Offloading Platooning Applications from 5.9 GHz V2X to Radar Communications: Effects on Safety and Efficiency

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About me

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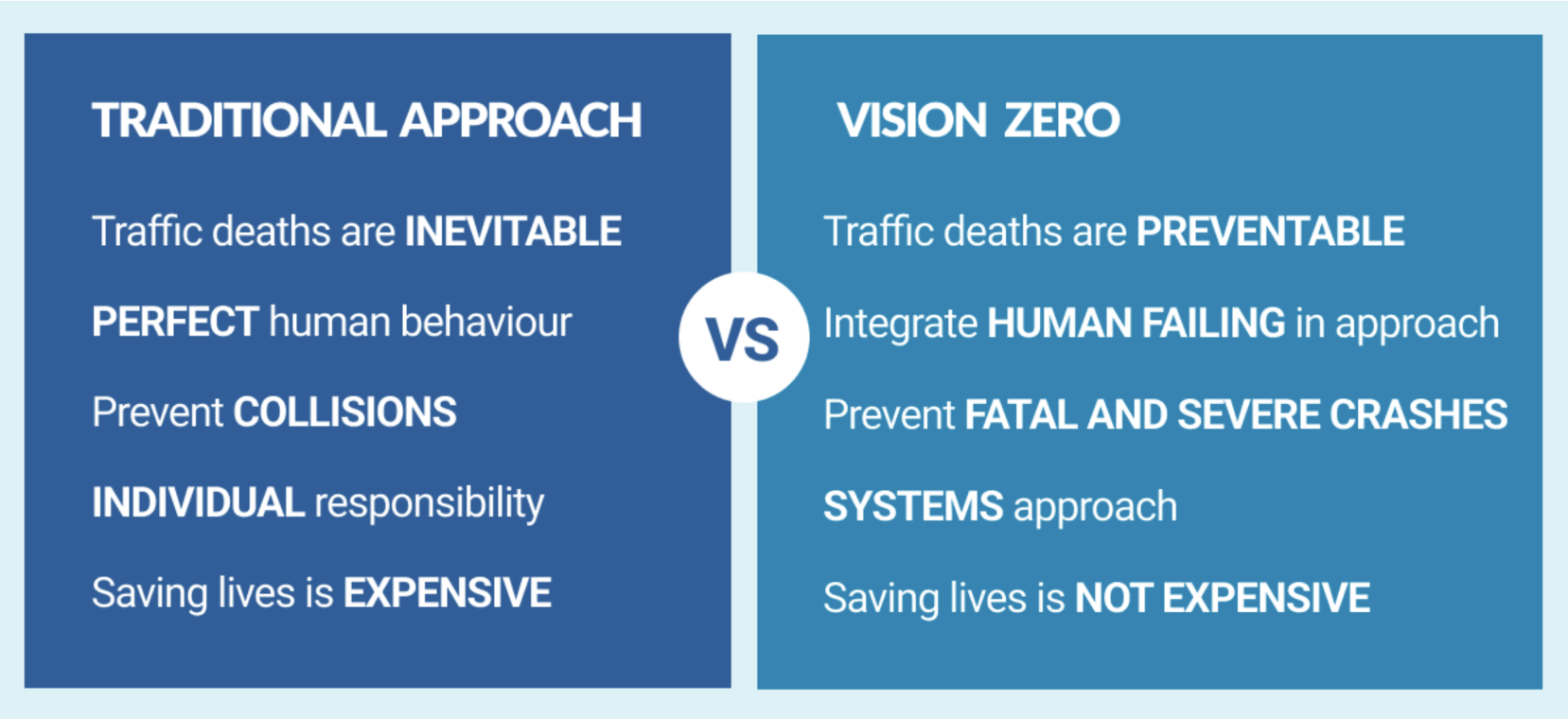
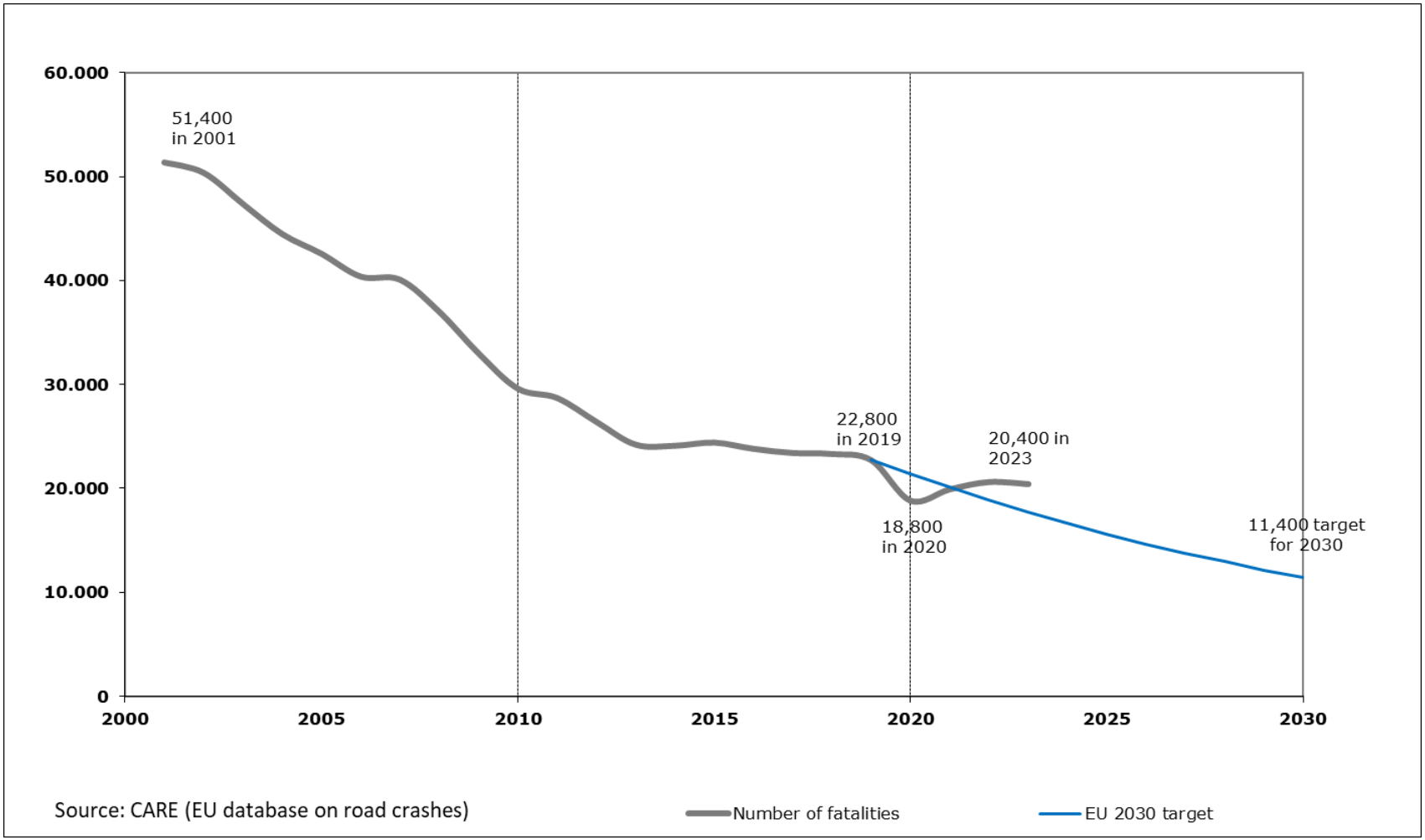
- Research interests: future mobility, transport flows, traffic simulations

Vision Zero



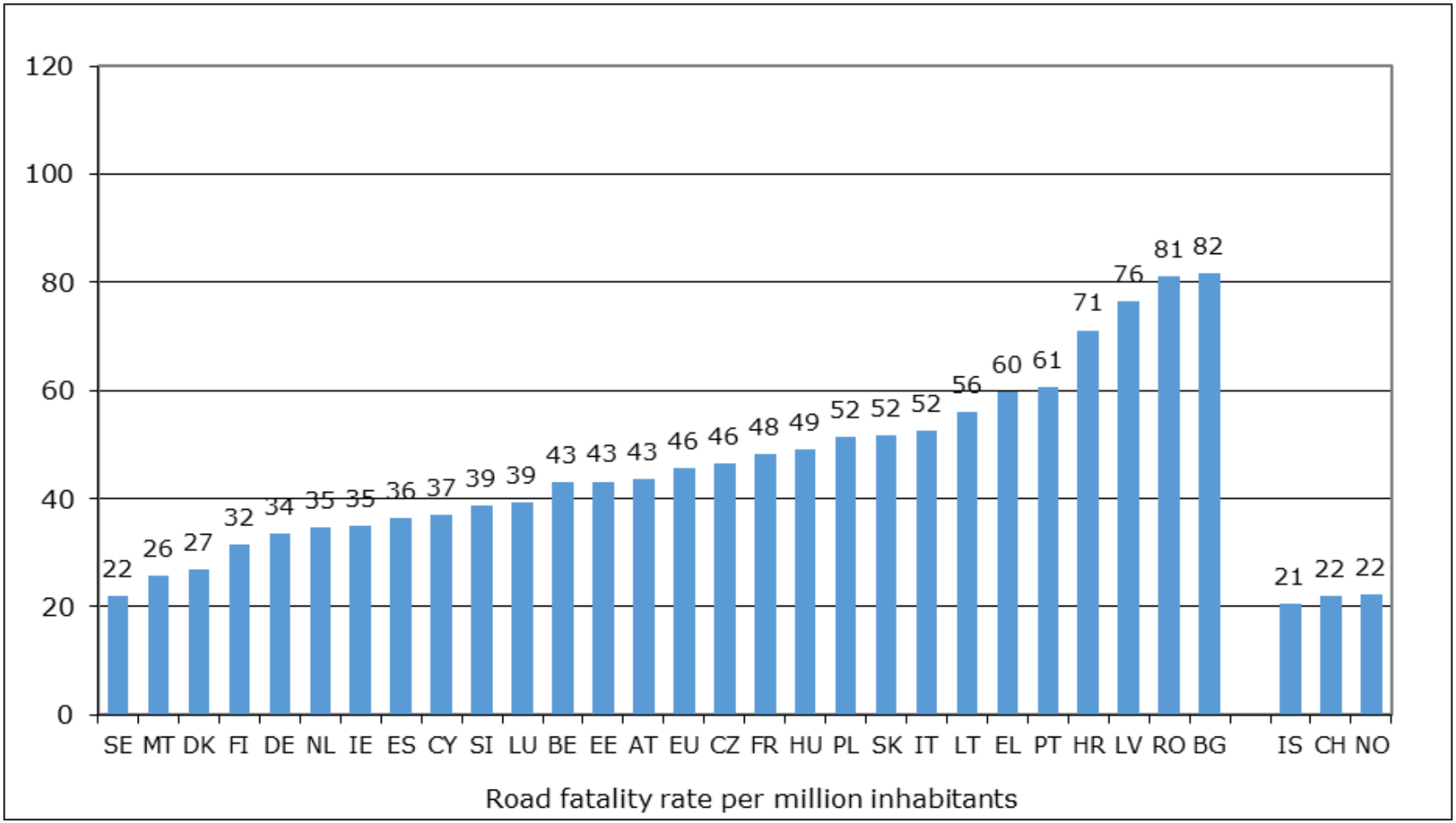
Source: Source: visionzeronetwork.org

Trend in the number of road traffic fatalities in the EU (2023)



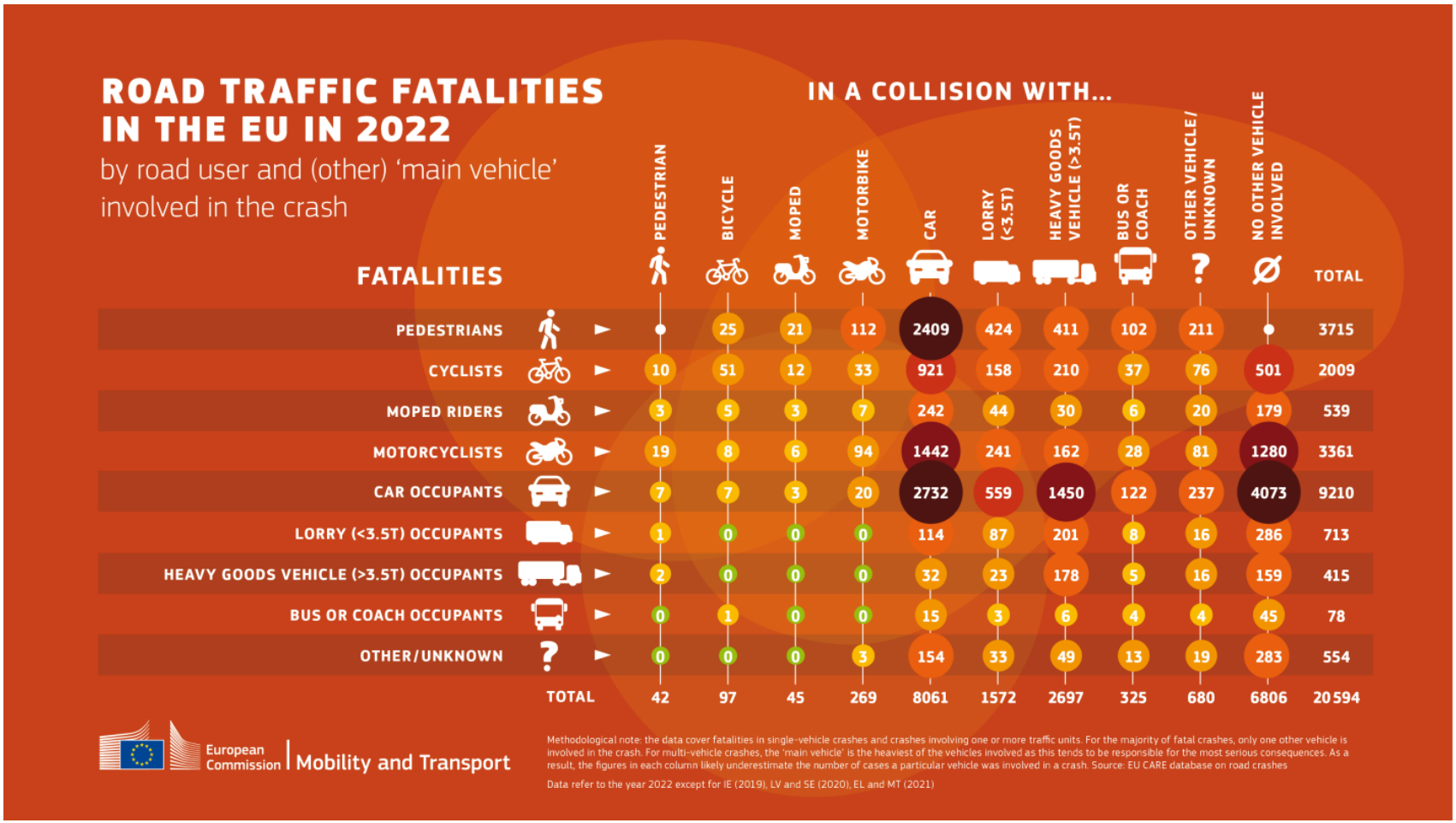
Source: transport.ec.europa.eu

Number of road fatalities per million inhabitants by country (prelim. 2023)



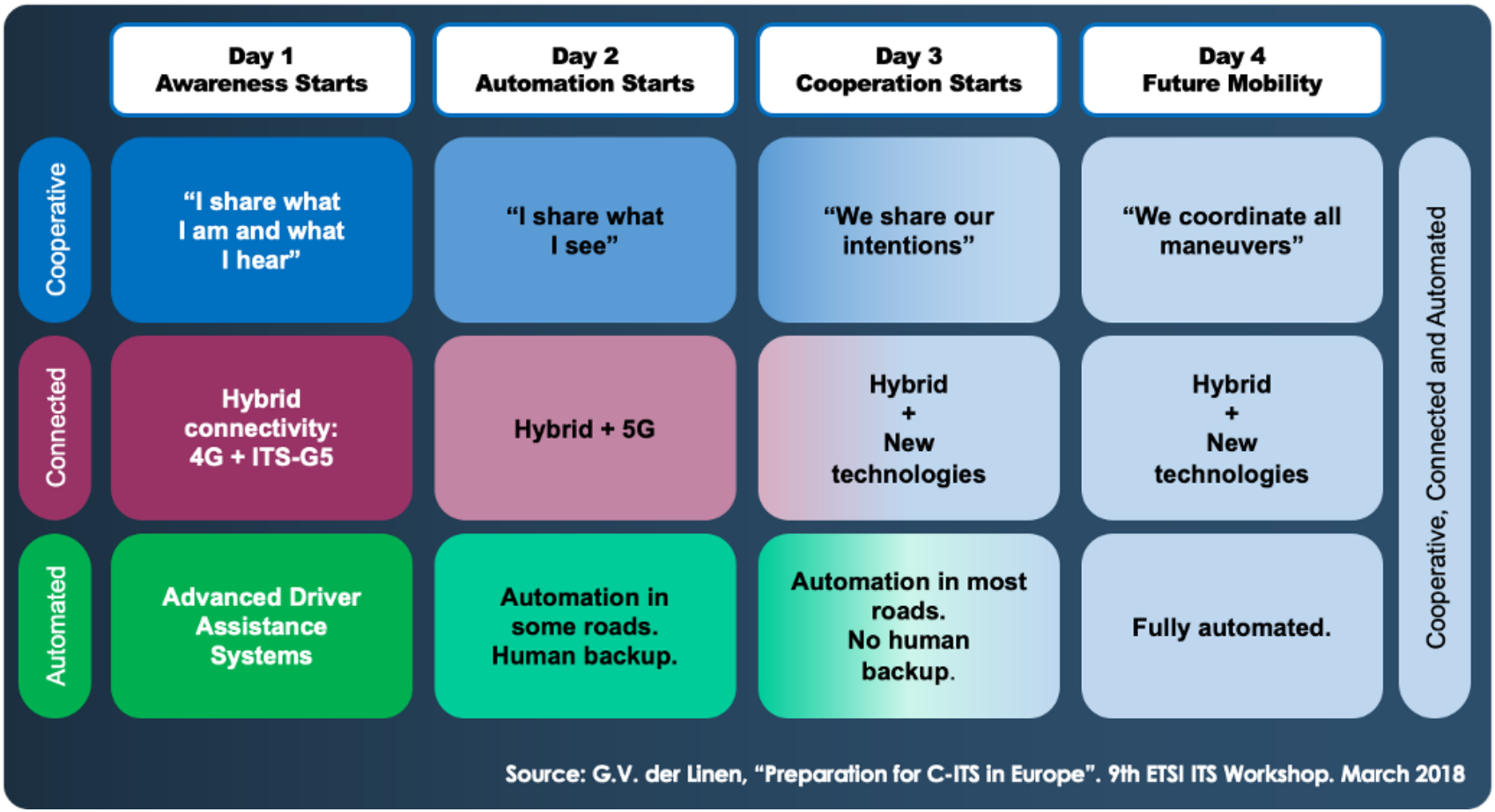
Source: transport.ec.europa.eu

Collision matrix (all roads), 2022



Source: transport.ec.europa.eu

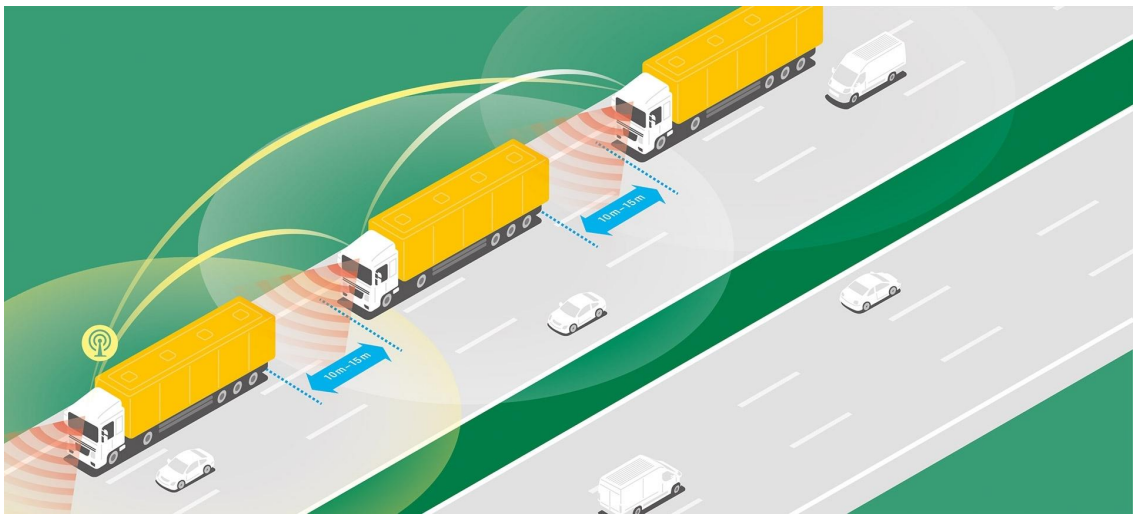
Cooperative, Connected and Automated Mobility



Cooperative, Connected and Automated Mobility

- Automated Mobility
- Cooperative Intelligent Transport System (C-ITS)
  - **Day 1**: Cooperative Awareness (CAMs), Decentralized Environmental Notification (DENMs)
  - **Day 2**: Collective Perception (CPMs)
  - **Days 3+4**: Maneuver Coordination (MCMs).

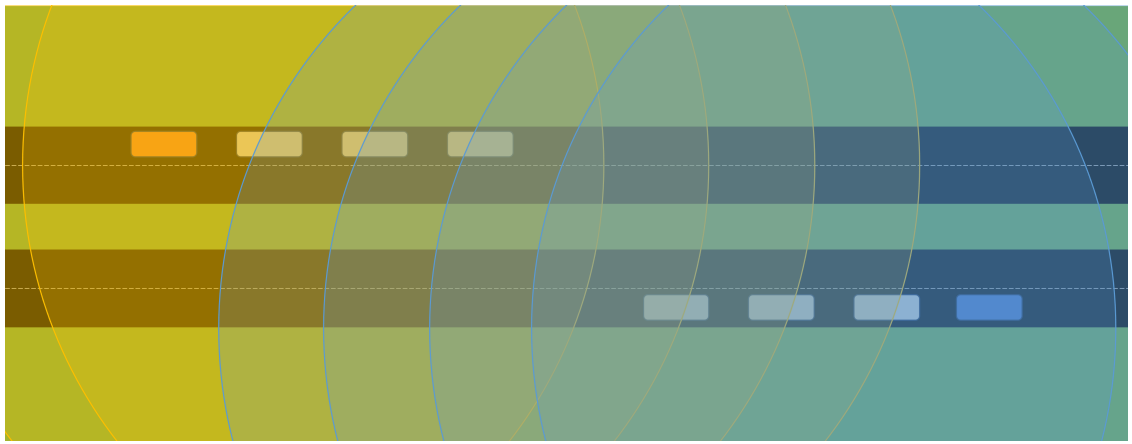
MC-example - platooning (PAMs + unicast PCMs)



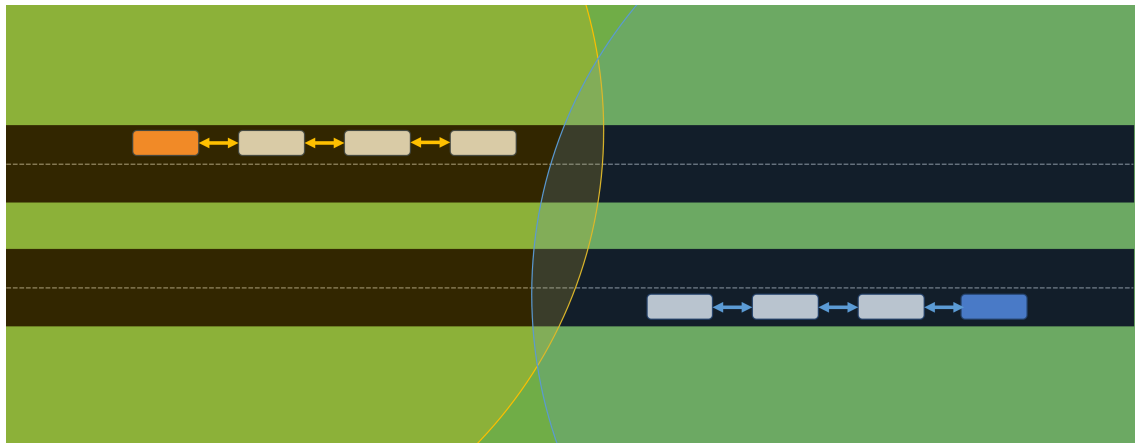
Source: rapp.ch

Network vs RadCom enabled platooning

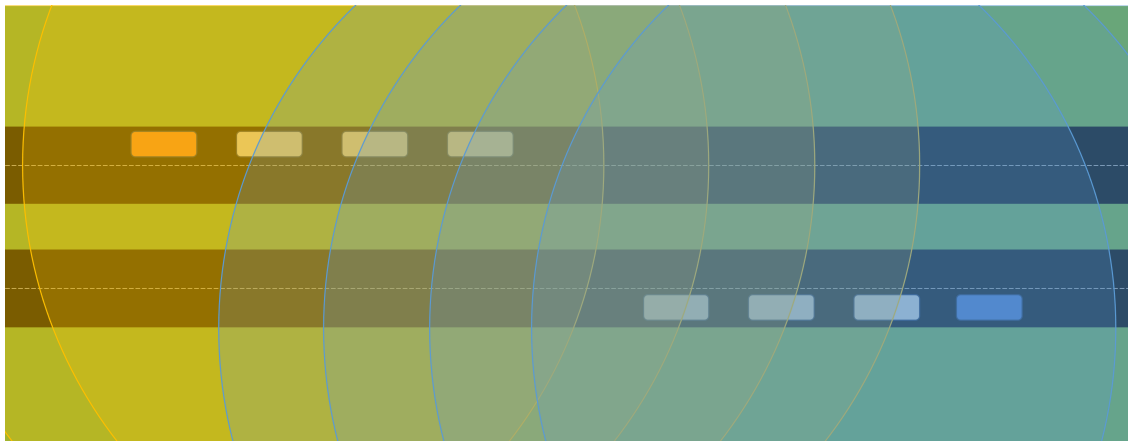
- WiFi-enabled platooning. Network nodes



- RadCom-enabled platooning. Network nodes



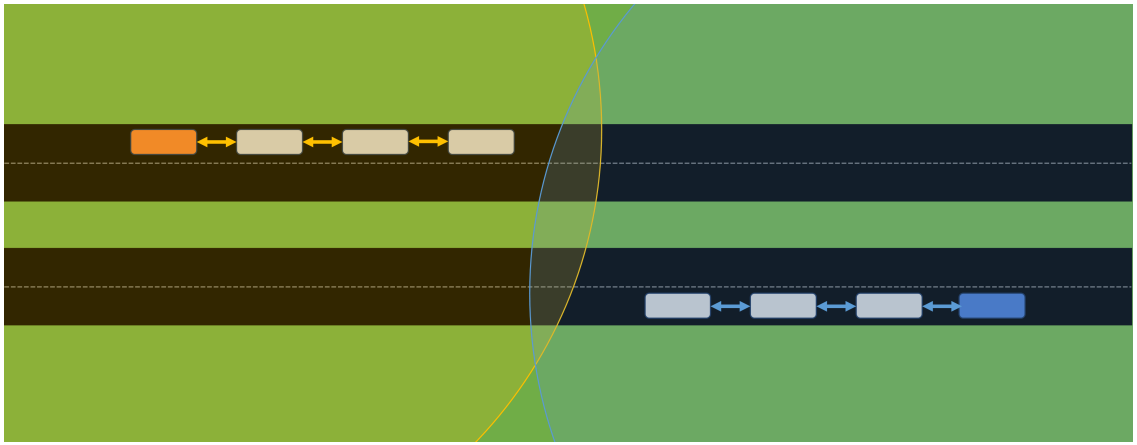
WiFi-enabled platooning



Feature	802.11p	802.11bd
Frequency bands	5.9 GHz	{5.9, 60} GHz
System bandwidth (at 5.9 GHz)	10 MHz	{10, 20} MHz
Data subcarriers (at 5.9 GHz)	48	48 & 52
MIMO	N/A	2×2 MIMO
Data rates (in 10 MHz)	3 to 27 Mbps†	Up to 39 Mbps
Relative veh. speed	252 km/h	500 km/h
mmWave (60 GHz)	Not supported	Supported
Localization	N/A	Supported

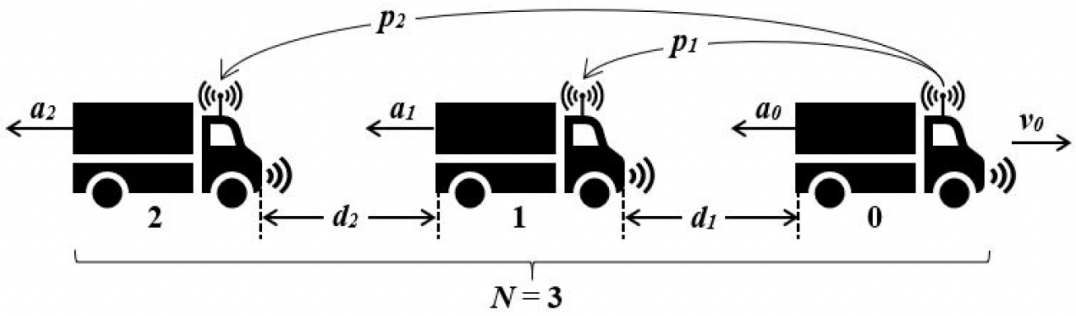
†Only 6 Mpbs is typically used.

RaadCom-enabled platooning (Preliminary results)



- Frequency — 76-81 GHz
- Bandwidth — 0.15-1 GHz
- Duty cycle — $\delta = 0.1$
- Capacity — $\delta \times 6.9$ Gbps [at 200 m]

Platooning scenario



- Safety metrics — probability to receive DENM

$$\underline{Q} = \prod_{n=1}^{N-1} C_{i-1,i} = \prod_{n=1}^{N-1} (1 - p_i^{\lfloor \frac{\tau_i}{T} \rfloor}), \qquad C_{i-1,i} > 0.99999$$

- Receiving times

$$\tau_i = \tau_i(d_{1,\dots,i}, a_{1,\dots,i}, v_0)$$

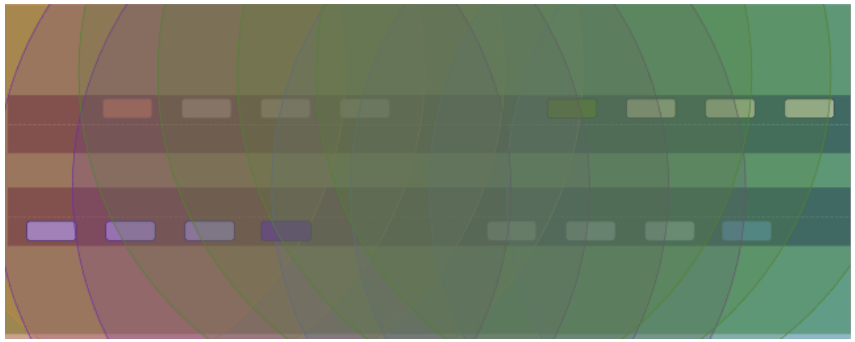
- Optimization for objective function

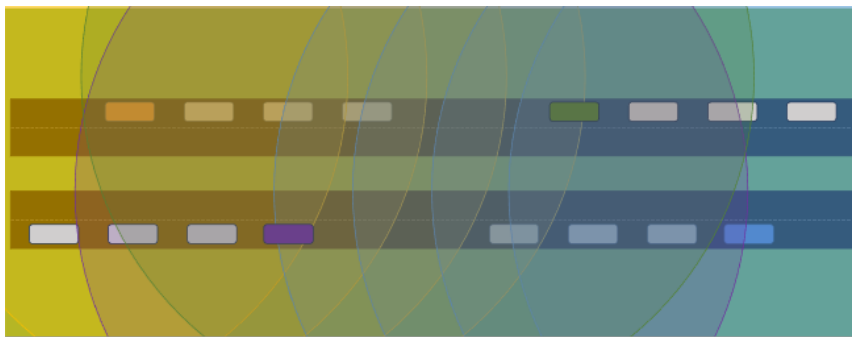
$$J = \sum_{i=1}^{N} A_i d_i$$

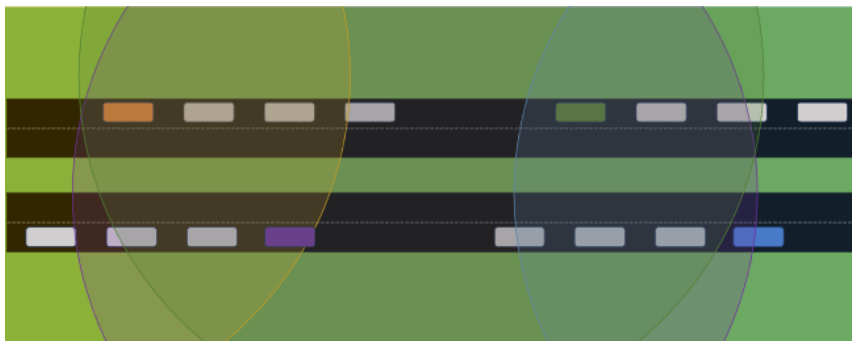
5.9 GHz Offloading to RadCom. PDR-Simulation

Artery (with Veins)

- Scenario:
  5 km road with four lanes in each direction
- Density: 30 veh/km per lane
- PCMs are sent at 20 Hz
- Measurements are taken for 30 seconds
- Metrics:
  Average packet delivery ratio (for the 30 messages)
- 3 RadCom penetration rates:
  0%, 50%, 100%

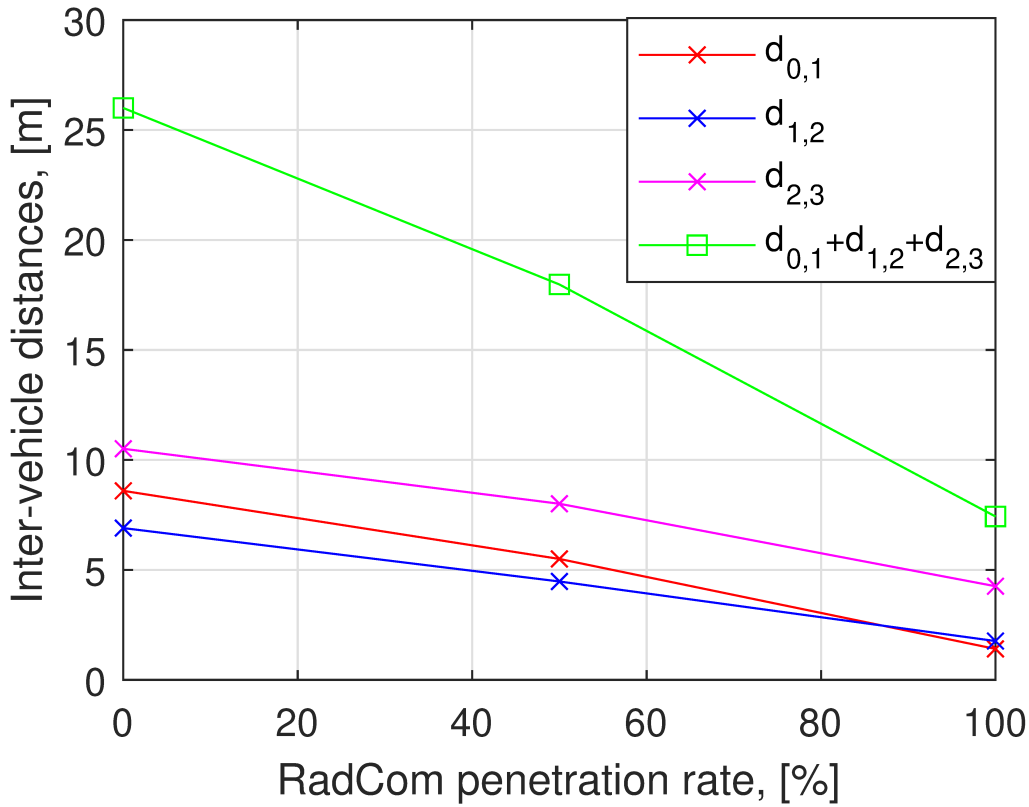






5.9 GHz Offloading to RadCom

RadCom Penetration Rate	PDR	S-CBR	Latency
0%	0.6985	0.6176	136.80 ms
50%	0.7859	0.6119	109.57 ms
100%	0.9015	0.2217	1.45 ms



Thank you!

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