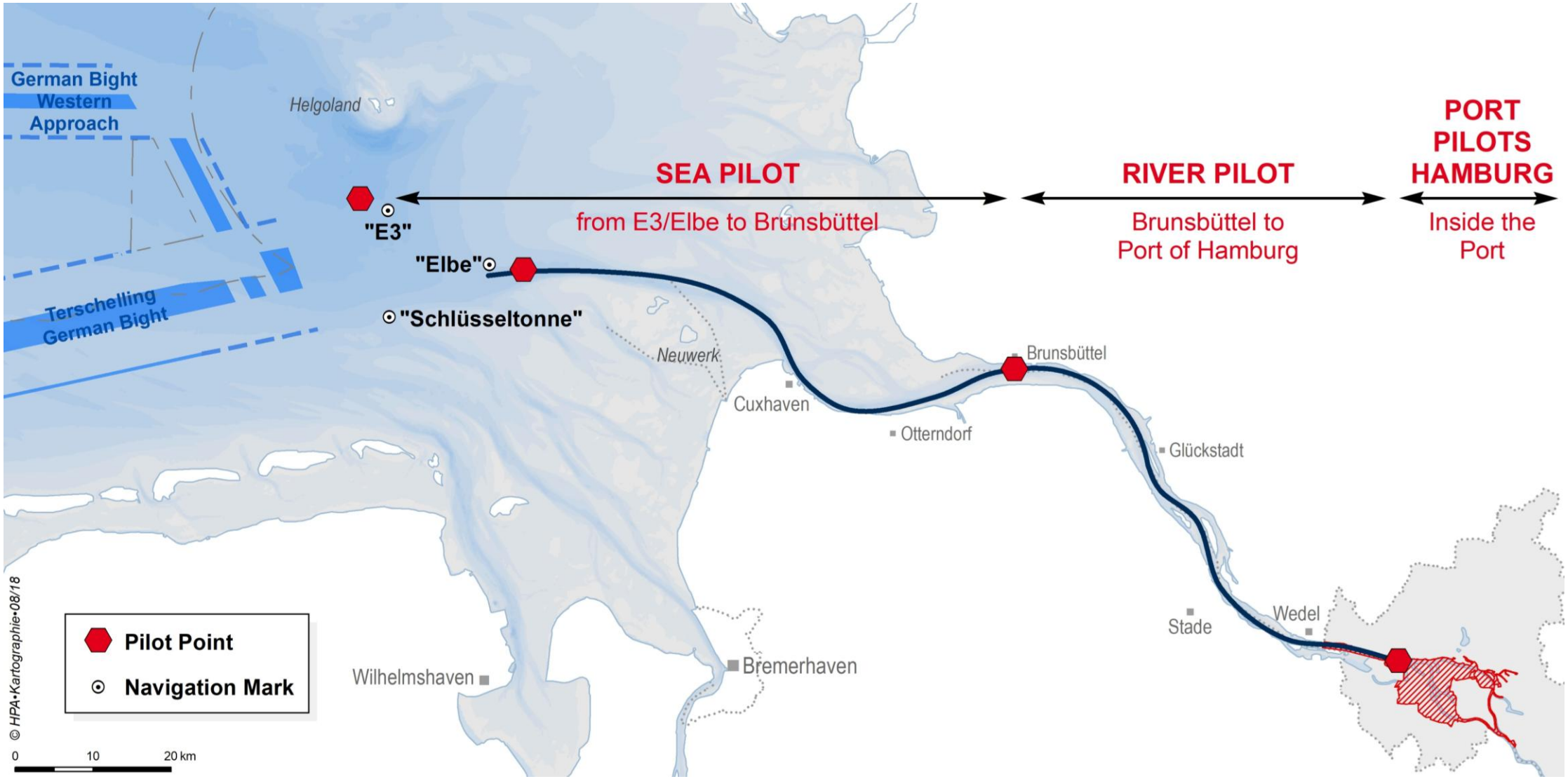
2026

Digitalizing the Road Last Mile for Ports and Multimodal Freight Terminals

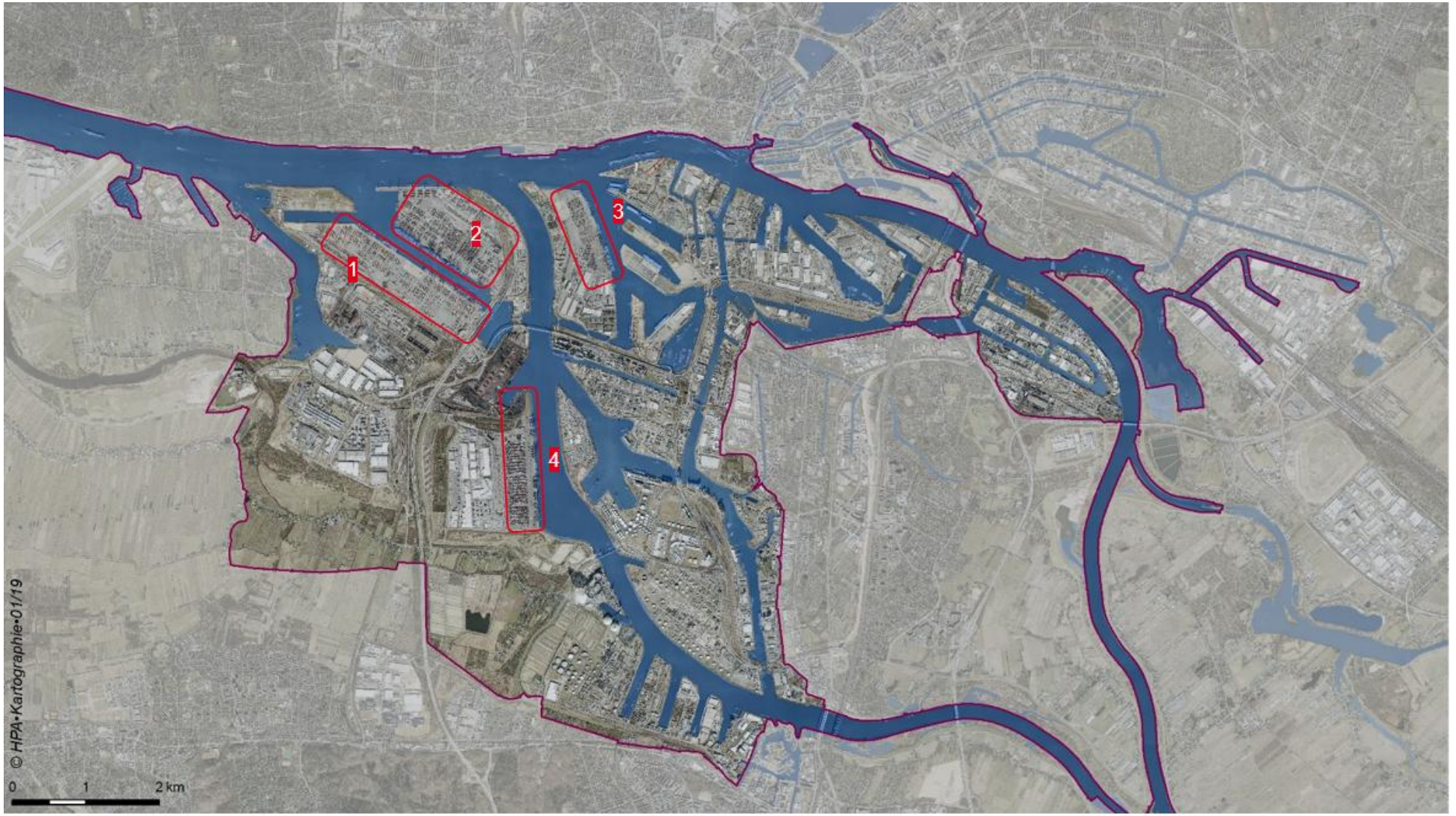
Hermann D. Grünfeld

Hamburg as a Hub and as a Gateway

Hamburg is located 82 nm away from the open sea



Aerial view of one of the largest seaports in the world with a total turn over of 115 mio. tons/y and 8,3 mio TEU/2025



Container throughput:
8.3 million TEU → +7.3%
compared to 2024

Hamburg is a universal port.
Goods of all kinds are turned over here...

Port of Hamburg – Versatile Universal Port Handles all types of cargo

→ Containers, bulk, project cargo, liquids, recyclables & waste

- > 71 km² area
- > 50 handling facilities & specialized terminals
- ~500 berths for mega-container vessels, bulk carriers, tankers, RoRo, feeders & inland vessels

- State-of-the-art equipment + highly skilled staff
  → fast and safe cargo handling

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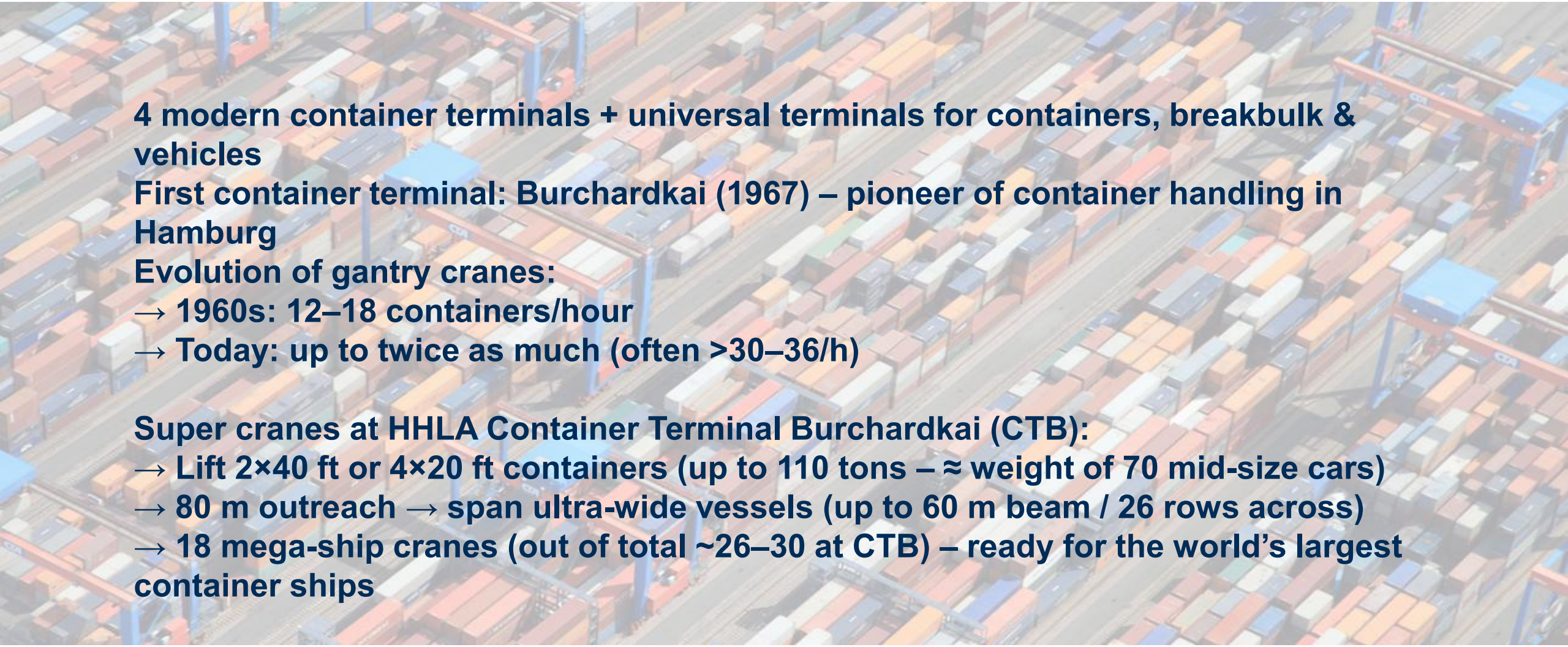
Container (8,3 Mio. TEU / Jahr)
Hamburg is Megaship-ready



4 modern container terminals + universal terminals for containers, breakbulk & vehicles
First container terminal: Burchardkai (1967) – pioneer of container handling in Hamburg
Evolution of gantry cranes:
→ 1960s: 12–18 containers/hour
→ Today: up to twice as much (often >30–36/h)

Super cranes at HHLA Container Terminal Burchardkai (CTB):
→ Lift 2×40 ft or 4×20 ft containers (up to 110 tons – ≈ weight of 70 mid-size cars)
→ 80 m outreach → span ultra-wide vessels (up to 60 m beam / 26 rows across)
→ 18 mega-ship cranes (out of total ~26–30 at CTB) – ready for the world's largest container ships

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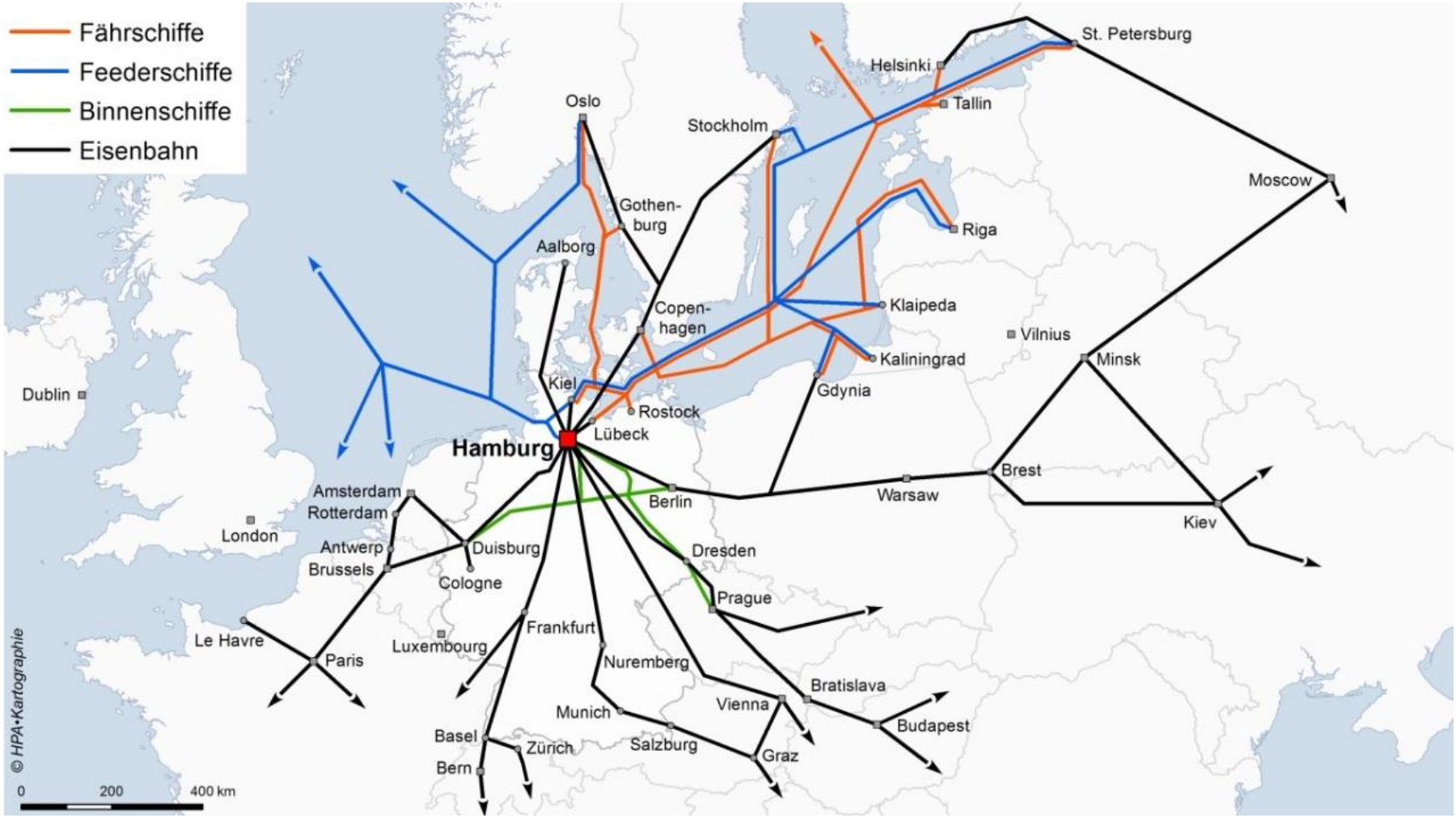
… Hinterland destinations and cargo mode

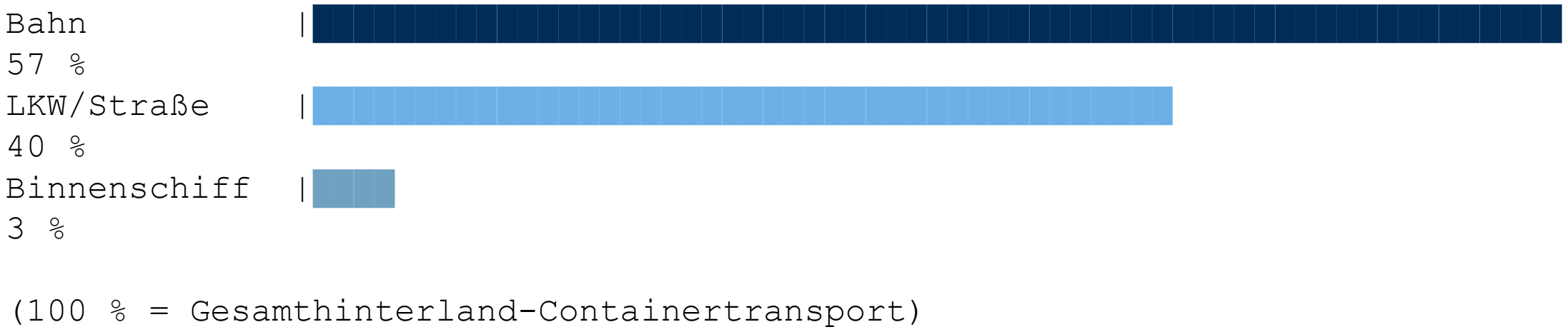
(schematized, no roads)



… Hinterland Modal Split

Typical distribution (based on 2024 and 2025 trend, in % of container hinterland traffic):

- **Rail: approx. 55–58%** (leading, absolute majority since 2024)
- **Truck (road): approx. 38–42%**
- **Inland waterway: approx. 3–5%** (relatively stable, but small share) Rail's lead was further consolidated in 2025 – despite truck dominance in other North Range ports (Rotterdam/Antwerp usually >60% trucks).



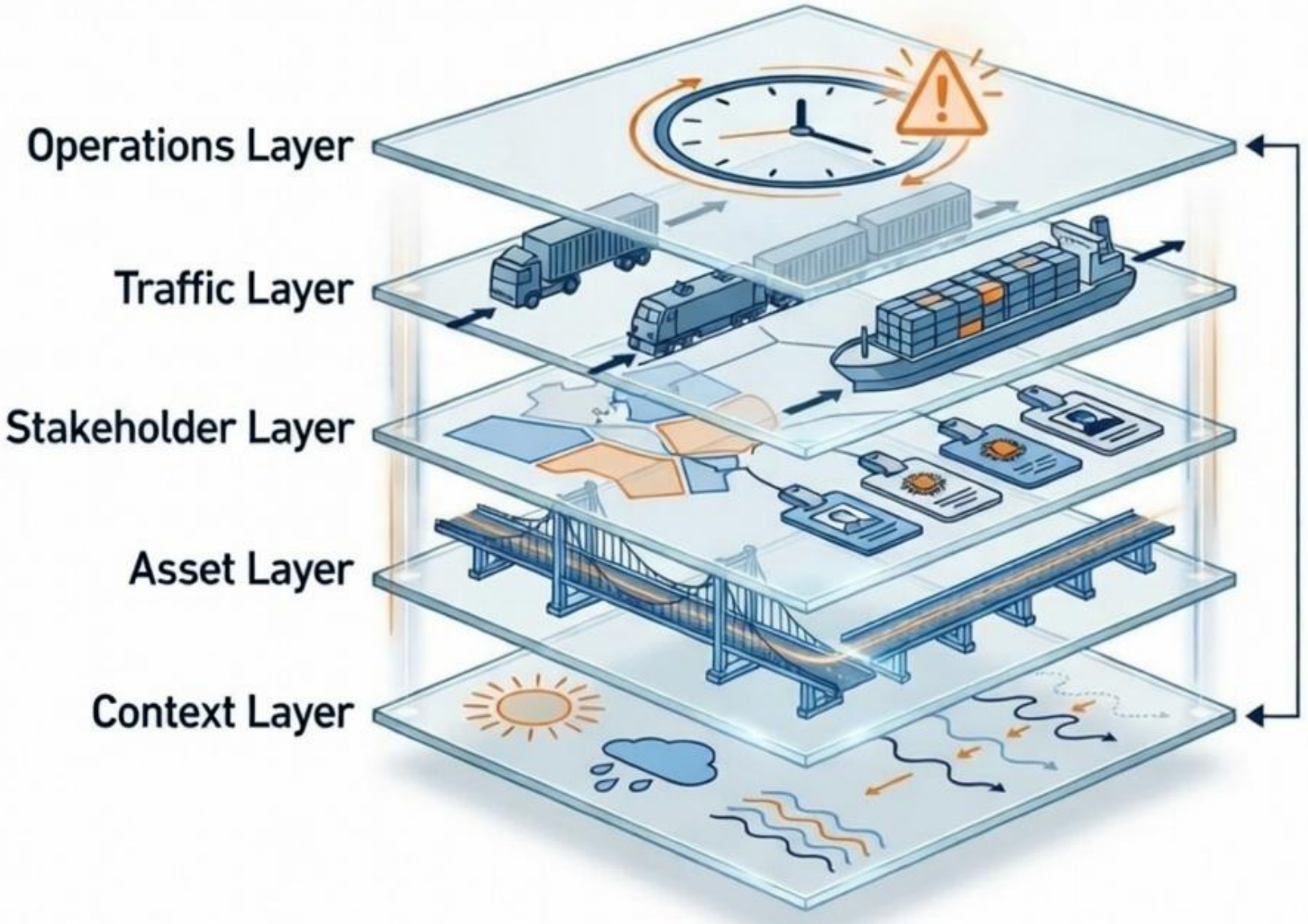
(100 % = Gesamthinterland-Containertransport)

PORT OF THE FUTURE: FROM DATA TO ORCHESTRATION

A strategic initiative to increase efficiency, safety and reliability of critical infrastructure in the Port of Hamburg.

HPA
Hamburg Port Authority

Port understood as a system of independent, but orchestratable data layers.



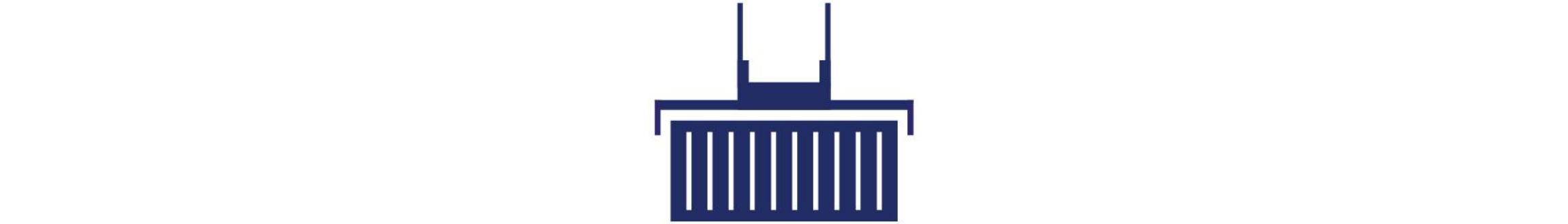
Orchestration:
Layers function independently, but can be combined for complex queries.

Trucks can only enter in a pre-booked time window (typically 1 hour)

Goal: Synchronize truck arrivals with terminal capacity
→ reduce bottlenecks, queues & congestion on roads/approaches

No valid slot?
→ No processing (containers not handled)

Benefits:
→ Better traffic flow & planning security for hauliers
→ Less waiting/idling → lower emissions & costs
→ Smoother operations for the entire supply chain



PRIO 3
OUTSIDE TOLERANCE RANGE

Rebooking must be done before arrival. Waiting at the terminal not permitted.

PRIO 2
PRIO 1 -60 MIN TOLERANCE RANGE

Will only be handled if capacity utilisation allows it.

The slots always comprise full hours, e.g. 8–9 a.m.

PRIO 1
BOOKED SLOT ±30 MIN TOLERANCE RANGE

Will be processed with top priority and can usually proceed directly to gate-in.

PRIO 2
PRIO 1 +60 MIN TOLERANCE RANGE

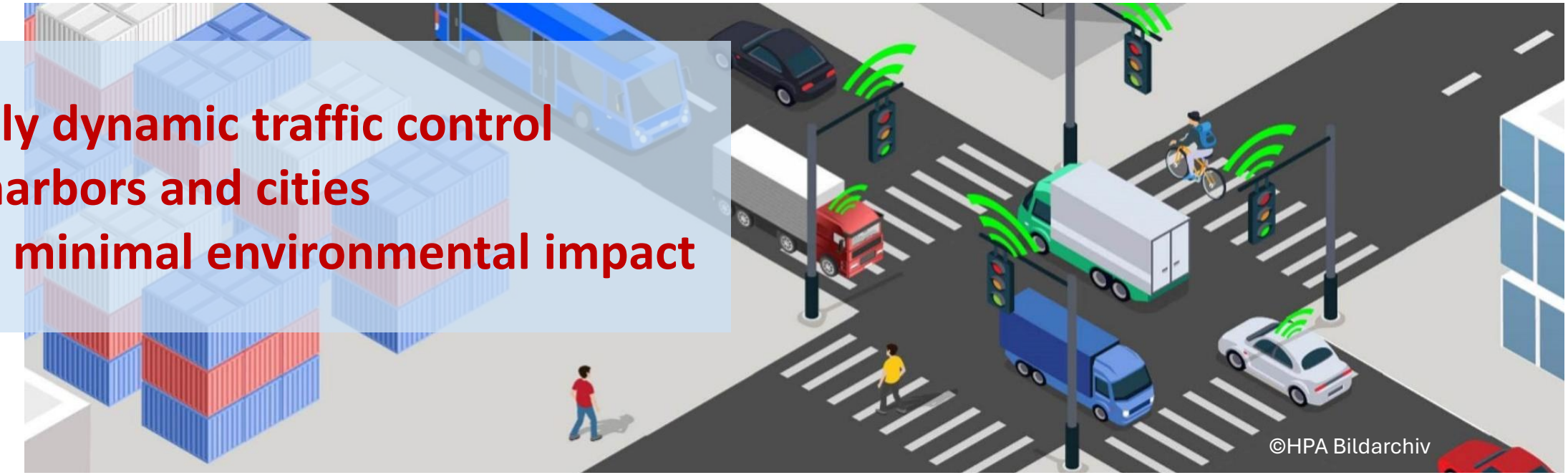
Will only be processed if capacity utilisation allows it.

PRIO 3
OUTSIDE TOLERANCE RANGE

Slot has expired; new booking must be made.

Our vision for the future

Highly dynamic traffic control for harbors and cities with minimal environmental impact



Responsive

Reacting to disturbances and traffic patterns in seconds.

Fair

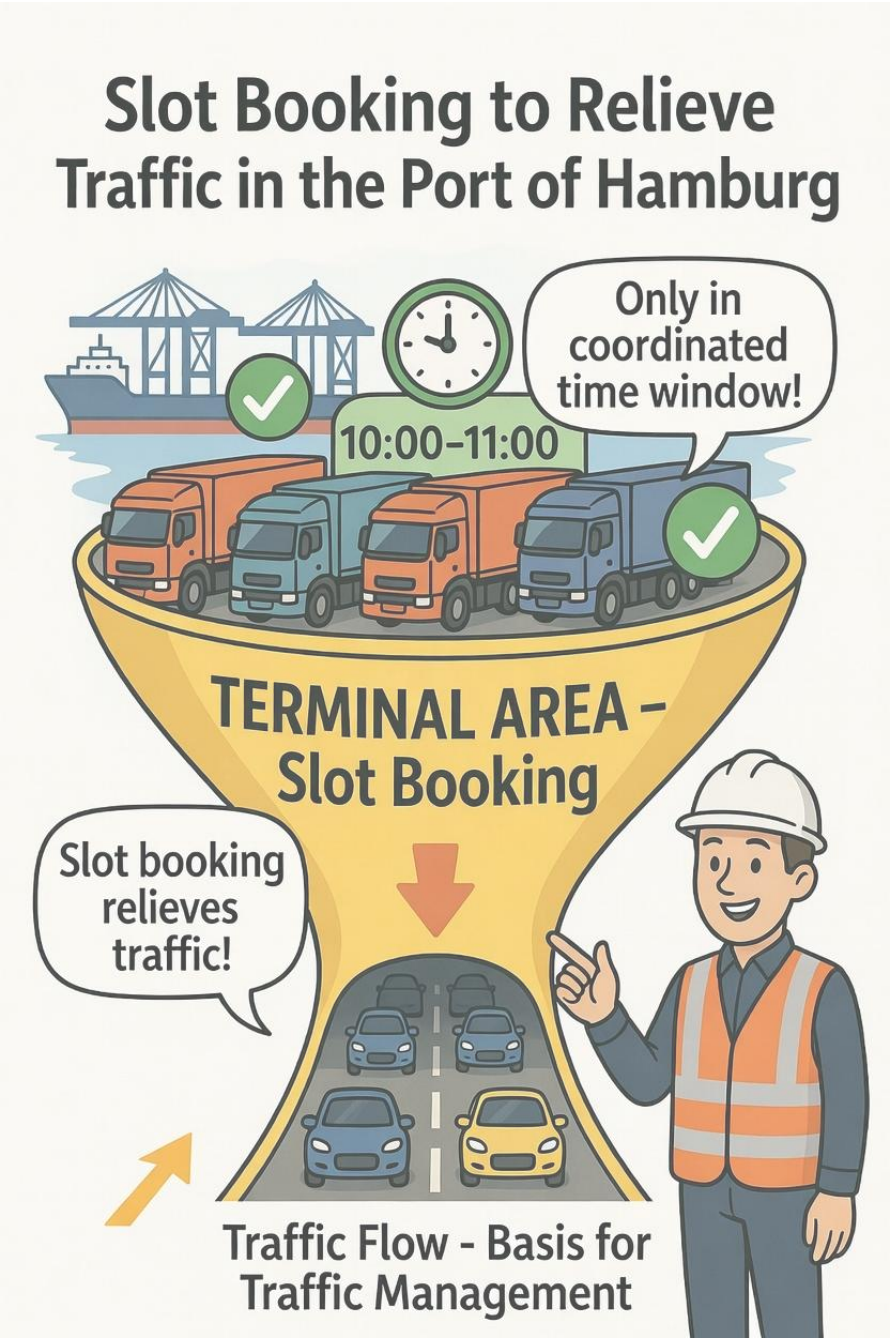
All road users reach their destination more quickly and the environment is protected.

Open

Digital Twin and data are available for planning and research projects and additional services.

Cost effective

No more need for highly sophisticated traffic light controllers.



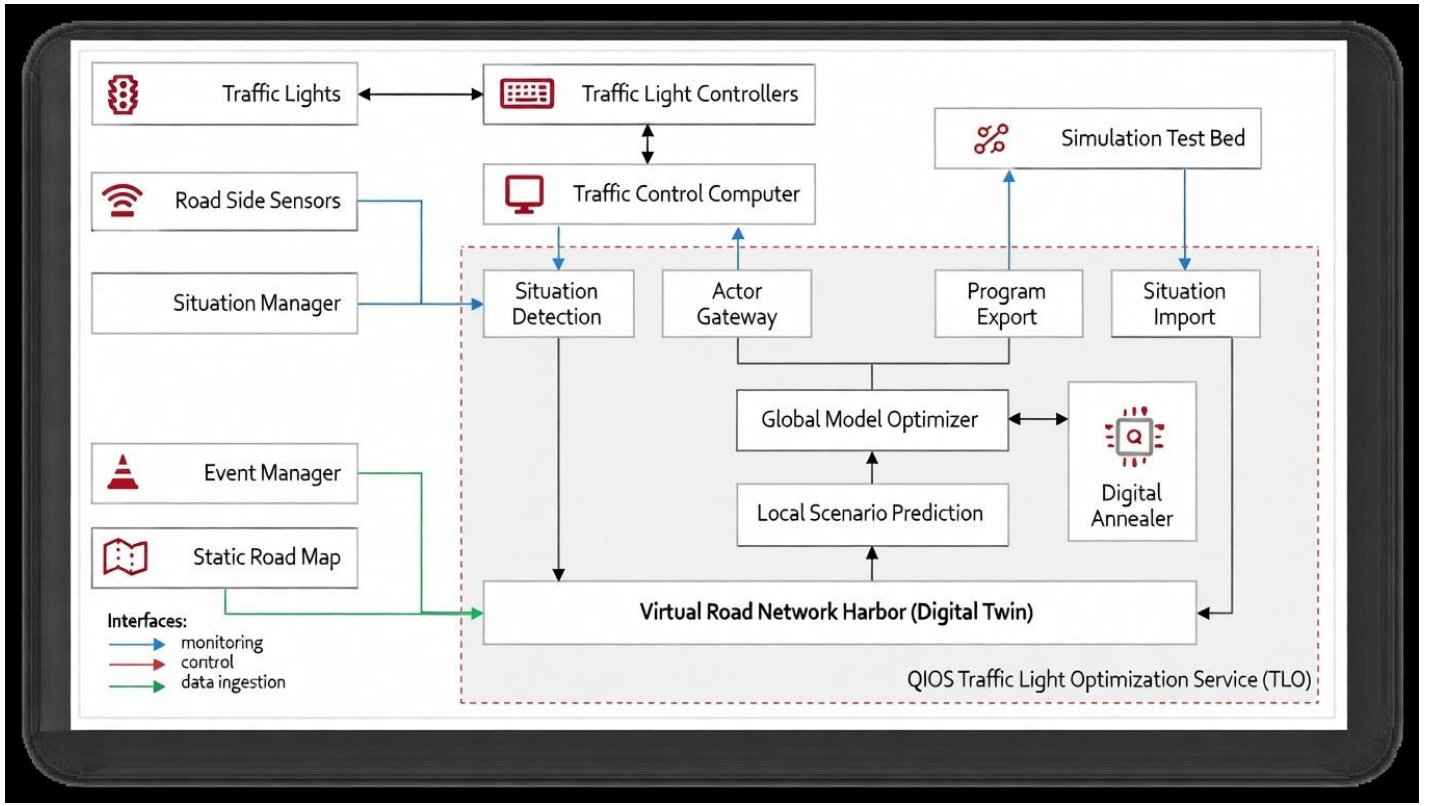
Traffic Flow – The Basis for Effective Traffic Management in the Port of Hamburg

Trucks can only access container terminals within a pre-agreed time window

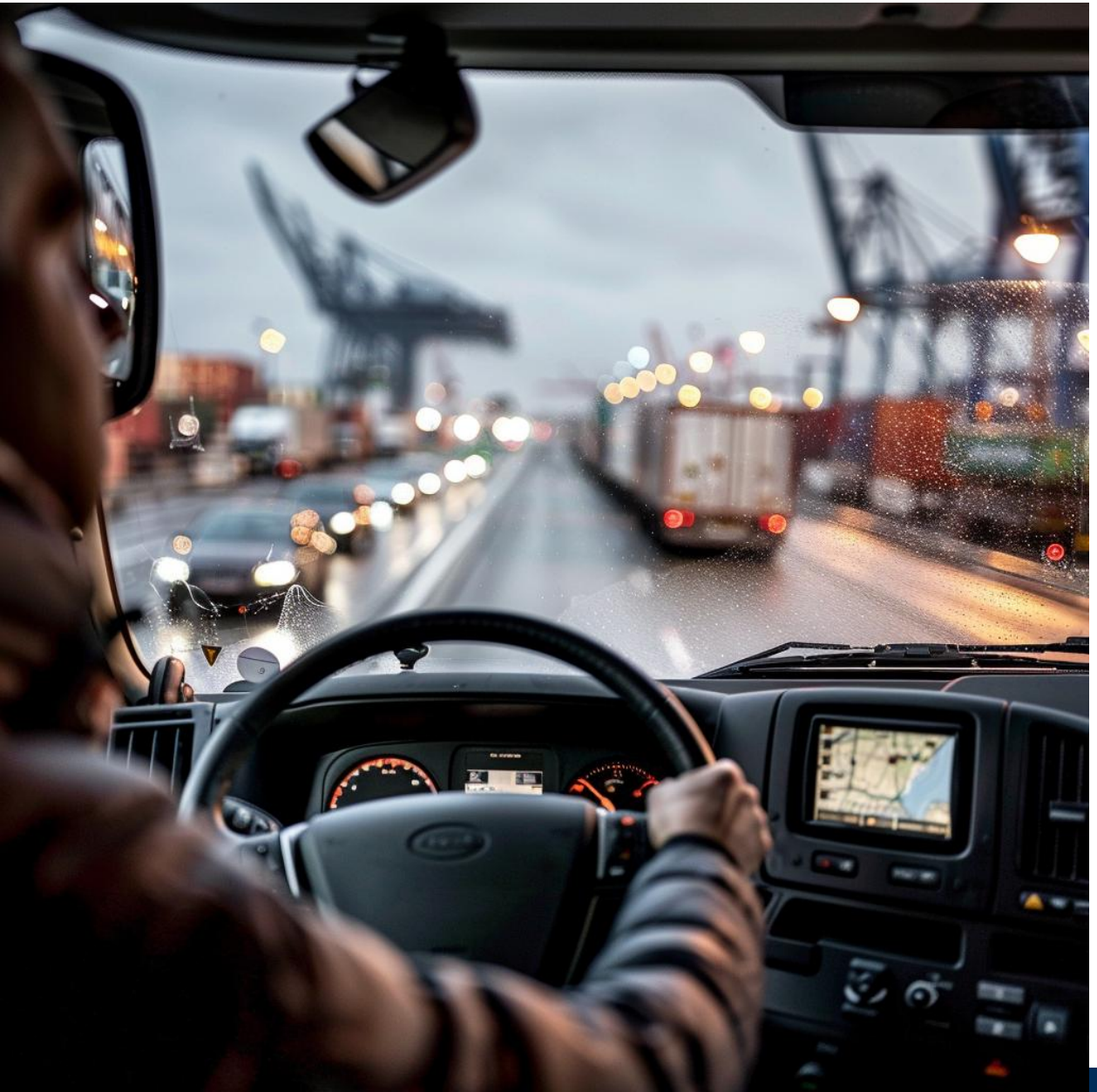
SANTANA/ MOZART“

Mobility OptimiZation and Analysis in Real Time

- Multi-year innovation project by the Port of Hamburg started in 2019
- Assisted by Fujitsu Smart City & Digital Incubation and the Institute of Highway Engineering and Transport Planning of the TU Graz
- Research and proof-of-concept phase completed 2023
- Real world Testing starts in Q4/2024
- Goal: Network-wide fully optimized cooperative traffic light control with QIOS



- Quantum Inspired Optimization Services (QIOS)
- SANTANA/MOZART combines real time sensor data, parallel traffic simulations and quantum inspired optimization to create a better traffic flow for all participants.
- Quantum Inspired Optimization Services by Fujitsu are used to calculate the best traffic light setting out of all reasonable traffic light combinations for all intersections in the Hamburg Port area.

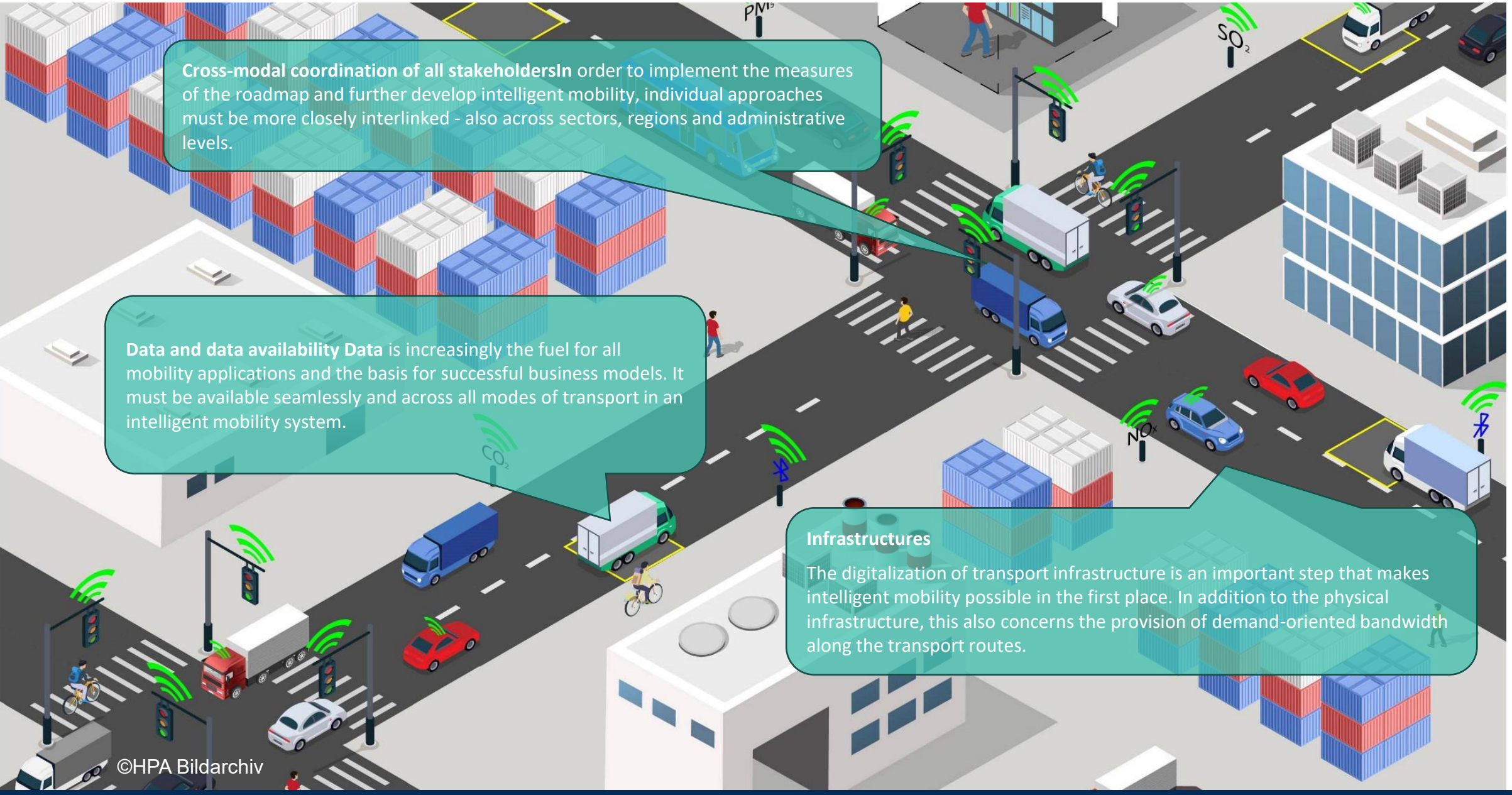


Traffic flow optimization

- Generating alternative phase sequences per crossing
- Running short-term simulations in parallel
- Selecting optimal solutions every 10 seconds
- Communicate results

MOZART
Digital twin: The test field

- Heavy traffic subnetwork in the port
  ---> Sub-network heavily burdened by heavy goods traffic
- 5 intersections controlled by traffic lights
- 20 km lanes
- Divided into 72 segments
- 4,000 vehicles per hour


Cross-modal coordination of all stakeholdersIn order to implement the measures of the roadmap and further develop intelligent mobility, individual approaches must be more closely interlinked - also across sectors, regions and administrative levels.
Data and data availability Data is increasingly the fuel for all mobility applications and the basis for successful business models. It must be available seamlessly and across all modes of transport in an intelligent mobility system.
Infrastructures
The digitalization of transport infrastructure is an important step that makes intelligent mobility possible in the first place. In addition to the physical infrastructure, this also concerns the provision of demand-oriented bandwidth along the transport routes.
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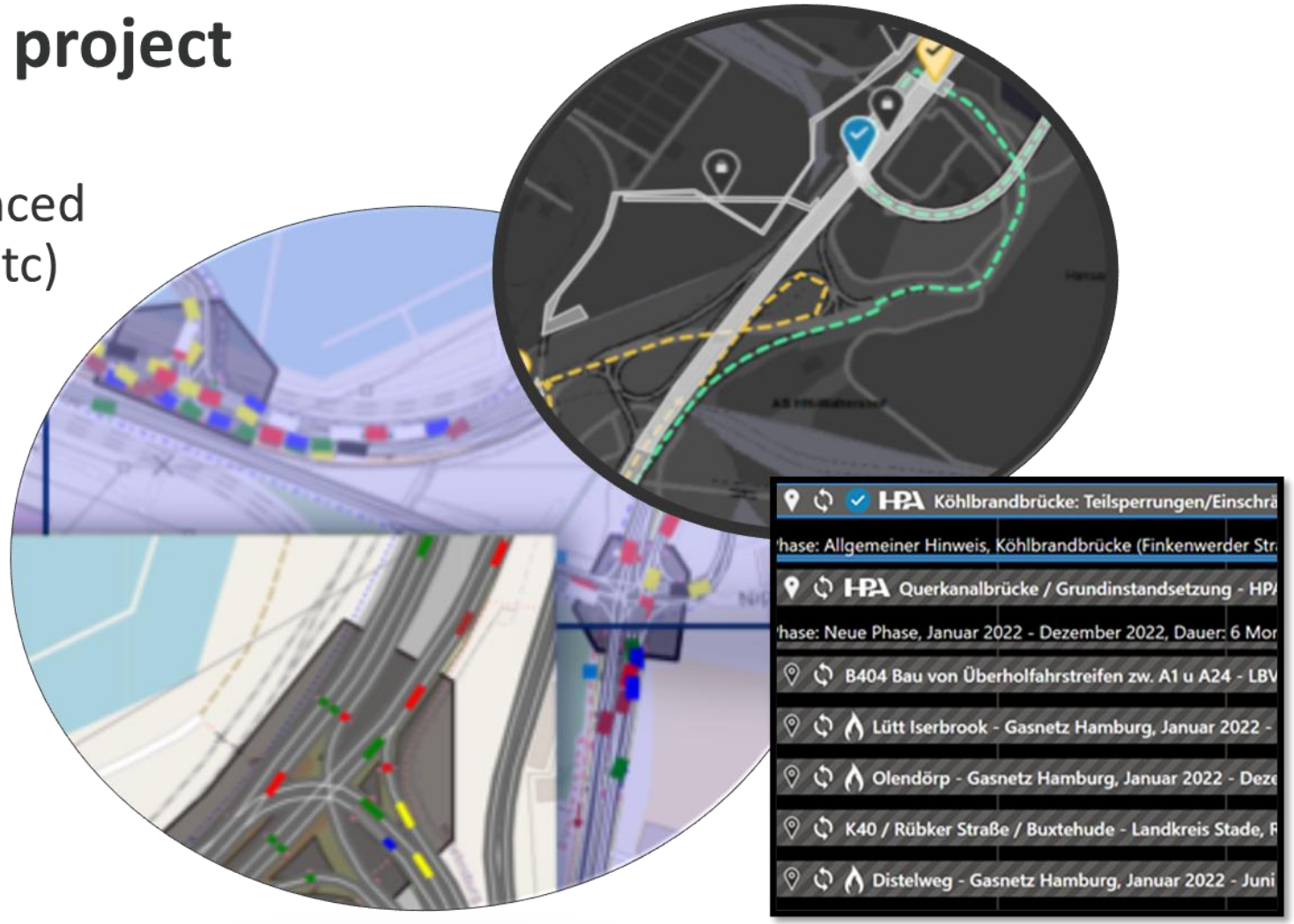
HPA Infrastructure support, which we could implement within the project

- Construction dates (announced road closures, restrictions etc)
- Detailed digital twin of a subnetwork

→ real time traffic analysis,

→ real time network optimization



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Impressum

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Hamburg Port Authority AöR

In Hamburg sagt man
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