

Agenda item: 9.6.2
Source: Lenovo, Motorola Mobility
Title: Discussion on Positioning Use Cases, Deployments and Operational Scenarios for V2X and Public Safety
Document for: Discussion and Decision

1 Introduction

During the RAN#88-e meeting [1], a RAN-level study item was approved to investigate the positioning use cases, requirements, and scenarios for in-coverage, partial coverage, and out-of-coverage scenarios relating to V2X and Public Safety use cases with the following objectives:

1. Identify the positioning use cases and requirements for V2X and public safety, based on the existing 3GPP work and input from industry fora.
2. Identify potential deployment and operation scenarios

Note: Studying the feasibility of the identified requirements is not in the scope of this SI.

Note: The work in this SI shall take into account the outcomes and progresses of NR positioning study in both Rel-16 and Rel-17.

Note: Work plan

- RAN#91: TR skeleton, initial input on Objective 1
- RAN#92: Finalize Objective 1, initial input on Objective 2
- RAN#93: Finalize Objective 2, approve the TR (SI target completion)

This contribution provides a further discussion on the remaining issues relating to V2X and Public Safety Positioning Use Cases and requirements (Objective 1) discussed during the RAN#91-e meeting. Furthermore, initial views on the potential deployment and operational aspects to support absolute and relative positioning in different types of coverage scenarios are provided.

2 V2X and Public Safety Use case and Requirements

V2X and Public Safety (PS) is seen as a safety critical location service, where both precise and timely absolute and relative UE positioning is required to enable environmental awareness from the network and especially from the UE perspective. In the context of V2X and ProSe applications, sidelink (SL) positioning is a key enabler of positioning in different types of coverage areas, especially for partial and out-of-coverage scenarios such as tunnels, underground parking and other remote areas without (or limited) network/GNSS coverage.

During the previous RAN#91-e meeting an initial set of positioning requirements for V2X and PS were captured in TR 38.845 [2]. The remaining open issues are discussed in the following sections.

2.1 V2X

Sidelink (SL) positioning can be seen as a necessary positioning technology for addressing V2X use cases, which can complement the existing array of onboard vehicular localization sensors and radar/lidar technologies, where neither GNSS nor the network is able to meet the positioning requirements.

Relative positioning among UEs is a key enabler to support the lateral and longitudinal localization requirements of V2X use cases. It can also be noted that according to [R.5.1-007] of TS 22.186 [3], the relative lateral positioning requirement is much tighter than today's absolute Rel-16/Rel-17 positioning requirements. Automated driving use cases require especially stringent positioning requirements for tight control.

The V2X positioning requirements were captured according to the 3 different groups identified by the 5GAA LS in [4]. However, it was unclear if these positioning use cases were applicable to either absolute or relative positioning requirements. In Annex, Table 2, we aim to clarify the applicability of each of the V2X positioning use cases to either absolute and/or relative positioning requirements to each of the requirement groups/sets.

It can be observed that each group has identifiable use cases that can apply to either absolute, relative or both absolute and relative positioning requirements.

Proposal 1: Consider the applicability of each of the use cases within a V2X positioning Group/set to either absolute and/or relative positioning requirements.

It should be noted that 5GAA can also further confirm if these use cases within each requirement set are applicable to absolute, relative or both absolute and relative positioning requirements. It should be further discussed whether an LS can be sent to 5GAA to this effect in order to clarify the absolute and relative positioning requirements.

Proposal 2: Send an LS to 5GAA to clarify and confirm the individual absolute and relative positioning requirements within each V2X positioning requirement group.

2.2 Public Safety: UAV-related Use cases

An issue for further discussion was the scope of UAV related positioning requirements related to PS [4]. The UAV positioning use case requirements can be broadly divided based on requirements related to commercial, safety and navigational related use cases.

According to TS 22.125 [6], the commercial positioning requirements are defined as follows:

Table 1: Commercial UAV positioning requirements [6]

Scenario	Accuracy (95 % confidence level)		Availability	Heading	Latency for position estimation of UE	UE Speed	Corresponding Positioning Service Level in TS 22.261
	Horizontal accuracy	Vertical accuracy					
8K video live broadcast	[0.5 m]	[1 m]	99%		1s	[<120 km/h]	5
Laser mapping/ HD patrol	[0.5 m]	[1 m]	99%		1s	[<120 km/h]	5
4*4K AI surveillance	[0.1 m]					[<60 km/h]	
Remote UAV controller through HD video	[0.5 m]	[1 m]	99%		1s	[<120 km/h]	5
Periodic still photos	[0.1 m]	[1 m]				[<60 km/h]	

NOTE: The positioning accuracy in this table is not related to navigation or safety.

Although the UAV commercial positioning requirements have been defined, this set of requirements may fall out of scope due to the commercial positioning requirements.

Observation 1: Commercial UAV positioning requirements are to be deemed out of scope of the SID.

In the context of PS use cases, Aerial positioning requirements have been identified and defined in TR 22.872 [7] for

- 1) Accurate positioning to support Unmanned Aerial Vehicle (UAV) missions and operations
- 2) Transport and inspection by drones for medical purposes

Observation 2: Mission Operations and Medical UAV positioning requirements in TR 22.872 may fall within the scope of Public safety use cases.

The docking phases, e.g. UAV take-off and landing have also been described in the context of relative positioning requirements and is identified in terms of the Guidance-Navigation-Control vocabulary as the rendezvous phase, which is performed after the homing phase. The requirements are further captured in [7] as follows:

In conclusion, the use cases requiring less than 0.2m accuracy can be supported by the following capabilities:

- An absolute positioning service with an accuracy less than 0.5 m in enhanced positioning areas (homing phase)
- A relative positioning service with an accuracy less than 0.1m (3D) when the involved UEs are within 5 m from each other (rendezvous phase).

However, the use of PC5 (SL) and the application of V2X/ProSe services for UAVs has not yet been discussed in 3GPP. Furthermore, the potential requirements have also been only discussed with regard to an output of a study, i.e. TR 22.872. Further discussion on capturing the UAV PS use cases is required.

Proposal 3: The scope and applicability of PC5 (SL) positioning for UAVs does not fall under the scope of the SID.

3 Deployment and Operation Scenarios

3.1 Network Coverage Scenarios and Spectrum Considerations

3.1.1 Network Coverage

The positioning requirements should be fulfilled in all considered coverage scenarios including in-coverage, partial coverage and out of coverage scenarios due to the safety critical nature of V2X and PS use cases. Partial coverage scenarios can enable assisted positioning or cooperative positioning between in-coverage and out-of-coverage UEs, while positioning in out-of-coverage can be beneficial in tunnels, indoor and deep urban scenarios, where network and GNSS coverage is absent or very limited. Figure 1 shows the supported network coverage scenarios, which can be captured during this RAN-based study phase.

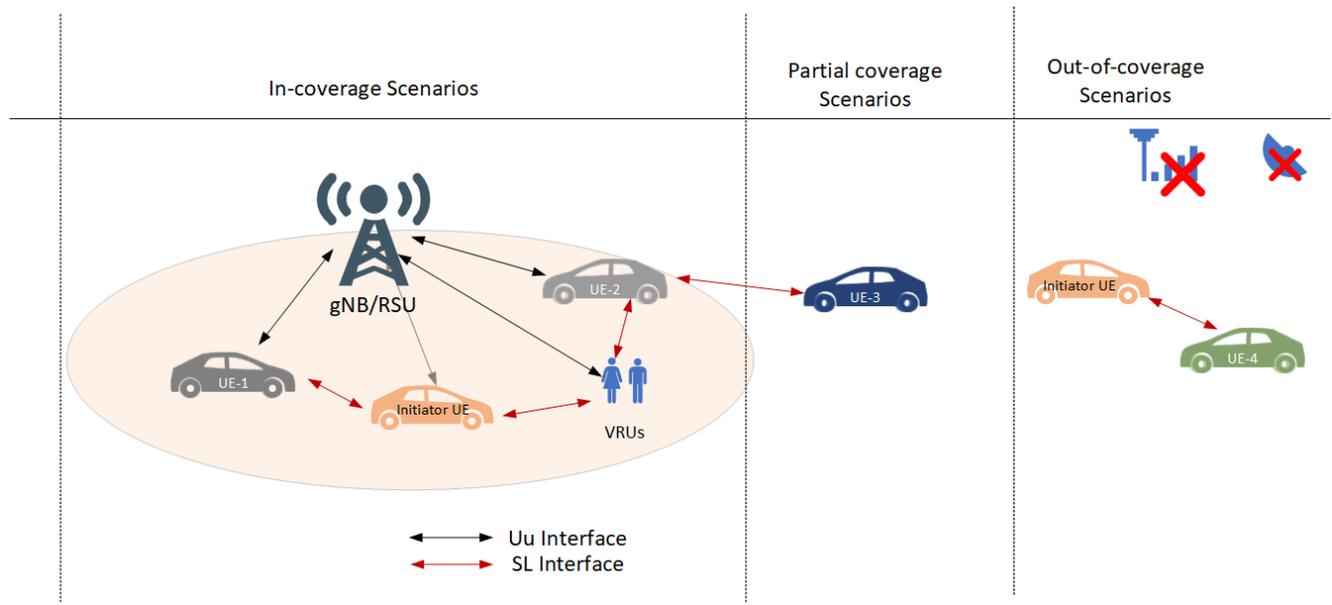


Figure 1: Support coverage scenarios for V2X and Public Safety Positioning

The initiator-UE is usually defined as the UE initiating the positioning session (determination of distance and orientation/attitude) relative to other UEs in the vicinity.

Proposal 4: Capture positioning support for in-coverage, partial coverage and out-of-coverage areas for both V2X and Public Safety use cases.

3.1.2 Spectrum Deployments

The performance accuracy of timing-based positioning schemes can be proportional to the amount of the transmission bandwidth required to resolve the time-of-arrival delay components of the channel impulse response at the receiver. The SL interface is a key enabler for V2X and PS UE-to-UE positioning in a variety of spectrum deployments.

The ITS band of 5850-5925 GHz has been allocated for basic safety C-V2X communications with bandwidths ranging from 20MHz up to 70 MHz, provided the whole band can be exploited for positioning. Although, the bandwidth in the ITS spectrum is limited, we envision that some use cases within the V2X Group 1 - Lax requirements shown in Annex. Table 2 can make use of the ITS band to satisfy some of the V2X positioning requirements. It should be noted that the spectrum rollout guidelines for the ITS band may vary depending on the region of operation.

Observation 3: ITS spectrum can fulfil some of the V2X positioning requirements, e.g. V2X Group 1 -Lax positioning requirements.

Licensed band operation for SL positioning can be considered an important and viable deployment option. The benefits of utilizing larger bandwidths for SL positioning, especially in FR2, e.g. up to 400 MHz can be realized with the assistance from the gNBs and can be used in a complimentary fashion to the existing positioning framework, where serving and neighbouring gNBs can configure suitable reference signals required for enabling positioning using a variety of techniques. Therefore, licensed band operations can satisfy both V2X and PS positioning requirements demanded in Groups 2 and 3. The limitation is that network coverage cannot be guaranteed in all scenarios, especially where safety is of paramount importance, e.g. during a natural disaster emergencies where network infrastructure may be damaged, position tracking in tunnel and underground parking scenarios.

Unlicensed band operation is also promising in terms of exploiting the large bandwidths available to improve the overall positioning accuracy. Existing technologies such as IEEE 802.15.4z (UWB), already exploit ultra-wide

bandwidths to improve ranging accuracy between devices within an indoor environment using very low transmit power. Enabling SL positioning using the unlicensed band or aggregating both licensed and unlicensed carriers can enable improved accuracy and therefore the fulfilment of PS relative positioning requirements especially in indoor scenarios.

Proposal 5: Support PC5 (SL) positioning in 3 different spectrum deployments to satisfy different V2X and Public Safety use cases including 1) ITS Band, 2) Licensed Band and 3) Unlicensed Band.

3.2 Radio Link Interface

As mentioned earlier and indicated in Figure 1, sidelink (SL) can enable both absolute (with network assistance) and relative positioning functionality, which can operate in a complementary fashion to current Uu-based positioning methods. The current positioning framework can only satisfy in-coverage positioning requirements, which are limited set of scenarios when considering both V2X and PS.

The positioning functionality should aim to build upon the current SL design as a baseline for considering the necessary procedures to enable positioning on the SL. Furthermore, the Uu interface can provide a variety of assistance information to help UEs determine the relative position with respect to other UEs in in-coverage and partial coverage scenarios. Cooperative positioning using the SL can also be supported and beneficial in partial coverage scenarios, where in-coverages UEs can perform relative positioning with out-of-coverage UEs.

We also view that the SL positioning can assist the network in obtaining a better absolute positioning estimate based on the assistance positioning information provided in the SL.

Furthermore, a unified framework for enabling SL positioning across all relevant use cases should be the eventual design goal, where network-based RAT-dependent, RAT-independent methods (e.g. GNSS, IMU, etc.) and potential SL-based positioning methods should be supported to fulfil different requirements based on the coverage scenario and spectrum deployment. Absolute and relative location awareness can be utilised in tandem for the benefit of V2X and PS applications.

Proposal 6: Positioning over both the Uu and PC5 (SL) interfaces are important for supporting a unified absolute and relative positioning framework.

3.3 Types of Location Requests and UE location estimation

There are several cases to consider when describing the type of location requests. The current LCS architecture can distinguish the following:

- Network Induced Location Request (NI-LR)
 - Serving AMF for a UE initiates location of the UE for some regulatory service (e.g. an emergency call from the UE).
- Mobile Terminated Location Request (MT-LR)
 - LCS client or AF external to or internal to a serving PLMN sends a location request to the PLMN (which may be the HPLMN or VPLMN) for the location of a target UE.
- Mobile Originated Location Request (MO-LR)
 - UE sends a request to a serving PLMN for location related information for the UE.
- Immediate location request
 - LCS client or AF sends or instigates a location request for a target UE (or group of target UEs) and expects to receive a response containing location information for the target UE (or group of target UEs) within a short time period which may be specified using QoS.
- Deferred Location Request
 - Similar to Immediate location request but LCS client/AF expects to receive a response containing the indication of event occurrence and location information if requested for the target UE (or group of target UEs) at some future time (or times), which may be associated with specific events. In Rel-16, only MT-LRs are supported.

Based on the above, it can be noted that the location request can originate from either a network entity in the core network or within a UE. Similarly, such requests can also be extended to SL positioning methods. However, location requests from the device (UE) in V2X and PS use cases are of critical importance due the safety nature of such requests, especially with regard to the determination of relative positions with respect to other UEs, when coordinating V2X tasks such as lane-level manoeuvring. Furthermore, in PS scenarios, it would also be critical to determine the relative location of victim UEs relative to the first responders for immediate response and action e.g, vertical relative position between different floors/levels of a building.

Moreover, depending on the nature of the location request, the location server or UE eventually computes the location estimate. To this effect, location estimates obtained using UE-assisted positioning techniques are computed at the location server, while location estimates obtained using UE-based positioning techniques are computed within the UE. Similarly, in the case of SL positioning the location estimate can also be computed at an entity residing the core network or at the UE.

UE-assisted positioning can enable absolute positioning requirements, while due to factors such as end-to-end latency are not suited for optimal relative positioning, while on the other hand UE-based SL positioning can better support relative positioning methods.

Proposal 7: Location request and estimation depends on the type of architecture and requires further input from SA WGs.

Proposal 8: From RAN perspective, both UE-assisted and UE-based positioning functionality for SL is considered feasible depending on e.g. the type and nature of the positioning request.

3.4 UE types for V2X and PS Positioning

In the context of V2X and PS, the potential UE types that can be considered for SL positioning in different coverage scenarios include (and subject to future UE capabilities):

- Vehicular UEs
- UEs with power constraints (limited battery life), which can also be considered as normal handheld UEs supporting both Uu and SL communication:
 - Vulnerable Road Users (VRUs).
 - ProSe UEs as part of the PS use cases
- Roadside Unit UEs: Can serve as stationary reference anchor nodes using SL, e.g. for performing timing-based positioning methods such as TDOA.

Observation 4: Energy efficient absolute and relative positioning are an important consideration for fulfilling the positioning use cases for power limited UEs.

Proposal 9: Vehicular UEs, RSUs and UEs with power constraints, e.g. VRUs, ProSe UEs can be considered for performing SL absolute and relative positioning.

4 Positioning KPIs

Additional positioning KPIs should also be considered given the new V2X and PS use cases, which are over and above what has already been considered for Rel-16/Rel-17 positioning especially in the context of relative positioning. These include:

- Relative Positioning Accuracy
 - Horizontal and Vertical accuracies
 - Lateral and Longitudinal accuracies in the case of V2X

- Orientation accuracy
 - Depending on the elevation and azimuth plane
 - FFS absolute or relative orientations
- Concurrent UEs performing relative location estimation
- Applicable coverage areas
 - In-coverage, partial coverage and out-of-coverage scenarios
- Positioning Update rate
- Mobility
 - Absolute velocity (horizontal in case of V2X use cases)
 - Relative velocity
- Integrity and Reliability of the positioning estimate
 - Alert limit (AL)
 - Time to alert (TTA)
 - Target Integrity Risk (TIR)
 - Other QoS parameters such as relative accuracy confidence intervals, etc.

Integrity and reliability of the absolute and relative location are important for safety critical services such as V2X, e.g. to enhance Advanced Driver-Assistance Systems (ADAS). Such errors may also affect the reliability and integrity of the relative location estimate considering that a UE may perform relative positioning with multiple UEs in close proximity. Integrity concepts such as AL, TTA and TIR can ensure the integrity and reliability in such use cases.

Observation 5: Integrity and reliability of a positioning estimate are especially important for safety critical use cases such as V2X and PS.

In addition, the positioning requirements need to target a high availability of 99% due to the density of UEs in a given area and especially due to the safety critical nature of the V2X and PS use cases.

Proposal 10: Consider at least the following additional positioning KPIs required for the V2X and Public Safety use cases:

- **Relative positioning accuracy**
- **Orientation/attitude accuracy**
- **Concurrent UEs performing relative location estimation**
- **Positioning update rate**
- **Mobility parameters including relative velocity**
- **Positioning integrity metrics**

5 Conclusions

This contribution has noted the following observations:

Observation 1: Commercial UAV positioning requirements are to be deemed out of scope of the SID.

Observation 2: Mission Operations and Medical UAV positioning requirements in TR 22.872 may fall within the scope of Public safety use cases.

Observation 3: ITS spectrum can fulfil some of the V2X positioning requirements, e.g. V2X Group 1 -Lax positioning requirements.

Observation 4: Energy efficient absolute and relative positioning are an important consideration for fulfilling the positioning use cases for power limited UEs.

Observation 5: Integrity and reliability of a positioning estimate are especially important for safety critical use cases such as V2X and PS.

The proposals based on the discussion are summarized as follows:

Proposal 1: Consider the applicability of each of the use cases within a V2X positioning Group/set to either absolute and/or relative positioning requirements.

Proposal 2: Send an LS to 5GAA to clarify and confirm the individual absolute and relative positioning requirements within each V2X positioning requirement group.

Proposal 3: The scope and applicability of PC5 (SL) positioning for UAVs does not fall under the scope of the SID.

Proposal 4: Capture positioning support for in-coverage, partial coverage and out-of-coverage areas for both V2X and Public Safety use cases.

Proposal 5: Support PC5 (SL) positioning in 3 different spectrum deployments to satisfy different V2X and Public Safety use cases including 1) ITS Band, 2) Licensed Band and 3) Unlicensed Band.

Proposal 6: Positioning over both the Uu and PC5 (SL) interfaces are important for supporting a unified absolute and relative positioning framework.

Proposal 7: Location request and estimation depends on the type of architecture and requires further input from SA WGs.

Proposal 8: From RAN perspective, both UE-assisted and UE-based positioning functionality for SL is considered feasible depending on e.g. the type and nature of the positioning request.

Proposal 9: Vehicular UEs, RSUs and UEs with power constraints, e.g. VRUs, ProSe UEs can be considered for performing SL absolute and relative positioning.

Proposal 10: Consider at least the following additional positioning KPIs required for the V2X and Public Safety use cases:

- **Relative Positioning Accuracy**
- **Orientation/attitude accuracy**
- **Concurrent UEs performing relative location estimation**
- **Positioning update rate**
- **Mobility parameters including relative velocity**
- **Positioning integrity metrics**

6 References

- [1] RP-201384, New SID: Study on scenarios and requirements of in-coverage, partial coverage, and out-of-coverage positioning use cases, LG Electronics, FirstNet.
- [2] TR 38.845, “Study on scenarios and requirements of in-coverage, partial coverage, and out-of-coverage NR positioning use cases (Release 17)”, V0.1.0, Mar. 2021.
- [3] TS 22.186, “Enhancement of 3GPP support for V2X scenarios (Release 16)”, V16.2.0, June 2019.
- [4] RP-210040, “LS reply to 3GPP RAN on requirements of in-coverage, partial coverage, and out-of-coverage positioning use cases”, 5GAA, March 2021.
- [5] RP-210838, “Moderator's summary for email discussion [91E][21][SL_positioning_TR]”, Moderator (LG Electronics), Mar. 2021.
- [6] TS 22.125, “Unmanned Aerial System (UAS) support in 3GPP”, V17.2.0, Sept. 2020.
- [7] TR 22.872, “Study on positioning use cases”, V16.1.0, Sept. 2018.

7 Annex

Table 2: Set of Positioning requirements according to V2X

V2X Positioning Requirement Set	Position Accuracy (m)	Confidence Level (%)	Positioning Service Level	Absolute Positioning Use case Applicability	Relative Positioning Use Case Applicability
Set 1: Lax Positioning Requirements	10 – 50	68-95	1 (TS 22.261)	Traffic Jam Warning - Urban Scenario on Road Warning	Traffic Jam Warning - Urban Scenario on Road Warning
				Traffic Jam Warning - Rural Scenario on Road Warning	Traffic Jam Warning - Rural Scenario on Road Warning
				Traffic Jam Warning - Highway Scenario on Road Warning	Traffic Jam Warning - Highway Scenario on Road Warning
				Rural Scenario on Route Information	
				Highway Scenario on Route Information	
				Software Update - Conventional-Routine/Urgent, Autonomous-Routine	
				Software Update - Autonomous-Urgent	
				Software Update - Without Infrastructure, Vehicle to Workshop	
				Remote Automated Driving Cancellation	Remote Automated Driving Cancellation
				HD Content Delivery - High-End Service for cars	
				HD Content Delivery - Low-End Service for cars	
				HD Content Delivery – Bus Passenger Service	
				Software Update of Reconfigurable Radio System	
				Patient Transport Monitoring	
Automated Valet Parking (Wake Up)	Automated Valet Parking (Wake Up)				
Set 2: Lane level Positioning Requirements	1 - 3	95-99	2, 3, 4 (TS 22.261)	Cross-Traffic Left-Turn Assist	Cross-Traffic Left-Turn Assist
				Intersection Movement Assist	Intersection Movement Assist
					Emergency Break Warning

					Lane Change Warning - lagging vehicle, leading vehicle, Highway
					Lane Change Warning - lagging vehicle, leading vehicle, urban
					Lane Change Warning - not permitted case, rural
				Vehicle Health Monitoring	
				Speed Harmonization	Speed Harmonization
				See-Through for Pass Manoeuvre	See-Through for Pass Manoeuvre
				Obstructed View Assist via CCTV	Obstructed View Assist via CCTV
				Obstructed View Assist via Remote Vehicles	Obstructed View Assist via Remote Vehicles
				Continuous Traffic Flow via Green Lights Coordination	Continuous Traffic Flow via Green Lights Coordination
				Vehicle collects hazard and road event for AV	Vehicle collects hazard and road event for AV
				Vehicles Platooning in Steady State	Vehicles Platooning in Steady State
					Cooperative Lane Merge
					Autonomous Vehicle Disengagement Report
				Accident Report	
					Awareness Confirmation
					Coordinated, Cooperative Driving Manoeuvre - Cooperative Lane Change
					Coordinated, Cooperative Driving Manoeuvre - Road Blockage
				Bus Lane Sharing Request	Bus Lane Sharing Request
				Bus Lane Sharing Revocation	Bus Lane Sharing Revocation
					Vehicle Decision Assist - RV Waiting for a Short Period of Time, RV Broken Down, Bus Having to Wait
					Vehicle Decision Assist - Slow Vehicle en Route
Set 3: Below meter	0.1 – 0.5	95-99	5, 6, 7	High Definition Sensor Sharing	High Definition Sensor Sharing

positioning requirements			(TS 22.186)	Vulnerable Road User - Awareness near potentially dangerous situations Urban	Vulnerable Road User - Awareness near potentially dangerous situations Urban
				Vulnerable Road User - Collision risk warning	Vulnerable Road User - Collision risk warning
				Real-Time Situational Awareness & High-Definition Maps	Real-Time Situational Awareness & High-Definition Maps
					Group Start
				Tele-Operated Driving (TOD)	Tele-Operated Driving (TOD)
				TOD support	TOD support
				TOD for Automated Parking	TOD for Automated Parking
					Cooperative Manoeuvres of Autonomous Vehicles for Emergency Situations
				High definition map collecting & sharing	High definition map collecting & sharing
					Automated Intersection crossing
				Infrastructure Assisted Environment Perception - Data Distribution about Objects on the Road	Infrastructure Assisted Environment Perception - Data Distribution about Objects on the Road
				Infrastructure Assisted Environment Perception - Individual Data Transmission in Form of Trajectories or Actuation Commands)	Infrastructure Assisted Environment Perception - Individual Data Transmission in Form of Trajectories or Actuation Commands)
				Infrastructure based Tele-Operated Driving	Infrastructure based Tele-Operated Driving
				Automated Valet Parking – Joint Authentication and Proof of Localisation	Automated Valet Parking – Joint Authentication and Proof of Localisation
					Coordinated, Cooperative Driving Manoeuvre - Pedestrian Crossing
					Cooperative Traffic gap
					Cooperative Lateral Parking
	Cooperative Curbside Management				