Seamless cross-border mobility: 5G-Blueprint approach

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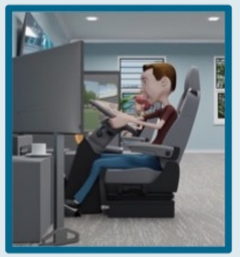
Outline

- 5G-Blueprint Project overview
- Achievements so far
- Lessons learned

5G-Blueprint project: Original concept

TELEOPERATED TRANSPORT



TECHNOLOGY – 5G NETWORK & ENABLING FUNCTIONS

Fast | **Reliable** | **Secure** | **Guaranteed** | **Cross-border**

ECONOMICS

- Reduction of waiting time
- Reduction labour shortage
- Economic growth
- Safer driving
- Facilitator automated mobility
- Complex business model

GOVERNANCE

- MNO SLAs
- ToD service SLAs
- Legislation
- Liability
- Data sharing

5G-Blueprint project: Refined concept

Driven in autonomous mode:
98.2 % of the trajectory*

27 years of R&D later …

2% issue

Edge & corner cases

5G-Blueprint approach

* https://www.cs.cmu.edu/~tjochem/nhaa/

5G-Blueprint Project overview

TECHNOLOGICAL

- Design and implement a **5G network for CAM services** — WP 5
- Develop and implement the **prototype of a TO system** — WP 4
- Implement and deploy enabling functions **guaranteeing safety** and increasing value — WP 6
- Validate the **end-to-end TO transport** solution supported by 5G in real-life cross-border scenarios — WP 4,5,6,7

BUSINESS

- 5G TO transport **market analysis** — WP 3,8
- **Commercial possibilities** — WP 3,8
- Positions the **possible role** of TO transport based on 5G **in CAM** — WP 3,8
- TO transport based on 5G connectivity **market adoption** — WP 5,8

REGULATORY

- Identify **regulatory issues** — WP 3,4,5,6,8
- Recommended actions — WP 3,4,5,6,8
- **Standardization** and best practices — WP 3,4,5,6,8

5G-Blueprint Project overview: Use cases and Trial sites

Vlissingen trial site (NL)

Automated docking

Vlissingen

Teleoperated crane

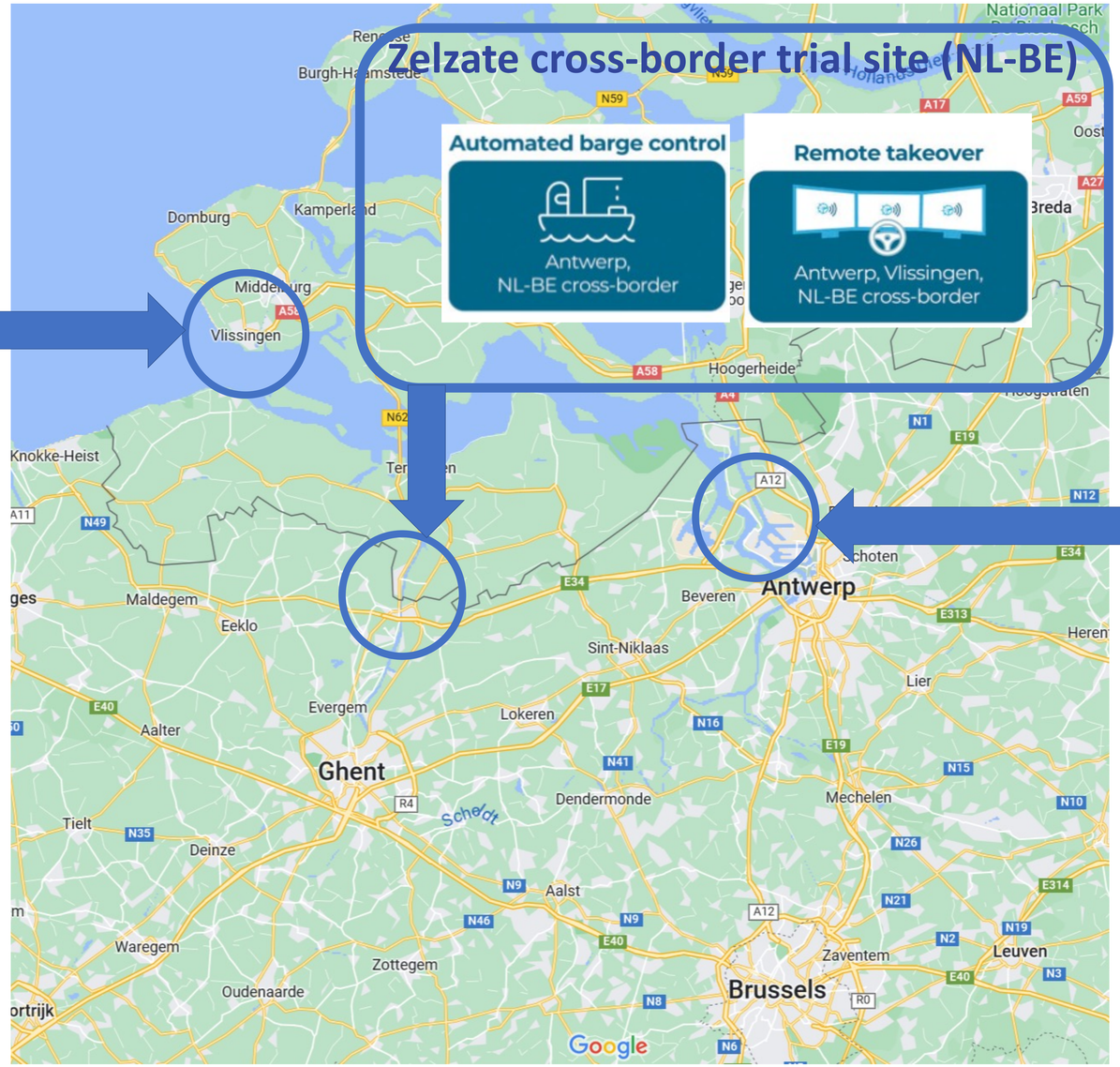
Vlissingen

CACC-based platooning

Vlissingen

Remote takeover

Antwerp, Vlissingen, NL-BE cross-border



Antwerp trial site (BE)

Automated barge control

Antwerp, NL-BE cross-border

Remote takeover

Antwerp, Vlissingen, NL-BE cross-border

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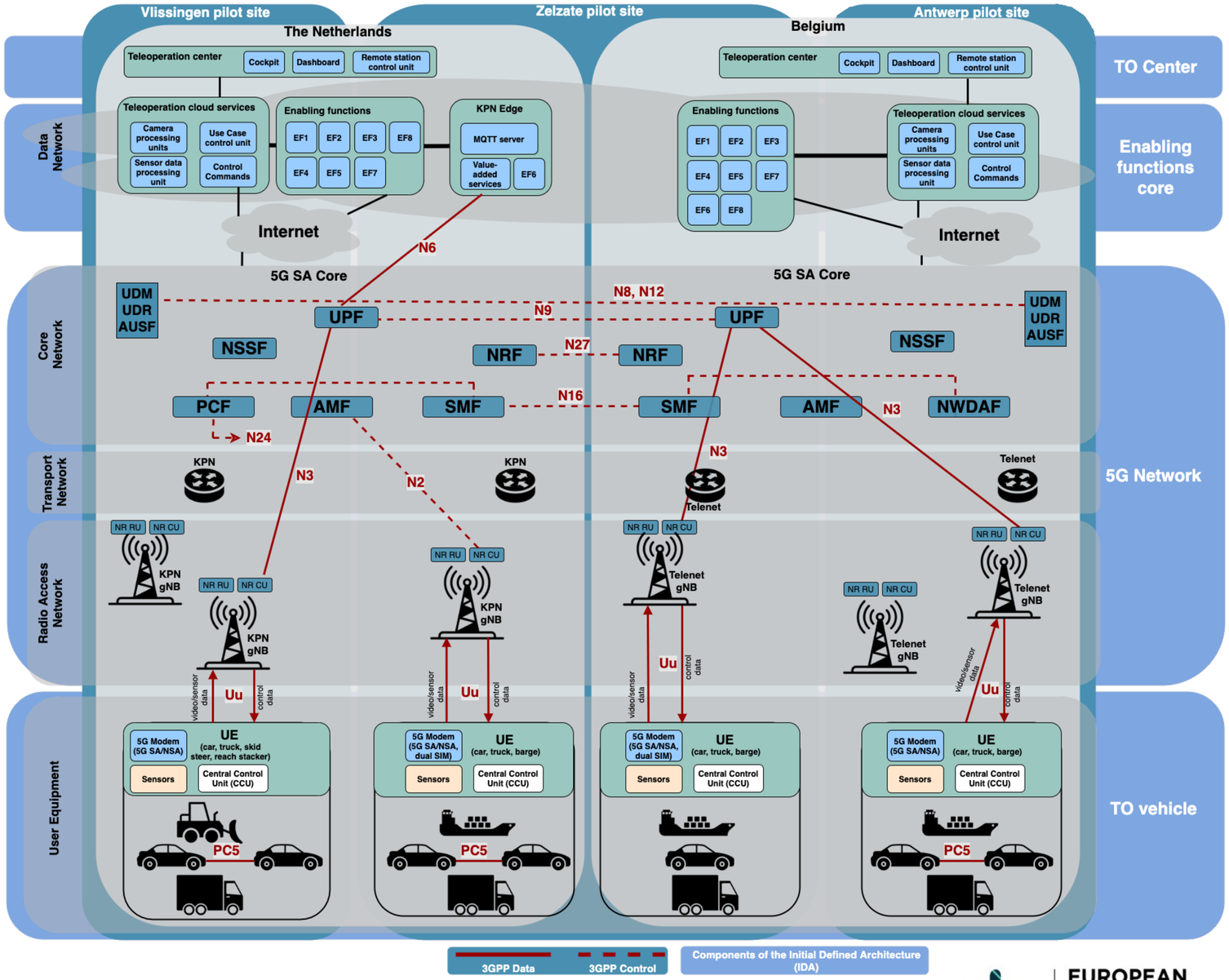
Achievements so far

5G SA in three trial sites

- Deployment of 5G SA in all three trial sites
- Seamless handover mechanisms captured
- 5G ecosystem:
  - UE (trucks, vehicles, vessels, skid steers)
  - 5G NR and Core
  - Data Network (UC components and EFs)
- Teleoperation center



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Achievements so far

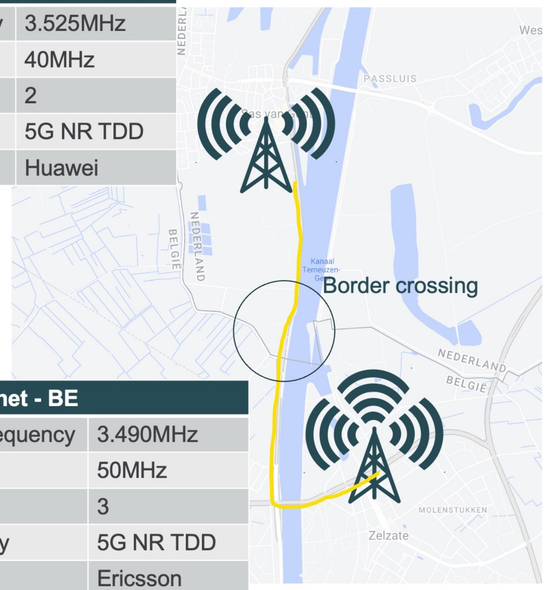
Seamless roaming

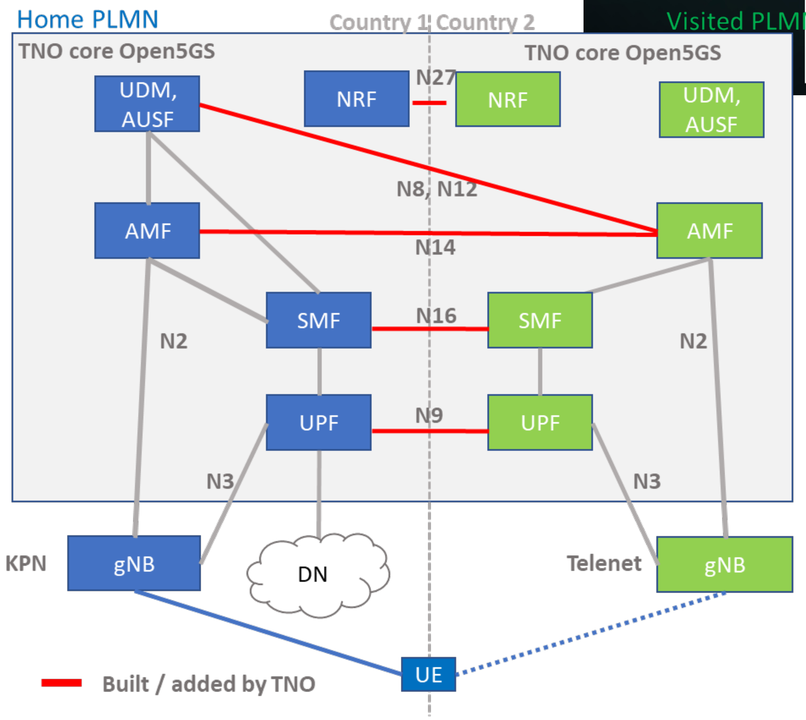
- 5G SA seamless roaming working and deployed at cross-border site
- Dual-sim working
- 5G Network deployment done in three trial sites
- Network evaluation done at BE and NL sites
- Successful seamless roaming demos

RAN FOR SA-N2 CROSS-BORDER HANDOVER

RAN KPN - NL	
Center Frequency	3.525MHz
Bandwidth	40MHz
Cells	2
Technology	5G NR TDD
Brand	Huawei

RAN Telenet - BE	
Center Frequency	3.490MHz
Bandwidth	50MHz
Cells	3
Technology	5G NR TDD
Brand	Ericsson





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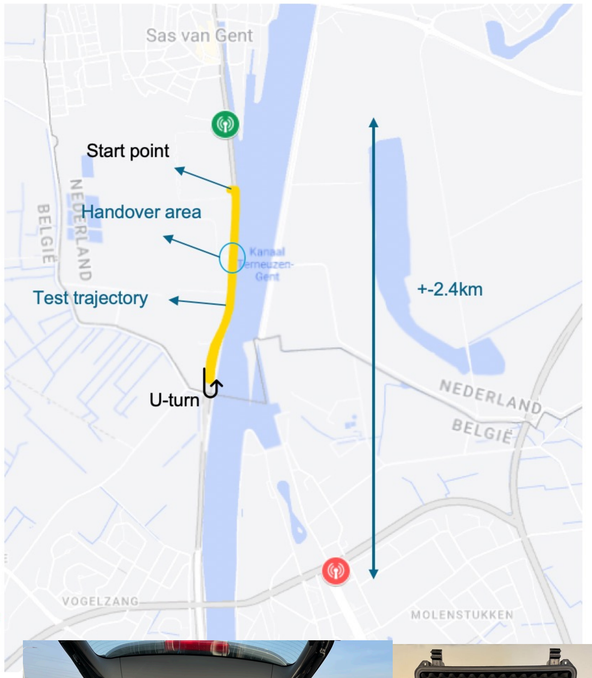
Achievements so far

Seamless roaming via N2

- Home routed (HR) SA roaming
  - Data traffic routed back to the home PLMN (HPLMN)
  - Authentication of UE's subscription done via home network (N8, N12)
  - Visited SMF and UPF connected via N16 and N9 to HPLMN.

- KPN 5G SA test network
  - 3.5GHz band 78 (3525MHz CF - 40Mhz bandwidth)
  - One gNB used
  - Huawei RAN, TNO core



- Telenet 5G SA test network
  - 3.5GHz band 78 TDD (3489.6 MHz CF - 50Mhz bandwidth)
  - One gNB used
  - Ericsson RAN, TNO core

Achievements so far

Seamless roaming via N14

Home routed (HR) SA roaming with the N14 interface:

- UE's PDU session data exchanged between home and visited networks via N14 interface
- Both visited and home networks are configured as equivalent PLMNs (E-PLMN)
- Roaming behaves similarly to a normal handover procedure
- No new PDU re-establishment at visited network needed
- Seamless roaming achieved, obtaining similar results for interruption times to a normal N2 handover procedure

N14 vs N2

Seamless cross-border N14 handover performs similar to the N2 handover, the main difference is that it depends on the latency between the cores

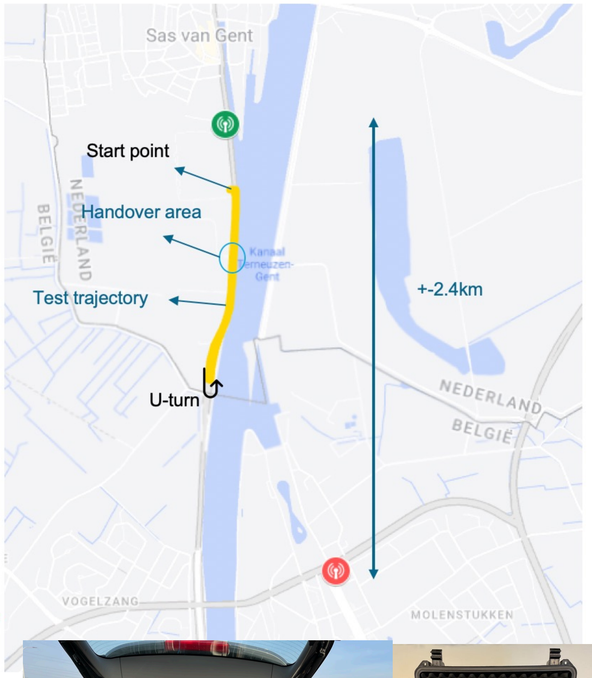
Lab results

Lab results:

- N2 handover: 100-120ms
- N14 handover: 100-150ms

Field results

- N14 handover: ~100ms
- Latency between the two cores: ~7ms → small impact compared to the other latency components



Lessons learned

Standardization potential

New procedure to enable Home-Routed Seamless roaming in 5G SA → **merges** N14 handover with Home-Routed Roaming (separate 3GPP TS 23.502 procedures)

Seamless roaming with inter-PLMN handover in **both** directions → procedure for V-PLMN to H-PLMN direction is also missing in standards.

Planning

5G-wise

- Handover decisions currently based on signal strength, exploring other criteria (allowed IMSI, service availability, contractual relations)
- Vast amount of configuration parameters → to be automated

Use case-wise

- Autodocking successfully tested with the full-scale trucks over 5G SA
- Teleoperation of vehicles and barges successfully tested over 5G SA in the national sites (BE, NL)
- Network testing demonstrated that its performance enables **safe teleoperation across borders**
- Teleoperation of vehicles and barges to be thoroughly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Thank you!