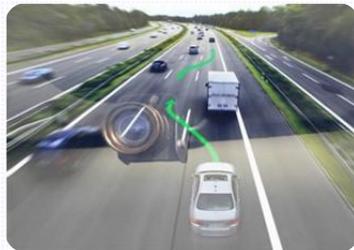


NR-V2X Requirements for Autonomous Driving

Uses Cases for Autonomous Driving Applications



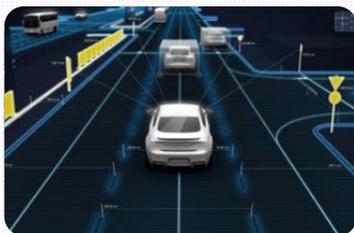
Vehicle Platooning



Cooperative Operation,
Sensor sharing



Remote Driving



Advanced Driving

NR-V2X Requirements defined in 3GPP SA1 (TS22.186)

Use Cases	E2E latency (ms)	Reliability (%)	Data rate (Mbps)
Vehicle Platooning	10	99.99	65
Advanced Driving	3	99.999	53
Extended Sensors	3	99.999	1000
Remote Driving	5	99.999	UL:25, DL:1
	Lateral (m)	Longitudinal (m)	
Positioning Accuracy	0.1	0.5	

Note: 5GAA may adjust the above requirements as per the inputs from car OEMs.

NR-V2X UU: Unicast Enhancements

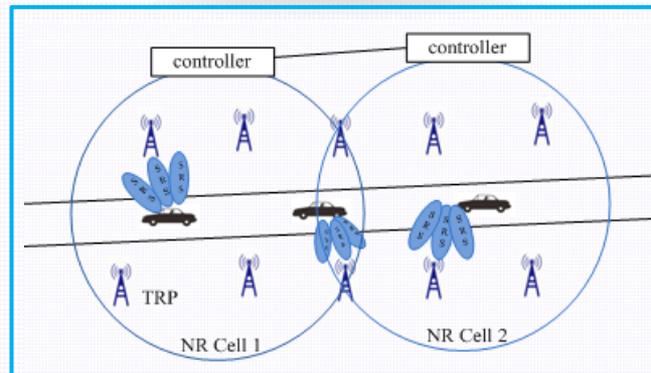
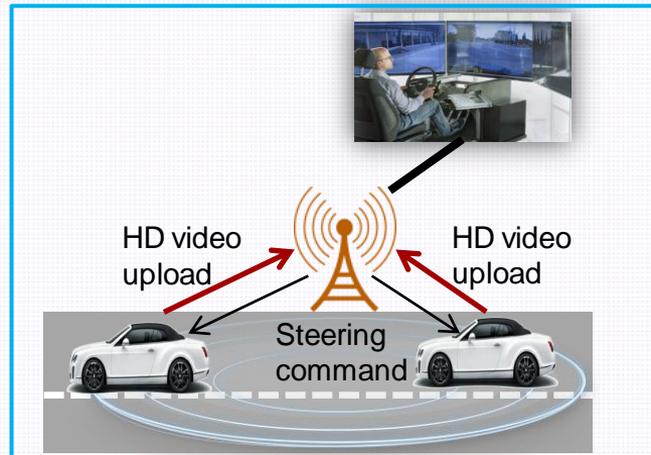
Motivation:

- Evaluate whether R15 NR Unicast can satisfy the requirements of advanced V2X applications. If cannot, identify the potential enhancements

Potential Enhancements:

- URLLC enhancements for the support of Remote Driving, which should be provided in a wide area (including cell edge)
- Mobility enhancements, for example UL-based mobility, given that vehicle UEs have no concerns on power consumption due to the transmission of UL tracking signals (e.g. SRS)

Note: overlapping with other R16 NR SI/WI should be avoided.



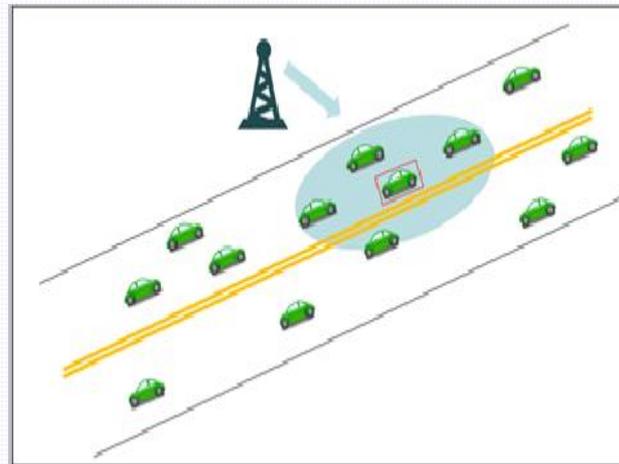
NR-V2X UU: Multicast

Motivation:

- As captured in TR 38.913: the RAN design for NR V2X shall provide communication via infrastructure, including MBMS support, for V2X services and advanced V2X services.
- Subject to regional regulation restrictions, high-definition map may only be allowed to dynamically downloaded, and in this case multicast mechanism is deemed essential.

Considerations:

- Same architecture as R15 NR Unicast (to avoid the complicated architecture of LTE MBMS, i.e. BM-SC, MCE and MBMS-GW)
- Multicast and Unicast can dynamically share radio resources
- High efficiency and high reliability (support MIMO, beamforming and HARQ/CSI feedback)



NR-V2X Sidelink: Design

Scenarios

- NR-Sidelink operation in NR coverage, in LTE coverage and out of coverage
- LTE-PC5 operation in NR coverage

Scheduling mode

- gNB scheduling (high priority) and UE autonomous scheduling

Synchronization source

- GNSS, gNB, Sidelink

Transmission Mode

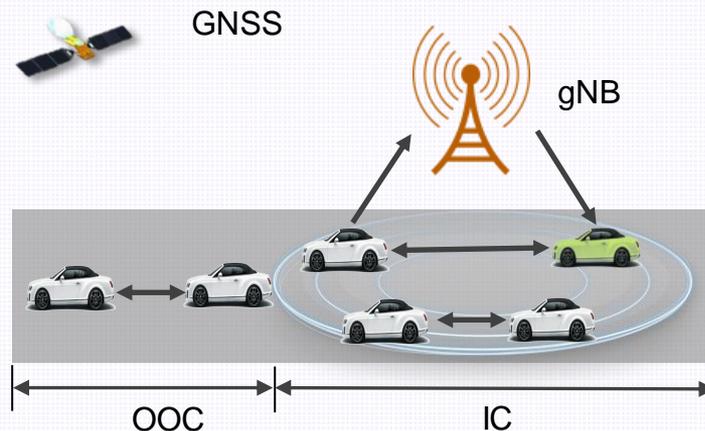
- Unicast, Groupcast and Broadcast

Physical layer design

- **Low latency, high reliability and high data rate Sidelink:**
 - (Flexible) Numerology, Short TTI, feedback and link adaptation
 - Multi-antenna, MIMO, Beamforming
- **Resource allocation:**
 - Optimization for busty traffic
 - NR-Uu control LTE-PC5, NR/LTE-Uu control NR-Sidelink

High layer design

- Flexible switch/duplication between UU and Sidelink



NR-V2X Sidelink: Relay and UE Cooperation

Motivation:

The direct link between two nodes (vehicle, gNB, RSU) may not be good enough to support efficient and reliable transmission:

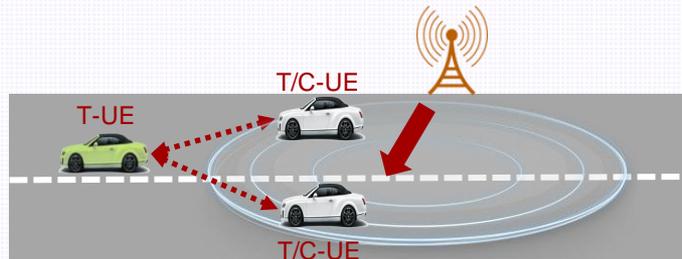
- A vehicle platoon may consist up to 20 vehicles, and the head vehicle needs to communicate with the tail vehicle(s).
- For Sidelink over mmWave, the direct beam between two vehicles may be blocked by another vehicle.
- gNB cannot address OOC vehicles for V2X services.

Considerations:

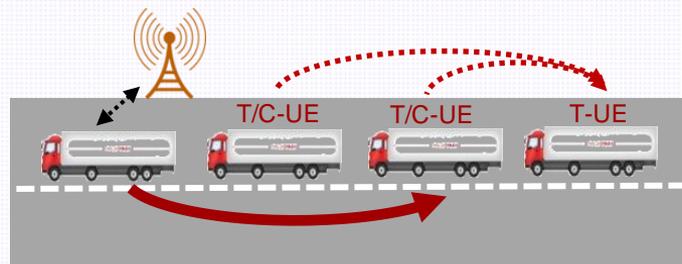
1. UE-to-UE relay and UE-to-Network relay for coverage extension
2. UE Cooperation to improve the reliability and coverage, for which two phases are included:
 - **Multicast Phase:** gNB/UE transmit data packets to the UE Cooperation group by UU/Sidelink multicast.
 - **Cooperation Phase:** C-UEs forward the cooperation information (data packets received during multicast phase) via Sidelink to T-UE to help the T-UE to decode the data packets.

T-UE (Target UE): Target of data packets delivery

C-UE (Cooperative UE): UE to cooperate with the T-UE for data packets reception



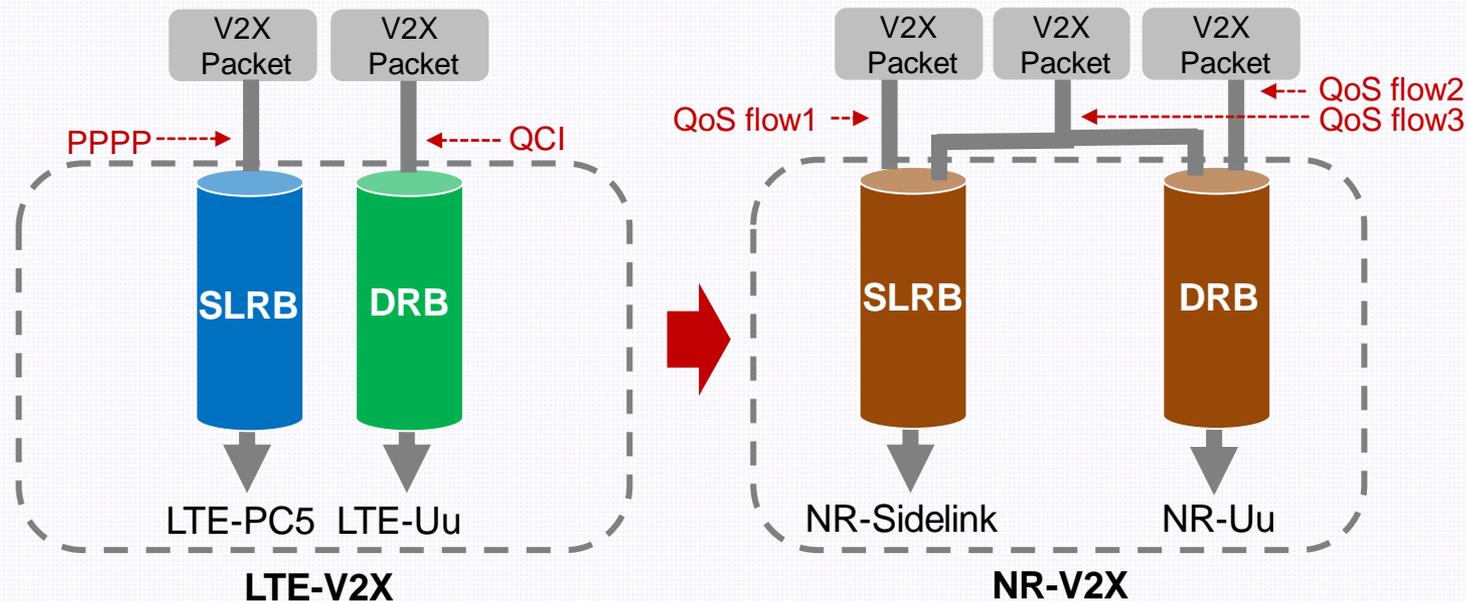
Scenario 1: Relay&UE Cooperation for OOC vehicles



Scenario 2: Relay&UE Cooperation in platoon

- Multicast link (UU/Sidelink)
- - -→ Cooperative Link

QoS Framework



Considerations:

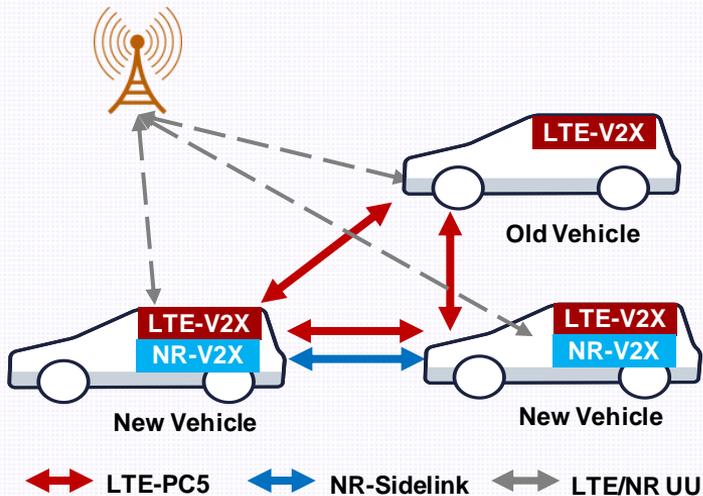
- A unified QoS-flow based framework can be used for NR-Uu and NR Sidelink.
- The QoS related parameters include Priority, Latency, Reliability and Date rate.
- E2E QoS Framework

NR-Sidelink is complementary to LTE-PC5

Basic Safety Application@5.9GHz by LTE-PC5

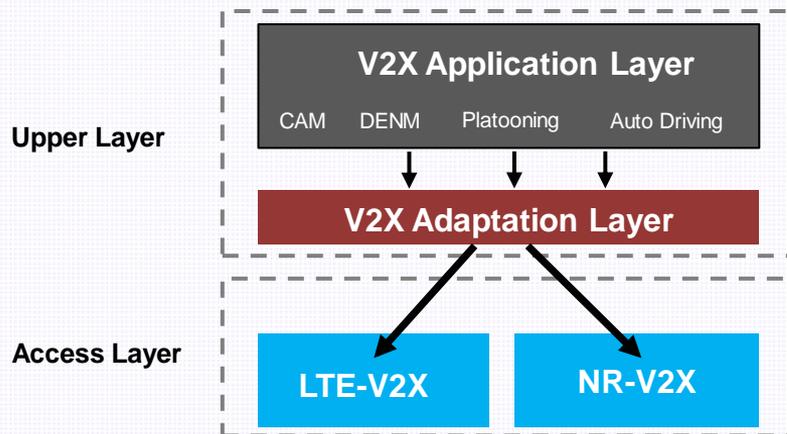
New vehicles equip with both LTE-V2X and NR-V2X to enable the inter-operability with old vehicles:

1. LTE-PC5: Basic safety applications
2. NR-Sidelink: Advanced autonomous driving applications



Flexible Selection Mechanism between LTE-V2X and NR-V2X

Provide policies/criteria to the UE to assist the radio technology selection, according to e.g. V2X application type, QoS requirements, UE capability etc



NR-Sidelink Frequency

Country/Region	Current ITS spectrum
Europe	5875-5905MHz 5905–5925MHz(extended) 63–64GHz
China	5905-5925MHz for LTE-V2X Trial
USA	5850–5925MHz
Japan	755.5–764.5MHz 5770-5850MHz (ETC)
Korea	5855-5925MHz

* Some mobile operators are also considering to use their IMT spectrum to provide value-added V2X services (over sidelink) in addition to basic safety services.

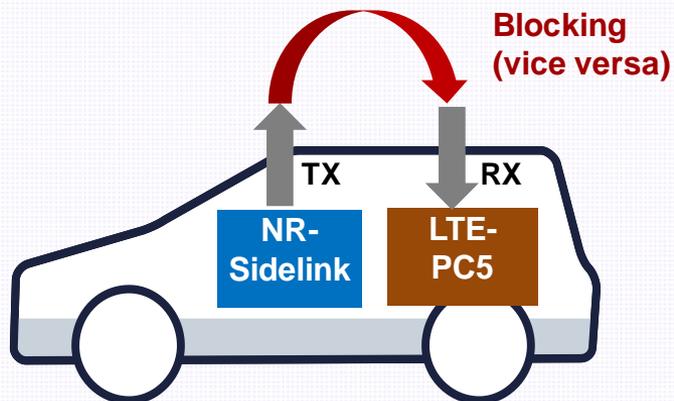
- **At the moment, the exact frequency band(s) for NR-Sidelink is not clear**

- **We prefer to study both sub-10GHz and mmWave in the SI**

- RAN1 already spent lots of efforts to study channel model for V2X communication over mmWave in V2X Evaluation Methodology SI
- We are open to discussion whether to study mmWave in a best effort approach

- **We prefer to study both ITS (unlicensed) bands and IMT (licensed) bands**

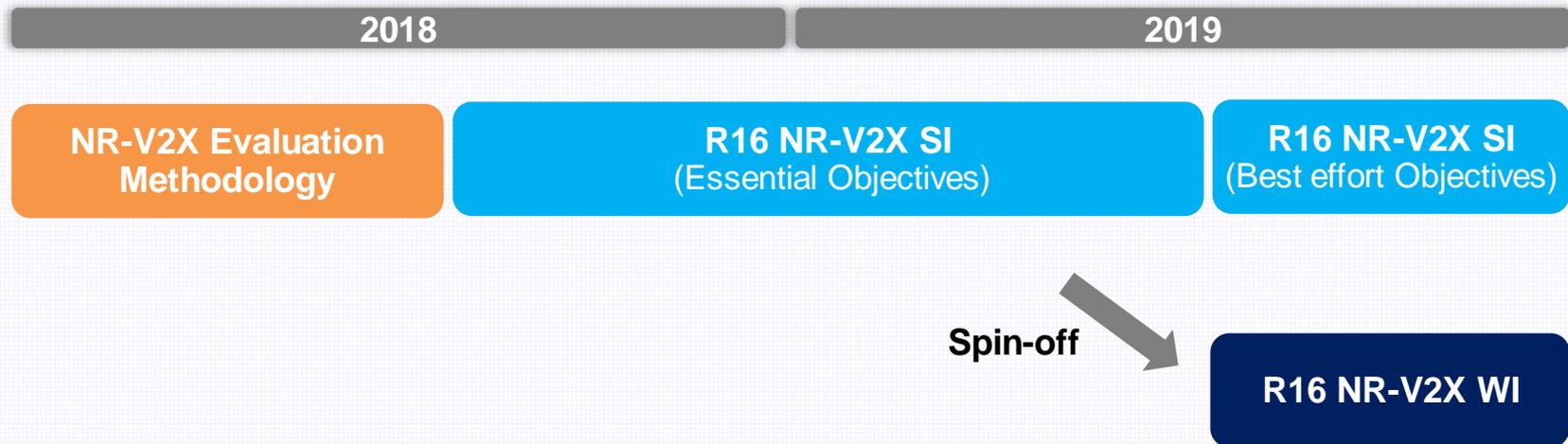
Coexistence Aspects



Assumption: NR-Sidelink and LTE-PC5 are equipped in the same vehicle

- **For coexistence between NR-Sidelink and LTE-PC5, we prefer to study neither co-channel coexistence nor adjacent channel coexistence**
- **We think the frequency band for NR-Sidelink should be a new band rather than 5.9GHz**
 1. NR-Sidelink and LTE-PC5 will mutually block each other in case of co-channel and adjacent channel deployment
 2. NR-Sidelink may require more than 70MHz spectrum in order to satisfy the requirements of advanced V2X applications (under discussion in 5GAA) and it exceeds the bandwidth of 5.9GHz.
- **There is no need to study the co-channel coexistence between NR-Sidelink and non-cellular RATs (e.g. 802.11p or CBTC)**
 1. If some coexistence mechanisms are needed due to EC mandate, the mechanisms should be specified in ETSI rather than in 3GPP

R16 NR-V2X SI/WI Organization



Note: the Time Unit for NR-V2X SI will be split for the NR-V2X SI and the parallel NR-V2X WI after June 2019



Thank you !

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