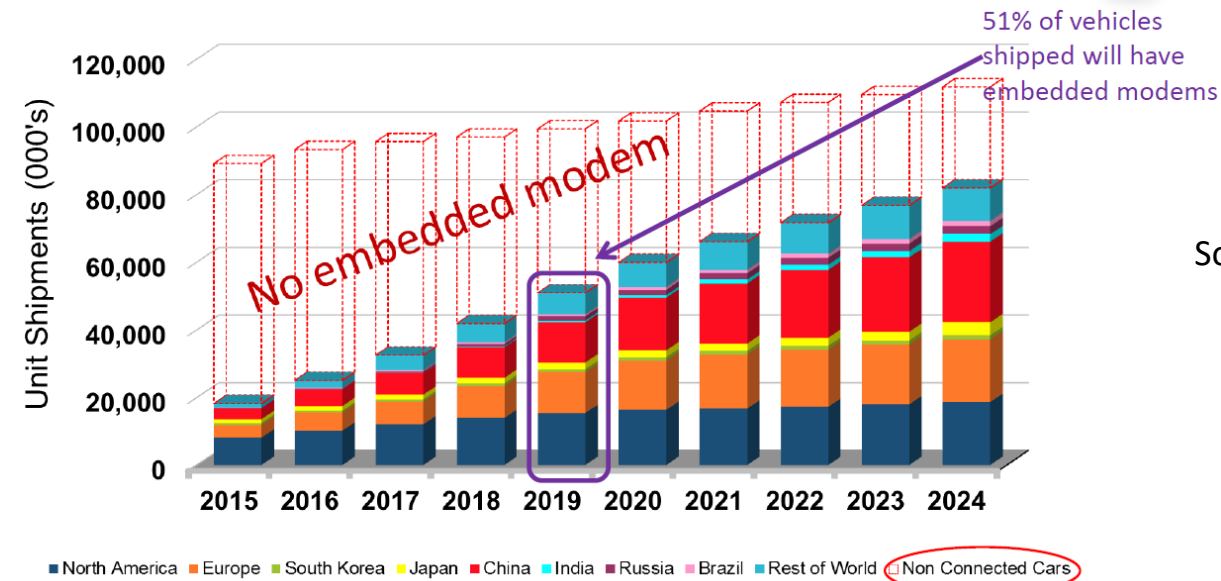# V2X: the Path towards Self-Driving Vehicles

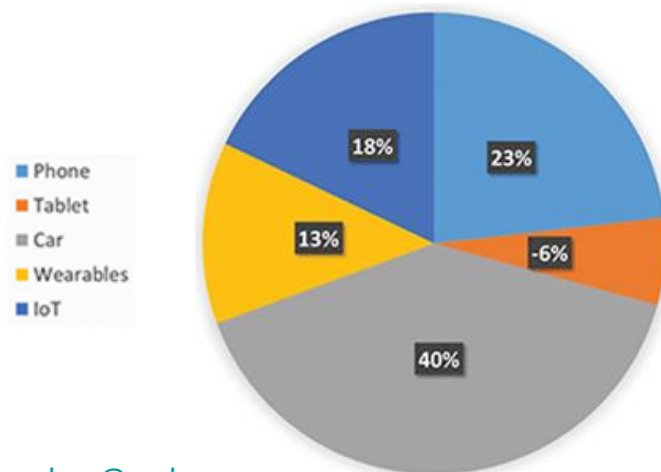Prof. Javier Gozalvez, j.gozalvez@umh.es

Universidad Miguel Hernández de Elche, Spain

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Connected vehicles: a reality

Source: A 5G Perspective on Connecting Cars,
Roger C. Lanctot, Strategy Analytics

AT&T in US: 32 million connected vehicles of 150 million total subscriptions

US Net-Add Device Distribution
9 months at 3Q 2018

Source: US Mobile Market Update Q1 2019,
Chetan Sharma Consulting

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V2X: Vehicle to Everything Communications

ITS Central Station

Cooperative C-ITS systems

Vehicle to Infrastructure (V2I)

V2I

Vehicle to Vehicle (V2V):
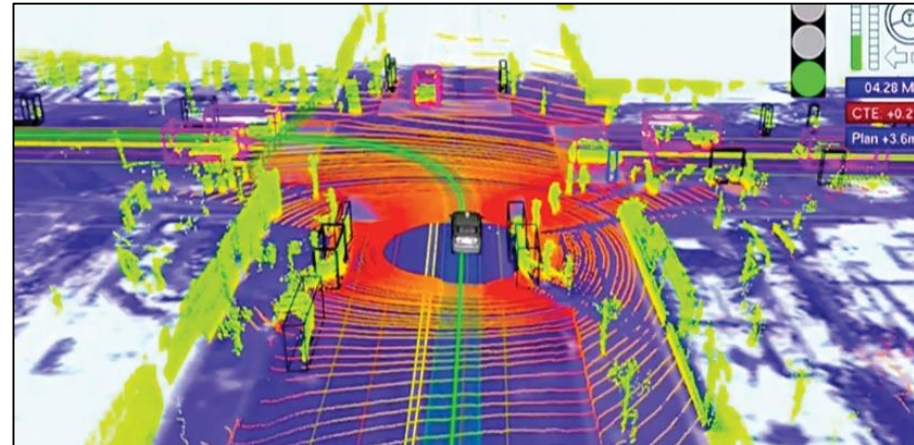exchange of positioning, speed information,…

V2P

V2V

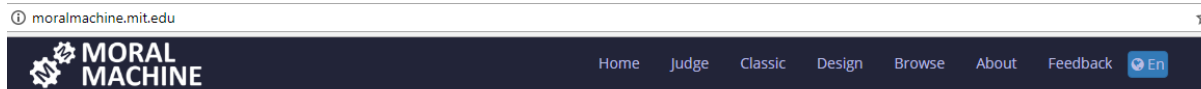V2V

V2V

V2X Applications

- Broadcasting awareness messages (few hundred bytes)

- Driver assistance services
  - Driver remains in control of the vehicle
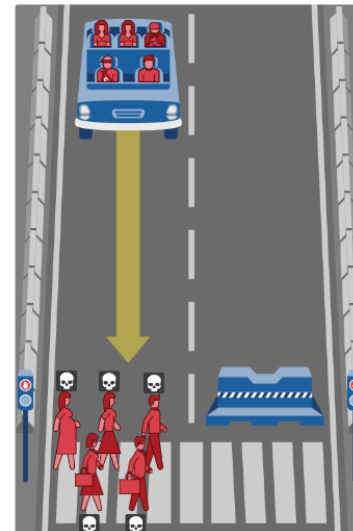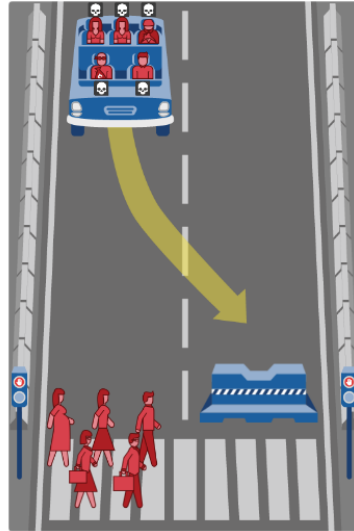 - No liability changes

Autonomous Vehicles

GPS (global positioning system)

Lidar (light detection and ranging)

Rear Camera

Video cameras

Ultrasonic sensors

Odometry sensors

Central computer

Radar sensors

Autonomous Vehicles

Autonomous Vehicles

The **majority (59%)** of U.S. drivers **want** autonomous technology in their next vehicle.

Adaptive Cruise Control

Automatic Emergency Braking

Lane Departure Warning/Lane Keep Assist

Self-Parking Technology

NewsRoom.AAA.com

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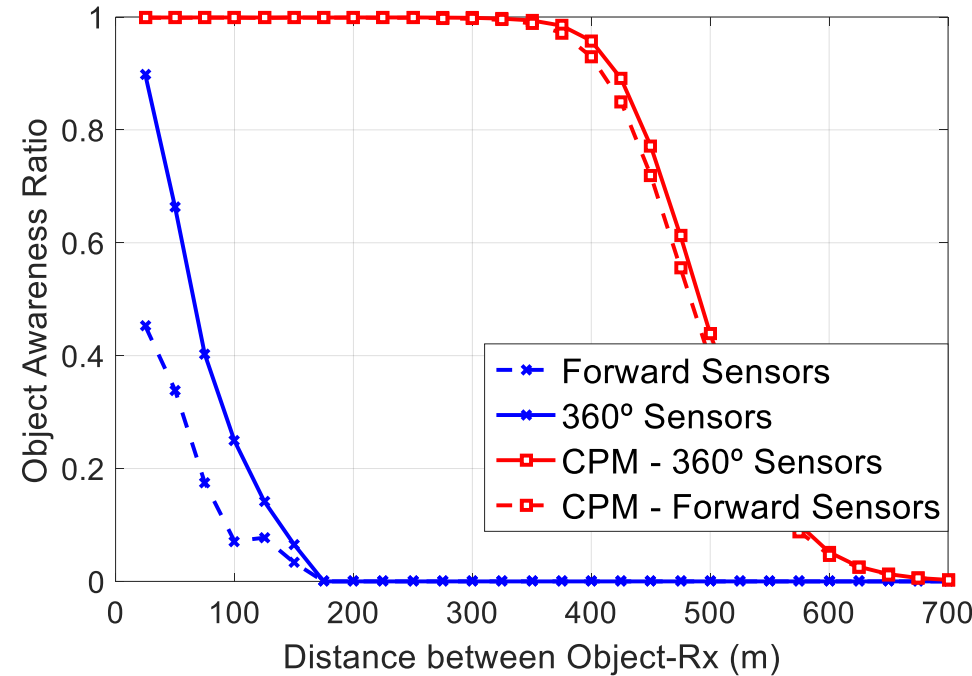*Miguel Hernández*

Challenge: Perception

V2X to exchange sensed data
Cooperative sensing or collective perception

Collective Perception

- ## ETSI TR 103 562: Collective Perception Service

Only vehicles in Line of Sight can be detected

Challenge: Automated Driving

Sense	→	Plan	→	Act
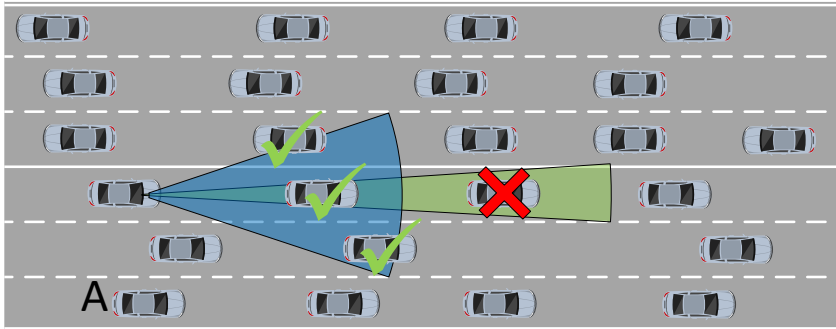
Perceive environment and create an abstract view

Calculate a plan to drive (i.e. trajectory)

Modify lateral and longitudinal control to follow trajectory

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Challenge: Automated Driving

Sense → Plan → Act

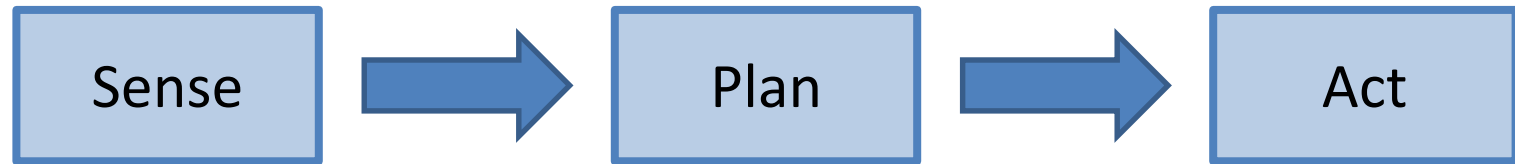Plan: what are the intentions of nearby vehicles?

Challenge: Automated Driving

Sense → Plan → Act

Plan branches to:

Prediction → Trajectory Calculation
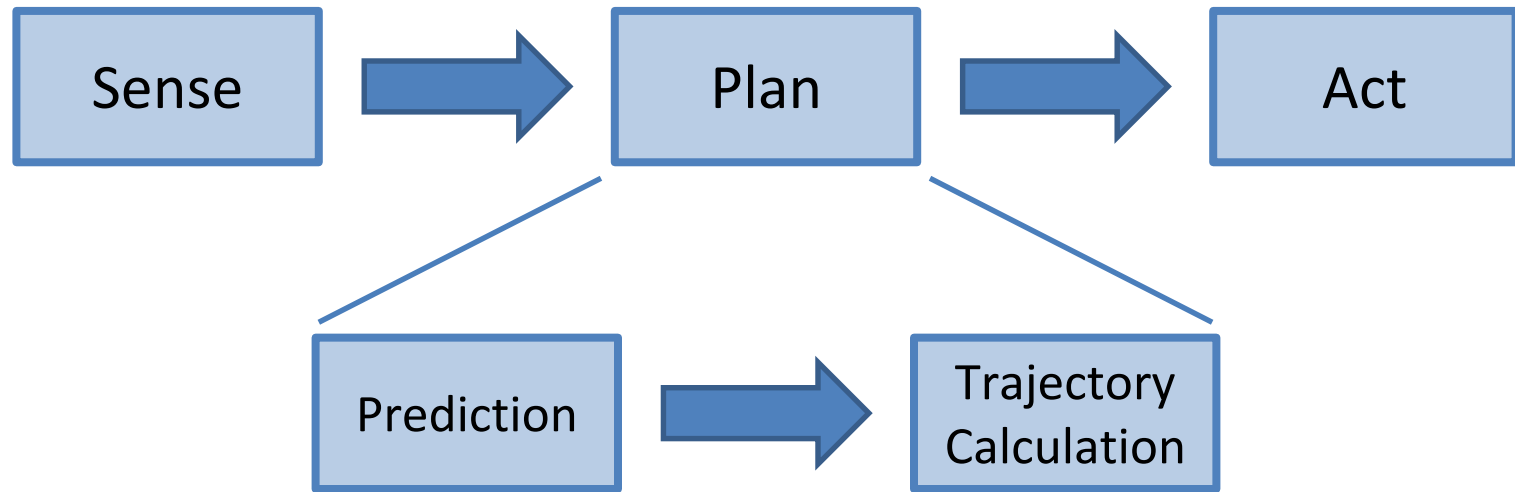
Estimate/predict how vehicles will move

Calculate trajectory without collisions with static & dynamic objects

V2X: exchange data about driving maneuvers

Cooperative driving or maneuver coordination

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V2X Connectivity: WiFi vs Cellular

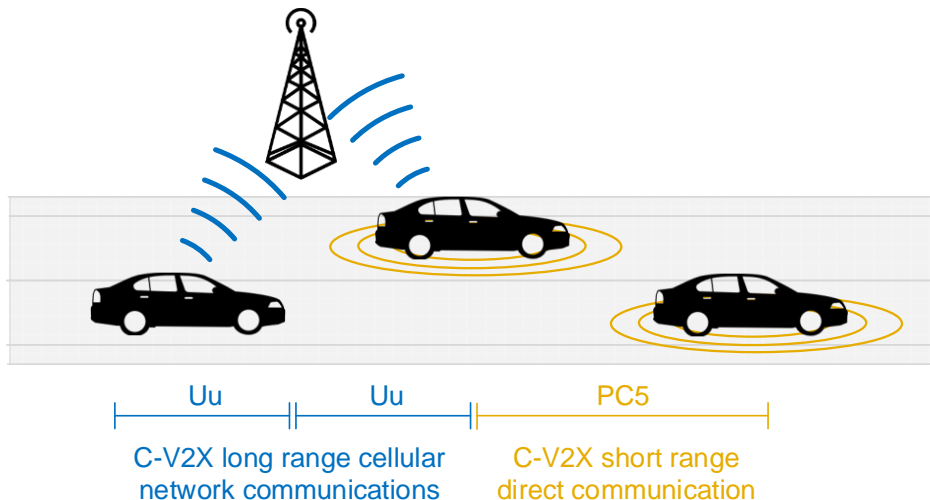- IEEE 802.11p (WiFi): adaptation of IEEE 802.11a
  - Standards: ETSI ITS-G5 (EU), DSRC (US)

- Cellular: 2 transmission modes for 4G LTE-V2X (C-V2X)
 - V2I and V2V sidelink or direct communications

Uu   Uu   PC5

C-V2X long range cellular network communications   C-V2X short range direct communication

V2V: mode 4 and mode 3

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V2X Connectivity: WiFi vs Cellular

- Better PHY layer of LTE-V2X

- Packet Delivery Ratio (system-level): 802.11p vs LTE-V2X mode 4
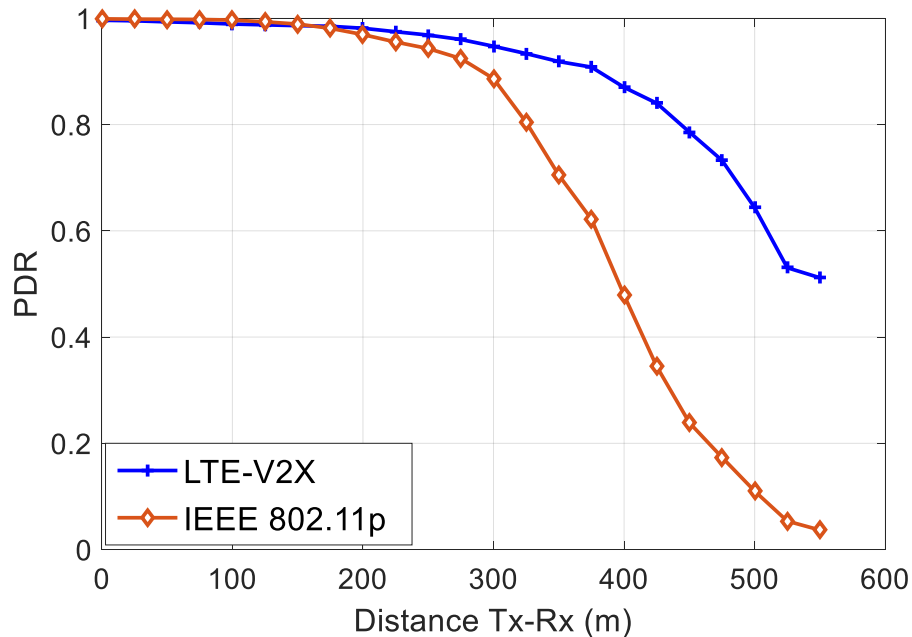
Traffic: periodic (200ms) & size of 190bytes
Low channel load (CBR ~0.1)
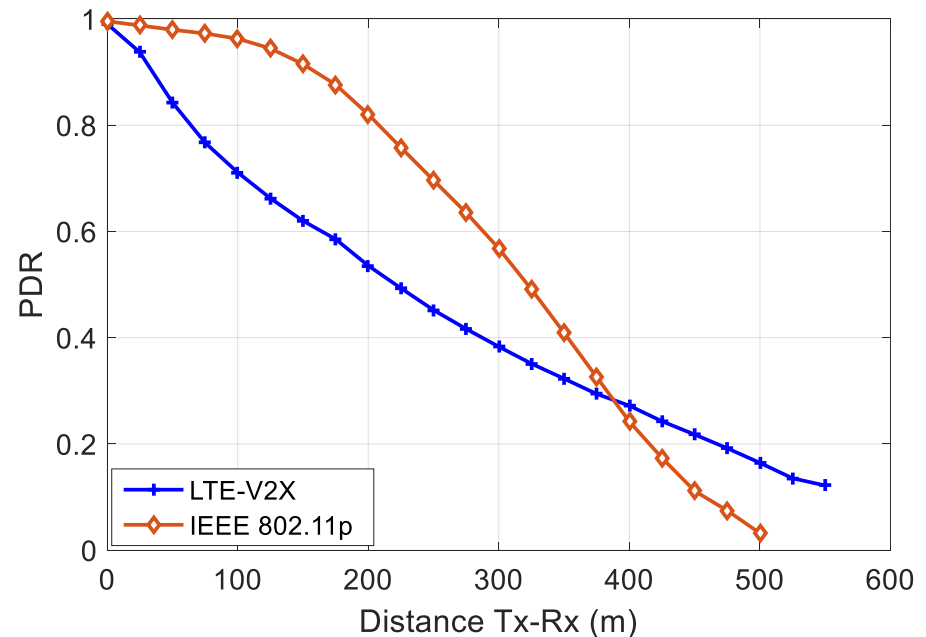
Aperiodic traffic
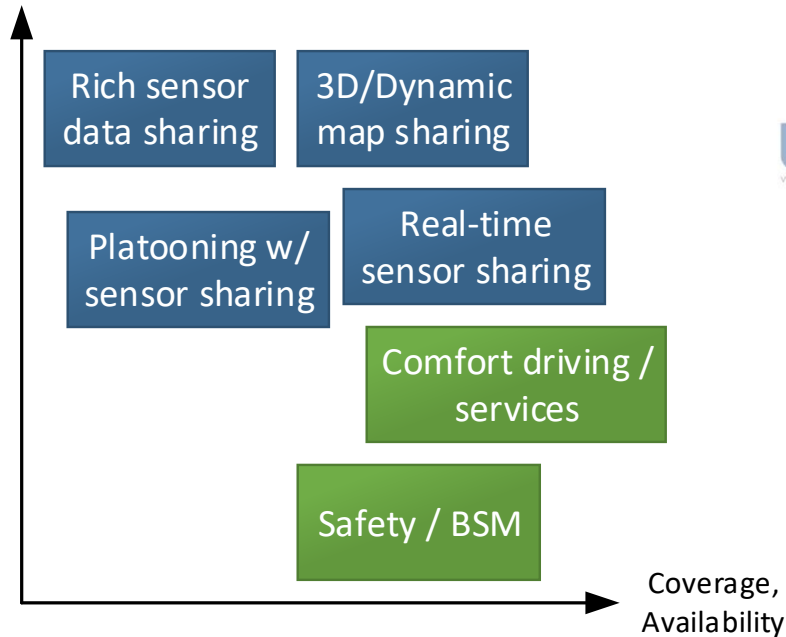Moderate/high channel load (CBR ~0.39-0.48)

CAR 2 CAR Communication Consortium, "Survey on ITS-G5 CAM statistics," Dec. 2018.
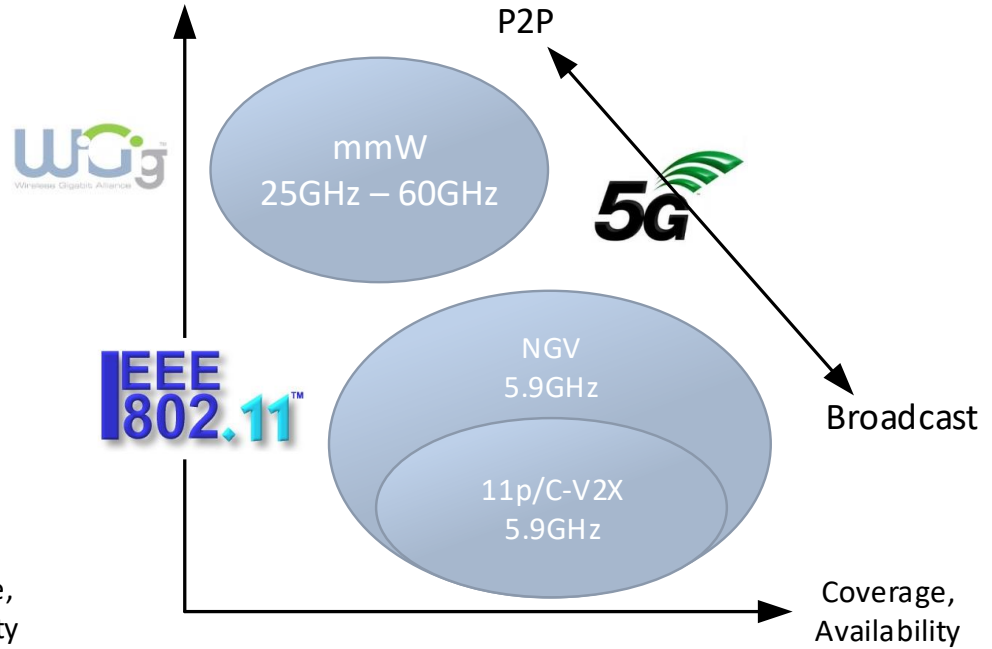
V2X Connectivity: WiFi vs Cellular

- Worldwide deployments
  - IEEE 802.11p: ~120,000 units sold as (May 2018, IHS Market)
    - Toyota in Japan (2015), GM in US (2017), Volkswagen in Europe (2019)

  - C-V2X chipsets available since 2018
    - In-vehicle commercial deployment from 2020 (source 5GAA)

- Delegated Act on C-ITS voted downed by EU member states
  - Hybrid communication: ITS-G5 for short range and long range V2I
  - Technology neutrality

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Roadmap

Data rate, Accurate positioning

Rich sensor data sharing

3D/Dynamic map sharing

Platooning w/ sensor sharing

Real-time sensor sharing

Comfort driving / services

Safety / BSM

Coverage, Availability

Data rate, Accurate positioning

P2P

WiGig

mmW
25GHz – 60GHz

5G

IEEE 802.11

NGV
5.9GHz

11p/C-V2X
5.9GHz

Broadcast

Coverage, Availability

Interoperability and coexistence versus performance

V2X roadmap = vehicular roadmap

V2X ecosystem: problem or opportunity?