5G-Drive and V2X Solution Results Achievements

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5G-DRIVE Project Objectives

▶ Research and Innovation Action project, funded under the Horizon 2020 Framework programme, closely linked with 5G PPP.

▶ 5G-DRIVE aims to bridge current 5G developments in Europe and China through joint trials and research activities in order to facilitate technology convergence, spectrum harmonisation and business.

34 months (Sep-18 – Jun-21)

17 partners from 10 countries

- ▶ Germany
- ▶ Finland
- ▶ Belgium
- ▶ Italy
- ▶ Switzerland
- ▶ Poland
- ▶ Greece
- ▶ Portugal
- ▶ United Kingdom
- ▶ Luxembourg

EU-China 5G trial collaboration

- 5G-DRIVE collaborates with 5G Large-scale Trial project led by China Mobile
  - Cover from terminals, RAN, transport network, core network, and 5G services
  - 3 Trial sites in 5G-DRIVE
  - 5G trial cities in Chinese twinning project

Encapsulation of WP4
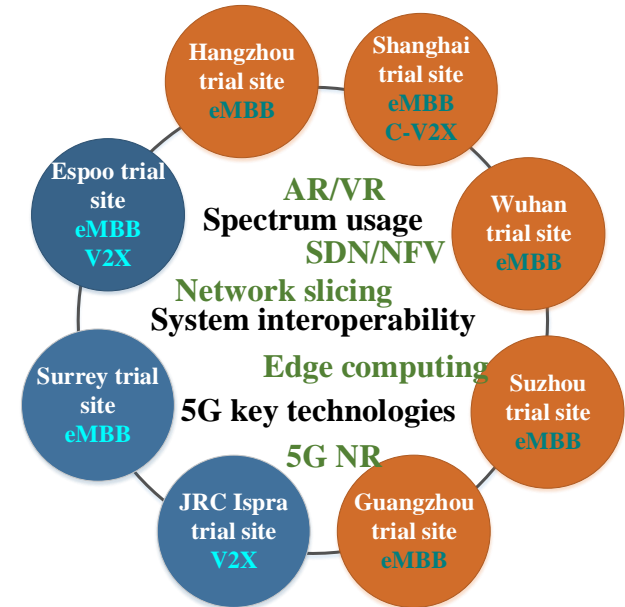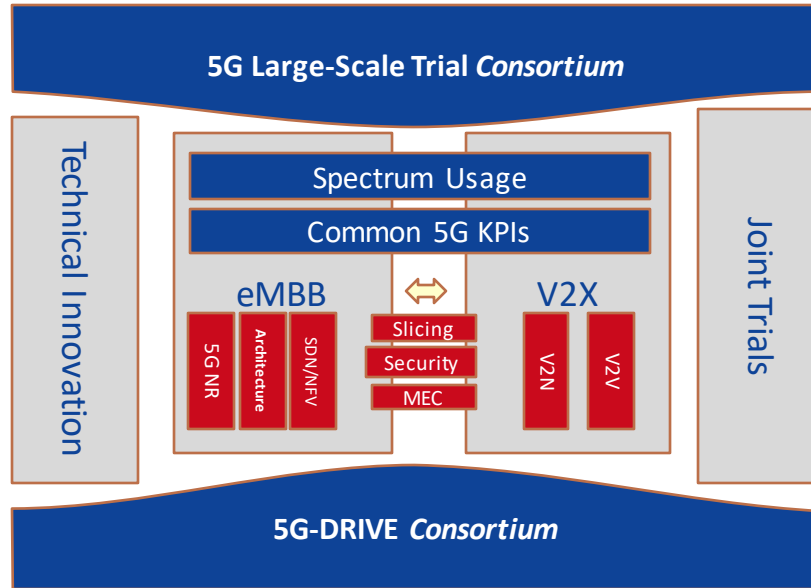
▶ Motivation

   ▶ Redefine transportation, providing real-time, highly reliable/low latency data flows to enable C-ITS

   ▶ C-V2X paves the way to connected and automated mobility (CAM)

   ▶ C-V2X is initially defined as LTE-V2X in 3GPP Release 14, designed to operate in several modes, Ad-hoc communication via PC5 interface was introduced to D2D mode.

▶ Objectives

   ▶ To define Joint V2X use cases together with Chinese partners,

   ▶ To jointly trial and demonstrate these Joint use cases;

   ▶ To ensure the feasibility and compare performance of LTE-V2X (latency, comm. ranges, feasibility to support CAM via LTE-V2X enabled application)

   ▶ …

▶ Frequency jamming attacks and misbehaviour detection system tests

▶ Laboratory tests: 1) conformance tests on ITS-G5 and on LTE-V2X;2) coexistence tests

▶ Auxiliary studies and test

   ▶ Simulation of V2X communication utilizing Mobile Edge Computing

   ▶ Key V2X link budget parameters and on field trial results

   ▶ Hybrid positioning for automated driving complemented by C-V2X comm.

- Joint EU-China V2X trials in Europe (5G-Drive)
  - Initial quality testing (reliability) of LTE-V2X assisted connected and automated driving
  - Performance of LTE-V2X $\longleftrightarrow$ impact factor 1: Number of LTE-V2X stations
    impact factor 2: Vehicle speed
    impact factor 3: Antenna height
  - Featured joint EU-China use cases : two day-1 C-ITS services
    - Intersection safety (intelligent intersection with VRU crossing)
    - GLOSA (individual speed advice to C(A)V utilising LTE-V2X comm.)
- Joint EU-China V2X trials in China(5G Large-scale Trial)
  - Interoperability tests between different vendors
  - V2I/V2V coverage tests
  - LTE-V2X performance tests: two featured joint EU-China use cases among 17 day-1 C-ITS services
    - Intersection safety (intersection collision warning)
    - GLOSA

▸ Trial architecture and setup description
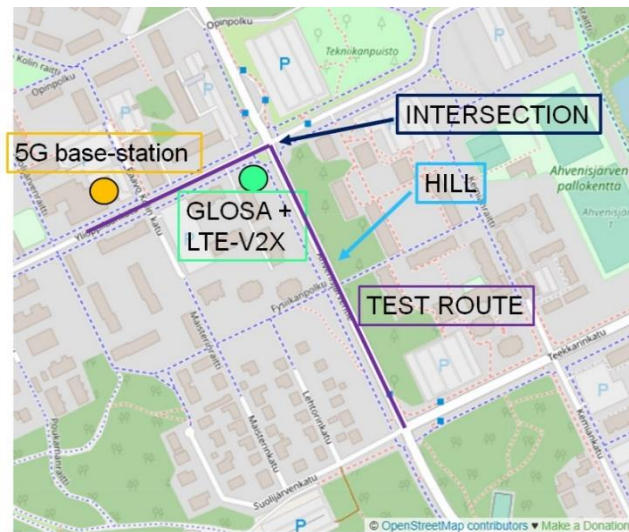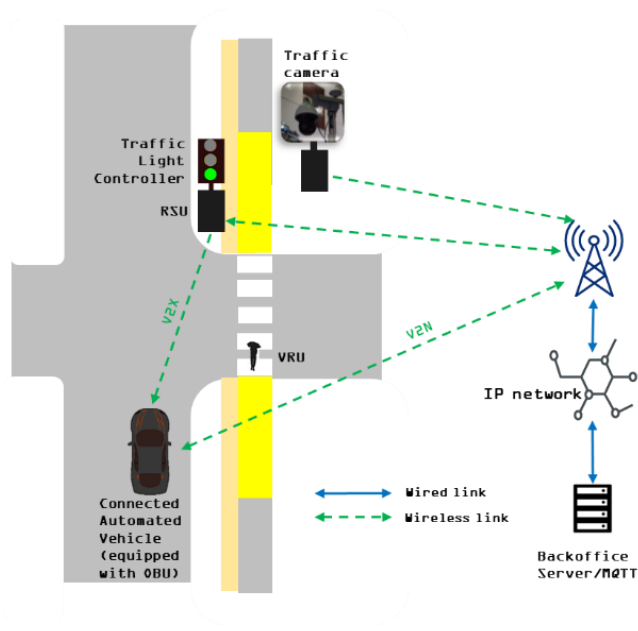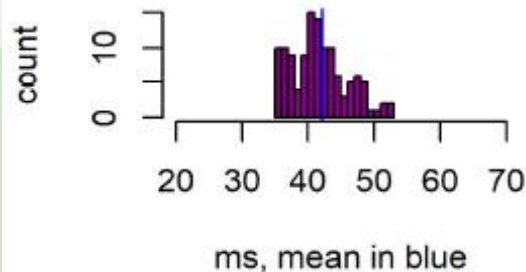
▸ Initial quality testing of LTE-V2X assisted connected and automated driving 24-25, Aug 2020


Msg size 799B, 122 items

KPI	Msg Size	200B	400B	800B	1500B
		5G latency (Server to Connected (Automated) Vehicle)			
Mean		37	44	46	36
Jitter		101	132	117	93
Lost msg		0	0	0	0
		LTE-V2X latency (RSU to OBU on Connected (Automated) Vehicle)			
Mean		37	40	42	36
Jitter		21	19	18	72
Lost msg		0	0	0	0

▶ **Performance of LTE-V2X** 9th Sep 2020

   ▶ Assumption 1: the number of emulated stations can affect LTE-V2X average latency

      ▶ Trial design 1: increase the number of emulated stations by decreasing the Msg interval

Msg Interval (ms)	1	5	10	20	50	150
# of stations	1000	200	100	50	20	~7
	5G latency (Server to Connected (Automated) Vehicle)					
mean	133	62	137	69	61	64
	LTE-V2X latency (RSU to OBU on Connected (Automated) Vehicle					
mean	32	28	25	25	24	24
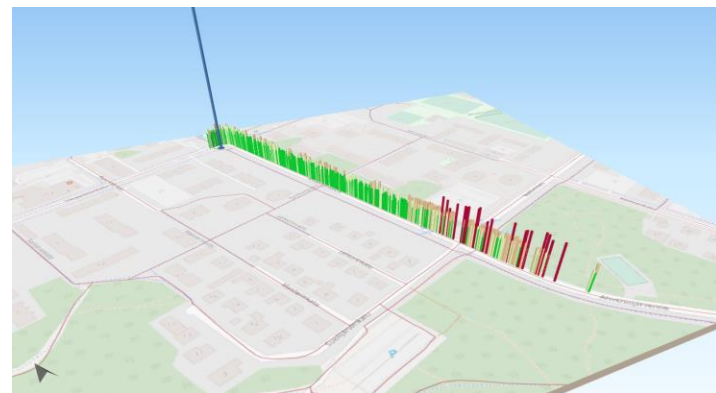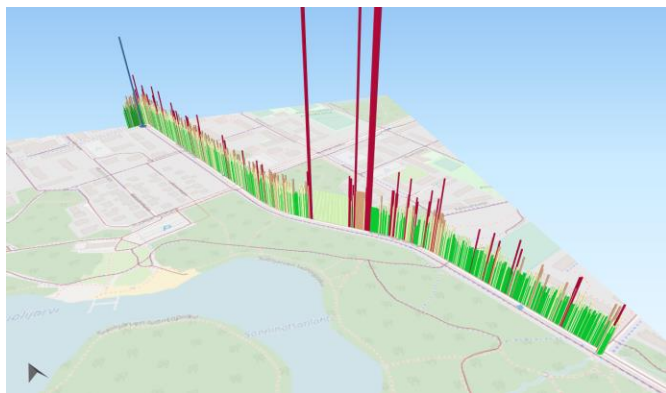
▶ **Performance of LTE-V2X** 24th Sep 2020

    ▶ Assumption 2: Vehicle speed can affect LTE-V2X average latency

        ▶ Trial design 2: increase driving speed between 10 ~ 40 km/hr

        ▶ Result: Under urban driving condition and speed, impact on LTE-V2X latency is not observable

| Driving speed (km/hr)	10	20	30	40
	5G latency (Server to Connected (Automated) Vehicle)			
Mean (ms)	66	130	73	94
	LTE-V2X latency (RSU to OBU on Connected (Automated) Vehicle			
Mean (ms)	24	25	24	24

▶ **Performance of LTE-V2X** 22nd Oct 2020

    ▶ Assumption 3: Antenna height can affect LTE-V2X average latency

   ▶ Trial design 3: increase antenna height on RSU from 1.4 ~ 3.8 meters

Antenna height (m)	1.4	2.8	3.8
Mean latency (ms)	35	30	26
Packet Loss Rate	32	19	9

- Featured joint EU-China use cases : two day-1 C-ITS services
  - Intersection safety (intelligent intersection with VRU crossing) 9th Sep 2020
  - GLOSA (individual speed advice to C(A)V utilising LTE-V2X comm.) 14~16 April 2021
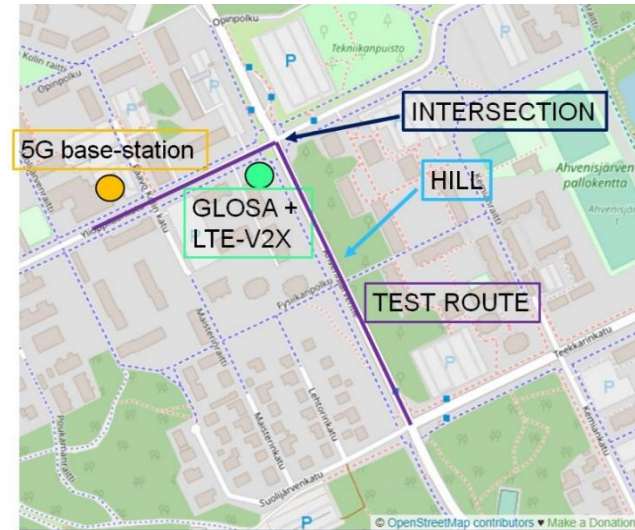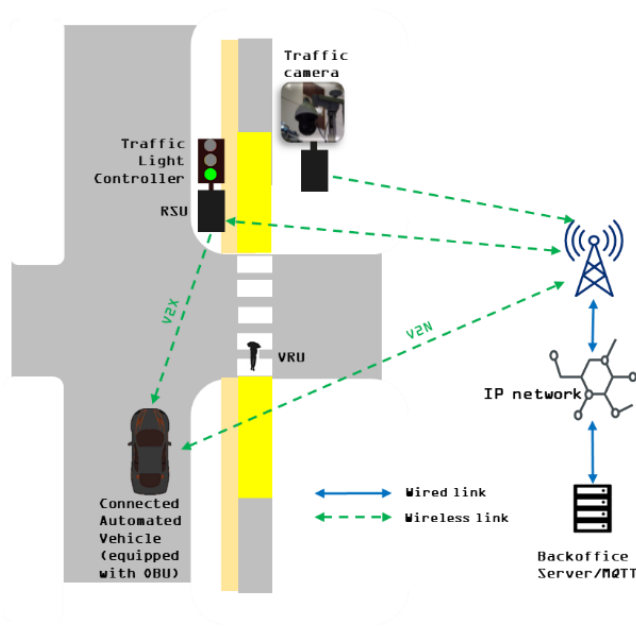
- ▶ Interoperability tests between different vendors
  - ▶ One RSU transmits SPaT and multiple OBUs from different vendors receive
  - ▶ One OBU transmits BSM and multiple RSUs from different vendors receive
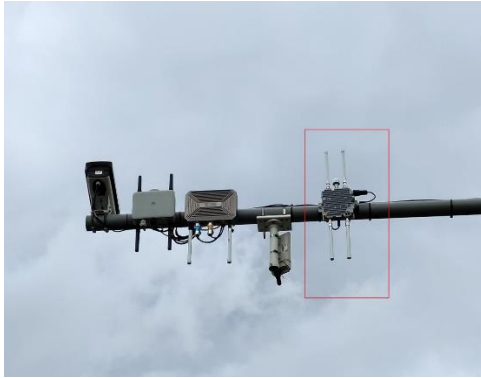

The RSUs from different vendors are deployed on a light pole at the No. 51 intersection

The OBU is placed on the top of the test car. The height of the antenna is about 1.5 m.

▸ **V2I/V2V coverage tests**

  ▸ V2I (OBU–RSU) coverage test under NLOS

  ▸ an OBU in a test vehicle was moving away from an RSU (installed ca. eight meters above ground level on a light pole)

PLR-Distance relation in NLOS environment
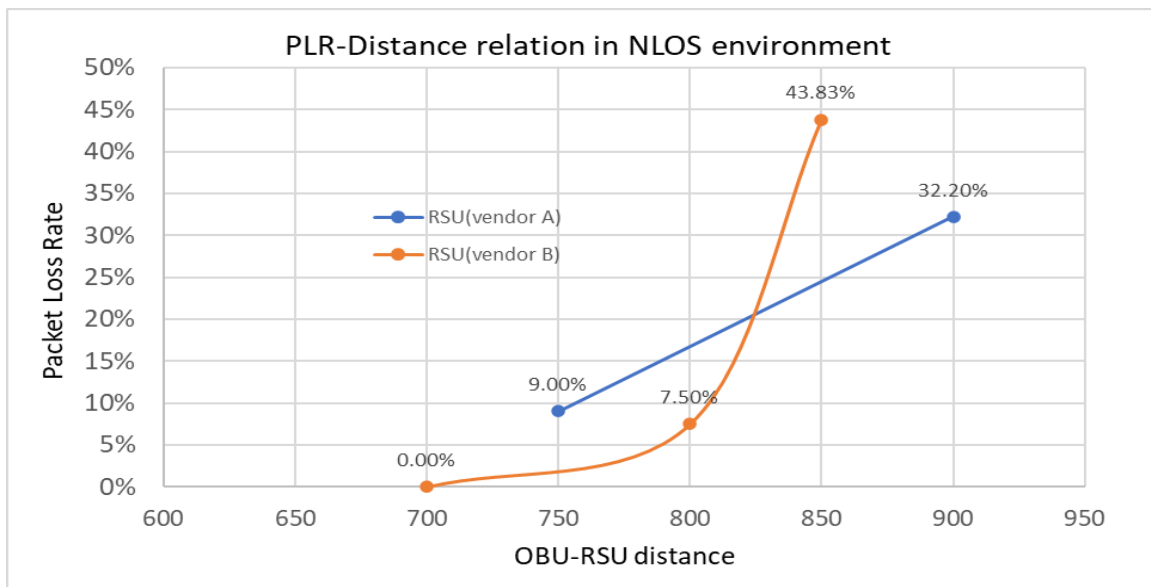
▶ **V2I/V2V coverage tests**

  ▶ **V2V (OBU–OBU) coverage test under LOS and NLOS**

    ▶ Driving mode

Driving mode: LOS/NLOS	OBU–OBU distance [m]	Latency mean [ms]	PLR
Near point	0	16.29	0%
Far point	400	15.5	0%

    ▶ Fixed positions

Fixed position: NLOS	OBU–OBU distance [m]	Mean latency [ms]	PLR
	400	15.32	0%
	450	18.81	17%

▸ LTE-V2X performance tests

  ▸ Intersection safety (intersection collision warning)

    ▸ One OBU and One RSU latency ≤ 25 ms, PLR ≤ 10%

    ▸ Twenty OBUs and RSUs latency ≤ 38 ms, PLR ≤ 10%

  ▸ GLOSA

Lessons learned and Outlook
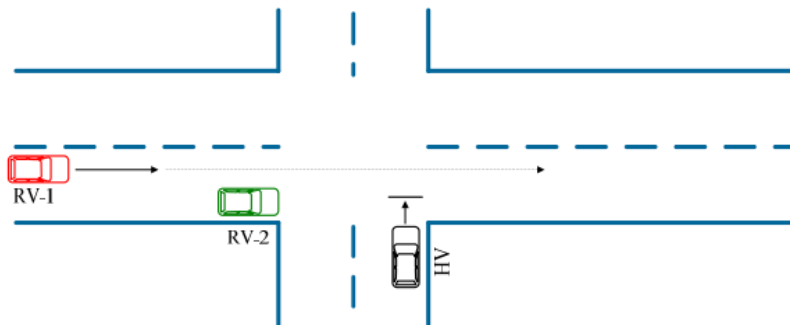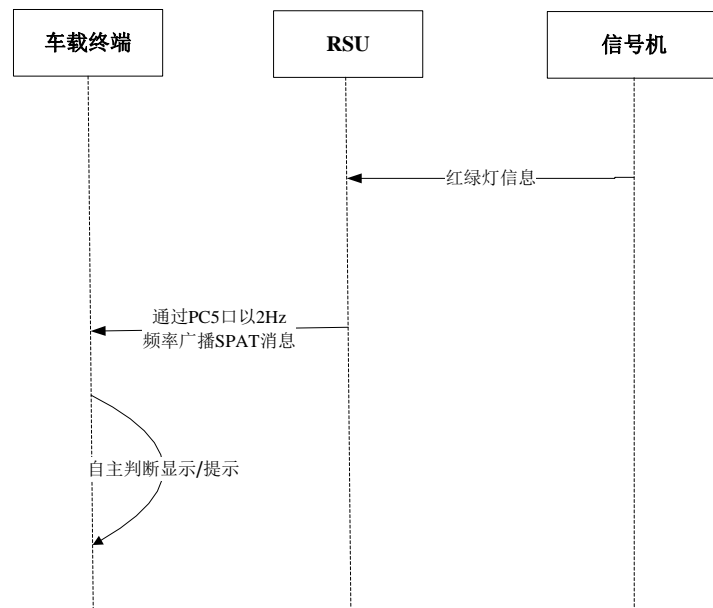
- Joint EU-China V2X trials: difficulties in the beginning of the collaboration but aligned by beginning of 2019.

- Pandemic impact and pandemic resilience plan
  - Former plan transferred to online format: joint EU-China V2X trial framework
  - Live streaming of demos
  - Joint work: report, publication and events

- Post-pandemic outlook
  - Online collaboration is the new norm
  - Potentials of C-V2X is the basis for added value of future work
  - Seeking the penetration points of C-V2X development and rollout in Europe

Thank you for your attention!

Find us at www.5g-drive.eu

Twitter: @5GDRIVE