Rail Baltica
Coordinated by RB Rail

DESIGN GUIDELINE

GEODETIC NETWORK ESTABLISHMENT FOR CONSTRUCTION STAGE OF RAIL BALTICA HIGH SPEED RAILWAY

RBDG-MAN-039-0100

Revision: 1.0

Author: Geogios Papastamos

Date: 28.11.2022

Document Development and Approval:

Ownership	
Document Owner	Virtual Design and Construction Department

Approved by	Decision No.	Date
CTO	-	06.06.2022
RB Rail MB		28.11.2022

Document History

This document has been issued and amended as follows:

Revision	Issue Date	Author	Issue purpose	Description of changes
1.0	20.05.2022	Georgios Papastamos	First issue	Technical specification for implementation of Geodetic Network during design stage
2.0				

Contents

ACRONYMS AND ABBREVIATIONS

The following acronyms and abbreviations are used throughout this document:

Abbreviation	Definition
BIM	Building Information Management. Set of technologies, processes and policies enabling multiple stakeholders to collaboratively design, construct and operate a Facility in virtual space. Including PIM (project information model) and AIM (asset information model).
BoQ	Bill of Quantities. An itemised list of classified materials, parts, and labour together with their unit cost and description what is basis for cost calculation, required to construct, install, maintain, and/or repair the infrastructure, specifically extracted from Rail Baltica BIM models.
CDE	Common Data Environment – RB Rail AS/Client is the owner of this platform. It is a central repository where construction project information is housed.
CP	Control Point – geodetic marks/benchmarks to be built in order to create new geodetic network for implementation of High-Speed Railway.
DG	Design Guideline. Set of predefined and standardized technically and economically justified engineering and design solutions for Rail Baltica infrastructure to be applied at design, construction and operation phases of Rail Baltica Railway, which forms an integral part of this Technical Specification. The Design guidelines may be changed by the Client, therefore, the Agreement always refers to the most current version of the Design guidelines.
DRCHS	Digital Information Requirements for Construction and Handover Stages.
DTD	Detailed Technical Design of Rail Baltica project.
EIR	Employer's Information Requirements. BIM Requirements which define the information that will be required from the Consultant for the development of the project and for the operation of the completed built asset.
GIS	Geographic Information System.
INS	Inertia navigation system.
PUO	Public Utility Organisations/Owners.
RB ELL22	The Unified Project dedicated coordinate system along the whole Rail Baltica Project Corridor.
RBDatum	The Geodetic Reference System dedicated to the Rail Baltica Project.
RBR	RB Rail AS.
SSP	Supervision Service Provider – service provider awarded with an Agreement to conduct supervision services for construction or railway and geodesy network construction specified in this document.
TBM	Tunnel Boring Machine.
TGMT	A Railway track geometry measuring trolley system.

DEFINITIONS

The following terms are used throughout this document:

Term	Definition
BIM Model	3D models containing information (PIM & AIM).
Contractor	Service provider awarded with an Agreement to conduct Rail Baltica highspeed railway construction Services specified in chapter 2 in this document
Client	RB Rail AS.
Country	Republic of Estonia/Republic of Latvia/Republic of Lithuania.
Programme	Representation (including graphical) of the time schedule, tasks and milestones agreed between the Consultant and Client at the initial stage of the Agreement's implementation and forming a part of legal obligations of the Consultant.
Rail Baltica highspeed railway	New 249 km/h conventional double track electrified European standard gauge (1435 mm) railway line on the route from Tallinn through Pärnu - Riga -Panevėžys - Kaunas to Lithuanian - Polish border, with the connection of Kaunas - Vilnius.
ORDER 0-3 Network	The hierarchy of the Project's Geodetic Network. (0 is the highest order) consisting of control points (CP).
Primary Geodetic Network	This network is indicated by two levels: Order 0 (CP0) and Order 1 (CP1).
Secondary Geodetic Network	This network is indicated by two levels: Order 2 (CP2) and Order 3 (CP3).
Service Provider	Service provider awarded with an Agreement to conduct supervision services for construction or railway and Geodesy network construction specified in this document.
Digital Format	For drawings, 2D or 3D, is a vector format (.dwg, .dgn, .dxf, .ifc and etc). For Tables or lists in xls, or ASCII format. Documents in word, or ascii format.

1 Introduction

1. The following technical specifications are made to make sure that Rail Baltica highspeed railway construction accuracy is in accordance with all applicable legislation and standards in all Baltic states and to ensure that all parties (e.g. designer, contractor, authorities, supervision etc.) are working in the same reference system to consolidate the planning, designing and to coordinate construction and maintenance.

2. It is mandatory that geodetic network for Rail Baltica project must be optimal in respect of geometry, accuracy and reliability. For this purpose, a dedicated to the Project geodetic network will be implemented, which will be connected to the local States Coordinate Systems to assure high accuracy during construction works, supervision and maintenance.

1.1 Geodetic Network

3. The Service provider shall follow EU directives, all Country's construction and other national legislation, EU standards, Country-specific legislation/standards/rules and other legal acts applicable for the provision of construction of geodetic network and construction supervision services.

2 Reference system

4. It is within the intention of RBR to establish a unified Reference System, along the whole corridor alignment. This Reference system (RBDatum) will be based on the Global Reference System WGS84. Due to the Rail Baltica project alignment length, it is important to define a coordinate projection system with the following characteristics:

    (a) Low distortion of engineering grids

    (b) Continuous, without different projection parameters zones, able to extend for kilometres

    (c) Unique scale factor along the alignment at ground level

5. When it is completed, it will be the RB ELL22 unified Project dedicated Coordinate System, applicable along the whole alignment of Rail Baltica Project.

6. A high accuracy levelling traverse will run along the whole alignment to secure internal geometry and will also be a part of the RB ELL22 system.

7. RBDatum will be directly connected to each country local coordinate system (presented in Table 1) and will have dedicated Coordinate System RB ELL22 when it is established.

Table 1. Countries' Coordinate and Altimetry systems

Country	Horizontal	Vertical
Estonia	L-EST 97	EH2000
Latvia	LKS-92	LAS-2000,5
Lithuania	LKS94	LAS07

8. In each country, all design and construction shall be carried out according to local coordinate system RBDatum. At cross-border section in addition to local coordinate system, WGS84 shall be used for seamless connection of neighbouring sections.

9. For acquisition of WGS 84 system, cross calculation parameters can be used, either country wide parameters or locally applied parameters. Precision calculation parameters shall be assessed with Static positioning. Cross calculation parameters shall be coordinated and approved with SSP.

10. If benchmarks are not installed accordingly, its Contractor's responsibility to construct all levels benchmarks according to this document chapter 3.

2.1 Detailed Technical Design and existing geodetic network

11. To create the RBDatum unified geodetic network Order 0, along Rail Baltica railway line, concrete monuments shall be constructed approximately every 5Km along the alignment, at accessible locations, not more than 2Km far from the designed railway alignment, that will be connected to the national geodetic grid.

12. Existing national networks shall be investigated to provide highest accuracy necessary for implementing high speed railway (Figure 1).

13. In addition, Geodetic benchmarks built by DTD Designer will be evaluated and -according to the results- included as a part of the geodetic network.

14. During Detailed Technical Design new benchmarks are going to be built. According to Detailed Technical Design Designer is obligated to build at least two benchmarks at the beginning and end of every design section in addition to benchmarks along the railway line in distance of 2-4 km that are built to connect survey area with national geodetic grid. At Cross-Border section Designer is obligated to build 5 geodetic benchmarks in distance of 2,0 km extending both sides of neighbouring countries. If benchmarks are not installed accordingly, its Contractor's responsibility to construct benchmarks according to this document chapter 3.

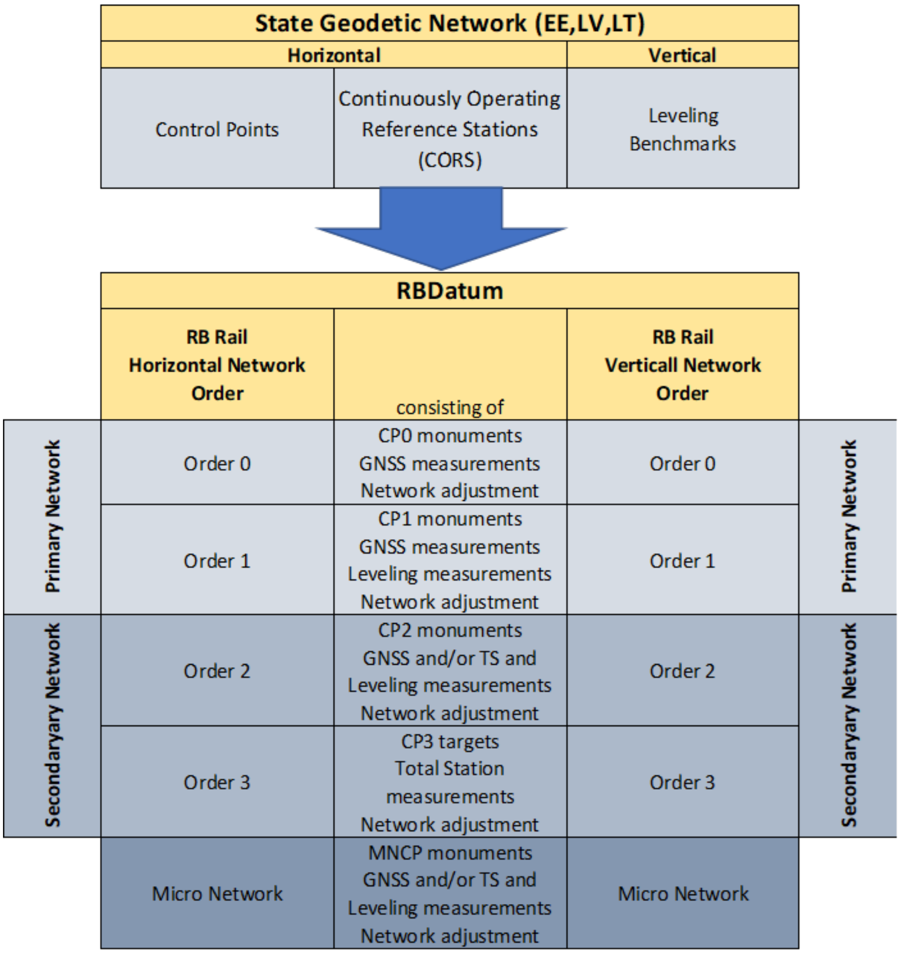

Figure 1. Geodetic Networks Classification

2.1.1 Estonian national geodetic network

15. Estonian national geodetic network system consists of three different classes of geodetic reference points:

(a) I class – 13 points (12 ground points and 1 GNSS). Distance between points 70-110 km with square error +/- 1 cm accuracy.

(b) II class – 199 points. Average distance between points is 15 km with square error +/- 1 cm accuracy.

(c) Densification Network – 3922 points. Average distance between points is 5 km with square error +/- 1...3 cm.

16. In Estonia, the heights of the EVRS system are denoted by the abbreviation EH2000. The calculation of EH2000 heights was based on the EVFR2007 solution (Solution 201703 / NKG2005LU). Heights' accuracy is estimated at +/- 1,7mm. The Reference Ellipsoids and Datums, as well as the Map Projections that are mainly used in each country and for Rail Baltica Design Studies stage are summarized in the following tables of paragraphs 2.2.

2.1.2 Latvian national geodetic network

17. Geodetic reference system of Latvia is formed by geodetic coordinate system of Latvia (hereinafter LKS-92) and normal heights system of Latvia (hereinafter LAS-2000.5). Implementation of the model of the geodetic reference system in an area shall be ensured by the national geodetic network.

18. LKS-92 shall be realized by Class 0, Class 1 and Class 2 markers of the global positioning network and system of permanent global positioning base stations "Latvian Positioning System" (hereinafter - LatPos):

    (a) Class 0 of the global positioning network (G0) with an accepted standard deviation 0 mm (4 points);

    (b) Class 1 of the global positioning network (G1) with the standard deviation 20 mm versus a network of Class G0 (41 point);

    (c) Class 2 of the global positioning network (G2) with the standard deviation 25 mm versus a network of Class G1 (752 points);

    (d) LatPos base stations with the standard deviation of co-ordinates 20 mm versus a network of Class G0 (48 pcs).

19. LAS-2000,5 shall be realized by Class 1 and Class 2 markers of the levelling network:

    (a) Class 1 of the levelling network (N1) with the standard deviation 1.0 mm/km (1911 point);

    (b) Class 2 of the levelling network (N2) with the standard deviation 2.0 mm/km (606 points).

20. The Reference Ellipsoids and Datums, as well as the Map Projections that are mainly used in each country and for Rail Baltica Design Studies stage are summarized in the following tables of paragraphs 2.2.

2.1.3 Lithuanian national geodetic network

21. Lithuanian national GNSS network consists of four different class of geodetic points:

    (a) 0 class – 4 points: Akmeniškiai (point code number – 34S-0311), Dainavėlė (point code number – 52S-0409), Meškonys (point code number – 73S-0312), Šašeliai (point code number – 55S-0408). Error of these points with respect to the initial geodetic points of the European geodetic networks shall not exceed 9 mm;

    (b) I class – 48 points. Distance between points 40 km, error of these points with respect to the initial geodetic points of 0 class geodetic networks are less than 6 mm;

    (c) II class – 1026 points. Distance between points 7-10 km, error of these points with respect to the initial geodetic points of 1 class geodetic networks are less than 5 mm;

    (d) III class - density of geodetic points of the network – 1 point / 5 km2. The position error of the geodetic points of the third class GPNS network with respect to the initial geodetic points of the first and second class GPNS networks shall not exceed 5 cm.

22. The Reference Ellipsoids and Datums, as well as the Map Projections that are mainly used in each country and for Rail Baltica Design Studies stage are summarized in the following tables of paragraphs 2.2.

2.2 Baltic Reference data

23. This paragraph identifies all data related to existing situation of Refence systems in 3 Baltic states. Table 2 and 3 is summarized information for The Consultant to use this data during Geodetic Network implementation process.

Table 2. Local Reference Ellipsoids/Datums data

Country	Estonia	Latvia	Lithuania
Country identifier	EE	LV	LT
CRS identifier	EE_L-EST97 / EST_LAMB	LV_LKS-92 / LV_TM	LT_LKS94 / LT_TM
CRS valid area	Estonia	Latvia	Lithuania
CRS scope	Coordinates of Points of the National Geodetic Network of Estonia		
CRS remarks		The LKS-92 coordinates are determined from the final solution of the EUREF BAL92 GPS-campaign	The LKS94 coordinates are determined from the final solution of the EUREF BAL92 GPS-campaign
Datum identifier	L-EST97	LKS-92	LKS94
Datum alias		Latvijas geodeziska koordinatu sistema 1992 (Latvian Geodetic Coordinate System 1992)	Lietuvos koordinačių sistema 1994 (Lithuanian Coordinate System 1994)
Datum type	geodetic	geodetic	geodetic
Datum anchor point		4 points of the EUREF BAL92 GPS-campaign	4 points of the EUREF BAL92 GPS-campaign
Datum realization epoch	1997	1992	1994
Datum valid area	Estonia	Latvia	Lithuania
Datum remarks	The ETRS89 coordinates are derived from the final solution of EUREF-ESTONIA97 in ITRF96, Epoch 1997.56 by transformation Estonia. In Gubler, E., Torres, J.A., Hornik, H. (eds): Report on the Symposium of the IAG	LKS-92 is consistent with ETRS89; LKS-92 is based on Resolution Number 213 of the Government of Latvia of June 4, 1992	LKS94 is consistent with ETRS89 see Resolution Number 936 of the Government of Lithuania of September 30th, 1994

Country	Estonia	Latvia	Lithuania
	European Reference Frame (EUREF) held in Prague, 2-5 June		
Prime meridian identifier	Greenwich	Greenwich	Greenwich
Prime meridian Greenwich longitude	0°	0°	0°
Prime meridian remarks			
Ellipsoid identifier	GRS 80	GRS 80	GRS 80
Ellipsoid alias	New International	New International	New International
Ellipsoid semi major axis	6 378 137 m	6 378 137 m	6 378 137 m
Ellipsoid shape	TRUE	TRUE	TRUE
Ellipsoid inverse flattening	298.2572221	298.2572221	298.2572221
Ellipsoid remarks	see Moritz, H. (1988): Geodetic Reference System 1980. Bulletin Geodesique, The Geodesists Handbook, 1988, Internat. Union of Geodesy and Geophysics	see Moritz, H. (1988): Geodetic Reference System 1980. Bulletin Geodesique, The Geodesists Handbook, 1988, Internat. Union of Geodesy and Geophysics	see Moritz, H. (1988): Geodetic Reference System 1980. Bulletin Geodesique, The Geodesists Handbook, 1988, Internat. Union of Geodesy and Geophysics

Table 3. Local Map Projections

Country	Estonia	Latvia	Lithuania
Coordinate system identifier	EST_LAMB	LV_TM	LT_TM
Coordinate system type	projected	projected	projected
Coordinate system dimension	2	2	2
Coordinate system axis name	northing	X / northing	X / northing
Coordinate system axis direction	North	North	North
Coordinate system axis unit identifier	metre	metre	metre

Country	Estonia	Latvia	Lithuania
Coordinate system axis name	easting	Y / easting	Y / easting
Coordinate system axis direction	East	East	East
Coordinate system axis unit identifier	metre	metre	metre
Operation identifier	EST_LAMB	LV_TM	LT_TM
Operation valid area	Estonia	Latvia	Lithuania
Operation method name	Lambert Conformal Conic Projection with 2 standard parallels	Transverse Mercator Projection	Transverse Mercator Projection
Operation method name alias		Gauß Krüger Projection	Gauß Krüger Projection
Operation method formula	Lambert Conformal Conic Projections, in Snyder, J.P., Map Projections – A Working Manual, Washington 1987, pages 107-109	Transverse Mercator Mapping Equations, in Hooijberg, Practical Geodesy, 1997, pages 81-84	Transverse Mercator Mapping Equations, in Hooijberg, Practical Geodesy, 1997, pages 81-84
Operation method parameters number	6	6	6
Operation parameter name	lower parallel	latitude of origin	latitude of origin
Operation parameter value	58°00’ N	0°	0°
Operation parameter remarks		0°, the Equator	0°, the Equator
Operation parameter name	upper parallel	longitude of origin	longitude of origin
Operation parameter value	59°20’ N	24° E	24° E
Operation parameter name	latitude grid origin / zero parallel	false northing	false northing
Operation parameter value	57°31’03.19415” N	-6 000 000 m	0 m
Operation parameter name	longitude grid origin	false easting	false easting
Operation parameter value	24°00’ E	500 000 m	500 000 m

Country	Estonia	Latvia	Lithuania
Operation parameter remarks		only one zone	only one zone
Operation parameter name	false northing	scale factor at central meridian	scale factor at central meridian
Operation parameter value	6 375 000 m	0.9996	0.9998
Operation parameter name	false easting	width of zone	width of zone
Operation parameter value	500 000 m	6°	6°
Operation parameter remarks		only one zone of 6° width with central meridian 24° E for LV in use	only one zone of 6° width with central meridian 24° E for LT in use

2.3 Geodetic control network accuracy and reliability requirements

2.3.1 Network structure – Control Points Classification

24. RBDatum Geodetic control network is classified in four different types of Control Points with different density level. (Figure):

    (a) CP0 – ORDER 0 Network control points every 5Km- highest precision primary level of network;

    (b) CP1 – ORDER 1 Network control points every 1.0Km-1.5Km- primary level of network;

    (c) CP2 – ORDER 2 network control points every 400m- secondary level of network;

    (d) CP3 – ORDER 3 network control points on Catenary posts- secondary level of network;

    (e) MNCP – Micro-Networks- directly connected to ORDER 0-3 levels and used for bridges, tunnels, and other structures.

25. All prepared data shall be integrated into RBR GIS platform and updated according to provided data. Prepared material shall be useable and linked with DTD designed BIM models. ORDER Network is described in this document chapter 3.2.

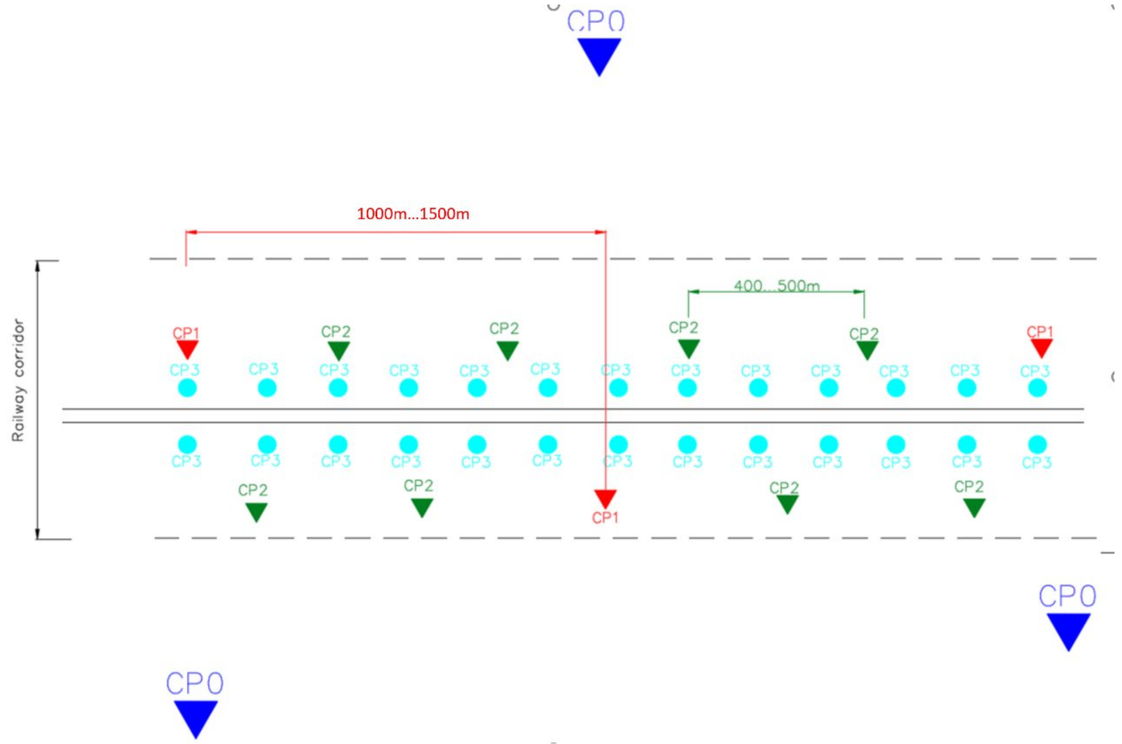

Figure 2. Scheme of CP for Rail Baltica project

3 Geodetic Network workflow

3.1 General instructions to the Contractor

26. The survey works needs to be carried out by Contractor during the construction of the Rail Baltica Project and this task shall include the following:

    (a) Establishment throughout the entire alignment length, of a unified basic horizontal network and a unified levelling control network within RB Rail Reference System (RBDatum) and connection with the already existing one (Figure 3).

    (b) Establishment of ORDER 1-3/MNCP (and ORDER 0, if its not implemented) horizontal and levelling control networks connected with the basic networks.

    (c) Updating of the topographical diagrams and compilation of new ones, where required, with connection to the basic horizontal and levelling control networks (ORDER 0-3 and MNCP).

    (d) Compilation of the cadastral diagrams and tables, when it is requested by local legislations.

    (e) Constant geometrical control of the alignment, stations, bridges, platforms, tunnels, etc. after their construction (for all construction phases).

    (f) Constant control to preserve the geometrical elements of the structures.

(g) “As Built” survey of structures upon completion of the permanent lining, as well as “As Built” survey of the Public Utility Objects network diversions and the reinstatement of all areas occupied for the Project needs.

(h) Establishment of horizontal and levelling networks for the construction of the trackwork connected with the permanent horizontal and levelling control networks.

(i) Constant geometrical control during the construction of trackwork (per section).

(j) “As Built” survey of the lines after the completion of the trackwork.

(k) Establishment of permanent horizontal and levelling control networks after the completion of all works in stations, tunnels, and bridges, which shall be connected to the basic and/or secondary horizontal and levelling control network.

(l) Constant control and update of all CPs geodetic networks, according to Table 4. All raw, postprocess data and results shall be submitted for approval to the Service and RB Rail.

Table 4. Geodetic Network Control Frequency

Network	Construction stage				Operational stage	
	before	active	inactive	after	before	active
CP0	once	annually	annually	biennially	once	biennially
CP1	once	biannually	annually	biennially	once	biennially
CP2	once	weekly	biannually	biennially	once	annually
CP3	-	-	-		once	biannually
Micro	once	weekly	biannually	biennially	once	annually

<table>
<tr><th></th><th colspan="3">RBDatum</th><th></th></tr>
<tr><th>obligation of</th><th>RB Rail Horizontal Network Order</th><th>consisting of</th><th>RB Rail Verticall Network Order</th><th>obligation of</th></tr>
<tr><td>Designer Consultant</td><td>Order 0</td><td>CP0 monuments
GNSS measurements
Network adjustment</td><td>Order 0</td><td>Designer Consultant</td></tr>
<tr><td rowspan="4">Contractor</td><td>Order 1</td><td>CP1 monuments
GNSS measurements
Leveling measurements
Network adjustment</td><td>Order 1</td><td rowspan="4">Contractor</td></tr>
<tr><td>Order 2</td><td>CP2 monuments
GNSS and/or TS and
Leveling measurements
Network adjustment</td><td>Order 2</td></tr>
<tr><td>Order 3</td><td>CP3 targets
Total Station measurements
Network adjustment</td><td>Order 3</td></tr>
<tr><td>Micro Network</td><td>MNCP monuments
GNSS and/or TS and
Leveling measurements
Network adjustment</td><td>Micro Network</td></tr>
</table>

Figure 3 Geodetic Network Obligation Status

27. All topographic measurements shall be accompanied by the required corrections due to pressure, temperature, and refraction.

28. For all survey works, the Contractor is obliged to obtain the approval of the Service and to update Service daily.

29. All topographical data (raw data, coordinates files, drawings) shall be stored in digital form and shall be transmitted to the Service immediately attached to submittals respectively and/or through e-mail provided it is requested by the Service and at a frequency that would have been mutually determined.

30. For all survey works required for the design and construction of the Project, RBDatum shall be used.

31. The Service shall supply the Contractor with all required topographical information upon which the existing design of the Project has been based.

32. The Contractor is responsible for verifying the adequacy and completeness of any information provided to him, related to every aspect of the Project. Moreover, the Contractor is responsible to update and supplement all diagrams and compile new diagrams at a width of at least 75m on either side of the Project's symmetry axis and at an area width of at least 100m at the locations of stations and shafts and wherever required. All topographical measurements, survey works, alignments, updating of drawings, compilation of new drawings, etc., shall be performed with the exclusive use of terrestrial methods.

33. All survey measurements, as well as the calculations, the results, and the drawings for all the survey works herein shall be submitted for approval to the Service in digital form too and shall be signed by the Chief of the Contractor's Survey Department.

34. The planning of the alignments and surveys (as well as their implementation) shall always be carried out based on hierarchy, starting from the general drawings which shall contain the reference data and the boundaries of the detailed drawings, to avoid any omissions and discrepancies on the detailed drawings.

35. The Contractor is obliged to submit to the Service for approval the organization chart of the personnel that shall staff the Survey Department, as well as the CVs, and the previous employment record certification, for all the above personnel, either executives or auxiliary personnel. The Survey Department shall consist of the Chief of the Department who shall be a University Graduate Survey Engineer. The requested experience shall be defined from the IB issuing the construction Tender, relative to the size and particularity of each Project. Indicatively, the head Surveyor must have been possessing at least 5 years of experience in projects of small scale and requirements, while for a country scale project (e.g. Latvia main rail) shall be of over 20 years. Moreover, it shall consist of experienced survey crews, while the Head of each crew shall be a University Graduate Survey Engineer who shall execute all measurements and shall have years of experience in projects of similar scale and requirements.

36. Alternatively, the Heads of the crews can be Technical Institute Graduates in a similar field, possessing 5 years of experience.

37. More specifically, as regards the Survey Crews to conduct all survey measurements related to the trackwork needs, the Heads shall be University Graduate Survey Engineers, with 5 years of experience in projects with special requirements and involving a degree of accuracy as required by topographical works for trackwork applications, who shall be approved by Service.

38. The entire personnel of the Department shall be adequate at any time – in terms of number and experience – to cover the needs of the Project.

39. For specific Geodetic/Surveying works depending on Country requirements level of surveyor for certificate might be different depending on local legislation (example of EE country in table 5). Contractor should execute in house indication of surveyor's levels for each works according to the example presented in Table 5.

Table 5. Level of certificate requirements for EE

Network level	Level of certificate required	Subcategory of certificate required
CP0	Level 7	Higher Geodesy (Geodetic networks)
CP1	Level 7	Higher Geodesy (Geodetic networks)
CP2	Level 6 or 7	Construction Geodesy or Higher Geodesy (Geodetic networks)
CP3	Level 6 or 7	Construction Geodesy or Higher Geodesy (Geodetic networks)
Local	Level 6 or 7	Construction Geodesy

3.1.1 Method Statement

40. For all the above and before the commencement of the Project's construction works, the Consultant is obliged to submit to RB for approval the Methodology for the execution of all Survey Works. Method Statement shall include but not limited to the following references. Content of information to be included in the document is presented in Table 6.

Table 6. Method of survey works content for Consultant

No.	Content topics
1.	General part -Introduction
1.1	Summary description of the project
1.2	Contractual obligations
1.3	Staffing of the survey department
1.4	general description of the methodology
2.	Reference Network
2.1	Establishment & increase of networks
2.2	Existing conditions
2.3	New network requirements
2.4	Preliminary activities
2.5	Contents of the submittals
2.6	Equipment
2.7	Solution methods, accuracy
2.8	Software
2.9	Maintenance
3.	Theoretical data
3.1	General description
3.2	Requirements
3.3	Software
3.4	Submittals
3.5	Forms
3.6	Approvals
3.7	Files

No.	Content topics
4.	Surveys works
4.1	General description
4.2	Requirements
4.3	Methods
4.4	Equipment
4.5	Software
4.6	Forms
4.7	Approvals
4.8	Submittals
5.	Health & safety
5.1	General description
5.2	Equipment
5.3	Conditions
5.4	Transportation
6.	Exchange of data with the Client/Service
6.1	General description
6.2	Templates of electronic files
6.3	Forms
6.4	Frequency
6.5	Storing
6.7	Filling

41. All the above shall be approved and inspected by the Service and RBR within regular time periods to be agreed upon, based on the progress of the construction works. The Service shall carry out the required inspections using the appropriate checklists.

42. The completeness of the survey works methodology is an essential factor, to timely resolve any possible deficiencies and problems that may affect the operation of the monitoring system of the construction works. Therefore, the submitted methodology must be approved by the Service and RBR, and any eventual comments must be considered by the Contractor. The recording of the results and the filing is performed based on the project's segmentation into Sections, as specified in advance. Data shall be provided according to RB Rail Design Guideline requirements. It is evident that the structure of the documents' filing system must be

accompanied by the appropriate digital data format for the purpose of the correct and immediate data exchange with RBR.

3.2 Basic Surface Network (CP0) - ORDER 0

3.2.1 Horizontal network (CP0) – ORDER 0

43. Control Point 0 (CP0). The CP0 Horizontal Network is the highest precision primary level network which is basic and most important Geodetic Network of the Project, for the following reasons:

    (a) It is the connection between the RBDatum Geodetic Network and each country's State Geodetic Network. (Horizontal and Vertical);

    (b) all activities including densification of networks are referred to this network (CP0);

    (c) it is the most accurate of all networks related to the project (ORDER 1-3, MNCP);

    (d) it will be the asset that will remain for all stages of the project (construction & operation).

44. CP0 horizontal network should be delivered to the Contractor. During the Construction Tendering period, the Tenderer shall check whether the CP0 Network is completed -according to the TS-by RB Rail, or not. If not, the Tenderer shall consider in his Financial Offer that he will take over the construction of the benchmarks and the measurements, respecting the instructions of this document and in constant communication with RB Rail Survey Coordinator. All the raw data of the measurements should be delivered to RB Rail for Postprocessing and Adjustments.

45. Control points (CP0) will be constructed along the railway corridor at intervals of approximately 5Km, not more than 2Km away from the alignment, at easily accessible locations and outside the influence zone of the Project or related roads.

46. The locations for CP0 construction should be at solid ground, with 10° from horizon clear sky view (no trees, structures, or other obstacles), not close to electric power lines. The positioning of these points shall be defined in cooperation with the Service.

47. Construction specifications for CP0 type of Benchmarks (monuments) are presented in Annex 1 of this document.

48. Measurements of this network shall be based on the GPS system, while the coordinates shall be given based on RBDatum reference system and the WGS84 reference system. The above network shall be linked with at least three points of the State reference network, for a length of 50Km of alignment.

49. The network shall be connected to at least three (3) points of the closest Continuously Operating Reference Stations (CORS) (EstPos, LatPos, LitPos), or Similar Private compatible included to the State Geodetic Points Database.

50. CP0 points shall be measured using Static Positioning method to get sub centimetre horizontal accuracy (Semi major error ellipsis axis ≤10 mm).

51. Real Time Kinematic Positioning is forbidden.

52. CP0 Network measurements shall be carried out according to these instructions (Figure 4):

(a) Per receiver setup at least 9 independent baselines should be measured simultaneously (3 to CORS, 2 to State Benchmarks, at least 4 to neighbouring CP0 control points)

(b) GDOP should be less than 7 and number of satellites more than 10.

(c) Acceptable occupation times for Static at 95% confident level and Double Frequency Receivers: 20 min + 2min per km (the longest baseline of a setup should be considered for this calculation).

(d) Recommended epoch rate: Static -15s.

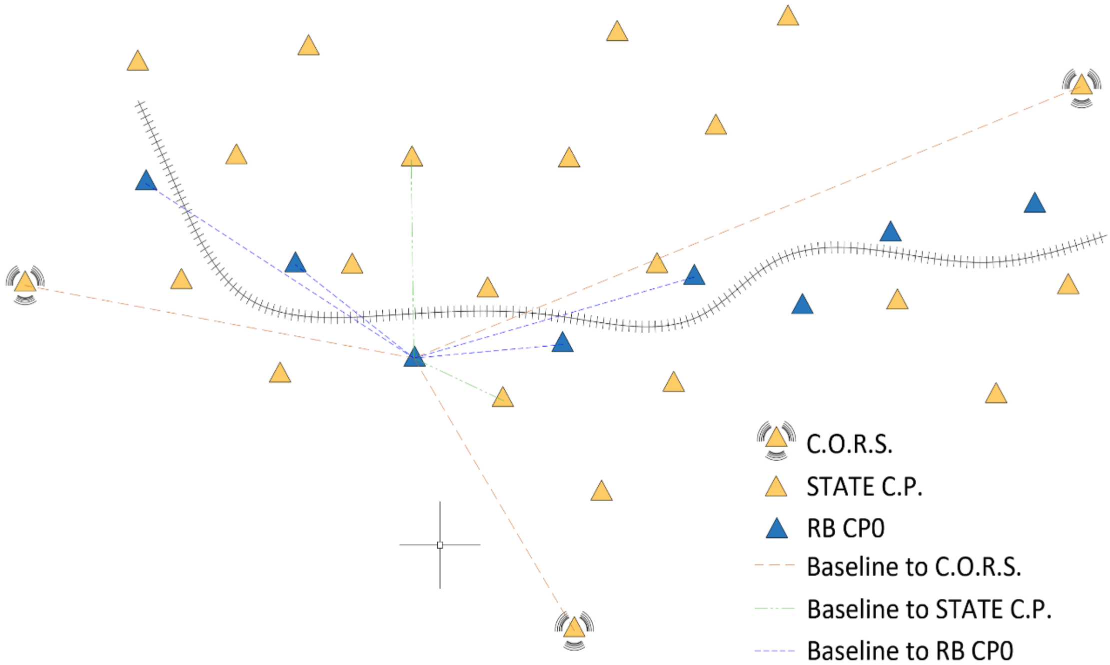

Figure 4. Scheme of GNSS baselines for each CP0 of Rail Baltica project

53. The solution and the adjustment of the network shall be carried out with the use of the appropriate software (using the method of the least squares), at a three-sigma confidence level. The coordinates shall be given based on the RBDatum reference system and on the WGS84 reference system, with the respective accuracy and standard deviations.

3.2.2 GNSS receivers minimum required specifications

54. To achieve correct accuracies, it is needed to follow these steps:

(a) dual-frequency with at least 9 channels;

(b) accuracy in static tracing shall be Hz ±(3 mm + 0,1 ppm) / V ±(4 mm + 0,5 ppm);

(c) ability to receive at least GPS L1, L2 and Galileo E1, E5a, E5b signals.

3.2.3 The software for the processing of the GPS

55. The software processing GPS measurements shall be capable to:

(a) be used in Windows environment and to trace the location using all tracing techniques - import / export Rinex files, as well as to produce reports for each executed work;

(b) transfer data, process data bases, automatically selecting the bases for solution and controls;

(c) control the closing of triangles / polygons;

(d) to resolve networks, change the reference systems (datum) and programming of measurements;

(e) select a local reference system that has been entered by a user;

(f) automatic conversion of coordinates to any reference system;

(g) select the geoid model;

(h) output results in various formats such as .dxf, ascii and other, to be compatible with all CAD and GIS systems;

(i) to perform automatic hierarchy of unified solution of data concerning the static and kinematic tracing (post processing kinematic & RTK) and conventional ground level observations;

(j) to perform automatic conversion of kinematic measurements after the solution of statistics using Least Squares Methodology;

(k) final coordinates values must be given showing to 3rd decimal.

56. The GPS system and the software to be used shall be submitted to the Service for approval.

3.2.4 General rules

57. The identification of the points of the basic horizontal network shall be permanent and, in a way, ensuring its preservation during the construction of the Rail Baltica project, as well as for their future use.

58. The methodology for the above works shall be submitted to the Service for approval, prior to the commencement of works.

59. The Contractor is responsible to maintain the points of the above network, and in case wear or obstacles is observed, the Contractor shall proceed to the replacement of the affected points and their incorporation into the basic horizontal network upon its re-measurement and re-calculation.

60. The above network shall be checked periodically, in time intervals to be agreed with the Service (in any case not greater than on-year intervals), while in case of disagreement among the results, the network shall be re-adjusted (paragraph 3.1 point (l)).

61. The primary measurements, the calculations, the results, their accuracy, the description, the securing of the points and the network diagrams shall be submitted each time to the Service in a digital form as well.

62. To achieve quality measurements bad weather conditions such as heat haze, heavy rain or fog, should be avoided when observations are made.

63. In case of high closure error, measurements shall be repeated.

3.2.5 CP0 Levelling Network

64. CP0 Levelling Network should be delivered to the Contractor. In case that by the commencement day, the CP0 Network is not completed by RBR, then the Contractor shall take over the measurements, respecting the instructions of this document and in constant communication with RB Rail Survey Coordinator. All the raw data of the measurements should be delivered to RB Rail for Postprocessing and Adjustments. The Contractor is entitled to be paid for this work.

65. The CP0 elevation control network will be established at the CP0 monuments, with elevation benchmarks as described at the monument's construction specifications.

66. This network will be measured by means of geometrical levelling traverses allet-retour and will be related with each State elevation network; moreover, it shall consist of an adequate number of loops, to ensure the maximum possible accuracy at its adjustment phase. The geometric levelling traverses shall be open, fully constrained on both ends to the levelling benchmarks of the existing State elevation network.

67. The elevation points shall be calculated using the least squares adjustment method. The accuracy of measurements of the network shall be in the order of ±1mm/Km.

68. The instruments to be used shall be high precision digital levels, with a minimum accuracy of ±0.7mm/Km, along with their corresponding invar rods to achieve the accuracy required and shall be submitted to the Service for approval. Hardware adjustment for environmental conditions shall be applied to the digital levels at least once per day, according to the temperature variations during the day.

69. The identification of the points of the levelling network shall be permanent and, in a way, ensuring their preservation during the construction of the Project, as well as for their future use.

70. The Contractor is responsible to maintain the points of the above network, and in case he observes any damages or obstacles, he shall proceed to the replacement of the affected points and their re-integration into the basic elevation network through its re-measuring and re-calculation.

71. The above network shall be checked periodically, in time intervals to be agreed with the Service (in any case not greater than on-year intervals), while in case of disagreement among the results, the network shall be re-adjusted.

72. The measurements, the calculations, the results, the description, the securing of the points and the network diagrams shall be submitted to the Service in a digital form as well.

73. The maximum length of a sight must be 40 meters, and the back sight/fore sight lengths from the same level station should be approximately equal.

74. To achieve quality measurements bad weather conditions such as heat haze, heavy rain, heavy wind or fog, should be avoided when observations are made.

75. In case of high closure error (values from Annex 1, table 14), measurements shall be repeated.

3.2.6 Horizontal network (CP1) – ORDER 1

76. The CP1 Horizontal Network is the connection between the CP0 Geodetic Network and the denser CP2 Geodetic Network. It shall consist of mutually visible pairs of points, while each one of the subject points shall necessarily be mutually visible with its immediate previous and subsequent point along the alignment. Mutual visibility is necessary to be achieved before the establishment of CP3 Geodetic Network (that the RoW will be clear), but not before.

77. Control points (CP1) shall be constructed by the contractor along the railway corridor at intervals of approximately 1.0Km-1.5Km, within the limits of the Project, but outside the influence zone of the Project.

78. The locations for CP1 construction should be at solid ground, with 10o from horizon clear sky view (no trees, structures, or other obstacles), not close to electric power lines. The positioning of these points shall be defined in cooperation with the Service.

79. Construction specifications for all CP types of Benchmarks (monuments) are presented in Annex 1 of this document.

80. Measurements of this order network shall be based on the GPS system, while the coordinates shall be given based on RBDatum reference system and the WGS84 reference system. The above network shall be linked with at least two neighboring points of the CP0 network.

81. CP1 points shall be measured using Static or Fast Static Positioning method to get sub centimetre horizontal accuracy (Semi major error ellipsis axis ≤10 mm).

82. Real Time Kinematic Positioning is forbidden.

83. CP1 Network measurements shall be carried out according to these instructions:

    (a) Per receiver setup at least 5 independent baselines should be measured simultaneously (2 to CP0 Benchmarks, at least 3 to neighbouring CP0 control points)

    (b) GDOP should be less than 7 and number of satellites more than 10.

    (c) Acceptable occupation times for Double Frequency Receivers, Static at 95% confident level: 20 min + 2min per km (the longest baseline of a setup should be considered for this calculation), and Fast Static at 95% confident level: 8 min + 1 min per km

    (d) Recommended epoch rate: Static -15s, Fast/Rapid Static - 5 or 10s

84. GNSS receivers minimum required specifications:

    (a) Dual frequency with at least 9 channels.

    (b) Accuracy in static tracing shall be Hz ±(3 mm + 0,1 ppm) / V ±(4 mm + 0,5 ppm);

    (c) Ability to receive at least GPS L1, L2, L5 and Galileo E1, E5a, E5b, signals.

85. The solution and the adjustment of the network shall be carried out with the use of the appropriate software (using the method of the least squares), at a three-sigma confidence level. The coordinates shall be given based on the RBDatum and on the WGS84 reference system, with the respective accuracy and standard deviations.

86. The software for the processing of the GPS measurements shall be the same of CP0 specifications. (3.2.3)

87. The GPS system and the software to be used shall be submitted to the Service for approval.

88. The identification of the points of the basic horizontal network shall be permanent and, in a way, ensuring its preservation during the construction of the Rail Baltica project, as well as for their future use.

89. The methodology for the above works shall be submitted to the Service for approval, prior to the commencement of works.

90. The Contractor is responsible to maintain the points of the above network, and in case wear or obstacles is observed, the Contractor shall proceed to the replacement of the affected points and their incorporation into the basic horizontal network upon its re-measurement and re-calculation.

91. The above network shall be checked periodically, in time intervals to be agreed with the Service (in any case not greater than on-year intervals), while in case of disagreement among the results, the network shall be re-adjusted. (paragraph 3.1 point (l))

92. The primary measurements, the calculations, the results, their accuracy, the description, the securing of the points and the network diagrams shall be submitted each time to the Service in a digital form as well.

93. To achieve quality measurements bad weather conditions such as heat haze, heavy rain or fog, should be avoided when observations are made.

94. In case of high closure error, measurements shall be repeated (values from Annex 1, table 14).

3.2.7 ORDER 1 Levelling Network

95. The ORDER 1 elevation control network will be established at the CP1 monuments, with elevation benchmarks as described at the monument's construction specifications. (Annex 1, figure 9 and 10).

96. This network will be measured by means of geometrical levelling traverses allet-retour and will be related with CP0 elevation network; moreover, it shall consist of an adequate number of loops, to ensure the maximum possible accuracy at its adjustment phase. The geometric levelling traverses shall be open, fully constrained on both ends to the levelling benchmarks of the CP0 elevation network.

97. The elevation points shall be calculated using the least squares adjustment method. The accuracy of measurements of the network shall be in the order of ±1mm/Km.

98. The instruments to be used shall be high precision digital levels, with an accuracy of ±0.7mm/Km, along with their corresponding invar rods to achieve the accuracy required and shall be submitted to the Service for approval. Hardware adjustment for environmental conditions shall be applied to the digital levels at least once per day, according to the temperature variations during the day.

99. The identification of the points of the levelling network shall be permanent and, in a way, ensuring their preservation during the construction of the Project, as well as for their future use.

100. The Contractor is responsible to maintain the points of the above network, and in case he observes any damages or obstacles, he shall proceed to the replacement of the affected points and their re-integration into the basic elevation network through its re-measuring and re-calculation.

101. The above network shall be checked periodically, in time intervals to be agreed with the Service (in any case not greater than on-year intervals), while in case of disagreement among the results, the network shall be re-adjusted.

102. The measurements, the calculations, the results, the description, the securing of the points and the network diagrams shall be submitted to the Service in a digital form as well.

103. The maximum length of a sight must be 40 meters, and the back sight/fore sight lengths from the same level station should be approximately equal.

104. To achieve quality measurements bad weather conditions such as heat haze, heavy rain or fog, should be avoided when observations are made.

105. In case of high closure error, measurements shall be repeated (values from Annex 1, table 14).

3.3 Horizontal network (CP2) – ORDER 2

3.3.1 Surface networks for horizontal and vertical control

106. The secondary horizontal control network (CP2) shall be implemented following the densification of the Primary (CP1) horizontal control network at locations mutually visible, fairly close to the alignment (not more than 40m away) in order to be used for the Project construction, at intervals of 400m-500m. These locations shall be defined in communication with the Service. It shall depend on at least two points of the Primary horizontal network.

107. CP2 points shall be measured from CP1:

    (a) a. using Static or Fast Static methods (applying the specifications of CP1 Geodetic Network-) until before the superstructure stage and/or

    (b) b. using Total Station measurement traversing method. For superstructure measurements (especially determining rail geometry) ONLY open traverse, constrained at both ends from CP1 shall be used to achieve millimetre accuracy. Following requirements shall be respected:

    (c) 2 full periods of observation (4 series) at each station shall be done. If the series closure is higher than the given tolerance accuracy tolerances, the 2 periods of observation shall be repeated.

    (d) Inner accuracy 1 mm point accuracy (horizontal + vertical) (Inner accuracy: between the total station and prism; Distance and angle measurements + Automatic Target Recognition to a prism).

    (e) To achieve quality measurements bad weather conditions such as heat haze, heavy rain or fog, should be avoided when observations are made.

108. The Contractor is responsible for the maintenance, the periodic checking and the replacement and re-definition (if necessary) of the points of the secondary horizontal network. The angular accuracy of the instruments to be used in the measurement of the network shall be 1” (0,3mgon) and at the distance of ±(2mm+2ppm) or better; the instruments shall be submitted to the Service for approval.

109. The Contractor ought to update, be in constant communication with the Service and submit the measurements, the calculations, the results, the diagrams, the descriptions, and the securing of the points in a digital form as well.

110. For the alignment and construction of the project, it shall be required to establish a horizontal network to be correlated on the Primary horizontal network with at least two (2) points of the Primary horizontal network (CP1 or higher order). The network to be developed for the alignment needs of the basic project and is within the influence zone of the Works must be checked regularly and – in any case – at least once a month.

111. Marking of the network points shall be made through an appropriate method approved by the Service.

112. For the network established, in line with this paragraph line 109, the Contractor shall submit to the Service the relevant measurements, calculations, results, diagrams, descriptions and securing of the points in a digital form as well.

113. The secondary elevation network (CP2) shall result following the densification of the Primary (CP0, CP1) elevation network with new benchmark points, as dictated by the needs of the construction works.

114. The establishment and the measurement of this network shall be carried out through geometrical levelling traverses allet-retour fully constrained on both ends with the benchmark points of the Primary elevation network.

115. The method of establishment, measurement and calculation and the accuracy of the measurements, the instruments and the submittals for this network shall be the same as those of the Primary elevation network. (Paragraph 3.2.5)

3.3.2 Underground networks for horizontal and vertical control

116. As far as underground Works are concerned, such as tunnels or stations, it is required to establish an underground horizontal control network which shall use the surface horizontal network as a reference network.

117. The connection to the surface network shall be carried out with the establishment of a secondary horizontal network which will be correlated with at least three points of the surface horizontal network.

118. The underground horizontal network shall have the appropriate length of sides to fit the characteristics of the tunnel alignment (not larger than70m.). The marking of the control points of this network shall be permanent, so that this marking be secured against any eventual damage due to the execution of construction works.

119. The expansion and densification of the underground horizontal network shall be affected by means of a method ensuring the control, each time a new point is established and measured. For this reason, at least two points of the surface horizontal network shall be used; however, these points shall be checked at regular time intervals from the surface horizontal network.

120. After the completion of the tunnel excavation works, the underground network must be measured once more by means of correlation on both ends (of the constructed tunnel) with at least four (4) points of the surface horizontal network, located in the areas of the two portals, with measurements and calculations of the same period.

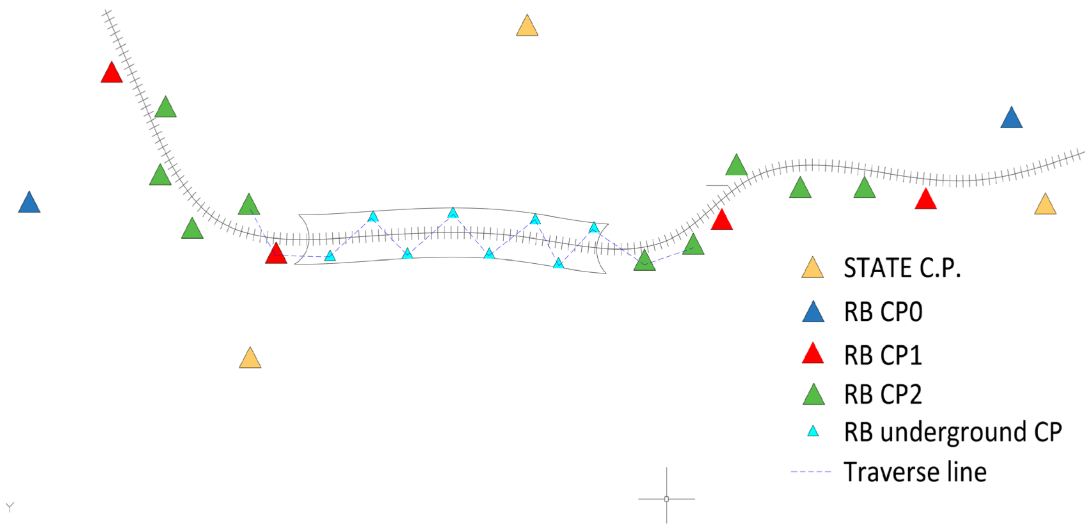

Figure 5. Scheme of underground Network traverse line

121. The underground horizontal networks shall be measured by instruments whose precision shall be ±2" (0.5mgon) for angles, and ±(2mm+2ppm) for distances.

122. The adjustment of the underground horizontal network shall be affected using the least squares method. The measurements, calculation and the results shall be submitted to the Service in digital form too. The method used for the measurement and processing, the software and the instruments must be approved by the Service.

123. In case of TBM use, the underground horizontal network shall be established as mentioned above, while its densification for the TBM alignment shall be affected through a network whose sides shall not be greater than 50m.

124. This network shall be controlled on a regular basis and the coordinates of the points shall be re-calculated, if necessary, and always in communication with the Service.

125. For the establishment of the underground levelling control network as reference network, the Secondary surface levelling network shall be used, which shall be checked in the same period by the Primary levelling network for any eventual deformation due to the execution of construction works. The underground network shall be established by lowering the surface network at a minimum of two points within the tunnel or the station. The points to be established from this lowering shall be used in the establishment of a network consisting in levelling traverses along the tunnel or the station.

126. The measurement of the levelling traverses shall be affected by means of open geometrical levelling traverses allet - retour, fully constrained on both ends (with the lowered elevation points).

127. The instruments to be used for the measurements shall be levels with a precision of +1mm/Km. The underground vertical network shall be checked at regular intervals to be agreed with the Service.

128. Underground benchmark points shall be established approximately every 50m and their marking shall be permanent.

129. The method of measuring, the instruments, and the software to be used shall be submitted to the Service for approval before the commencement of the works.

130. The underground elevation network shall be adjusted using the least squares method. The measurements, the calculations and the results shall be submitted in a digital form as well.

3.4 Horizontal network (CP3) – ORDER 3

131. CP3 points are for high precision construction and maintenance of track. CP 3 will be located on the catenary masts.

132. The specifications pertaining to the establishment of these networks are the same with those mentioned in paragraph 3.3.2 of this document.

133. The locations of the points of these networks shall be selected in communication with the Service. The measurement data, the measurement method, the calculations, the results, the securing, the marking of the points and the diagrams for these networks shall be submitted to the Service for approval in a digital form as well.

134. Contractor shall be aligned with IBs before installing the CP3 benchmarks on catenary masts for defining their type, position, orientation and density, in order to be compatible with the Track Geometry Measuring Trolley(s) that IBs owe or will purchase, to monitor the rails during operation.

3.5 Micro-network Control Point (MNCP)

135. Micro-network control points (MNCP) shall be placed close to structures of high construction standards (e.g. bridges, tunnels, stations, overpasses, etc) but outside the influence zone of the structure. Micro-networks can be used for Deformation Monitoring as well.

136. Micro-networks have increased density of control points around each structure and are of high precision internal geometry. The location of each MNCP should offer clear line of sight to the structure and to as many as possible other MNCPs, to strengthen the network. Specifications of type of Benchmarks (monuments) are presented in Annex 1, figure 9 and 10 of this document.

137. MNCP points can be directly connected with the CP0 and/or CP1 Network (Horizontal and Vertical).

138. The horizontal control micro-network (MNCP) shall be implemented close and around the structure, at such locations that as many MNCP as possible are mutually visible. These locations shall be defined in communication with the Service. It shall depend on at least two points of the CP0, CP1 and CP2 horizontal networks. (Figure 6)

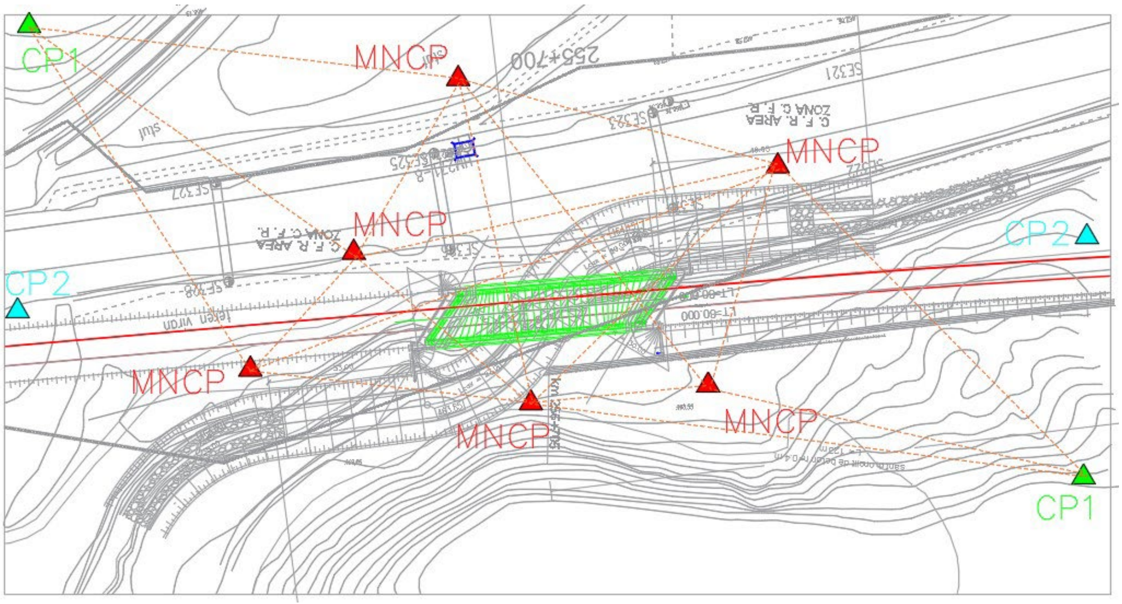

Figure 6. Scheme of a Micro Network

139. MNCP points shall be measured from CP0, CP1 or CP2, using Static or Fast Static methods (applying the specifications of CP1 Geodetic Network) and Total Station measurements.

140. From each MNCP, 2 full periods of observation (4 series) towards all other visible MNCP shall be done. If the series closure is higher than the given tolerance accuracy tolerances, the 2 periods of observation shall be repeated.

141. The solution and the adjustment of the network shall be carried out with the use of the appropriate software (using the method of the least squares), at a three-sigma confidence level. The coordinates shall be given based on the RBDatum reference system and on the WGS84 reference system, with the respective accuracy and standard deviations.

142. Inner accuracy 1 mm point accuracy (horizontal + vertical) (Inner accuracy: between the total station and prism; Distance and angle measurements + Automatic Target Recognition to a prism).

143. To achieve quality measurements bad weather conditions such as heat haze, heavy rain or fog, should be avoided when observations are made.

144. The Contractor is responsible for the maintenance, the periodic checking and the replacement and re-definition (if necessary) of the points of the secondary horizontal network. The angular accuracy of the instruments to be used in the measurement of the network shall be 1” (0,3mgon) and at the distance of ±(2mm+2ppm) or better; the instruments shall be submitted to the Service for approval.

145. The Contractor ought to update, be in constant communication with the Service and submit the measurements, the calculations, the results, the diagrams, the descriptions, and the securing of the points in a digital form as well.

146. For the network established, in line with paragraph 3.3.1 line 109, the Contractor shall submit to the Service the relevant measurements, calculations, results, diagrams, descriptions and securing of the points in a digital form as well.

147. The establishment and the measurement of this network shall be carried out through geometrical levelling traverses allet-retour fully constrained on both ends with the benchmark points of the Primary elevation network. In case the topography of the Micro-Network area is

not appropriate for levelling (steep slopes, river crossing, etc.) then the Special Trigonometric Heighting Method could be applied.

3.6 Setting out – alignment control

148. The Contractor shall carry out all survey works related to the setting out and the execution of all Rail Baltica Projects, shall process the field data, shall make the necessary calculations and shall submit any drawings required for the completion of the project.

149. All the above works, which shall be based on the Methodology of Survey Works described in paragraph 3.1.1, shall correlated with the RBDatum horizontal and elevation control network (at surface and underground levels), which shall be densified and controlled, as stipulated in the paragraphs 3.2 and 3.3 herein.

150. The Contractor shall be responsible for the correct and proper implementation of all theoretical lines, dimensions and gradients required for the construction of the project, in accordance with the construction and/or contractual documents.

151. The Contractor's instrumentation and the entire survey equipment shall be accurate, suitable for the surveys required, in compliance with the recognized technical standards and in proper condition, properly adjusted and calibrated at all times, while it shall be submitted to the Service for approval, before the commencement of each phase of the works. The surveying works shall be executed by survey crews, as these are defined in paragraph 34 line of paragraph 3.1 and who staff the Survey Department. In addition, the Contractor shall inform the Service – through a pertinent submittal – whenever a calibration of any survey instrument is performed.

152. The Head of the Survey Department, who will be in constant communication with the Service, shall have the overall responsibility for the co-ordination of the above work crews, as well as for the reliability of the networks and the accuracy of the data related to the alignment (as defined in paragraph 34 line of paragraph 3.1).

153. All original data and records shall be stored and filed by the Contractor based on the project's segmentation and in such a way to be easily accessible and comprehensible by the Service. The Service or its designated representatives shall be entitled to make use and to always check the above data. The Contractor shall provide the Service with the required equipment and personnel and facilitate the Service, or its representatives whenever and wherever so requested. The results of the measurements and calculations, as well as the calculations themselves shall be always at the Service's disposal, in a digital form as well.

154. The Contractor is obliged to provide an additional license to RBR for the software that he uses.

155. At any time during the execution of the Project, the Service reserves the option to check the overall surveying work (such as field data, measurements, lines, grades, points, markers, and drawings) or any part thereof. Regardless of whether the Service proceeds on this option or not, the Contractor shall not be released from his responsibility for the accuracy and the correctness of the surveying work. The Contractor shall be responsible for any lines, dimensions, grades, points, or measurements not complying with the applicable construction tolerances as well as for any resultant defect in the performance of Work. The Contractor shall perform all additional surveys required in view of correcting errors resulting during the construction works and /or identified by the Service's review in relation to the overall topographical surveying work or any part thereof.

156. Calculations, triangulations, and field surveys, including surveys of the main control lines in view of determining alignment of major structural elements shall be performed at the accuracy degree required by the Contract.

157. If the Contractor makes use of trigonometric points, control points and levelling benchmarks, which have been established either by himself or by any contractor before him, he shall be obliged to verify the accuracy and correctness of the surveying data provided to him and accept the responsibility for all measurements in relation to the above.

158. A map of equipment and methodologies that are not acceptable, acceptable, recommended, or mandatory, is presented at the next page. To highlight the most important surveying principals during construction, that contractor shall respect:

(a) Continuously Operating Reference Stations (EstPos, LatPos, LitPos) or Similar Private compatible included to the State Geodetic Points Database, can only be used for RTK staking out or quantity surveying of earthworks (RoW, top-soil removal, cuts, fills, foundations, consolidation, dumping or loaning areas or queries, stockpiles of materials), in general wherever a construction or installation tolerance is more than ±10cm

(b) -RTK with using Base/Rover (set up only on approved control points of any ORDER network), can be used for earthworks and small or mid-scale structures, like pile walls, culverts, fencing, and in general wherever a construction or installation tolerance is more than ±3cm

(c) -For staking out and controlling structures like, buildings, stations, platforms, bridges, overpasses, underpasses, ditches- and in general whatever is related with water flow, superstructure, and rails installation, and in general wherever a construction or installation tolerance is less than ±3cm, usage of Total Station and/or digital level with appropriate methodology with respect to the structure is mandatory.

(d) -Except the initial stage of rails installation, all the next stages till the final positioning, shall be stake out by using TGMT with GNSS/INS or TGMT with total station, to achieve the requested millimetre precision.

(e) -Equipment and accessories must be properly maintained, regularly checked, and calibrated for accuracy at the beginning of any survey project to ensure that the equipment is operating properly.

(f) - Control Points checks shall be performed prior to any construction staking to ensure the monuments have not been disturbed and are within their original RB RAIL Minimum Construction Horizontal and Vertical Accuracy Tolerance for the item being staked.

159. Table 9. of Annex1, is summarizing the equipment and methodologies accepted, recommended or rejected, depending on the stage of Project and type of activity.

3.7 Geometrical controls and “As-Built” Survey of the Works

160. The Contractor shall conduct with the required accuracy both the geometrical controls upon the completion of each individual section of the structures executed throughout all Project construction phases (consolidation, cutting, filling, subbase, base, ballast, temporary and permanent lining) for stations, tunnels, structures, the remaining buildings, as well as the “as built” survey (using surveying methods) of all Rail Baltica works upon completion of each section of the alignment. Measurements shall be executed using equipment and methodologies according to Table 9. of Annex1.

161. During the excavation phase of stations, tunnels, bridge foundations and the remaining structures, the geometrical control of the works shall be carried out approximately every 2 meters and, during the temporary and permanent lining phase, the aforementioned geometrical control shall be conducted approx. every 5 meters. The geometrical control shall be submitted to the Service, in a way to be agreed upon, upon the completion of each individual section of the structure.

162. After the completion of the construction of the permanent lining of tunnels, stations, bridges and other structures or any part thereof, the Contractor shall proceed to the accurate survey (as built survey) of the envelope approx. every 10m. In addition, after completing the construction of the buildings and the remaining structures, the Contractor shall accurately survey these buildings and their bearing elements (columns, walls, slabs, vertical axes etc.).

163. All the above works (geometrical controls and "as built" survey works) shall include the survey of the "as-built" envelope of the stations and tunnels, as well as the calculation of the horizontal and vertical offsets from the theoretical position. Based on these results, the Contractor shall submit documents presenting every measured as-built cross section as compared to its theoretical position, indicating the offset between the surveyed points and the theoretical alignment. The coordinates of each surveyed point shall be presented for every cross section, correlated both on the BIM 3D models, drawings and the documents. The Contractor will present in a diagram, complete with measurement results and the calculation method, the horizontal and vertical offsets from the as-built axis as compared to the theoretical one. Moreover, the Contractor shall provide the drawings reference numbers which are used for the theoretical base map (e.g. Layout Plan and Longitudinal Profile).

164. The data shall be submitted to the Service progressively depending on the completion of each of the above phases or part thereof.

165. The above data shall be presented in the form (to be agreed with the Service) of BIM 3D models, appropriate drawings, technical reports, containing all details related to the dimensions, the materials, etc., in a digital form as well.

166. The "as built " survey after the completion of the respective portions of the Rail Baltica projects shall include adjacent buildings, structures and installations, so as to reflect the actual situation.

167. For tunnels, the Contractor shall keep daily records for all tunnel fronts, which shall be at the disposal of the Service, upon request.

168. Moreover, the Contractor is obliged to submit designs for the reinstatement of the occupied areas, and "as-built" drawings for the reinstatement of all occupied areas, with accurate measurements at 1:200 scale.

169. Finally, the Contractor shall submit the "as-built" BIM 3D models and drawings for the PUO networks diversions (in 1:100, 1:50 scales), as well as drawings for the traffic diversions (in 1:500 scale), upon completion of the works.

170. The above "as-built" BIM 3D models and drawings shall satisfy the requirements of RBR DG and the competent Authorities and shall be submitted to these Authorities and to the Service in a digital form as well for information and/or approval.

171. For all the above topographical survey works, RB Rail reference system shall be used as reference system and the measurements shall be executed in co-relation to the ground level CP0, CP1 and CP2 horizontal and elevation control networks.

172. As-built measurements shall be done by laser scanning and/or photogrammetry devices that provide at least 1,0 cm accuracy relative to constructed geodetic network described in chapter

2 in this document. Requirements for laser scanning and photogrammetry are described in “Digital Information Requirements for Construction and Hangover stages”.

3.8 Horizontal and Elevation Network for Trackwork

173. The specifications mentioned in paragraph 3.4 of this article apply for the establishment of the CP3 horizontal and elevation network, which is based on the CP2 horizontal and elevation network and shall be used in the construction of the trackwork. In addition, all survey measurements, the calculations, and the results shall be submitted to the Service for approval in due time and in digital form as well.

3.9 Trackwork alignment and geometrical control

174. The specifications and obligations mentioned in paragraph 3.4 of this article apply for trackwork alignment and control.
175. In order to geometrically check the trackwork alignment in all construction phases, the data pertaining to the concreting of the lines (lining and levelling) shall be submitted to the Service.
176. Control measurements for track quality shall be done according to EN-13848. The values for accuracy and measurement uncertainty depend on the type of measuring system and are given in the corresponding parts of the standard EN 13848-2, EN 13848-2 and EN 13848-4.
177. Following paragraphs define additional requirements for works required by EN 13231.

3.9.1 Relative Track geometry

(a) Acceptance measurements shall be carried out within a period not exceeding 6 weeks or after passage of maximum 1 500 000 tonnes after the completion of the works.

(b) Relative track geometry shall be measured by a track recording vehicle or by a track construction and maintenance machine fitted with measuring equipment, both shall be in accordance with series EN 13848.

(c) Relative track geometry longitudinal level and alignment shall be measured for both rails using D1 and D2 wavelength measurement methods. All measurements shall be sampled at constant distance-based intervals not larger than 0,5m.

(d) Standard deviation shall be calculated for every rail separately with a section length of 200m. Measured sections shall overlap with each other.

(e) For track geometry quality number of isolated defects per 1,0 km shall be counted according to EN 13848- for following geometrical parameters.

(f) All measured tolerances shall be in compliance with EN 13231-1 Table 1 speed range 230 km/h< V ≤260km/h

3.9.2 Absolute track position

(a) Distances between tracks shall comply with tolerances for lateral position of the track. Accepted track shall comply with AP2 class in Table 3 in EN 13231

(b) Geodetic measurements for verification of the absolute track positions shall be done using geodetic reference system built by Contractor.

3.9.3 Other parameters and verifications.

(a) SSP shall measure squareness of the sleepers. Permissible deviations from squareness of the sleepers shall be +/-10 mm

(b) Accepted ballast cross section shall comply with the tolerances in EN 13231 Table 3.

3.10 As-Built Survey of the Trackwork

178. After the completion of the trackwork construction, submittal shall be made to the Service of the As-Built BIM 3D models and drawings, survey data (coordinates, elevations, gradients), as well as any deviations from the theoretical line.

179. In order to preserve the characteristic points of the alignment even after the completion of the construction works, their coordinates shall be submitted to the Service and the respective horizontal and vertical data shall be placed on the catenary masts in a plasticized form.

3.11 Construction Tolerances

180. The methods adopted by the Contractor for checking the alignment - implementation of the Works and tolerances shall be subject to the Service's approval. No tolerances beyond those specified in the Contract documents or/and construction drawings shall be permitted.

181. During the construction, the Contractor may be required to remove and replace in a correct manner any section of the Project including, but not limited to, concrete linings, piles and structural reinforced concrete works which have been constructed outside the specified tolerances. In this case, the Contractor shall propose eventual remedial measures for the Service's review. It is at the Service's exclusive discretion to decide whether these measures are acceptable or whether full reconstruction in accordance with the specification is required. In case the Service accepts works of a lower quality or smaller dimensions as compared to the specified ones, then the appropriate cuts in the Contract Price shall be made.

182. Before delivery of the works Contractor shall perform all necessary measurements for railway track to define compliance for minimum tolerances according to EN 13231. Control measurements for track quality shall be done according to EN-13848. The values for accuracy and measurement uncertainty depend on the type of measuring system and are given in the corresponding parts of the standard EN 13848-2, EN 13848-2 and EN 13848-4.

3.12 Updating and supplementing of the topographical diagrams

183. The Contractor is obliged to convert all topographical diagrams provided to him and which shall be in different reference systems, to diagrams using the RB Rail system as a reference system.

184. The Contractor is obliged and responsible to constantly update the survey drawings with data obtained from the surface and underground level networks and structures, as these structures keep changing until the completion of the works, as well as after their completion, and compile new diagrams, wherever required. All measurements and diagrams shall use the RB Rail system as a reference system and all survey works shall be correlated with the basic and the secondary horizontal and elevation network of the project.

185. On the diagrams, the elevations at curbs shall be recorded at the same points in pairs, so that the height of the curbs may derive from the subtraction of the two elevations.

3.13 Construction of control points.

186. The construction of a geodetic mark and the materials used depends on the type of geodetic network and the characteristics of the soil at the location of the geodetic mark, which is determined in the design of the geodetic work and survey planning. Geodetic marks shall be secured in ground with concrete foundations with anchor placed below the freezing point of the ground. Each constructed point shall meet required accuracy tolerance between neighbouring points (Table 7).

Table 7. The accuracy tolerances are expressed as relative *ppm accuracy between neighbouring points

Point class	Horizontal accuracy (*ppm)	Vertical accuracy (*ppm)
CP1	2	1
CP2	4	1

187. Observations where distance is lower than 200 meters the maximum Hz standard deviation is 2mm.

188. CP spatial data shall be part of Rail Baltica project as BIM models, for this reason all plans and documentations shall be prepared according to DG BIM EIR general requirements. Every control point shall be identified by unique code according to DG BIM EIR requirements. Spatial data should be linked or integrated directly into the modelling structure and the data model of the BIM.

189. New control points shall be built and marked according to Rail Baltica specifications or each Baltic country local legislation:

    (a) Estonia – „Geodeetiliste tööde tegemise ja geodeetilise märgi tähistamise kord, geodeetilise märgi kaitsevööndi ulatus ning kaitsevööndis tegutsemiseks loa taotlemise kord" – 06.07.2013.

(b) Latvia – Cabinet of Ministers Regulations No.497 "Regulations for local geodetic network".

(c) Lithuania –"Dėl techninių reikalavimų reglamento GKTR 2.12.01:2001 patvirtinimo", Dėl Valstybinės geodezijos ir kartografijos tarnybos direktoriaus 2000 04 12 įsakymo NR. 28 „Dėl techninių reikalavimų reglamento GKTR 2.08.01:2000 patvirtinimo" and „Lietuvos Respublikos geodezijos ir kartografijos įstatymas".

190. Every Point Card shall have information required by local legislation and WGS84 coordinates. At cross-border sections (10km) every control point control card shall also include neighbouring country information as required by neighbouring country legislation.

191. Design life for all CP0s and CP1 shall be at least 30 years.

3.14 Cross-border section

192. Cross-border section is 10km long section that extends 5,0 km to both neighbouring countries. At Cross-border section each Control Point shall have RBDatum coordinate sets and WGS84 (Table 8).

Table 8. Cross border sections data

Estonia – Latvia border section	Latvia – Lithuania border section
WGS84 and	WGS84 and
RB ELL22 and/or	RB ELL22 and/or
L-EST97	LKS-92
LKS-92	LKS-94

193. Due to different height systems used in all Baltic States a common height system based on Amsterdam 0 shall be established in Cross border sections by the Consultant and adjusted according to required accuracy to existing height datums used in Baltic States, unless RB ELL22 is already established and delivered.

194. Contractor shall consider control points at border sections already built during DTD phase, if they are checked and proven reliable at the commencement period.

3.15 Documentation

195. Construction of new geodetic grid shall be documented according to applicable law in specific country where works has been done. In addition to requirements stated in legislation following reports shall be provided. At cross-border section control point documentation shall be done according to both neighbouring country legislation

196. In the course of the surveying works a report of measurement work shall be created which must consist of:

(a) List of measuring instruments (type, numbers and specification),

(b) Description of the measurement scheme

(c) Results of the inspection and calibration of the measurement instruments and the measurement data

(d) In the course of calculation works a report shall be created which must consist:

(e) Description of the calculation's methodology.

(f) Used software.

(g) The measurement scheme and calculation result together with the accuracy estimates.

(h) Documentation of constructed control points shall consist of following:

(i) Reference system and height system

(j) realisation;

(k) parameters;

(l) map projection;

(m) datum;

(n) sources (Official documentation of the used reference system);

(o) Control point network

(p) monumentation information including picture of control point and construction drawings;

(q) maintenance specification;

(r) list of national control points used as starting points for the horizontal and vertical control;

(s) technique used for the surveying and equipment;

(t) adjustment calculus reports, analysis and point precision (relative accuracy between points);

(u) control network drawing (static survey, traverse, levelling line);

(v) list of the new points, coordinates, heights.

197. Documentation of constructed control points shall consist of following:

198. Reference system and height system:

(a) realisation;

(b) parameters;

(c) map projection;

(d) datum;

(e) sources (Official documentation of the used reference system);

199. Control point network:

(a) monumentation information including picture of control point and construction drawings;

(b) maintenance specification;

(c) list of national control points used as starting points for the horizontal and vertical control;

(d) technique used for the surveying and equipment;

(e) adjustment calculus reports, analysis and point precision (relative accuracy between points);

(f) control network drawing (static survey, traverse, levelling line);

(g) list of the new points, coordinates, heights.

4 Construction supervision

200. Following chapter defines additional requirements for “Common minimum requirements regarding construction supervision rules” document regarding railway construction and geodetic network construction supervision services.

201. Main responsibilities:

(a) Confirming the quality of new geodetic network for constructing highspeed railway according to requirements in this document and applicable standards and legislations.

(b) Confirming that constructed volumes, layers widths and thicknesses are carried out in accordance with the project on the basis of BIM model and BOQ;

(c) Confirming that track geometry complies with minimum tolerances according to applicable standards and legislations.

(d) Continuous reporting of possible deviations during construction.

202. SSP shall:

(a) timely obtain information on the possible deviation of the construction from project conditions and data;

(b) find out the deviations between the project and as-build data and report to Client if necessary

4.1 Construction supervision plan

203. Construction SSP shall develop respective Construction supervision plan or quality control plan which must be submitted and approved by Client and respective authorities required by state law. Construction supervision plan or quality control plan regarding construction of Geodetic network and construction of high-speed railway supervision services shall consist in minimum of:

(a) construction and material quality control procedures, including descriptions of the works to be inspected, inspection frequencies, possible tests or measurements;

(b) procedures for notification of construction deficiencies and their elimination.

(c) procedures of fulfilling main tasks defined in chapter 4.2 and 4.3 in this document.

4.2 Geodetic grid construction supervision

204. To ensure the quality of construction geodetic reference system, height system and control network an External SSP shall inspect the chosen reference system, height system and the control network.

205. In accordance to high speed railway construction accuracy requirements and scope of work defined in respective local law, the SSP shall perform all necessary tasks to ensure that the quality of constructed geodetic network is in accordance to all applicable laws and standards for constructing highspeed railway.

206. The main tasks (not limited to) before construction works SSP is obligate to:

(a) to get obtained with defined requirements of design solutions for establishing of geodesy grid,

(b) to develop quality control system of geodetic works in accordance with the specifics and scope of the geodetic works to be performed;

(c) to get acquainted with Contractor developed work execution plan and quality assurance plan for geodetic works, in case of any discrepancies with respective national requirements and design solutions, object such Contractor’s proposals and give notification to Client,

(d) Review, approve and provide opinion for Contractor Survey Plan before beginning of construction works;

(e) Verify imposed standards and regulations

(f) Check and coordinate the compliance of the Contractor's subcontractors with the terms of the Contract;

(g) check and verify calibration certificates of instruments used for survey works, inform the Client about the use of non-compliant equipment;

(h) To review and approve Contractor method of railway track construction using CP2 geodetic network points to assure railway track construction tolerances according to EN 13231.

207. Main tasks (not limited to) during geodetic network construction Supervision service provides is obligated to:

(a) to be involved in construction process implementation and to check constructed control point by recording implementation data online in RB Rail AS GIS map platform and filling in required data.

(b) to constantly inform the Client about the quality and progress of the Work;

(c) check and demand compliance with Survey plan and Work execution plan during geodetic network construction.

(d) check documentation of control points.

(e) check whether prepared data is integrated into RBR GIS platform.

(f) document and submit deviations from the requirements provided in Contract and applicable legislations. Deviations shall be reported to Client immediately.

(g) to check whether all control points are constructed according to state law and Survey plan

(h) conduct regular control measurements for Control points according to procedure described in Construction Supervision plan submitted to and approved by Client.

(i) inspect and verify measurement deviations for control points (CP0, CP1, CP2, CP3, MNCP);

(j) review, and approve calculation parameters for implementing unified RBDatum and WGS 84 system across all Baltic states;

(k) review, and approve cross border established height system (systems) with existing height data in the neighbour country;

(l) make entries in the construction work log, including deficiencies found during site inspections and the absence of the responsible construction work manager in time of performed construction works;

(m) visually record (for example, in a photograph) the completion of the construction work stages specified in the construction supervision plan;

(n) inspecting the management of measurement data collected in the field and data in BIM models (designed information);

(o) Evaluate, check and, if compliance, approve the construction drawings, reports, certificates, documents certifying the conformity of materials and products, test reports of materials and works submitted by the Contractor and submit them to the Contracting Authority within 5 working days of their submission by the Contractor;

(p) verifying the final documentation produced by construction company whether implemented geodetic network is in accordance with accuracy requirements in this document and applicable standards and legislations in specific country where CP are built in;

208. Supervisory Consultant shall prepare reports of:

(a) Review of existing geodetic networks before beginning of construction works;

(b) Review, measurement verification and calculation reports produced by Contractor;

(c) final report presenting the detailed assessment and presenting non-conformities including recommendations for improvement.

(d) provides systematic and random errors of networks CP0, CP1 and CP2.

5 Construction supervision

209. To ensure the quality, preciseness, and correctness of as-built high speed railway compliance to Detailed Technical Design, Technical Specifications, BoQ and applicable European Standards, an external Supervision services shall be provided.

210. Following chapter defines additional scope of work for construction SSP.

211. Main tasks (not limited to) for SSP during Railway construction

(a) to ensure construction compliance for DTD and BoQ

(b) participate and ensure compliance with DTD and BoQ in the marking works of structural layers, track and systems

(c) conduct control measurements of railway embankment, cuttings, prepared subgrades, sub-ballast and ballast geometrical parameters (widths, thickness, volume) in order to define structural layers geometry compliance to DTD , BIM models and BoQ. Control measurements in order to define as-built drawings compliance for DTD and BoQ shall be done after 60,0m.

(d) evaluate and approve as-built models

(e) propose changes in BIM models according to approved as-built data, if necessary;

(f) construction SSP shall compare as-built data (volumes, geometry) with BIM models of DTD Design after each stage of construction works, in case of non-conformities deviations shall be reported to Client and Contractor immediately

(g) visually record (for example, in a photograph) the completion of the construction work stages specified in the construction supervision plan;

(h) Organize both work and admission committee meetings if necessary.

(i) Prepare deductions and financial calculations from the cost of the Work performed if there are changes in the volumes in the Contract or the Contractor has performed the work to a poor standard.

(j) Organize and formalize intermediate and final inspections of mentioned superstructure construction Works, approve the Contractor's application for acceptance of the Work when the Work has been completed in accordance with the Contract and submit to the Client a confirmation of completion of the Work and submit a final report within one month of issuance;

(k) create a report after completion of works for certain structural layer

212. SSP shall use measurement devices that provide at least 1,0 cm accuracy relative to constructed geodesy network described in this document. Allowable deviations and measurement methods for certain structural layer height, width, slopes, crossfalls, alignment and evenness are described in “Earthworks & Track Bed Layers technical specifications”.

6 RB Rail Additional supervision

213. Client (RB Rail) shall supervise all works mentioned in this document starting from building new Control points for geodetic network till acceptance of railway track

214. Main tasks for RB Rail supervision:

(a) Regular site visits to ensure SSP and contractor work quality.

(b) Approve SSP reports

(c) Random checks for As-built data vs. design

(d) Regular laser scanning and/or photogrammetry to follow construction work progress. Additional Supervision process using laser scanning/photogrammetry methods is described in “BIM use cases for Construction and handover stage” document in chapter “3.6.1. Regular laser scanning and photogrammetry reports from the Additional Supervision”.

(e) UAV (drone) video recording to capture construction work progress after every major construction phase. UAV video recording is described in DRCHS.

7 Unified geodetic grid for maintenance

215. An essential ingredient for successful running of a High-Speed Railway is well-developed and advance maintenance system.

216. The track condition tends to deteriorate due to external factors, such as the frequent passage of heavy trains and deformation of the track bed. These factors make the railway track drift away from its designed geometric position and result in track irregularities so accurate measurement of the track geometry is a task of fundamental importance for adjusting deformed tracks and ensuing high operational safety.

217. The overall railway track geometry condition of the existing line is inspected regularly by dedicated track inspection trains or track recording vehicles owned by the railway management department. Dedicated track inspection trains can survey at high speed, but provide only relative information which hardly conforms to the accuracy requirements in the determination of the track geometric deformation and their related localization for tasks such as precise track adjustment applications

218. Lightweight and flexible track geometry measuring trolleys (TGMTs) in combination with high precision geodetic surveying apparatus shall be used for geometry measurements of unloaded tracks, and provide follow-up accurate measurements after the dedicated track inspection train for regular maintenance of existing lines and accurate measurement for alignment, precise adjustment, or tamping applications during the railway construction stage

219. The TGMT with GNSS/INS module can realize submillimetre relative accuracy in inner track geometric parameter measurement including the track deformation/displacement or track irregularity measurement, however this is not sufficiently accurate for determining the absolute position of the track when millimetre absolute positioning accuracy is required. Therefore, TGMT with total station shall be used to get submillimetre accuracy relative to track geodetic control network. For that purpose, CP3 control points located on catenary masts shall be used by specific TGMT system.

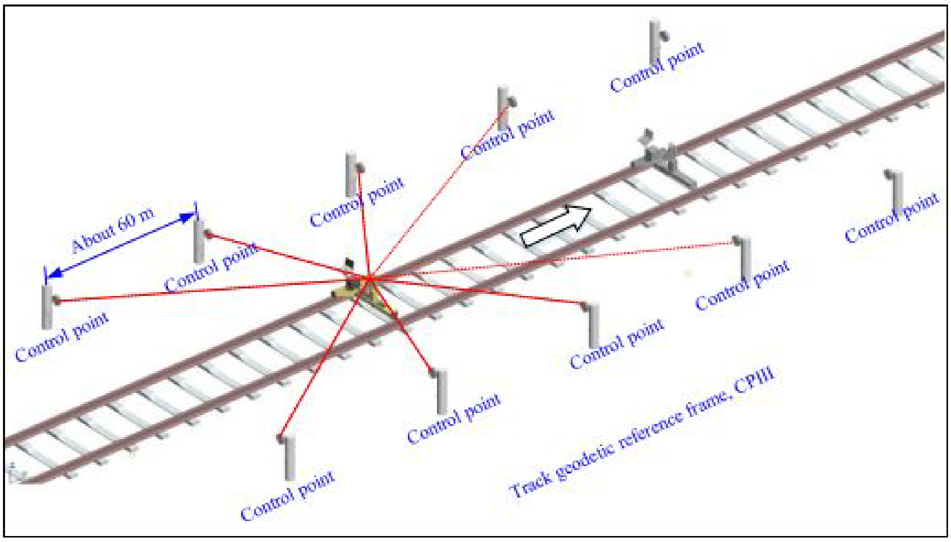

Figure 7. Maintenance with geodetic Trolley system

220. Possible deviations in operating phase will be identified using as-build data in BIM environment that is approved by Construction supervision service provider

221. To define possible embankment settlement which also infects catenary masts a regular measurement shall be done for CP3 using CP2 and CP1 implemented by Contractor during geodetic network construction.

222. Since geodetic network will be built (except WGS84) in total on 4 coordinate systems (RB ELL22, L-EST97, LKS92 and LKS94) with unified height datum it gives a variety of options for using different maintenance devices in the future, even in cross-border sections.

223. Rail Baltica project will be prepared using assets register system which will be integral system to GIS and BIM models. Infrastructure manager/r's will be responsible for Rail Baltica railways maintenance, and for automated maintenance and operational works it is obligatory to use asset register system in which to find exact location on constructed Rail Baltica railway line will help CP grid.

7.1 Alternative system for regular maintenance.

224. As Geodetic Network for Rail Baltica project will be implemented (except WGS84) in total on 4 coordinate systems (RB ELL22, L-EST97, LKS92 and LKS94) it can allow for Infrastructure manager/r's to decide to transfer this grid to unique coordinate system or to ETRS89. For choosing another system (for example ETRS89-LAEA) it will be possible by using local coordinates from every point.

225. In case of a need Infrastructure manager/r's can apply ETRS89 system for the whole Rail Baltica implemented geodetic grid or adapt EU geoid models and coordinates in creating of a new unified grid system using existing data.

226. In case geodetic network will be built by different parties, each section Contractor shall ensure that implemented geodetic network is aligned with neighbouring section.

7.2 Geodetic grid construction supervision

227. To ensure the quality of construction geodetic reference system, height system and control network an RBR shall inspect the chosen reference system, height system and the control network.

228. In accordance to high speed railway construction accuracy requirements and scope of work defined in respective local law, RBR shall perform all necessary tasks to ensure that the quality of constructed geodetic network is in accordance to all applicable laws and standards for constructing highspeed railway.

229. The main tasks (not limited to) before construction works RBR is obligate to:

(a) to get obtained with defined requirements of design solutions for establishing of geodesy grid;

(b) to develop quality control system of geodetic works in accordance with the specifics and scope of the geodetic works to be performed;

(c) to get acquainted with Designer/Consultant developed work execution plan and quality assurance plan for geodetic works, in case of any discrepancies with respective national requirements and design solutions, object such Designer/Consultant ’s proposals and give notification to the Client;

(d) review, approve and provide opinion for Designer/Consultant Survey Plan before beginning of works;

(e) verify imposed standards and regulations;

(f) check and coordinate the compliance of the Designer/Consultant 's subcontractors with the terms of the Contract;

(g) check and verify calibration certificates of instruments used for survey works, inform the Client about the use of non-compliant equipment;

(h) to review and approve Designer/Consultant method of statement.

8 References

Design Guideline documents.

9 Annexes

Annex1. Detailed Technical requirements

Table 9. Equipment and Methodologies per activity

	TOTAL STATION			Level			Rod		GNSS					Laser Scanning	TGMT	Aerial Mapping	Photogrammetry	GPR Locator
activity	Low 5"	Mid 2"	High 1"	Optical	Optical w micrometer	Digital	Telescopic	Invar	Static	Fast Static	RTK	PPK	GIS					
Geodetic Network Establishment																		
0-Connection with State														n/a	n/a	n/a	n/a	n/a
1-Close to Project														n/a	n/a	n/a	n/a	n/a
2-ROW														n/a	n/a	n/a	n/a	n/a
3-Maintenance									n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cadastral/Expropriation surveys				n/a	n/a	n/a	n/a	n/a	n/a	n/a					n/a		n/a	n/a
Preliminary Surveys																		
Aerial Mapping	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		n/a			n/a
Conventional									n/a	n/a					n/a	n/a		n/a
ROW									n/a	n/a					n/a			n/a
Underground facilities	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Construction Surveys																		
Geodetic Networks																		
Geodetic Network Control														n/a	n/a	n/a	n/a	n/a
Geodetic Network Densification														n/a	n/a	n/a	n/a	n/a
Geodetic Micro Network Establishment														n/a	n/a	n/a	n/a	n/a
Expropriation Stakeout				n/a	n/a	n/a	n/a	n/a	n/a	n/a		n/a		n/a	n/a	n/a	n/a	n/a
Data extraction	office																	
Staking Out																		
Earthworks									n/a	n/a		n/a		n/a	n/a	n/a	n/a	n/a
Mid accuracy structures' staking									n/a	n/a		n/a		n/a	n/a	n/a	n/a	n/a
High accuracy structures' staking									n/a	n/a		n/a		n/a	n/a	n/a	n/a	n/a
Rails initial installation staking									n/a	n/a		n/a		n/a		n/a	n/a	n/a
Tamping Loops surveying												n/a		n/a		n/a	n/a	n/a
Field Changes	as Stakeout																	
Request for Inspection	as Stakeout																	
Intermediate Quantity Surveys for IPCs																		
Eartworks									n/a	n/a		n/a			n/a			
Mid accuracy structures									n/a	n/a		n/a			n/a	n/a		
High accuracy structures									n/a	n/a		n/a			n/a	n/a		
Final Quantity Surveys	as Intermediate Quantity Surveys																	

	TOTAL STATION			Level			Rod		GNSS					Laser Scanning	TGMT	Aerial Mapping	Photogrammetry	GPR Locator
activity	Low 5"	Mid 2"	High 1"	Optical	Optical w micrometer	Digital	Telescopic	Invar	Static	Fast Static	RTK	PPK	GIS					
As built surveys / QA/QC	as Intermediate Quantity Surveys																	
Maintenance																		
Geodetic Network Control									n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Rail Geometry									n/a	n/a				n/a		n/a	n/a	n/a
Rail Clearance									n/a	n/a						n/a	n/a	n/a
Geotechnical & Structural Monitoring																		
Preconstruction surveys, for Monitoring									n/a	n/a					n/a			n/a
Deformation Monitoring surveys																		n/a
Post construction surveys, for Monitoring									n/a	n/a					n/a			n/a

- NOT ALLOWED
- ACCEPTABLE
- RECOMMENDED
- MANDATORY

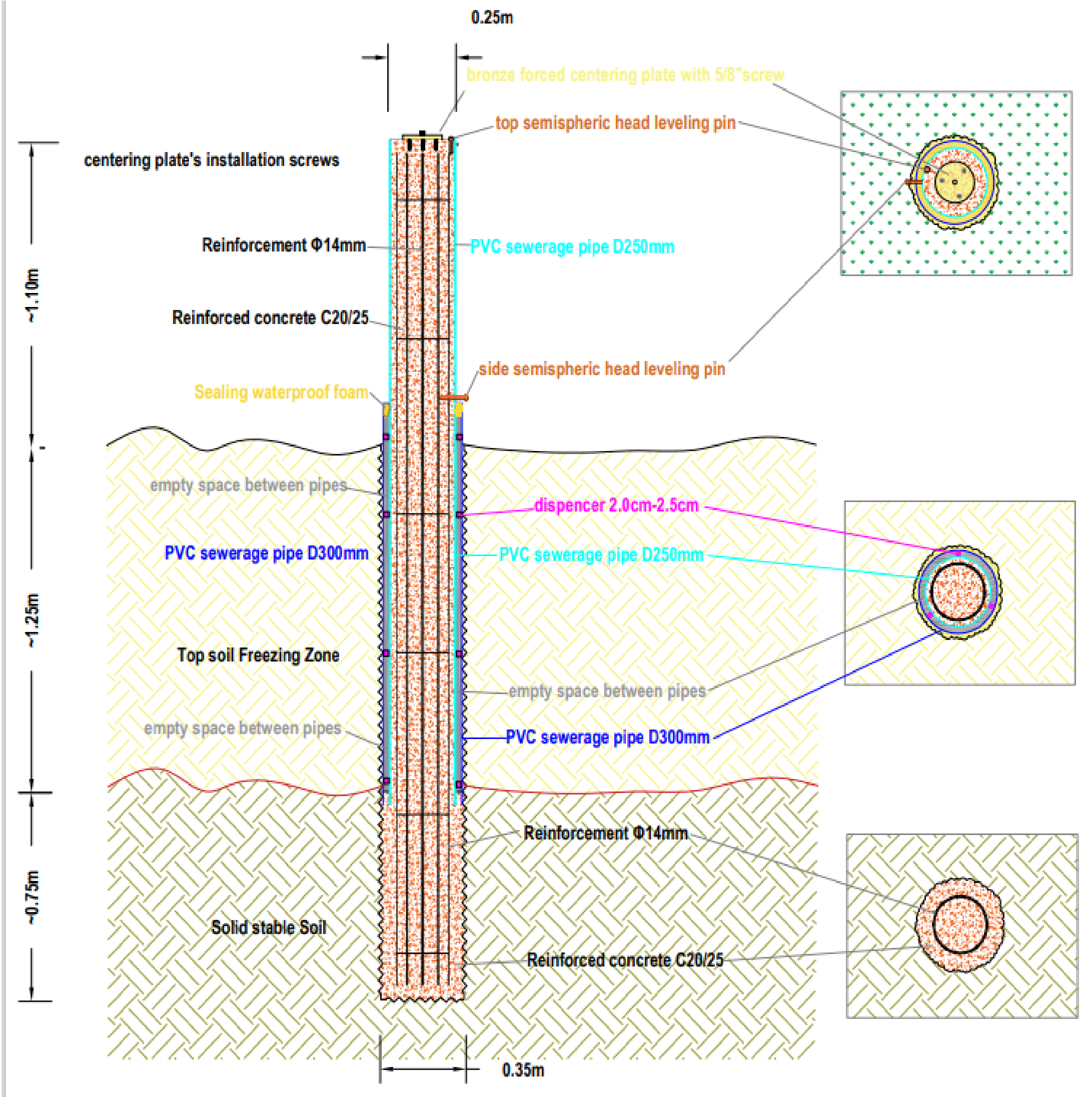

Figure 9. Monument for CP0, CP1, CP2, MNCP at non-urban areas, and if possible, at urban areas.

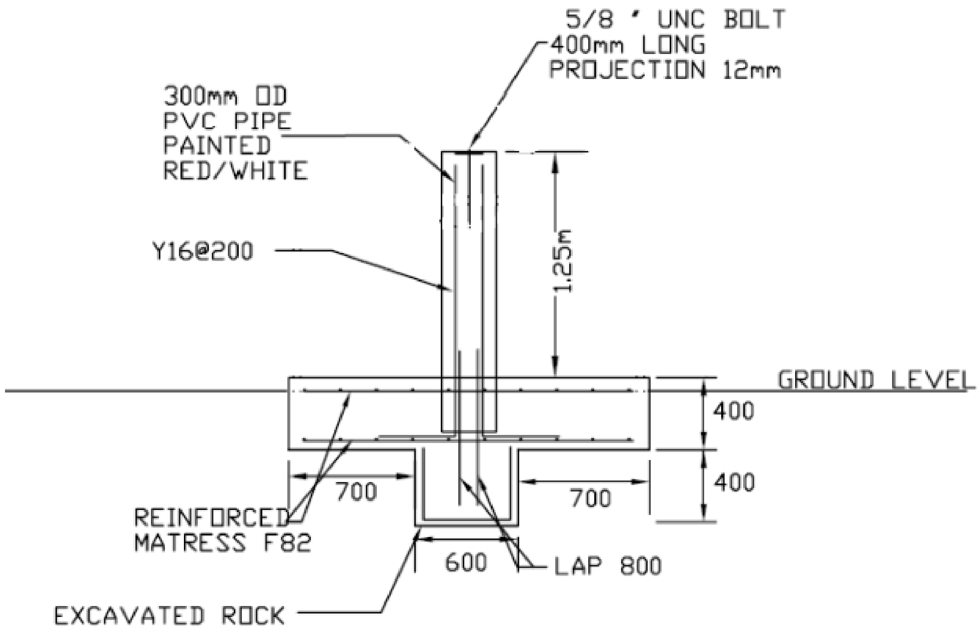

Figure 10. Monument for CP0, CP1, CP2, MNCP at urban areas. (a)

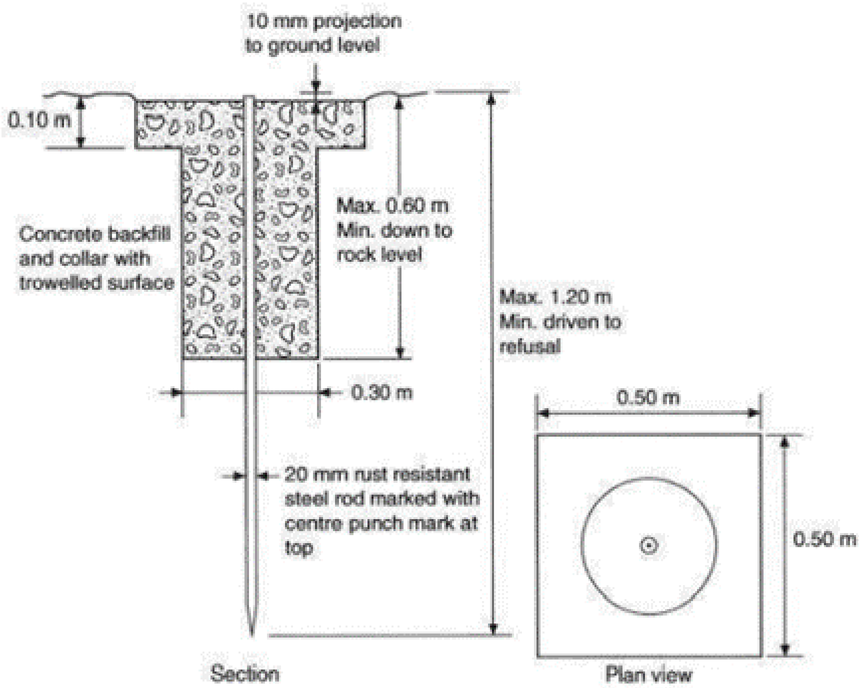

Figure 10. Monument for CP0, CP1, CP2, MNCP at urban areas (a)

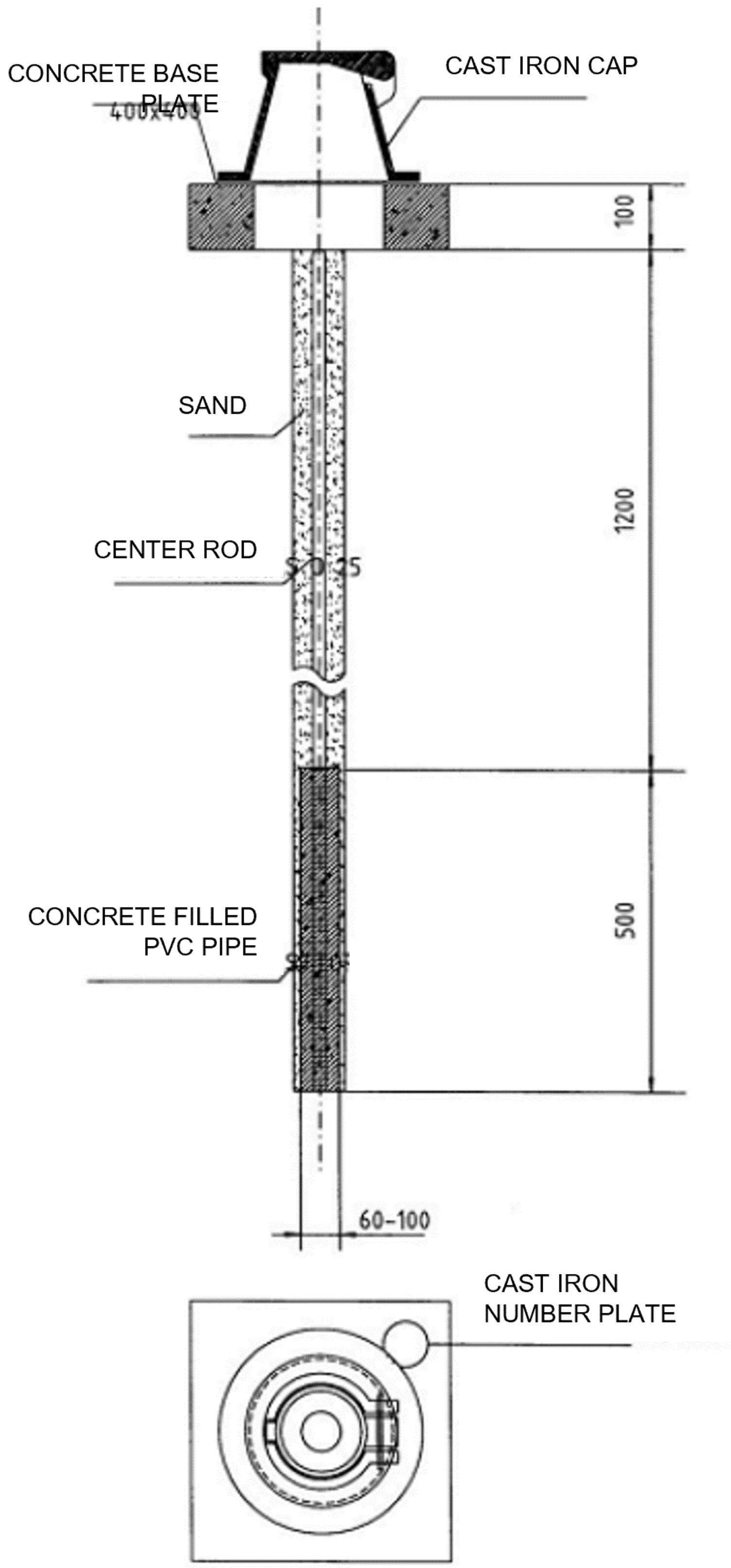

Figure 10. Monument for CP0, CP1, CP2, MNCP at urban areas (b)

Table 10. GNSS Method vs Order level

ORDER	0	1	2	3	4
Technique					
Classic Static	✓	✓	✓	✓	✓
Fast Static / Rapid Static		✓	✓	✓	✓
Guide to minimum station spacing km [1]	10	5	0.5	N/A	N/A
Typical station spacing in km [2]	10-100	5-15	0.5-5	>0.05	N/A
Independent occupations per station [3] at least 3 times (% of total stations)[4] at least 2 times (% of total stations)[4]	40% 100%	20% 100%	10% 100%		
Minimum independent baselines at each station	4	4	4	3	2

Table 11. Minimum GNSS Occupation Time

Single Frequency			
Length of Baseline	**< 5 Km**	**> 5 to <10Km**	**> 10 to <15km**
Static	20 minutes	20 to 50 minutes[1]	50 to 75 minutes[1]
Fast Static @ 95% confident level	15 minutes	15 to 20 minutes	N.A.
Double Frequency			
Length of Baseline	**< 5 Km**	**> 5km to <15Km**	**> 15 to <50Km**
Static @ 95% confident level	20 minutes	20 to 50 minutes	50-130 minutes[1]
Fast Static	8 to 10 minutes[1]	10 to 20 minutes[1]	N.A.

Table 12. EDM Observation Requirements

ORDER	**0**	**1**	**2**	**3**	**4**
Number of days of observations	2	1	1	1	1
Number of sets of full measurements[1]	4	4	2	1	1
Move prisms between sets[2]	Yes	Yes	Yes	Optional	--
Range of fine readings[3]	<2(5+d)mm	<2(5+d)mm	<2(5+d)mm	7ppm	15 ppm
Difference between two sets[3]	<2(5+d)mm	<2.5(5+d)mm	<2.5(5+d)mm	--	--
Difference between means of each day's measurements[3]	< 3(5+d)mm	--	--	--	--
Observation between 2 hours before local noon, and 2 hours before local sunset[4]	Yes	Yes	Yes	Optional	Optional
Atmospheric dial setting (where possible)	Zero	Zero	Zero	Optional	Optional
Allow minimum warm up time[5]	Yes	Yes	Yes	Optional	Optional
Thermometer type	Mercury in glass	Mercury in glass	Mercury in glass	Mercury in glass	Mercury in glass
Graduation Interval	< 1^{0}C	< 1^{0}C	< 1^{0}C	< 1^{0}C	< 1^{0}C
Estimate temperature to	0.1^{0}C	0.1^{0}C	0.1^{0}C	0.1^{0}C	0.1^{0}C
Estimate pressure to	0.3 hPa	0.3 hPa	0.3 hPa	0.3 hPa	0.3 hPa
Wet bulb readings or relative humidity readings	Yes	Yes	Yes	Optional	--
Metrology at both ends of measured lines before and after measurements	Yes	Yes	Yes	At time of observations	--
Reciprocal vertical angles[6]	Yes simultaneous	Yes simultaneous	Yes	Optional	Optional
National standard traceability of EDM	Yes	Yes	Yes	Yes	Yes

Table 13. Electro-Optical EDM Reduction Procedures

ORDER	0	1	2	3	4
Additive constant correction	Yes	Yes	Yes	Yes	Yes
Reflector additive constant correction	Yes	Yes	Yes	Yes	Yes
Cyclic error correction	Yes	Yes	Yes	Yes	Optional
Frequency correction	Yes	Yes	Yes	Baseline	Baseline
Barometer correction	Yes	Yes	Yes	Yes	Optional
Thermometer correction	Yes	Yes	Yes	Yes	Optional
1st velocity correction (atmospheric correction.)	Yes	Yes	Yes	Atmospheric dial	Atmospheric dial
Arc to chord correction (beam curvature correction.)	Yes	Yes	Yes	Over 5 km	Optional
2nd velocity correction (dip correction)	Yes	Yes	Yes	Over 5 km	Optional
Chord to chord correction (combined slope & mean sea level)	Yes	Yes	Yes	Combined Scale Factor	Yes
2nd chord to arc correction (geoidal chord to arc correction.)	Yes	Yes	Yes	Optional	Optional
Geoid to ellipsoid correction	Yes	Yes	Yes	Optional	Optional

Table 14. Differential Levelling Observation Procedure

ORDER	0	1	2	3	4
Instrument leveled by "unsystematic" method [1]	Yes	Yes	Yes	Yes	Optional
"Leap-Frog" system of progression used [2]	Yes	Yes	Yes	Yes	Optional
Staff readings recorded to nearest	0.01mm[3]. For digital levels take the mean of five with an indicated standard deviation. of 0.0002 or less.	0.1mm. For digital levels as for Order 0 but with an indicated standard deviation. of 0.001 or less.	0.1mm. For digital levels as for Order 1.	1mm. For digital levels as for Order 1.	10mm
Temperature recorded (When used).	Start, middle, finish and pronounced changes	At start and finish of each leveling run and at pronounced changes of temperature			--
Maximum length sight	30m.	40m.	60m.	80m.	100m.
Minimum ground clearance of line of sight	0.5m.	0.5m.	0.5m.	0.3m.	0.2m.
Back-sight and fore-sight lengths to be equal within	1% (Set out by taped measurement).	2%	3%	4%	5%
Observing times (Local Mean Time)	Any time atmospheric & weather conditions are fine		Any time provided atmospheric conditions allow positive resolution of staff graduation.		
Two-way leveling	Yes	Yes	Yes	Optional	Optional
Even number of instrument set-ups between bench marks.	Yes	Yes	Optional	Optional	Optional
Minimum number of holding marks used for temporary suspension of leveling	Not to be suspended	Not to be suspended	2	2	1
Minimum number of holding marks used for temporary suspension of leveling > 5 days	Not to be suspended	Not to be suspended	overlapping marks re-leveled within		1
			2√d	12√d	
Maximum allowable misclosure (mm) of forward and reverse leveling runs [4]	1.5√d	1.5√d	3√d	12√d	24√d
Minimum number of bench marks used to prove datum	3	3	2	2	2
Datum bench marks to be double leveled	Yes	Yes	Yes	Optional	Optional
Maximum misclosure (mm) on datum bench marks	1.5√d	1.5√d	3√d	12√d	24√d

Table 15. Differential Levelling Equipment Testing

ORDER	**0**	**1**	**2**	**3**	**4**
System test prior to commencement (eg ISO, DIN or Princeton)	Yes	Yes	Yes	Optional	Optional
Maximum standard error in the slope of the line of sight as determined by the system test	Spirit level: 1"/2mm run Automatic or digital: 0.4" setting accuracy.	Spirit level: 1.5"/2mm run. Automatic or digital: 0.4" setting accuracy.	Spirit level: 4"/2mm run. Automatic or digital: 0.8" setting accuracy.	Spirit level: 10"/2mm run. Automatic or digital: 1.0"setting accuracy.	--
Vertical collimation check (eg. Two-Peg Test) Frequency Maximum collimation error	Daily 2" or 0.3 mm over 30m. (Digital levels can "Store" the results)	Daily 2" or 0.8 mm over 80m.	Daily 4" or 1.5 mm over 80m.	Daily 10" or 4 mm over 80m.	As required 10" or 4 mm over 80m.
Level cross-hair verticality check	Yes	Yes	Yes	Yes	Optional
Staff calibration frequency	Immediately prior to commencement of leveling, and at 3 monthly intervals whilst in continued use.			Within 6 months of use.	Optional
Staff bubble verticality to be within	5' [1]	10'	10'	10'	10'
Thermometers accurate to	0.5℃	1℃	1℃	1℃	Optional