7%	10,1%	9,2%	5,6%	9,6%

SOURCE: Statistics Estonia, Last-Updated 2017-02-16

The revenue forecast is based on the assumption that terminal owners operate under competitive conditions, continue doing their business, as usual, setting the load handling charges in line with the current situation in the market and earning the market's average EBITDA margin. For period 2010-2016 the average EBITDA margin for the Estonian rail transport sector was 15,4%.

The observation of the market situation revealed the following average prices for load handling:

- Container 75 €/TEU,
- Ro-Ro 30 €/trailer,
- Dry Bulk 7,0 €/t,
- General Cargo 5,0 €/t,
- Liquid Bulk 7,0 €/t and
- Additional services 1,5 €/t

** Based on interviews with stakeholders.*

In calculating the revenue for the Ro-Ro terminal, the total Ro-Ro freight flow internal Muuga Harbour is taken into account as the Ro-Ro area investment is calculated on the basis of the total Ro-Ro handling volumes. All other revenue calculations are based on Rail Baltic to other mode exchange freight flows internal Muuga Harbour.

The results for the financial return on investment for terminal owners are summarized in Table 53 and Table 54.

Table 53. Financial return on investment of terminals (Alternative I)

TERMINAL OWNERS	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2030	2035	2040	2045	2050	2055
Revenues																
Load handling																
Container										9,8	12,5	20,8	24,5	27,1	29,8	32,6
RoRo (Rail Baltic)										0,7	1,2	1,6	2,0	2,4	2,9	3,5
Dry Bulk										12,9	15,5	19,9	19,0	17,5	15,7	14,0
General Cargo										6,3	7,5	9,2	8,5	7,8	7,1	6,4
Liquid Bulk										2,4	3,0	4,0	4,0	4,0	4,0	4,1
RoRo (other modes)										6,0	8,8	9,1	9,3	9,4	9,3	9,3
Additional services										8,0	10,1	14,0	14,8	15,3	15,8	16,4
Total Revenues										**46,1**	**58,6**	**78,5**	**82,1**	**83,5**	**84,7**	**86,3**
Residual value																**10,7**
Total inflows	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**46,1**	**58,6**	**78,5**	**82,1**	**83,5**	**84,7**	**96,9**
CAPEX																
Track in terminals areas								2,6	2,6			0,7		2,0		
RMG									4,0			1,0		2,0		
forklifts & wheel loaders									0,9							
RoRo area								6,3	6,3			1,3		1,2		
Planning and administration costs						0,8	0,8	0,8	0,8			0,4		0,6		
Contingencies (10%)						0,0	0,0	0,9	1,4			0,3		0,5		
Replacement costs												0,9		17,5		
Total CAPEX	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,8**	**0,8**	**10,6**	**16,0**	**0,0**	**0,0**	**4,5**	**0,0**	**23,8**	**0,0**	**0,0**
OPEX																
Direct costs																
Freight carrier charges										9,3	10,9	13,0	12,9	12,7	12,6	12,5
Port charges and fees										1,5	1,6	2,7	2,7	2,4	2,0	1,6
Tracks maintenance costs										0,1	0,1	0,1	0,1	0,1	0,1	0,1
Equipment maintenance costs										0,4	0,4	0,4	0,4	0,5	0,5	0,5
Energy										2,7	3,4	4,7	4,9	5,1	5,3	5,5
Personnel										1,4	1,4	1,5	1,5	1,6	1,6	1,6
Indirect costs										26,0	33,0	44,2	46,2	47,0	47,7	48,6
Total operating expences										**41,4**	**50,8**	**66,6**	**68,7**	**69,5**	**69,8**	**70,4**
Total outflows	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,8**	**0,8**	**10,6**	**16,0**	**41,4**	**50,8**	**71,1**	**68,7**	**93,3**	**69,8**	**70,4**
Net cash flow	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**-0,8**	**-0,8**	**-10,6**	**-16,0**	**4,8**	**7,8**	**7,4**	**13,4**	**-9,8**	**14,9**	**26,6**
FNPV (C)	**112**															
FRR (C)	**23,6%**					Average EBITDA margin			**16,1%**							

Table 54. Financial return on investment of terminals (Alternative IIIb)

TERMINAL OWNERS	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2030	2035	2040	2045	2050	2055
Revenues																
Load handling																
Container										9,8	12,5	20,8	24,5	27,1	29,8	32,6
RoRo (Rail Baltic)										0,7	1,2	1,6	2,0	2,4	2,9	3,5
Dry Bulk										12,9	15,5	19,9	19,0	17,5	15,7	14,0
General Cargo										6,3	7,5	9,2	8,5	7,8	7,1	6,4
Liquid Bulk										2,4	3,0	4,0	4,0	4,0	4,0	4,1
RoRo (other modes)										6,0	8,8	9,1	9,3	9,4	9,3	9,3
Additional services										8,0	10,1	14,0	14,8	15,3	15,8	16,4
Total Revenues										**46,1**	**58,6**	**78,5**	**82,1**	**83,5**	**84,7**	**86,3**
Residual value																**10,7**
Total inflows	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**46,1**	**58,6**	**78,5**	**82,1**	**83,5**	**84,7**	**96,9**
CAPEX																
Track in terminals areas								2,6	2,6			0,7		2,0		
RMG									4,0			1,0		2,0		
forklifts & wheel loaders									0,9							
RoRo area								6,3	6,3			1,3		1,2		
Planning and administration costs						0,8	0,8	0,8	0,8			0,4		0,6		
Contingencies (10%)						0,0	0,0	0,9	1,4			0,3		0,5		
Replacement costs												0,9		17,5		
Total CAPEX	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,8**	**0,8**	**10,6**	**16,0**	**0,0**	**0,0**	**4,5**	**0,0**	**23,8**	**0,0**	**0,0**
OPEX																
Direct costs																
Freight carrier charges										9,6	11,4	13,7	13,6	13,6	13,5	13,5
Port charges and fees										1,5	1,6	2,7	2,7	2,4	2,0	1,6
Tracks maintenance costs										0,3	0,3	0,3	0,3	0,4	0,4	0,4
Equipment maintenance costs										0,4	0,4	0,4	0,4	0,5	0,5	0,5
Energy										2,7	3,4	4,7	4,9	5,1	5,3	5,5
Personnel										1,4	1,4	1,5	1,5	1,6	1,6	1,6
Indirect costs										26,0	33,0	44,2	46,2	47,0	47,7	48,6
Total operating expences										**41,9**	**51,5**	**67,5**	**69,7**	**70,6**	**71,0**	**71,7**
Total outflows	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,8**	**0,8**	**10,6**	**16,0**	**41,9**	**51,5**	**72,0**	**69,7**	**94,5**	**71,0**	**71,7**
Net cash flow	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**-0,8**	**-0,8**	**-10,6**	**-16,0**	**4,3**	**7,1**	**6,5**	**12,4**	**-11,0**	**13,7**	**25,3**
FNPV (C)	**101**															
FRR (C)	**22,0%**							Average EBITDA margin	**14,8%**							

Financial profitability

Since MCTRB is aimed at the provision of a general interest service and investment owners and operators will not be the same entities, a consolidated financial analysis is carried out to assess the profitability of the investment.

In total, the new rail infrastructure, freight carriers, and terminal owners are consolidated for financial analysis. The profitability of the investment is measured independently of the internal payments - the cash flows between the owners and the operators are excluded.

The results for the financial return on investment of the consolidated analysis are summarized in Table 56 and Table 57 (123 p.-124).

The most cost-effective alternative

On the basis of the results of a preliminary financial analysis **the most cost-effective solution is Alternative I**, which ensures the lowest total capital expenditure and future handling fee per ton for Rail Baltic to other mode exchange freight flows internal Muuga Harbour.

Key outcomes of the consolidated analysis are the following:

Table 55. Key outcomes of the consolidated financial analysis

	Alternative I	Alternative III
Investment cost (undiscounted)	**171 mln €**	**190 mln €**
Future handling fee per ton		
Infrastructure access charge	0,92 €/t	1,09 €/t
Freight carrier charge	1,32 €/t 0,16 €/tkm	1,40 €/t 0,29 €/tkm
Freight carrier OPEX without infra access charge	0,31 €/t	0,21 €/t
Load handling in terminals	8,41 €/t	8,43 €/t
Net present value calculations		
Revenues excluding internal payments	932 mln €	933 mln €
Residual value	6 mln €	7 mln €
Investment cost	-122 mln €	-139 mln €
Replacement cost	-19 mln €	-19 mln €
Operating expenses excluding internal payments	-669 mln €	-664 mln €
FNPV (C)	**128 mln €**	**118 mln €**
FRR (C)	**9,9%**	**8,8%**

The main difference between the two alternatives lies in the location of the train station and in the length of tracks. The lengths of electrified double-track mainline and not electrified single-tracks from marshalling yard to terminals are different for each alternative. For alternative IIIb the mainline is 1.15 km longer and also includes a long overpass railway bridge before train station and much more earthworks and retaining walls (in total +20.5 million euros in monetary terms).

Due to the difference of distances from marshalling yard to terminals (the difference is a total length of 1.85 km), the shunting maneuvers activity costs will be lower for alternative IIIb.

Financial analysis, however, showed that cost savings associated with shorter maneuvering tracks will not cover the higher investment cost.

The cost-effectiveness of the project is quite good, and this is especially true for the owners of the terminals. Here it should be borne in mind that terminal operators have made significant investments in the past, but they are under-utilized. By launching Rail Baltica, they can make full use of these investments. The added investments are relatively small and it leads to a high margin. If all investments are made from scratch, the margins would be much lower.

Table 56. Financial return on investment of the consolidated analysis (Alternative I)

CONSOLIDATED ANALYSIS	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2030	2035	2040	2045	2050	2055
Revenues excluding internal payments																
Railway infrastructure owner										0,2	0,3	0,4	0,5	0,5	0,5	0,5
Carrier										0,8	0,9	1,1	1,1	1,1	1,1	1,0
Terminal owners										46,1	58,6	78,5	82,1	83,5	84,7	86,3
Total revenues excluding internal payments										**47,2**	**59,9**	**80,0**	**83,6**	**85,0**	**86,2**	**87,8**
Residual value																**26,1**
Total inflows	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**47,2**	**59,9**	**80,0**	**83,6**	**85,0**	**86,2**	**113,9**
CAPEX																
Railway infrastructure owner			7,1	7,5	1,2	3,2	3,2	43,5	43,5					6,8		
Carrier									13,1					3,3		
Terminal owners						0,8	0,8	10,6	16,0			3,6		6,3		
Replacement costs												5,9		48,0		
Total CAPEX	**0,0**	**0,0**	**7,1**	**7,5**	**1,2**	**4,1**	**4,1**	**54,1**	**72,6**	**0,0**	**0,0**	**9,5**	**0,0**	**64,4**	**0,0**	**0,0**
OPEX excluding internal payments																
Railway infrastructure owner										1,0	1,0	1,0	1,0	1,0	1,0	1,0
Carrier										2,4	2,4	3,0	3,0	3,0	3,0	3,2
Terminal owners										32,1	39,9	53,6	55,8	56,7	57,2	57,9
Total operating expences excluding internal payments										**35,4**	**43,2**	**57,5**	**59,8**	**60,8**	**61,3**	**62,2**
Total outflows	**0,0**	**0,0**	**7,1**	**7,5**	**1,2**	**4,1**	**4,1**	**54,1**	**72,6**	**35,4**	**43,2**	**67,1**	**59,8**	**125,2**	**61,3**	**62,2**
Net cash flow	**0,0**	**0,0**	**-7,1**	**-7,5**	**-1,2**	**-4,1**	**-4,1**	**-54,1**	**-72,6**	**11,8**	**16,7**	**13,0**	**23,8**	**-40,1**	**25,0**	**51,7**
FNPV (C)	**128**															
FRR (C)	**9,9%**					Average EBITDA margin			**28,4%**							

Table 57. Financial return on investment of the consolidated analysis (Alternative IIIb)

CONSOLIDATED ANALYSIS	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2030	2035	2040	2045	2050	2055
Revenues excluding internal payments																
Railway infrastructure owner										0,3	0,4	0,5	0,5	0,6	0,6	0,6
Carrier										0,8	1,0	1,2	1,1	1,1	1,1	1,1
Terminal owners										46,1	58,6	78,5	82,1	83,5	84,7	86,3
Total revenues excluding internal payments										**47,2**	**60,0**	**80,2**	**83,8**	**85,2**	**86,4**	**88,0**
Residual value																**29,7**
Total inflows	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**47,2**	**60,0**	**80,2**	**83,8**	**85,2**	**86,4**	**117,7**
CAPEX																
Railway infrastructure owner			14,3	0,8	1,2	3,9	40,1	52,1	16,0					7,0		
Carrier									13,1					3,3		
Terminal owners						0,8	0,8	10,6	16,0			3,6		6,3		
Replacement costs												5,9		48,3		
Total CAPEX	**0,0**	**0,0**	**14,3**	**0,8**	**1,2**	**4,8**	**40,9**	**62,7**	**45,1**	**0,0**	**0,0**	**9,5**	**0,0**	**64,9**	**0,0**	**0,0**
OPEX excluding internal payments																
Railway infrastructure owner										1,2	1,2	1,3	1,3	1,5	1,5	1,5
Carrier										1,6	1,6	2,0	2,0	2,0	2,0	2,2
Terminal owners										32,3	40,1	53,8	56,0	57,0	57,5	58,2
Total operating expences excluding internal payments										**35,0**	**42,8**	**57,1**	**59,4**	**60,5**	**61,0**	**61,9**
Total outflows	**0,0**	**0,0**	**14,3**	**0,8**	**1,2**	**4,8**	**40,9**	**62,7**	**45,1**	**35,0**	**42,8**	**66,6**	**59,4**	**125,4**	**61,0**	**61,9**
Net cash flow	**0,0**	**0,0**	**-14,3**	**-0,8**	**-1,2**	**-4,8**	**-40,9**	**-62,7**	**-45,1**	**12,2**	**17,1**	**13,5**	**24,4**	**-40,2**	**25,4**	**55,8**
FNPV (C)	**118**															
FRR (C)	**8,8%**					Average EBITDA margin			**29,0%**							

6.5. Economic analysis

As in the financial analysis, the economic analysis will be conducted for the 2 most promising pre-selected alternatives: Alternative I and Alternative IIIb. The main difference between the alternatives arises from capital expenditures and operating costs, while associated externalities are similar for each alternative.

Fiscal corrections

As part of the economic analysis, identifiable fiscal transfer payments will be eliminated from the project cash flow. These include basic transfers, like payment involving salaries (income tax) and other taxes (fuel and electricity excise taxes). The net financial flows for each year of analysis have therefore been adjusted by applying coefficients to remove social taxes as well as fuel and electricity excise taxes.

Labour market distortions, such as minimum wages and unemployment benefits, typically result in a higher monetary salary than the opportunity cost of labour (the people would be willing to work at lower pay). Consequently, labour costs are adjusted for the shadow wage rate of a specific region.

The conversion factor for labour CF= 0,79 taking into account the unemployment rate[35], income tax and social security tax as done in EC Guide [36] (Shadow wage for not-competitive labour market SW = FW (1-u) (1-t)). Indirectly then, a fiscal correction is also made for labour costs.

The fiscal correction conversion factor for diesel fuel CF= 0,51 taking into account excise duty for 0,493 €/liter and for electricity CF= 0,94 taking into account excise duty for 4,47€/MWh[37].

Conversion from market to shadow prices

In the CBA the objective is to appraise the social value of the investment. In some situations observed prices do not provide a fair measure of the social opportunity costs. This is usually due to market distortions. This issue is addressed by adopting conversion factors to convert from financial costs to economic costs.

Given that as an EU financed project all materials for the Rail Baltica project will be bought from EU countries, we assume that there will be limited price distortions. Therefore a Standard Conversion Factor of 1,0 is adopted in line with EC guidance in situations where the planning authority does not offer its own estimates.

Labour costs have, however, had the tax element of wages removed by applying a further conversion factor of 0,79 to account for the taxes.

All other conversion factors used in the analysis are summarized in the table below.

Table 58. Conversion factors for the economic analysis

Type of cost	CF	Notes
Standard conversion factor (SCF)	1,00	SCF
Labour	0,79	Shadow wage for non-competitive labour market SW=FW (1-u) (1-t)
Materials	1,00	Traded good; CF = SCF
Equipment	0,88	64% materials (cf = SCF), 30% labour, 6% profit (cf = 0)
Maintenance costs	0,88	64% materials (cf = SCF), 30% labour, 6% profit (cf = 0)
Construction works	0,86	45% materials, 22% equipment, 27% labour, 6% profit (cf = 0)
Other expenses	1,00	CF=SCF
Planning and administration costs	1,00	100% labour (high-skilled)
Residual Value	0,88	Weighted by the type of project costs: 89% equipments, 11% constructions

[35] http://pub.stat.ee/px-web.2001/Dialog/varval.asp?ma=ML442&lang=1
[36] Guide to cost-benefit analysis of investment projects (Economic appraisal tool for Cohesion Policy 2014-2020), p. 59
[37] https://www.emta.ee/eng/business-client/excise-duties-assets-gambling/about-excise-duties/rates-excise-duty

Monetizable socio-economic costs and benefits

The second step of the economic analysis is to include in the appraisal those project impacts that are relevant for society, but for which a market value is not available. Appropriate conversion factors applied to the financial values of the operating revenues already capture the most relevant non-market benefits a project may generate.

When non-market impacts do not occur in the transactions between the producer and the direct users/beneficiaries of the project services but fall on uncompensated third parties, these impacts are defined as externalities. In other words, an externality is any cost or benefit that spills over from the project towards other parties without monetary compensation.

In the case of MCTRB project, non-market impacts are evaluated by using the method of long-run marginal costs. The main economic cost and benefit of externalities can be divided into two categories:

- Alternatives-dependent ones arising directly from MCTRB as handling the extra freight flows bring extra costs to the local environment – increase in noise and air pollution and negative climate change.
- Undistributed benefits and costs from the Rail Baltica Global Project as MCTRB is part of the overall Rail Baltic project and it shares the economic costs and benefits of the global Rail Baltic project as well (air pollution reduction, climate change mitigation, noise reduction, travel time savings, travel safety increase etc).

Costs to the local environment – noise

Increased maneuvering frequency and extra shunting activities will increase local noise pollution costs due to the increase of vehicle kms travelled. For the estimation of noise pollution, monetized cost of noise for freight train outside urban areas is estimated to be 0,0241 €/vkm[38].

Costs to the environment – climate change

Increased maneuvering frequency and extra shunting activities increase effects from climate change. In line with the Rail Baltica study, the monetized cost of climate change for freight train is estimated to be 0,01267 €/vkm[39].

Costs to the environment – emissions

Although Rail Baltica is an electrified line, shunting maneuvers will still be done by diesel locomotives, therefore increased maneuvering frequency and extra shunting activities will increase local emission costs. For the estimation of the monetized cost of increased gas emissions, the monetized cost of gas emissions for freight diesel locomotive is estimated to be 1,5751 €/vkm[40].

Costs and benefits from the Rail Baltica global project

MCTRB is part of the overall Rail Baltica project and it shares the economic costs and benefits of the global Rail Baltic project as pollution reduction, climate change mitigation, noise reduction, freight time savings, freight carrier operating profit, additional freight transportation savings/expenses, freight carrier operating profit, additional freight transportation savings/expenses, heavy truck operating profit loss, excise tax loss - heavy trucks.

Table 59. Undistributed benefits and costs from the Rail Baltica Global Project

Economic benefits and costs	
Air pollution reduction	3 268 mln €
Climate change mitigation	3 024 mln €
Noise reduction	843 mln €
Travel time savings	5 276 mln €
Travel safety increase	892 mln €
Other socio-economic benefits/expenses	2 925 mln €

[38] Rail Baltica Global Project CostBenefit Analysis Final Report (30 April 2017), p 180 (Update of the Handbook on External Costs of Transport (2014) has been reviewed and scientifically estimated costs of noise pollution per vkm have been extracted.)
[39] Rail Baltica Global Project CostBenefit Analysis Final Report (30 April 2017), p 181 (Update of the Handbook on External Costs of Transport (2014) has been reviewed and scientifically estimated costs of noise pollution per vkm have been extracted.)
[40] Update of the Handbook on External Costs of Transport (2014) has been reviewed and scientifically estimated costs of gas emissions per vkm have been extracted. (https://ec.europa.eu/transport/themes/sustainable/studies/sustainable_en)

Source: Rail Baltica Global Project CostBenefit Analysis Final Report (30 April 2017), p.186

These Values are generated by the Rail Baltica Global Project and are the same for both alternative. Yet they cannot be determined for MCTRB individually due to the strong network effects and interdependencies. The individual economic impact of the MCTRB, as it is an integral part of the Rail Baltic project, is not reliably quantifiable.

Let's mark the MCTRB's imaginary share in the socio-economic impact of the Rail Baltica Global Project with variable X. For the analysis at hand, these effects are not decisive since they both affect the alternatives in questions in the same way (for both +X). Thus, they can be cancelled out or neglected when it comes to comparing the two alternatives. So with regard to the above table, the basis for the decision-making is effectively comparing the $ENPV_{I}$+X with the $ENPV_{IIIb}$+X.

Additional Socio-Economic Benefits

In addition to monetizable socio-economic benefits/costs, the "Rail Baltica Global Project CostBenefit Analysis Final Report" indicates many unquantifiable socioeconomic benefits, which create additional value-added for the society. Some of them can be extended to the MCTRB as well and they are referenced below. However, as they are the same for both alternatives in question, there's no need to analyze them in detail, since this does not affect the order of the alternatives in any way.

Catalytic effect on businesses located near rail station

It is planned to increase commercial space together with other improvements in all Rail Baltica stations. The development of Muuga terminal together with other Rail Baltica-supporting infrastructure will create the need for other business infrastructure like office space and dining areas, thus further improving the station areas.

Indirect productivity effects on other business sectors

New transport links increase mobility and connectivity, thus creating a more productive and competitive business environment. Productivity improvements in one part of the supply chain lead to further improvement for the whole chain, thus driving economic growth, which is directly linked to increased transport demand.

In case of Rail Baltica, new business parks specialized in cargo and passenger handling and other supporting activities can be built around or nearby Rail Baltica stations and its supporting infrastructure, especially intermodal terminals in each country.

Through increased export and from business activities around intermodal terminals, local municipalities will experience increased tax revenues, which will lead to further improvements in the city, on which other businesses will be able to capitalize

Increased transport capacity

Rail Baltica will save costs and potentially discover new markets in Central and Southern Europe for Baltic businesses exporting grain, wood (and wooden products) and other commodities that are currently being transported by sea, which requires additional link in the supply chain and is available only in countries with sea boarders. With a rail connection to Central Europe, commodities will be delivered straight to distribution terminals with a wide catchment area leading to increase revenues and cost saving for the whole supply chain.

Induced impact of Port

One of the core freight sources for Rail Baltica are southward exports from Finland, all of which are expected to be serviced via Muuga Harbour, as a result, there is a potential for a positive spillover effect. The port turnover is expected to rise noticeably, creating induced impact on the economy. In addition, Rail Baltica flows serve as a means of diversification of traditional freight flows via Baltic ports (transit freight from CIS to Western Europe).

Economic performance

After the correction of price/wage distortions and the choice of an appropriate social discount rate, it is possible to calculate the project's economic performance using the following indicators:

- economic net present value (ENPV):
  (the difference between the discounted total social benefits and costs);
- economic internal rate of return (ERR):
  (the rate that produces a zero value for the ENPV);

The results for Economic return on investment for consolidated analysis are summarized in Table 60 and Table 61 (žemiau and 129.)

Table 60. Economic return on investment of consolidated analysis (Alternative I)

ECONOMIC CONSOLIDATED ANALYSIS	cf.	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2030	2035	2040	2045	2050	2055
Revenues excluding internal payments																	
Railway infrastructure owner	1										0,2	0,3	0,4	0,5	0,5	0,5	0,5
Carrier	1										0,8	0,9	1,1	1,1	1,1	1,1	1,0
Terminal owners	1										46,1	58,6	78,5	82,1	83,5	84,7	86,3
Total Revenues excluding internal payments											**47,2**	**59,9**	**80,0**	**83,6**	**85,0**	**86,2**	**87,8**
Residual value	0,88	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	**22,8**
Undistributed benefits and costs from the Rail Baltica Global Project																	
Air pollution reduction		These Values are generated by the Rail Baltica Global Project and are the same for both alternative. Yet they cannot be determined for MCTRB individually due to the strong network effects and interdependencies.															
Climate change mitigation																	
Noise reduction																	
Travel time savings																	
Travel safety increase																	
Other socio-economic benefits/expenses																	
ECONOMIC BENEFITS		**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**47,2**	**59,9**	**80,0**	**83,6**	**85,0**	**86,2**	**110,7**
CAPEX																	
Construction	0,86	0,0	0,0	0,0	0,0	0,0	0,0	0,0	37,1	37,1	0,0	0,0	1,7	0,0	7,2	0,0	0,0
Equipment	0,88	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	14,5	0,0	0,0	0,9	0,0	4,3	0,0	0,0
Planning and administration costs	1,00	0,0	0,0	0,4	0,8	1,2	4,1	4,1	4,1	4,1	0,0	0,0	0,4	0,0	1,6	0,0	0,0
Replacement costs	0,88	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	5,2	0,0	42,1	0,0	0,0
Total CAPEX		**0,0**	**0,0**	**0,4**	**0,8**	**1,2**	**4,1**	**4,1**	**41,2**	**55,6**	**0,0**	**0,0**	**8,1**	**0,0**	**55,3**	**0,0**	**0,0**
OPEX																	
Maintenance costs	0,88										0,9	0,9	1,0	1,0	1,1	1,1	1,1
Personnel	0,79										1,8	1,8	1,9	1,9	2,0	2,0	2,0
Fuel consumption	0,51										0,7	0,7	0,9	0,9	0,9	0,9	1,0
Port charges and fees	1,00										1,5	1,6	2,7	2,7	2,4	2,0	1,6
Energy	0,73										1,9	2,4	3,4	3,6	3,7	3,8	4,0
Other expenses	1,00										26,6	33,6	44,9	46,9	47,7	48,4	49,3
Total operating expences excluding internal payments											**33,4**	**41,0**	**54,8**	**56,9**	**57,8**	**58,3**	**59,0**
Alternatives-dependent costs																	
Noise increase											0,002	0,002	0,003	0,003	0,003	0,003	0,003
Climate change increase											0,001	0,001	0,002	0,002	0,002	0,002	0,002
Air pollution increase											0,144	0,144	0,188	0,188	0,188	0,188	0,205
Total external costs											**0,1**	**0,1**	**0,2**	**0,2**	**0,2**	**0,2**	**0,2**
TOTAL ECONOMIC COSTS		**0,0**	**0,0**	**0,4**	**0,8**	**1,2**	**4,1**	**4,1**	**41,2**	**55,6**	**33,6**	**41,2**	**63,1**	**57,1**	**113,3**	**58,5**	**59,3**
NET ECONOMIC BENEFIT		**0,0**	**0,0**	**-0,4**	**-0,8**	**-1,2**	**-4,1**	**-4,1**	**-41,2**	**-55,6**	**13,6**	**18,7**	**17,0**	**26,5**	**-28,3**	**27,8**	**51,4**
ENPV		**149+X**															
ERR		**15,7%**															

Table 61. Economic return on investment of consolidated analysis (Alternative IIIB)

ECONOMIC CONSOLIDATED ANALYSIS	cf.	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2030	2035	2040	2045	2050	2055
Revenues excluding internal payments																	
Railway infrastructure owner	1										0,3	0,4	0,5	0,5	0,6	0,6	0,6
Carrier	1										0,8	1,0	1,2	1,1	1,1	1,1	1,1
Terminal owners	1										46,1	58,6	78,5	82,1	83,5	84,7	86,3
Total Revenues excluding internal payments											**47,2**	**60,0**	**80,2**	**83,8**	**85,2**	**86,4**	**88,0**
Residual value	0,88	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	**26,0**
Benefits from the Rail Bltica Global Project																	
Air pollution reduction																	
Climate change mitigation																	
Noise reduction		These Values are generated by the Rail Baltica Global Project and are the same for both alternative. Yet they cannot be determined for MCTRB individually due to the strong network effects and interdependencies.															
Travel time savings																	
Travel safety increase																	
Other socio-economic benefits/expenses																	
ECONOMIC BENEFITS		**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**47,2**	**60,0**	**80,2**	**83,8**	**85,2**	**86,4**	**114,0**
CAPEX																	
Construction	0,86	0,0	0,0	0,0	0,0	0,0	0,0	26,7	43,2	16,5	0,0	0,0	1,7	0,0	7,4	0,0	0,0
Equipment	0,88	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	14,5	0,0	0,0	0,9	0,0	4,3	0,0	0,0
Planning and administration costs	1,00	0,0	0,0	0,4	0,8	1,2	4,8	4,8	4,8	4,8	0,0	0,0	0,4	0,0	1,6	0,0	0,0
Replacement costs	0,88	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	5,2	0,0	42,4	0,0	0,0
Total CAPEX		**0,0**	**0,0**	**0,4**	**0,8**	**1,2**	**4,8**	**31,4**	**47,9**	**35,7**	**0,0**	**0,0**	**8,1**	**0,0**	**55,7**	**0,0**	**0,0**
OPEX																	
Maintenance costs	0,88										1,2	1,2	1,4	1,4	1,7	1,7	1,7
Personnel	0,79										1,8	1,8	1,9	1,9	2,0	2,0	2,0
Fuel consumption	0,51										0,4	0,4	0,5	0,5	0,5	0,5	0,6
Port charges and fees	1,00										1,5	1,6	2,7	2,7	2,4	2,0	1,6
Energy	0,73										1,9	2,4	3,4	3,6	3,7	3,8	4,0
Other expenses	1,00										26,4	33,5	44,8	46,8	47,6	48,3	49,2
Total operating expences excluding internal payments											**33,3**	**40,9**	**54,6**	**56,8**	**57,9**	**58,3**	**59,0**
Alternatives-dependent costs																	
Noise increase											0,001	0,001	0,002	0,002	0,002	0,002	0,002
Climate change increase											0,001	0,001	0,001	0,001	0,001	0,001	0,001
Air pollution increase											0,083	0,083	0,110	0,110	0,110	0,110	0,125
Total external costs											**0,1**	**0,1**	**0,1**	**0,1**	**0,1**	**0,1**	**0,1**
TOTAL ECONOMIC COSTS		**0,0**	**0,0**	**0,4**	**0,8**	**1,2**	**4,8**	**31,4**	**47,9**	**35,7**	**33,4**	**41,0**	**62,9**	**56,9**	**113,7**	**58,4**	**59,2**
NET ECONOMIC BENEFIT		**0,0**	**0,0**	**-0,4**	**-0,8**	**-1,2**	**-4,8**	**-31,4**	**-47,9**	**-35,7**	**13,9**	**19,0**	**17,3**	**26,9**	**-28,5**	**28,0**	**54,8**
ENPV		**140+X**															
ERR		**13,6%**															

Table 62. Socio-economic analysis results

		Alternative I	Alternative IIIb
Financial income and expenses with fiscal corrections			
Revenues excluding internal payments		757 mln €	758 mln €
Residual value		4 mln €	4 mln €
Investment cost		-80 mln €	-92 mln €
Replacement cost		-13 mln €	-13 mln €
Operating expenses excluding internal payments		-517 mln €	-516 mln €
Socio-economic benefits and costs			
Alternatives-dependent benefits and costs			
Noise increase		-0,027 mln €	-0,016 mln €
Climate change increase		-0,014 mln €	-0,008 mln €
Air pollution increase		-1,749 mln €	-1,016 mln €
Undistributed benefits and costs from the Rail Baltica Global Project			
Air pollution reduction	*3 268 mln €*	X	
Climate change mitigation	*3 024 mln €*		
Noise reduction	*843 mln €*		
Travel time savings	*5 276 mln €*		
Travel safety increase	*892 mln €*		
Other socio-economic benefits/expenses	*2 925 mln €*		
Socio-economic performance indicators			
Economic net present value (ENPV)		**149 mln € + X**	**140 mln € + X**
Economic internal rate of return (EIRR)		**15,7%**	**13,6%**

The socio-economic analysis shows that even without additional effects of the Rail Baltica Global Project, the socio-economic net present value are positive for both alternatives. Comparing two alternatives, again, alternative I outperforms alternative IIIb for the same reasons as in case of financial analysis.

Breakdown of global socio-economic benefits and costs by investment-share

The Rail Baltica Global CBA has been prepared and the assumptions/considerations regarding passenger and freight flows and financial operations made with the consideration of single united infrastructure across the Baltic States not as a combination (sum) of national components. Therefore, based on the calculations there is not a single objective criterion or method how to split the results into three separate individual countries or functional units[41].

There are possibilities of simply breaking-down the benefits/costs given a certain investment-share. So, MCTRB's imaginary share in the socio-economic benefits/costs of the Rail Baltica Global Project could be proportional to the cost of MCTRB's investment compared to the total cost of the Rail Baltic global project investment. Table 63 gives a simple arithmetic division of the benefits/costs, but no criterion can be considered as being more appropriate than any other.

Table 63. Breakdown of socio-economic benefits and costs by investment-share[42]

	Rail Baltic global project	Estonian allocation	MCTRB's imaginary share
CAPEX, M EUR	3 889 mln €	896 mln €	89 mln €[43]
Socio-economic impact	4 581 mln €	1 123 mln €	**112 mln €**

SOURCE: Rail Baltica Global Project CostBenefit Analysis Final Report (30 April 2017), p 154, 186

[41] Rail Baltica Global Project CostBenefit Analysis Final Report (30 April 2017), p.190
[42] discounted values
[43] arithmetic mean of alternative I and alternative IIIb, discounted

6.6. Analysis of the profitability parameters

Sensitivity and risk analysis is based on the methodology of the European Commission guidelines for cost-benefit analysis of investment projects[44]. For calculating the probability distribution of IRR and NPV the Monte Carlo method is used by using the "Oracle Crystal Ball 11" simulation software[45].

Steps for assessing the project sensitivity and risk are:

- sensitivity analysis
- finding probability distributions for critical variables
- risk analysis

Sensitivity analysis

Sensitivity analysis allows the determination of the "critical" variables or parameters of the model. Such variables are those whose variations, positive or negative, have the greatest impact on a project's financial and/or economic performance. The analysis is carried out by varying one element at a time and determining the effect of that change on IRR or NPV. Generally a parameter is considered critical, if an absolute variation of 1% around the best estimate gives rise to a corresponding variation of not less than 0,5% (half a percentage point) in the NPV (i.e. elasticity is half a unity or greater).

The following table shows the categories of the parameters used in the financial and economic analysis:

Table 64. Identification of critical variables

Categories	Variables
Parameters of demand analysis	Freight flows
	Infrastructure access charge
	Freight carrier charges
	Load handling charges
Parameters of financial analysis	Investment cost
	Port charges and fees
	Average salary
	Maintenance costs
	Fuel consumption
	Fuel price
	Energy cost
	Indirect costs of terminal owners
Parameters of the economic analysis	Economic external costs

Table 37 provides the estimated effect on results of financial and economic performance indexes in case of +1% change applied to the variables tested. Variable is considered critical if a variation of the variable of 1% corresponds to at least one percentage point variation in IRR or NPV

According to the analysis, the critical variables are:

- Indirect costs of terminal owners
- Load handling charges

[44] Guide to cost-benefit analysis of investment projects (Economic appraisal tool for Cohesion Policy 2014-2020) http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf
[45] http://www.oracle.com/technetwork/middleware/crystalball/overview/index.html

- Freight flows
- Investment cost

Table 65. The percentage change applied on the parameters tested: +1%

Variable tested	ENPV variation (consolidated I)	ENPV variation (consolidated IIIb)
Indirect costs of terminal owners	2,8%...-2,8%	5,9%...-6,0%
Load handling charges	-1,8%...1,8%	-2,0%...2,0%
Freight flows	-1,8%...1,8%	-1,9%...1,9%
Investment cost	0,6%...-0,6%	0,8%...-0,8%
Energy cost	0,2%...-0,2%	0,2%...-0,2%
Average salary	0,2%...-0,2%	0,2%...-0,2%
Port charges and fees	0,1%...-0,1%	0,2%...-0,2%
Maintenance costs	0,1%...-0,1%	0,1%...-0,1%
Fuel consumption	0,1%...-0,1%	0,1%...-0,1%
Fuel price	0,1%...-0,1%	-0,1%...0,1%
Freight carrier charges	-0,1%...0,1%	0,1%...-0,1%
Infrastructure access charge	0,0%...0,0%	0,0%...0,0%
Economic external costs	0,0%...0,0%	0,0%...0,0%

Sensitivity testing leads to the calculation of switching values. The switching value of a variable is that value that would have to occur in order for the ENPV of the project to become zero, or more generally, for the outcome of the project to fall below the minimum level of acceptability.

Table 66. Switching values of critical variables

	Base case	ENPV = 0	Switching Value (%)
Alternative I			
Indirect costs of terminal owners	56,30%	70,26%	25%
Freight flows	62 666 737	28 582 533	-54%
Load handling charges	5,48	2,41	-56%
Investment cost	170 650 817	444 984 330	161%
Alternative IIIb			
Indirect costs of terminal owners	56,30%	103,64%	84%
Freight flows	62 666 737	30 690 426	-51%
Load handling charges	5,49	2,59	-53%
Investment cost	190 023 867	438 359 225	131%

Scenario analysis is a specific form of sensitivity analysis. While under standard sensitivity analysis the influence of each variable on the project's financial and economic performance is analyses separately, scenario analysis studies the combined impact of determined sets of values assumed by the critical variables. In particular, combinations of 'optimistic' and 'pessimistic' values of a group of variables could be useful to build different realistic scenarios, under certain hypotheses. In order to define the optimistic and pessimistic scenarios it is necessary to choose for each critical variable the extreme values in the range defined by the distributional probability. Project performance indicators are then calculated for each combination.

Table 67. Scenario analysis

	Optimistic scenario	Base case	Pessimistic scenario
Indirect costs of terminal owners	28%	56%	84%
Freight flows	422	281	141
Load handling charges	2,74	5,48	8,22
Investment cost (I)	85	171	256
Investment cost (IIIb)	95	190	285
ENPV (I)	**318+X**	**149+X**	**-115+X**
ENPV (IIIb)	**409+X**	**140+X**	**-272+X**

Risk analysis

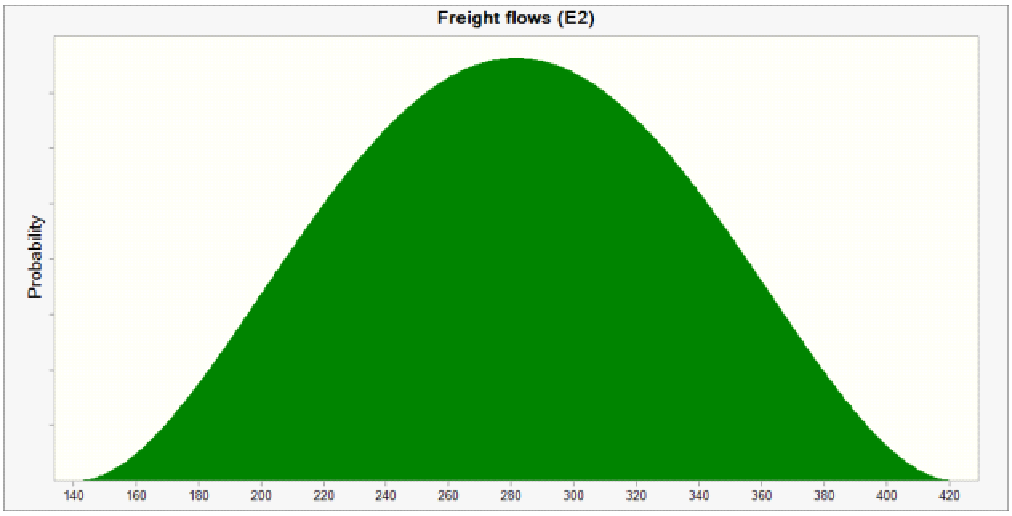
The next step is to assign a probability distribution to each of the critical variables, defined in a precise range of values around the best estimate, used as the base case, in order to calculate the expected values of financial and economic performance indicators.

For each critical variable, the probability distribution, in which range the variable could be the most likely, was determined. The corresponding assumptions are following:[46]

Assumption: Freight flows

BetaPERT distribution with parameters:

Minimum	141
Likeliest	281
Maximum	422

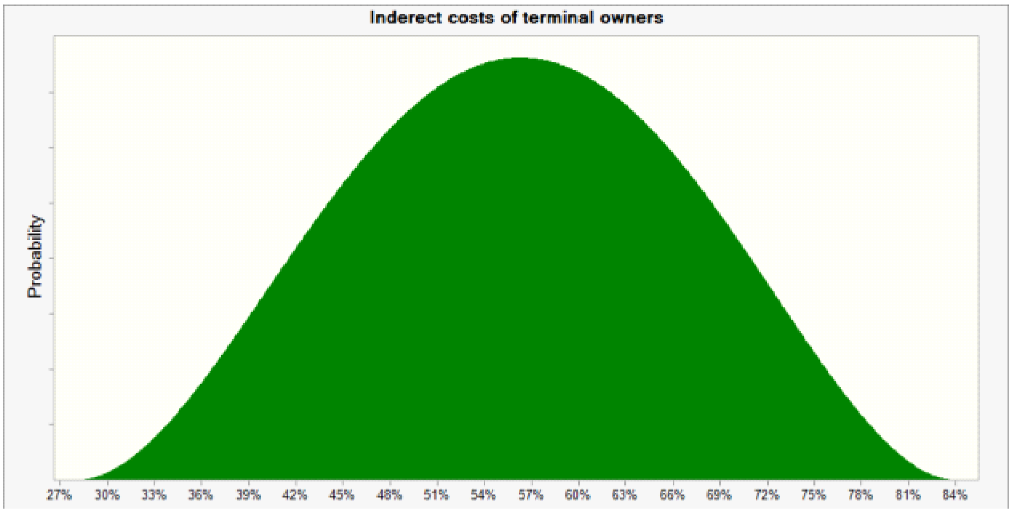


[46] The betaPERT distribution is derived from the beta distribution and is commonly used in project risk analysis for assigning probabilities to task durations and costs. It is also used as a "smoother" alternative to the triangular distribution. It is a continuous probability distribution.

Assumption: Indirect costs of terminal owners

BetaPERT distribution with parameters:

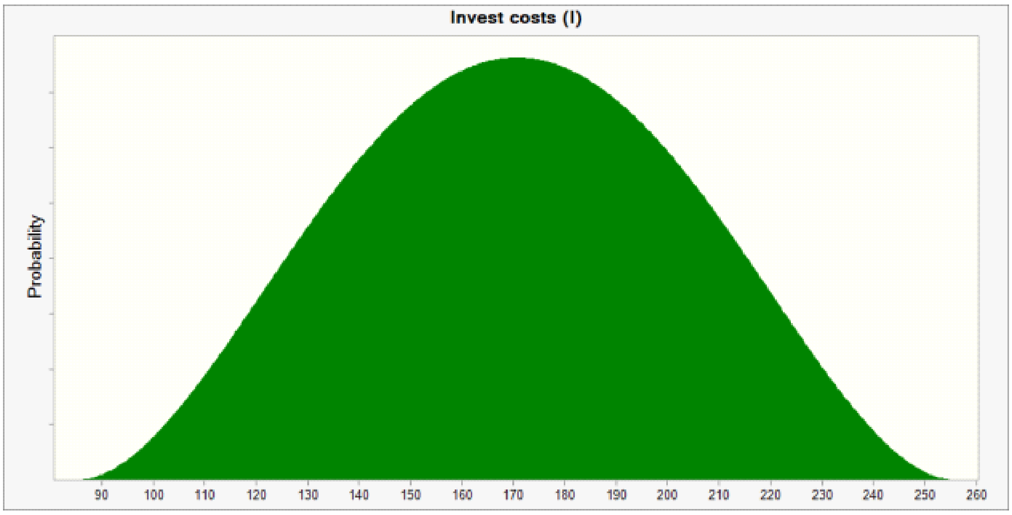
Minimum	28%
Likeliest	56%
Maximum	84%



Assumption: Invest costs (I)

BetaPERT distribution with parameters:

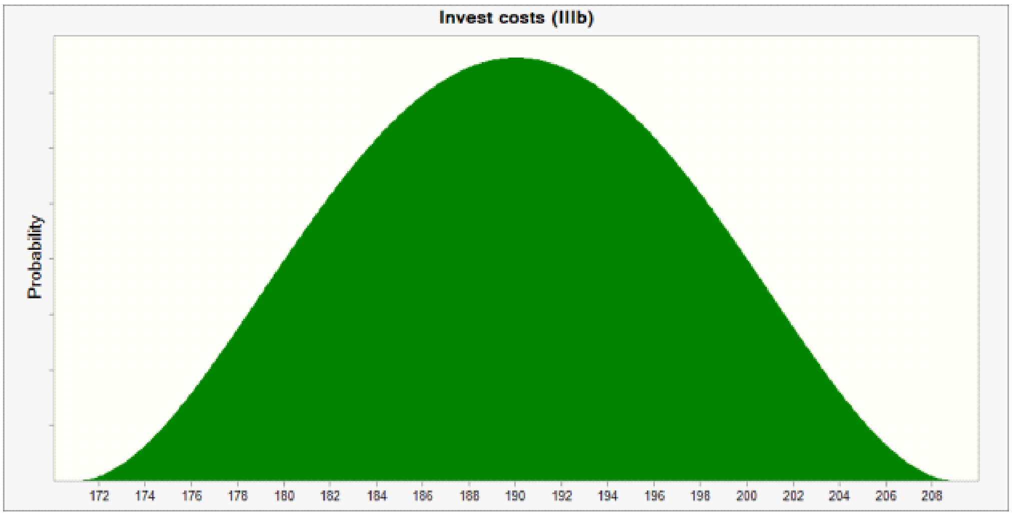
Minimum	85
Likeliest	171
Maximum	256



Assumption: Invest costs (IIIb)

BetaPERT distribution with parameters:

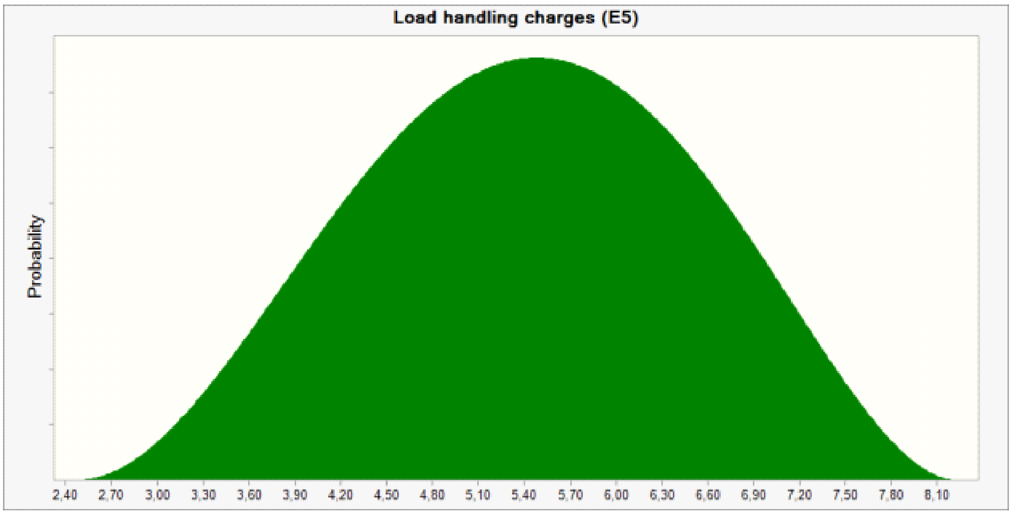
Minimum	171
Likeliest	190
Maximum	209



Assumption: Load handling charges

BetaPERT distribution with parameters:

Minimum	2,47
Likeliest	5,48
Maximum	8,22



Having established the probability distributions for the critical variables, it is possible to proceed with the calculation of the probability distribution of the NPV of the project.

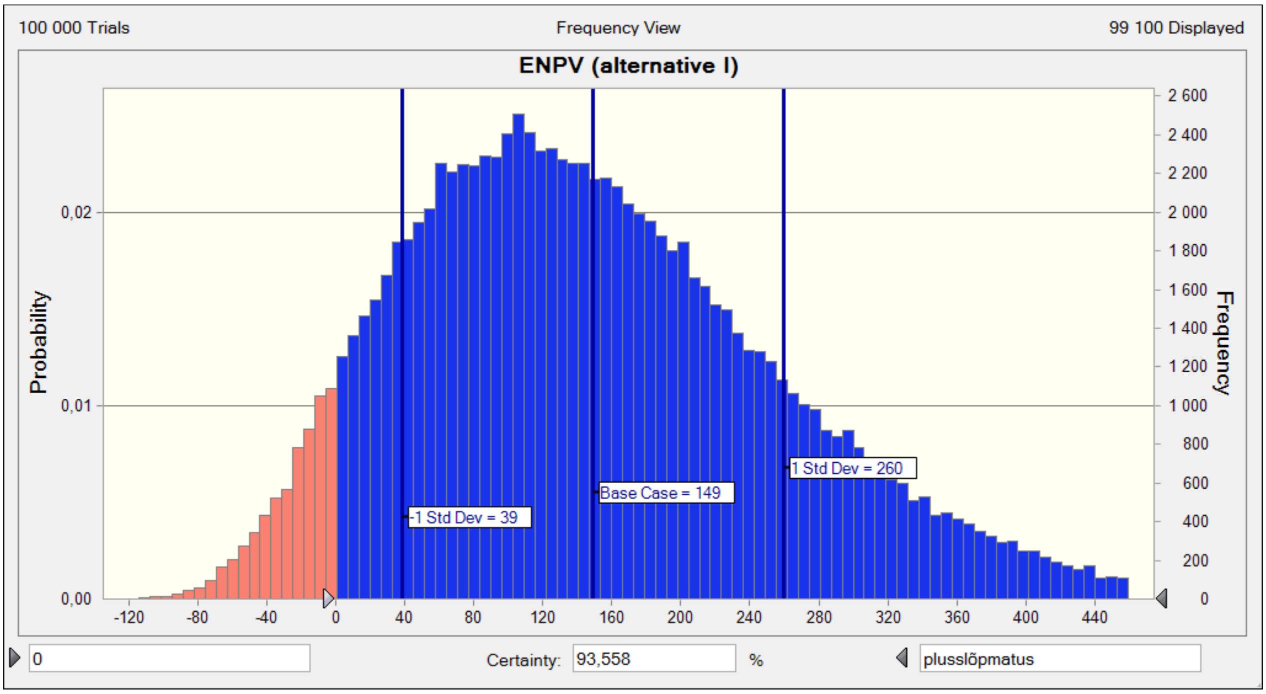
For this purpose the Monte Carlo method is used. The method consists of the repeated random extraction of a set of values for the critical variables, taken within the respective defined intervals, and then calculating the performance indices for the project (NPV) resulting from each set of extracted values. By repeating this procedure for a large enough number of extractions a pre-defined convergence of the calculation are obtain as the probability distribution of the NPV. For Monte Carlo simulation "Oracle Crystal Ball 11" simulation software[47] is used.

Results of the analysis are summarized in Table 68 and Table 69 with the characteristics as an annex on an MS Excel file worksheet "Risk Analysis".

The project risk analysis indicates a low level of risk and the probability of the project objectives being achieved is high. The risk analysis indicates a probability of 93,5% that the economic net present value for alternative I will be positive (ENPV> 0) and with probability of 68% ENPV will remain at range 39+X ... 260+X million euro (one standard deviation from the expected base value).

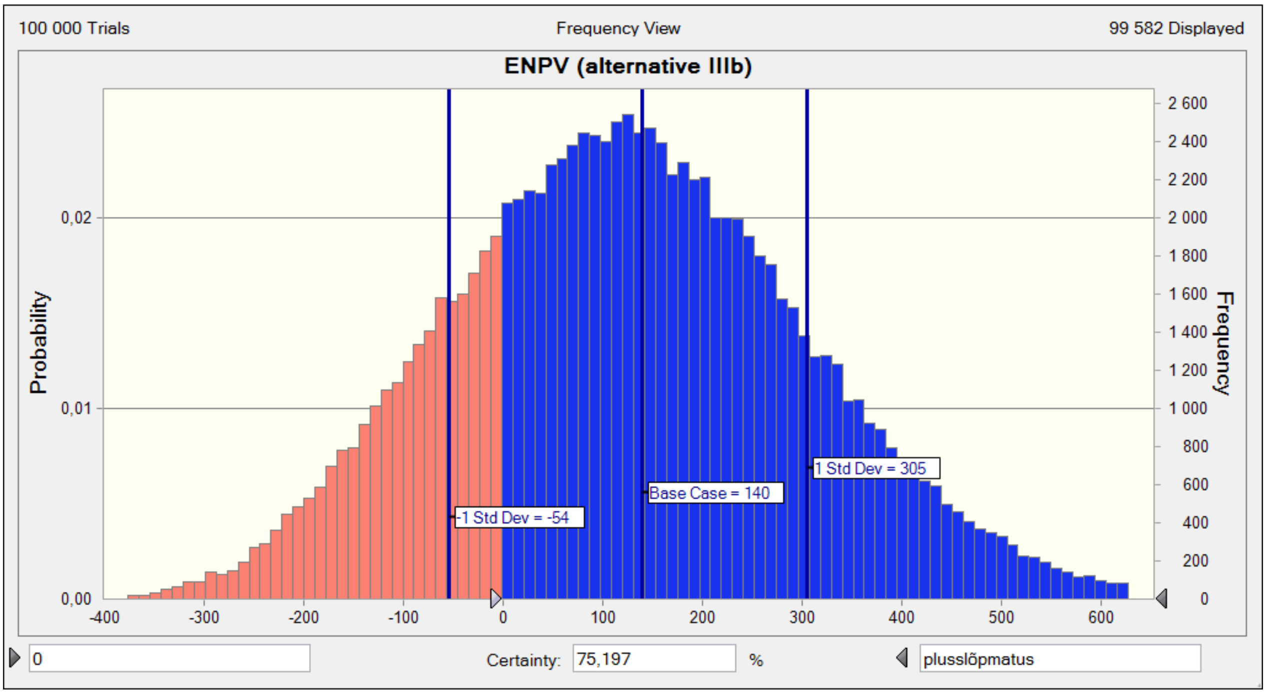
Also there is a probability of 75,2% that the alternative IIIb net present value will be positive (FNPV> 0) and with probability of 68% FNPV will remain at range -54+X ... 305+X million euro (one standard deviation from the expected base value).

Table 68. Risk analyses for alternative I



[47] http://www.oracle.com/technetwork/middleware/crystalball/overview/index.html

Table 69. Risk analyses for alternative IIIb



7. WP 4 – Action plan implementation and preparation of an initial design

Execution cost, action plan with key milestones and the associated risk assessment

Execution costs were calculated for Alternative I and Alternative IIIb. Both alternatives were phased for the years of 2025, 2035 and 2045. The most crucial period is the first phasing period where the main functionalities of a marshalling yard and connecting infrastructure will be developed.

Phasing of 2035 and 2045 would involve mainly replacement costs of the phase 1 and 2 investments, partial expansion of the marshalling yard and additional expansion of the technical capacities of the terminals operated by private entities. 2035 and 2045 phasing will not affect rail connection from marshalling yard to the entrance of the individual terminals. Terminal inner tracks and equipment functionalities will be affected but these investments will be covered by terminal owners. Regarding the land cost it is assumed that the land will be bought in phase one. It is assumed that private terminal operators will be able to expand their operations within the boundaries of their territories.

Table 1 and Table 2 summarize the yearly breakdown of investment plan for the both alternatives. In these tables the years refer to the years in which the investments is actually made. For both alternatives investment costs are split between the public and private sector as following:

- main line, bridges, station, marshalling yard, depot and tracks to terminals are public investments (the totals highlighted in yellow);
- tracks in terminals areas, loading/unloading equipment, Ro-Ro area and locomotives for shunting are private investments.

Activity plan consists of necessary preparatory activities such as general examination of the sites, spatial planning activities, environmental analysis, procurement procedures, approval management, construction activities and the terminal equipment purchase.

The detailed activity plan of Alternative I is shown at table 3 and Alternative IIIb is shown at table 4.

The comparative GANTT chart designed for the first implementing period is available in annex 1.

For both alternatives January 1st, 2019 was applied as the starting date. In creating the suitable project execution timeframe, we benchmarked similar projects in Europe and assessed the most common risks in the context of Muuga terminal. In Table 1 the yellow highlighted area represents the investment costs to be made by the railway infrastructure owner while the green highlighted areas represent the private investment (terminal operators).

Table 70. Yearly breakdown of investment plan for Alternative I (mln euros)

		2019	2020	2021	2022	2023	2024	2025	2035	2045	Total
Public investment	**RAILWAY INFRASTRUCTURE OWNER**										
	Main line						2,1	2,1			**4,3**
	Railway bridges										**0,0**
	Marshalling yard						14,0	14,0		4,8	**32,7**
	Signalling and telecommunication						4,8	4,8		0,5	**10,0**
	Depot						3,7	3,7			**7,4**
	Changes to 1520mm tracks						0,7	0,7			**1,4**
	Track (1435) from marshalling yard to terminal						9,1	9,1			**18,2**
	Roads						2,2	2,2			**4,4**
	Land plot	6,1	6,1								**12,3**
	Planning and administration costs	0,4	0,8	1,2	3,2	3,2	3,2	3,2		1,0	**16,3**
	Contingencies (10%)	0,6	0,6				3,7	3,7		0,5	**9,1**
	Replacement costs								5,0	18,9	**23,9**
	Total for RAILWAY INFRASTRUCTURE OWNER	**7,1**	**7,5**	**1,2**	**3,2**	**3,2**	**43,5**	**43,5**	**5,0**	**25,6**	**139,9**
Private investment	**CARRIERS**										
	Loco							11,6		2,9	14,5
	Project management costs							0,3		0,1	0,4
	Contingencies (10%)							1,2		0,3	1,5
	Replacement costs									11,6	11,6
	Total for CARRIERS	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**13,1**	**0,0**	**14,9**	**28,0**
	TERMINAL OWNERS										
	Track in terminals areas						2,6	2,6	0,7	2,0	7,7
	Equipment for loading/unloading							4,9	1,0	2,0	7,9
	Ro-Ro area						6,3	6,3	1,3	1,2	15,2
	Planning and administration costs				0,8	0,8	0,8	0,8	0,4	0,6	4,4
	Contingencies (10%)						0,9	1,4	0,3	0,5	3,1
	Replacement costs								0,9	17,5	18,4
	Total for TERMINAL OWNERS	**0,0**	**0,0**	**0,0**	**0,8**	**0,8**	**10,6**	**16,0**	**4,5**	**23,8**	**56,7**
	Total CAPEX	**7,1**	**7,5**	**1,2**	**4,1**	**4,1**	**54,1**	**72,6**	**9,5**	**64,4**	**224,6**

** In this table the years refer to the years in which the investments are actually made*

The biggest infrastructure expenditures in both scenarios will be foreseen for the years 2023 and 2024. This is when marshalling yard phase one and the connecting rails to terminals will be developed. Connections to the terminals are designed to sustain the demand to the very end of the forecasting period. In addition to railway infrastructure, roads, bridges, culverts and other associated technical infrastructure will be built.

Public investment will be followed by private investment to the terminals. These are mainly terminal inner tracks, loading equipment, parking spots, ramps etc. Final elements of private investment component are locomotives and rolling stock.

Marshalling yard is to be developed in two phases. For 2045 expansion of marshalling yard is foreseen for covering the projected peak of the trade flow. Connecting railways between the marshalling yard and terminals will be done in the first phase and they sustain the demand from low to high from 2025 – 2055. For railways only replacement cost should be considered. It is assumed that the land appropriation and general planning for phase 2 will be done together with phase 1 procedures.

For 2035 and 2045 we have calculated approximate replacement cost for the previous investments. Details are shown in Table 1 and Table 2.

Table 71. Yearly breakdown of investment plan for Alternative IIIb (mln euros)

Public investment

Private investment

	2019	2020	2021	2022	2023	2024	2025	2035	2045	Total
RAILWAY INFRASTRUCTURE OWNER										
Main line					6,2	8,3	2,1			**16,6**
Railway bridges					3,3	4,4	1,1			**8,7**
Marshalling yard					9,8	13,1	3,3		5,0	**31,2**
Signalling and telecommunication					3,6	4,8	1,2		0,5	**10,0**
Depot						3,7	3,7			7,4
Changes to 1520mm tracks						0,7	0,7			1,4
Track (1435) from marshalling yard to terminal						9,1	9,1			18,2
Roads						2,2	2,2			4,4
Land plot	12,7									**12,7**
Planning and administration costs	0,4	0,8	1,2	3,9	3,9	3,9	3,9		1,0	**19,0**
Contingencies (10%)	1,3				3,3	4,4	1,1		0,5	**10,6**
Replacement costs								5,0	19,2	**24,2**
Total for RAILWAY INFRASTRUCTURE OWNER	**14,3**	**0,8**	**1,2**	**3,9**	**40,1**	**52,1**	**16,0**	**5,0**	**26,2**	**159,6**
CARRIERS										
Loco							11,6		2,9	14,5
Project management costs							0,3		0,1	0,4
Contingencies (10%)							1,2		0,3	1,5
Replacement costs									11,6	11,6
Total for CARRIERS	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**13,1**	**0,0**	**14,9**	**28,0**
TERMINAL OWNERS										
Track in terminals areas						2,6	2,6	0,7	2,0	7,7
Equipment for loading/unloading							4,9	1,0	2,0	7,9
Ro-Ro area						6,3	6,3	1,3	1,2	15,2
Planning and administration costs				0,8	0,8	0,8	0,8	0,4	0,6	4,4
Contingencies (10%)						0,9	1,4	0,3	0,5	3,1
Replacement costs								0,9	17,5	18,4
Total for TERMINAL OWNERS	**0,0**	**0,0**	**0,0**	**0,8**	**0,8**	**10,6**	**16,0**	**4,5**	**23,8**	**56,7**
Total CAPEX	**14,3**	**0,8**	**1,2**	**4,8**	**40,9**	**62,7**	**45,1**	**9,5**	**64,9**	**244,2**

** In this table the years refer to the years in which the investments are actually made*

According to the timetable, the phase one of both alternatives, alt I and IIIb, can be finalized by the end of 2025. The prerequisite for this is a well-functioning project management and construction management system. This system should be initiated as early as 2018. Without this the whole project could be delayed several years. This is particularly important during the construction phase. For the construction phase one (phase 2025 with the start date of RB January 1, 2016) at least four parallel running sequences should be carried out with independent contracts between 2019-2025:

- *base infrastructure construction contract (drainage, embankment etc),*
- *communications construction contract (electricity, automatics, telecommunications),*
- *train communication and management construction contract,*
- *civil engineering construction contract (roads, bridges),*
- *rail infrastructure construction contract.*

While most of these contracts could be executed as design and build (yellow FIDIC) contracts, there are few crucial elements that probably cannot be done like this. ERTMS and train communication and management systems for example should be fully designed before construction tender. This and other elements of construction management issues should be studied in the form of separate analysis (construction logistics). We recommend to carry it out within 2018.

Hereby Alternative I activity plan for the years 2019-2025 is presented:

Altenative I activity plan 2019-2025			
Task Name	Duration	Start	Finish
Alt I - Foundation ground examination, contamination analysis, acoustic expertise, simulation of operations	8 months	Tue 01.01.19	Mon 12.08.19
Alt I - Procurement process for the preliminary design	4 months	Tue 12.07.22	Mon 31.10.22
Alt I - Perform „Preliminary Design“ and cost calculation for all crafts based on the masterplan	9 months	Tue 01.11.22	Mon 10.07.23
Alt I - Approval process for the first phase of construction	4 months	Tue 11.07.23	Mon 30.10.23
Alt I - Procurement of construction works and supervision	6 months	Tue 31.10.23	Mon 15.04.24
Alt I - Construction works of public networks	18 months	Tue 16.04.24	Mon 01.09.25
Alt I - Purchase of terminal equipment	4 months	Tue 02.09.25	Mon 22.12.25

With regard to investments of 2035 and 2045 two major investment categories are relevant: replacement costs and infrastructure costs. When it comes to replacement costs the respective planning should start at least 3 years earlier if planning process is counted in. Without planning elements 24 months is minimum. This includes the technical design of the extended marshalling yard + replacement costs. The same activity plan applies both to Alt I and Alt III b.

Altenative I activity plan 2045			
Task Name	Duration	Start	Finish
Alt I - Detailed land use plan	12 months	Jan2042	Dec 2042
Alt I - Procurement process for the technical design of the marshalling yard extension + replacement costs	4 months	Oct 2042	Feb 2043
Alt I - Perform technical design for the marshalling yard extension + replacement works	7 months	Mar 2043	Sept 2044
Alt I – Procurement process for the works	4 months	Oct 2043	Jan 2044
Alt I – Construction of the marshalling yard extension + replacement works	10 months	Mar 2044	Oct 2044

Alternative IIIb activity plan for the years 2019-2025 is the following:

Altenative IIIb activity plan 2019-2025			
Task Name	Duration	Start	Finish

Alt IIIb - Foundation ground examination, contamination analysis, acoustic expertise, simulation of operations	8 months	Tue 01.01.19	Mon 12.08.19
Alt IIIb - Negotiations with the land owners and land expropriation	10 months	Tue 23.04.19	Mon 27.01.20
Alt IIIb - Detailed land use plan with the strategic environmental impact analysis	16 months	Tue 28.01.20	Mon 19.04.21
Alt IIIb - Procurement process for the preliminary design	4 months	Tue 20.04.21	Mon 09.08.21
Alt IIIb - Perform „Preliminary Design" and cost calculation for all crafts based on the masterplan	12 months	Tue 10.08.21	Mon 11.07.22
Alt IIIb - Approval process for the first phase of construction	4 months	Tue 12.07.22	Mon 31.10.22
Alt IIIb - Procurement of construction works and supervision	6 months	Tue 01.11.22	Mon 17.04.23
Alt IIIb - Construction works of public networks	24 months	Tue 18.04.23	Mon 17.02.25
Alt IIIb - Purchase of terminal equipment	4 months	Tue 18.02.25	Mon 09.06.25

During the WP4 we also assessed the most common risks associated with the project. In the context of a major rail infrastructure project, risk is defined as the potential for the completed new railway system project being unable to function as intended at the project conception, resulting from uncertainty about the project. It can represent anything from cost overrun, project delay, safe construction and operation, and system integrity. In that sense, it is much broader than financial or safety risks usually considered for projects.

In the initial phase the highest risks are associated with the land appropriation and planning processes. In that context Alternative I is riskier. The reason for this derives from the complex land ownership issues (described in detail in the environmental analysis section of the current work), the number of interested parties is higher. This applies also to the planning process of Alternative I. Therefore, the planning process in case of Alternative I could be longer than in Alternative IIIb.

With regard to the construction activities, Alternative IIIb could require somewhat more time than Alternative I. Alternative IIIb involves expensive and time-consuming overpasses and bridges and goes through the highly congested area. This risk however could be potentially reduced with the proper construction management by engaging several contractors for predefined slots as described earlier.

The biggest risk with Alternative IIIb is the uncertainty with the former coal terminal area. This area was planned as a buffer to cover peak demand of RORO and container traffic beyond 2035. According to the information obtained as of January 2018, the Port of Tallinn might not be in favour of utilizing former coal terminal area for the purposes planned with the current study. The risk mitigation strategy here would be to engage other terminal operators with similar profile and handling capacity. These are for example Northshore Terminal & Logistics Park (NTLP) and Muuga Dry Port (RRK). Both projects are currently in the development phase, but provided that these terminals will be developed as planned, these two terminals could handle the volumes of the forecasted period and beyond. In order to use that option, Rail Baltic implementing body should solve the connection issues associated with these two terminals (how to connect with the RB main line or marshalling yard). This should happen in parallel with the Rail Baltica main line engineering process. The second option to mitigate the risks associated with the former coal terminal area is to reconsider the dry port terminal option. This should be studied in a separate analysis apart from this study.

8. WP4 Addendum – Action plan implementation and preparation of an initial design

General

Although not required in the Terms of Reference, it is apparently necessary to give explanation about the chosen design solutions in Working Package 4. This regards design principles as well as particular itemization within the pre-selected Alternatives A I and A IIIb. Further explanations are given regarding the size and location of the RORO areas.

Design principles

At the current planning stage (initial design), a number of necessary inputs can be obtained as best-practice based assumptions only, since the reliable input data will become available during the further planning process of rail baltica. In accordance with the Scope of Work, the target of the initial design is to show the general location of the main objects (freight terminals, railway station, connecting tracks) and their relation in a way that allows for a sufficient estimation of the needed territory and the investment costs.

Focussing on the main objects, no details are shown for objects (depot, terminal equipment etc.). However, the expected amounts of investment objects are considered in the cost estimations, but detailed layouts depend on too many conditions that are to be defined in later planning stages. Therefore, only principal solutions are given.

For both, main and ancillary objects, the best practice assumptions were taken assuming rather disadvantageous conditions. This regards, for instance,

- the operation of mixed freight trains instead of block trains, causing much higher shunting effort.
- The construction height of bridges of 1.0 m beneath rail surface
- A structural gauge of the 1520 mm lines for electric traction using catenary

This approach is to ensure that the solution will work under real conditions. However, this also means that in later planning stages, when more details about the future conditions become known or predictable, it is more likely that the effort for infrastructure erection will decrease instead of increase.

Although not all terminal operators expressed an interest in getting connected to the 1435 mm infrastructure, the principal solution allows for the connecting of all existing terminals. However, the layout was developed for the most challenging terminals only. Varying it for other terminals is not supposed to cause more effort.

To reduce investment costs, the general approach is to change as little as possible, but as much as necessary in the existing infrastructure. This regards especially such infrastructure objects that are not easy to relocate, e.g. bridges, buildings and railway tracks. The more flexible infrastructure elements are), the more acceptable a relocation is considered to be (pipeline and road alignment, electricity transmissions, ditches). A general survey, which of these infrastructure elements are needed in future at all, could not be made, except in some obvious cases (e.g. coal terminal). Therefore, the schemes assume that all existing infrastructure is kept in the widest reasonable extend.

Alignment parameters

The detailed final alignment parameters of the rail baltica infrastructure are not developed yet, an according consultancy project is currently (November 2017) ongoing. In working package 2, the most important alignment parameter of the Estonian 1520 mm infrastructure and the regular values of the German standards for the 1435 mm tracks are shown. For the working package 4, more challenging values apply to make it most probable that the chosen parameter are within the later defined standards for the rail baltica infrastructure. This also ensures full compatibility with the UIC guidelines, and provides a certain contingency for difficult conditions. The following main parameter rare used for the track layout of both alternatives (A I and A IIIb).

Table 72: alignment parameter for 1435 mm, 1520 mm and the choice for the intial design

Parameter	Standard value 1520 mm	Standard value 1435 mm	applied
Minimum track distance open line	4,60 m	4,00 m	5,00 m

Minimum track distance stations	4,00 m	4,50 m	5,00 m
Minimum curve radius line track	400 m	300 m	400 m
Minimum curve radius station track	150 m	180 m	150 m
Maximum gradient	12 ‰	12,5 ‰	10 ‰
Usable track length	1050 m	1000 m	1050 m
Smallest turnout geometry	150 1:9	190 1:9	190 1:9

Besides this a number of other parameter is used:

- Usable length of:
  - Arrival departure tracks: 1050 m
  - Sorting tracks: 650 m
  - 4 of the sorting tracks provide longer usable length to be used as alternative departure tracks
  - Turnout track for train decomposition: 1050 m
  - Turnout track for terminal feeding: 650 m or length of the terminal loading track + 50 m
- 6 m (1435 mm) / 10 m (1520 mm) intermediate straight section between curves of opposite direction (S-shape)
- 0 ‰ gradient in the station tracks

On the other hand, a number of simplifications is used to keep the effort in the reasonable extend for this project stage:

- No vertical or horizontal transition curves are considered, but no turnouts are located in the probable areas of such transition curves
- The station head geometry is not optimised to fit within topological constraints or to minimise the required space
- The necessary vertical space between rail surfaces at a level free crossing is assumed with 8,0 m (7 m structural gauge + 1 m bridge construction). For a railway bridge crossing a road it is 6,0 m respectively (5 m vehicle clearance + 1m bridge construction)

In any case, the elaborations within this analysis cannot substitute an accurate planning to be made when the applicable parameters are developed and can be applied. Additionally, the dominant shunting operation in the port area allows for several exemptions from standard values due to the low speeds.

To achieve a high level of transport safety only level free crossings of 1520 mm and 1435 mm main line tracks are envisioned. Crossings on the same level apply to shunting tracks only. Also no level crossings of 1435 mm line tracks with roads are accepted.

Since the design parameter for RB are still developed, crucial influences, especially turnout geometry and track distance, are not defined yet and were replaced by reasonable assumptions as described above. Therefore, the current planning stage cannot design details of the solutions, although the required scale allows for visualisation of details. This applies especially for locations, where turnout geometry and track distance are of big influence, namely at the station ends and track branchings at multi track terminals. The target of the current planning stage is to demonstrate that technical solutions with acceptable parameter exist to facilitate all required functions within the existing port infrastructure. Depending on the final design parameter and decisions of the terminal operators and other stakeholders, there is always potential for optimisation in later stages.

This regards, e.g. the crossings of 1520 and 1435 mm tracks in front of the new assumed container / RoRo terminal, where a solution can be found with less crossings than in the visualisation. Therefore, only one such crossing is regarded in the cost values for the CBA. Without knowing the detailed parameter, it is useless to elaborate the solution in more detail, but will cost significant effort that is not justified at this planning stage.

Another example is the track length in the station, which is assumed to be nearly identical in both Alternatives. However, the particular geometry cannot be defined yet, and the drawings do not allow for conclusions about the particular geometry in the station ends.

Use of dual gauge solutions

In WP 2.1 (Chapter 1.2.1) the possible technical and technological solutions to provide 1435 mm railway connection to the particular terminals are described and the recommendation is given:

- to use separate (parallel) facilities for each gauge, whenever possible
- to use gauntled tracks, where separation of both gauges is not possible
- to use transhipment to the other gauge or road trucks, if both aforementioned solutions are not possible, but a dry port solution will be established.
- to use railway trucks, if the aforementioned solutions cannot be established

Applying these principles, the layout of the alternatives A I and A IIIb could be drafted in a way that all existing port terminals (including the former coal terminal, which is assumed as most probable location of a new RoRo and container terminal) can be connected to the Rail Baltica network parallel to the existing 1520 mm connections)[48]. Gauntled tracks are not necessary within the "public" (outside the actual terminals)port territory. This is promoted by the fact that the existing railway infrastructure is dimensioned for much higher transport volumes as expected within the forecasted time horizon, so parts of it can be substituted by the new 1435 mm facilikties.

Therefore, principally no other mean of connection is necessary. However, within the terminals, the operators may decide whether they prefer establishing new transhipment facilities for the 1435 mm system, the use of the existing ones by substitution of some of the 1520 mm facilities by new 1435 mm ones or a dual gauge track. Since the majority of freight volumes on the rail baltica is supposed to be intermodal freight, some operators dealing with other commodities may not be interested in a connection to 1435 mm tracks, but prefer road or railway trucks and respective transfer or transhipment procedures to facilitate occasional deliveries from the rail baltica network. But this needs to be decided by the operators based on their own business expectations and cost calculations.

Basically, a separate 1435 mm track connection can be offered to all interested terminal operators, so no dual gauge solutions are required.

Connection to RB main line

For the design of the rail baltica main line as well as for the 1435 mm facilities in the port territory, clear interfaces between both planning areas need to be defined to allow for a seamless design of the railway. This is of special importance, since the railway infrastructure is not very flexible in design, compared with road alignments.

However, currently an exact definition of an interface is not possible, since the design parameter for rail baltica are still in the stage of development. Not to talk about the design works that of course could not start yet. Therefore, it is best practice not to define a particular interface yet, but to assume a certain corridor, in which the infrastructure has to be located. This is done for rail baltica main line, and the technical parameter of the railway infrastructure for the port territory are chosen in a way that a connection is possible to all reasonable main line alignments within this corridor. The general assumption is that the rail baltica main line is parallel to the existing railway, and the next constraint for the elevation is the underpass under the Eesti Raudtee tracks and roads around Peterburi tee / Vana Narva mantee. So a crucial parameter would be the horizontal distance to the Eesti Raudtee line, which does not only depend on rail baltica's alignment parameter, but also on the ownership of its infrastructure and some other conditions not defined yet.

Both the Rail Baltica main line and the access to the port are designed in such a way that different interface options could be used. This is good practice for such planning stage, when the alignment parameter are not determined yet. Especially this avoids the wrong impression that the very crucial planning interface is defined already.

However, also the impression of mismatching plans has to be avoided. Therefore, a solution for the connection is indicated in the drawings of both Alternatives. The preliminary alignment of RB main line in the related area envisions

[48] The maps do not show the particulars of all possible connections to terminals, but only exemplarily the connection to the respective terminal area.

the same parameter as the existing (1520 mm) line. Further to the South, the gradient of RB main line deviates due to the necessary level free crossing around Peterburi tee / Vana Narva mantee.

Figure 77: Area in which the preliminary alignments of RB main line and Muuga port railway infrastructure overlap

A connection between the preliminary alignments of RB main line and the port 1435 mm railway infrastructure is ensured by providing an area, in which the alignments can overlap. Such area is defined as shown in Figure 77 as an appr 300 m long and 25 m wide strip, with its Western edge approximately 5 m from the existing railway line. The preliminary alignment of RB main line provides a straight section with a slope of 7.0 ‰ here. Since these are exactly the alignment parameter of the port 1435 mm railway infrastructure in this section in Alternative I, the connection of both plannings is trivial. Adjustments in vertical and horizontal alignment are still possible by adapting the adjacent curve radii or gradients. This may become necessary, when the distance between both railway lines is finally defined.

Since Alternative IIIb is not running parallel to the existing line, the situation is more challenging, but still without causing significant problems. The decisive difference is the vertical alignment, where the existing constraints (railway bridges near the port station and over the port access road) suggest a higher elevation of the 1435 mm tracks. The resulting height difference between existing and new railway line of up to 8,5 m is no problem for the vertical alignment, since it can be compensated by a more gentle gradient of the adjacent RB main line Southwards (currently 7.0 ‰). In case that A IIIb is selected, the preliminary RB alignment has to be adjusted respectively. The resulting slope depends on the detailed design of the other relevant constraint, the necessary level free crossing around Peterburi tee / Vana Narva mantee.

The differing elevation of existing and RB main line in Alternative A IIIb has consequences for the horizontal alignment, too. To avoid costly retaining wall constructions, the elevated RB line is supposed to be located on an embankment, which again should be within the planning corridor of RB. With a necessary base width of approximately 30 m of the 8 m high embankment, it nearly completely occupies the rail baltica planning corridor. This suggests that the distance between existing and RB main line may be more than the assumed 10 m, but still within both, planning corridor and overlap area. To regard the embankment height lowering with the distance to the port, a not exactly parallel alignment with the existing rail is the most promising option. The exact values depend on the final longitudinal profile of the RB main line, but the maximum necessary variation is supposed to remain within the planning corridor and the overlap area.

Limit for quantities estimation

A clear definition of the project border is necessary for the purpose of the Cost-Benefit-Analysis to have comparable parameter for both alternatives. Therefore, the construction costs are estimated in both alternatives until an identical cross section, which is sufficiently exact defined at the Southern end of “plot 5”, as shown in Figure 78. For the cost estimation, the particular track geometry is not relevant.

Figure 78: Defined limit for infrastructure construction cost estimations for the Alternatives.

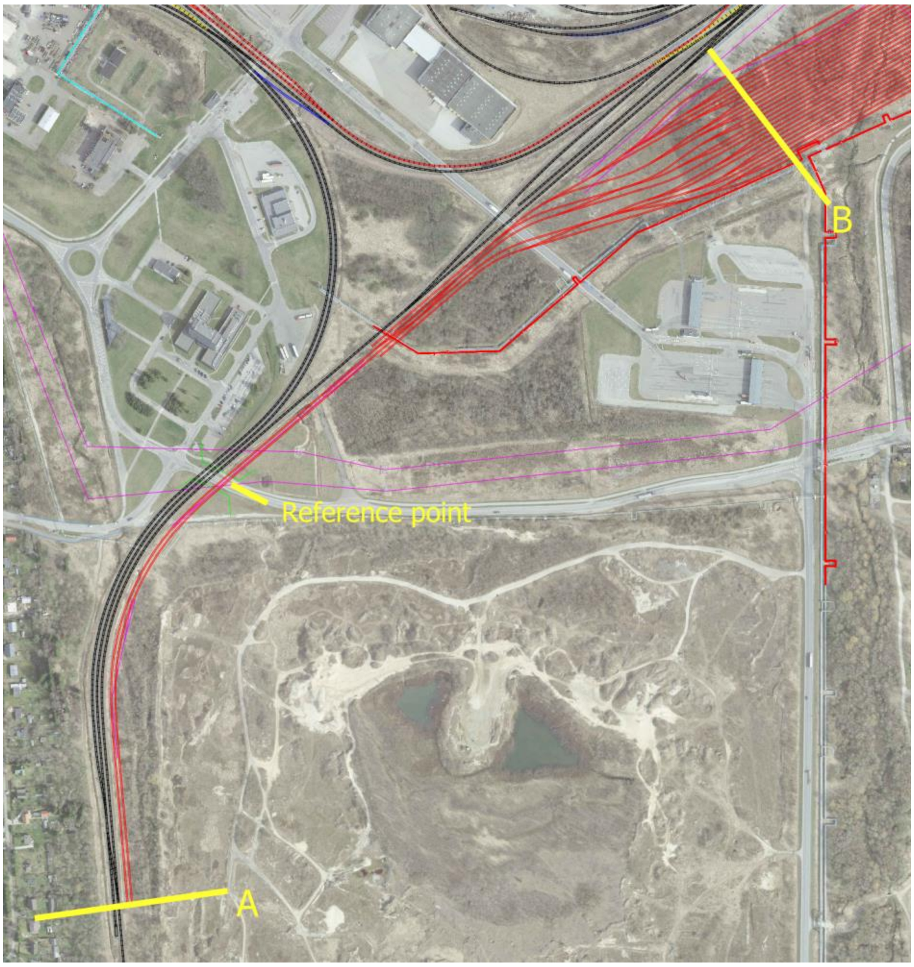
Longitudinal profile

In alternative A I the elevation of 1435 mm line and station is basically the same as for the existing 1520 mm railway facilities. Differences may occur at the Southern end of the alignment only, where the gradient of the rail baltica does not need to be as steep as for the existing (1520 mm) line due to the underpass near the intersection Peterburi / Põhjaranna tee. However, the alignment in this section is not subject of the analysis for the MCTRB. For the existing line of Eesti Raudtee, Therefore, the existing longitudinal profile for the 1520 mm line is a more exact and reliable basis for further planning stages.

The reference point for the longitudinal profile of Alternative A I is the existing crossing in south-west direction. It is defined as RB MCTRB 10.000. In Eastern direction the track spreads up to the sorting tracks, in south-western direction it continues to the main line.

The longitudinal section is marked in Figure 79 with the yellow bars – starting at the “A”marked bar in the direction to “B”.

Figure 79: Location of reference station for longitudinal profile of the turnout track in alternative A I.



As a significant way mark the crossing marked with "Reference point" in Figure 79 is shown in detail in Figure 80. The track-km is set as 10.000 and increases in the direction to the sorting tracks until track–km 11.000 and decreases in the direction to the main line until track-km 9.500. This section is covered by the longitudinal section.

The longitudinal section shows a continuous decline in the direction towards Muuga port. The ground level altitude above sea level at the "A"-bar line is 10.5 m (referring to www.xgis.maaamet.ee). The height above sea level at the "B"-bar line is 3,5 m. The decline is quite steady and shows only small divergences which can also be due to measuring inaccuracy. As mentioned above, an exact measurement is not possible, as long the distance between existing line and rail baltica is not defined. The slope of the 1435 mm railway line section (red line) has an average decline of 7.0 ‰ towards the road crossing (which will be a road bridge in future) and of 4,7 ‰ between that crossing and the beginning of the station area. The station tracks itself, starting with the arrival/departure tracks and the longer sorting tracks, both providing 1050 m usable length, are envisioned without incline or decline (0 ‰).

Figure 80: Location of reference station for longitudinal profile of the turnout track in alternative A I.

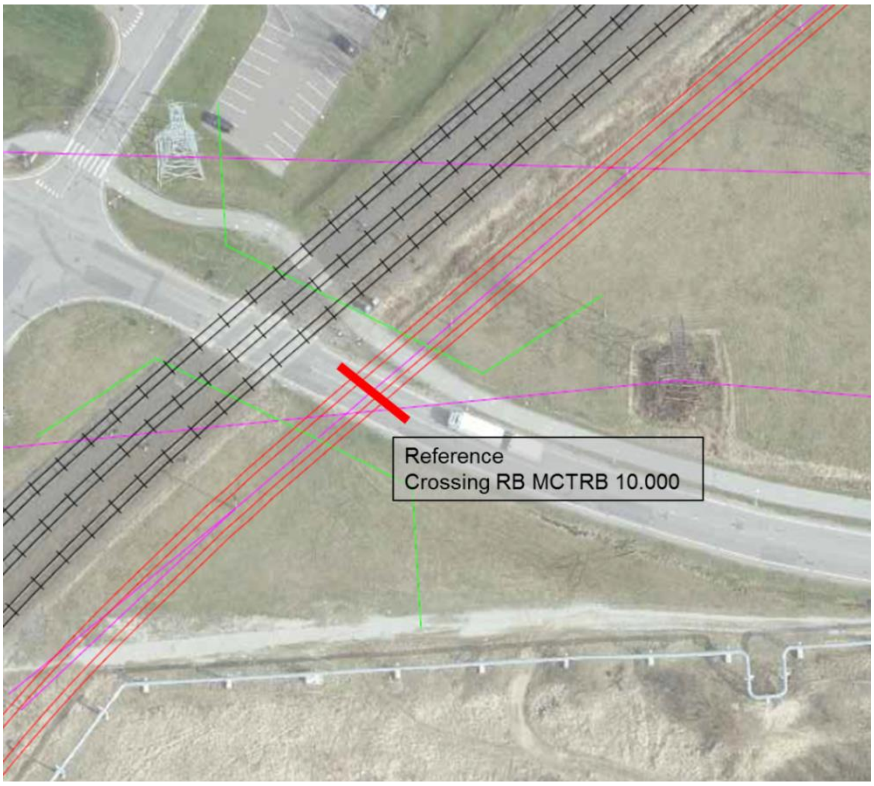


Figure 81. Longitudinal section of alternative A I.

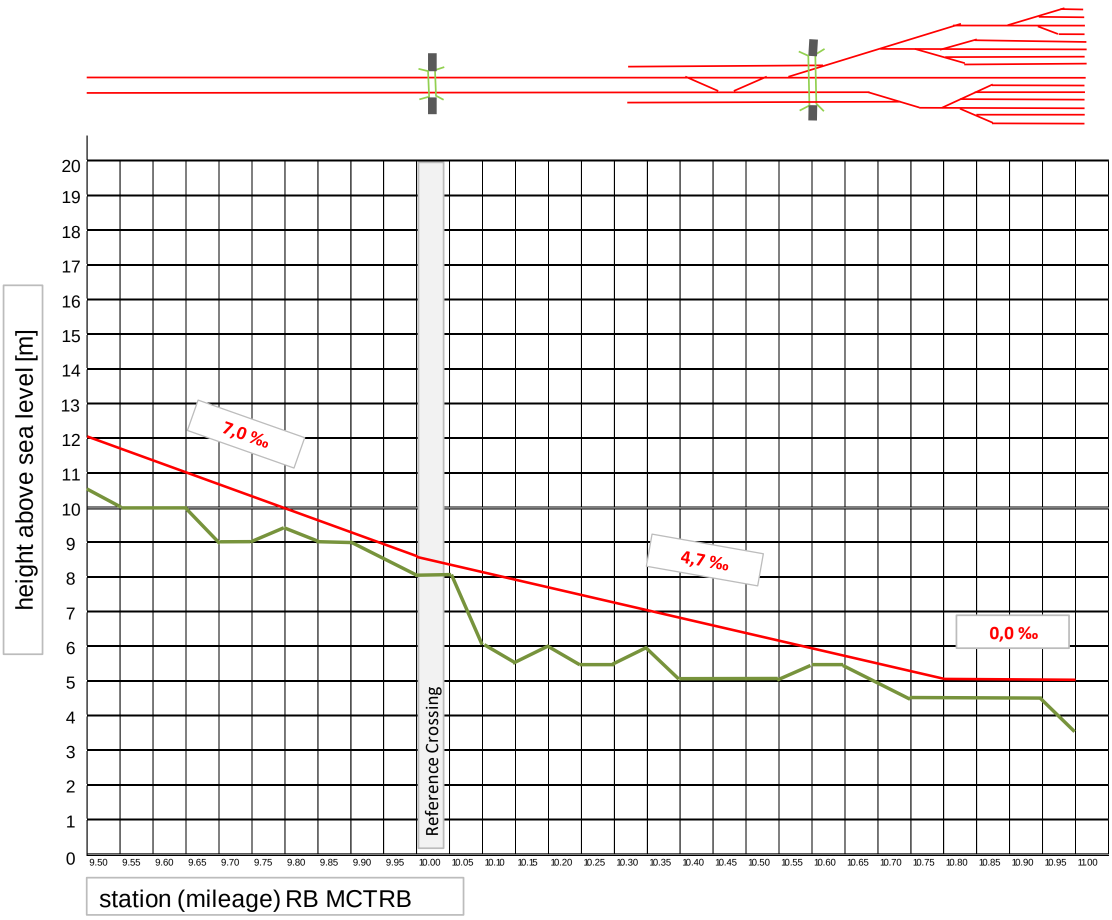
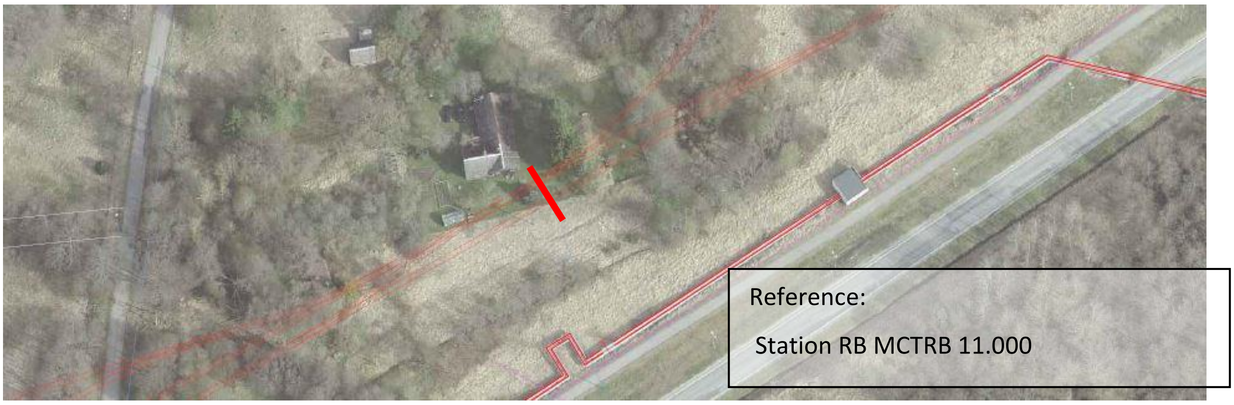


Table 73: Elevation values along the rail baltica line in the approach of the Muuga port station

station	elevation [m above sea level]				resulting		RB elevation above
(RB MCTRB)	RB (1435)	ER (1520)	ground level	other	gradient (RB)		ground level [m]
9.500	12.00	12.00	10.50		7.0	‰	1.50
9.550	11.65	11.65	10.00		7.0	‰	1.65
9.600	11.30	11.30	10.00		7.0	‰	1.30
9.650	10.95	10.95	10.00		7.0	‰	0.95
9.700	10.60	10.60	9.00		7.0	‰	1.60
9.750	10.25	10.25	9.00		7.0	‰	1.25
9.800	9.90	9.90	9.50		7.0	‰	0.40
9.850	9.55	9.55	9.00		7.0	‰	0.55
9.900	9.20	9.20	9.00		7.0	‰	0.20
9.950	8.85	8.85	8.50		7.0	‰	0.35
10.000	8.50	8.50	8.00		4.7	‰	0.50
10.050	8.27	8.33	8.00		4.7	‰	0.27
10.100	8.03	8.15	6.00		4.7	‰	2.03
10.150	7.80	7.98	5.50		4.7	‰	2.30
10.200	7.57	7.80	6.00		4.7	‰	1.57
10.250	7.33	7.63	5.50		4.7	‰	1.83
10.300	7.10	7.45	5.50		4.7	‰	1.60
10.350	6.87	7.28	6.00		4.7	‰	0.87
10.400	6.63	7.10	5.00		4.7	‰	1.63
10.450	6.40	6.93	5.00		4.7	‰	1.40
10.500	6.17	6.75	5.00		4.7	‰	1.17
10.550	5.93	6.58	5.00		4.7	‰	0.93
10.600	5.70	6.40	5.50		4.7	‰	0.20
10.650	5.47	6.23	5.50		4.7	‰	-0.03
10.700	5.23	6.05	5.00		4.7	‰	0.23
10.750	5.00	5.88	4.50		0.0	‰	0.50
10.800	5.00	5.70	4.50		0.0	‰	0.50
10.850	5.00	5.53	4.50		0.0	‰	0.50
10.900	5.00	5.35	4.50		0.0	‰	0.50
10.950	5.00	5.18	4.50		0.0	‰	0.50
11.000	5.00	5.00	3.50		0.0	‰	1.50

Figure 82: Location of reference station for longitudinal profile of the turnout track in alternative A I.



Due to the hilly ground in the area of the envisioned turnout track along Nuudi tee, a longitudinal profile for the turnout track is considered to be relevant by Client. This is principally justified, but there are some special conditions to be observed:

- Neither gradient nor elevation of the turnout track are not critical, as long as they are meeting some basic requirements, like:
    - Moderate gradient not more than 4 ‰
    - Incline to the dead end of the track
    - Steady incline.
- The altering ground level (between 6 and 17 m) along the envisioned track alignment will require a considerable cutting. Detailed elevation in such cases will usually be designed by measurement of earthworks, where cuttings and near embankments are arranged in a way to minimize the necessary earthworks, considering also demand and distance of other earthworks to use the turnout track's subsoil as convenient pitch site. Therefore, the particulars also depend on the soil quality.

For the purpose of cost benefit analysis a reasonable assumption about the quantity of earthworks can be made, but a longitudinal profile for this section would needs to regard the above mentioned conditions. Therefore, not a sole profile is demonstrated, but the 2 options that aiming in:

- Smallest effort of earthworks, applying:
    - The maximum acceptable gradient (4 ‰) and
    - A steady incline of the station tracks by approximately 1 m , resulting in an Eastern station head elevation of 6 m
- Best operational conditions, applying:
    - Plain station tracks with 5m elevation in the Eastern station head,
    - Minimised incline of the turnout track (0,5 ‰) and
    - Little incline from the station to the turnout track (4 ‰)

A combination of both approaches is possible, and the longitudinal profiles of both options actually define the limits of the exercisable solutions.

For the purpose of drawing up the longitudinal profile, a reference mileage needed to be defined for the distances. The location is shown in Figure 83.

Figure 83. possible longitudinal profiles for the turnout track along Nuudi tee in alternative A I

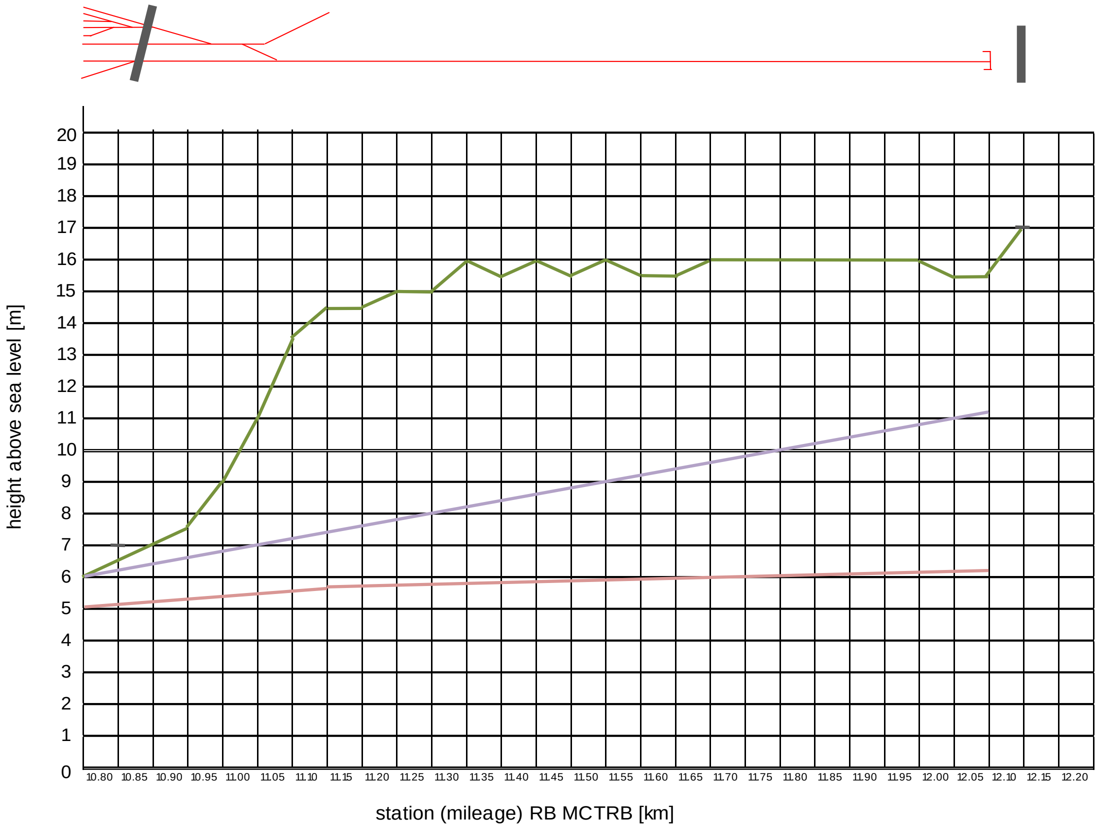
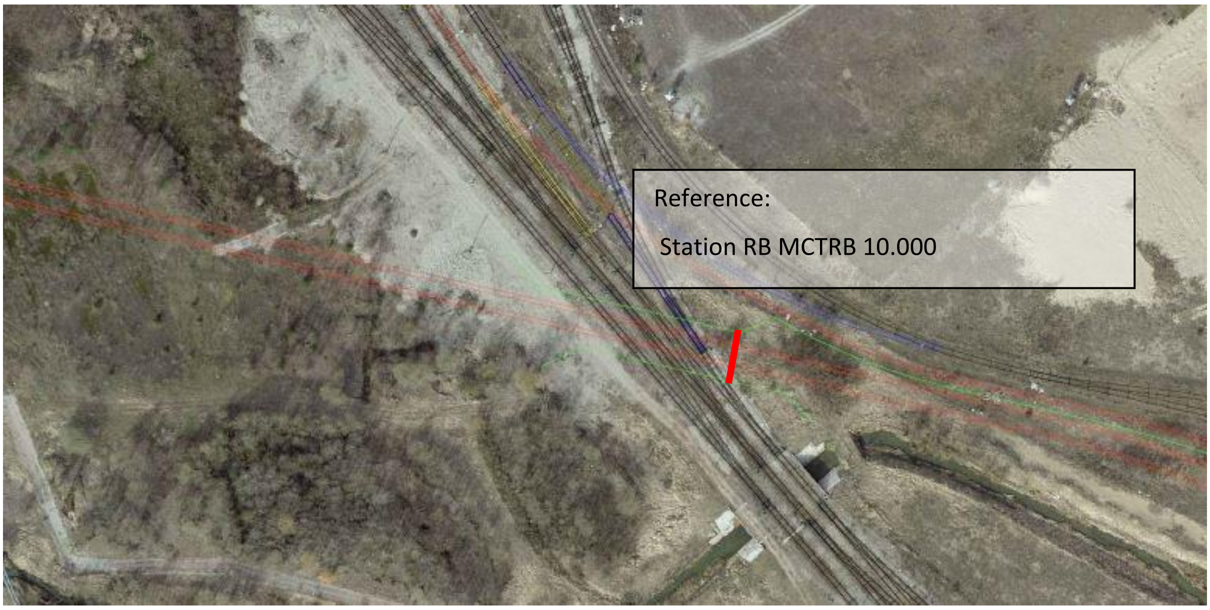


Table 74: Elevation values along the rail baltica line in the approach of the Muuga port station

station	elevation [m above sea level]				resulting gradient (RB)			RB elevation above ground level [m]	
(RB MCTRB)	RB (min)	RB (max)	ground level	other	min	max			
10.800	5.00	6.00	6.00		2.0	4.0	‰	-1.00	0.00
10.850	5.10	6.20	6.50	road 7.0	2.0	4.0	‰	-1.40	-0.30
10.900	5.20	6.40	7.00		2.0	4.0	‰	-1.80	-0.60
10.950	5.30	6.60	7.50		2.0	4.0	‰	-2.20	-0.90
11.000	5.40	6.80	9.00		2.0	4.0	‰	-3.60	-2.20
11.050	5.50	7.00	11.00		2.0	4.0	‰	-5.50	-4.00
11.100	5.60	7.20	13.50		2.0	4.0	‰	-7.90	-6.30
11.150	5.70	7.40	14.50		0.5	4.0	‰	-8.80	-7.10
11.200	5.73	7.60	14.50		0.5	4.0	‰	-8.78	-6.90
11.250	5.75	7.80	15.00		0.5	4.0	‰	-9.25	-7.20
11.300	5.78	8.00	15.00		0.5	4.0	‰	-9.23	-7.00
11.350	5.80	8.20	16.00		0.5	4.0	‰	-10.20	-7.80
11.400	5.83	8.40	15.50		0.5	4.0	‰	-9.68	-7.10
11.450	5.85	8.60	16.00		0.5	4.0	‰	-10.15	-7.40
11.500	5.88	8.80	15.50		0.5	4.0	‰	-9.63	-6.70
11.550	5.90	9.00	16.00		0.5	4.0	‰	-10.10	-7.00
11.600	5.93	9.20	15.50		0.5	4.0	‰	-9.58	-6.30
11.650	5.95	9.40	15.50		0.5	4.0	‰	-9.55	-6.10
11.700	5.98	9.60	16.00		0.5	4.0	‰	-10.03	-6.40
11.750	6.00	9.80	16.00		0.5	4.0	‰	-10.00	-6.20
11.800	6.03	10.00	16.00		0.5	4.0	‰	-9.98	-6.00
11.850	6.05	10.20	16.00		0.5	4.0	‰	-9.95	-5.80
11.900	6.08	10.40	16.00		0.5	4.0	‰	-9.93	-5.60
11.950	6.10	10.60	16.00		0.5	4.0	‰	-9.90	-5.40
12.000	6.13	10.80	16.00		0.5	4.0	‰	-9.88	-5.20
12.050	6.15	11.00	15.50		0.5	4.0	‰	-9.35	-4.50
12.100	6.18	11.20	15.50		0.5	4.0	‰	-9.33	-4.30
12.150			17.00	road 17.0		3.3	‰		

In alternative A IIIb the gradient between the railway overpass and the 1435 mm station is decisive, so a longitudinal profile is a fundamental input for the assessment of the solution. The critical point is the beginning of the descent from the railway bridge and the station. This point was defined as the reference for the longitudinal profile with the mileage (Station RB MCTRB) 10.000. The location of this reference station is shown in Figure 84.

Figure 84: Location of reference station for longitudinal profile of alternative A IIIb.



Starting from this reference station, the elevation of the 1435 mm rail baltica line tracks, the ground level and of the existing 1520 mm main line (when adjacent) are taken in a distance of 50 m each. Towards the station, the profile ends were the tracks achieve a plain gradient in the station. Towards the open line, the profile was drawn up at a section of 1500 m. At this point, the alignment of the adjacent rail baltica line tracks becomes more defining for the parameter of the designed infrastructure. Also the existing plan of the Muuga port territory ends there. Consequentially, the longitudinal profile covers a section of 2.5 km length, where a height difference of 13 m applies. Integrating the ground level into the longitudinal profile of the line, a separate elevation model describing the elevation of the line above ground level becomes not necessary.

Additionally, the crossing railway tracks, roads and waters are displayed in the longitudinal profile. For better orientation, on top of the profile the schematic track topology is given, too.

The ground level was taken from the official maps available at https://www.maaamet.ee/et . It is available with a exactness of 0,5 m, which is sufficient for the current planning stage. The actual ground level was taken from the center of the RB double track line.

The relevant constraints for the vertical alignment are:

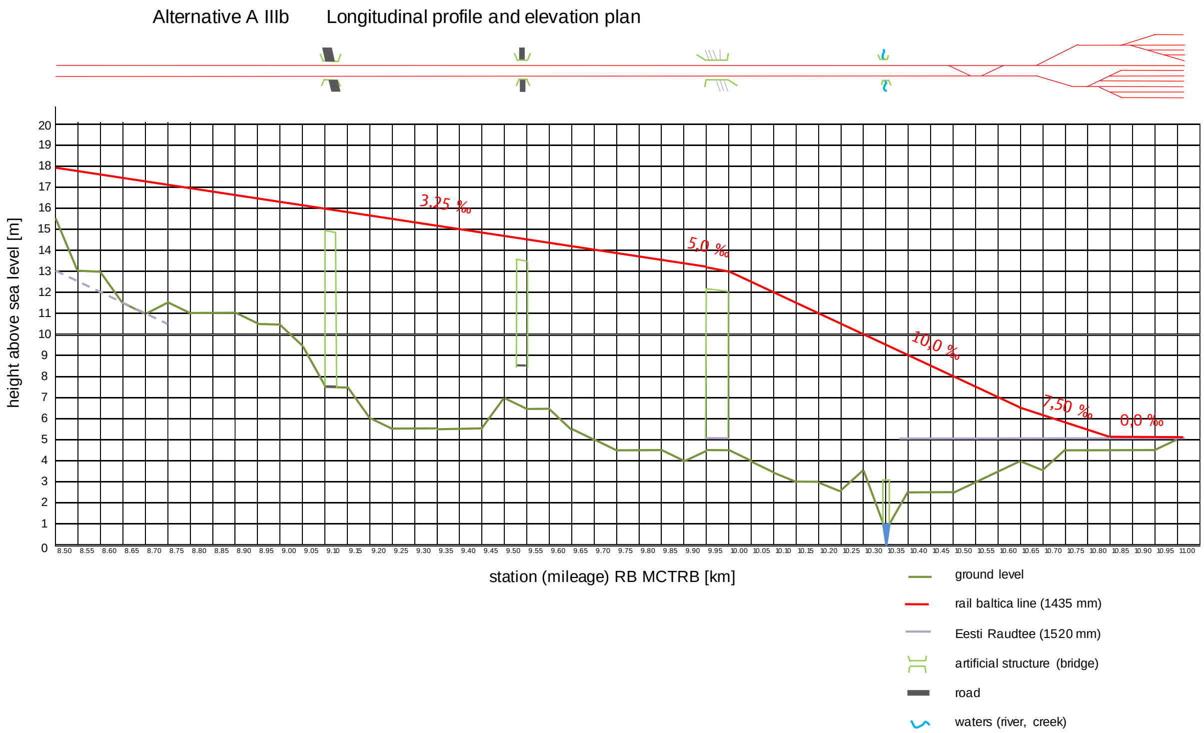
- The arrival/departure tracks in the station need to have 0 ‰ gradient at the same elevation as the existing station (1520 mm)
- 8,0 m height difference between 1520 mm and 1435 mm rail surface
- 6,0 m height difference between road surface (Põhjaranna tee bridge) and rail surface.

The other existing constraints did not become relevant in the chosen vertical alignment. The turnouts on the Western station head are partly located in a gradient. This is not problematic, but an allocation in a vertical transition curve has to be avoided.

The resulting values for ground level, railway and relevant other elevations are shown in Figure 85.

The longitudinal profile of the line section adjacent to the Muuga port station (terminal) is given in Figure 85 and as separate Annex for more recognizable details.

Figure 85: longitudinal profile for the line section of rail baltica (1435 mm) in the Muuga area, alternative A IIIb.



The arrangement with a 10 ‰ gradient after the station is not very desirable, since accelerating freight trains will start inclining immediately after departure. However, no better arrangement could be made with the applied assumptions. But there is potential for optimization of the gradient in later planning stages in:

- Different layout of the Western Station head with adjacent 600m (instead of 400m) curve allows for longer track length before the overpass, reducing the necessary incline.
- Exact definition of bridge construction height
- Elevation of the station area
- Acceptance of minor gradient (0,5 ‰) in the arrival/departure tracks

For the current situation, a calculation was made showing that a locomotive with a starting effort of 300 kN can start a 2400 t train in that gradient and curve radius. A starting effort of 300 kN is a common value for modern electric locomotives (e.g. Siemens ES 64 / Vectron, Alstom Prima, Bombardier Traxx).

The calculation of the maximum startable train load is demonstrated in the following section.

$$mstart = \frac{Fhook + (i + wb) \cdot mloco \cdot g}{-[1{,}3 \cdot (i + wb) - 0{,}006] \cdot g}$$

With:

- m_{start} as maximum startable train load
- F_{hook} = **300 kN** as starting effort of the locomotive
- m_{loco} = **84 t** as weight of the locomotive
- i = **0,01** as the gradient (10 ‰)
- w_b = **0,0048** as coefficient of the train resistance , calculated as:

$$Wb = \frac{\mu \cdot (0{,}72 \cdot lb + 0{,}47 \cdot db)}{R}$$

With:

- µ = **0,22** as friction coefficient
- l_b = **1,8 m** as bogie pitch of an Y25 bogie
- d_b = **15,8 m** as bogie pivot pitch of a container platform wagon
- R = **400 m** as the relevant curve radius

The calculated result is **2401,5 t**.

Table 75: Elevation values along the rail baltica line in the approach of the Muuga port station

station	elevation [m above sea level]				resulting	RB elevation above
(RB MCTRB)	RB (1435)	ER (1520)	ground level	other	gradient (RB)	ground level [m]
8.500	17.96	*13.00*	15.50		3.3 ‰	2.46
8.550	17.80		13.00		3.3 ‰	4.80
8.600	17.64		13.00		3.3 ‰	4.64
8.650	17.48		11.50		3.3 ‰	5.98
8.700	17.31		11.00		3.3 ‰	6.31
8.750	17.15	*10.50*	11.50		3.3 ‰	5.65
8.800	16.99		11.00		3.3 ‰	5.99
8.850	16.83		11.00		3.3 ‰	5.83
8.900	16.66		11.00		3.3 ‰	5.66
8.950	16.50		10.50		3.3 ‰	6.00
9.000	16.34		10.50		3.3 ‰	5.84
9.050	16.18		9.50		3.3 ‰	6.68
9.100	16.01		7.50	road 7.5	3.3 ‰	8.51
9.150	15.85		7.50		3.3 ‰	8.35
9.200	15.69		6.00		3.3 ‰	9.69
9.250	15.53		5.50		3.3 ‰	10.03
9.300	15.36		5.50		3.3 ‰	9.86
9.350	15.20		5.50		3.3 ‰	9.70
9.400	15.04		5.50		3.3 ‰	9.54
9.450	14.88		5.50		3.3 ‰	9.38
9.500	14.71		7.00		3.3 ‰	7.71
9.550	14.55		6.50	road 8.5	3.3 ‰	8.05
9.600	14.39		6.50		3.3 ‰	7.89
9.650	14.23		5.50		3.3 ‰	8.73
9.700	14.06		5.00		3.3 ‰	9.06
9.750	13.90		4.50		3.3 ‰	9.40
9.800	13.74		4.50		3.3 ‰	9.24
9.850	13.58		4.50		3.3 ‰	9.08
9.900	13.41		4.00		3.3 ‰	9.41
9.950	13.25	5.00	4.50		5.0 ‰	8.75
10.000	13.00	5.00	4.50		10.0 ‰	8.50
10.050	12.50		4.00		10.0 ‰	8.50
10.100	12.00		3.50		10.0 ‰	8.50
10.150	11.50		3.00		10.0 ‰	8.50
10.200	11.00		3.00		10.0 ‰	8.00
10.250	10.50		2.50		10.0 ‰	8.00
10.300	10.00	5.00	3.50		10.0 ‰	6.50
10.350	9.50	5.00	1.00	ditch 1.0	10.0 ‰	8.50
10.400	9.00	5.00	2.50		10.0 ‰	6.50
10.450	8.50	5.00	2.50		10.0 ‰	6.00
10.500	8.00	5.00	2.50		10.0 ‰	5.50
10.550	7.50	5.00	3.00		10.0 ‰	4.50
10.600	7.00	5.00	3.50		10.0 ‰	3.50
10.650	6.50	5.00	4.00		10.0 ‰	2.50
10.700	6.13	5.00	3.50		7.5 ‰	2.63
10.750	5.75	5.00	4.50		7.5 ‰	1.25
10.800	5.38	5.00	4.50		7.5 ‰	0.88
10.850	5.00	5.00	4.50		7.5 ‰	0.50
10.900	5.00	5.00	4.50		0.0 ‰	0.50
10.950	5.00	5.00	4.50		0.0 ‰	0.50
11.000	5.00	5.00	5.00		0.0 ‰	0.00

RORO-Development and usage of the available space

Table below describes the RORO-Development over the time horizon until 2055. It becomes obvious, that the required RORO space will more than double from approx. 16.000 m² in 2025 to 34.000 m² in 2055. The major amount of trailers will arrive and leave Muuga via road. However, the share of trailers transported by rail to and from Muuga will also increase due to the trailerization effect from 11% in 2025 to 37% in 2055 out of the total number of handled RORO semi-trailers in Muuga.

Table 76: Capacity calculation for RORO zone

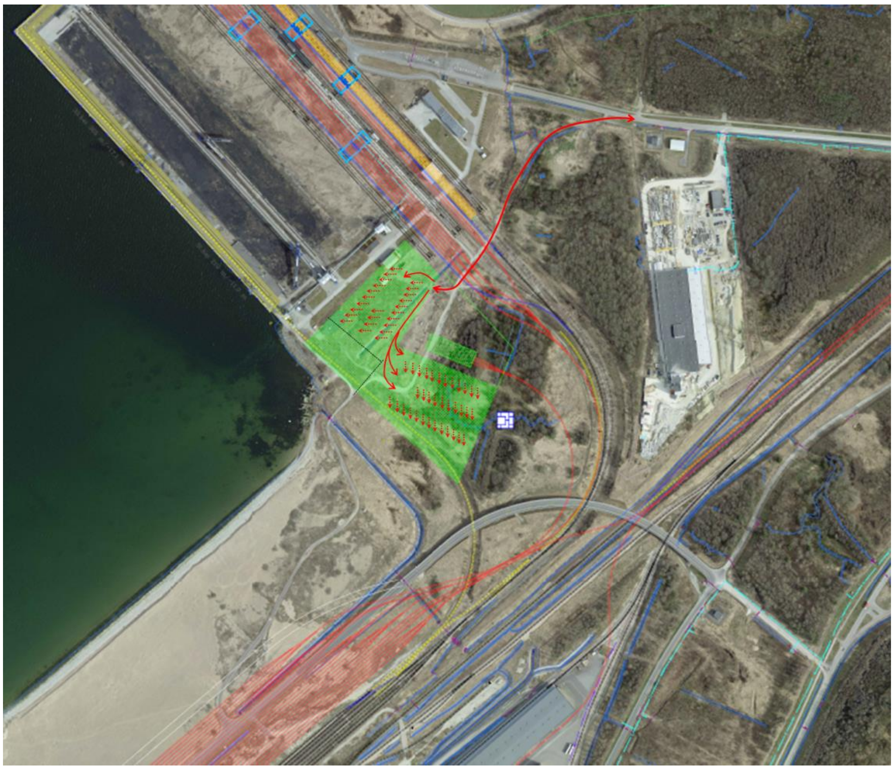
R- RORO	2025	2035	2045	2055
Inbound trucks Road-RORO [t / year]	1.642.262	2.802.219	2.840.684	2.717.744
Inbound trucks Rail-RORO [t / year]	218.597	611.274	903.293	1.310.103
Outbound trucks RORO-Road [t / year]	1.354.514	2.312.229	2.396.485	2.235.214
Outbound trucks RORO-Rail [t/ year]	172.319	391.534	577.655	829.296
Inbound trucks Road-RORO [semi-trailers / day]	278,53	475	482	461
Inbound trucks Rail-RORO [semi-trailers / day]	37	104	153	222
Outbound trucks RORO-Road [semi-trailers / day]	230	392	406	379
Outbound trucks RORO-Rail [semi-trailers/ day]	29	66	98	141
Inbound + outboud trucks RORO per day	**575**	**1.037**	**1.139**	**1.203**
Number of parking slots RORO	**224**	**405**	**445**	**470**
Required space [m2]	**16.384**	**29.585**	**32.491**	**34.301**

The phasing strategy which is thoroughly described in WP 2 states, that both terminals – TK and the former coal terminal may both serve RORO flows starting in Stage I (2025) – launch of Rail Baltica Operations in Muuga harbour. According to Port of Tallinn, before 2025, a certain amount of trailer shall be relocated from the old city harbour to Muuga. For this amount of trailers, TK area shall be used for parking and pre-sorting of trailers. Picture below demonstrates the envisaged areas. The total estimated parking area at TK on the demonstrated Figure 1 amounts to 13,000 m². The empty containers (container depot) which are now located at that area can be relocated to the development areas of TK. The delivery of semi-trailers proceeds over the southern road connection Figure 86 demonstrates the routing of trailers on TK area (from hinterland or from RORO ferries to container terminal – loading station, from loading station to hinterland or to RORO ferries). The connection to the loading station (container terminal) will be organized along the RORO parking zone through the former container depot. That is, there will be a need to relocate a part of the container depot to the TK development areas. As already mentioned in WP2 and WP3, the loading station focuses on the cranable semi-trailers which are loaded along the tracks (parking positions for loading 01, 02, 03 etc. – see Figure 33 in WP2 report). The loading of non-cranable semi-trailer proceeds at the end of the tracks (in case RoLa trains will arrive in Muuga).

The increasing demand for RORO will be covered by the additional areas at the former coal terminal, where the rest (21.000 m²) can be located. Figure below demonstrates the allocation of RORO parking and sorting areas at the Coal Terminal.

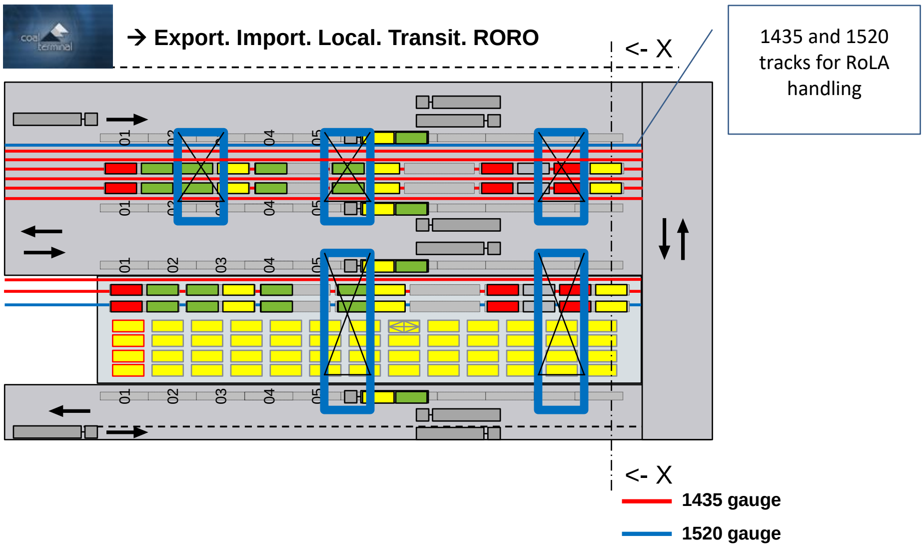
Figure 86: Traffic scheme of trailers on the TK area

Figure 87: Traffic scheme of trailer on the coal terminal area



For the efficient loading and unloading of trailers it is essential to have the RORO areas in the immediate proximity to the piers which is given for both terminals. For coal terminal – short transport distance from rail (unloading/loading) to RORO area is given for the presented configuration. The delivery of trailers by road – independent on Alternative - proceeds over the existing northern road connection (marked yellow in the Figure 3). The handling of semi-trailers with tractors (RoLa) proceeds on the both sea-side tracks in the "Coal" Terminal, which will be constructed without deadlocks.

Figure 88: 1435 and 1520 track for RoLa loading and unloading

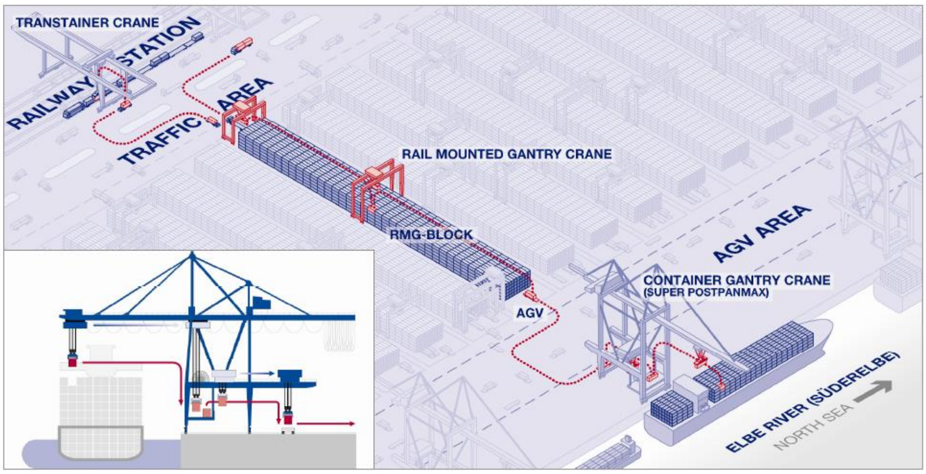


On both terminals (TK and coal terminal area) a principle of handling process of import and export sea-bound containers is as follows:

a) unloading from the train (railway station – container terminal)
b) transport to container storage (existing TK container storage are via tug master
c) get in via RTG, get out via RTG
d) transport to the container gantry crane – ship to shore cranes – via tug master
e) loading of container to the vessel

Figure below demonstrates the depicted process (see Figure 89):

Figure 89: Principle of handling process of import and export sea-bound containers at TK (Source: DB AG)



Crossing of 1520 / 1435 mm tracks in former hump area (A I)

In Alternative A I the existing hump of the 1520 mm station becomes virtually not usable anymore, although it has not to be removed. Consequentially, train splitting has to be made (as it is today's practice, too, due to the small traffic volumes) by drawing back into a turnout track. In case of implementation of A I, this track will be crossed by the connection track from station to terminals of the 1435 mm system (see Figure 90), leaving a drawback length of little more than 300m without blocking the 1435 mm track. This turnout track does not need to be used, when the most Northern station tracks, dedicated for the current container and coal terminals, will remain in use.

Figure 90: Situation of the crossing of 1435 mm and 1520 mm systems in the former hump area in Alternative A I.

Since the same crossing needs to be used by shunting moves of the 1435 mm system feeding nearly all terminals, concerns occured for the capacity of this infrastructure element, which may become a bottleneck in both systems. To evaluate the mutual obstructiuons, an estimation of the occupation of the crossing is performed, using the following assumptions:

- Length of a shunting rake ("group length") is:
  - 600 m for container and trailer transport
  - 300 m for fertiliser
  - 200 m for all other freights
- The trains are splitted into rakes of the according length, creating a respectively higher number of shunting moves than train rides ("shunting factor")
- Container and trailer wagons are loaded in both directions, while all other freights run empty in one direction. So the train numbers for arriving and departing trains as basis of the calculation have to be added. Only for container and Trailer (RoRo) the respectively higher number is counted ("relevant trains").
- All rakes on the 1435 mm system pass the crossing twice (to and from the terminal). On the 1520 mm system, rakes shorter than 300m do not need to occupy the crossing regularly, but may occasionally do anyway ("on crossing": 0,5). 50% of the container and trailer (RoRo) traffic is using the most Northern tracks, not touching the crossing. Since the others do twice, the resulting factor ("on crossing") is 1.

- The 1435 mm rakes transferring from station to terminal use the crossing at a speed of 7 ms^{-1} (25,2 kmh^{-1}), while in the 1520 mm system the speed of the moves doing train splitting is assumed with an average of 3 ms^{-1} (10,8 kmh^{-1}).
- Every direct occupation of the crossing causes additional occupation of 75 s each for preparation and cancellation of the shunting route (150 s in total).

Since more frequent moves on the crossing cause a higher occupation than longer shunts, the assumptions tend to more moves of shorter rakes. On the other hand, it is assumed that very short rakes of a few wagons would be jointly transferred to the differing terminals.

The resulting occupation time is shown in Table 77.

Table 77: Estimation of occupation times

Commodity	train/day				relevant trains		group	shunting factor		on crossing		relevant shunting		occupation time		
	1435		1520		1435	1520	length	1435	1520	1435	1520	moves on crossing		per move [s]		total [s]
	in	out	in	out			[m]					1435	1520	1435	1520	
Container	5.9	8.0	6.3	2.3	8	6.5	600	1.25	1.42	2.0	1.0	20.00	9.21	236	350	7937
RoRo	5.6	3.5	0.0	0.0	6	0	600	1.25	1.42	2.0	1.0	15.00	0.00	236	350	3536
Oil	0.0	0.0	0.1	0.0	0	0.5	200	3.75	4.25	2.0	0.5	0.00	1.06	179	217	230
Fertilizer	0.1	0.0	1.0	0.0	0.5	1	300	2.50	2.83	2.0	2.0	2.50	5.67	193	250	1899
Wood	0.4	0.9	0.1	0.0	1.5	0.5	200	3.75	4.25	2.0	0.5	11.25	1.06	179	217	2239
Metal	0.0	0.0	0.0	0.0	0.5	0	200	3.75	4.25	2.0	0.5	3.75	0.00	179	217	670
Building materials	0.7	0.6	0.0	0.1	1.5	0.5	200	3.75	4.25	2.0	0.5	11.25	1.06	179	217	2239
Chemicals & paper	0.6	1.0	0.0	0.0	2	0.5	200	3.75	4.25	2.0	0.5	15.00	1.06	179	217	2909
Solid mineral fuels	0.0	0.8	0.0	0.0	1	0	200	3.75	4.25	2.0	0.5	7.50	0.00	179	217	1339
											□	**86.25**	**19.13**		s	**22998**
															min	383
															h	**6.39**

Although an occupation time of less than 6 h 30 min per day is not problematic yet, it has to be noted that such occupation rate already causes significant interference between the moves. This applies both, within each and between the systems. As a result, the assumed volumes can be handled on this particular element, but not all of them at the desired time. Consequentially, certain protractions in the shunting operation will occur. The extend of such protractions depend on the particular organization of the works. Risks could be mitigated in cooperation with private terminal developers (Muuga Dry Port has expressed readiness to develop 1435/1520/trailer loading solutions).

Alternative layout options:

Alternatives A I and AIIIb:

A request was made, why in the envisioned container/Ro-Ro terminal at the site of the coal terminal the 2 loading tracks 1520 mm are not directly side-by side to avoid crossing of the 1435mm tracks. The new terminal consists of 2 modules, which are supposed to be constructed successively according to the identified demand. Therefore, it is not predictable yet, which track will be needed at which stage, but it is most likely that each module will need a 1520 mm loading track. As in all other drawings and sketches, the displayed solution is just exemplarily to show the technical feasibility, but it is no substitute for a proper design which has to address the details before construction.

The same applies to all other track arrangements in loading terminals and a number of other details.

A similar situation exists for the shunting yard (station) that also is supposed to be constructed in phases. The cargo flow, the handling technology and the resulting dimensioning are based on assumptions. The assumptions were chosen to most likely exclude later necessary extensions, but it includes potential for later optimisation. To indicate a phasing for particular elements on this basis is possible, but cannot be sincere and would create a risk to mislead future planning steps.

Alternative A I:

Changing 1435 mm and 1520 mm track in existing TK container terminal to avoid 1 crossing of both gauges is not possible, since the curve to the second part (TK 400) of the TK container terminal would be too tight.

Alternative A IIIb:

On request of the Client, a separate turnout track to serve the existing TK container terminal is added as option. It runs parallel to the connecting tracks (1435 mm and 1520 mm) from the stations to the Western terminals on their Northern side, lowering to underpass the road bridge in its most Northern opening with sufficient structural gauge. The lowering will be kept until the end of the track at Hoidla tee, providing an additional safety for the road against runaway trains.

This optional turnout track has a useable turnout length of 570 m. Establishing it would require considerable earthworks to lower it under the lower existing opening of the road bridge. Therefore, the option is rather expensive. On the other hand, the existing old track to the TK terminal may be used as turnout track for the TK terminal as well, where such restrictions do not apply. Concerns about hampering the road traffic on the road crossing (Hoidla tee) are hardly justifiable, considering that only 6.5 container / RoRo trains per day are forecasted for the 1520 system as maximum, with likely at least half of it using the larger new terminal at the coal terminal territory. Furthermore, Hoidla tee is of importance mostly for the TK terminal, which can be accessed alternatively without crossing the track. The Eastern parts of the port will receive another access road for the new container/RoRo terminal anyway, decreasing the demand for internal road traffic on Hoidla tee.

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