Influence of infrastructure antenna location and positioning system availability to open-road C-V2X supported Automated Driving

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Paper motivation

- Fast rise of automated driving (AD)
- AD uses on-board sensing systems; C-V2X improves perception range of AD
- 5G-Drive projects aims that are presented in this paper
  - To study the trial V2X experiments with 3GPP Rel-14 conformed LTE-V2X devices on open-roads automated driving in Finland
  - To jointly trial with 5G Large-scale project on two joint V2X use cases
  - To examine the potential of low latency and influence on positioning system of LTE-V2X communication in terms of road safety benefits to AD

System architecture of LTE-V2X enabled automated driving

- Trial architecture and setup description
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Problem definition and methodology

- Performance of LTE-V2X challenge←→ impact factor: Antenna height
  - Test route ca. 350 meter long, approaching a four-way intersection, pedestrian crossings
  - 5.9 GHz Qualcomm® C-V2X DPs, one on roadside, one in the vehicle
  - Three different antenna height installations on trailer: 1.4 meter, 2.8 meter and 3.8 meter

- Automated vehicle positioning issue - Error correction challenge
  - Densely-built area in Espoo, small forests, and big and underground parking hall (tens of meter underground inside bedrock)
  - Equipped test-lab vehicle (Integrated RTK device and LTE-V2X OBU; LTE-V2X RSU was installed at stationary position at the entry of parking hall)

Results discussion

Variating antenna height

- Performance of LTE-V2X 22nd Oct 2020
  - Assumption: Antenna height can affect LTE-V2X average latency
    - Trial design: increase antenna height on RSU from 1.4 ~ 3.8 meters

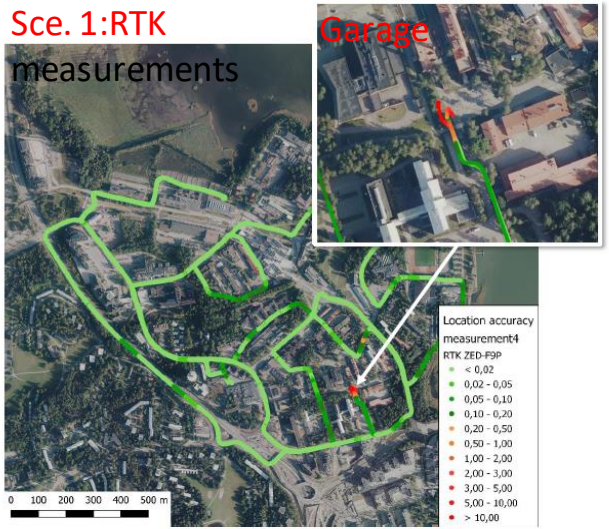
Antenna height in RSU [m]	Message size [bytes]	Latency mean [ms]	Jitter [ms]	Maxdist [m]	Packet Loss Rate [%]
1,4	250	35	9	385	32
1,4	750	33	12	311	12
2,8	250	30	9	368	19
2,8	750	32	9	288	11
3,8	250	26	8	373	9
3,8	750	27	7	305	7

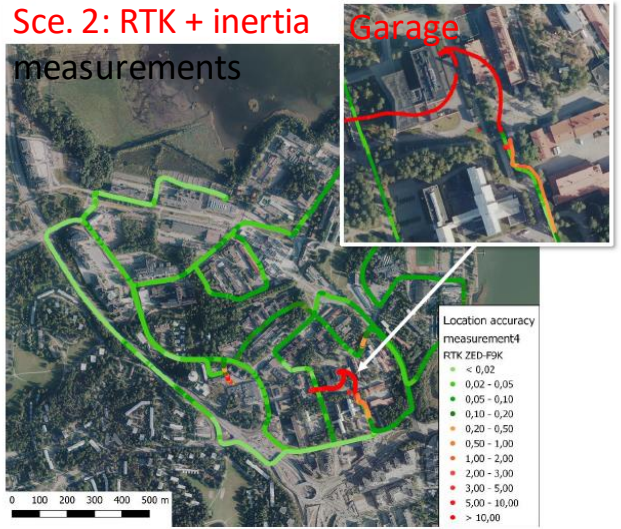
Results discussion

- Trial design

- Baseline

Measurement 4 : Location accuracy





- Enhancement results
  - RSU and OBU communication is extremely limited without GNSS coverage.
  - With GNSS repeater, possible to get satellites signal underground (validation still to be done).

Conclusions and Outlook

- Preliminary conclusions
  - Antenna height has significant influence of availability of C-V2X devices
  - High frequencies (5,9 GHz) are very sensitive under non-light-of-sight (7%~32%)
  - The enhanced accurate positioning showed limitation when GNSS signals are unavailable or unstable.
- Outlook
  - A few challenges in C-V2X roll-out
  - More studies on the performance of C-V2X (simulation supports assumptions)
  - Measurements of Low latency are still not optimal; C-V2X's potential awaits full discovery

Thank you for your attention!

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