

5G for Internet of Vehicles

IOTWeek

Aarhus,  
17-21 June 2019

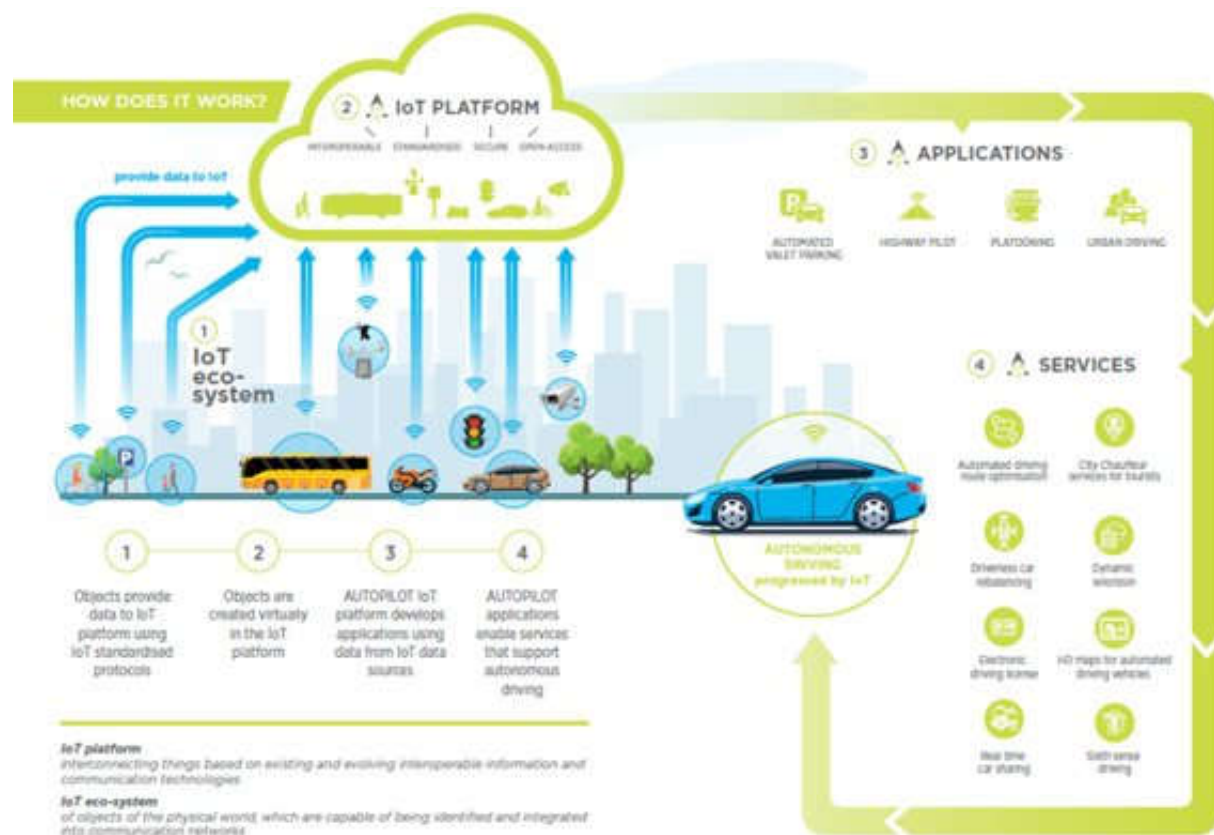
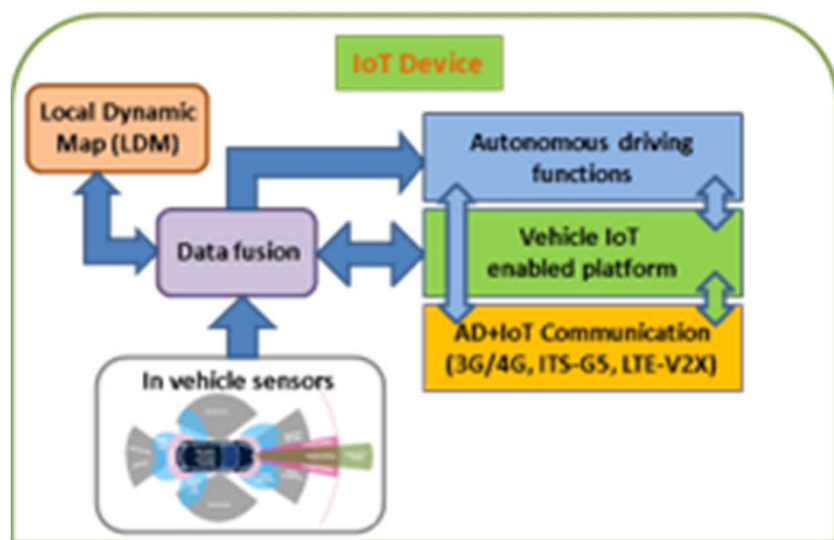
Dr. Ovidiu Vermesan, SINTEF, Norway

Merging automotive and IoT technologies to move forwards Automated Driving towards a new dimension

- Enhance the driving environment perception with “IoT enabled” sensors
- Foster innovation in automotive, IoT and mobility services
- Contribute to the development of IoT Standardisation and ecosystem
- Use and evaluate advanced V2X connectivity technologies
- Involve Users, Public Services, Business Players to assess the IoT socio-economic benefits for Mobility

## IoT to transform automated driving

### Vehicle IoT integration

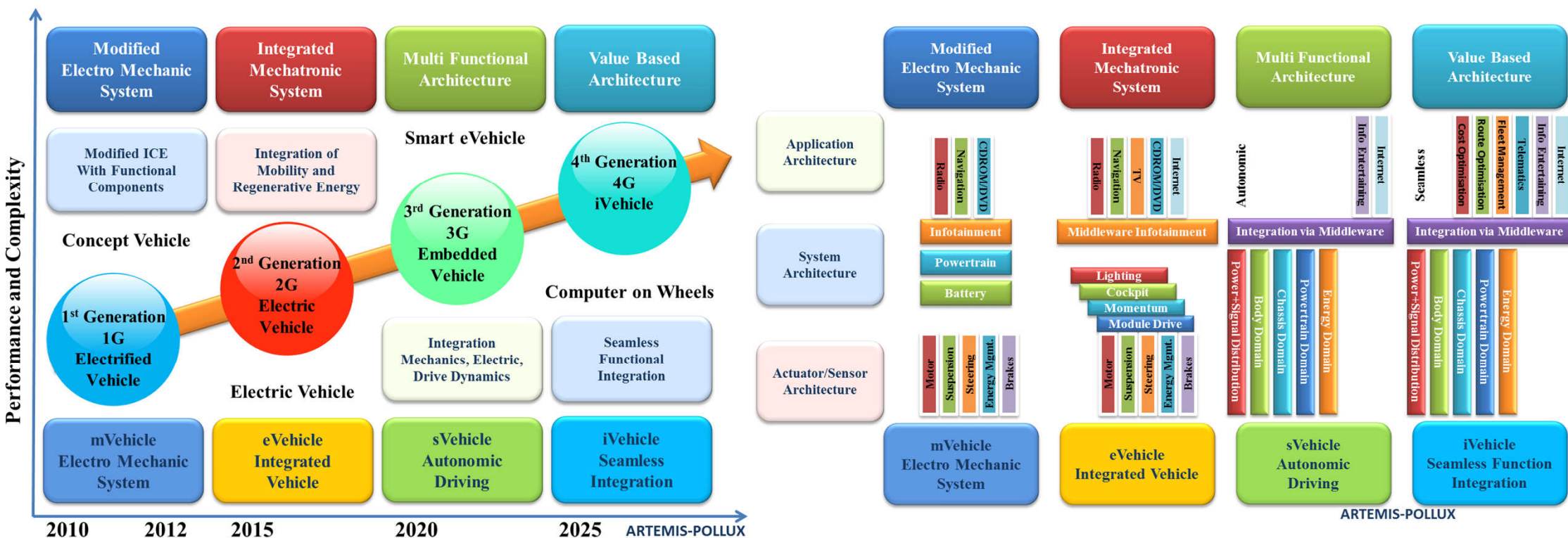




# EVs generations



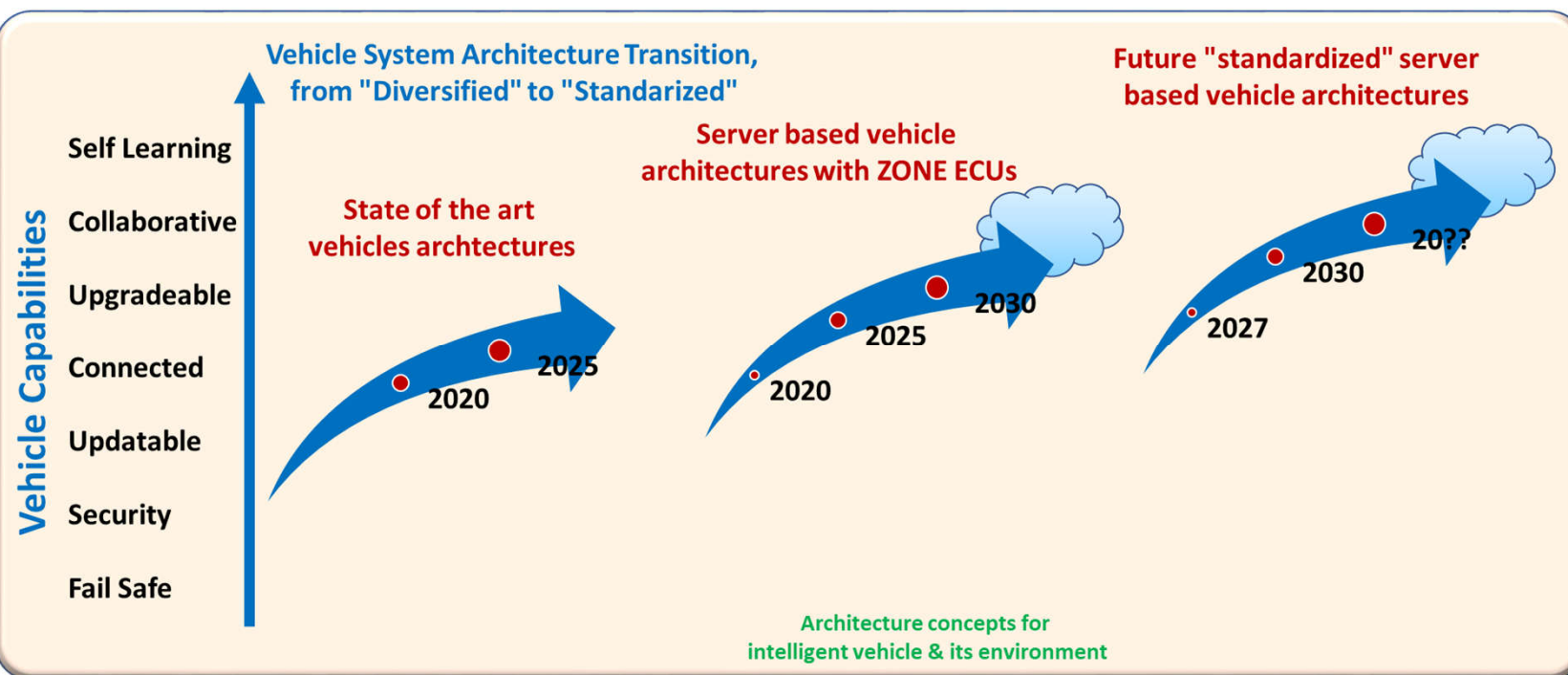
European  
Large-Scale Pilots  
Programme



# Vehicles capabilities



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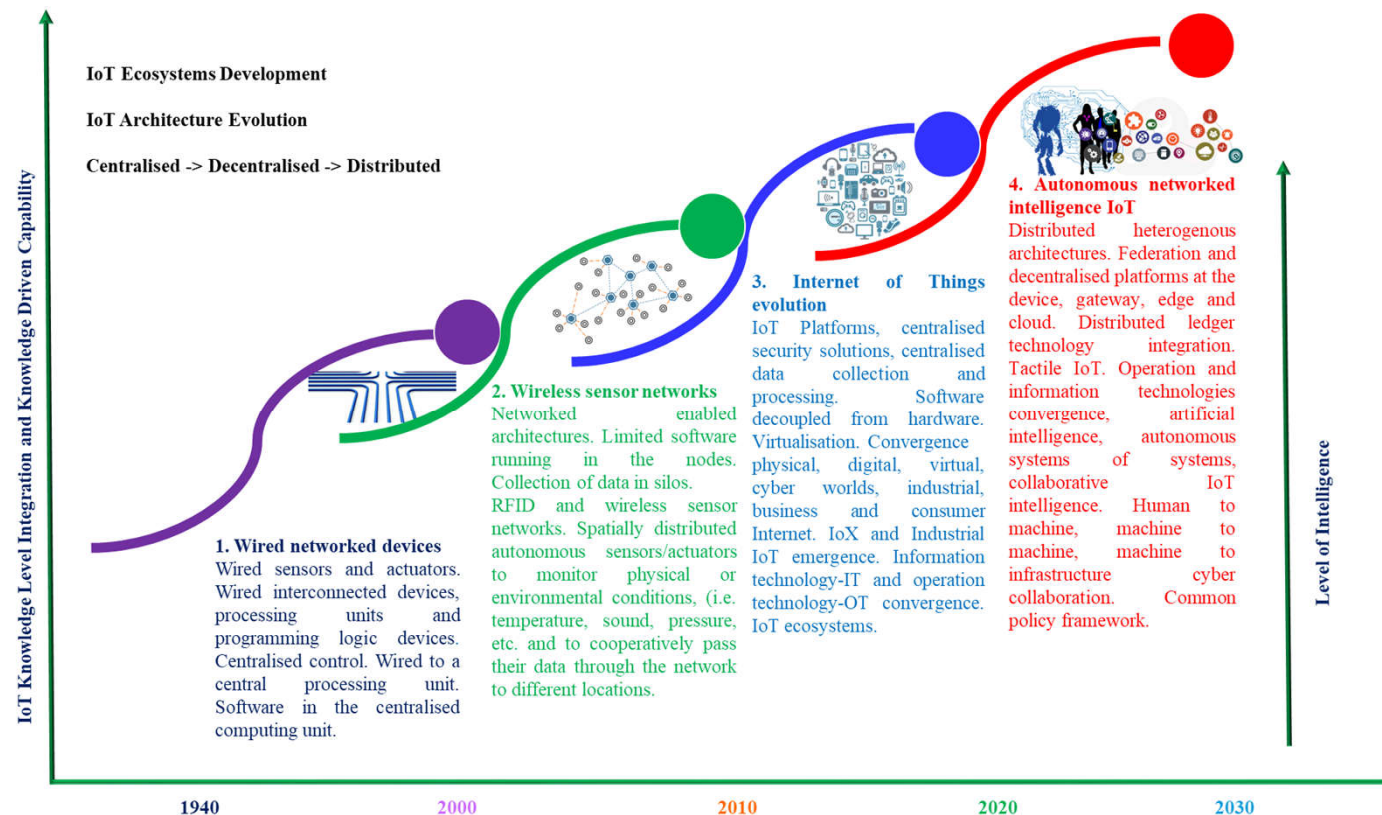
"From diversified" to "standardised" and addressing the safety validation of the electronic components and systems that are part of the new automotive high-performance computing platforms.

New system architectures for in-vehicle electronics, (Source: Adapted from T. Maier, Continental, April 2019)

# IoT generations



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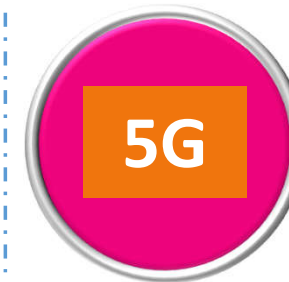
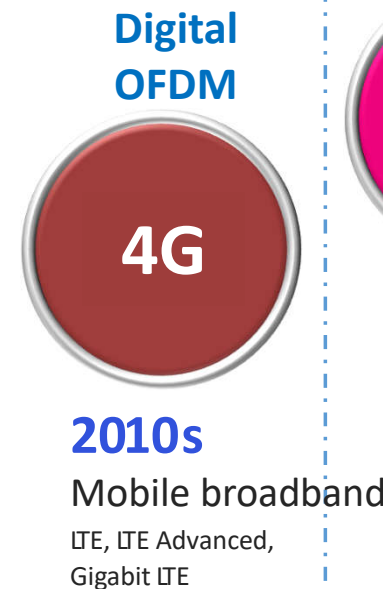
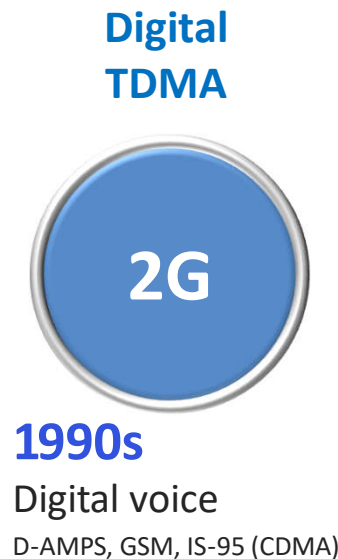
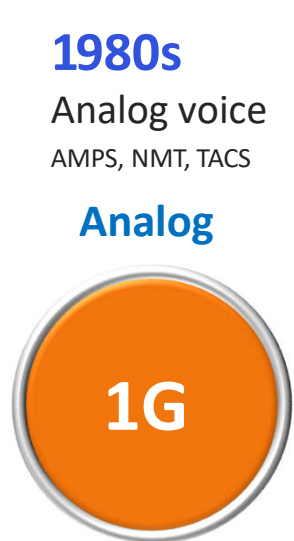
(Source: IERC 2018)

# Cellular generations



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*10 billion human beings communication*  
*Radio Access Network Centric*  
*Cellular*



*More than the air  
interface*

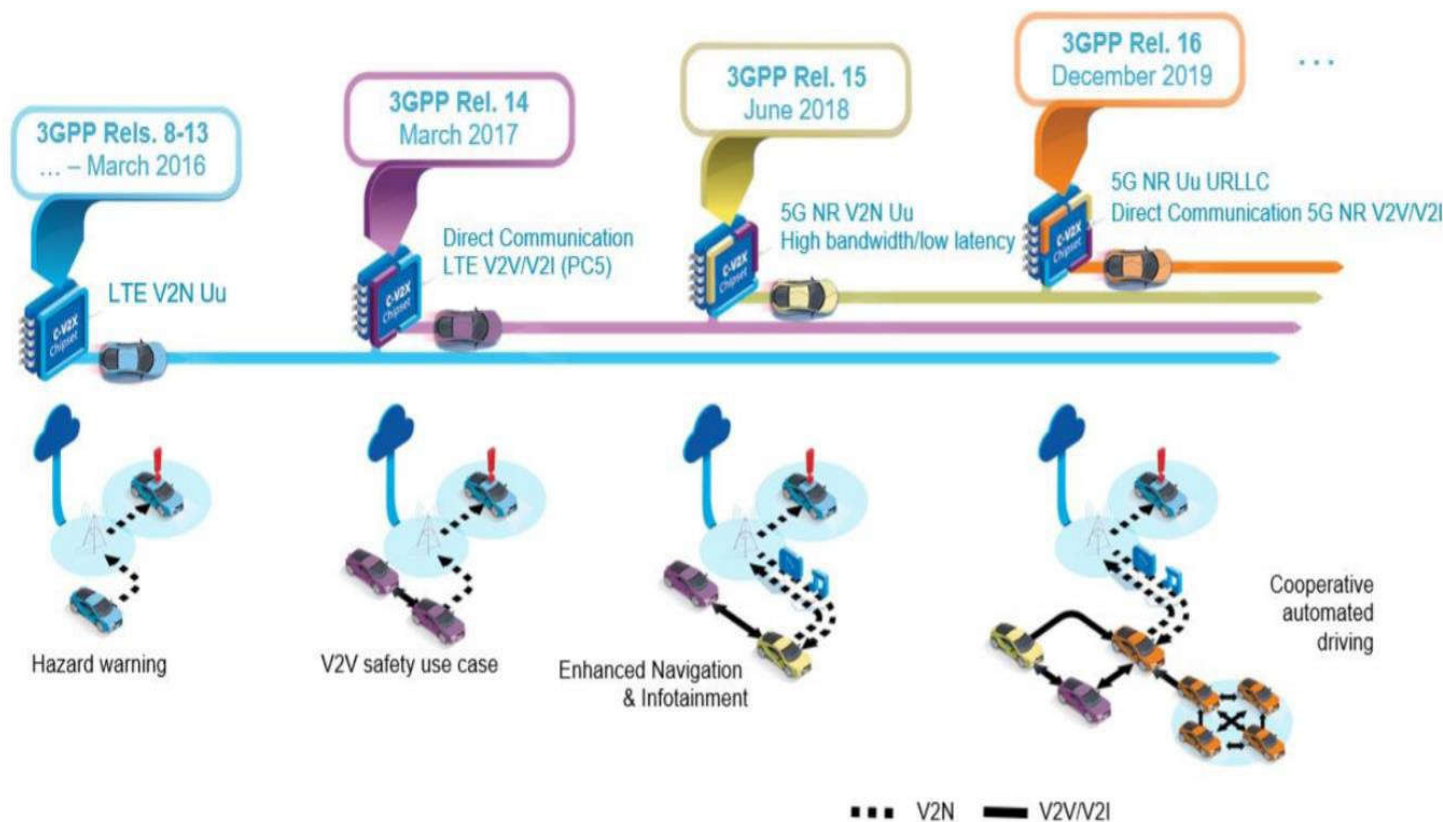
*Cellular meshed hybrid*  
*Holistic approach*  
*500 billion things control*



# C-V2X Evolution with 3GPP Release



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Source: <http://5gaa.org>

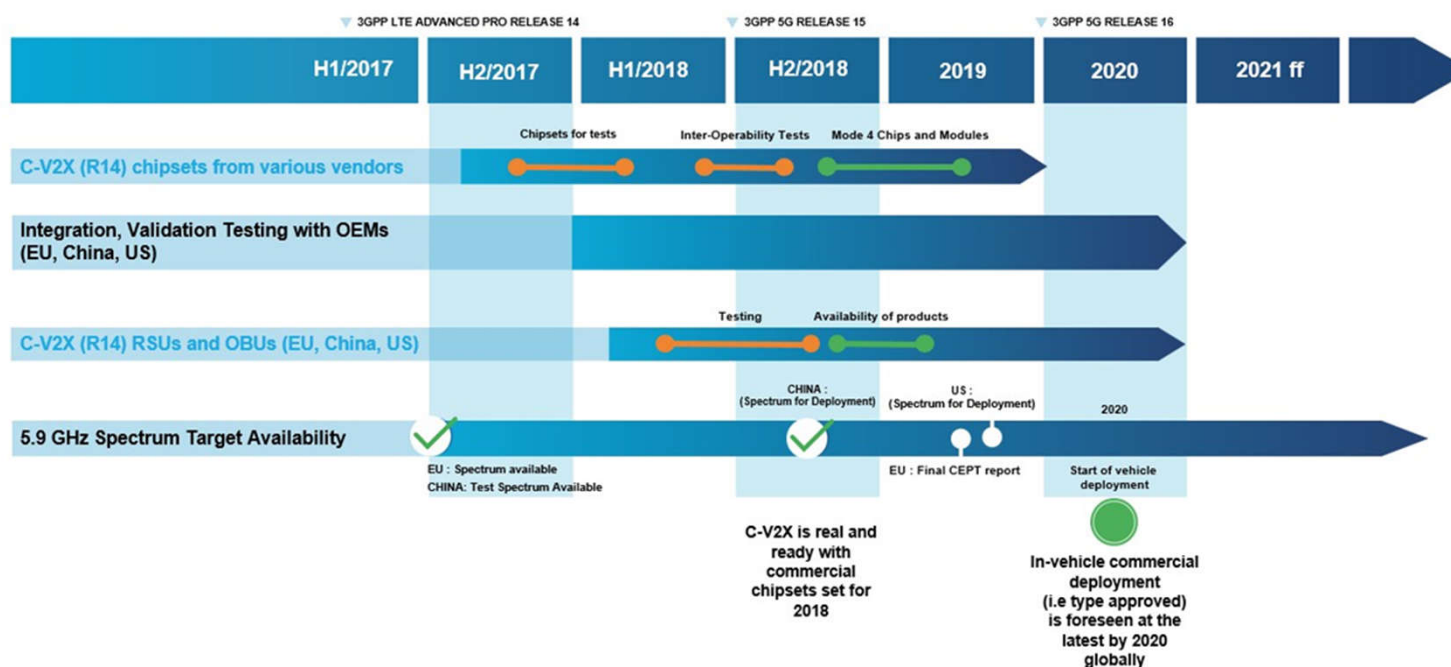


# C-V2X Evolution with 3GPP Release



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## Timeline for deployment of C-V2X (V2V/V2I)



Source: <http://5gaa.org>

# V2X Intelligent Connectivity + Mobility



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Convergence of 5G, IoT/IIoT, AI, edge computing

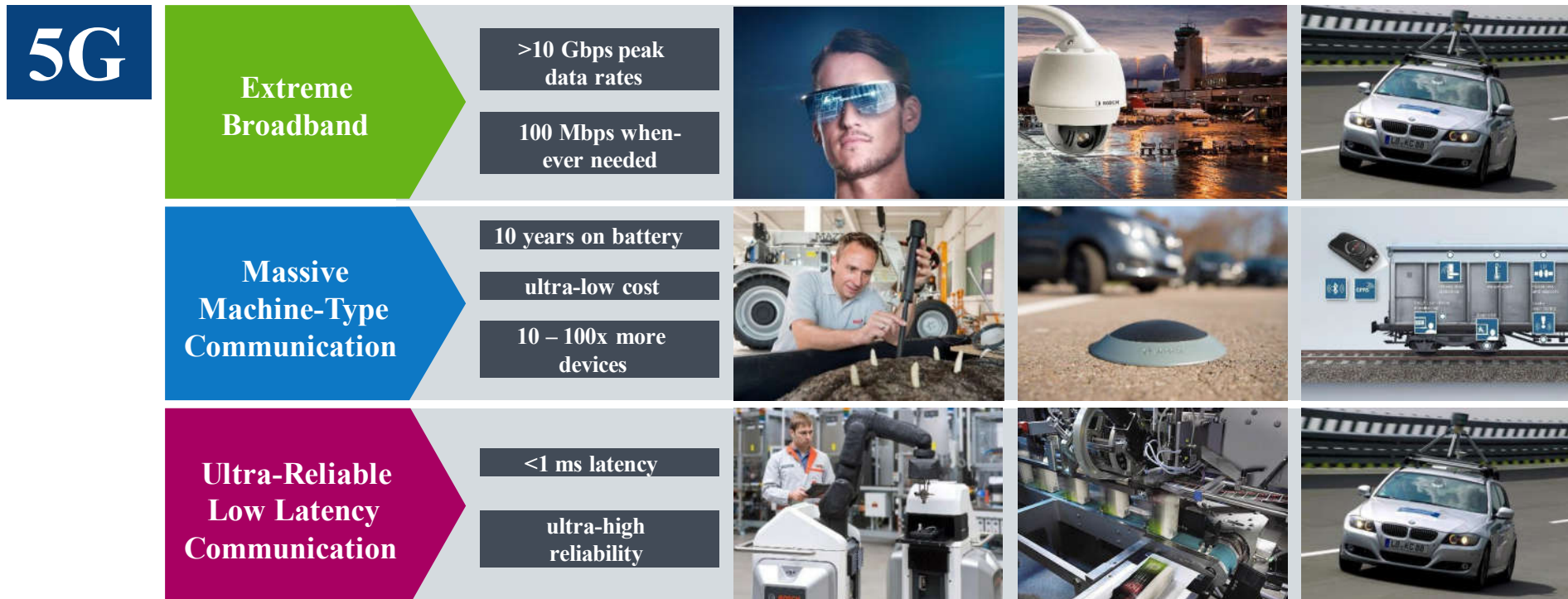


Image: BOSCH

# Vehicle view



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## Radar

Bad weather conditions  
Long range  
Low light situations



## Camera

Interprets objects/signs



## Lidar

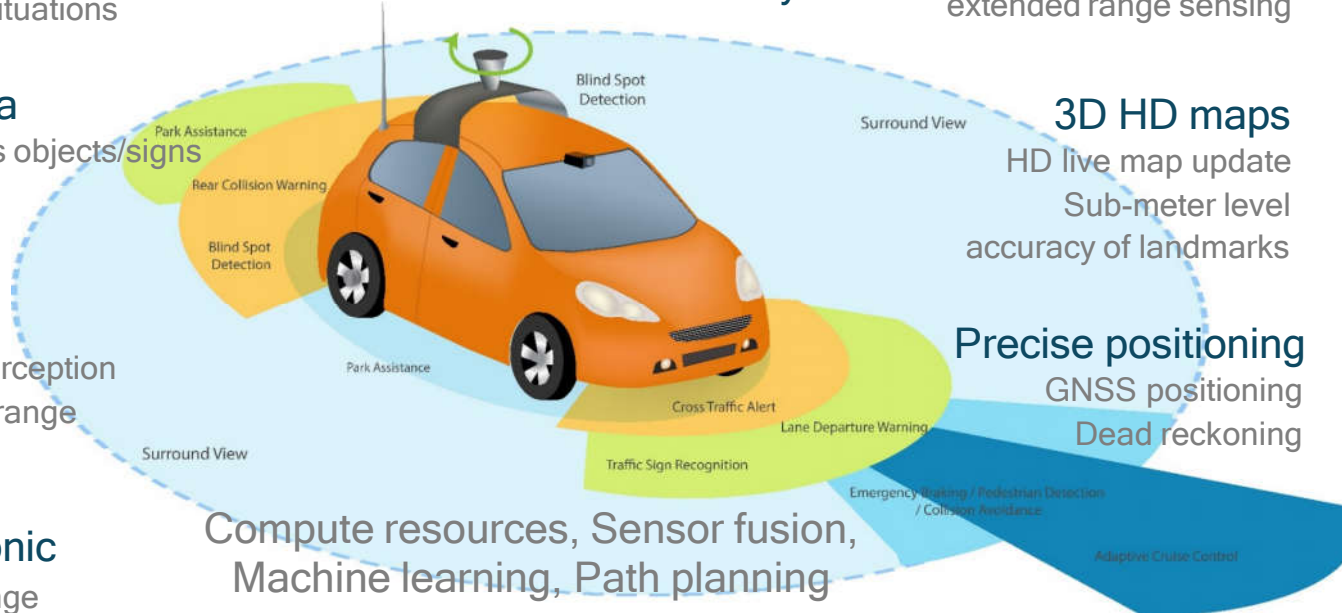
Depth perception  
Medium range



## Ultrasonic

Short range

## Advanced Driver Assistance Systems



## V2X wireless sensor

See-through, 360°  
non-line of sight sensing,  
extended range sensing

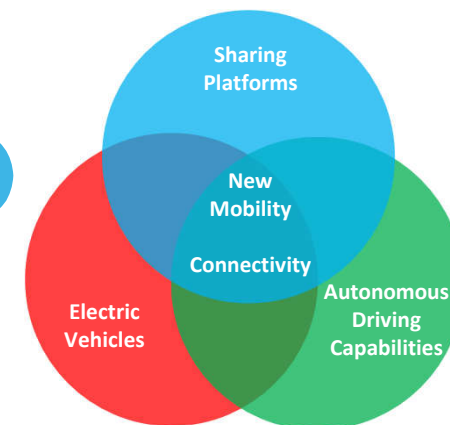


## 3D HD maps

HD live map update  
Sub-meter level  
accuracy of landmarks

## Precise positioning

GNSS positioning  
Dead reckoning

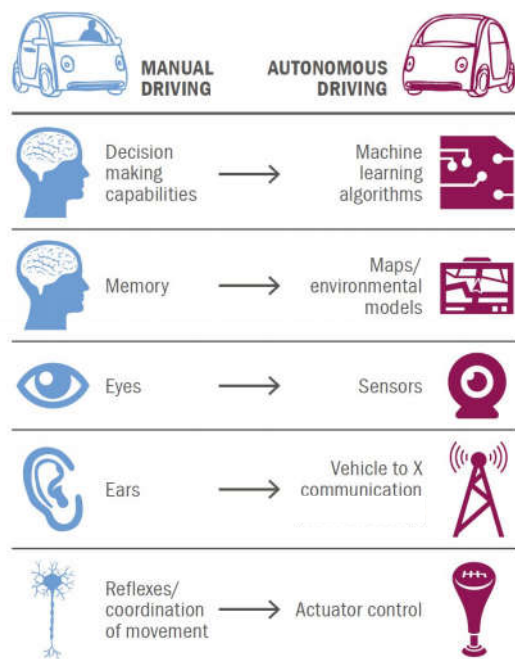


# CAV Vehicle Technology Roadmap



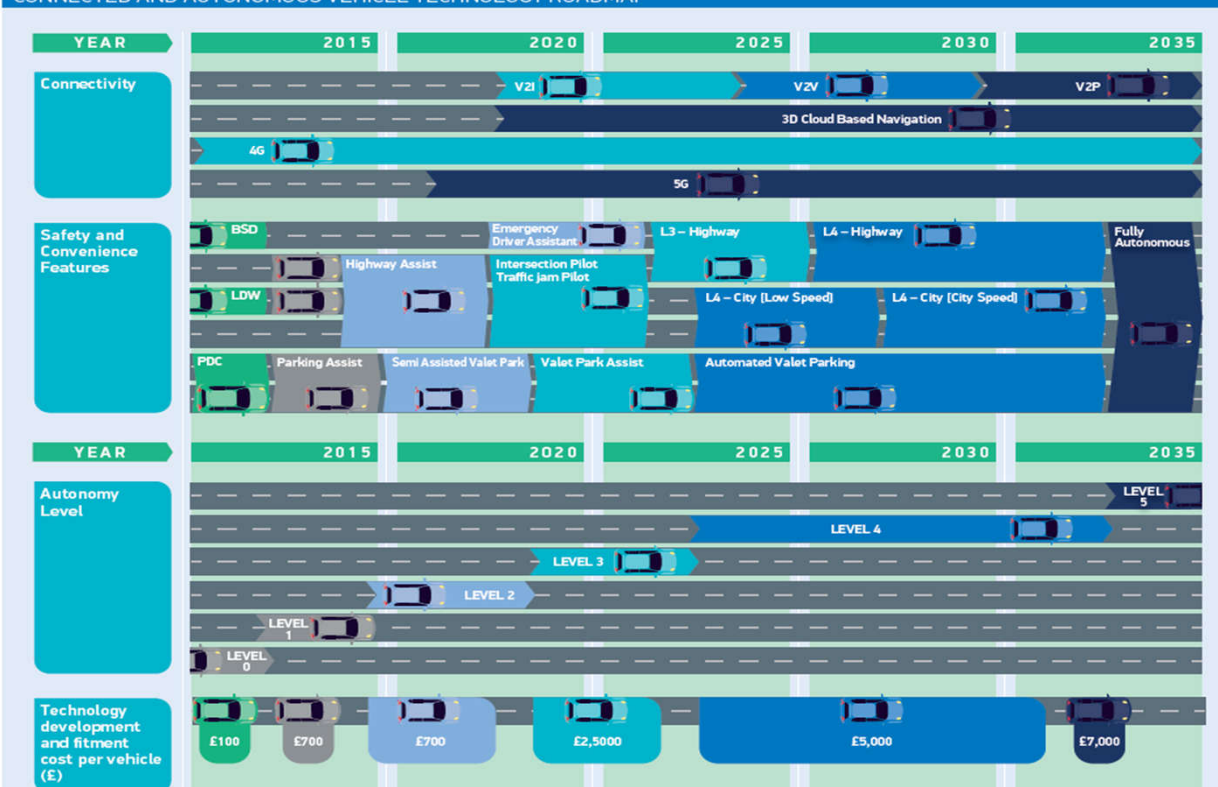
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REMOVING THE HUMAN FROM THE DRIVER'S SEAT  
Replacing sensory functions with technology



Source: Roland Berger

## CONNECTED AND AUTONOMOUS VEHICLE TECHNOLOGY ROADMAP



Source: SMMT/Frost and Sullivan



# Wireless technologies in V2X



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- Two Competing Wireless Standards:
  - **DSRC** (Dedicated Short Range Communications)
  - **C-V2X** (Cellular V2X)
- **DSRC:**
  - Defined by IEEE
  - Dedicated radio in the 5.9 GHz band
  - PHY layer uses 802.11p
- **C-V2X:**
  - Defined by 3GPP
  - Dedicated radio in the 5.9 GHz band
  - Additional radio in the licensed cellular band (LTE/5G NR)



# Overview of DSRC - ITS G5



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- DSRC was introduced over 10 years ago to add intelligence to transportation systems
- Uses 802.11p wireless technology in the 5.9 GHz band
- Key features enabled by DSRC:
  - Speed detection, collision avoidance, real-time road condition, toll payments, autonomous driving vehicle collaboration
- Mature technology with proven road-tested experience
- Limited market adoption:
  - Not governmentally mandated to be installed in new cars
  - Other technologies have solved some of the use-cases: RADAR, LiDAR, ultrasonic sensors, electronic toll systems
  - Latency of DSRC limits maximum speed for effectiveness

# Overview of C-V2X



## Perception

Sharing of high throughput sensor data and real world model



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- C-V2X defined as part of the 3GPP initiative
  - C refers to cellular technologies (4G LTE/5G NR)
- Builds on the capabilities of DSRC, and also adds a wide-area connection to the cellular network (key for autonomous driving)
- Requires (at least) two radios to operate:
  - Cellular radio (sub 6GHz or mmwave): LTE/NR
  - Dedicated radio (5.9 GHz): improves on 802.11p
- Lower latency = operates at higher vehicular speeds
- Adoption timing unclear:
  - New technology: automotive market adoption is delayed
  - Not governmentally mandated to be installed in new cars



## Path planning

Intention and trajectory sharing for faster, yet safe maneuvers



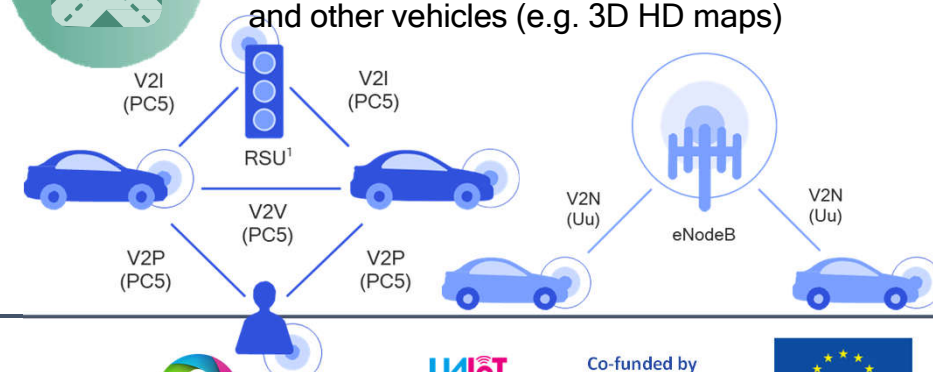
## Coordinated driving

Exchanging intention and sensor data for more predictable, coordinated autonomous driving



## Real-time local updates

Real-time sharing of local data with infrastructure and other vehicles (e.g. 3D HD maps)



# Evolving C-V2X towards 5G for AD



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## D2D communications

R12/13



## Enhanced safety

C-V2X R14 (Ph. I) C-V2X R15 (Ph. II)



## Autonomous driving

C-V2X R16 5G NR support (Ph. III)  
(Advanced safety applications)



Established foundation  
for basic D2D comm.

Enhanced communication's range  
and reliability for V2X safety

Ultra-reliable, low latency, high throughput  
communication for autonomous driving

Network independent	No	Yes	Yes
Communications <sup>1</sup>	Broadcast only	Broadcast only	Broadcast + Unicast/Multicast
High speed support	No	Yes	Yes
High density support	No	Yes	Yes
Throughput		High throughput for enhanced safety	Ultra-high throughput
Latency		Low latency for enhanced safety applications	Ultra-low latency
Reliability		Reliability for enhanced safety application	Ultra-high reliability
Positioning	No	Share positioning information	Wideband ranging and positioning

1. PHY/MAC communications; R16 is still under development

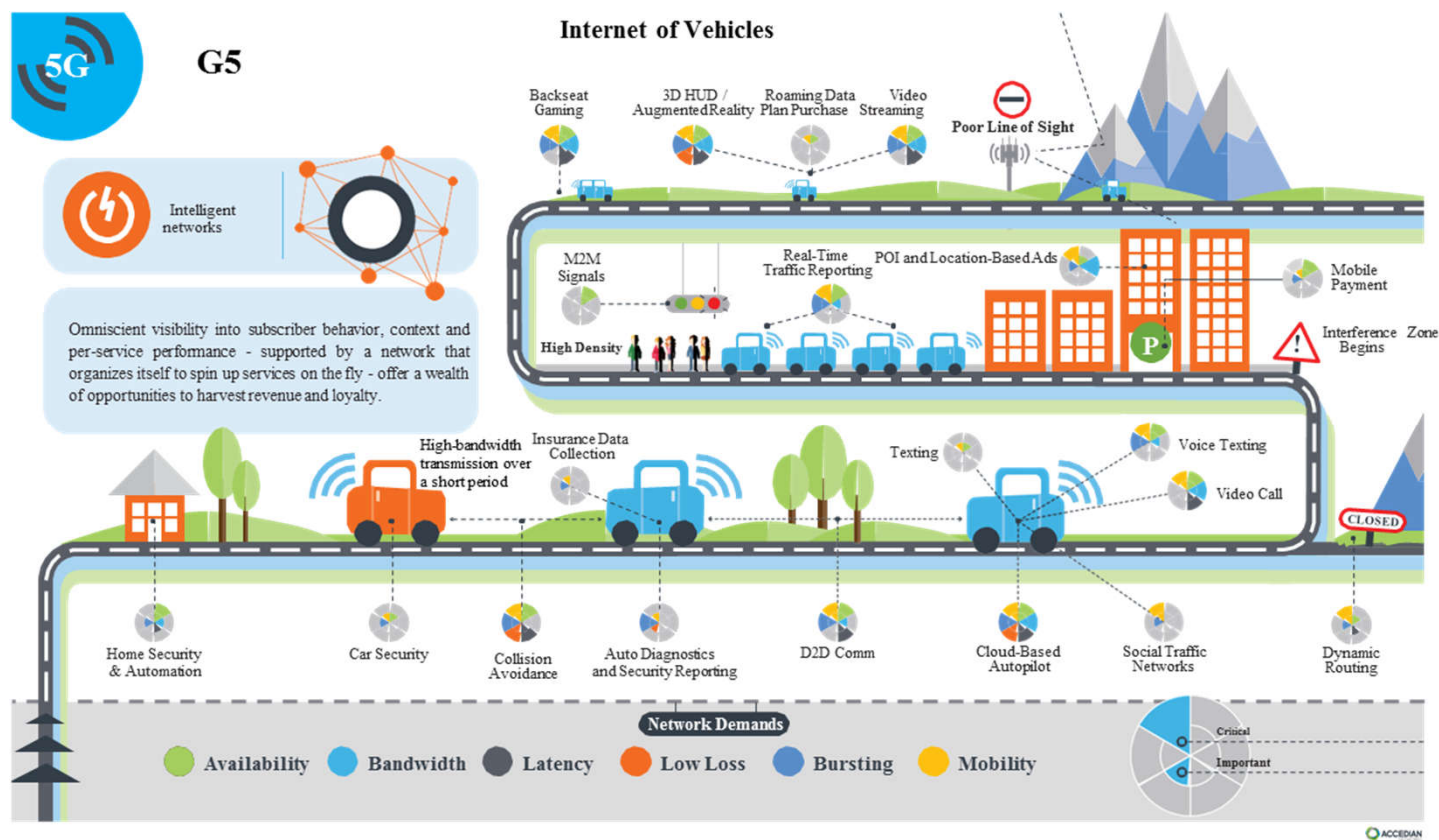
Source: Qualcomm



# Communication infrastructure



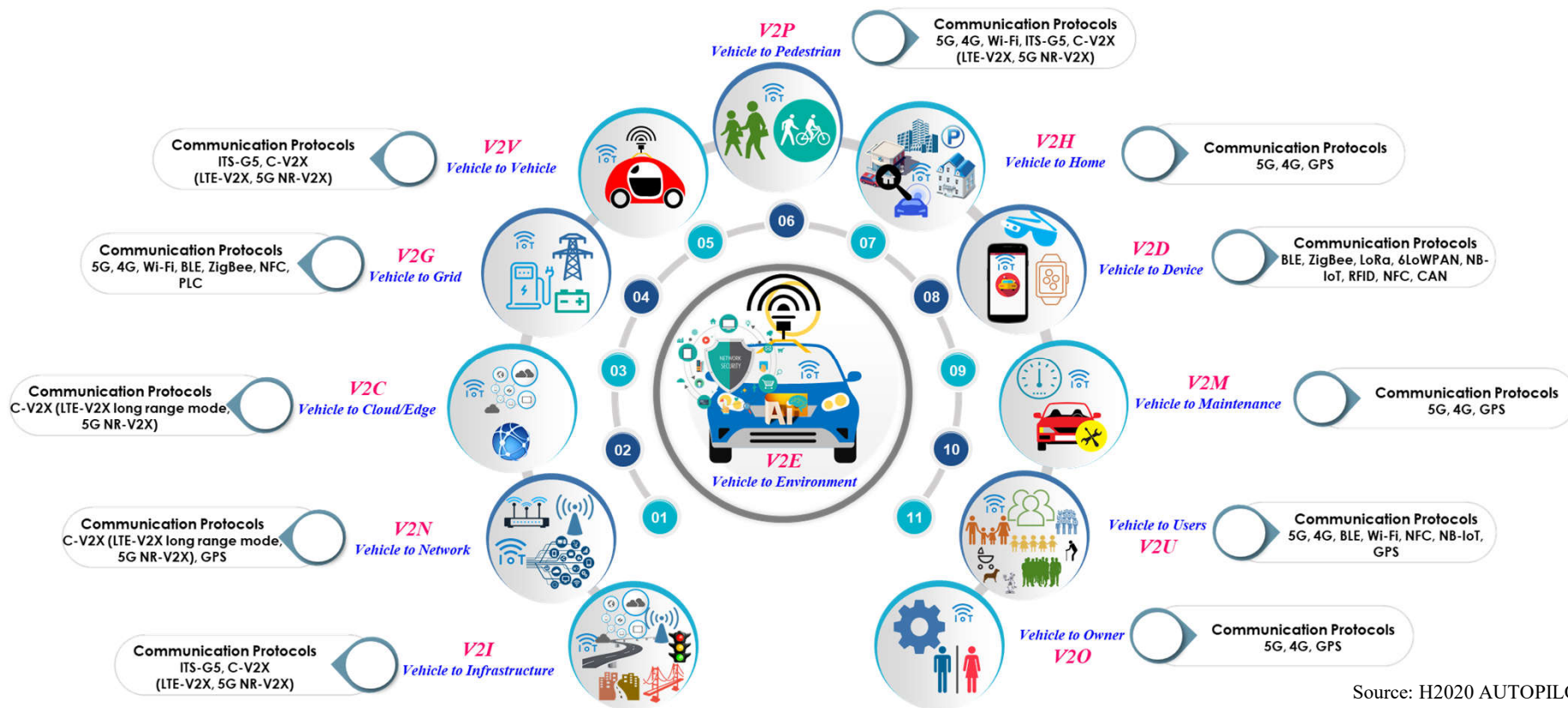
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# Vehicle to Environment Communication



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Source: H2020 AUTOPILOT



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Edge Computing

IoT

AI



Platform Integration

V2X

Sensing/Actuating

Connectivity



Map



Auto  
Drive

Enjoy life

ACTIVAGE  
PROJECT

AUTOPILOT



MONICA

SYNCHRONICITY



EATE-IoT



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