SECUR

Safety Enhancement through Connected Users on the Road

Deliverable 2.1

Technical document: PC5 based on 3GPP Release 16 (mode 2)

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EXECUTIVE SUMMARY

This document is the technical document of PC5 based on Release 16 technology. It gathers general information, performances KPI (data rate, range & reliability, latency, congestion, mobility and positioning) and technology's characteristics. For the same reason that for PC5 R14 technology, we focus on V2X communication that does not depend on the network infrastructure, then the distributed radio resource management is considered (Mode 2).

During the SECUR V2X study this technology under early-stage status, few information was found. It is worth noting that the technology is almost the same than R14-PC5 for broadcast and therefore for most of the safety services. The increase of performances will be noticeable for unicast and multicast-based services such as "See Through", platooning, etc. In this case the performance of R16-PC5 will be sufficient for a large panel of advanced services. This document focuses only on NR-V2X of PC5 R16.

ABBREVIATIONS

3GPP	3rd Generation Partnership Project
4G	4G is the fourth generation of broadband cellular network technology, succeeding 3G and preceding 5G
5G	In telecommunications, 5G is the fifth-generation technology standard for broadband cellular networks
5GAA	5G Automotive Association
ASIL	Automotive Safety Integrity Level
BC	Bicyclist
BLE	Bluetooth Low Energy
C2C-CC	Car 2 Car Communication Consortium
CAM	Cooperative Awareness Message
CBR	Channel Busy Ratio
C-ITS	Cooperative Intelligent Transport Systems
CPM	Cooperative Perception Message These messages broadcast information on detected object to its surrounding.
D2VO	Datex-II Vehicle Obstruction
D2WRRC	Datex-II Weather Related Road Conditions
DENM	Decentralized Environmental Notification Message
ECTL	European Certificate Trust List
ETSI	European Telecommunications Standards Institute
EU	European Union
GDPR	General Data Protection Regulation
IP	Internet Protocol
ITS-G5	Direct communication technology based on Wi-Fi. European name for WAVE or DSRC.
IVS	In-Vehicle Signage
KPH	Kilometers per hour
KPI	Key Performance Indicator
LOS	Line-of-sight
LTE	Long Term Evolution
MAPEM	MAP Extended Message
NLOS	Non-line-of-sight
OBU	On-Board Unit
PC	Passenger Car
PC5	Direct communication technology based on mobile network (3GPP). PC5 is one part of C-V2X/LTE-V2X that enable direct communication between objects.
PD	Pedestrian
PDR	Packet Delivery Ratio
PER	Packet Error Rate
PKI	Public Key Infrastructure
PTW	Powered Two-wheeler
REL	Release
RSU	Road Side Unit
RTK	Reel Time Kinematic
SB	Steering Board
SPATEM	Signal Phase And Timing Extended Message

TTC	Time To Collision
UC	Use case
UK	United Kingdom
Uu	Radio interface in cellular communication between a user equipment (UE) and the cellular network base station.
V2I	Vehicle-To-Infrastructure
V2N	Vehicle-To-Network (Uu communication)
V2P	Vehicle-To-Pedestrian
V2V	Vehicle-To-Vehicle
V2VRU	Vehicle-To-Vulnerable Road User
V2X	Vehicle-To-Everything (i.e. vehicle to any type of other station)
VAM	VRU Awareness Message
VRU	Vulnerable Road User (motorcyclist, bicyclist and pedestrian)
WG	Working Group
WP	Work Package
WP1	SECUR Work Package n°1: Accidentology study
WP2	SECUR Work Package n°2: V2X technologies study
WP3	SECUR Work Package n°3: Potential of V2X to improve ADAS performances and final use cases selection
WP4	SECUR Work Package n°4: Development of testing connected targets
WP5	SECUR Work Package n°5: Test and assessment procedures

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1. General information

1.1 Technology's name

PC5 based on Release 16 (NR-V2X) mode 2

1.2 Operating frequency band

5.9 GHz

1.3 Standard (access layer)

1.3.1 Standardization organization

European Telecommunications Standards Institute ETSI (TR 137 985)
3rd Generation Partnership Project (3GPP)

1.3.2 Standard Level of maturity [Draft/In work/Released/Rework]

R16 has been released in 2020 and the release 17 is under development.
The R16 introduced the sidelink mode of operation in the 5G NR interface, thus enabling 5G-V2X [1].

1.3.3 Is the organization active?

Yes, even in the R16 has been completed and the effort is put on the next releases.

1.4 Communication profile

There is no communication profile for 3GPP Release 16 mentioned in standardization like ETSI. Release 17 is expected in 2022.

1.5 All supported communication types (broadcast…)

In the 3GPP R16 specifications, NR-V2X has not been developed to replace LTE-V2X for services LTE-V2X can already provide (i.e. Broadcast) [2]. It has been designed to complement LTE-V2X in order to support new use cases [3]. That means that in any case NR-V2X and LTE-V2X must coexist in ITS bands since NR-V2X is a different incompatible radio technology. The rationale behind this choice comes from the fact LTE-V2X was considered as under deployment and coexistence between the two technologies will be necessary anyway.

The PC5-R16 adds unicast and multicast (groupcast) communication types on the sidelink. It is relevant for advanced ITS services.

1.6 V2X systems capability (V2V, V2I, V2N, V2VRU)

Table 1 - Type of Communication supported

V2X Type	Supported or not?	Mandatory infrastructure(s)/hardware for the technology operability
V2V	Supported	On-Board Unit (OBU)
V2I	Supported	On-Board Unit (OBU) + Roadside Unit (RSU)
V2N	Not Supported	/
V2VRU	Supported	OBU or P-ITS-S (Personal ITS Station) supporting PC5 R16.

1.7 TECHNOLOGY'S DEPLOYMENT MATURITY

No real deployment yet.
It is worth noting that almost all experimentations are done with only one technology provider (mainly Qualcomm) and therefore there is no interoperability feedback yet.

1.8 WHERE IS THE TECHNOLOGY USED? (ONLY WITH THE SAME COMMUNICATION PROFILE)

As far as we know there is no product on the market nor announcement for chipset that supports the 3GPP Rel16 standards. The experiments have been conducted with Qualcomm chipset and with the experimental development [4]. Based on openair interface[1] initially developed at Eurecom [4], an implementation of NR-V2X has been announced[2].

[1] https://openairinterface.org

[2] https://openairinterface.org/news/openairinterface-releases-5g-nr-software-stack/

2. Performances

At the time of this study, version 16 of PC5 is still new and very little real testing has been done. This technical document will not be complete due to the lack of information available at the time of the study.

However, you will find a simulation [5] below showing the estimated performances of this technology.

2.1 DATA RATE

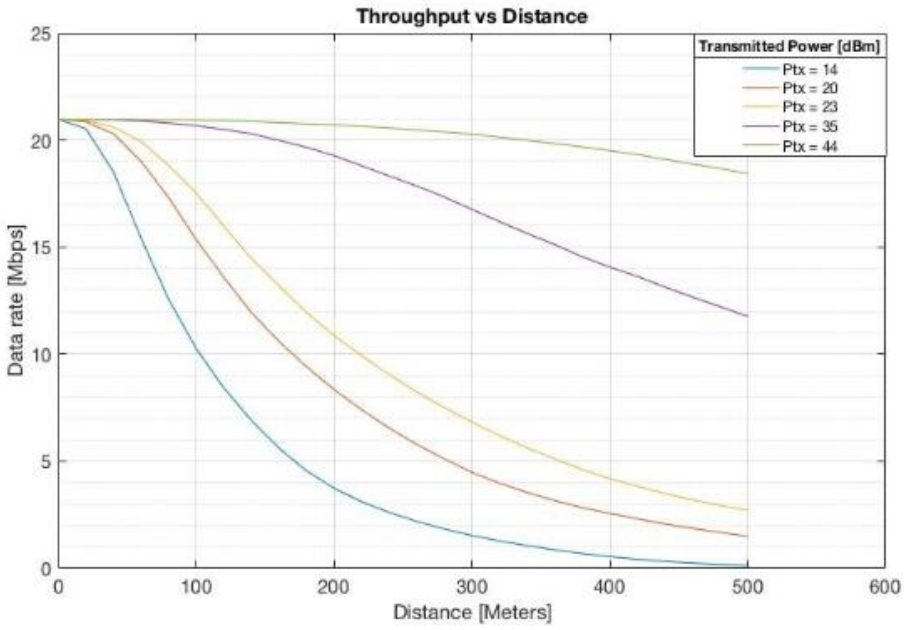

Figure 1: Data rate vs distance simulation results [5]

In known tests and/or simulations the bandwidth is enough for safety services. The results are the same than for R14-PC5 since the same technology is used for broadcast with few adaptations in the Semi Persistent Scheduling algorithm. The difference will be strong for unicast and multicast communications where the available bandwidth is larger.

In [5] a simulation-based evaluation of 5G NR is performed.

2.2 RANGE AND RELIABILITY

Figure 2, show the simulated PER in relation to the distance for several transmission power.

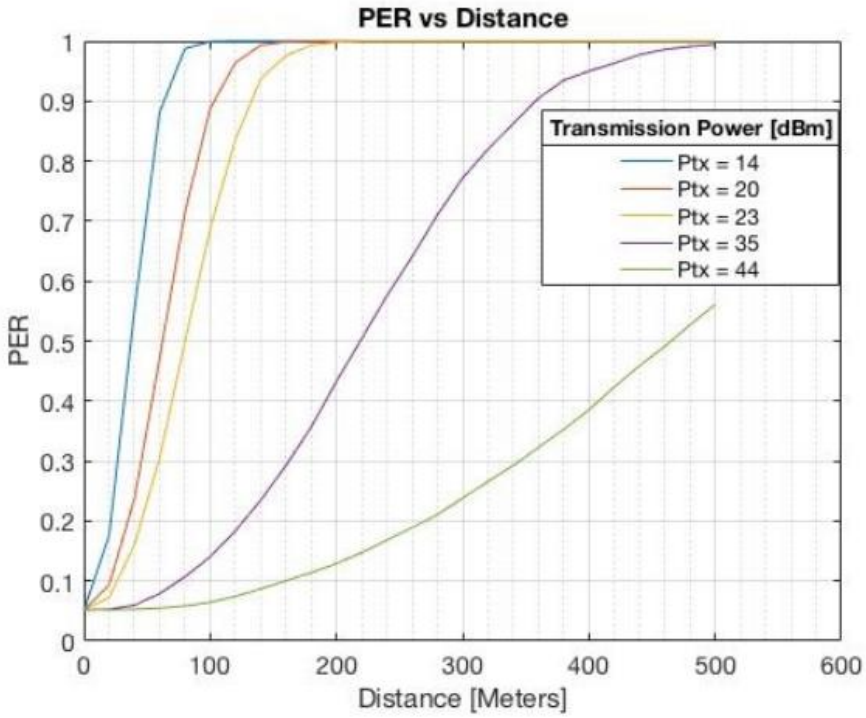

Figure 2: PER vs Distance simulation results [5]

2.3 LATENCY

Figure 3, show the simulated latency in relation to the distance for several transmission power.

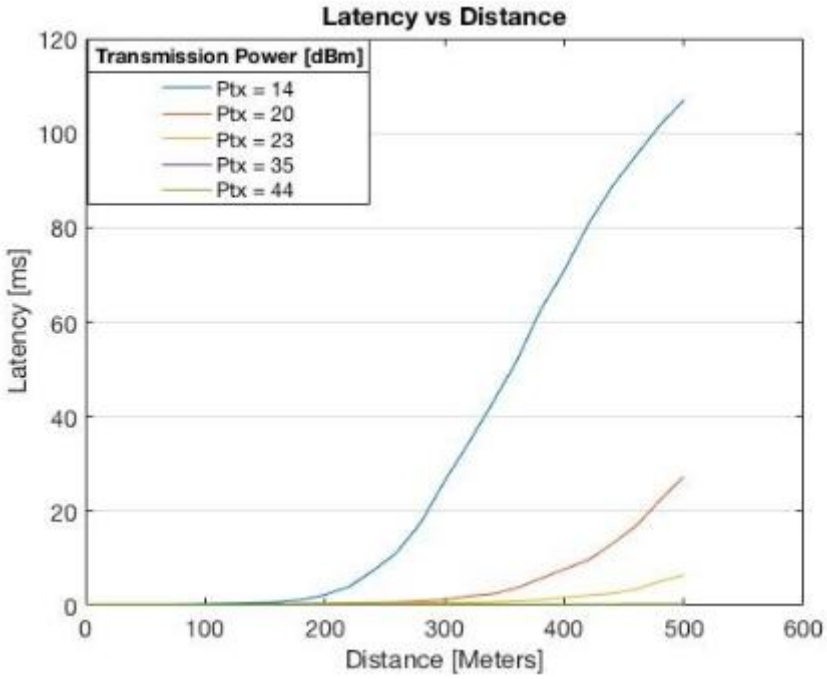

Figure 3: Latency vs Distance simulation results [5]

NR-V2X provides very good performances well adapted to advance ITS services (cooperative perception, cooperative manoeuver) [6].

2.4 CONGESTION

Information missing in the literature, early stage of the technology.

2.5 MOBILITY

Information missing in the literature, early stage of the technology.

2.6 POSITIONING

Information missing in the literature, early stage of the technology.

3. Technology characteristics

3.1 SUPPORTED MESSAGES

Table 2 - Supported messages by PC5-rel16

Type	Rate
Collective Awareness Message (CAM)	1-10 Hz
Decentralized Environmental Notification Message (DENM)	1-10 Hz
Infrastructure-to-Vehicle-Notification Message (IVIM)	/
Signal Phase and Timing Extended Message (SPATEM)	10 Hz
MAP Extended Message (MAPEM)	1 Hz
Collective Perception Message (CPM)	1-10 Hz
Signal Request Extended Message (SREM)	/
Signal Status Extended Message (SSEM)	/
Maneuverer Coordination Message (MCM)	/
Multimedia Content Dissemination Message (MCDM)	/
VRU Awareness Message (VAM)	1-10 Hz
Service Announcement Essentiel Message (SAEM)	/

3.2 COHABITATION AND INTERFERENCES

Table 3 - Cohabitation with other V2X technologies

Technology's name	Co-channel coexistence [OK] / Interferences [NOK]	Interoperability [OK / NOK]
ITS-G5 based on IEEE 802.11p	NOK	NOK
ITS-G5 based on IEEE 802.11bd	NOK	NOK
PC5 based on 3GPP rel 14	NOK	NOK[3]
PC5 based on 3GPP rel 16	OK	OK
PC5 based on 3GPP rel 17	*	OK
4G	NA	NA
5G	NA	NA
BLE	NA	NA
Wi-Fi	Ok (1)	NOK

* No information during the study.
(1) The [5GAA-2] study concludes that interferences between Wi-Fi devices operating in U-NII-4 unlicensed bands could impact the performances of LTE-V2X operating in the ITS upper bands. the U-NII-4 band corresponds to the ITS lower bands that has been free by FCC in USA [FCC-20201118]. It should be the same for 5G-V2X for broadcast messages.

3.3 SECURITY

3.3.1 CONSIDERATION OF GDPR

The technology meets the requirements of GDPR. By design, pseudonymization with sophisticated pseudonym and authorization ticket change strategy.

3.3.2 DOES THE TECHNOLOGY MEET THE EU REQUIREMENTS IN TERM OF SECURITY?

This technology meets the requirements of EU in term of security. EU has published dedicated requirements as EU Certificate Policy and EU Security Policy. Moreover, PKI is used. However, the system is able to fulfil EU-Security regulation requirements for the European V2X-trust system (European Certificate Trust List "ECTL" Requirements) but is not considered yet.

[3] In-device coexistence mechanisms are under development at 3GPP.

CONCLUSION

Concerning the deployment of the technology, PC5 Release 16 is a technology where there is very few studies, tests or project pilots. Moreover, unlike other type of direct communication, there is not yet V2X profiles standardized in order to permit OEM and infrastructure providers to communicate and be interoperable, there is only the V2X messages ones that remains applicable. However, the interoperability with other technologies that use the same frequency band (e.g., ITS-G5), there is a major issue in today's ecosystem. Indeed, there is not yet standardization or guidelines to employ these technologies that are not designed to co-exist.

Concerning the pure performance of the technology, PC5 Release 16 present sufficient performances to address all SECUR use-cases from a range, latency & congestion point of view based on the different sections of the document. Indeed, NR-V2X also allows broadcast and could be used for ITS service in place of PC5-R14, which already address SECUR use-cases. However, as far as we know there is no performance evaluation of this type of communication. The simulation results available in literature show very good performances. But there are very few experimentations and often with only two or three devices, it is then too early to conclude on the performance in real situation and interoperability has not been proven. Thus it could both address low-latencies critical safety use cases & informative use cases.

Finally, from the privacy point of view, the design itself of direct communication through ITS-G5 is proven private by design from ANSSI (Agence Nationale de la Sécurité des Systèmes d'Information) & BSI (Bundesamt für Sicherheit in der Informationstechnik) which are the French & German information system security agencies.

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Partners

Contributors

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