Driver Assistance Systems for LRV

Dr. Ruprecht Anz, UK Light Rail Conference

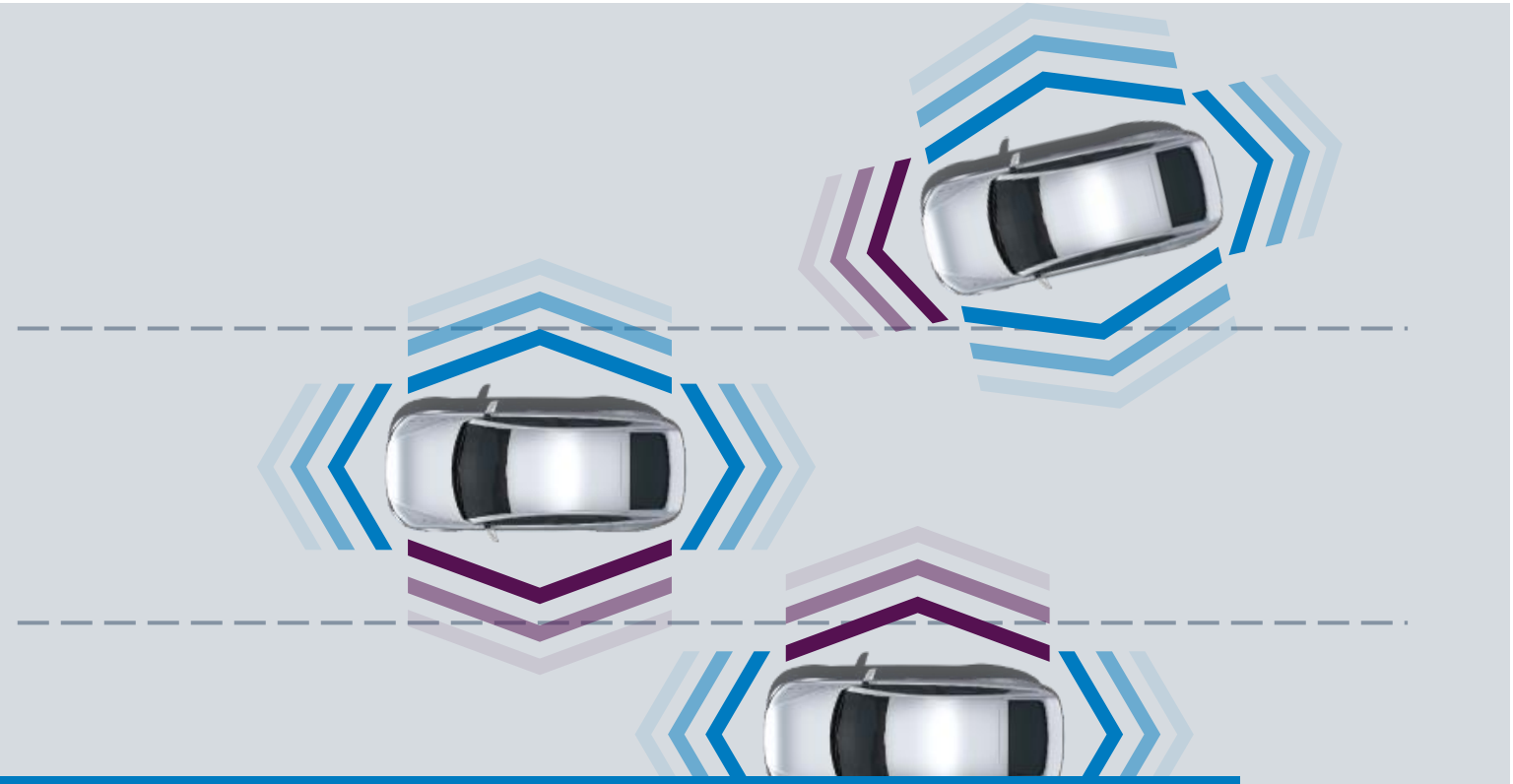
11th - Wednesday 12th of July - Gateshead

Tuesday

BOSCH

Bosch Tram Assist Suite

Driver assistant systems become mandatory



Bosch is transferring the technology from road to rail.
When will driver assistance system become state of the art in urban rail transport?

Mandatory systems for new passenger Cars in 2024 in the EU*

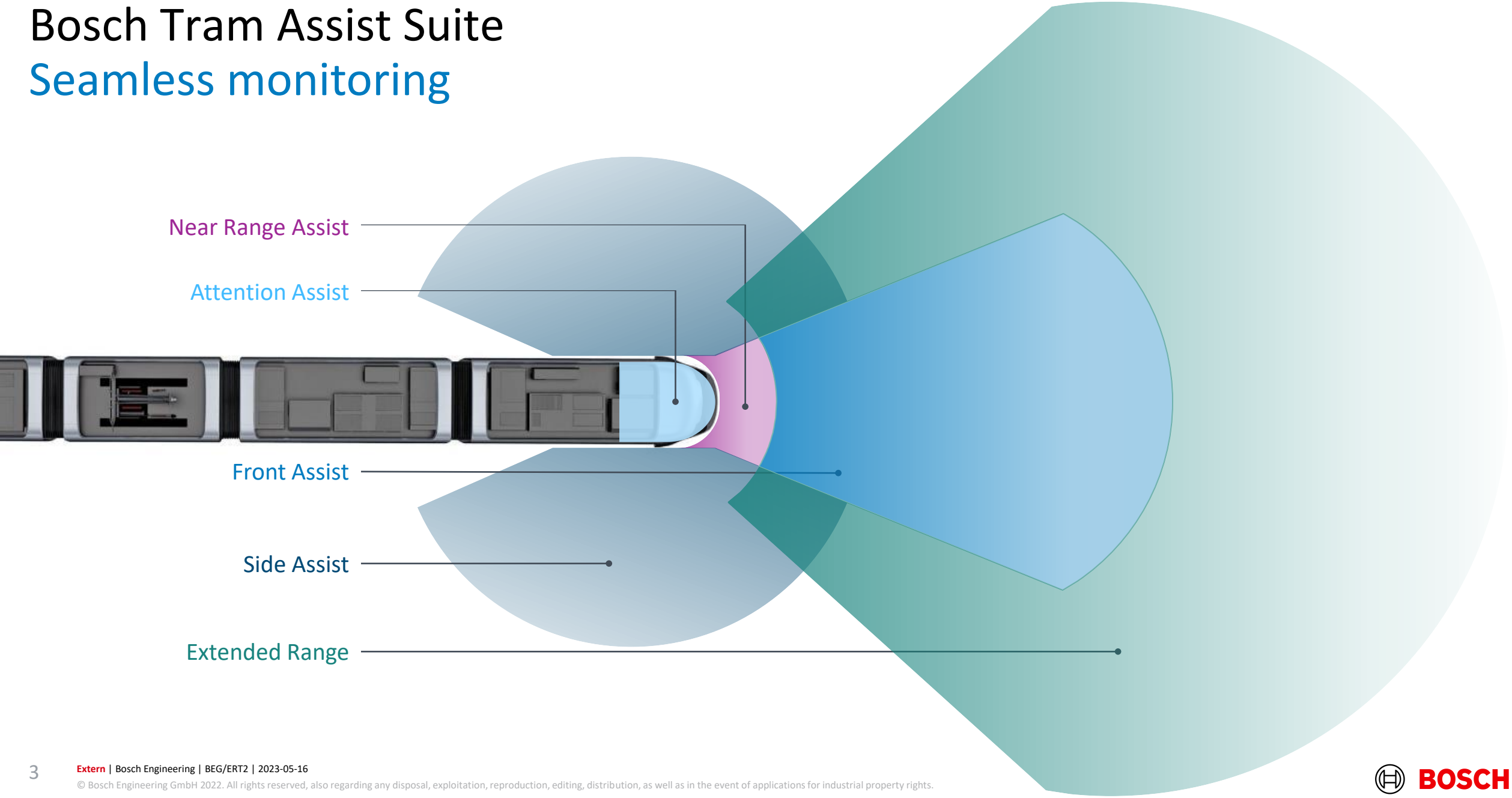
- Emergency brake assist
- Speed assist
- Event data recorder
- Drowsiness/attention assist
- Alcohol interlock installation facilitation
- Reverse driving assist
- Tyre pressure monitoring
- Line keeping assist
- Emergency brake light

*Quelle:
https://www.tuev-nord.de/de/privatkunden/ratgeber-und-tipps/technik/fahrassistenzsysteme
https://eur-lex.europa.eu/eli/reg/2019/2144/oj

BOSCH

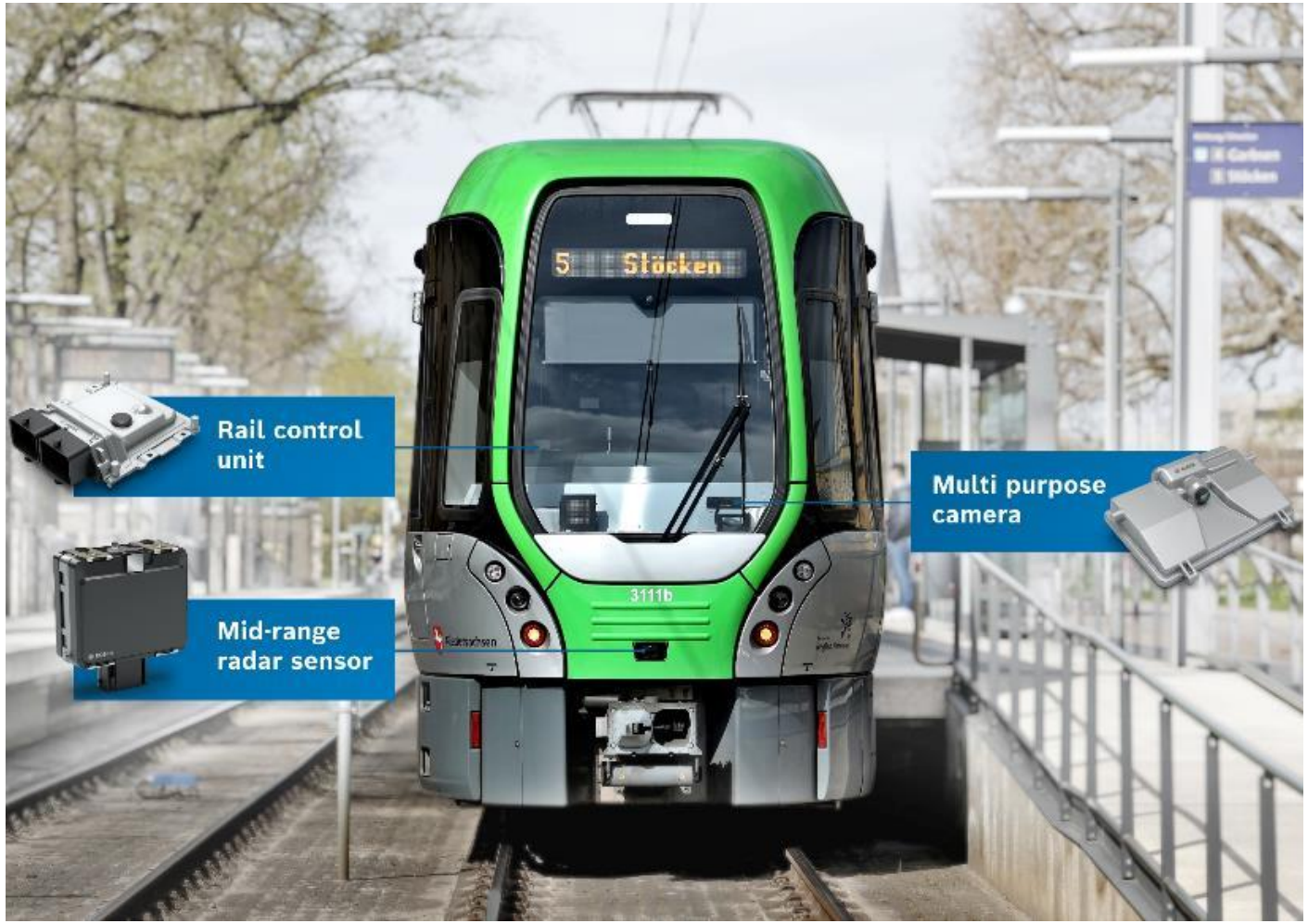
Bosch Tram Assist Suite

Seamless monitoring



Advances of driver assistance Systems for LRV

Less collisions, higher availability

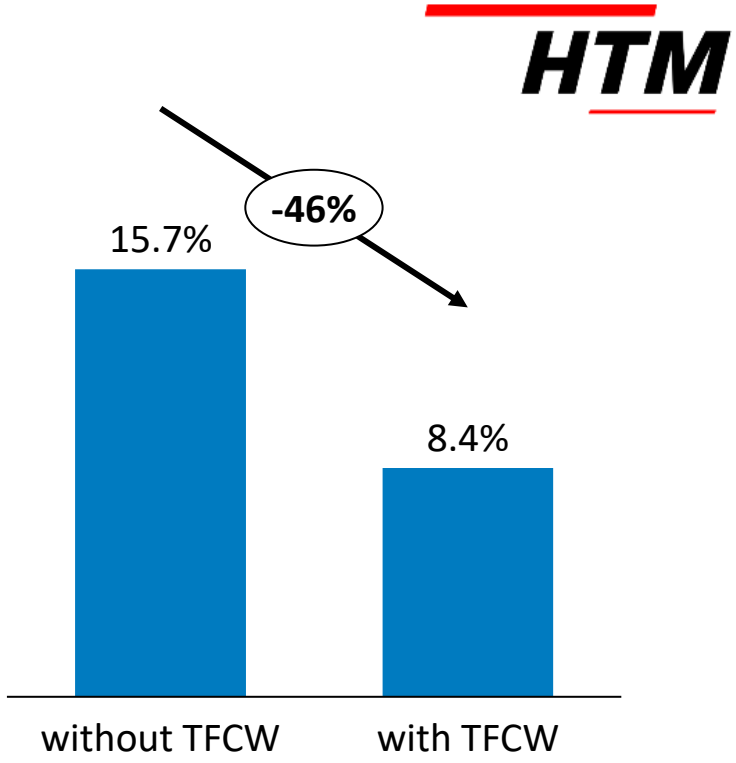


- In public operation since 2017 (Frankfurt, The Hague, Amsterdam, Hannover, …)
- One of the leading technologies in collision avoidance for trams
- Based on proven and reliable automotive components
- Robust multi-sensor principle with AI technology
- Compliant with VDV recommendation 191
- Certified to EN 50155 and EN 50657
- Homologated in several EU applications and in the US

Advances of driver assistance Systems for LRV

Retrospective analysis of accident data

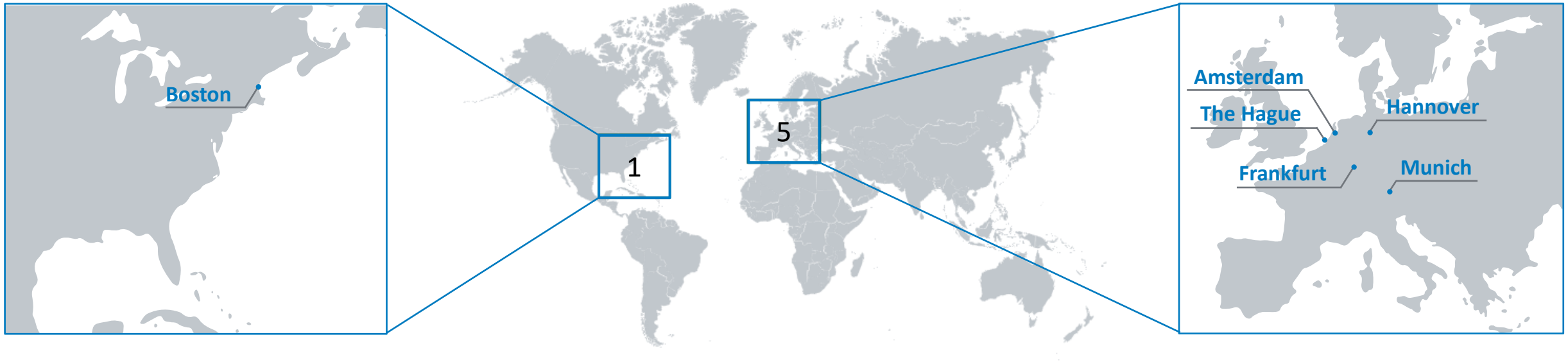
- Network operator HTM has more than 200 Vehicles, 70 trams are equipped with Bosch TFCW
- Trams with and without TFCW are operating on the same lines
- Collisions of all vehicles have been analysed for more than one year
- The rate of **forward collisions** compared to the total number of documented incidents turned out to be 46% lower



The achievable rate of improvement depends on the local conditions of the network

Tram forward collision warning (TFCW)

Selected references & success stories



BOSTON
- 600 systems
- In operation planned 2023
- MBTA

ULM
- 12 systems
- In operation since 2018
- SWU

AMSTERDAM
- 25 systems
- In operation since 2019
- GBV

THE HAGUE
- 140 systems
- In operation since 2018
- HTM

HANNOVER
- 100 systems
- In operation since 2017
- Üstra

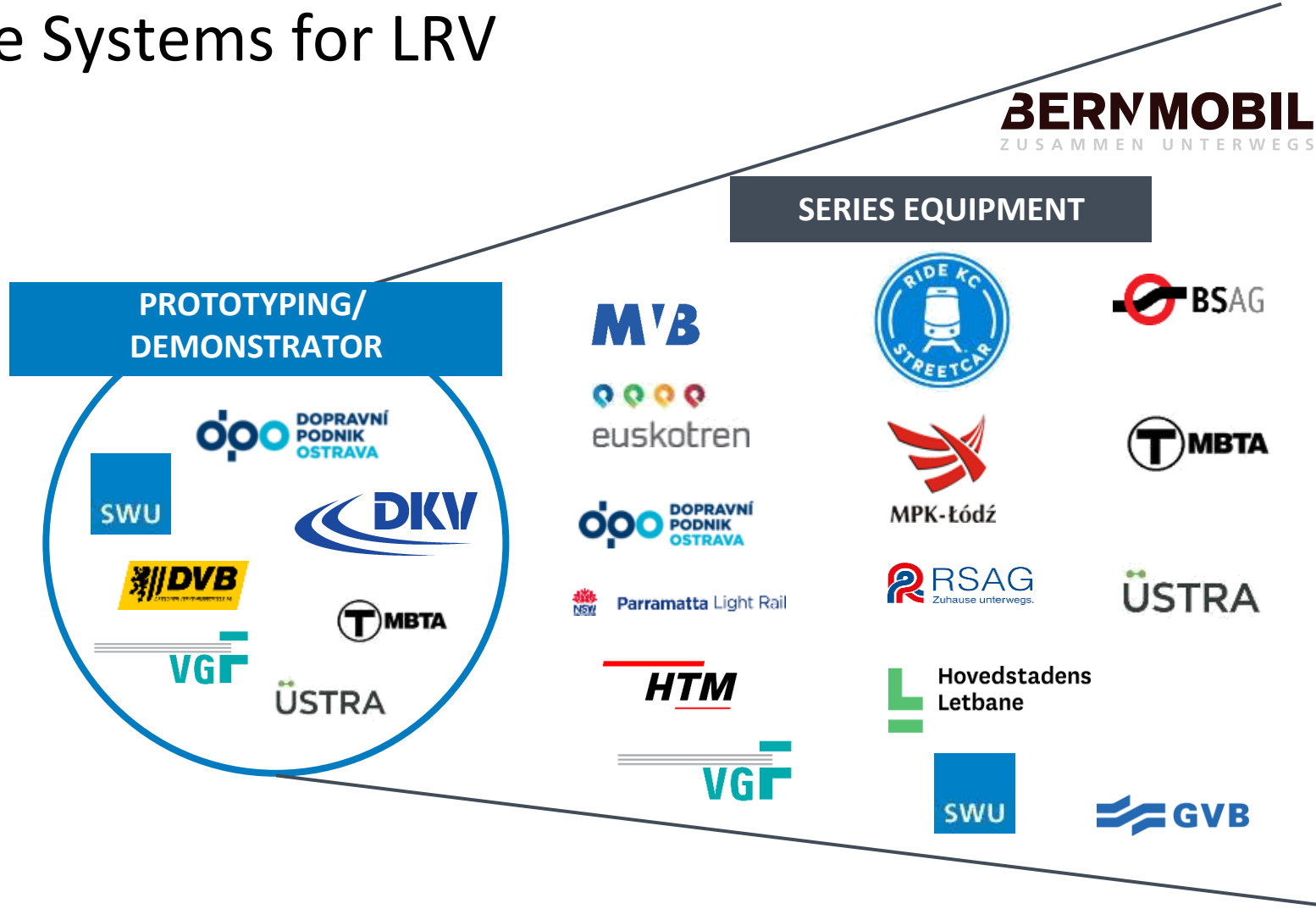
FRANKFURT
- 118 systems
- In operation since 2017
- VGF

BOSCH

Advances of driver assistance Systems for LRV

Motivation of our customers

- Less accidents
- Less injuries
- Less repair costs
- Increased availability
- Improved punctuality
- Less stress for the driver
- Less invest into infrastructure
- Improved Energy efficiency
- More comfort for the passengers



An even safer and more efficient operation of trams for better passenger journeys!

BOSCH

Front Assist – Status System Design

Detection and Warning Strategy Requirements

TP - / FP – rate (All obstacles above)

✓ ≥ 85 %

TP – rate**

✗ ≤ 1/8 h

FP - rate

Legend:

Speed Range | Speed Range | Speed Range

Distance Collision Avoidance | Distance Collision Warning

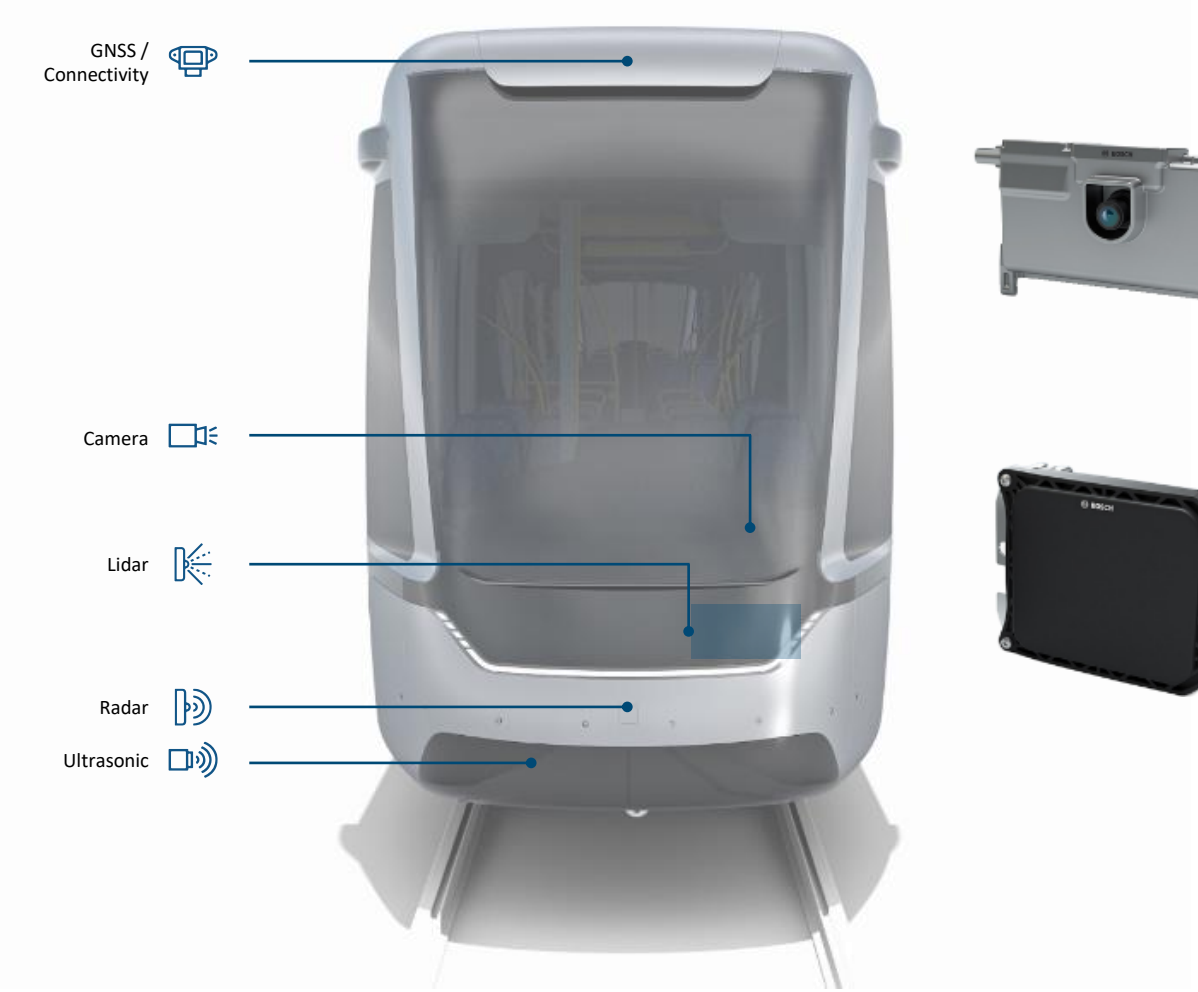
* Collision avoidance with deceleration -1.4 m/s² and reaction time 1s

** At nominal weather conditions, at daylight and twilight

BOSCH

Bosch Tram Assist Suite

Front Assist: Hardware configurations



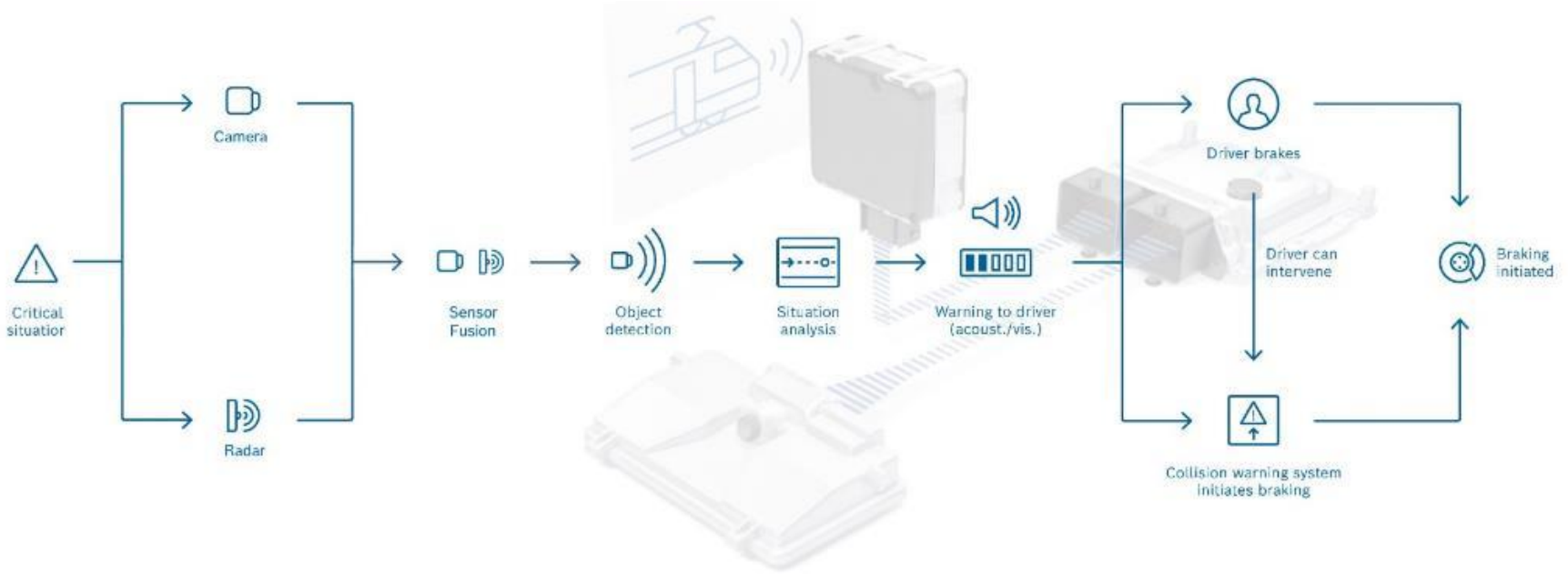
	TFCW	Front Assist	Front Assist Plus
GNSS / Connectivity	-	✓	✓
Camera	✓	✓ new gen.	✓ new gen.
Lidar	-	-	✓
Radar	✓	✓ new gen.	✓ new gen.
Ultrasonic	✓ optional	✓ optional	✓ optional

BOSCH

Tram Forward Collision Warning (TFCW)

Collision warning / avoidance system overview & sequence

- TFCW uses a multi sensor approach that is well proven in use in automotive.
- Every sensor principle has strength and weaknesses
- ***By combining different sensors, the shortcomings of the individual sensor can be overcome and the overall performance is increased.***



Bosch Tram Assist Suite
Digital map and localization (DML)

Customer benefit

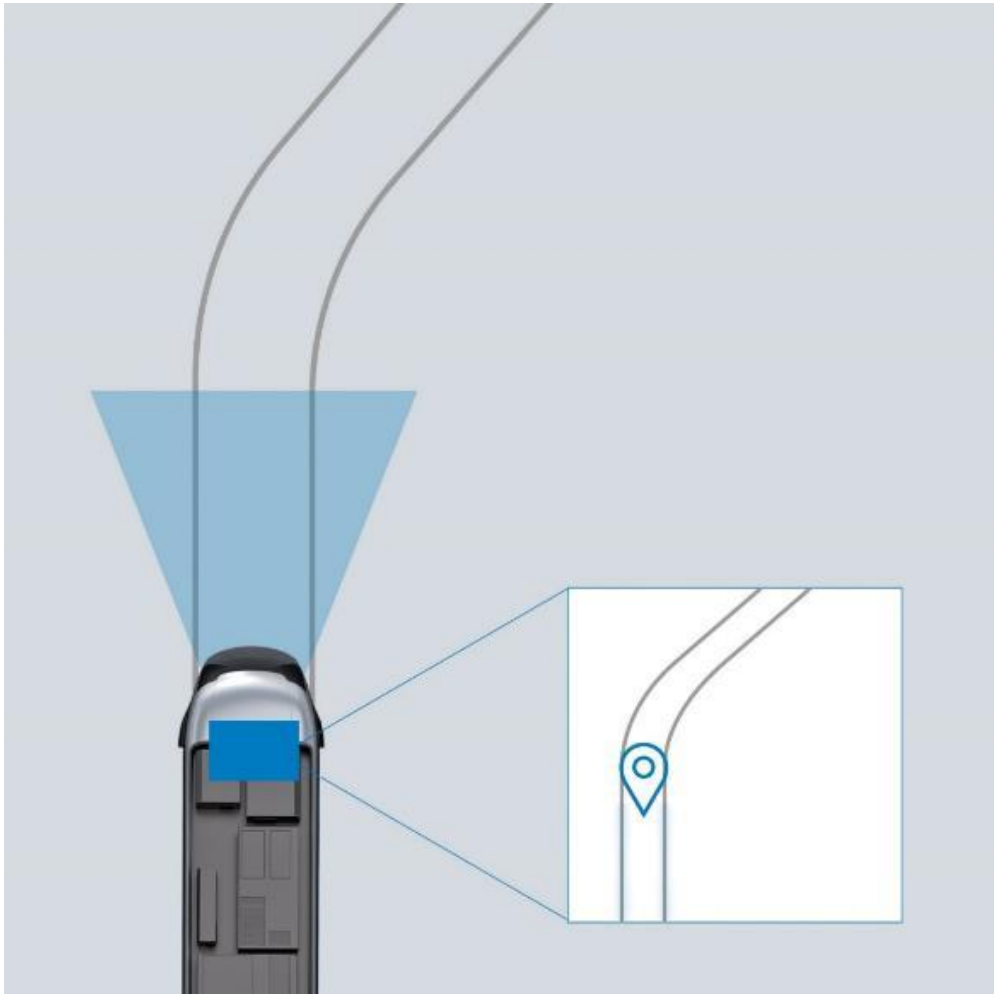
- Improved performance due to better information on the curse of the track

Use cases (DML basic)

- Avoidance of systematic FPs by geo-masking
- Identification of POIs (e.g. Buffer stops)
- Warning strategy dependant on location
- Warning on over speeding

Use cases
(higher accurate localisation with TEC+/-0,5m with)(DML plus)

- Obstacle detection and warning at higher distances and narrow curves and beyond switches
- Improved recognition of signs and signals,
- Target braking



Bosch Tram Automation Suite

Perception for Depot automatization/ train preparation

Customer benefit

- Saving of personal cost by driving automatically (driverless) within defined areas

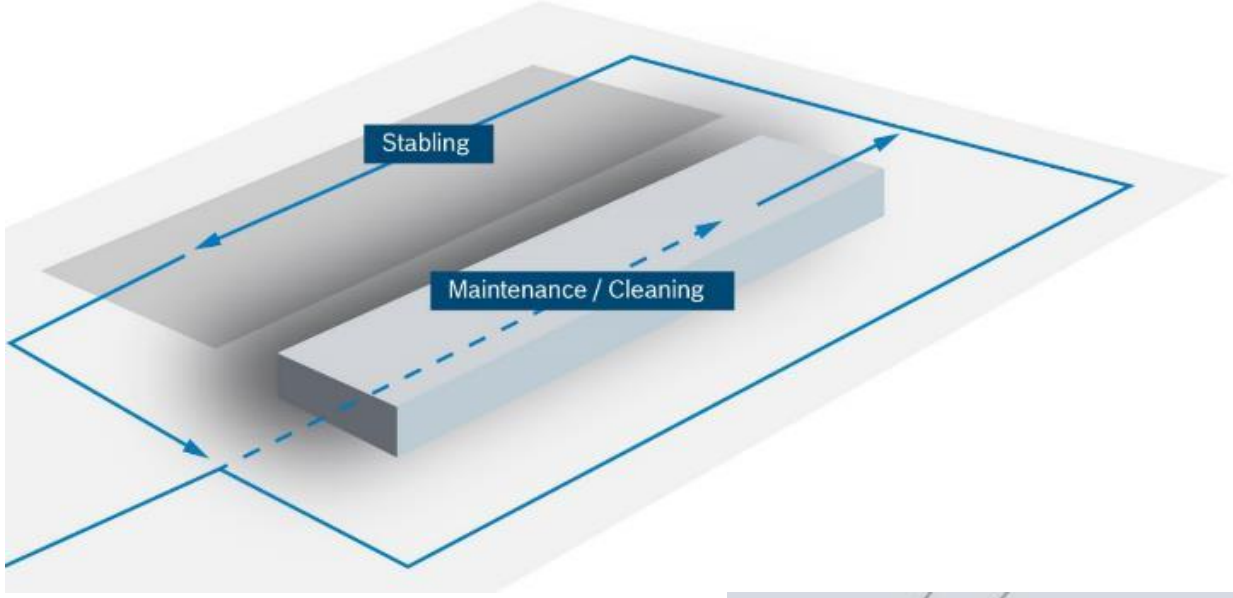
Use cases

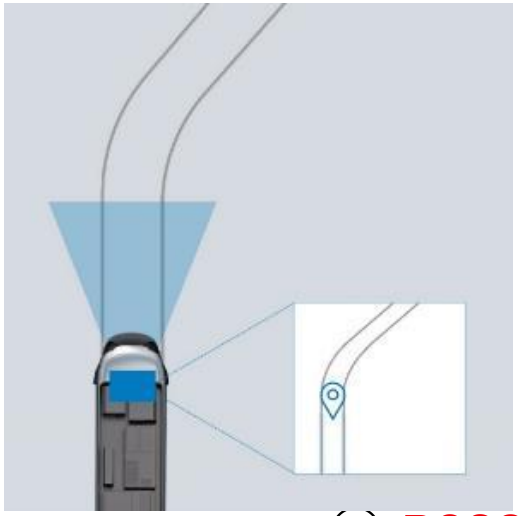
- Automated stabling at the beginning and the end of the missions (driver is at first/last station) to/from depot
- Driving between parking facility or to the workshop (e.g. cleaning, sanding, repair, …) within the depot

Bosch delivery

Obstacle detection system with extended use cases at limited speed (SIL level to be defined; SIL1…2 expected)

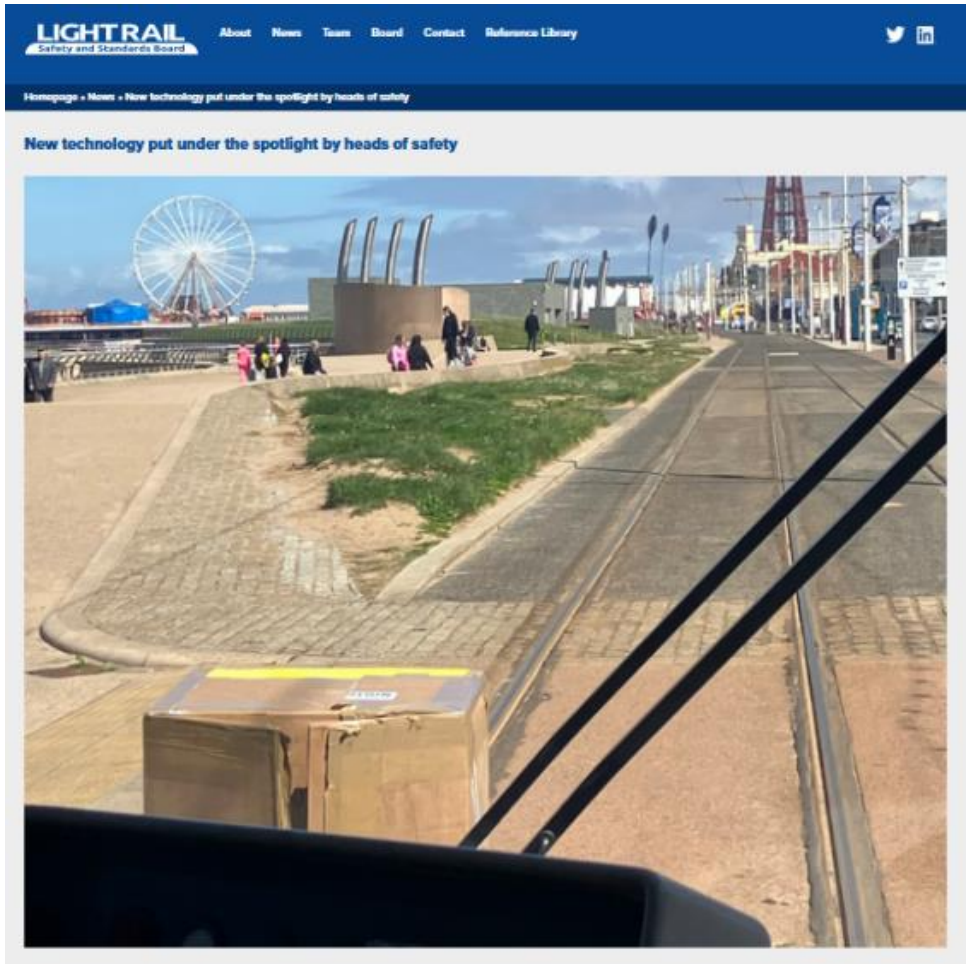
- Free Space detection, tram is stopped if “any obstacle” is in front
- Digital map with detection of “landmarks” for improved localisation





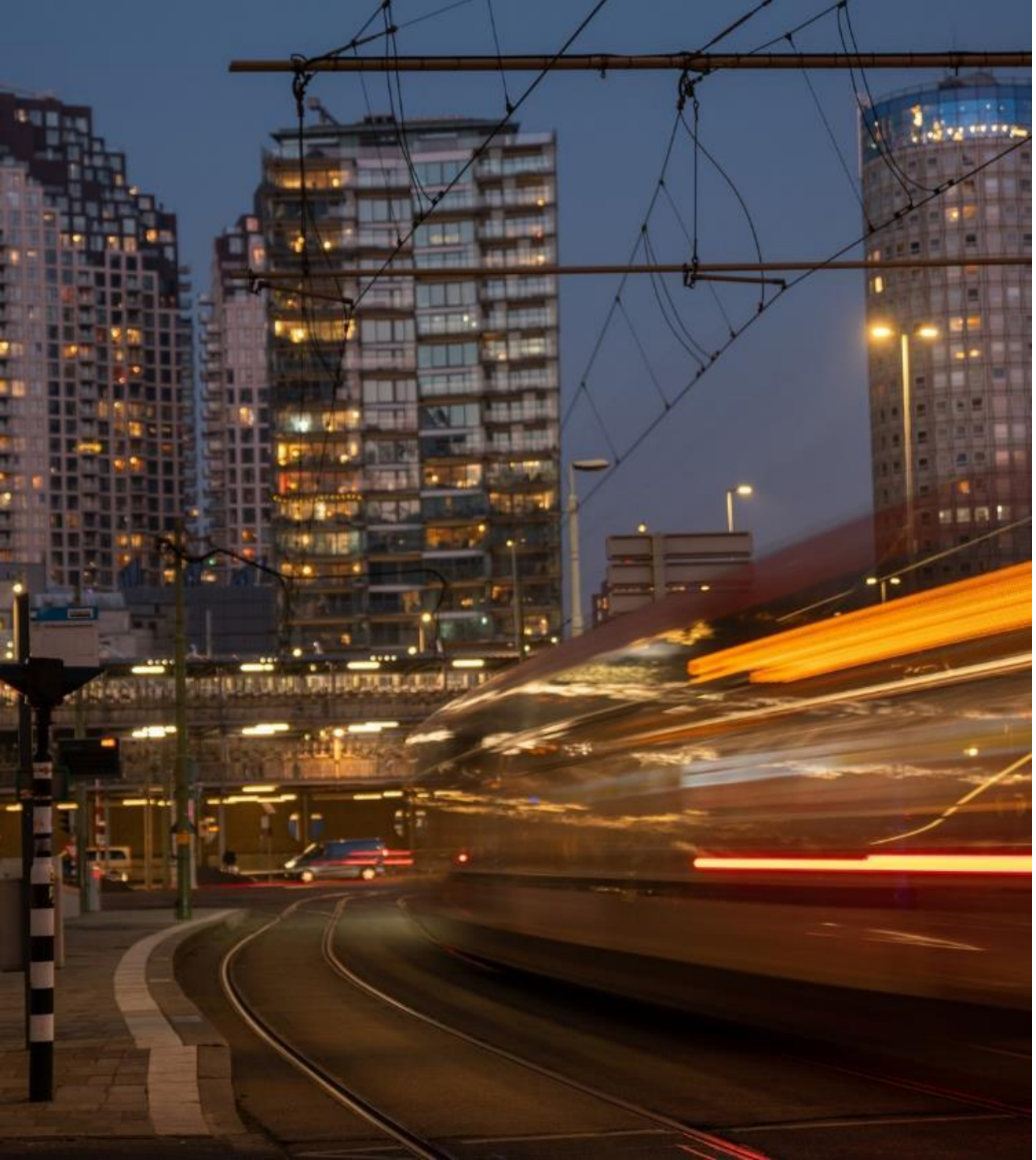
Bosch Tram Assist Suite

Tests in the UK: Blackpool and Sheffield



LRV Assist:
Summary

- Driverless trams will not be reality for the next decade
- Shortage of drivers is a growing concern for many tram operators in Europa, offering a modern workspace will be more important
- Traffic will increase in most cities, this leads to more stress for drivers
- Bosch has established the forward collision warning system as stat of the art
- Assistance systems can help to reduce accidents, delays for the customers and stress from the driver.
- More assistance systems are possible. Contact us for a POC or demonstration



Thank you for your attention

When it comes to driver assistance systems for LRV all tracks lead to Bosch.

Dr. Ruprecht Anz

+49(160)90436209

Ruprecht.Anz@de.bosch.com

www.bosch-engineering.de

BOSCH