ERAdiate lecture series

Connected and Autonomous Driving

Environment perception for Autonomous Driving

Zilina

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8 October 2018

AUTOPILOT

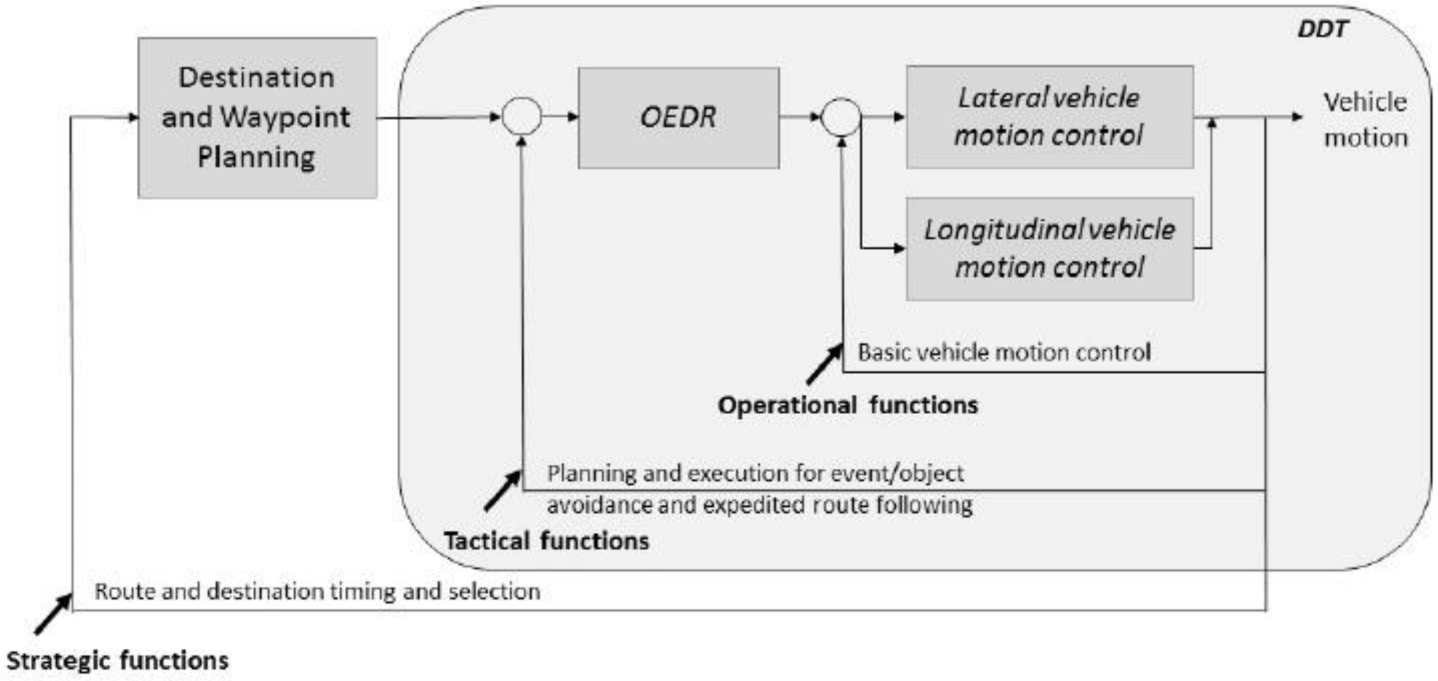
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731993

Autonomous Driving concept


>2025
FULLY AUTOMATED
› Monitoring of the system not required
› Driver does not need to be able to take over the driving task
2020
HIGHLY AUTOMATED
› Monitoring of the system not required
› Driver needs to be able to take over the driving task with lead time
2016
PARTIALLY AUTOMATED
› Monitoring of the system required
› Driver needs to be able to take over the driving task at any moment

SAE – J3016

Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles



OEDR: Object and Event Detection and Response

SAE – J3016

Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles

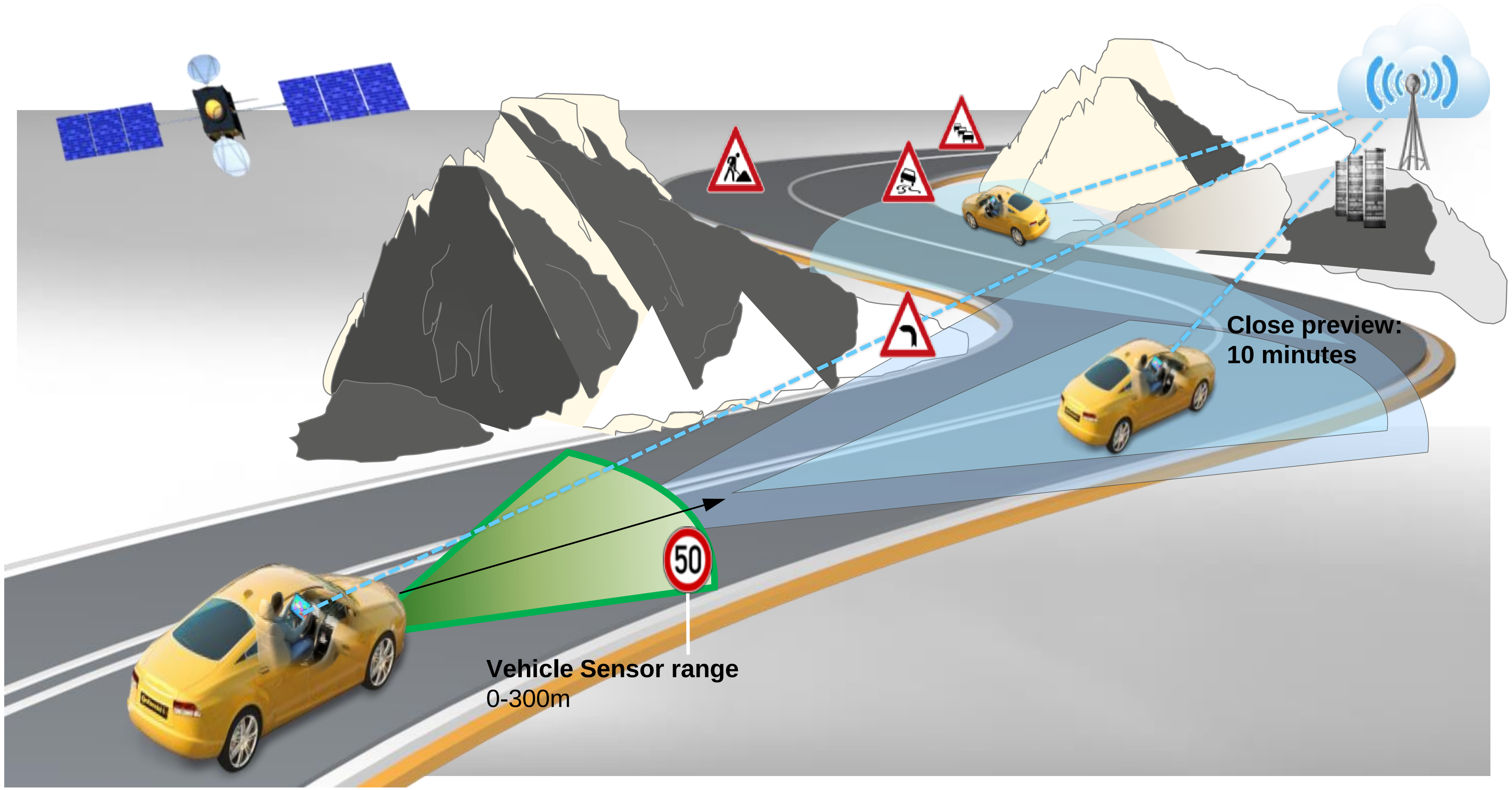
Level	Name	Narrative definition	DDT		DDT fallback	ODD
			Sustained lateral and longitudinal vehicle motion control	OEDR		
Driver performs part or all of the *DDT*						
0	No Driving Automation	The performance by the *driver* of the entire *DDT*, even when enhanced by *active safety systems*.	*Driver*	*Driver*	*Driver*	n/a
1	Driver Assistance	The *sustained* and *ODD*-specific execution by a *driving automation system* of either the *lateral* or the *longitudinal vehicle motion control* subtask of the DDT (but not both simultaneously) with the expectation that the *driver* performs the remainder of the *DDT*.	*Driver* and *System*	*Driver*	*Driver*	Limited
2	Partial Driving Automation	The *sustained* and *ODD*-specific execution by a *driving automation system* of both the *lateral* and *longitudinal vehicle motion control* subtasks of the *DDT* with the expectation that the *driver* completes the *OEDR* subtask and *supervises* the *driving automation system*.	*System*	*Driver*	*Driver*	Limited
ADS ("*System*") performs the entire *DDT* (while engaged)						
3	Conditional Driving Automation	The *sustained* and *ODD*-specific performance by an *ADS* of the entire DDT with the expectation that the *DDT fallback-ready user* is *receptive* to *ADS*-issued *requests to intervene*, as well as to *DDT performance-relevant system failures* in other *vehicle* systems, and will respond appropriately.	*System*	*System*	*Fallback-ready user* (*becomes the driver during fallback*)	Limited
4	High Driving Automation	The *sustained* and *ODD*-specific performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	*System*	*System*	*System*	Limited
5	Full Driving Automation	The *sustained* and unconditional (i.e., not *ODD*-specific) performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	*System*	*System*	*System*	Unlimited

Environment perception

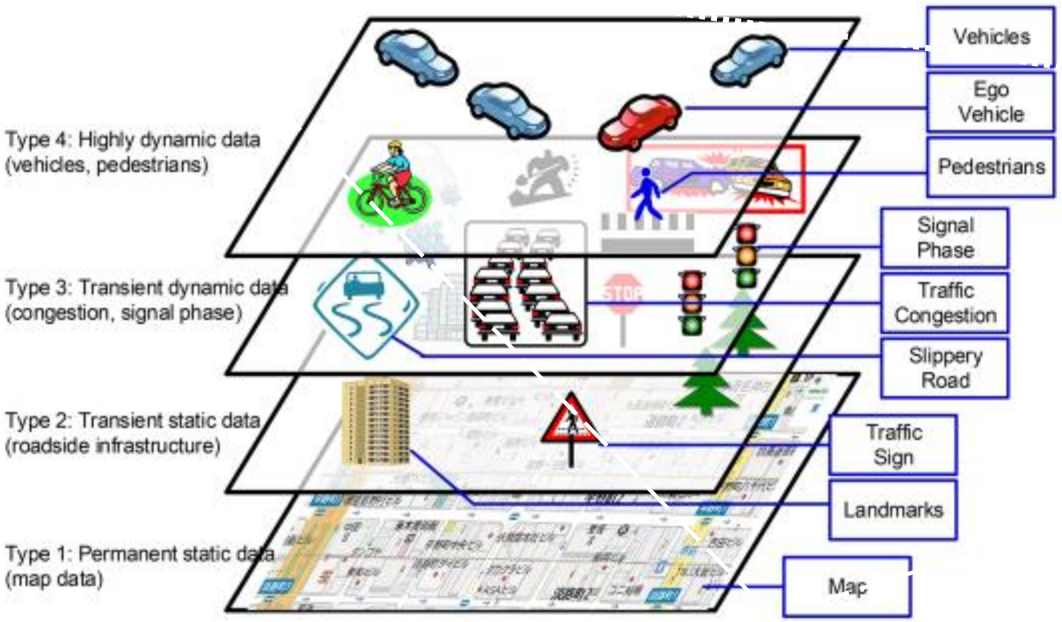
Driver and ADS need environment perception

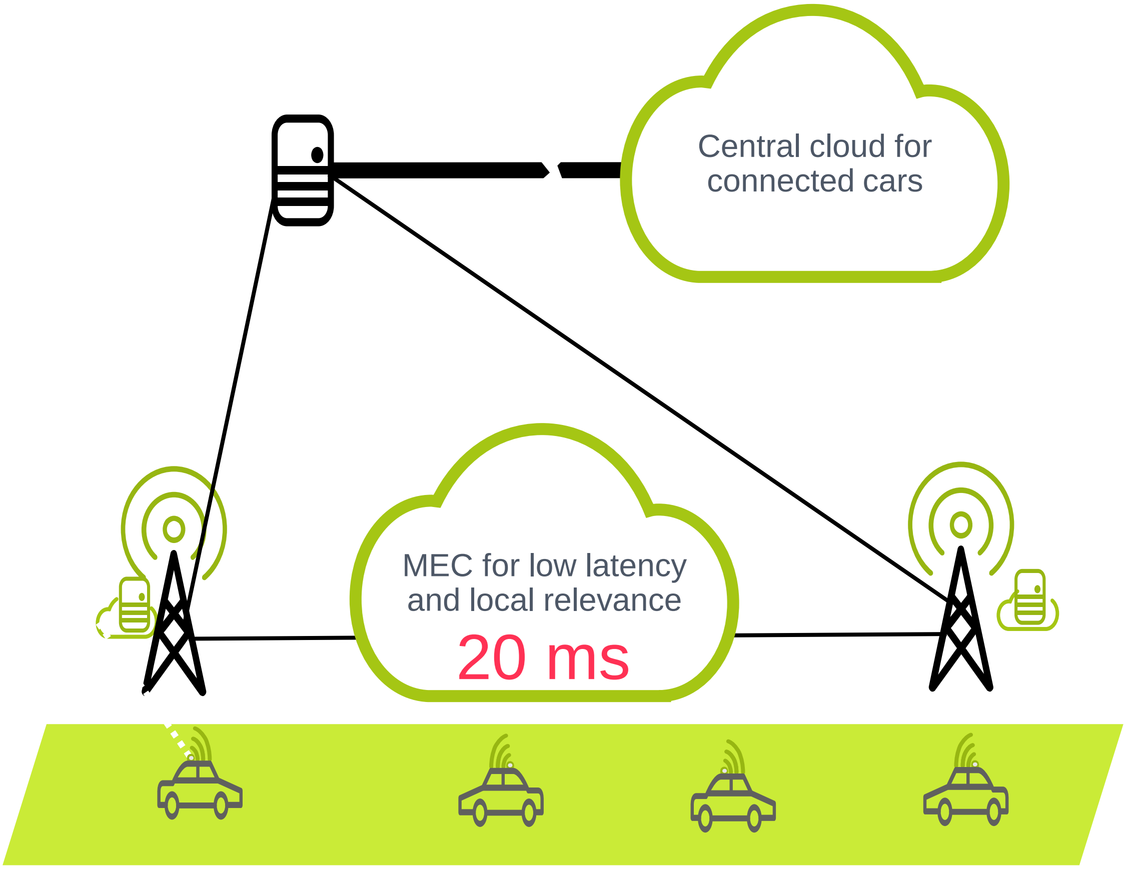
Vehicle sensor limitations

Object and event detection



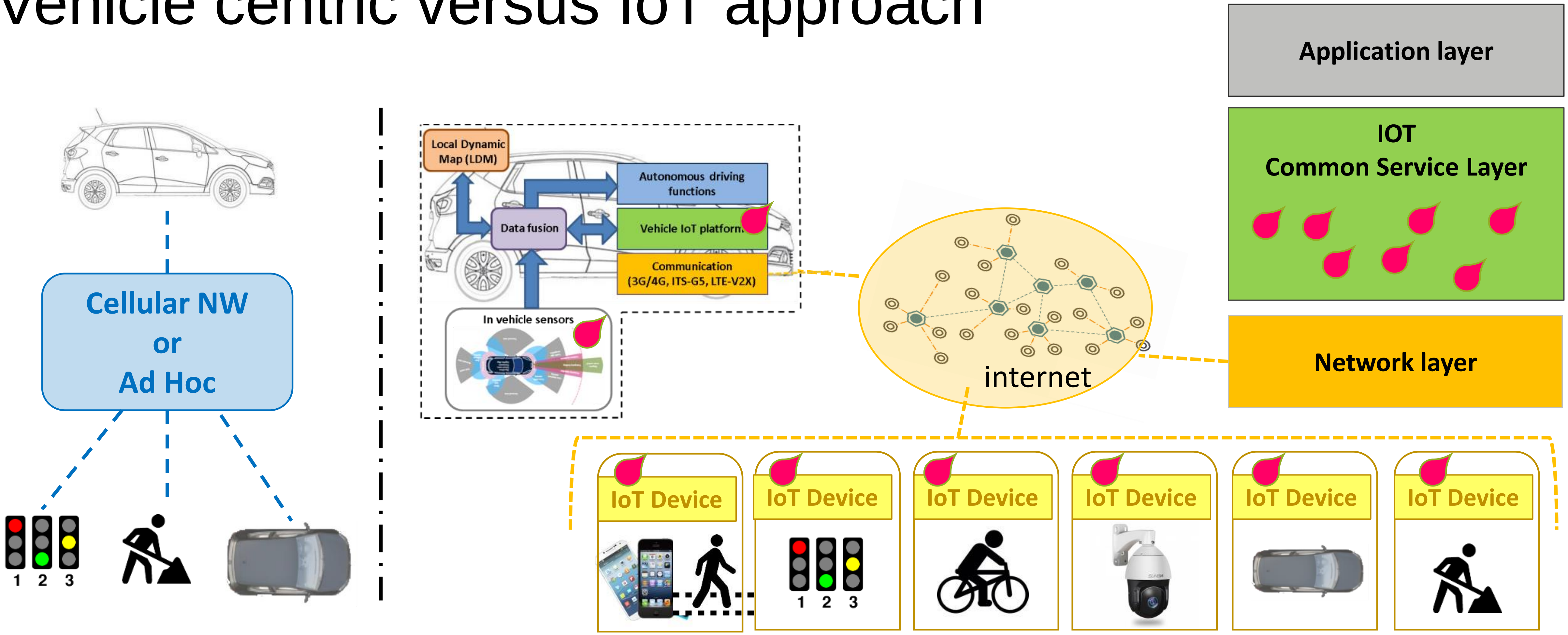
Local Dynamic Map – provided by connectivity



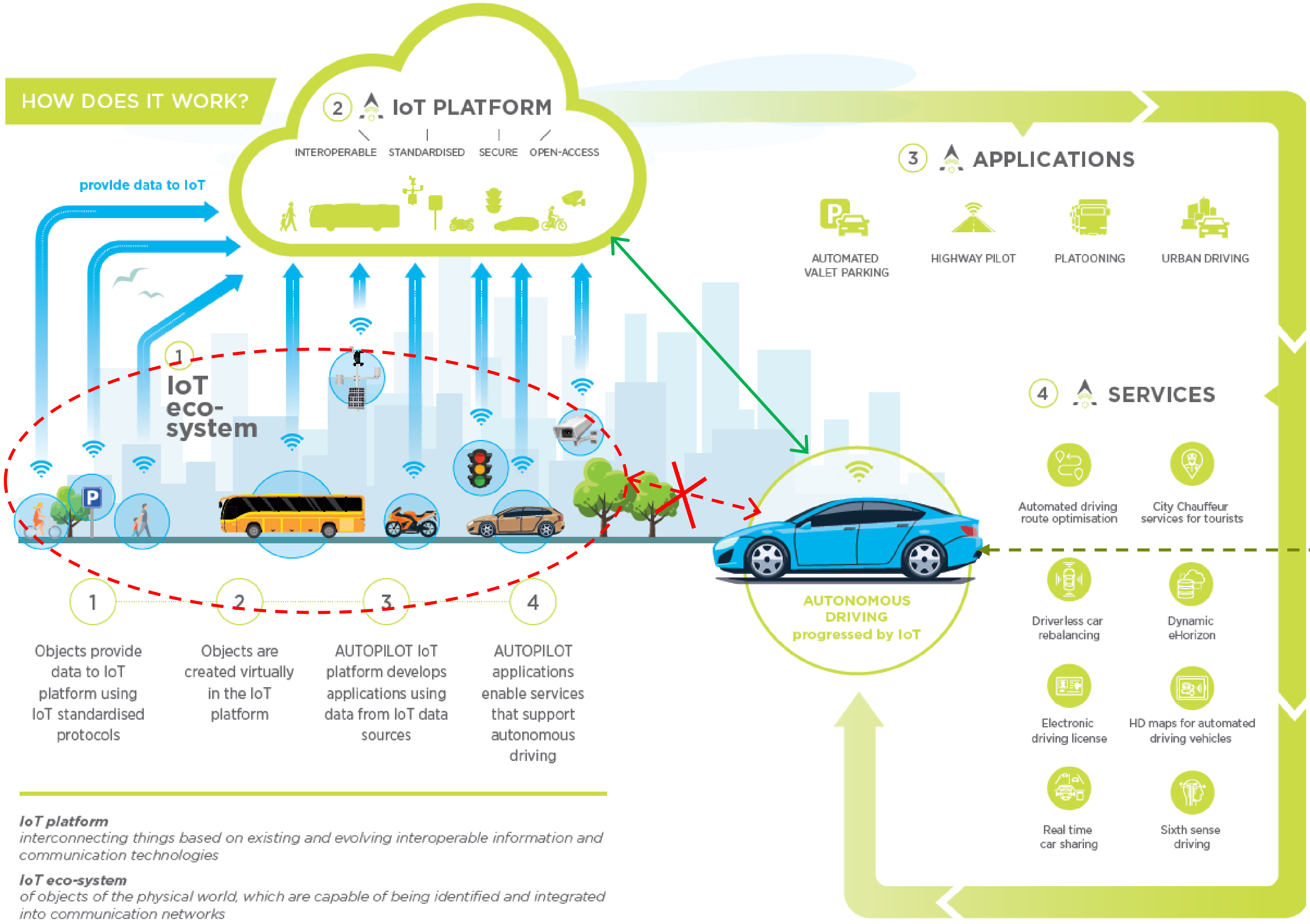


How to use the connectivity

Vehicle centric versus IoT approach



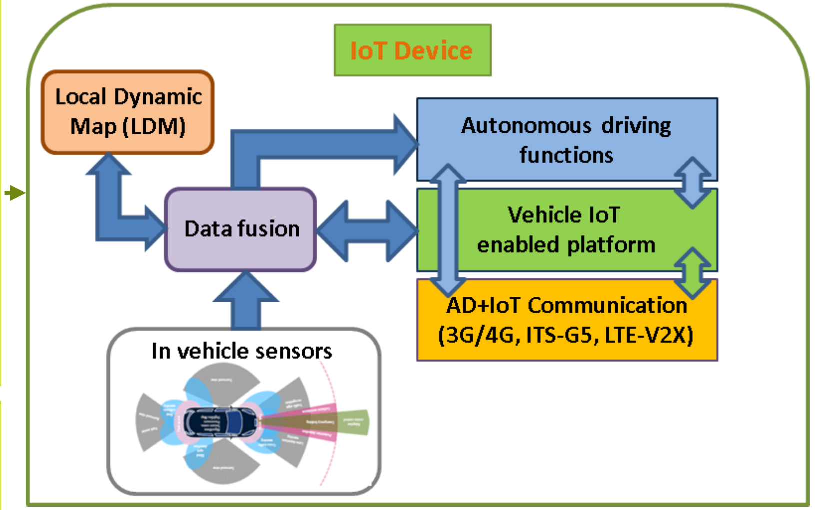
IOT to transform automated driving



IoT platform
interconnecting things based on existing and evolving interoperable information and communication technologies

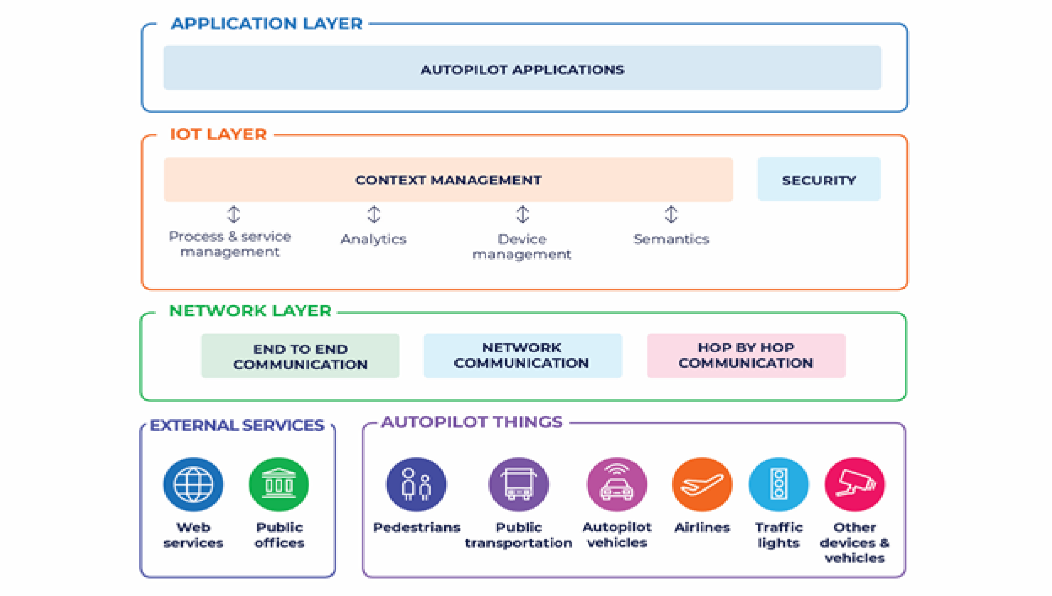
IoT eco-system
of objects of the physical world, which are capable of being identified and integrated into communication networks

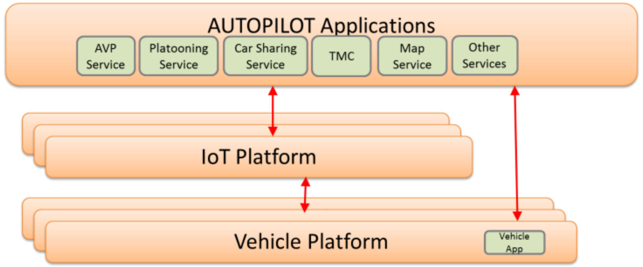
Vehicle IoT integration

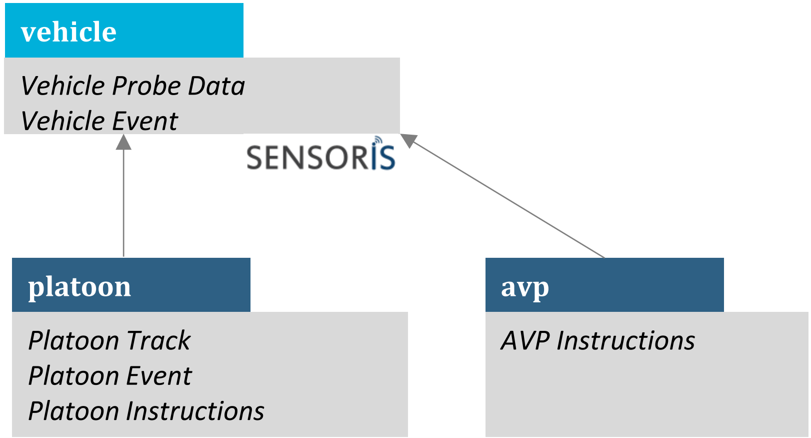


Implementation

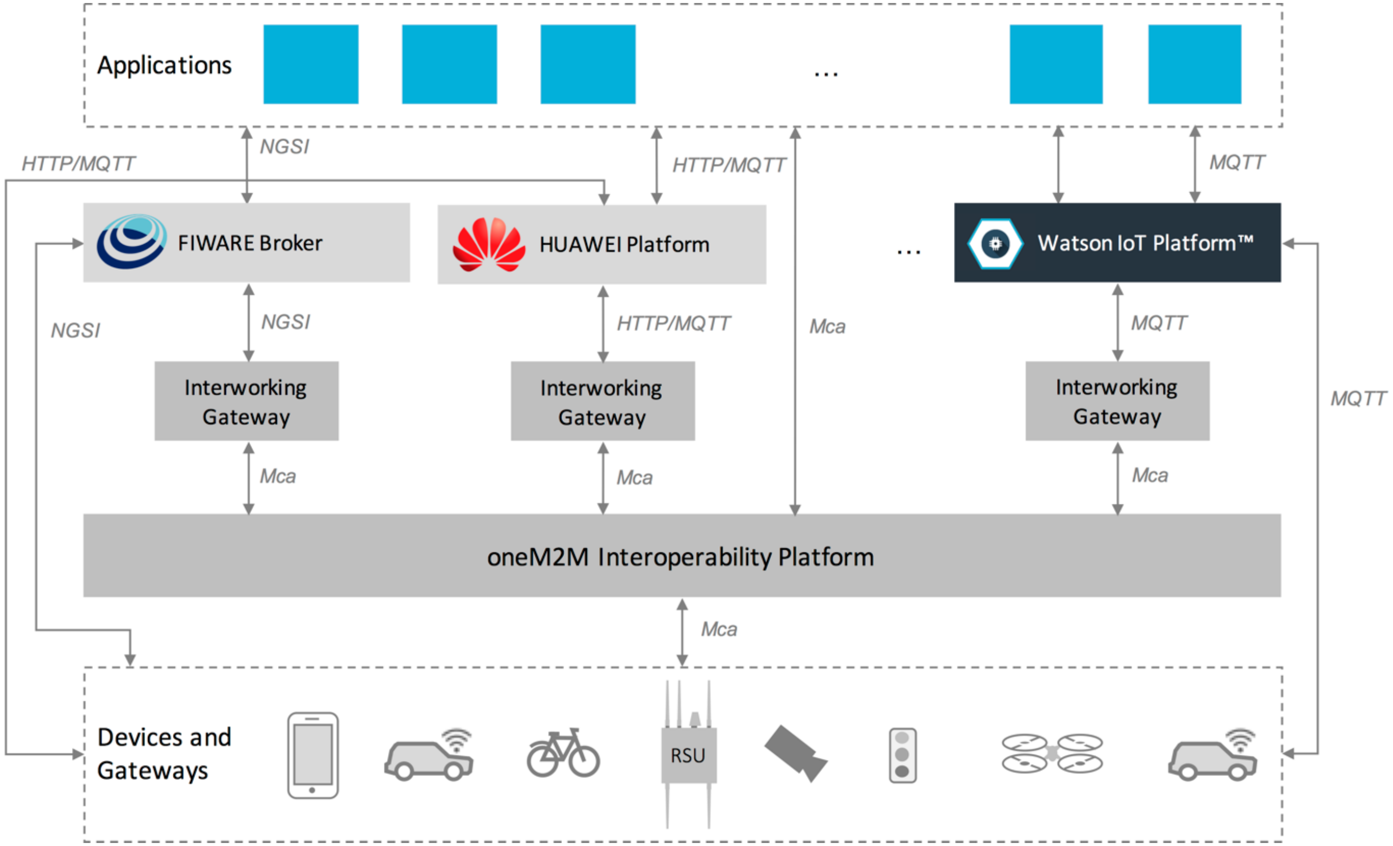
IoT Platforms and Data Models





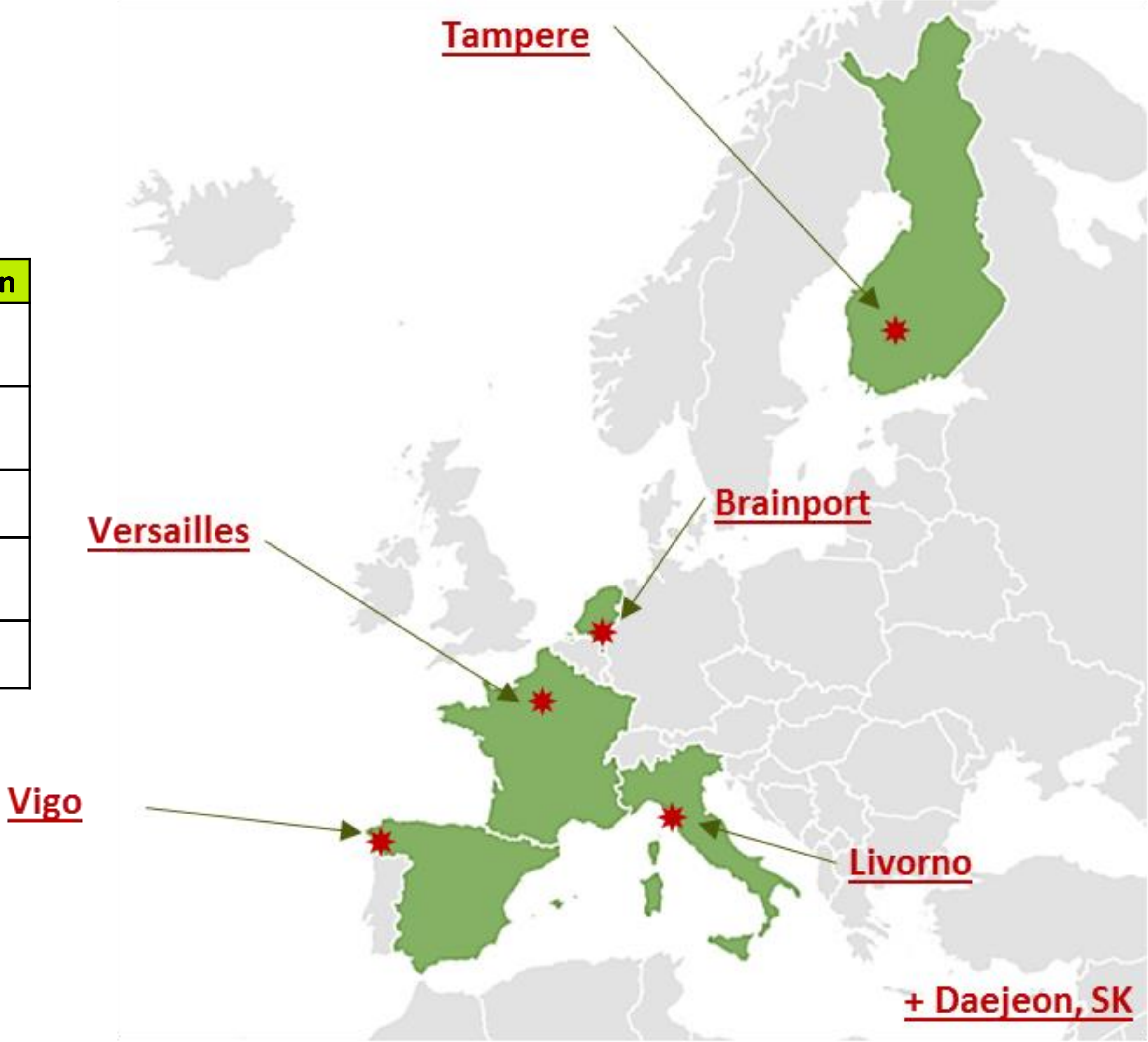


AUTOPILOT IoT – federated platform



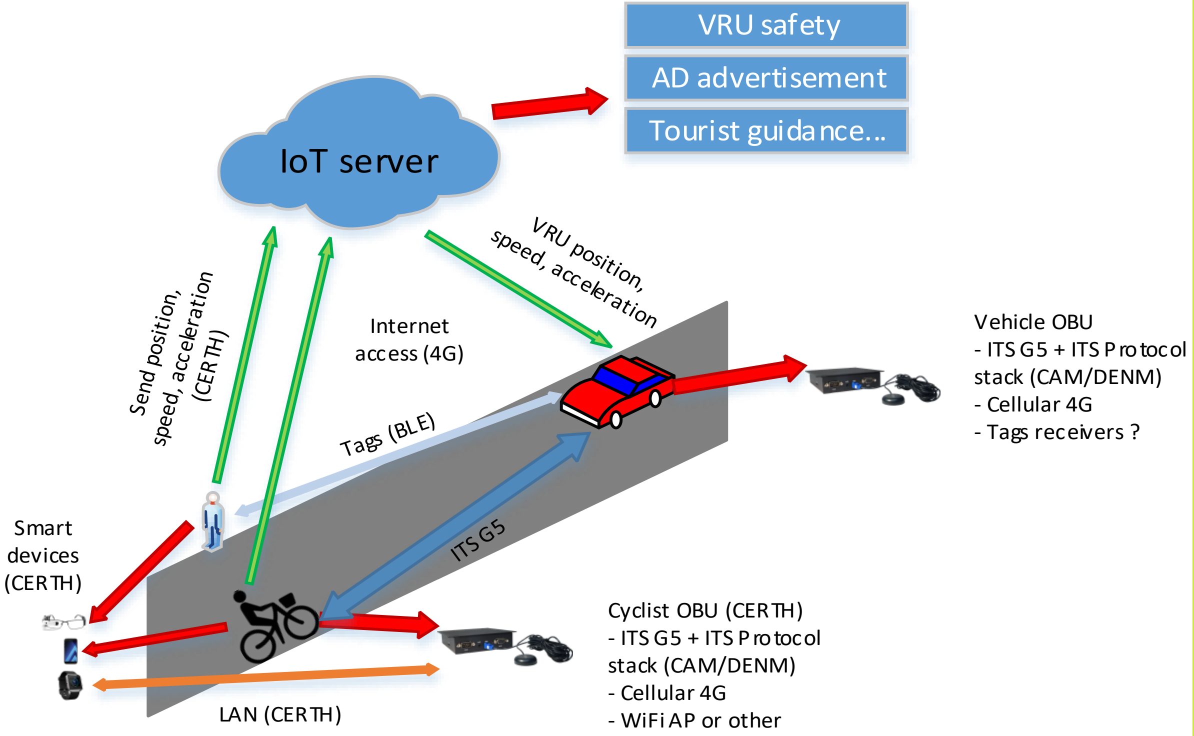
Pilot sites

Use cases	Tampere	Versailles	Livorno	Brainport	Vigo	Daejeon
Automated valet parking	X			X	X	
Highway Pilot			X	X		
Platooning		X		X		
Urban Driving	X	X	X	X	X	X
Car Sharing		X		X		



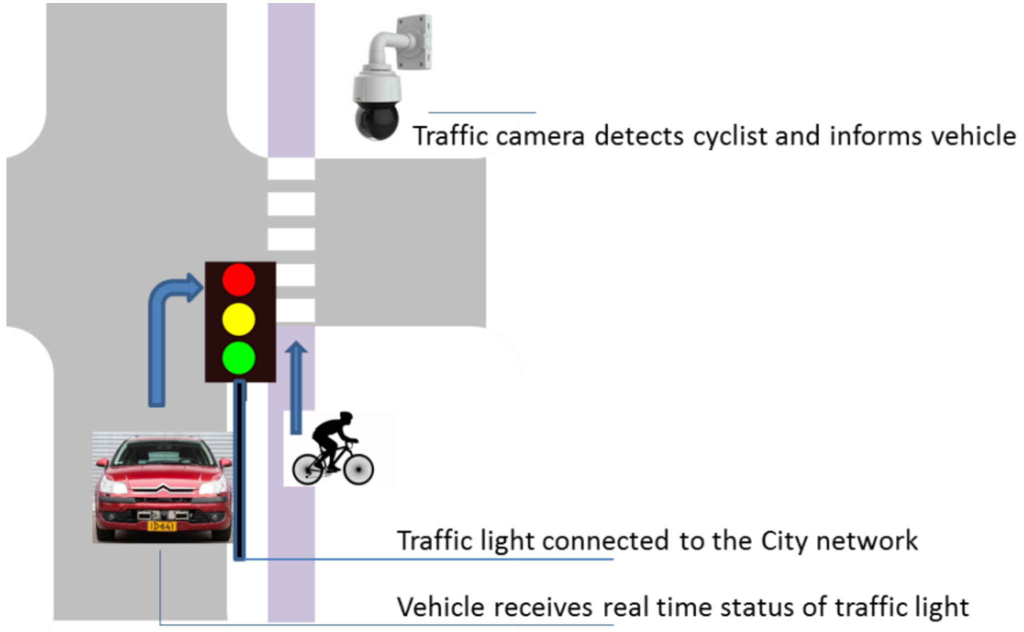
Versailles, France – VRU detection

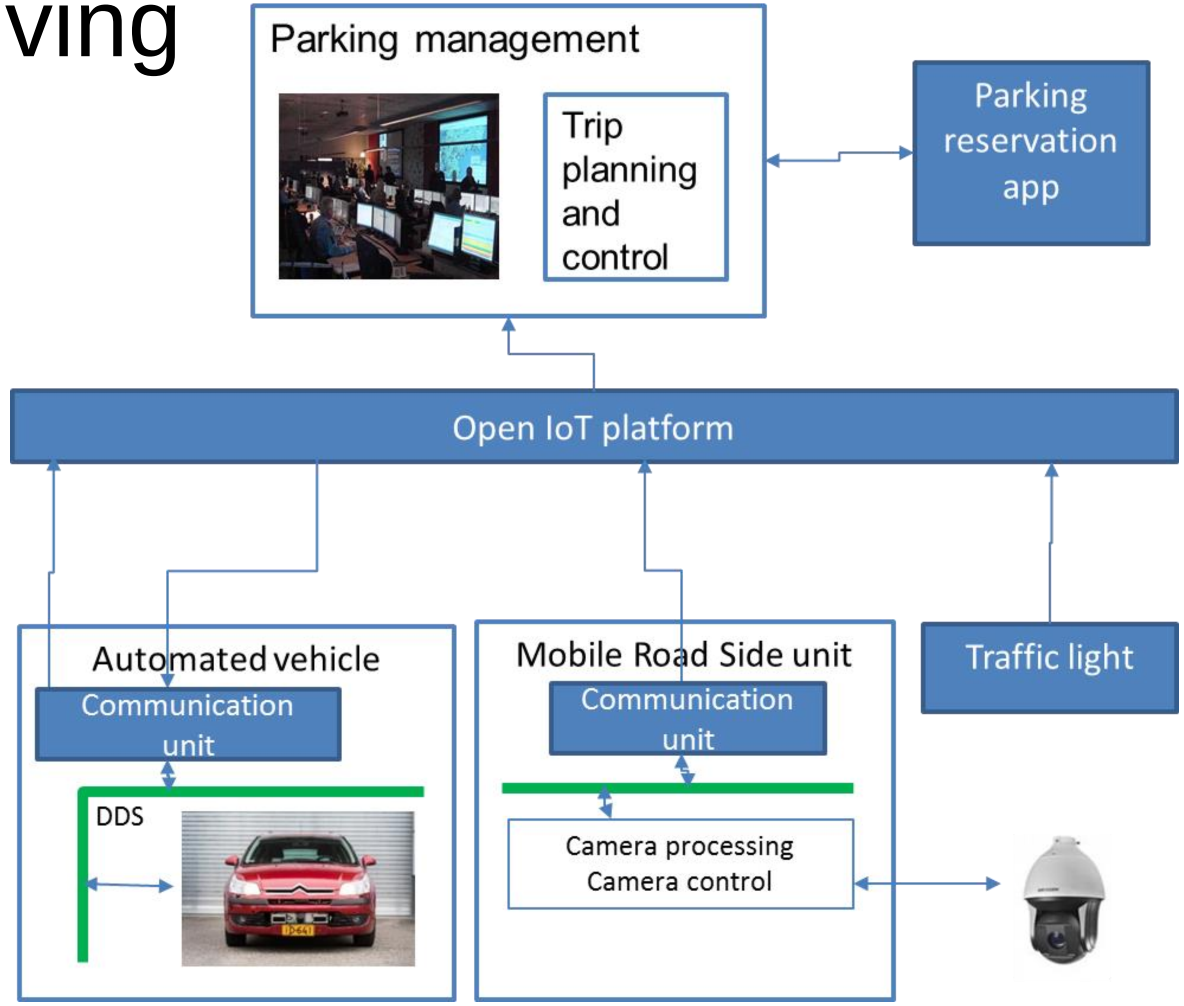
- **Vulnerable Road User detection :** pedestrians and cyclists are equipped with smart phones/-watches/-glasses as well as OBU integrated to the bicycles
  - VRU info are gathered in the IoT platform and used by the vehicle
  - IoT information is used for enhance in-vehicle sensors and improve safety
  - IoT provides information to VRU's about upcoming vehicles



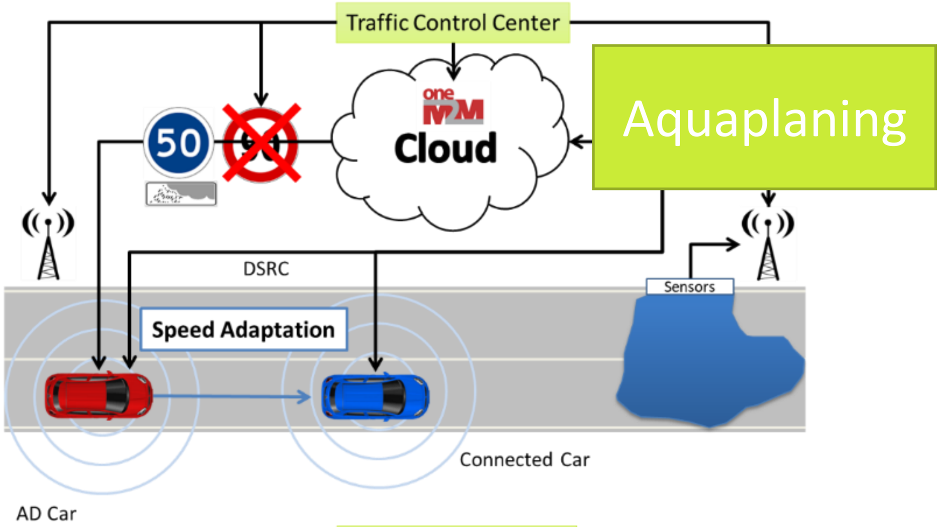
Tampere, Finland – urban driving

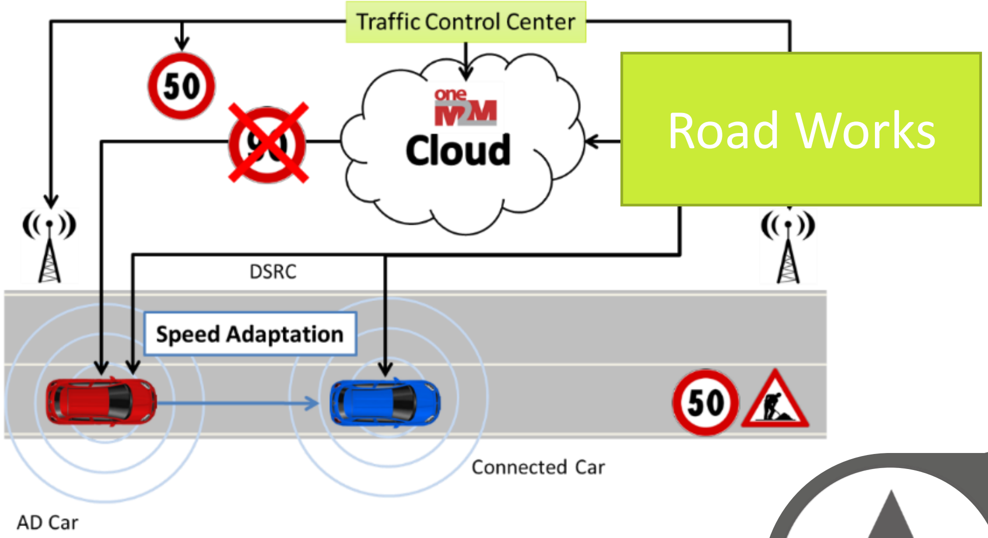
- IoT utilization:
  - AD support using traffic cameras
    - Object detection at mobile road side unit and transmission to IoT platform





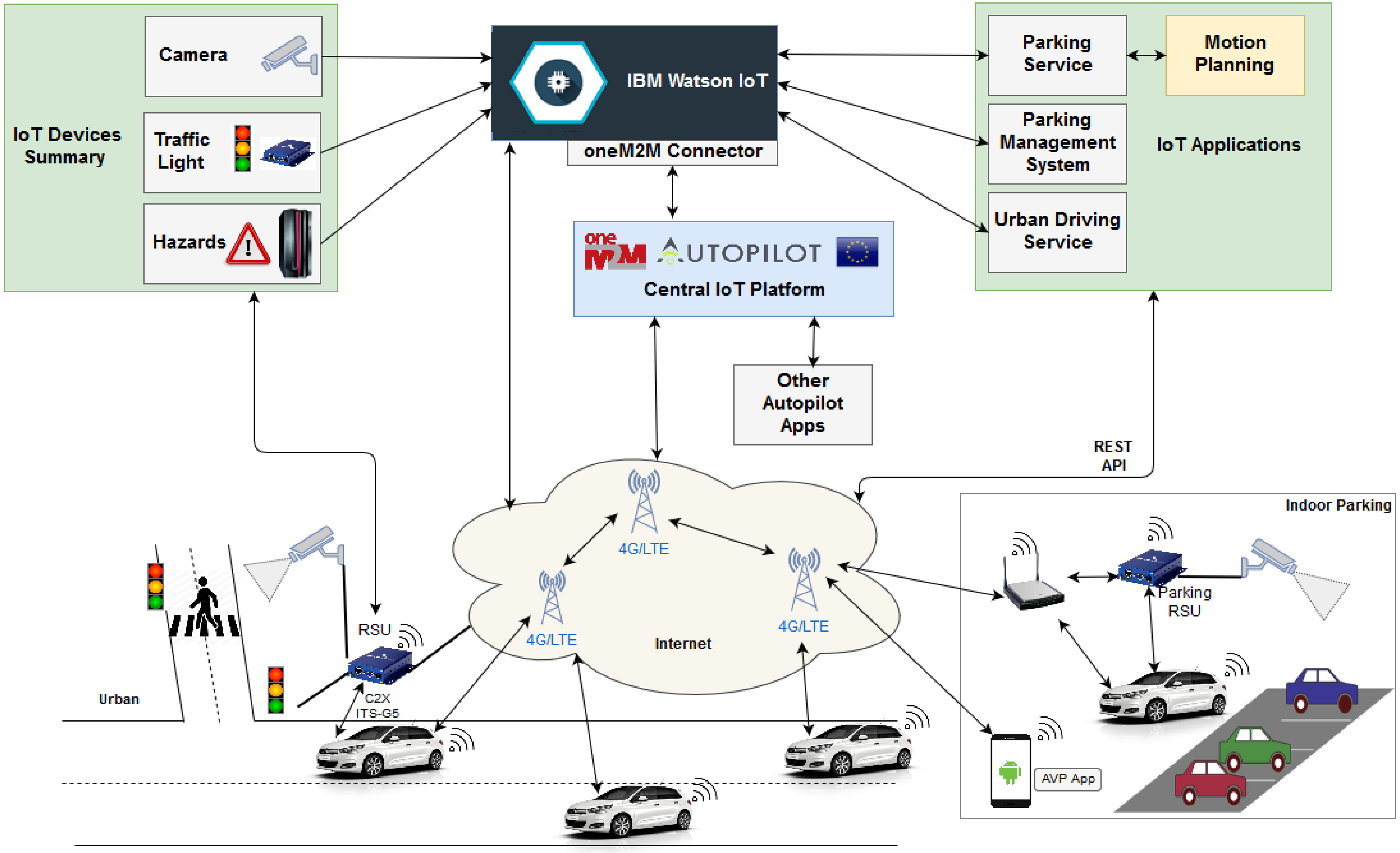
Livorno, Italy - highway





- **Scenario:**
  - Livorno- Florence public highway
- **Target:**
  - Avoiding accidents in dense traffic environment featuring 40,000 vehicles / day (heavy trucks 20%)
- **Tackling with:**
  - common events:
    - road works (poorly flagged in case of urgent works)
  - specific events:
    - rain water standings (Tuscany is rainy in autumn/spring)

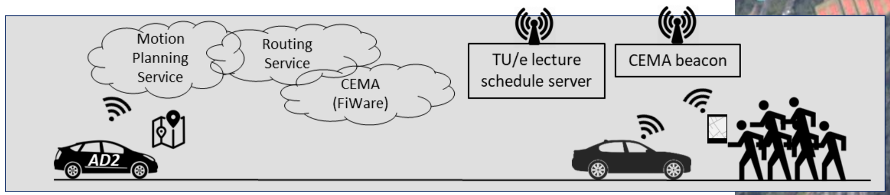
Vigo, Spain – urban driving and AVP

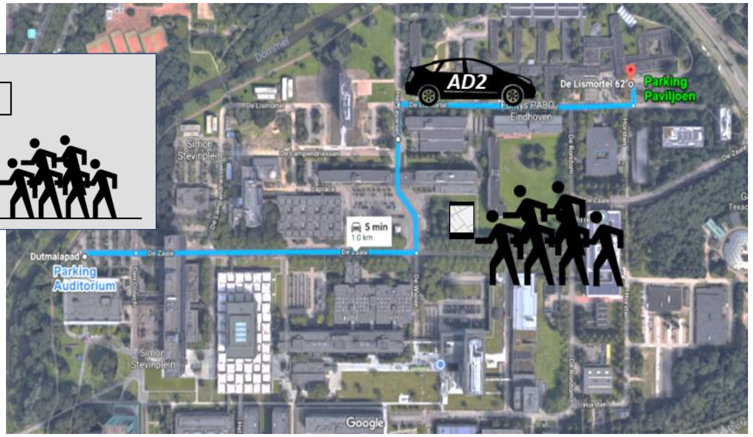


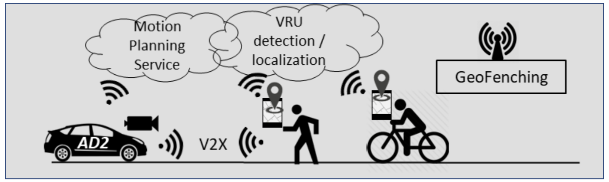
- Information provided by IoT: traffic light status, hazard warning (I2V), pedestrian detection by infrastructure/vehicle. IoT platform inside the vehicle.
- IoT integration will set the basis for enabling the access to a wider volume of data to the Mobility Management centre. IBM and Sensinov/TNO External IoT platform for Urban Driving

Eindhoven – car relocation

- Driverless car distribution over Eindhoven University campus
- Exploiting crowd estimation, lecture schedule information and VRU detection using IoT
- Testing of AUTOPILOT Smart Phone app that could potentially be offered to the campus community
- **IoT** can predict logistics and congestion based on data of crowd estimation & historical data of campus residents
- **IoT** provides VRU data to driverless car to change driving behavior in more crowded areas & inform VRU of driverless vehicle status



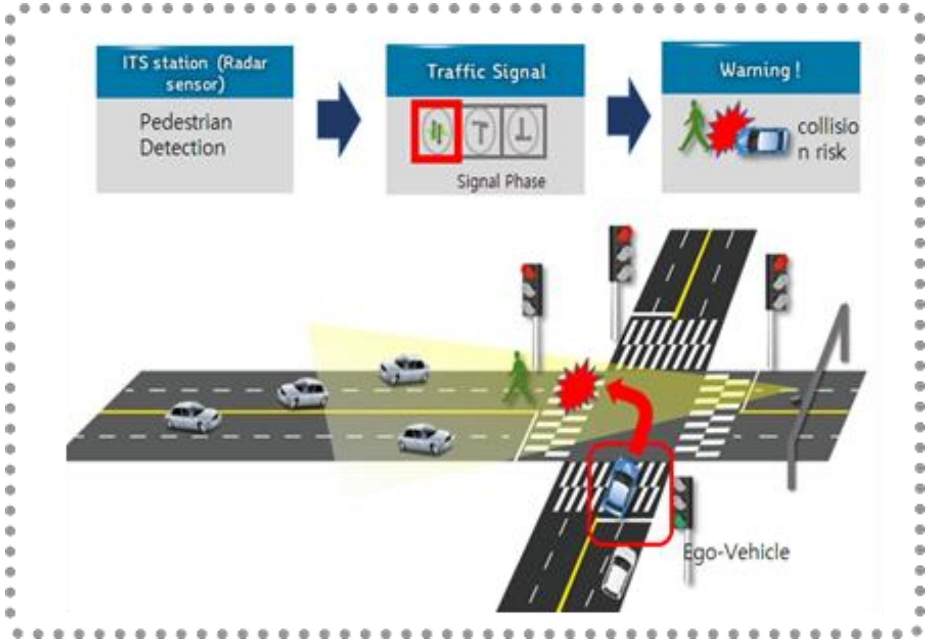




Daejeon – Intersection Safety System

- **URBAN DRIVING** with **Intersection safety system (ISS)** based on IoT (combining traffic signals & road infrastructure sensors)
- I2V wireless networking will provide the Local Dynamic Map to improve vehicle safety
- 3 connected vehicles used
- 2 use cases at intersection
  - Pedestrian warning at crosswalk
  - Signal violation warning
- Partners involved:

ETRI METABUILD CO., LTD.



Project information

European IoT Platforms Initiative

European IoT Large-Scale Pilots Programme

AIOTI Alliance for Internet of Things Innovation

5 Large Scale Pilots on IoT are funded by the European Commission

- AUTOPILOT is the Pilot about Connected and Automated Driving
- 3 Years Innovation Action: 01/01/2017 – 31/12/2019
- 44 beneficiaries – coordinator: Francois Fischer, ERTICO
- Project costs: 25 m€ - EU contribution: 20 m€
- European Commission: DG CONNECT unit E.4 – IoT / H.2 Smart Mobility & living / A.1 Robotics & Artificial Intelligence

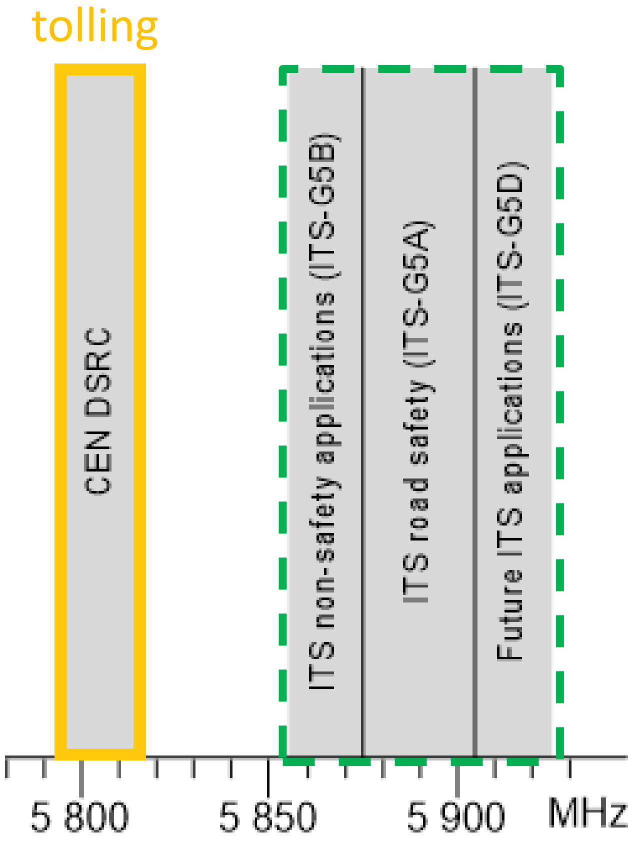
The 5 Large scale pilots are cross coordinated and supported by 2 CSA:

- CREATE-IoT (create-iot.eu) CREATE-IoT
- U4IoT (www.u4iot.eu) U4IoT

Next steps – 5G

V2X: ITS-G5

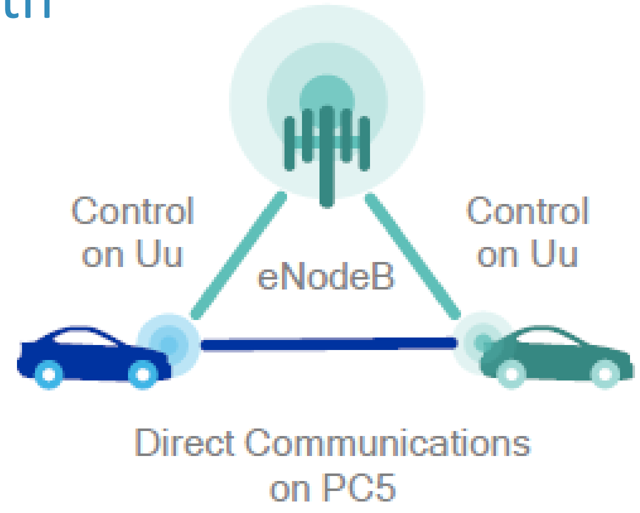
- Standard = IEEE.802.11p based on WIFI 802.11a y
- ITS Regulated Band of 5.855-5.925 (70 Mhz) - unlicensed
- Unmanaged = ad-hoc NW, e.g. no access point
- Easy to deploy, no licence but limited performances:
  - 1 Mbps - Low efficiency – LoS (Light Of Sight) only
  - Low coding scheme efficiency no Automatic Repeat Request
  - Low device density - High probability of congestion - Poor security
- Not appropriate for internet access & data transmission
- No evolution path



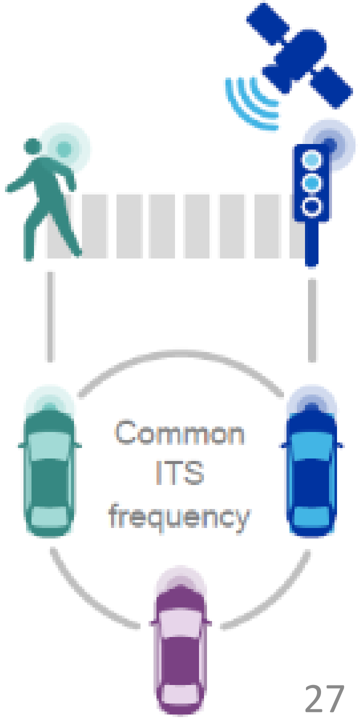
V2X: C-V2X (cellular V2X) / LTE-V

- Use of LTE Uu interface (LTE usual interface with eNobeB)
- or the PC5 (D2D) outside of network coverage or network assisted
- 2x better performances due to:
  - Longer transmission time
  - SC-FDM waveform
  - Turbo code and HARQ
- Low security in direct mode – high security over Uu
- Evolution path

Network assisted

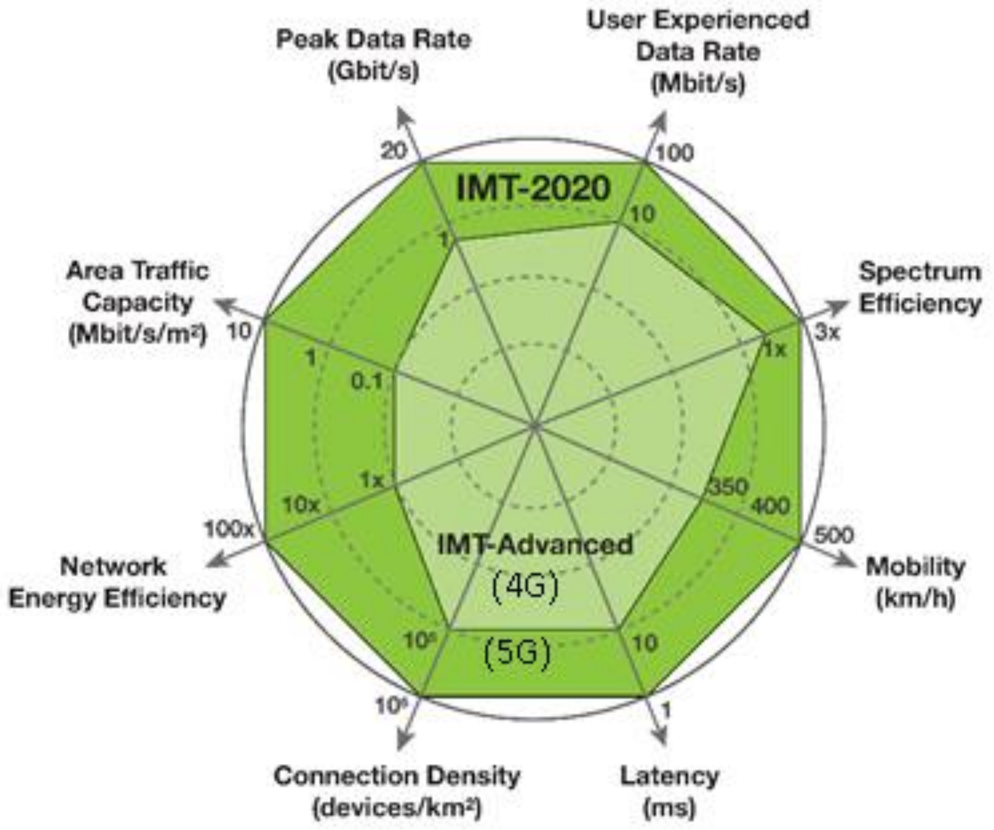


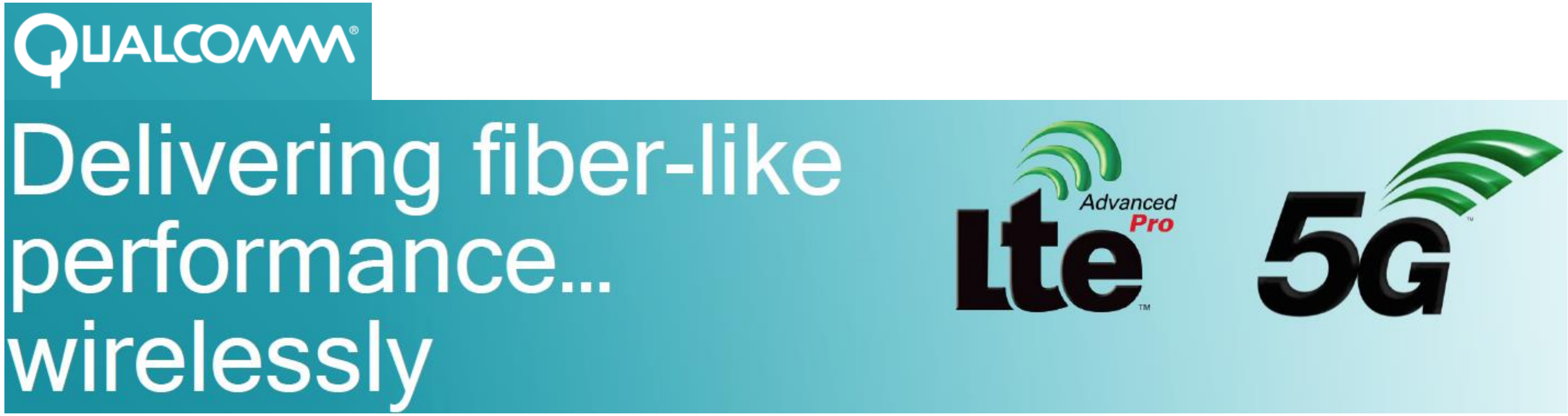
Self managed
Direct communication
Via PC5
GNSS for synchronisation



5G vision

- Ultra high speed radio access
  - Up to 20 Gbps (20x better than 4G)
  - Download a 4K HD movie < 1’
- Ultra Low Latency
  - For mission critical including autonomous driving
  - Ultra reliable latency < 1ms (10x better as 4G)
- Massive Connectivity
  - IoT – 20 to 50 billion connected devices in 2020 with various needs (kbps to Gbps)
  - Up to x1000 device density compare to 4G

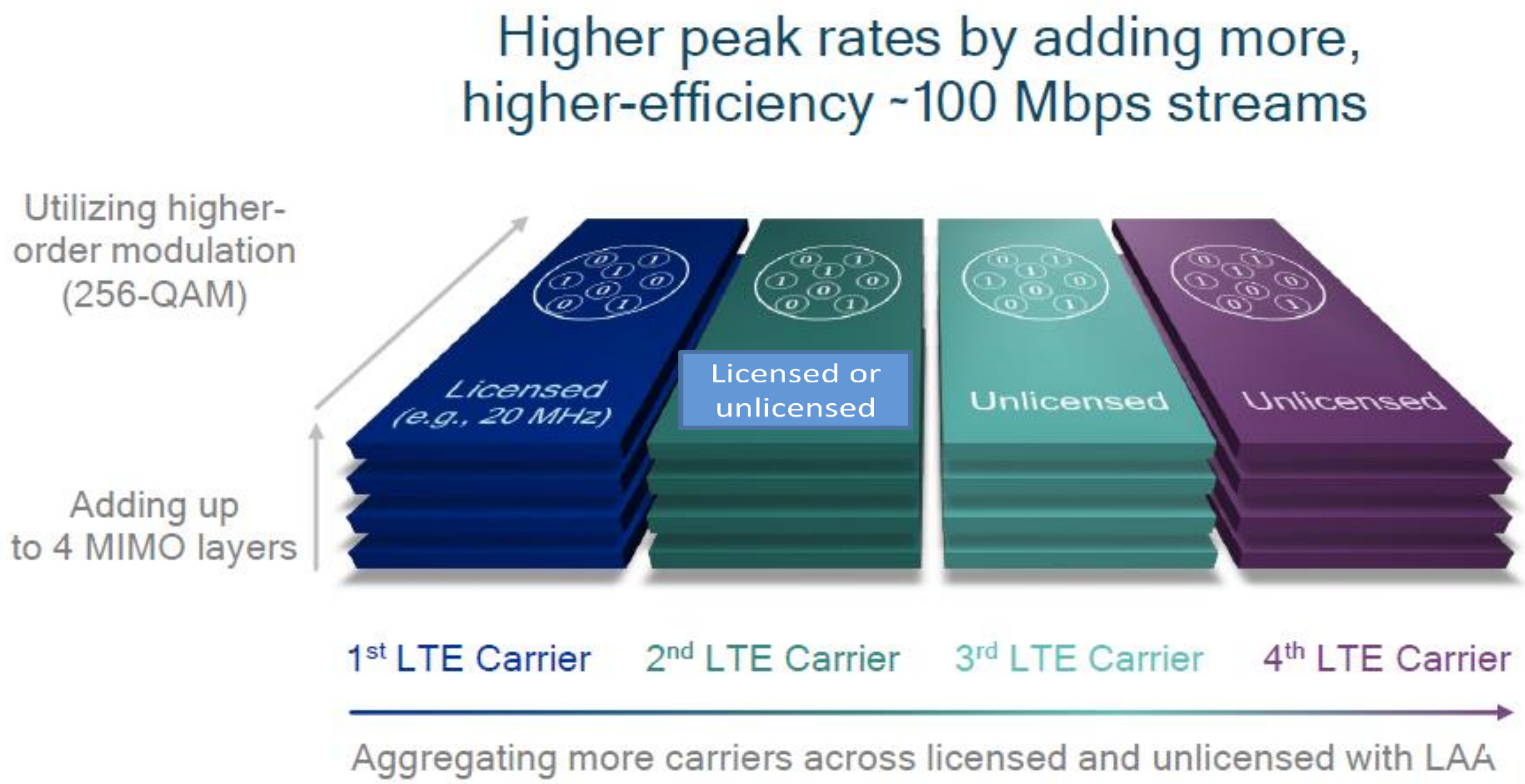



QUALCOMM
Delivering fiber-like performance... wirelessly
Lte Advanced Pro
5G

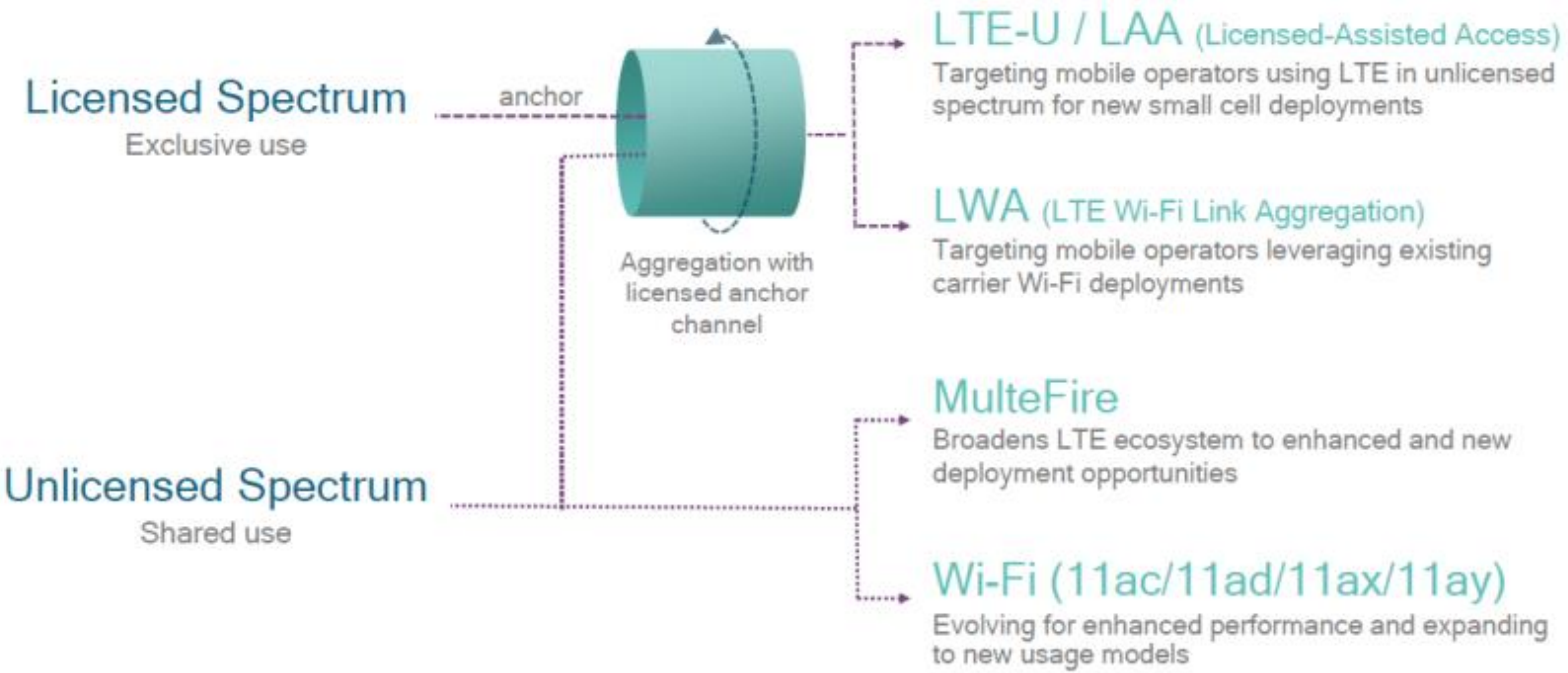

3GPP
A GLOBAL INITIATIVE
The Mobile
Broadband Standard
5G

5G NEW FEATURES

Ultra-high speed radio access



Unlicensed Spectrum



Massive IoT

- Prepare to support as many as a trillion connected devices
- IoT have sporadic and heterogenic communication needs – different size, applications, power feeding
- Massive capacity to scale at eNodeB with appropriate IoT radio accesses:
  - NarrowBand IoT (NB-IoT) – 2G like volume of data for tens of thousands device in a cell
  - LTE for Machines (LTE-M) – uses network slices with lower data rates (200 kbps for instance)
  - non-LTE based accesses
    - SigFox – LoRaWAN (low power)
- Massive MIMO (32x32 or 64x64)

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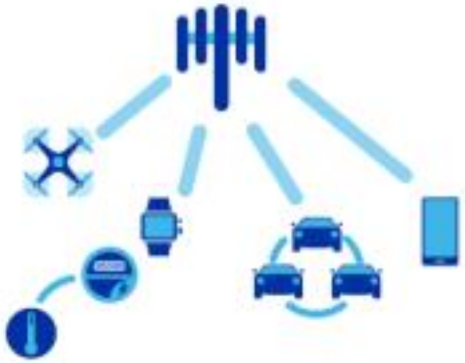
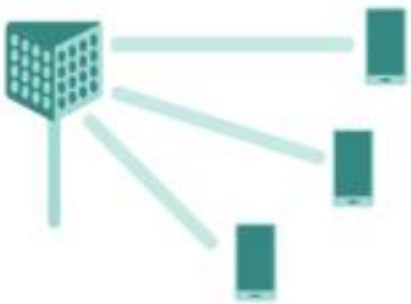
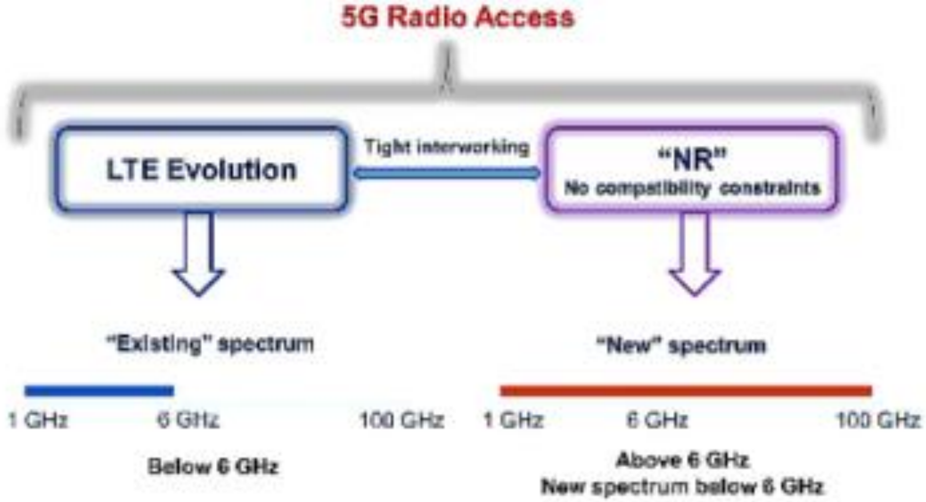
New Radio

Sub-6 GHz
Ubiquitous coverage and capacity for a wide-range of 5G use cases



Mobilizing mmWave
Large bandwidths for extreme throughput and capacity





Stage 3 completion for 5G NR NSA by December 2017 (RAN#78)[1]

Stage 3 completion for 5G NR SA by June 2018 (RAN #80)[2]

Virtualisation

- Exploit the ongoing trends for NW deployment:
  - Use off the shelf servers instead of dedicated HW for NW components
  - Use of C-RAN (Centralised RAN): Use Open Cloud architecture for operating network function (SW Defined Networks)
- Create virtual network “slices” to deploy specific offers
  - NFV: Network Function Virtualisation
  - MEC: Mobile Edge Computing
  - Creating vEPC (virtual Evolved Packet Core)

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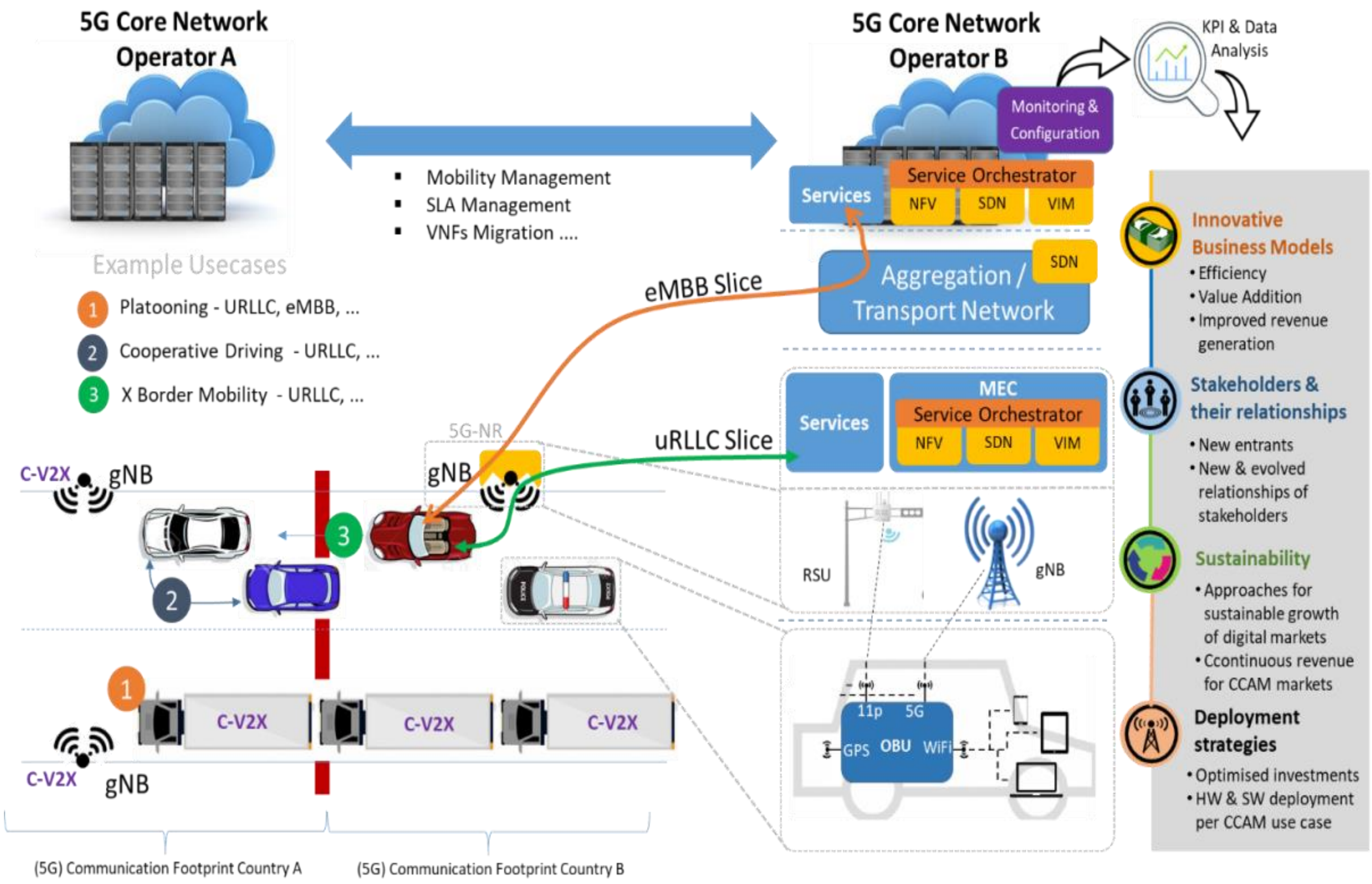
5G-MOBIX – 5G for CCAM

Overall concept and trial architecture

5G for CCAM
3 actions
50 m€



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825496

5G-MOBIX phases

P1 Deployment Requirements

- Assess the 5G for CCAM deployment requirements on the major EU transport routes
- Select and map suitable use cases for 5G-MOBIX corridors
- Perform use-case-specific technical & cost-benefit analysis for each corridor

P2 Development, Integration and Trials

- Develop the corridors by integrating 5G technologies
- Carry out trials to assess the 5G capabilities for automated driving
- Identify business enablers

P4 Deployment Strategy

- 5G deployment plan for EU
- Inputs for regulation
- Inputs for interoperability & Recommendations for Standardization
- New Business Models

P3 Evaluation & Dissemination

- Evaluate 5G technical aspects for different stakeholders: operators, service providers, automobile manufacturers, etc.
- Ensure the outreach of project's impact to all relevant stakeholders

5G – MOBIX project information

- Innovation action – DG CONNECT – unit E1 – Future connectivity systems
- Start date: 01/11/2018
- 50 beneficiaries – 8 international partners (CN – KR)
- Coordinator François FISCHER – ERTICO
- EU funding: 21,4 m€
- Complementary Grant
  - ICT-17: 5G EVE - 5GENESIS - 5G-VINNI
  - ICT-18: 5G-CARMEN - 825050 5GCroCo - 825496 5G-MOBIX

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Automated driving
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Valeo

Thank you for your attention!

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731993