Justification of Junfied Geodetic Network for Rail Transport Infrastructure Project Rail Baltica

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1. THE NEED FOR THE DEVELOPMENT OF GEODESIC NETWORK FOR THE RAIL BALTICA PROJECT

Rail Baltica is a new railway infrastructure project aimed at integrating the Baltic States into the European railway network. Five European Union countries are participating in the project: Poland, Lithuania, Latvia, Estonia and, albeit indirectly, Finland. Rail Baltica will reach a maximum speed of 249 km / h for passenger transport and 120 km / h for freight transport (Rail Baltica – simtgades…, [b.g.]; Eiropas standarta platuma…, [b.g.]).

The total length of the Rail Baltica route is 870 km, of which:

- 213 km in Estonia;
- 265 km in Latvia;
- 392 km in Lithuania (Tehniskie rādītāji, [b.g.]).

During the research, the project implementers have identified discrepancies in coordinates and altitudes at the national borders in the event that the project is implemented using the existing coordinate and altitude systems provided separately in each of the Baltic States. Already at the initial design stage, it was found that a mismatch in the plane of almost 6 m would form on the Estonian-Latvian border and a mismatch in the plane of almost 2 m on the Latvian-Lithuanian border. As well as the use of different height systems in separate countries for the implementation of one project creates a height mismatch on cross-border sections that reach a mismatch of at least 10-15 cm.

This result contributes to the need to introduce a single geodetic network, which would also benefit the operational phase and the further development of Rail Baltica's railway infrastructure.

In order to implement the railway infrastructure project Rail Baltica in Latvia, the project implementers have set a requirement to provide a unified geodetic network for the project

implementation, which would support not only the design and construction phase, but also the operation phase and further railway infrastructure development.

The existing and used geodetic support systems in the Baltic States are provided with different accuracy classes and the density of points in these network classes is not sufficient to build a high-speed railway project.

Evaluating the accuracy of the geodetic support systems used in the Baltic States and their network point classes, it is concluded that the existing geodetic support systems do not provide a permanent geodetic support system for the implementation of projects, the design and construction of which determine high accuracy. Therefore, the authors propose to use the Global Geodetic System WGS-84 for the implementation of Rail Baltica's unified geodetic network, which provides a unified coordinate system on a global scale and eliminates coordinate differences in different countries. And in order to be able to use Rail Baltica's unified geodetic network also at the national level, it must be connected to the respective State geodetic network within each Baltic state.

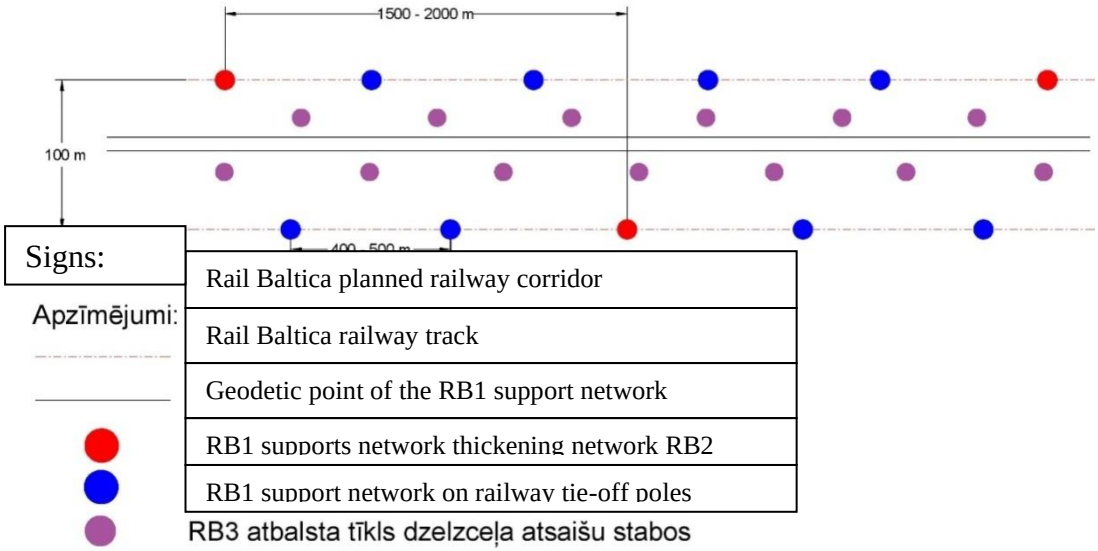
2. LOCATION AND CONSTRUCTION OF SINGLE GEODESIC NETWORK POINTS

Within the framework of the research, the location of the main route of the railway infrastructure project Rail Baltica in Bauska region is studied in order to study the necessity and possibilities of the introduction of the geodetic network in the territory of Latvia.

In the study area, which was selected for Bauska region, it was found that there is no point of the National or Local Geodetic Network in the vicinity of the Rail Baltic sub-route, which could be used as an additional point in the establishment of a unified Geodetic network of Rail Baltica. It can be concluded from the research of the territory that in the process of creating a unified geodetic Rail Baltica it is necessary to envisage geodetic points to be rebuilt and strengthened in nature.

Rail Baltica's unified geodetic network is planned to be located in the territory of the railway corridor, the width of which is approximately 100 m. The authors assign the following classification to the Rail Baltica geodetic network:

- RB1 - the first class of the geodetic network, which would be strengthened against the World Geodetic System WGS-84 used in the Baltic States; average distance between points1500 - 2000 m depending on the terrain situation and location at a distance of 50 m from Rail Baltica track axles;
- RB2 - the second class of the geodetic network, which would be fixed against the RB1 class or would be introduced as an RB1 thickening network; average distance between points 400 - 500 m depending on the terrain situation and location 50 m from Rail Baltica track axles;
- RB3 - brand railway tie-off poles to ensure railway control during operation; the tie-down poles are placed at a distance of 80 - 100 m from each other and at a distance of 2 m from the track center line; for the preparation of a unified geodetic network the author assumes a distance between the tie-off poles of 100m (InstallingCatenary Masts, [b.g.]). For a layout of the items, see picture 1.1.



1.1.picture. Unified geodetic network point layout scheme (Source: created by the author)

Rail Baltica's unified geodetic network will be implemented using three geodetic network point classes to achieve the highest possible accuracy. It is necessary to implement RB1 networks in all Baltic States, ensuring uniform use of the network and ensuring the

same accuracy, which would be the core network for the implementation of RB2 and RB3 networks, thus ensuring the unity of networks in all Baltic States.

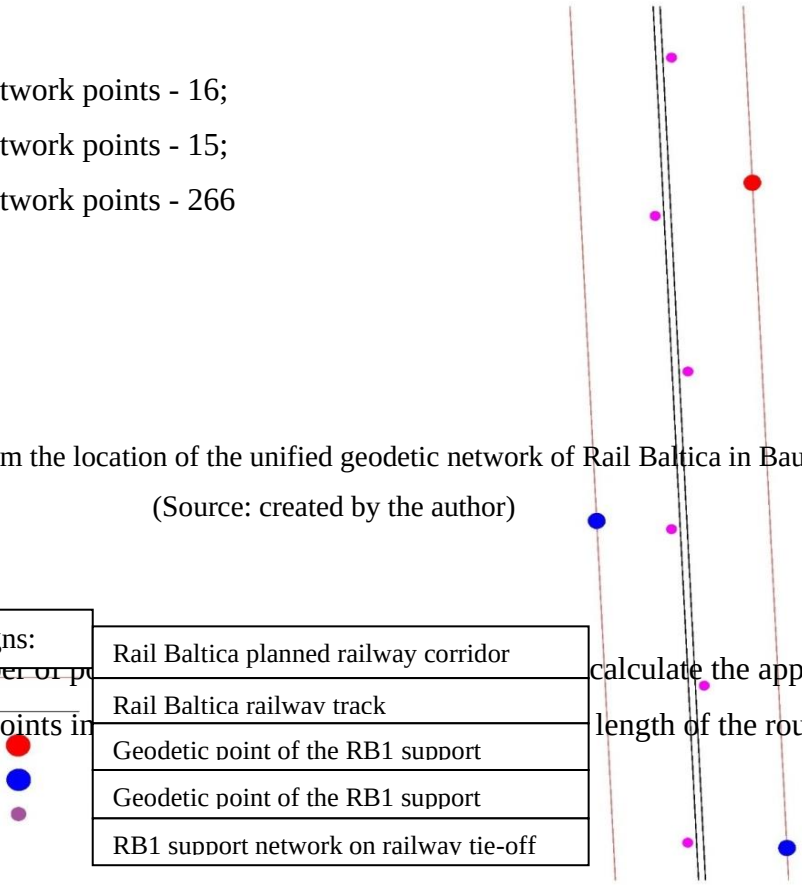
Network classes RB1 and RB2 would ensure the construction of railway foundations, while network class RB3 would ensure the unloading and construction of high-precision railway tracks, as well as ensure the maintenance of the railway during operation.

As the points of the RB1 and RB2 geodetic networks are intended to provide both a horizontal and a vertical network, it is proposed to install the points in nature as permanent bottom marks or rappers, the center of which would be covered with a protective cover.

A separate point fixing structure is offered for each of the single geodetic point classes.

In the research area selected by the author in Bauska region, a plan for the location of points of a unified geodetic network was developed in accordance with the point layout scheme proposed by the author. in the figure (see Figure 1.2). The points of the geodetic network with classes RB1 and RB2 were located, indicating the area of the protection zones specified in the Protection Zones Law within a radius of 5 m from the point of the geodetic network. The following number of Rail Baltica unified geodetic network points are located in Bauska region:

- RB1 network points - 16;
- RB2 network points - 15;
- RB3 network points - 266



1.2. Excerpt from the location of the unified geodetic network of Rail Baltica in Bauska region (Source: created by the author)

From the number of points in [illegible] calculate the approximate number of required points in [illegible] length of the route in

Bauska region and in each of the Baltic States. The distribution of points by country is shown in the table (see Table 1.1).

1.1. table

Number of required points to be installed in the Baltic States (Source: created by the author)

Posms	**Length (km)**	**RB1 points**	**RB2 points**	**RB3 points**	Together :
Bauska municipality	*27*	*16*	*15*	*166*	*197*
Estonia	213	126	118	1309	1553
Latvia	265	157	147	1629	1933
Lithuania	392	232	218	2410	2860
Together:	870	515	483	5348	

The location of the points in the geodetic network may be different, taking into account various influencing factors, such as visibility, railway structures, terrain, ground clearance, etc., but maintaining the specified distance between the points defined in the classes:

- RB1 - mutual point distance 1500 - 2000 m;
- RB2 - mutual point distance 400 - 500 m;
- RB3 - the mutual point distance is assumed to be 100 m, as this distance is assumed as the location of railway tie-offs at the tracks.

3. RAIL BALTICA UNIFORM GEODESIC NETWORK MEASUREMENT METHODOLOGY

The implementation of Rail Baltica's unified geodetic network is planned to be implemented through three classes of geodetic networks, gradually achieving the required high accuracy for the construction of railway infrastructure. In the initial stage with the global positioning system it is necessary to introduce a geodetic network for geodetic control for future works. These

networks then need to be properly compacted to form a geodetic network that will be used for precise track placement. (Gikas, 2005).

The introduction of the first point class of the Rail Baltica unified geodetic network, connecting it to the WGS-84 with GPS devices, will ensure the unity of the geodetic network in all Baltic countries, thus eliminating coordinate discrepancies on cross-border sections of the country.

The accuracy of geodetic network points proposed by the author is as follows:

- Survey of RB1 network points with global positioning technology in static method versus WGS-84 system, height is determined by leveling;
- Measurement of RB2 network points with a tachometer, securing it against the RB1 network;
- RB3 network point measurement is provided by various measurement methods, providing high-precision measurements with a mean error of +/- 1 mm.

An important requirement for the establishment of this geodetic network is to ensure its unity for the implementation of one project in all three Baltic States - Estonia, Latvia, Lithuania. To meet this requirement, the authors propose to create a first-class network RB1 in all Baltic countries, surveying it with the global positioning method, using several surveying stations in the surveying process. To measure the second class network RB2 with a tachymeter against the already implemented first class network, but to implement the third class network RB3 so that it can be measured with both a tachymeter and a leveler, as well as with remote sensing technologies.

4. BENEFITS OF INTRODUCING A SINGLE GEODESIC NETWORK

Just like the Rail Baltica railway infrastructure project, the implementation of a unified geodetic network of Rail Baltica is a novelty in the Baltic States and the geodetic industry, which will provide accurate coordinates with uniform accuracy in the implementation of this project in the Baltic States.

The implementation of a unified geodetic network provides an opportunity to introduce elements of novelty in the already existing process of geodetic network development regulated by regulatory enactments.

The main and only beneficiary of the implementation of Rail Baltica's permanent unified geodetic network would be the Rail Baltica railway infrastructure project, as the requirements for its development were set aside to the Rail Baltica project.

The introduction of such a geodetic network would eliminate the discrepancies of coordinates for the implementation of one project in several countries, which results in more serious problems - discrepancies at the national border sections, without providing the possibility to implement a single project in several countries.

The introduction of a single geodetic network would not only eliminate errors on cross-border sections, but would also make it possible to start surveying railway infrastructure from anywhere on the route, as well as ensure uniform accuracy throughout the route.

Rail Baltica's unified geodetic network would also be unique in that the Baltic States have so far not practiced creating a permanent, unified geodetic network for the implementation of a separate project in order to ensure high-quality project implementation.

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