Performance Evaluation of 3GPP GNSS-RTK in a 5G Cross-border Network

26. Mobilfunktagung Osnabrück

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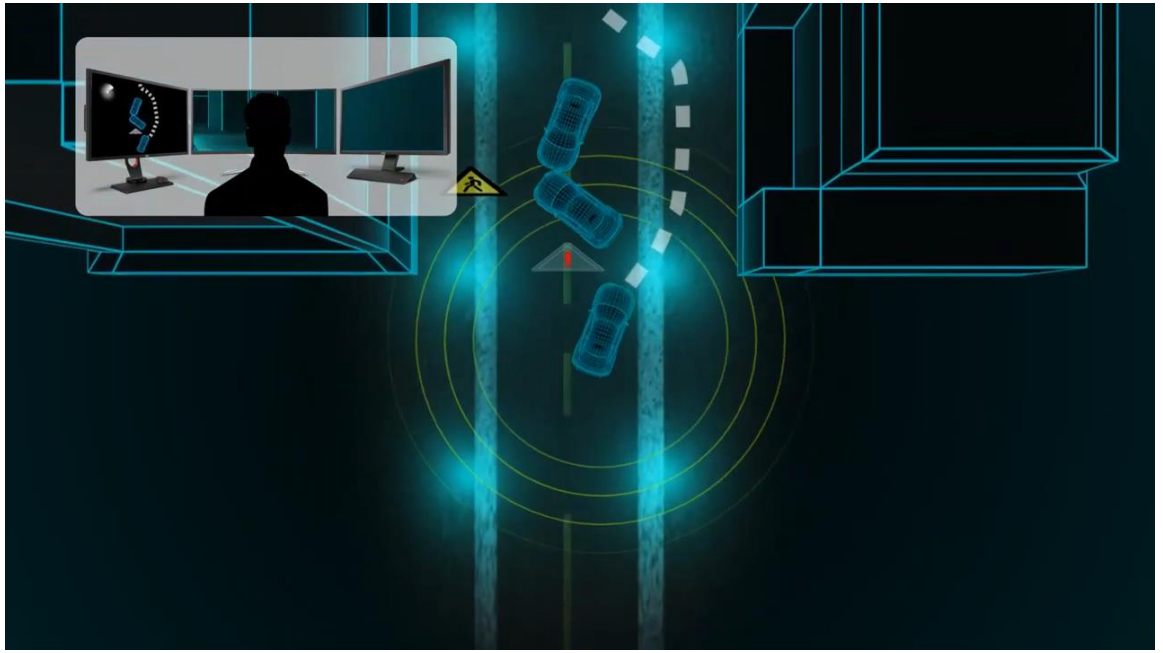
Outline

- Motivation & 3GPP GNSS-RTK at a Glance
- 3GPP Timeline
- Architecture
- Experiment Setup
- Results
- Conclusion & Outlook

3GPP GNSS-RTK at a Glance

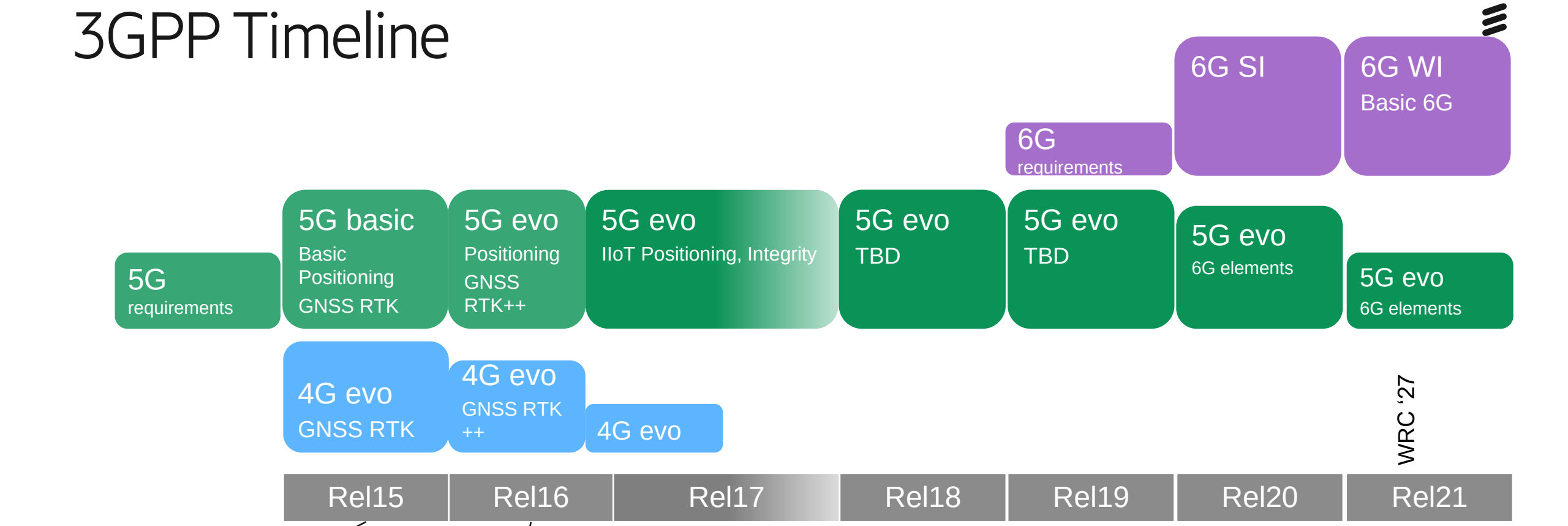
- Provides correction information to reach single-digit cm-level accuracy of Global Navigation Satellite System (GNSS) positioning
- Full potential unfolded when “broadcast” variant deployed, but also possible with unicast
  - Industries can exploit the solution with existing clients / networks
  - Critical mass of users is created to motivate client and network development for broadcast
- Uses “System Information Block (SIB)” broadcast to distribute GNSS-RTK[1)] information very efficiently
  - **Today SIB9 is used to set the clock in smart phones and other devices**
- Allows to charge for the service, as data can be encrypted
  - Decryption keys only provided to service subscribers



Link to Video

1) RTK: Real-Time Kinematic

3GPP Timeline



GNSS NRTK OSR
GNSS NRTK SSR p1
Unicast
4G/LTE broadcast

GNSS NRTK SSR p2
5G/NR broadcast

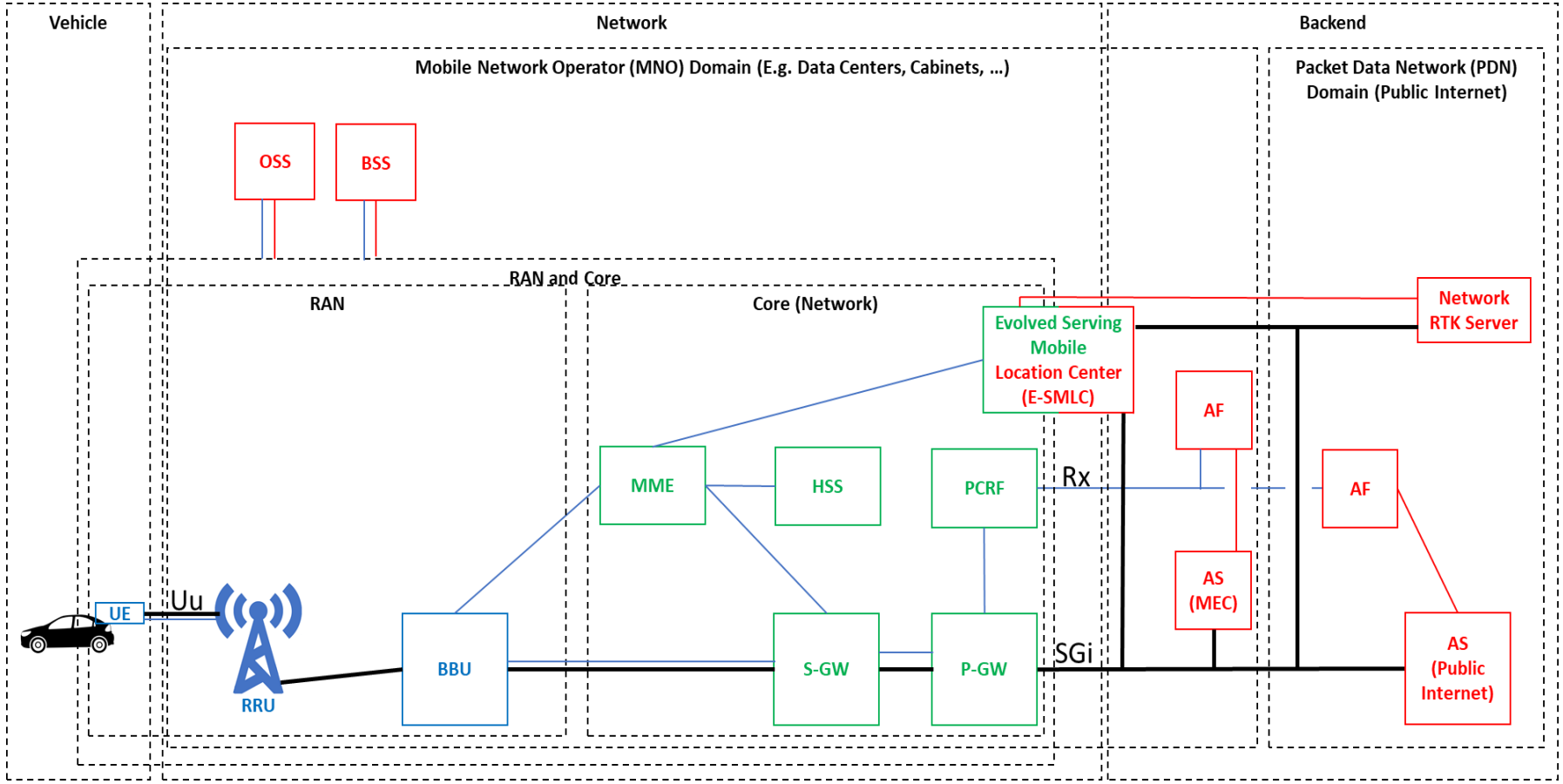
NRTK: Network RTK
O/SSR: Observation/State Space Representation

Architecture

MME: Mobility Management Entity
HSS: Home Subscriber Server
BBU: Baseband Unit
PSRF: Policy and Charging Rules Function
P/S-GW: Packet Data Network/Serving Gateway

OSS: Operation Support System
BSS: Business Support System
MEC: Mobile Edge Computing/Cloud
AF: Application Function
AS: Application Server

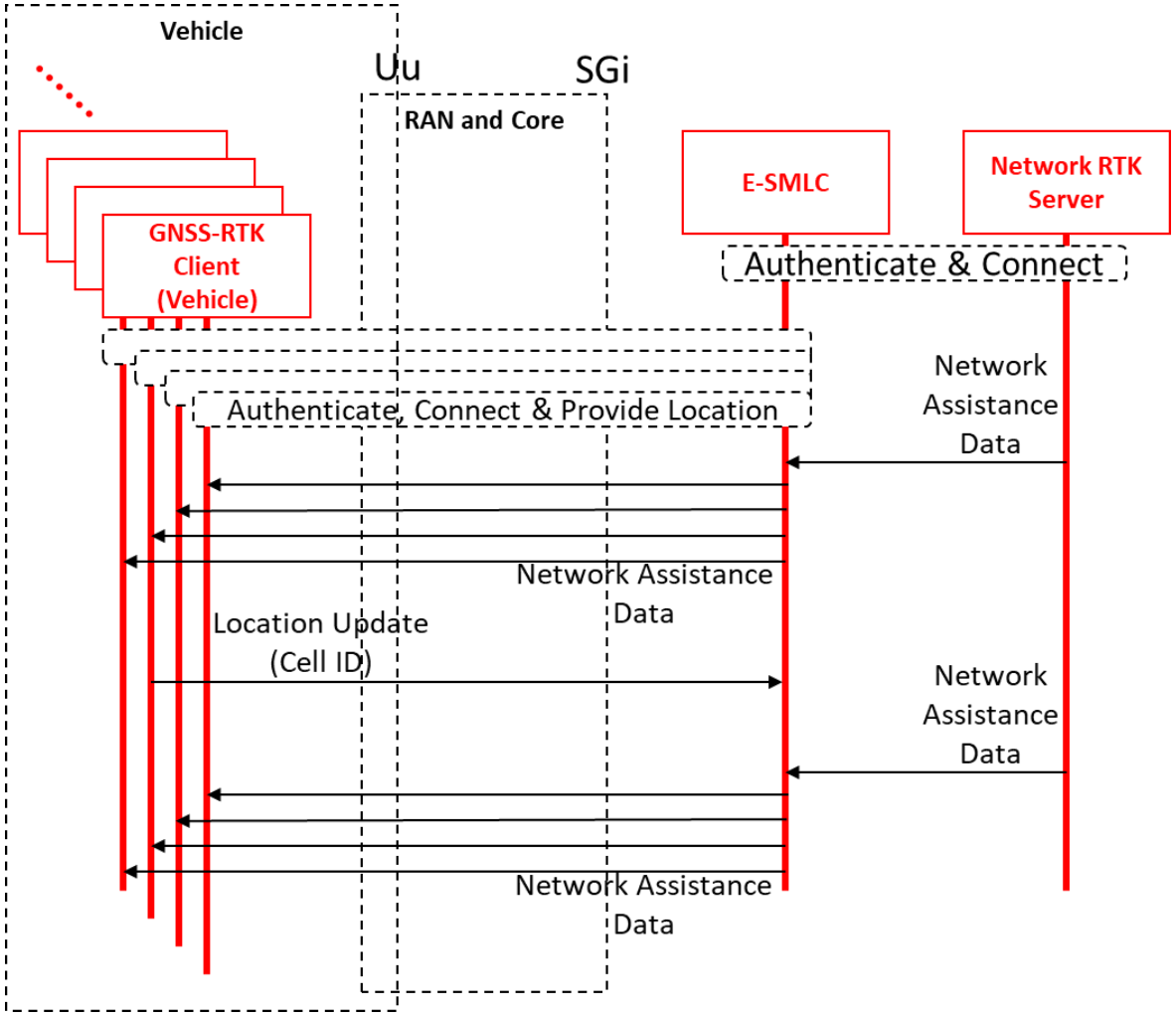
- 5G Non-standalone (NSA) shown, but also specified for standalone (SA)
- As Core Network function (for broadcast) or outside of Core Network (unicast)
- Can be part of Core also for unicast, e.g. to query UE location from MME



Architecture

Unicast:

- Client can provide location (Cell ID)
- Alternative: E-SMLC gets this information from MME
- **Same** information sent to all vehicles in the area
  ➔ Consuming many radio resources



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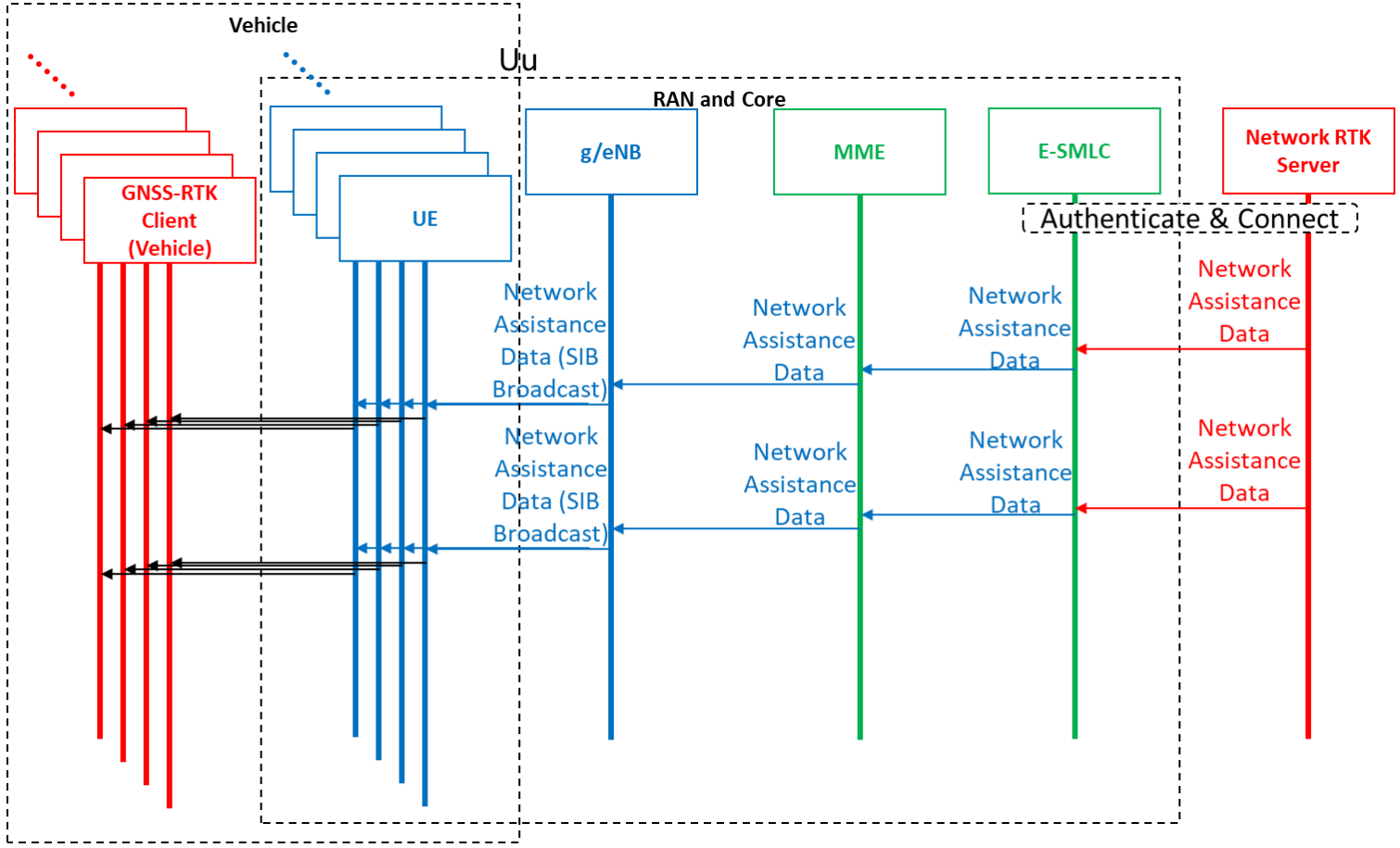
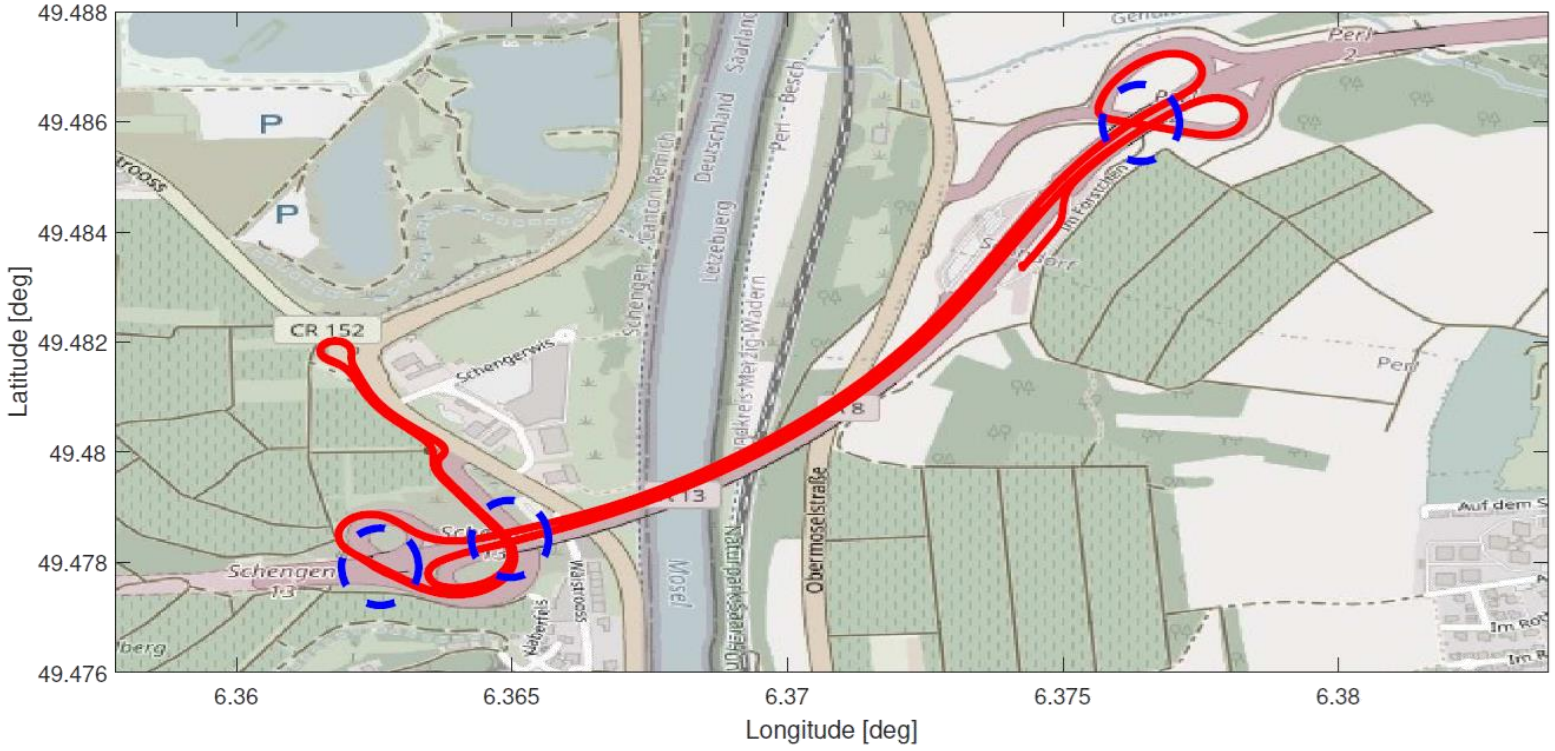
Broadcast:

- Uses SIB broadcasting
- No need for the client or MME to provide vehicle position
- Very efficient use of radio resources
- Optional: encrypted, MME provides keys to users with subscription



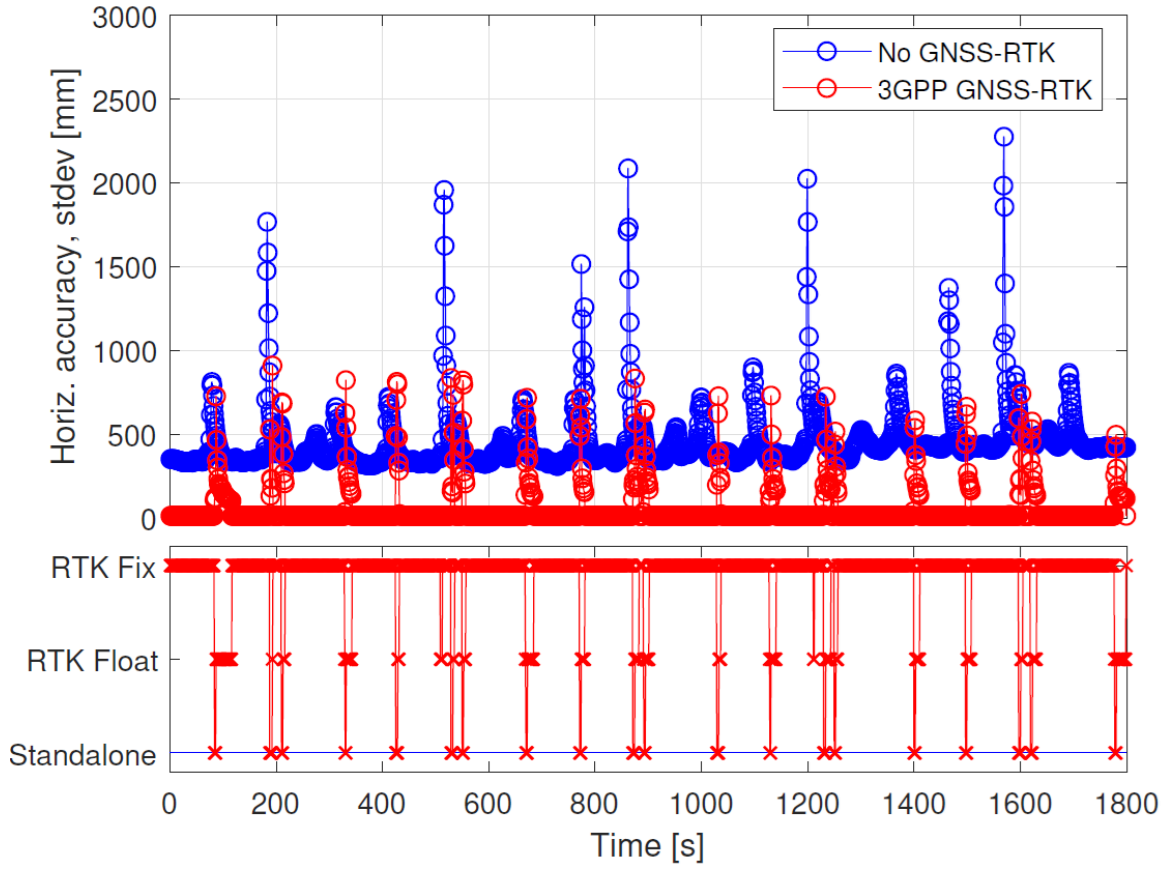
Experiment Setup

- ~1.5 km with **3 underpasses**
- 5GCroCo 5G network with Location Server in Sweden
  - Unicast; client provides Cell ID
  - Prototype
  - Commercial version available from Q3 2022
- RTK vs. no RTK
- 30 min per experiment
- u-blox F9P with Ericsson client software
  - Commercial-grade software exists
  - But: we needed access to all u-blox output to get accuracy / fix
- Correction data from Trimble RTX service (Thank you!)



Results

- 1-sigma accuracy and “fix state” was evaluated
- u-blox does not provide details how they assess 1-sigma accuracy
  - By definition, it corresponds to 68 % error probability
  - Allows to calculate likelihood for larger errors/deviations through according Normal Distribution
- Single-digit (RTK) vs. double-digit (no RTK) position accuracy when view on sky not covered
- Position error increases when underpass covers view on sky
  - GNSS-RTK fix transitions to “floating”, sometimes even completely lost (standalone)



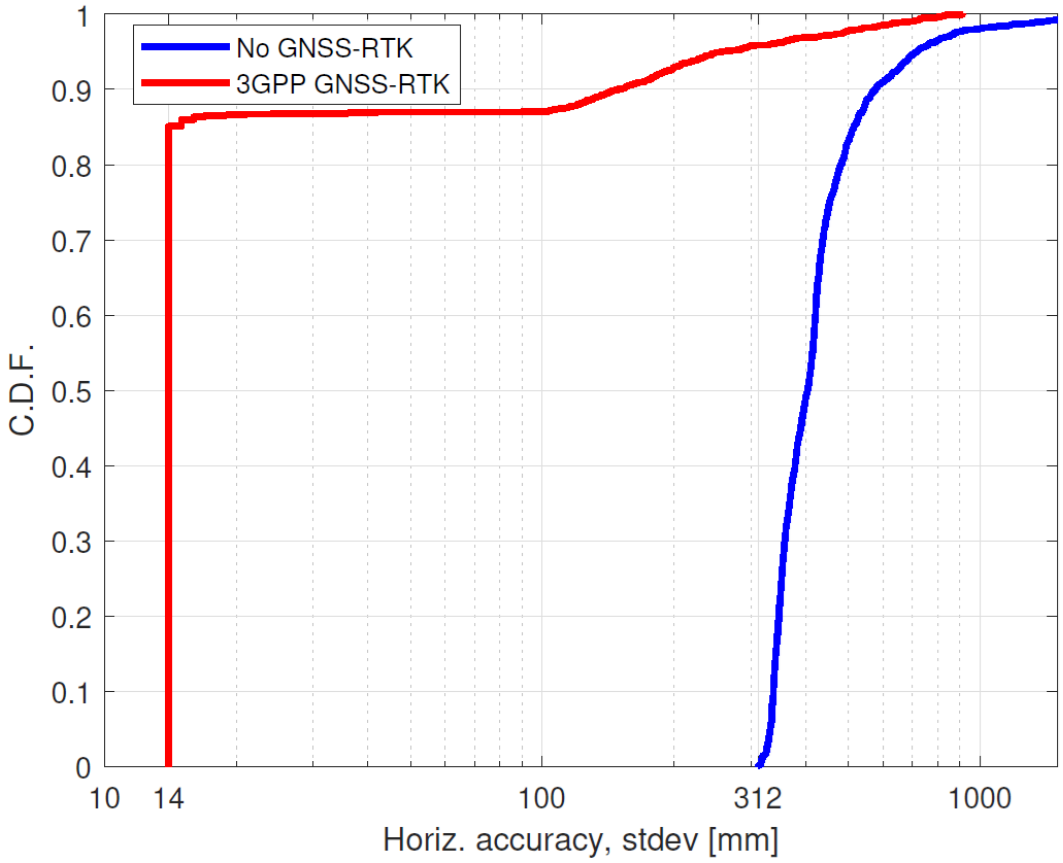
Results

GNSS-RTK:

- 1.4 cm 1-sigma position accuracy when view on sky not covered
- Never exceeds 1 m

No GNSS-RTK

- 30 – 55 cm 1-sigma position accuracy when view on sky not covered
- 1 m exceeded with ~3 % probability



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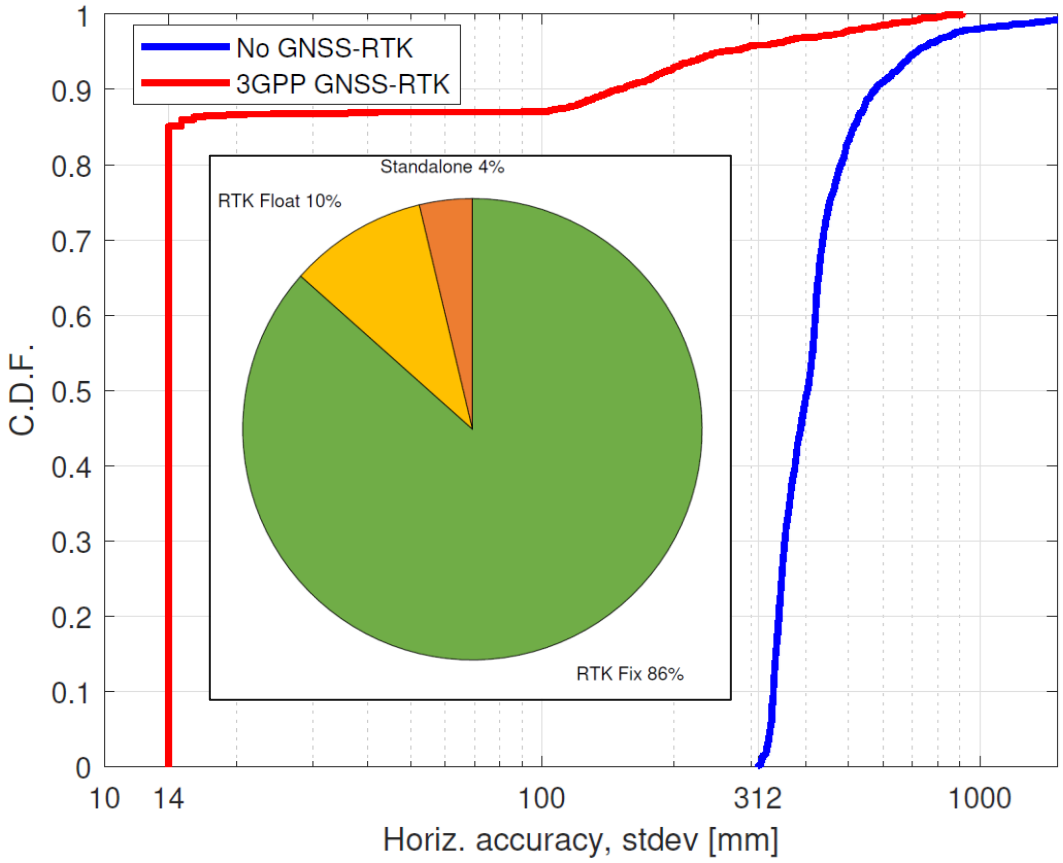
This result only applies for the particular test path, esp. the ratio how much view on sky is covered



Conclusion & Outlook

- 3GPP GNSS-RTK architecture and rationale behind it was presented
  - An open and widely supported solution for GNSS-RTK for all industry sectors (verticals)
  - Enable Mobile Network Operators to provide GNSS-RTK information very efficiently (once “broadcast” variant is supported in network and client devices)
- Measurement results from trials at the border Germany-Luxembourg were collected and analyzed:
  - GNSS-RTK provides single-digit centimeter accuracy (when view on sky not covered)
  - 1-sigma error never exceeded 1 m (even when view on sky covered)
- Outlook (Question for follow-up architecture work):

  Do we have to adapt the 3GPP GNSS-RTK Core architecture to support this in multi Mobile Network Operator scenarios?