Rail Baltica

Electrification subsystem deployment

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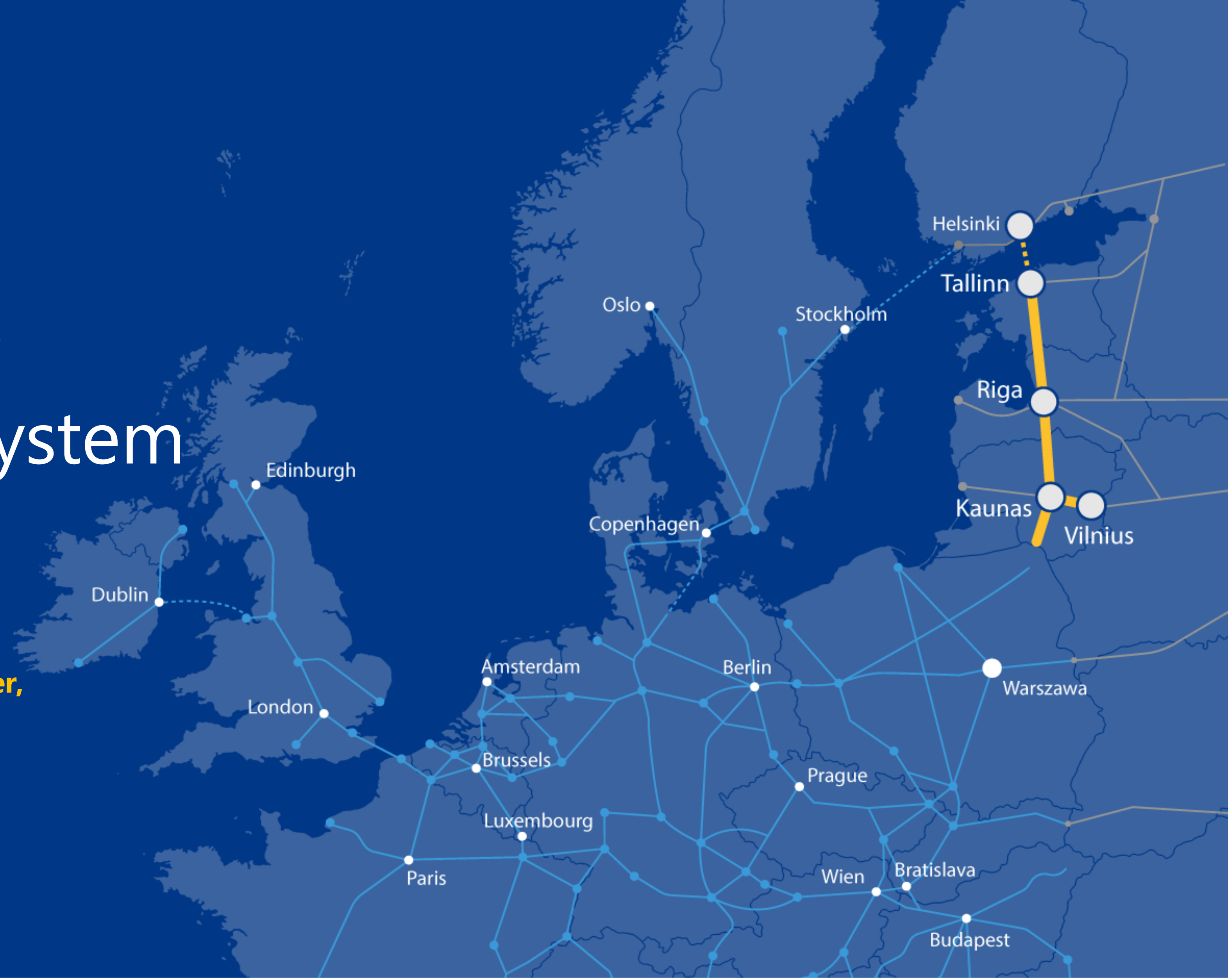
September 2023



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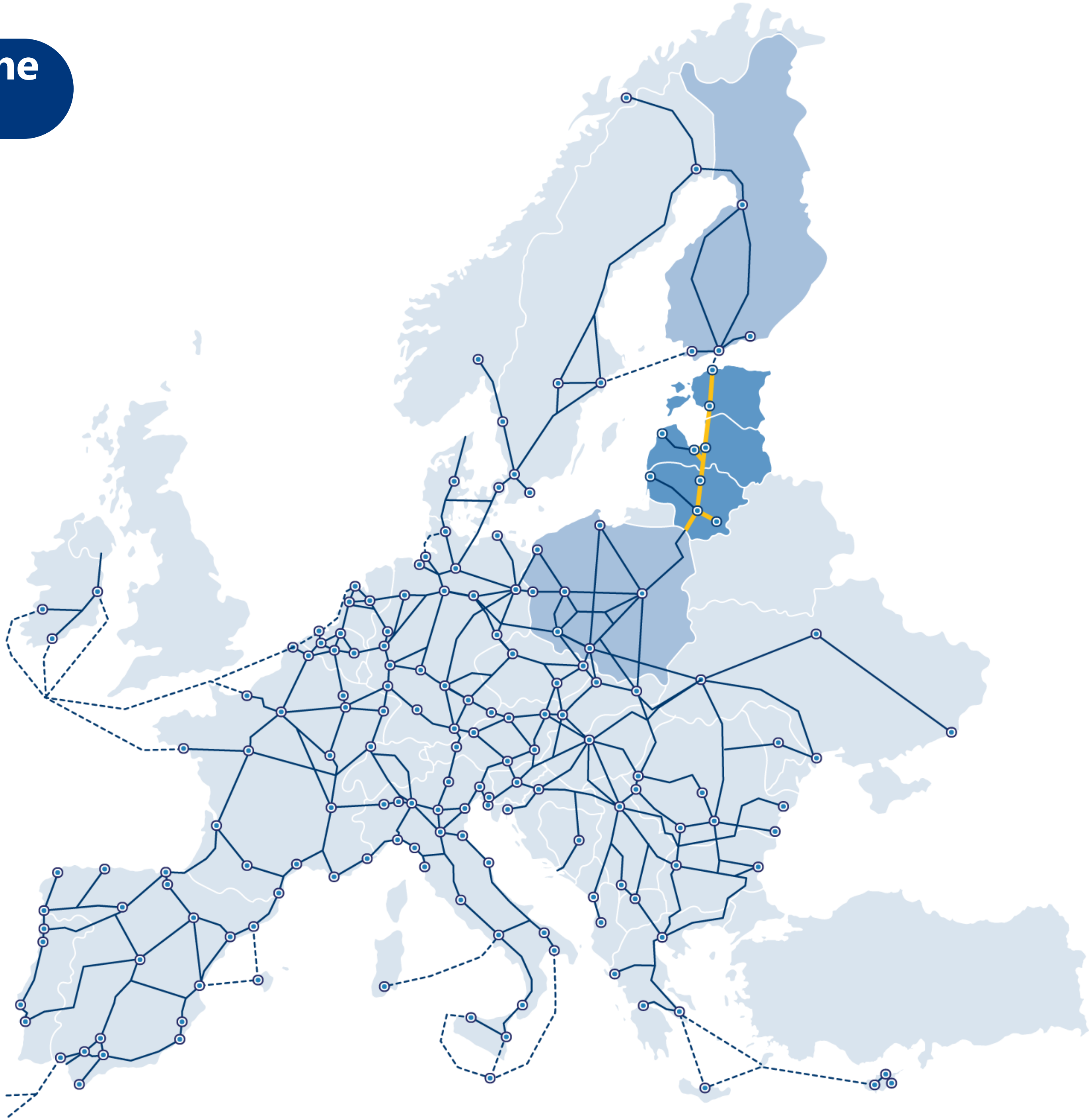
About Rail Baltica

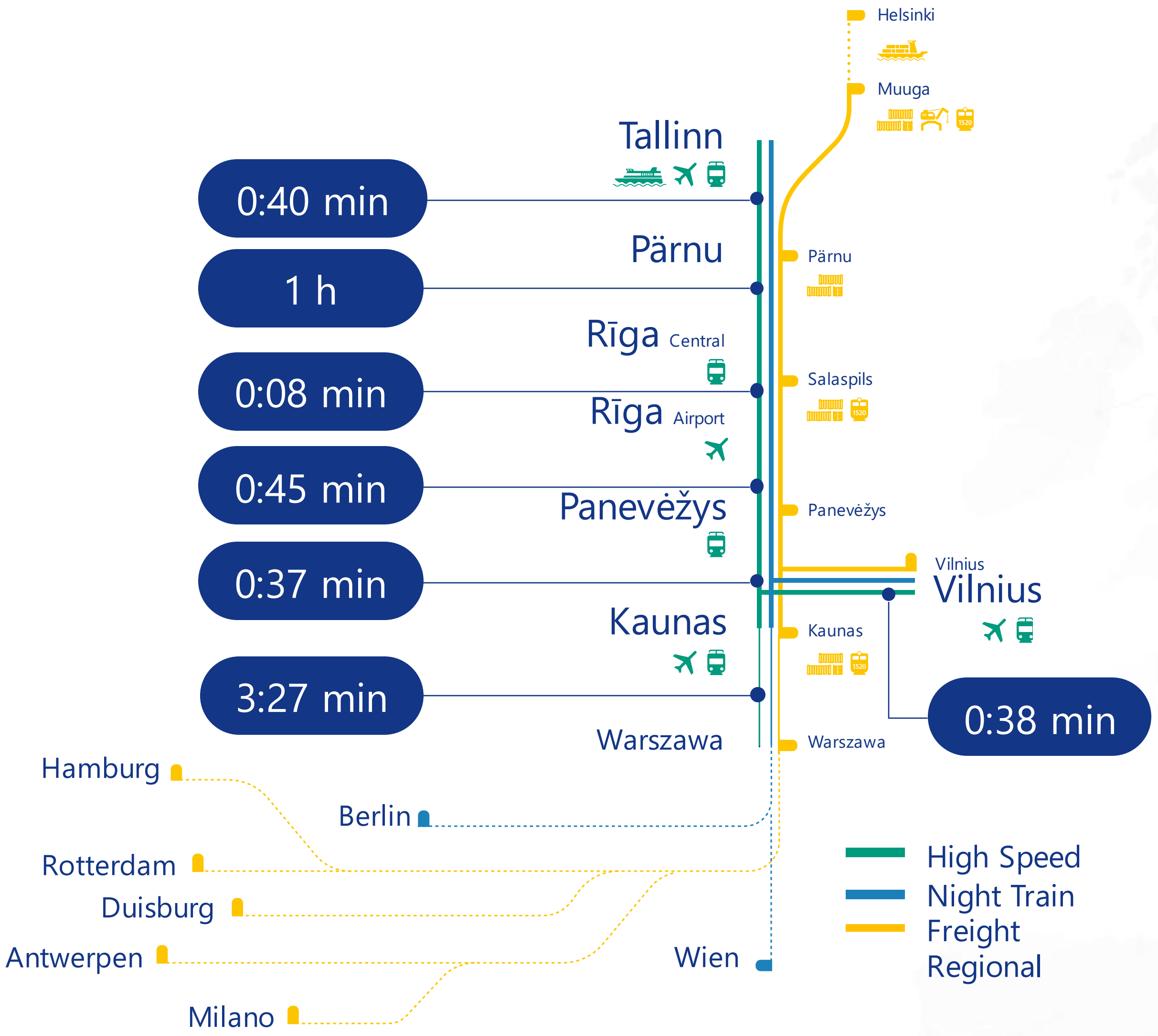
Rail Baltica: geopolitical obligation for the EU added value

- Part of the North Sea - Baltic Sea TEN-T corridor
- Part of the Baltic Sea - Black Sea - Aegean Sea TEN-T corridor*
- The basis for a new economic and security corridor in the Baltic region and the European Union
- Key element of connection of Ukraine and Moldova to Baltic Sea ports



*According to 5/12/2022 General Agreement of the TTE Minister's Council

Basis for a new economic corridor, and military mobility



- **870 km greenfield railway infrastructure**
- **1435 mm Double track**
- **ERTMS Level 2 + FRMCS**
- **Electrified 2x25kV AC**
- **Maximum length of freight trains: 1050m**
- **Axle load 25t**
- **SE-C (Swedish) loading gauge**
- **Design speed:**
  249 km/h for passenger trains
  120 km/h for freight trains

Rail Baltica
Linking nations, people, places

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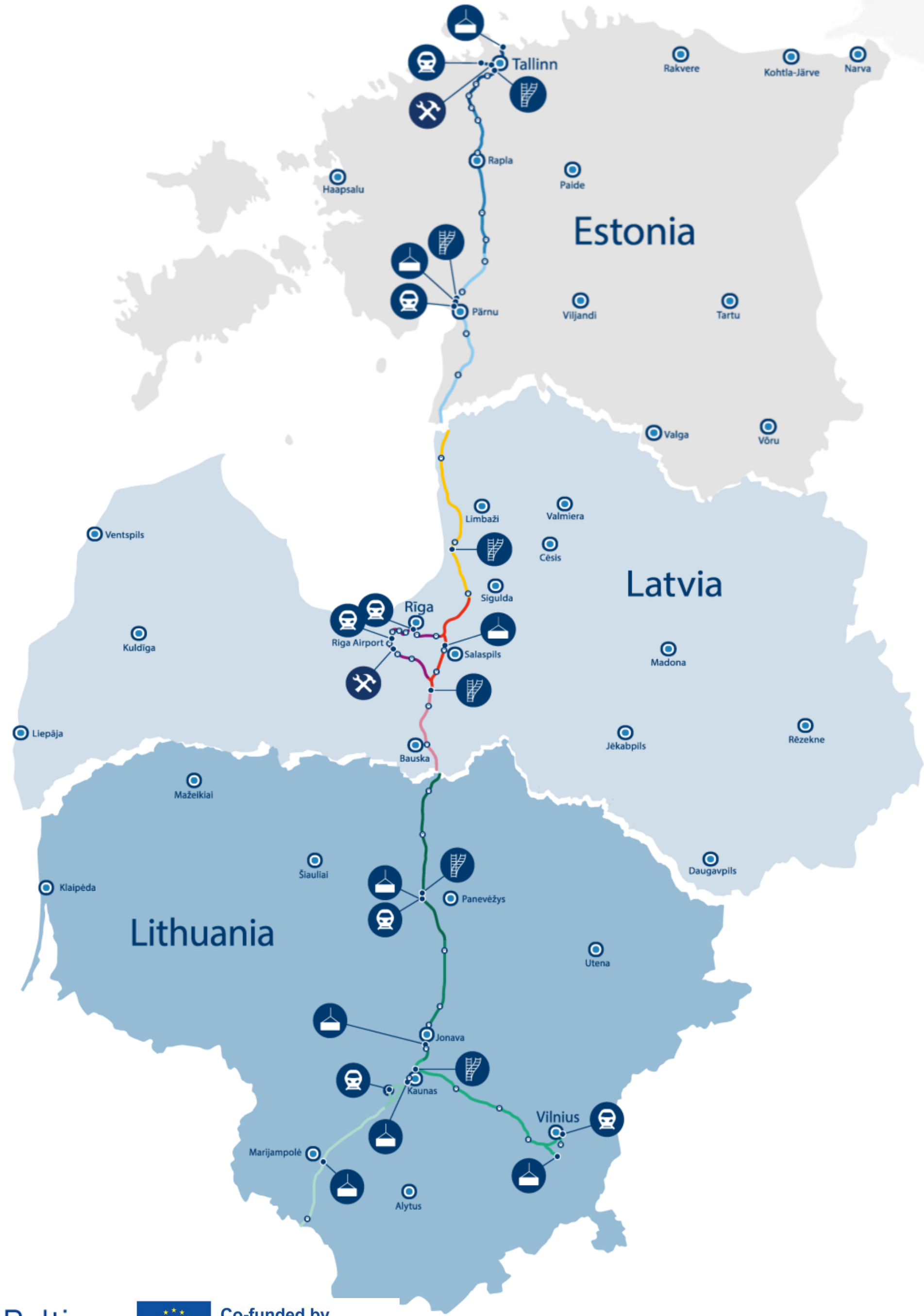


Rail Baltica progress in 2023

Design & Planning

- Design works advanced on more than 640km
- Alignment for Kaunas – Lithuanian/ Polish border chosen, also on section Kaunas – Vilnius, design works to commence in 2023
- Synchronizing schedule with Poland

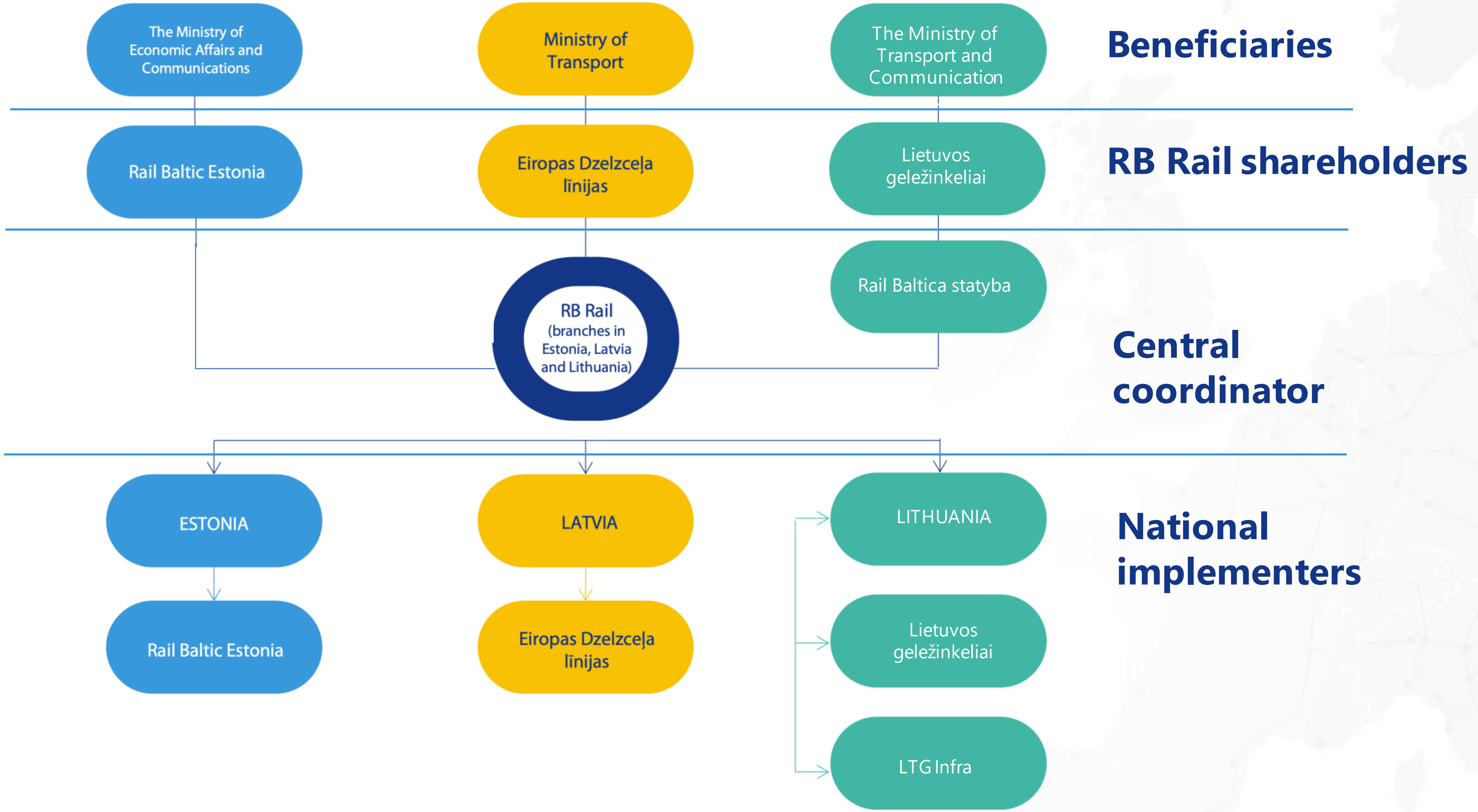
Construction

- First phase works progressing in all three countries (stations, bridges, viaducts, animal passages, etc.)
- Main line construction procurements ongoing in Lithuania, Latvia and now - also in Estonia
- Consolidated materials procurements progressing
- Preparing logistic plan

Railway subsystems development

- ENE subsystem 870km design & build procurement ongoing
- CCS subsystem procurement design & built ongoing
- Interface agreements with Polish railway network under preparation
- Engagement with EU and UIC partners on FRMCS standardisation ongoing

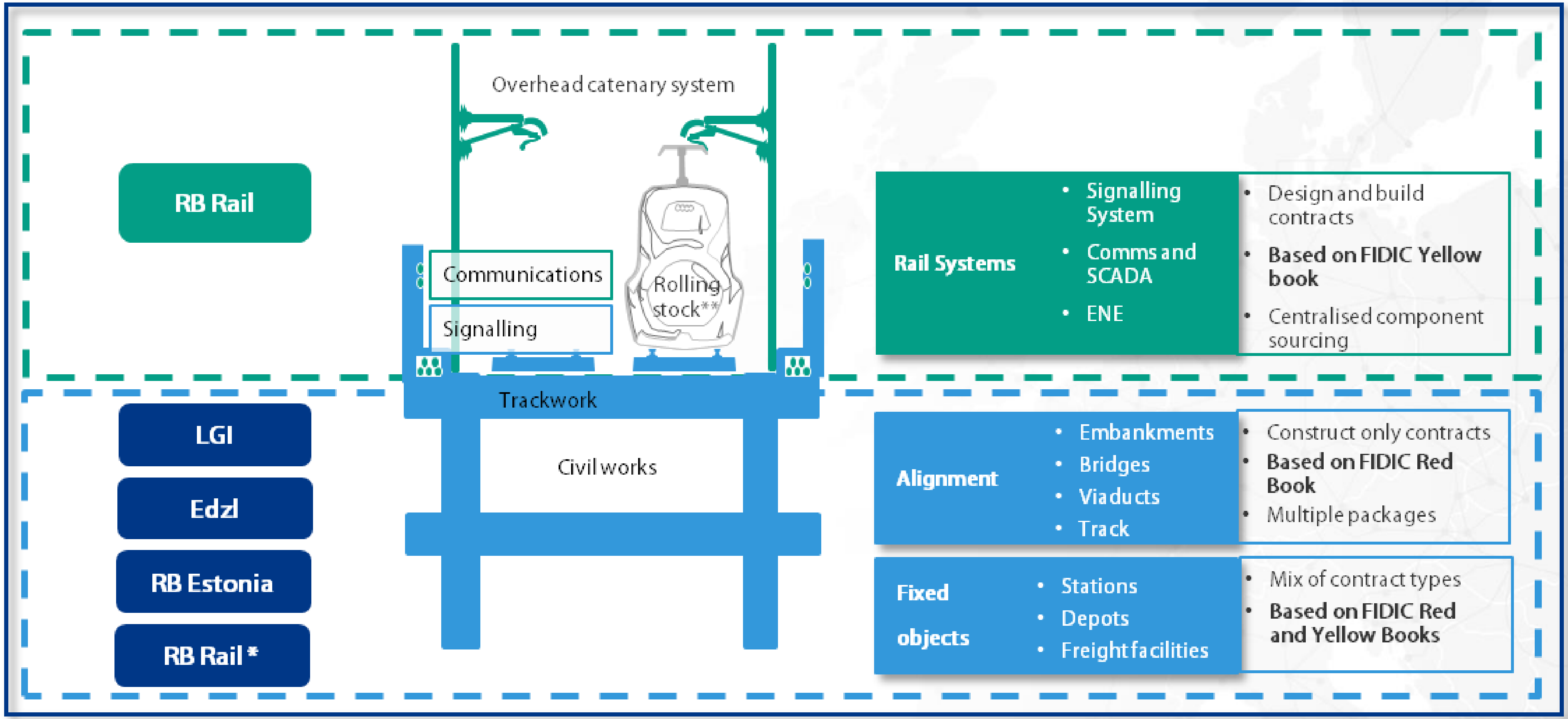
Project delivery team



- Standartisation
- Support
- Compliance

Rail Baltica contracting overview

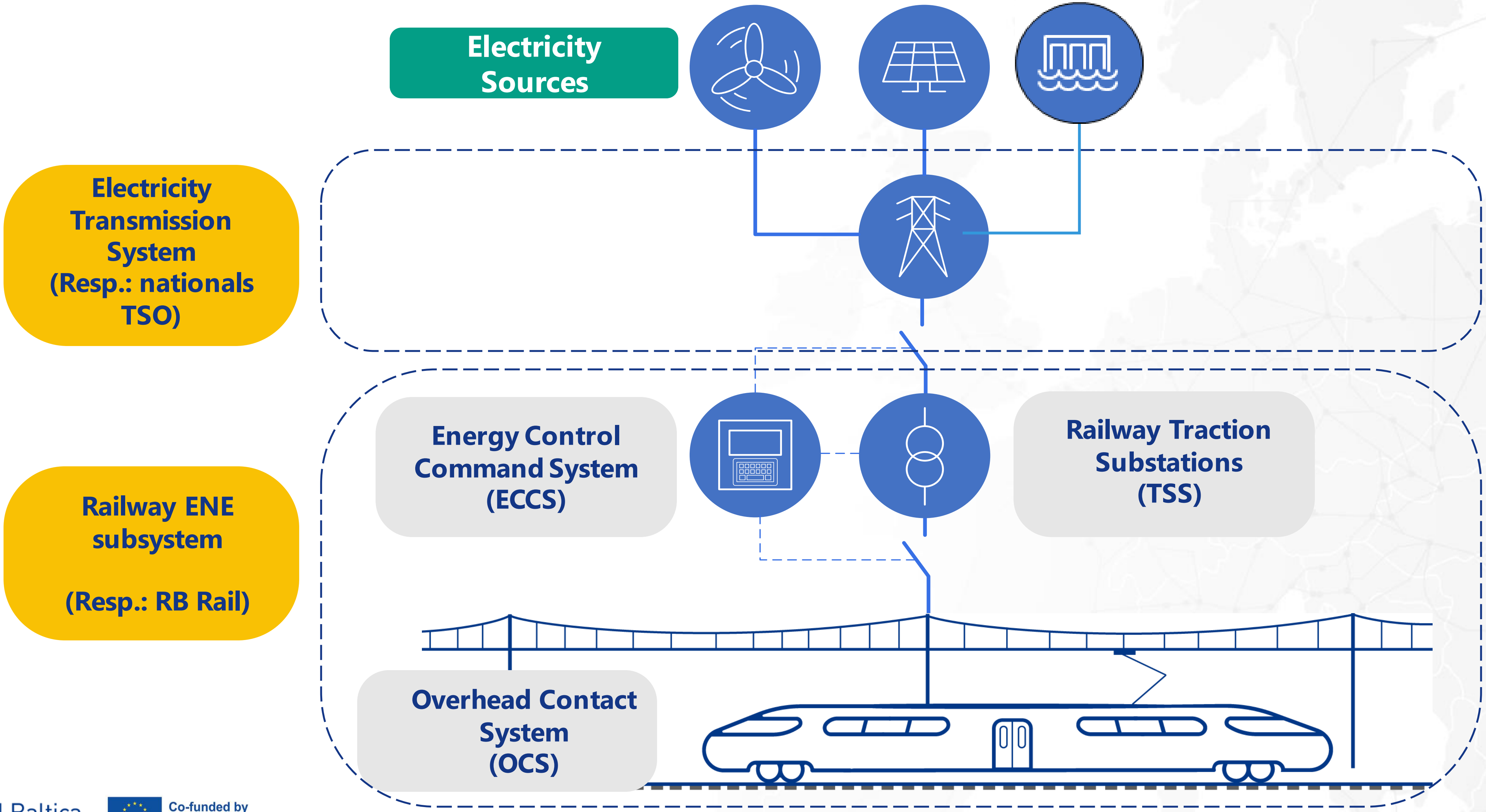
Contracting Entities | Assets | Contracting Approach



* RB Rail is responsible for cross border elements of alignment ** Rolling stock procurement is not part of the project scope

Rail Baltica Energy Subsystem: Scope

Rail Baltica ENE Scope



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Expectations

- ✓ Railway users (Passenger services, Freight Services)
- ✓ Power utilization (energy saving, efficiency, renewable energy sources, load management)
- ✓ **Restrictions from power networks (disbalance, reactive power, capacity)**
- ✓ Railway value for money (Investment, Operation, Maintenance)
- ✓ Reliability
- ✓ Safety (operation, maintenance)
- ✓ Local conditions (geographical requirements, local legislation, experience)
- ✓ Environment compatibility (EMC, noise emissions, climate)
- ✓ Regulations (local, International)
- ✓ Project specific conditions (intergovernmental agreements, overall project delivery process, parallel activities, interfaces)

Energy subsystem: safe, reliable, minimising environmental impact, reducing LCC - covering all operational needs

Rail Baltica Energy Subsystem: Analysis

Rail Baltica ENE subsystem design methology

Design Guidelines (2017)

4 main volumes
- Traction Power system
- Catenary
- ECCS
- Non traction

Operational Plan (2018)
- Infrastructure parameters
- Rolling stock benchmarking
- Transport plan (services timetable)

ENE Strategy study (2020)

7 volumes
- Energy demand
- TSO requirements
- Energy suppliers
- TSS
- OCS
- ECCS
- Procurement strategy

ENE Concept Design (2022)
- Power supply simulation
- Component definition
- Sizing and scope definition
- Open for technologies

Constractor to endorse CD

ENE Generic and Detailed Technical Design (2024-2025)
- Reference architecture
- Detailed solutions
- Components' selection
- Detailed design and construction permits

ENE Technical Architecture selection process

TRACTION SIMULATION

- 2 X 25 kV + SVC(*)
- 1 X 25 kV + SVC(*)
- 2 X 25 kV + SFC
- 1 X 25 kV + SFC

Decision making process

Multi Criteria Analysis

Main Criteria:

- Technical Complexity
- Operation & Maintenance
- Environmental & Territorial Use
- RAMS and Security
- Life Cycle Cost

ENE Architecture Selected

ENE Concept Design and Technical Specifications for the selected technology

Define specific solutions for:

- OCS (negative feeder or not)
- TPS (PP, SWP or not)
- TSS locations, detailed agreement with TSO

Generic and Detailed Design (Contractor)

In all feeding points along the line is necessary to implement additional equipment to achieve TSOs quality parameters

- SVC = Static Variable Compensators
- SFC = Static Frequency Convertor

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Simulation

Simulation Objectives

- Sizing the System - Maximum values in the worst case
- System configuration Optimise length of feeding electrical sections and electrification type
- Power demand estimation Evaluation of the energy consumption according different operation along the time

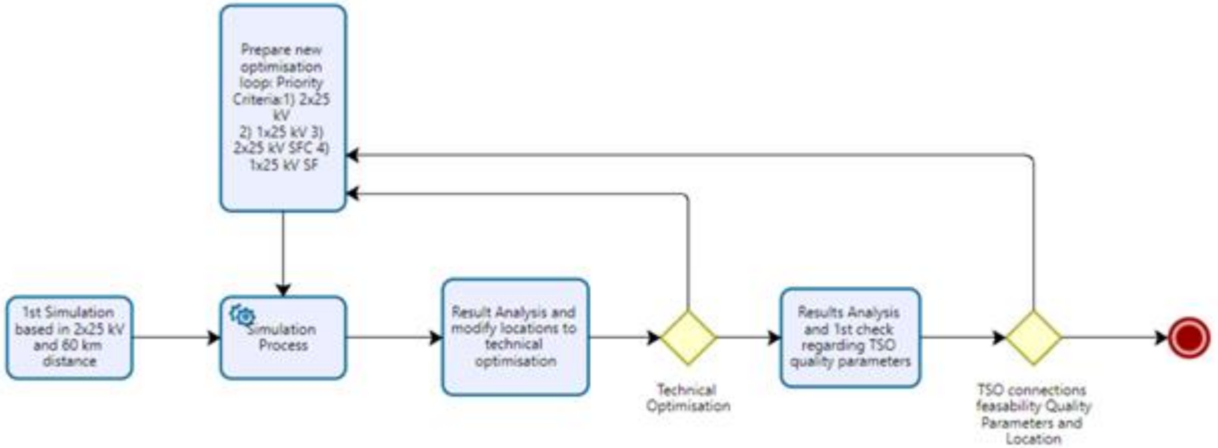
Input data:

- Operational Plan,
- Train composition (passenger / freight)
- Timeline (scenario up to 2056)
- Borders of the project (self-supporting system)

TS Placement & Sizing Simulation Process

Based on two loops:

1. Internal loop electrical simulation
2. TSS feasibility and eventual changes of placement (TSO quality requirements including unbalance)

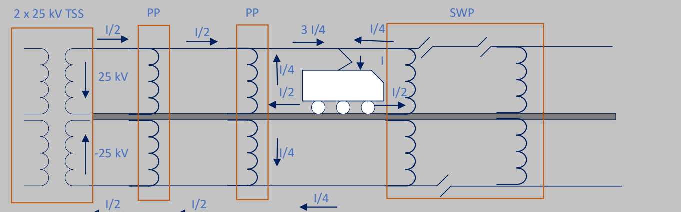


Simulation

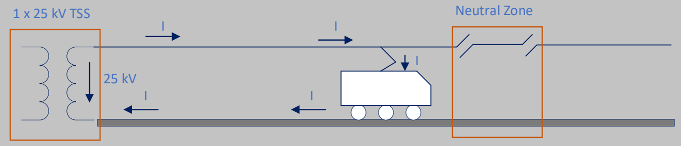
Different traction technologies

ENE ARCHITECTURE
FEASIBLE OPTIONS:

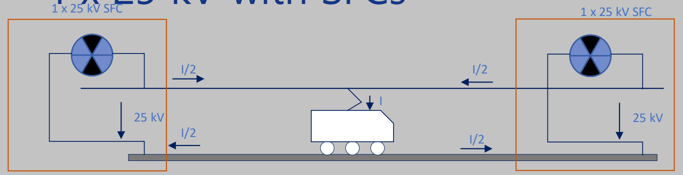
- 2 x 25 kV



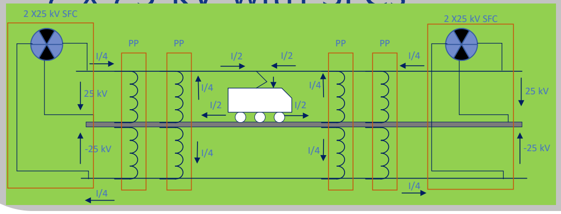
- 1 x 25 kV



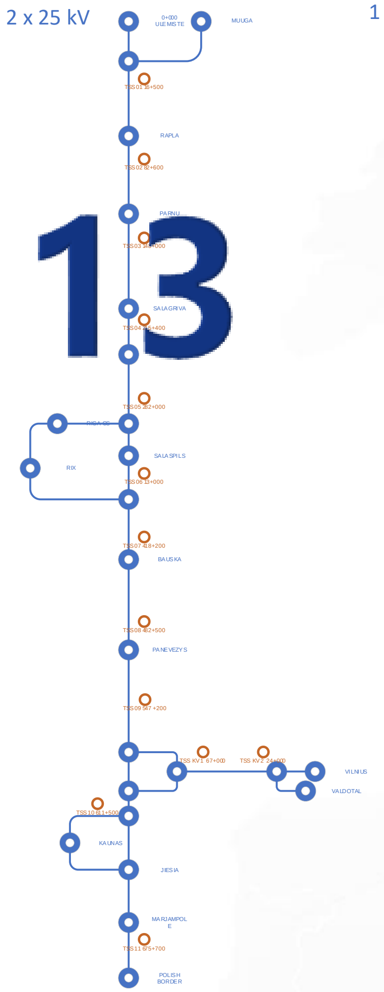
- 1 x 25 kV with SFCs

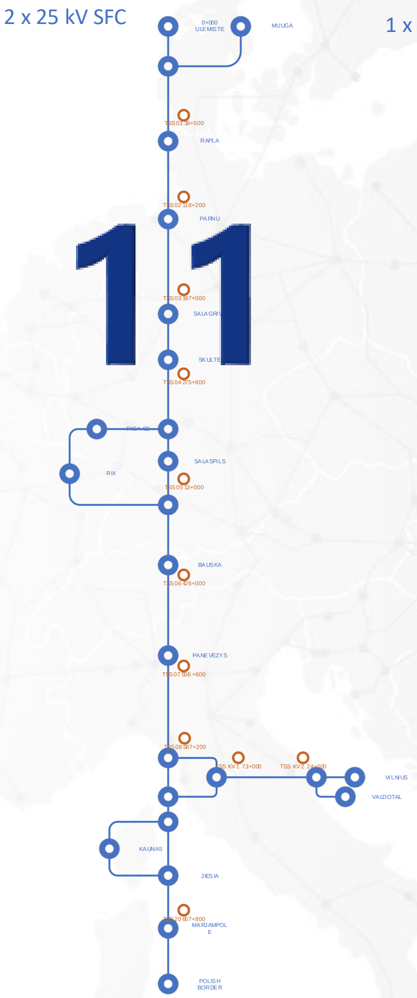


- 2 x 25 kV with SFCs



Number of connection points to power supply grid





Main MCA Technical Parameters

	TSO Connections	Overload Capability	Unbalance Correction	Electromagnetic Perturbances	Overall System Efficiency	Interference Sensitive Areas
2 X 25 kV + SVC(*)	13	↑	→	↑	↓	→
1 X 25 kV + SVC(*)	24	↑	→	↓	↓	↓
2 X 25 kV SFC	10	↓	↑	↑	↑	→
1 X 25 kV SFC	16	↓	↑	↓	↑	→

Rail Baltica Energy Subsystem: Results

Key benefits

- ✓ **Symmetrical load:** possible supply from extreme weak electrical grids, no need to have a high short-circuit power in the feeding point. No unbalance, minimum harmonics to HV network, Possible to connect to lower-voltage nodes.
- ✓ **Parallel feeding:** no neutral sections needed; more energy (including regenerated) distributed along the line
- ✓ **Longer feeding distance:** thanks to parallel feeding functionality
- ✓ **Load control:** independent active and reactive power control. Full control of catenary voltage – better voltage level stabilisation
- ✓ **Reversable operation**: allowing transfer of energy back to the grid. It shall be possible to inhibit or limit this functionality of the SFC

New features unlocked (comparing to traditional solution)

- ✓ **Less environmental impact:** due to reduced number of connections, less area needed for HV transmission lines as well as traction substations;
- ✓ **Reactive power compensation:** SFC shall be able to manage the reactive power absorption/generation, independently from the traction power load, to support the TSO in an optimized management of the high voltage grid;
- ✓ **Controllable functionality:** SFC power electronics control functionality allows to manage the injected energy of every parallel SFC into OCS. This allows to optimize the load sharing and the working point of each SFC, avoiding unnecessary energy flows, improving the overall efficiency of the system.
- ✓ **Modularity** of SFC power electronics allows internal redundancy. This helps to optimise maintenance time by reducing non-operation time.
- ✓ **Synchronisation with traditional 1x25/2x25 kV systems:** possibility to extend the existing electrified railway sections
- ✓ **Railway operations reduced:** no neutral sections, no need to switch off power / lower pantograph
- ✓ **Regenerated braking energy** is kept within railway system – due to single phase OCS

New services possible – (in addition to OCS feeding)

1. Smart grid functionality – possibility to manage load of every traction substation, while keeping no impact on railway services, energy can be bought where it is cheaper in the network;
2. Reactive power compensation;
3. Adaptation to gradual increase of railway operations;
4. Connection to local renewable energy sources – by employing direct connection to SFC system DC part.

Rail Baltica Energy subsystem: Scope in a nutshell

870 km of double track – **approx. 2 200 km** of overhead catenary

Approx. 50 000 masts

Approx. 4 350 tonnes of copper

10 Railway Traction Substations only! Static Frequency Converters with 2x25 kV overhead contact line feeding

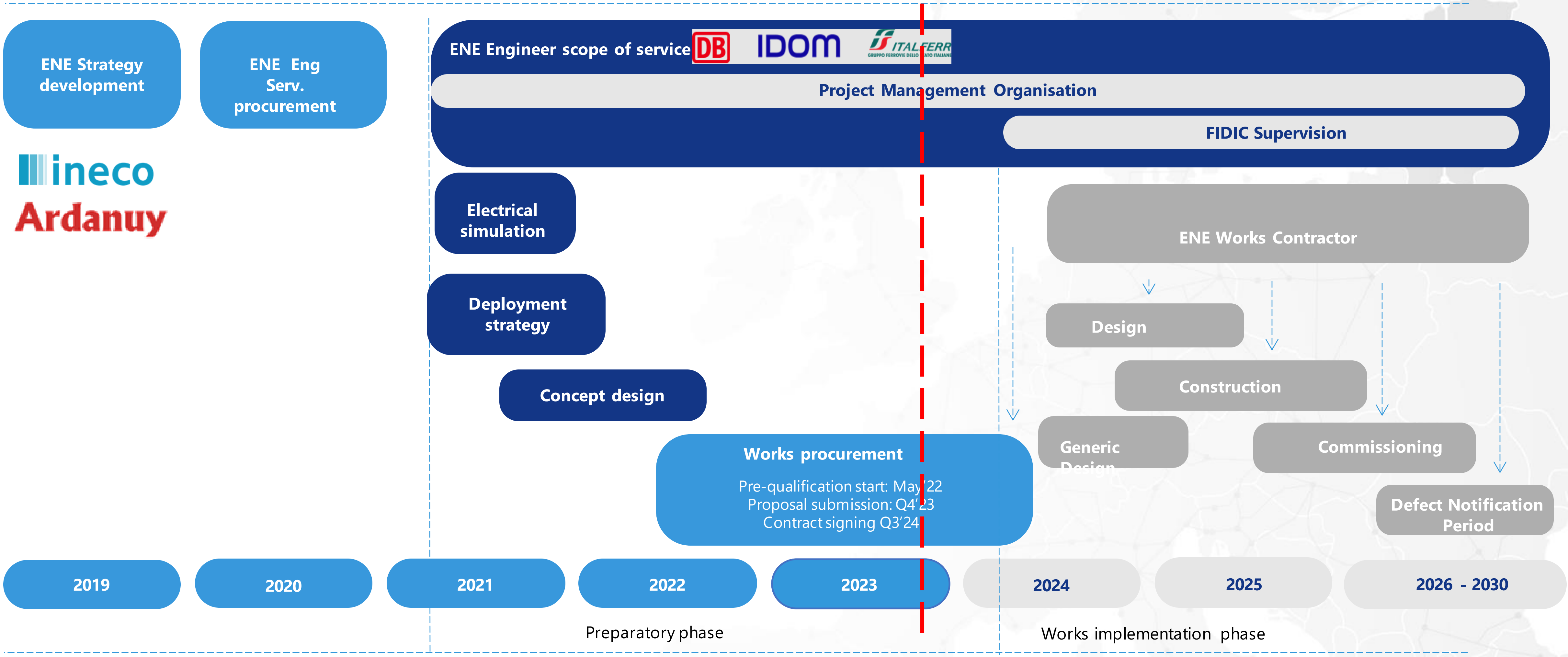
Energy Control Command System

Rail Baltica ENE subsystem will set up 2 world premieres:

Single railway electrification implemented on the territories of **3 States**

Unique electrical section implemented in 3 States – Estonia, Latvia and Lithuania

Rail Baltica ENE deployment timeline



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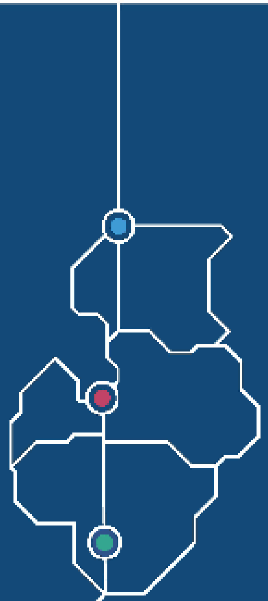
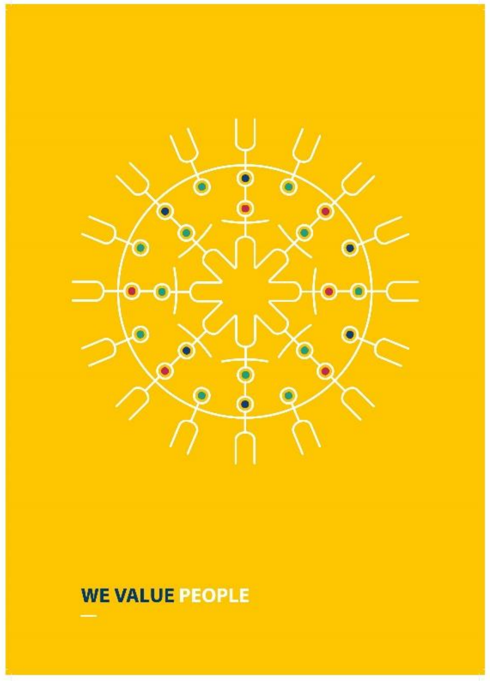


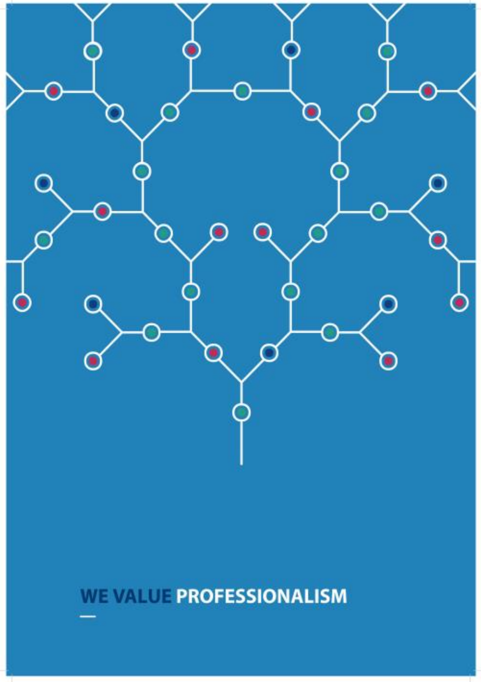
OUR VISION

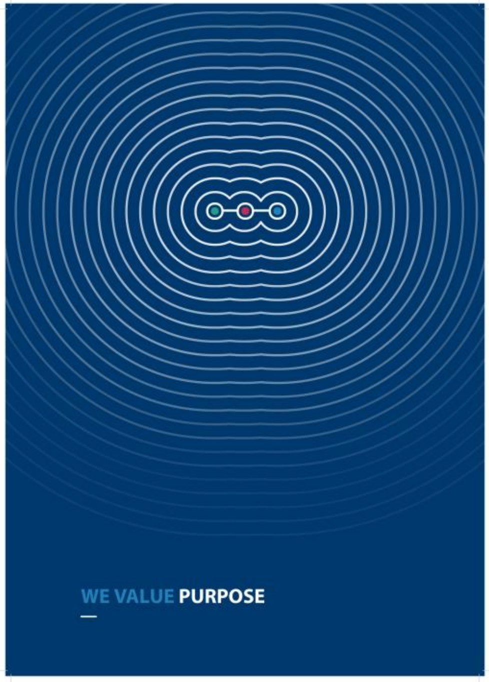
Connected Baltics in a connected Europe

OUR MISSION

We are delivering a seamless mobility for people, goods and services to accelerate social and economic development in the Baltics and beyond







Thank you!