Radio Interference Measurements for Urban Cooperative Intelligent Transportation Systems

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Motivation: Urbanization


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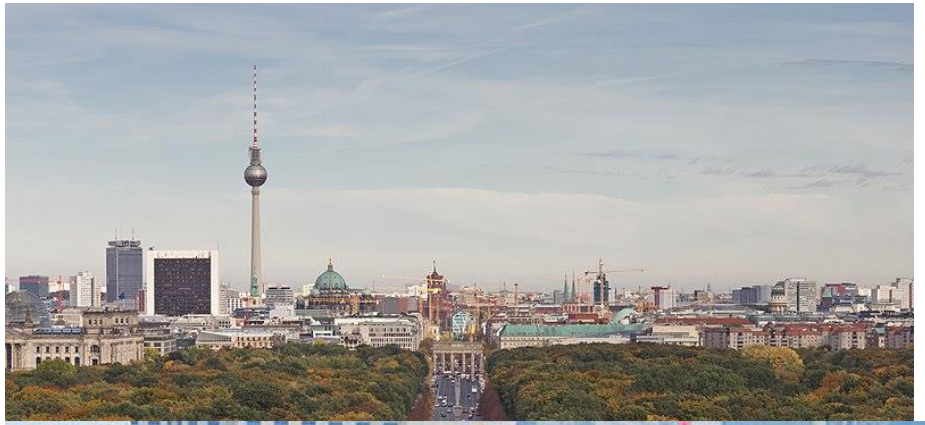

Transportation:

- Congestion
- Delays
- Inconveniences

Future Cooperative Intelligent Transportation Systems (C-ITS):
Mitigate negative effects through digitalizing and networking

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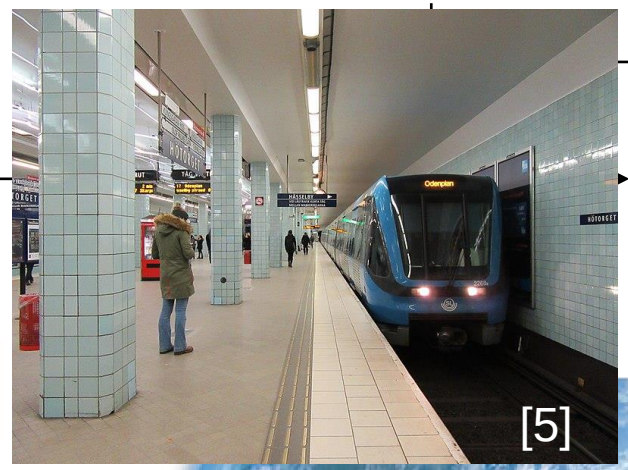
Cooperative Intelligent Transportation Systems (C-ITS): Technology

Technology	Road ITS		Urban rail ITS
	ITS-G5 (IEEE 802.11p)	LTE Cellular-V2X (3GPP R14, R15)	DSSS, modified IEEE 802.11a WLAN
	IEEE 802.11bd Next Generation V2X (NGV)	5G NR C-V2X (3GPP R16, R17)	ETSI Joint Task Force ITS & Rail Telecommunications (JTFIR)
	Range < 1 km 5.9 GHz ITS band	Direct PC5 sidelink: Range < 1 km 5.9 GHz ITS band	Range < 1 km Upper 5.9 GHz ITS band


[5]

Coexist of technologies?

Yes / No


[6]

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Measurement Campaign V2X-DuRail

(Vehicle-to-Everything-Radio for Digital, Urban Rail Communications)

Urban Rail ITS

5.9 GHz

Road ITS

5.9 GHz

Severity of interference between Urban Rail and Road ITS?

Measurement Campaign: Vehicles

Saftey-of-Life (SoL) - Car

Mercedes G400,

KN Measurement-Bus

Mercedes Sprinter

DB advanced TrainLab

Multiple-unit train Series 605 (ICE TD)

Source: Advanced TrainLab

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Measurement Campaign: Radio Equipment

RUSK Channel Sounder
DLR-KN

Main characteristics

- Technology-independent
- Frequency: 5.2 GHz
- Bandwidth: 120 MHz
- Snapshot rate = 488 Hz
- Tx Power = 46 dBm
- Interference link Measurement-Bus - Train

ITS-G5 (IEEE 802.11p)
Cohda Wireless
MK5 OBU

LTE C-V2X (3GPP R14)
Cohda Wireless
MK6EVK

Main characteristics

- Frequency: 5.9 GHz
- Bandwidth: 10 MHz
- Packet rate = 64 Hz / 300 Hz
- Tx Power = 33 dBm
- Link BS – Train
- Interference link SoL-Car – Train, Measurement-Bus – Train

IEEE 802.11a
ETTUS Research
USRP B210 &
GNU Radio IEEE802-11
SDR transceiver

Main characteristics

- Frequency: 5.9 GHz
- Bandwidth: 10 MHz
- Packet rate = 10 Hz
- Tx Power= 33 dBm
- Link BS – Train

- Frequency: 5.9 GHz
- Bandwidth: 5 MHz
- Packet rate = 32 Hz
- Tx Power= 33 dBm
- Link BS – Train

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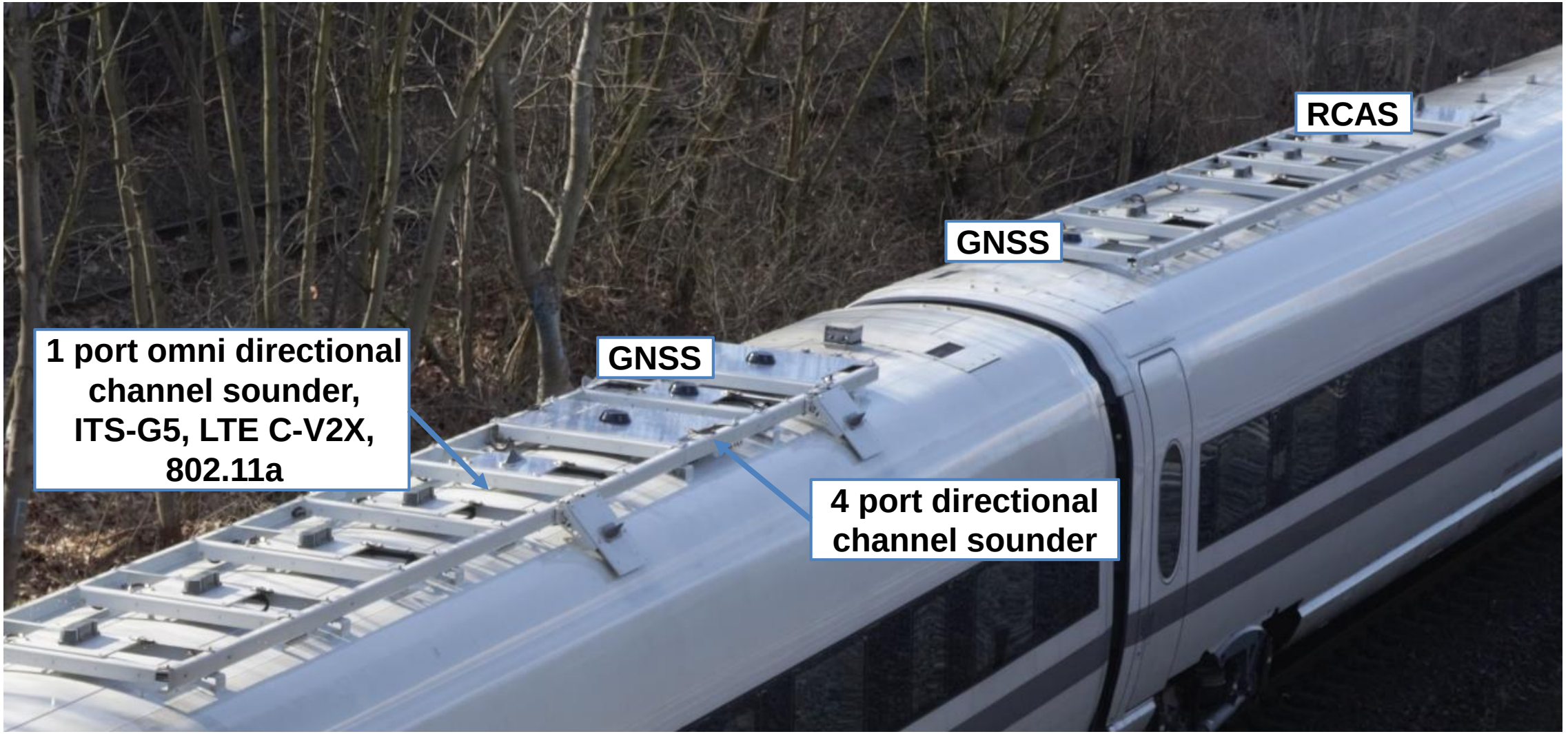
Measurement Campaign: Train Antennas



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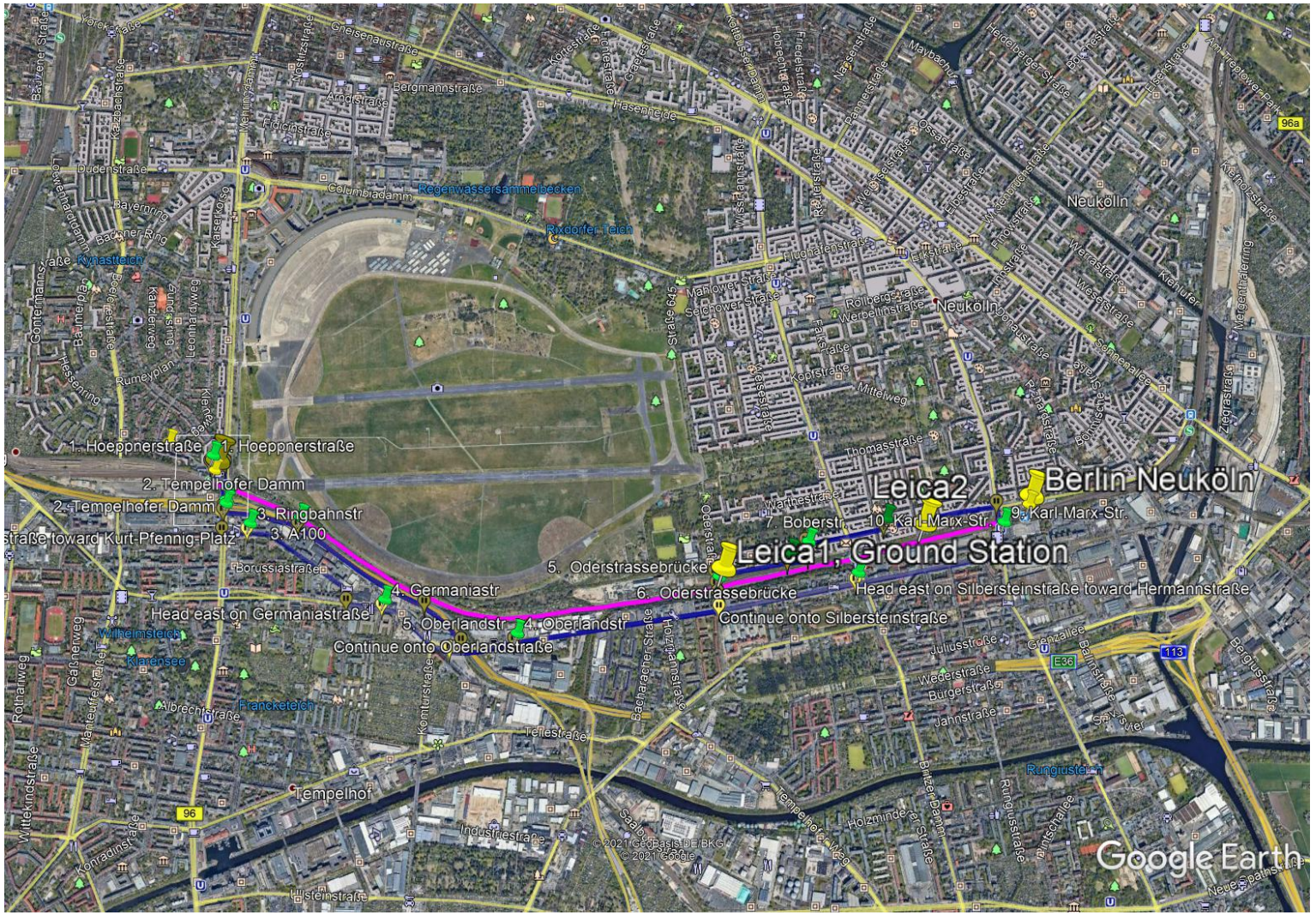
Measurement Campaign in Berlin:

4 day measurements:

- Day 1 & 2 Tempelhof – Neukölln
  - Train:
    Back & forth between Tempelhof and Neukölln
  - Measurement-Bus & SoL-Car Maneuvers:
    - Drive parallel & along train
    - Cross railway tracks (bridge, underpass)
    - Drive parallel, but in opposite direction of train
- Day 3 & 4 Grunewald – Tempelhof



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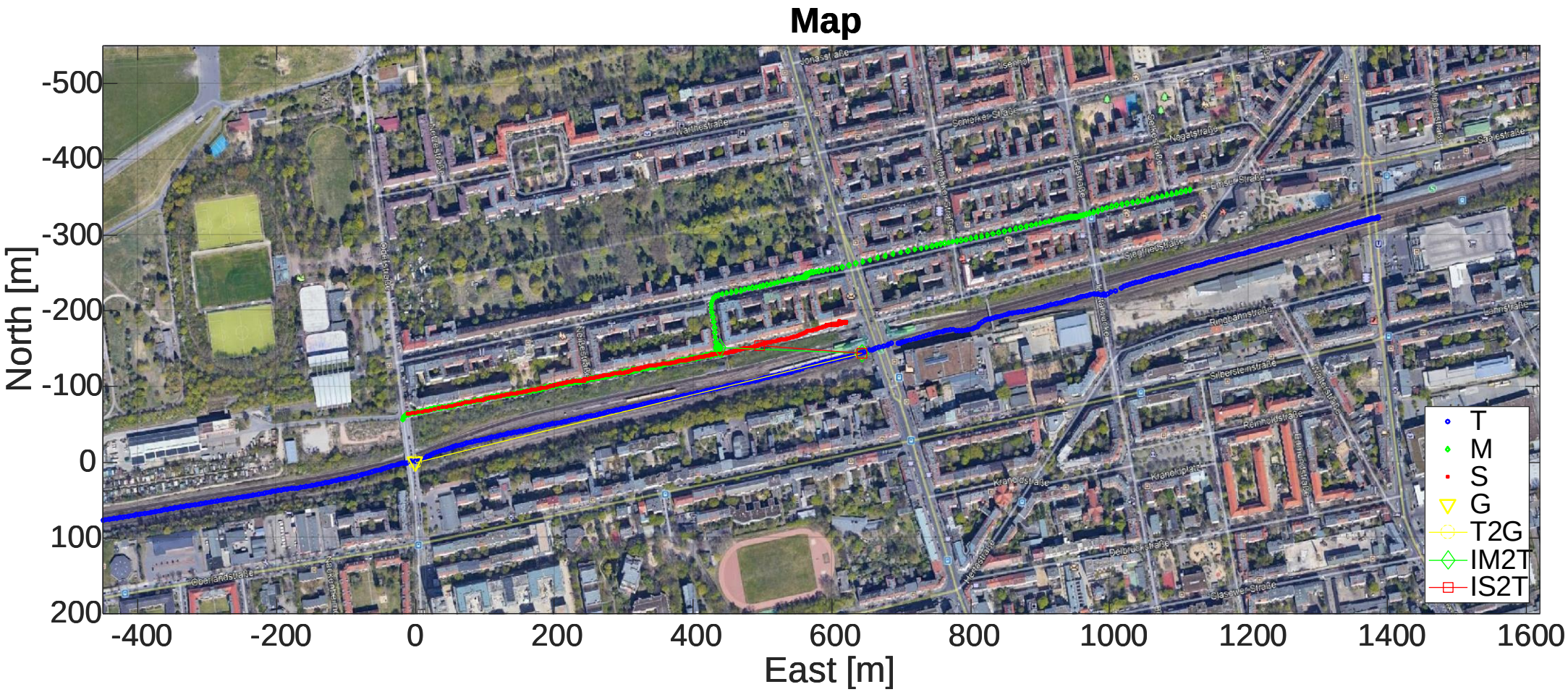
First Results, Adjacent Channel Interference



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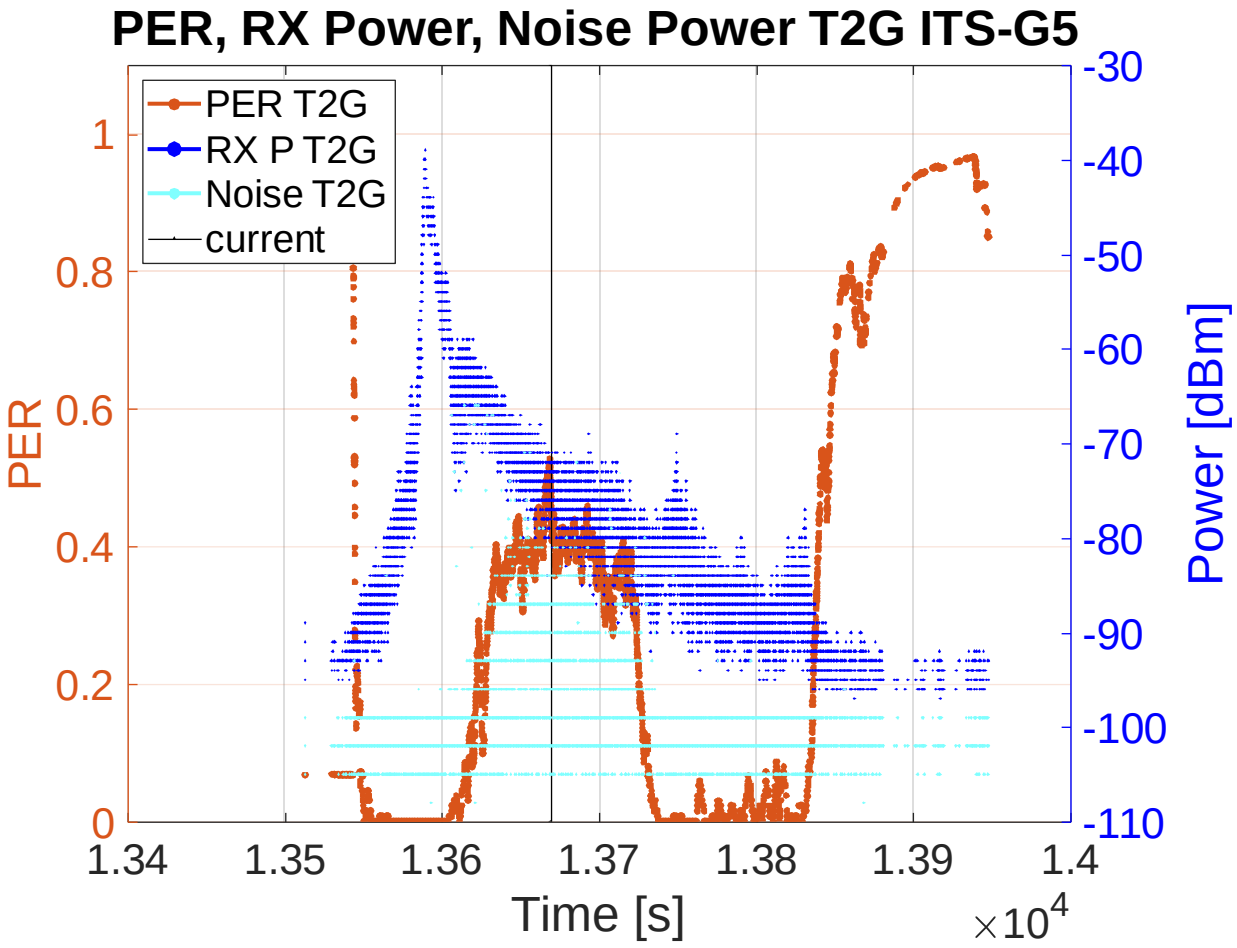
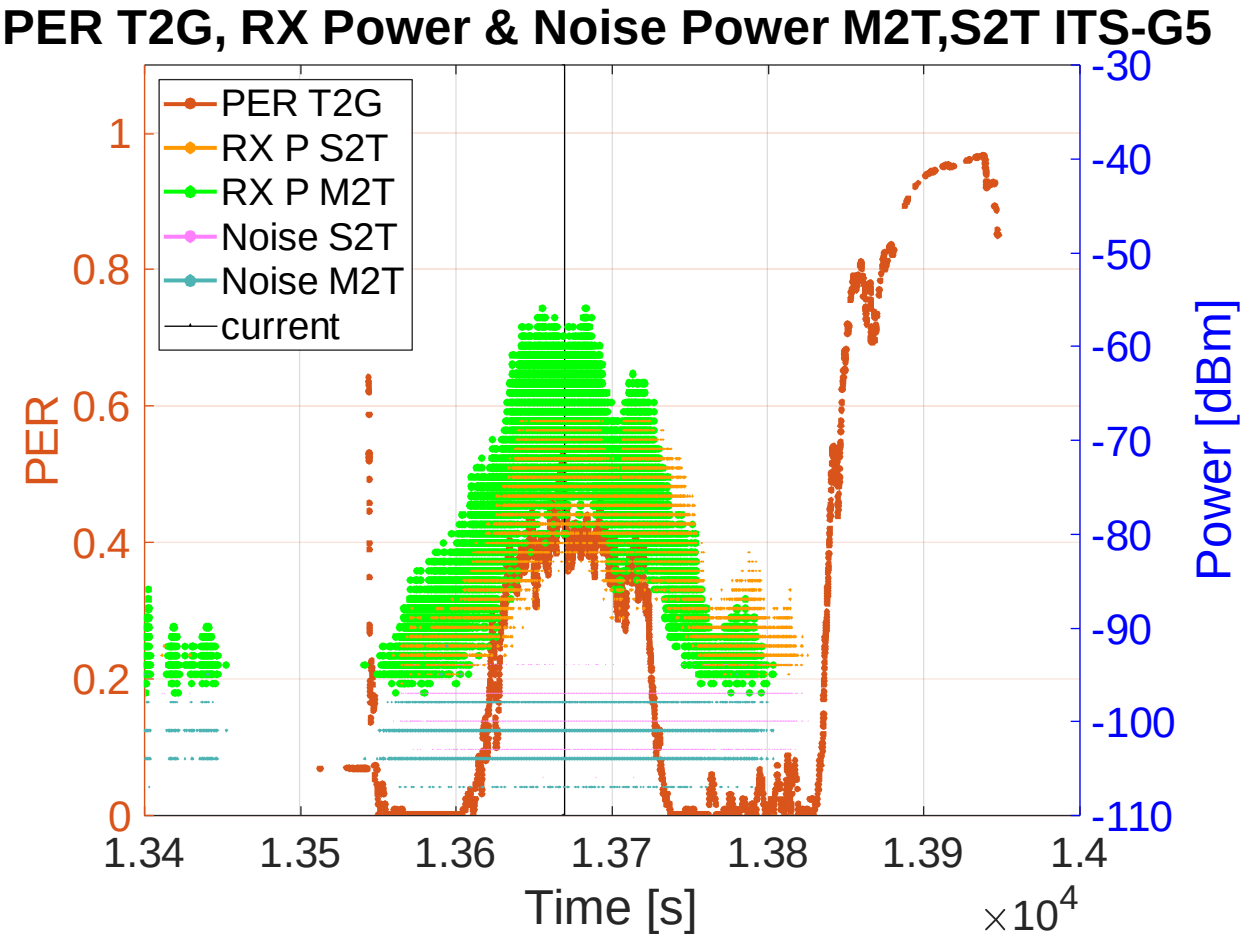
First Results, Adjacent Channel Interference for T2G ITS-G5





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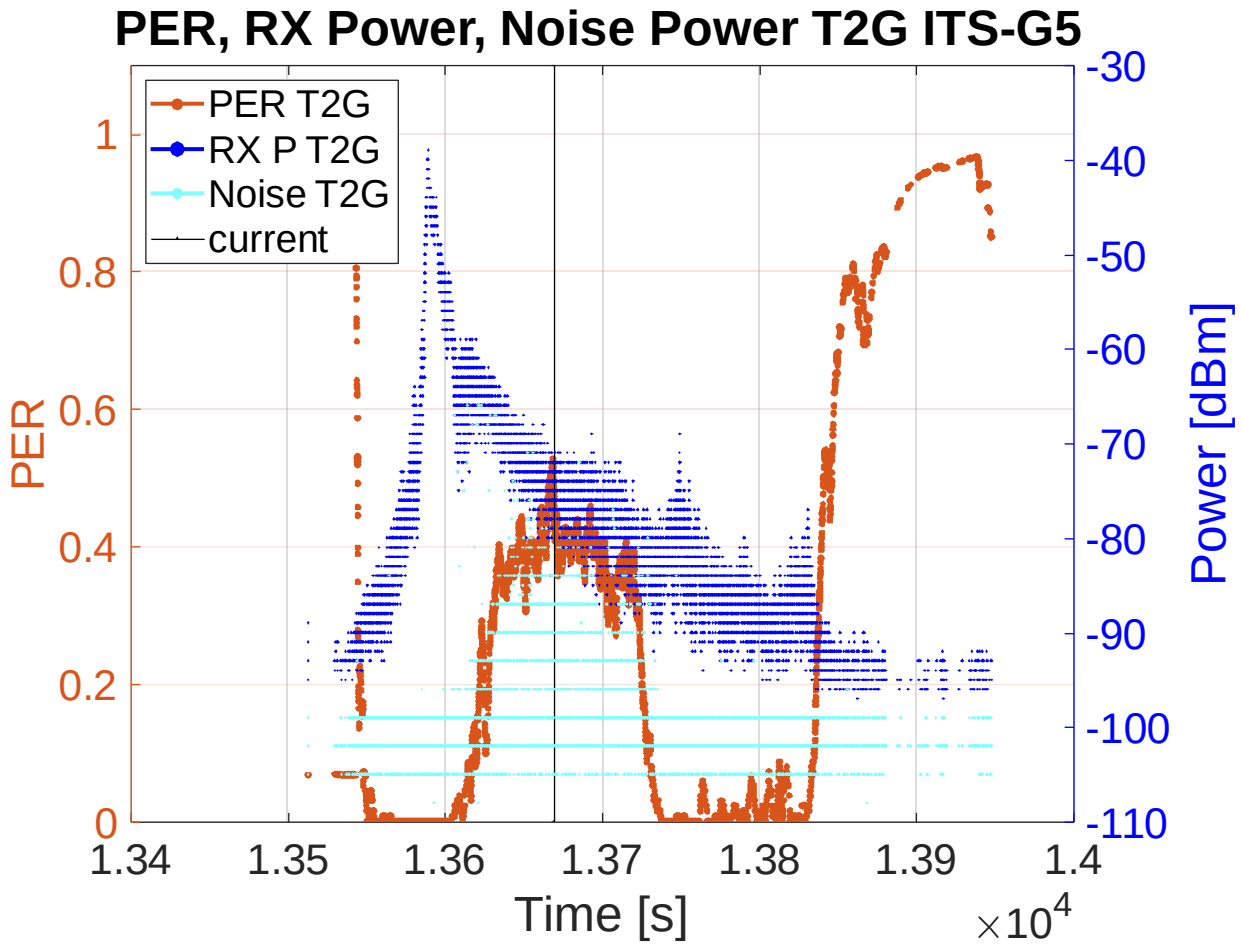
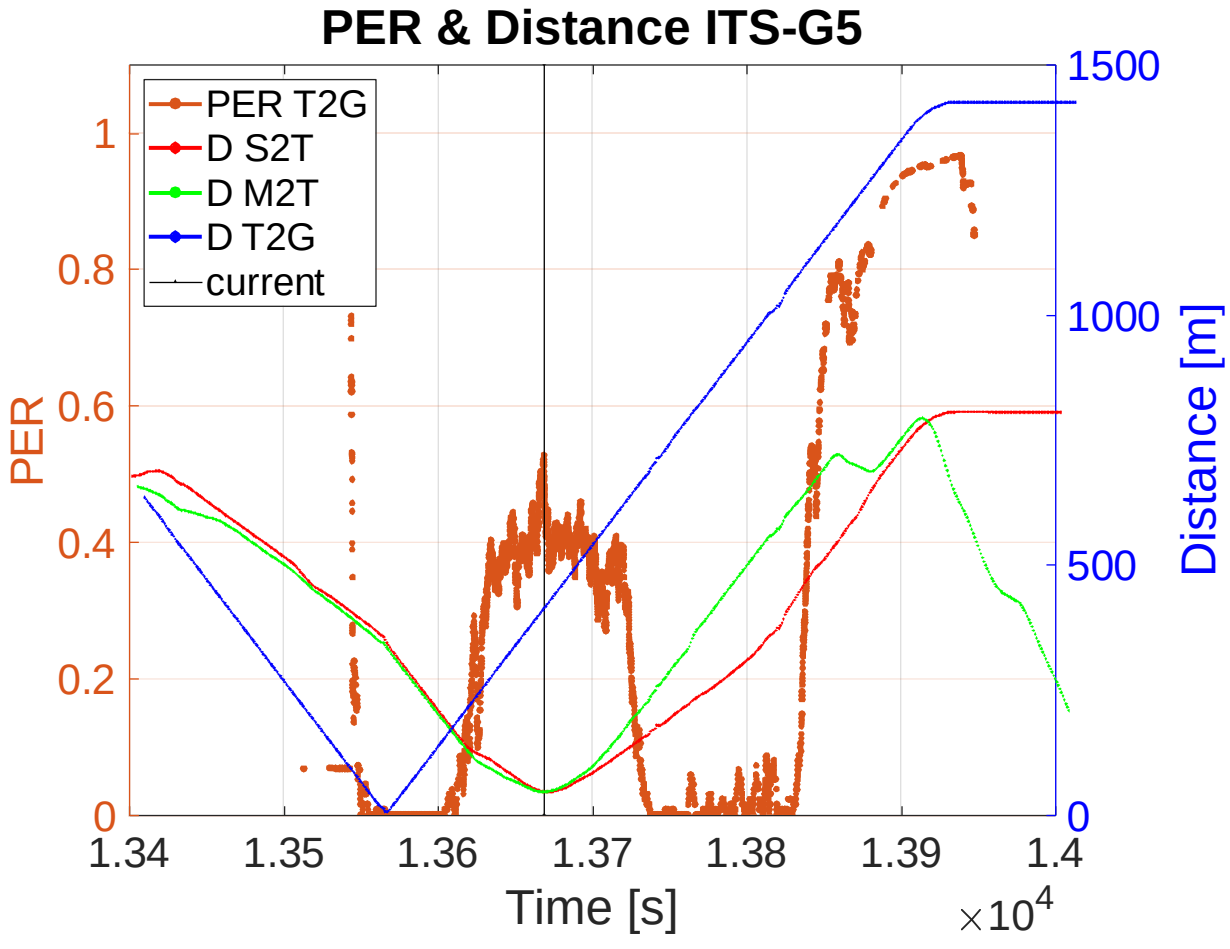
First Results, Adjacent Channel Interference for T2G ITS-G5





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Summary

V2X-DuRail radio interference measurements:

- 4 measurement days in Berlin:
  DB advanced TrainLab, DLR-KN Measurement-Bus & SoL-Car, BS
- 100% of maneuvers successful:
  Different setups on interference victim T2G link between BS and train (802.11a, ITS-G5, LTE C-V2X) and interfering cars (ITS-G5)
- Adjacent channel interference:
  PER > 39% in LOS despite more than 20 dB adjacent channel rejection
- Proposal:
  200m protection zone in LOS around train to mitigate interference from V2X signals of Road ITS

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Outlook

- PhD candidate: Analyze all scenarios including channel sounder data
- Measurement data available through mCLOUD and DLR-KN website: https://mcloud.de/, V2X-DuRail
- ETSI JTFIR:
  - Measurements Metro Paris September 2021: RSS with ITS-G5
  - Technical Report & Standardization

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References

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