



**Vehicle to Network to Everything (V2N2X):
Architecture, Solution Blueprint, Use Case Implementation
Examples and Business Perspectives on V2N2X Deployments**

5GAA online session, 18 June, 16:00 – 17:00 (CEST)

Structure

1. Opening remarks & introduction
2. V2N2X architecture
3. V2N2X Solution Blueprint and Use Case Implementation Examples
4. Business perspectives
5. Closing remarks
6. Q&A

Introduction

- 100s of Millions of connected vehicles are on the road today
- Too many car accidents around the world and resulting with injuries and casualties
- Focusing on the connectivity over the cellular networks
- Bring full complete solution, cover all aspects to create 'standard' document for deployment
- 5GAA terminology of C-V2X covers both network and the short range communication

Motivation

- Increase road users' situational awareness
- Will work wherever cellular coverage is available
- Can be deployed in vehicles that are already on the road
- The need to provide methods to implement and business model

V2N2X WITR content

- Work Item Lead: General Motors – Yohay Buchbut
 - Co-Lead: China Mobile - Yinxiang Zheng
- E2E solution architecture
 - Lead: Deutsche Telekom - Johannes Springer;
 - Co-Leads: Ericsson - Tomas Nylander & Yunpeng Zang;
- Use Case Implementation Examples
 - Lead: Verizon – Shammi Amin, Jyoti Sharma;
 - Co-Lead: Vodafone - Tony Sammut
- Business perspectives
 - Lead: Monotch - Menno Malta;
 - Co-Lead: Monotch - Gary Lin

V2N2X White-Paper complemented by two Technical Reports



- ❑ **For** ecosystem stakeholders interested in using cellular networks for V2X services and applications:
 - *Automotive OEMs (OEMs), Infrastructure Owners, and Operators (IOOs), Service Providers (SPs)*
- ❑ **To** understand the V2N2X architecture, cross-stakeholder information sharing concept, and V2N2X technical details
- ❑ **By** existing use case implementation examples
 - *Traffic event information sharing; Traffic signal information sharing and priority request, Emergency vehicle approaching, HD Map handling, Automated valet parking, Object detection and sharing, and Vulnerable road user protection.*

V2N2X architecture

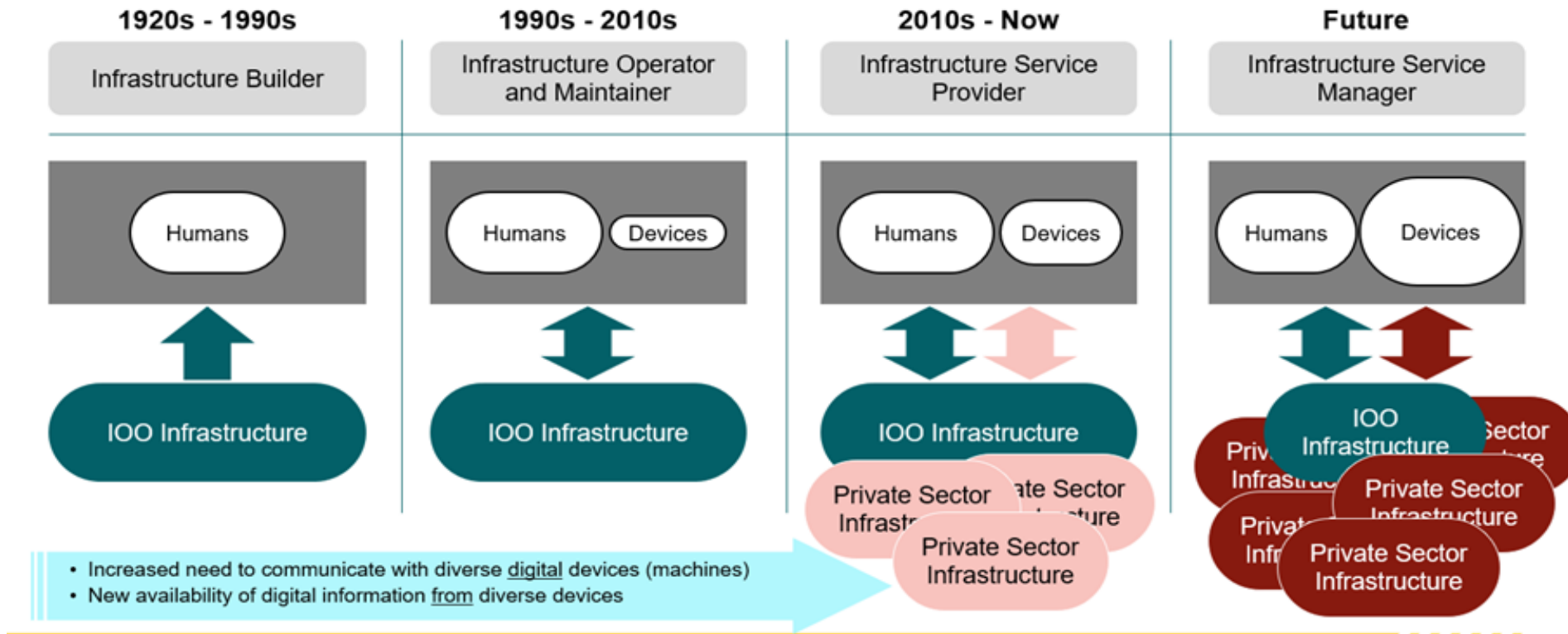
Tomas Nylander, Ericsson



<https://5gaa.org/road-traffic-operation-in-a-digital-age-a-holistic-cross-stakeholder-approach/>

Evolving steps in road traffic management

From an Analog to a Shared Digital Future



How to gain

- Scale (systems/operation)
- E2E Consistency
- Rapid benefits
- Improvements in road safety and efficiency

Maintaining

- Local autonomy
- Trust in IOOs' digital information

Major evolution steps in road traffic management (Source: FHWA, Dec. 2023)

IOO: Infrastructure Owner and Operator (aka 'road authority/road operator')

Benefits in Overcoming Challenges with V2N2X:

Realization of seamless data management means that we need transformation

Elements of transformation and representation – can be shown in the short term and can be broadly deployed in the mid- to long-term

Capital Investment → Operations

Physical → Digital

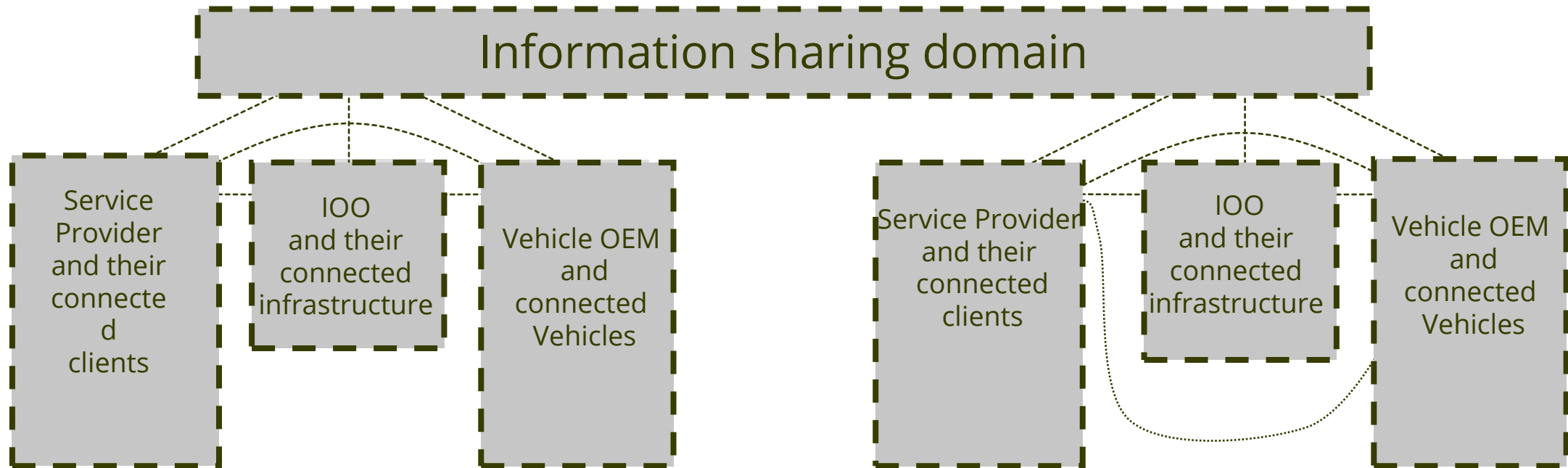
Information silos → Information dissemination

We define a deployable architecture and accompanying enterprise relationships...

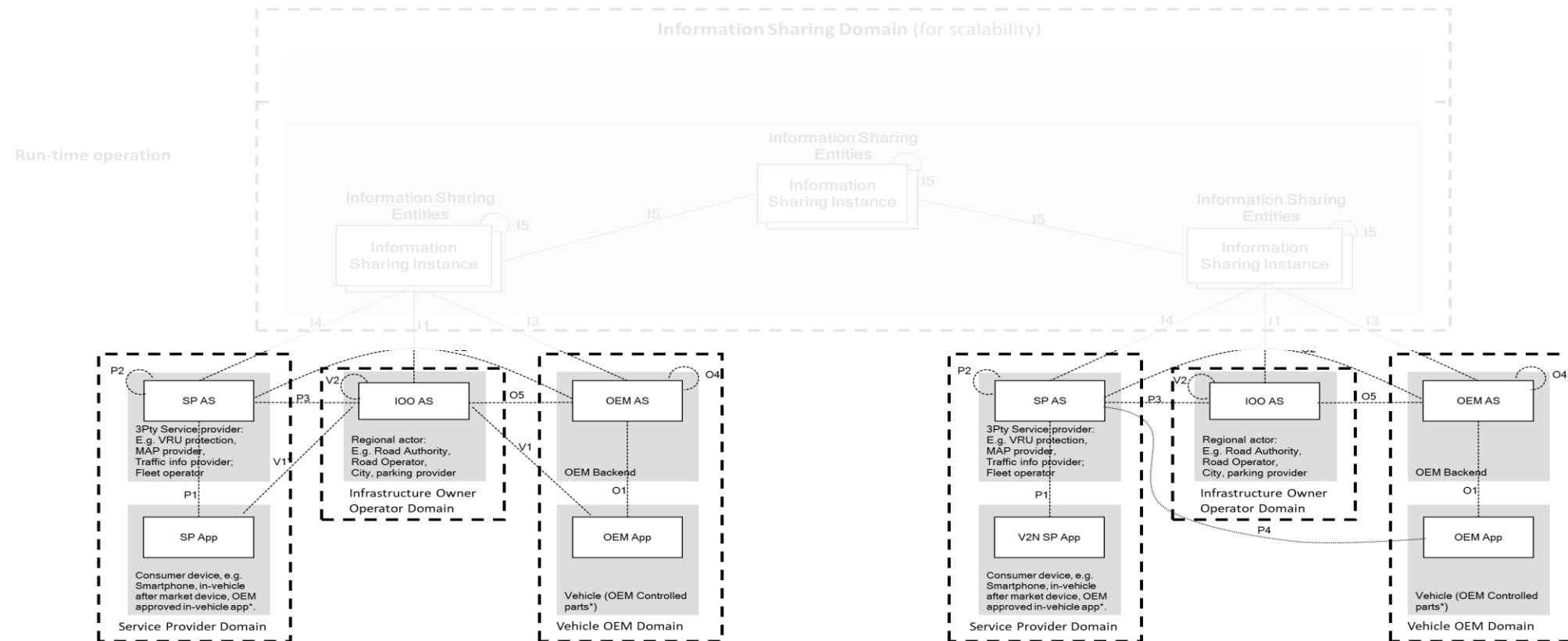
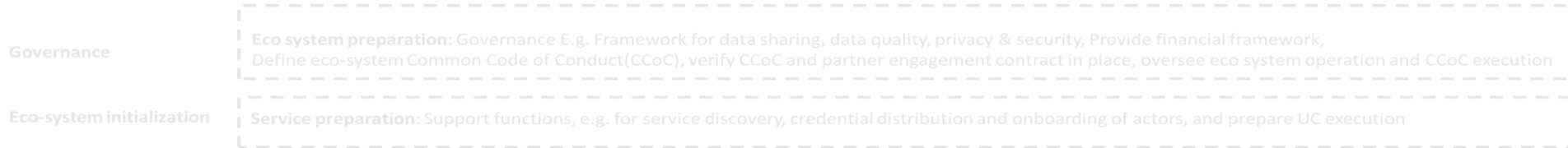
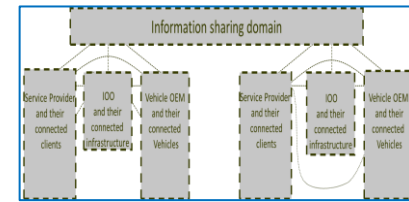
- Nationwide and cross-jurisdictional, cross-industry extensibility
 - Local, regional and state agencies
 - Vehicle OEMs
 - Communication service providers
 - Applications
- Includes structure for models of:
 - Governance
 - Initiation
 - Operations

...to address a broad range of **mobility and use cases** for systems management and to individual traveler.

Abstract view of an application-level reference architecture



V2N2X applied architecture overview



Some key concepts for information sharing using backend communication (Details in whitepaper and report)

- Standard IT security on application layer (E.g. TLS, X509 certificates)
- Privacy based on user consent, ensured by backend systems
- Application level interoperability
- Message Queuing Protocol (AMQP) with Publish/subscribe methods
- Meta data to enhance information and to allow filtering
- Geocasting/geo-referencing (e.g. 'Quadtree')
- Federated information assisted by a HTTP REST based protocol
- Discovery functions

V2N2X Solution Blueprint, and Use Case Implementation Examples

Presenter:
Yunpeng Zang (Ericsson)



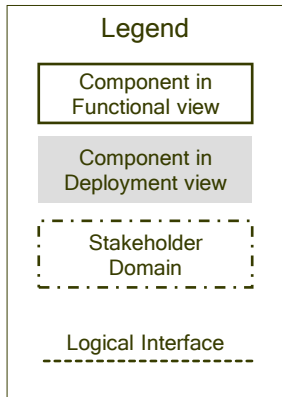
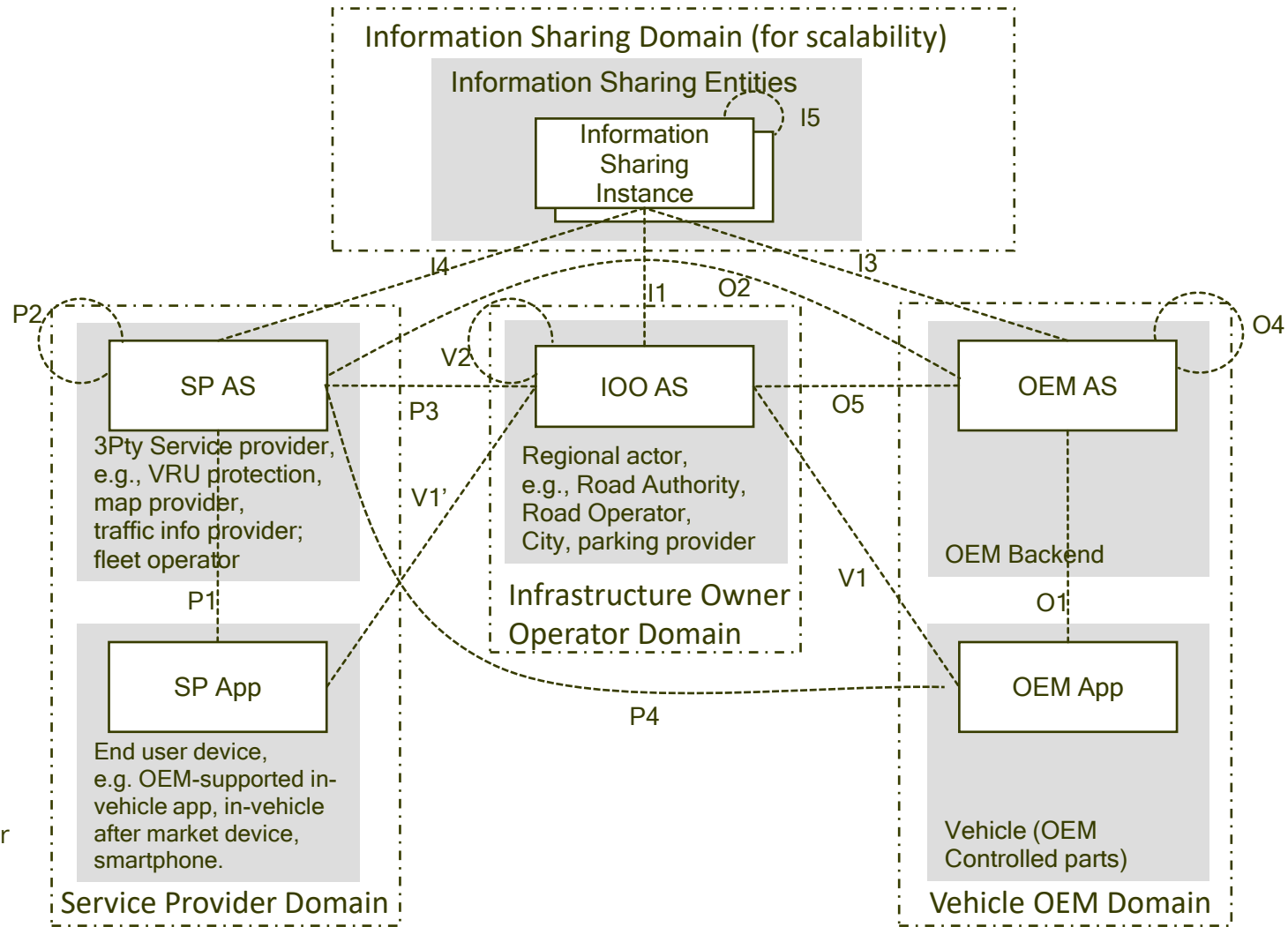
TECHNICAL REPORT

Vehicle-to-Network-to-Everything (V2N2X) Communications:
Architecture, Solution Blueprint, and
Use Case Implementation Examples

[Link to the technical report](#)

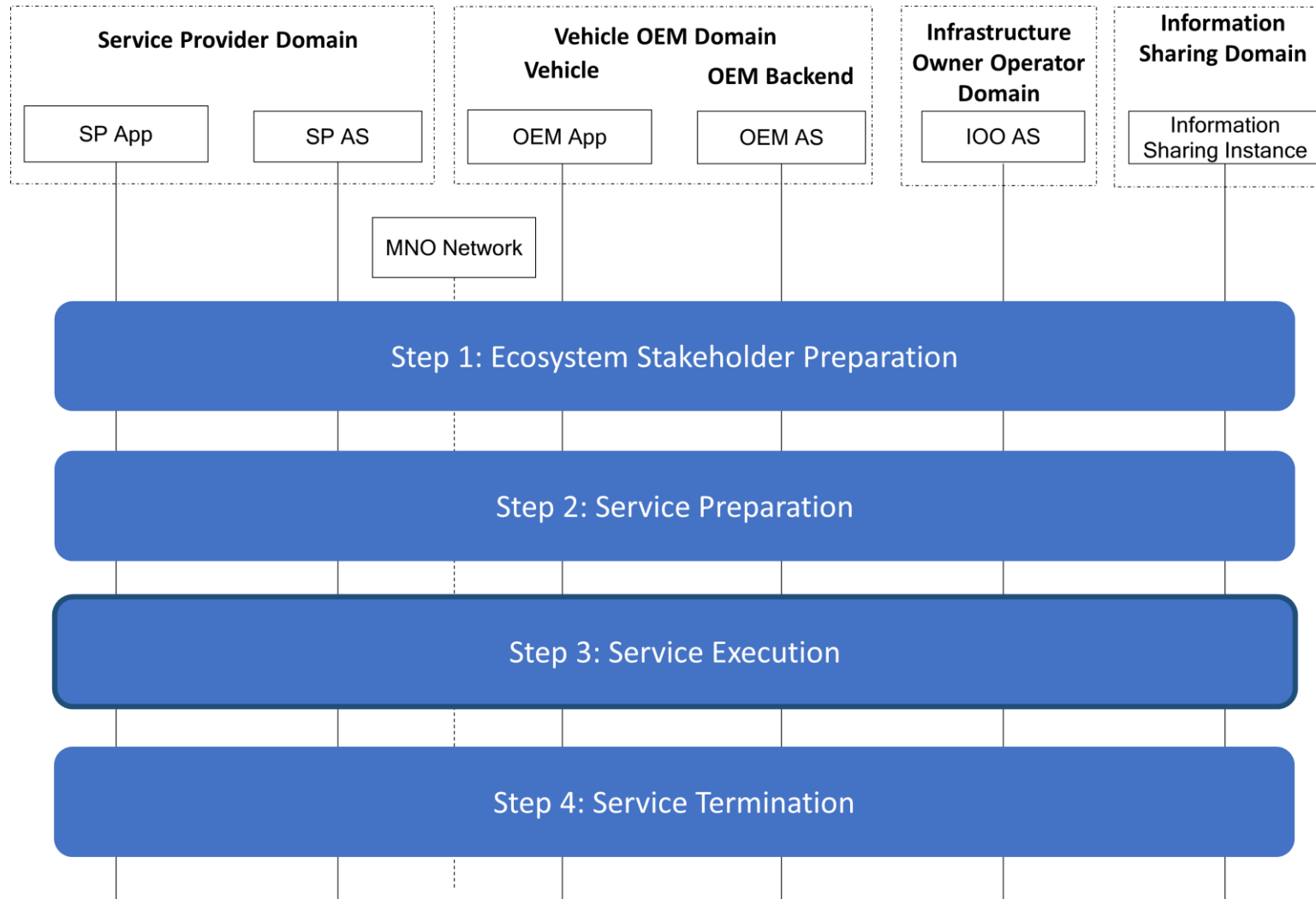


V2N2X Application Layer Reference Architecture



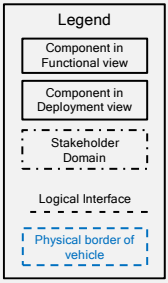
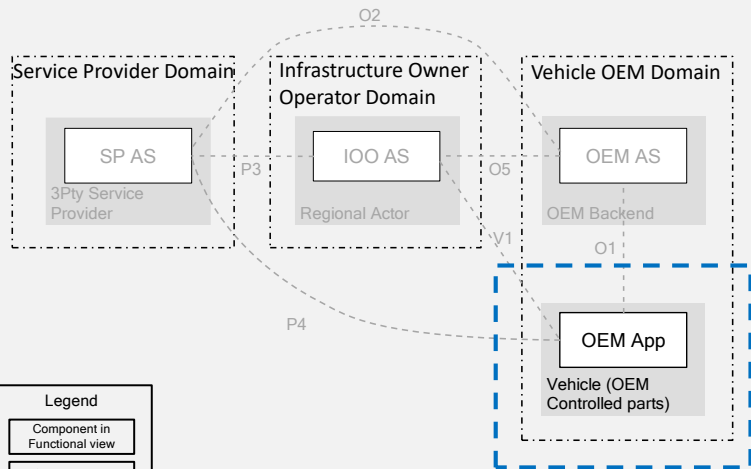
APP: Application
 AS: Application Server
 IOO: Infrastructure Owner and Operator
 OEM: Original Equipment Manufacturer
 SP: Service Provider

Hight level sequence diagram of V2X services

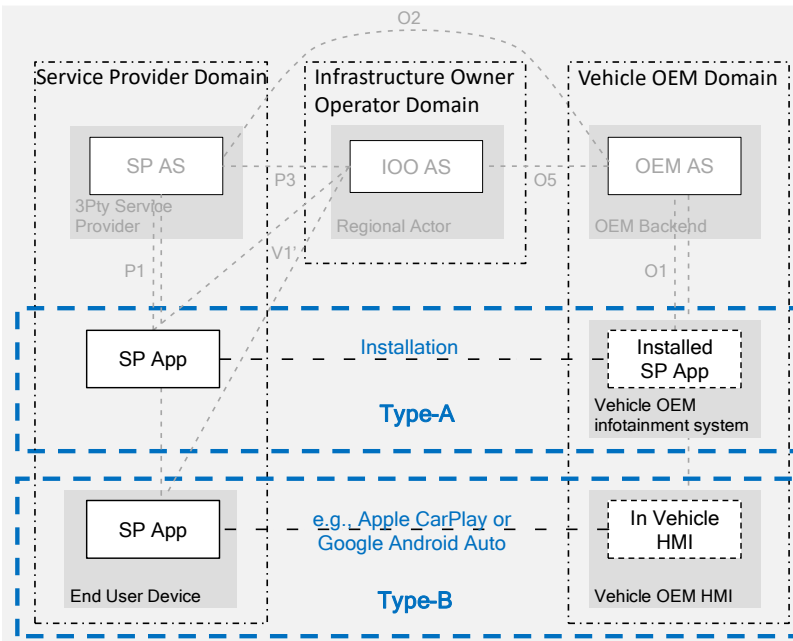


In-Vehicle Deployment Options

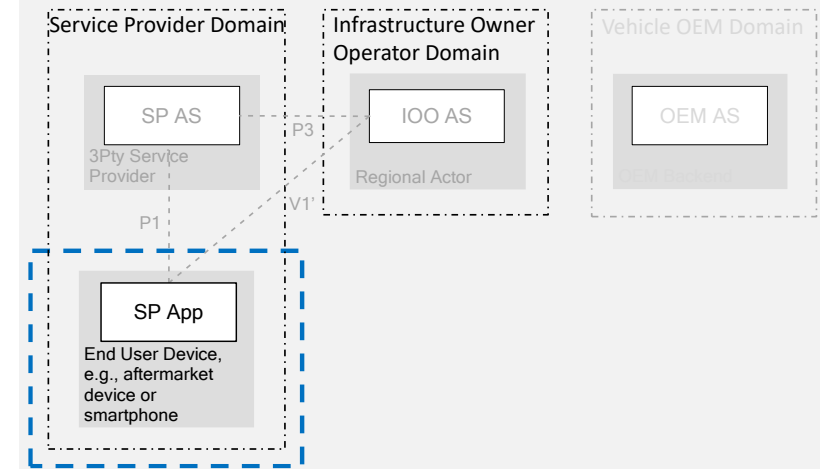
Option I: OEM App (Automotive OEM-controlled)



Option II: SP App (Automotive OEM-supported)



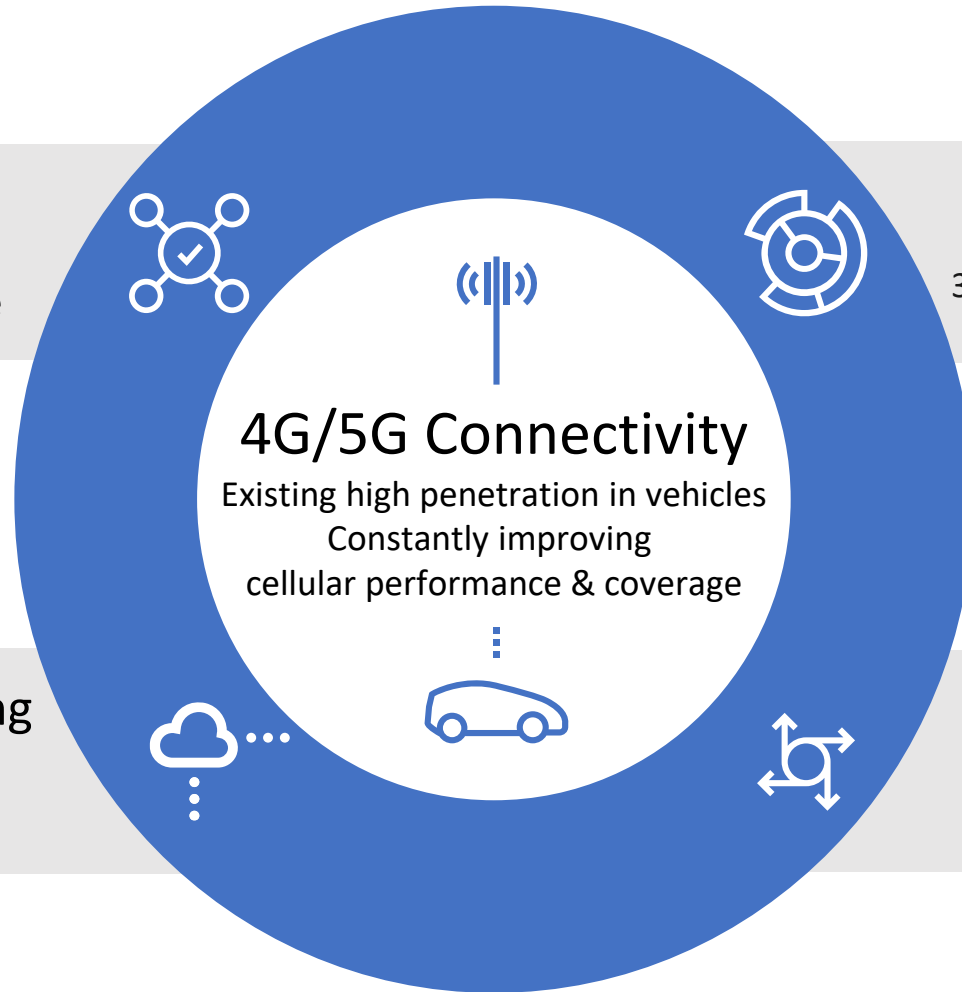
Option III: SP App (Automotive OEM-independent)



Cellular network features and deployment options

Quality of Service (QoS) & Network Slicing

Application level QoS, V2X network slice



Network Exposure & APIs

3GPP network exposure and CAMARA APIs

Multi-access Edge Computing (MEC)

Federated multi-MNO MEC



Local Breakout (LBO)

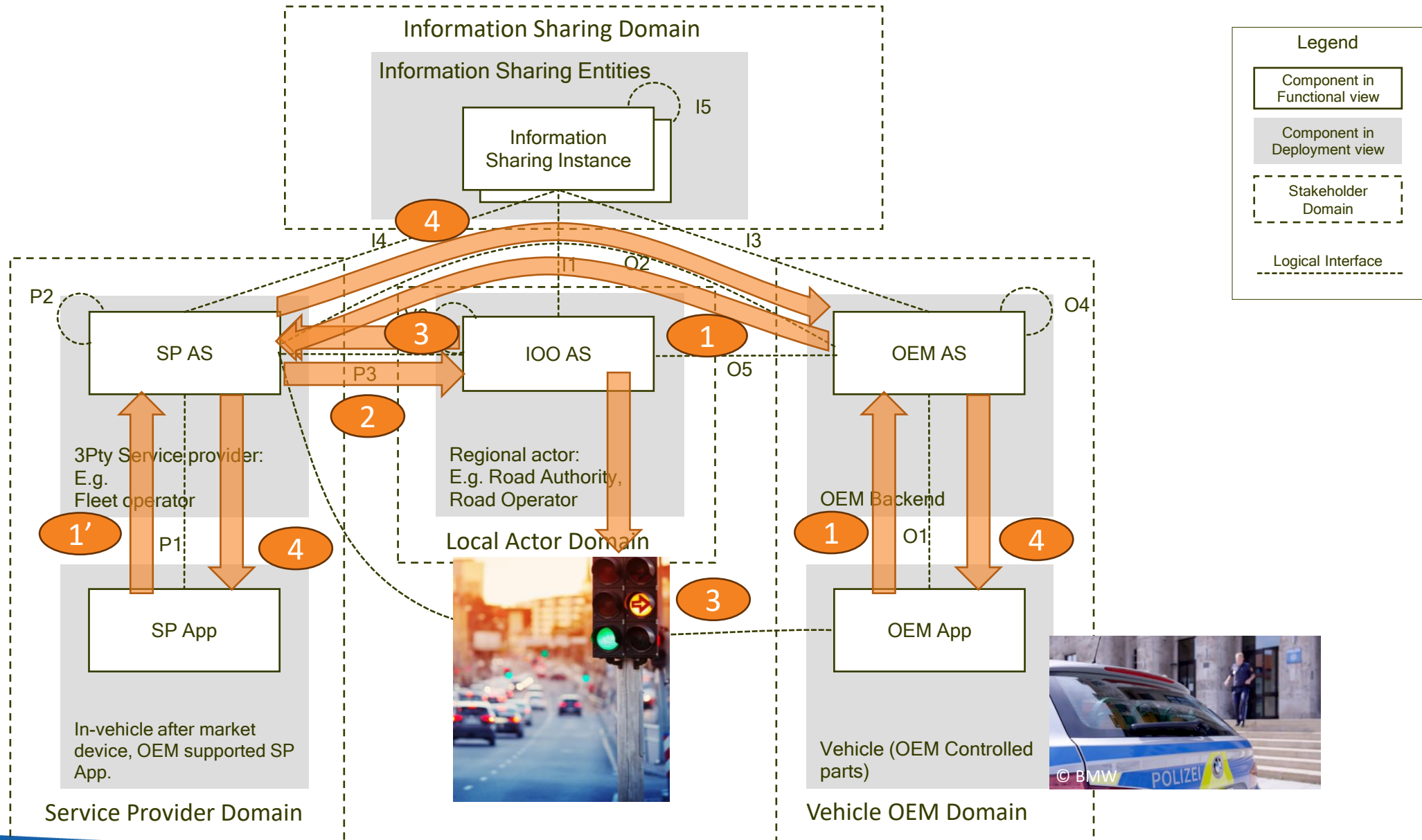
Regional breakout & Possible deployment with MEC



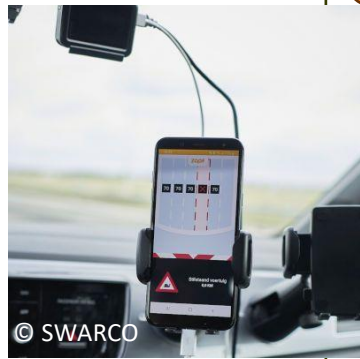
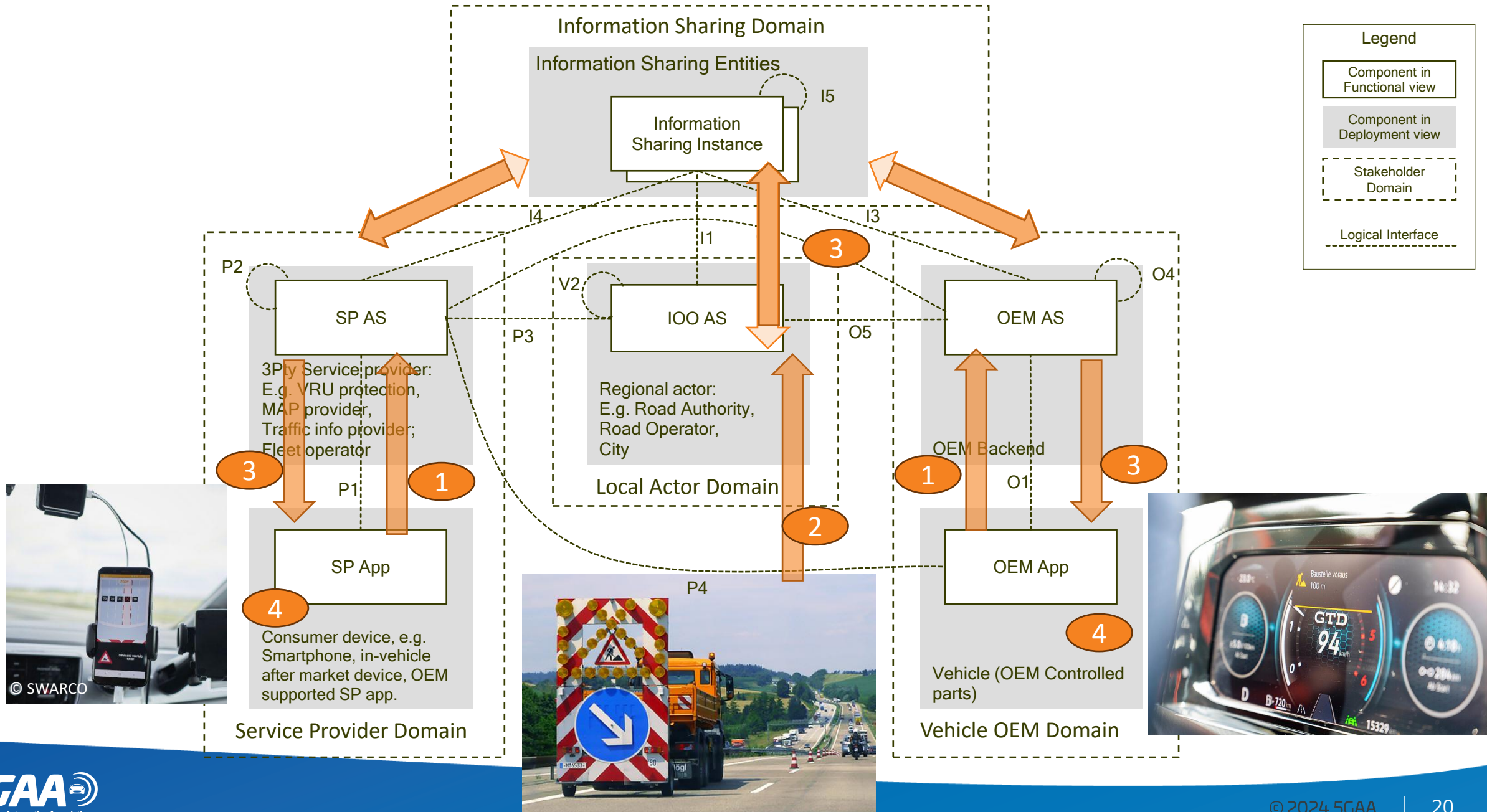
Use Case Implementation Examples

- **Traffic Signal Priority Request**
- **Traffic Event Information Sharing**
- Vulnerable Road User protection – VRU Collision Risk Prediction and Alert
- Traffic Signal Information Sharing
- Emergency Vehicle Approaching
- HD MAP Handling
- Automated Valet Parking/Automated Vehicle Marshalling
- Object Detection and Sharing

Traffic Signal Priority Request



Traffic Event Information Sharing



© SWARCO



Summary of V2N2X Architecture and Deployment Solutions

- V2X Use Cases (UCs) supported by existing cellular networks combined with cross-stakeholder information sharing.
- Especially for I2V/V2I UCs requiring long communication distance but less stringent latency.
- V2N2X solutions have been proven by various deployments.
- More demanding V2X UCs can be addressed by cellular communications in the future, thanks to improving network coverage, radio capacity and features.

Business Perspectives

Presenter: Menno Malta
(Monotch)



[Link to the technical report](#)

Large scale V2N2X deployment examples

Examples

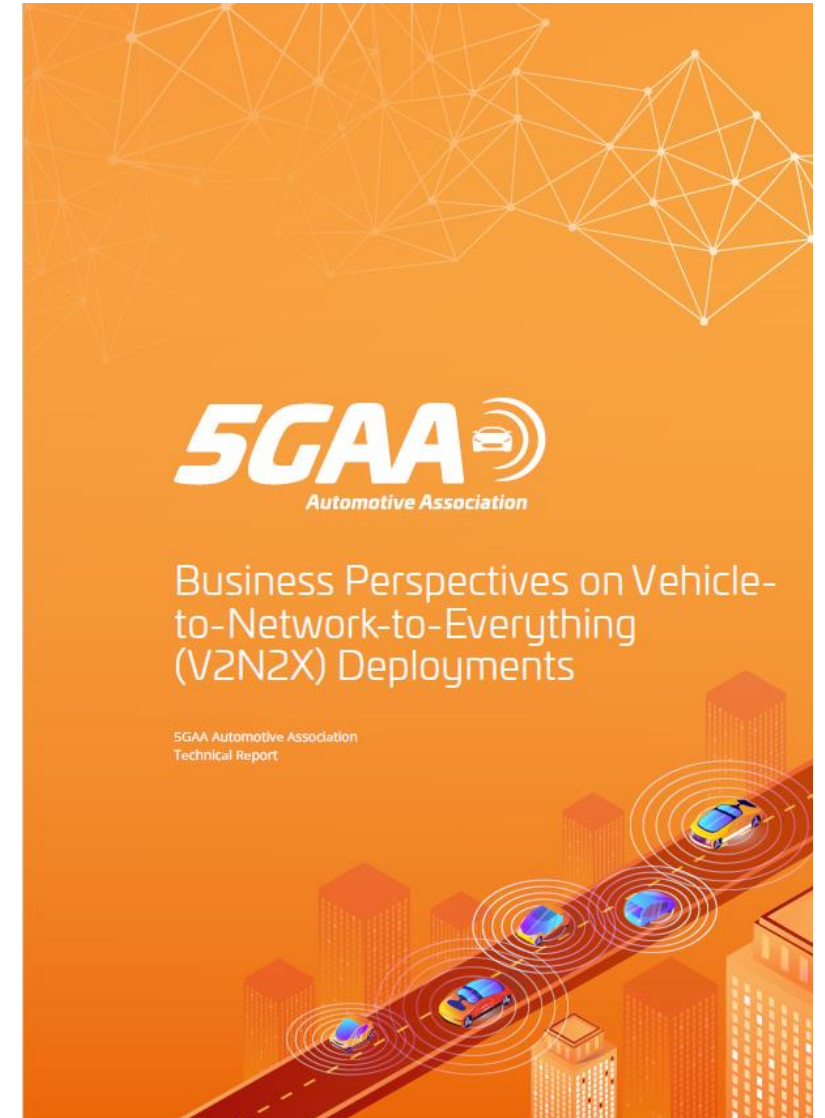
- The Netherlands (Talking Traffic, Safety Priority Services)
- Flanders, Belgium (Mobilidata)
- The US (Cloud Safety Alert Service)
- China (Wuxi)

Selection criteria

- Use the cellular network to exchange data with road users
- Cover a significant geographical area
- Serve, or expect to serve within the next 12 months, at minimum 100,000 unique road users
- Focus on deployment

Highlights analysed deployments

- **Broad range** of public-private actors from multiple sectors
- In The Netherlands **2.5 million passenger cars (out of 8.6m)** are consuming and sharing real-time data through aftermarket solutions.
- In Belgium the road authority is deploying **29 use cases**.
- More than **1.8 million vehicles** in the United States and Canada receive alerts of a safety hazard (emergency vehicles, road works).
- Wuxi (China) pilot site Intelligent Connected Vehicles has reached **about 700km**, including the deployment of over **400 pieces** of intelligent roadside equipment (TLC's, sensors etc.).



Analyzed example deployments

- ✓ Deployment summary description
- ✓ Use-cases
- ✓ Connections
- ✓ Actors, roles and revenue flow

Actors and revenue flow

Public actors	Role(s)	Investing in/Paying for
Ministry of IenW	Policymaker	Information system
Rijkswaterstaat/NDW (national highways authority)	IOO	Data producing works, speed limit
AZN (Joint ambulance services) and local Fire services		Data producing (status message)

Private actors	Role(s)	Revenue stream	Paying for
			Not specified
		Services +	Private owners
		to IOO	Ministry
			n.a.

Use cases

- ▶ In-car display of actual dynamic and static speed limits;
- ▶ Dynamic pre-emption/priority for designated road users such as emergency vehicles or public transport at intersections equipped with smart traffic lights;
- ▶ Optimisation of traffic flow at intersections by using traffic data transmitted by connected vehicles.

- ▶ 900 Gantries with lane signalling, dynamic speeds or text VMS;
- ▶ 100 moveable bridges and managed tunnels;
- ▶ 300 dynamic zone 30 VMS near schools;
- ▶ AWV weather station information;
- ▶ Integrated information of yearly 12.000 traffic hindrance events managed by the Flanders Traffic Centre
- ▶ 1,759 intersections with traffic lights being gradually converted to connected ITLCs;
- ▶ Track&trace of all AWV Winter service vehicles;
- ▶ Track&trace of all AWV authorised crash absorber vehicles and slow moving vehicles at mobile roadworks;

V2N2X Business perspective

- V2N2X is a subset of \$20 Bn market (2030)*
- Indirect communication via the cellular network (e.g., V2N2X, I2N2V) constitute the most significant yet untapped V2X channel*
- Key Factors driving market growth:
 - Growing societal challenges (addressed globally by public policies)
 - Digitalization / Tech capabilities / Network coverage & capabilities
 - Legislation (specifically the EU)
 - EURO NCAP Vision 2030

**Sources in Technical report*

Profiles Direct V2N2X Stakeholders

Infrastructure Operators and Owners

Vehicle OEMs

Gains

- influence behaviour of road users
- reduce investments in field equipment
- get (near real time) insights on the behaviour of road users
- getting information about road conditions
- innovative image
- deploying dynamic traffic management policies

Jobs to be done

- Provide safer transport
- Contribute to a more efficient transport system
- more sustainable transport
- more equitable transport



- investing in technology that does not result in instant impact
- replacing/supplementing fuel tax

Pains

Gains

- offer enhanced services based on data that is only available through the cellular network
- innovative corporate image
- gather additional insights into customer behaviour
- the opportunity to experiment with a 'service menu'

Jobs to be done

- Meeting legislation
- Improving the delivery of safety-relevant applications
- improvement of customer comfort
- the generation of additional service revenue



- Lack of scalable solutions
- Access to Infrastructure data
- reduce the need for investments in technology without short / medium term results
- reduce future physical 'legacy' in-car equipment

Pains

Business models in example deployments*

- **IOOs** are digitalizing operations, investing in, and sharing an increasing amount of data
- **Service/App Providers** have business models around Consumer subscriptions & monetization of road user data
- **Tech providers** have business models around supporting development, deployment and connectivity

**Talking Traffic (The Netherlands) / Safety Priority Services (The Netherlands) / Mobilidata (Flanders, Belgium) / Cloud safety alert service (US) / ICV Zones (China)*

Conclusions

- V2N2X Deployments are growing in data, use-cases and connections
- Example deployments and market factors show a way forward:
 - IOOs have access to early, yet significant, benefits
 - Vehicle OEMs expected to become more active in the V2N2X eco-system in the future
 - V2N2X eco-system offers excellent capabilities to standardize and harmonize data and manage privacy and security
- Some technical concerns: data quality, security, privacy
- Need for continuous education of the eco-system on existing large-scale showcases and cellular coverage

Closing remarks

Closing remarks

- TR covers all relevant areas in high detail >> plug and play 😊
- V2N2X and short-range communication can and will co-exist
- The two techs will be used as one in complementary mode
- V2N2X can work immediately and effectively (as we just heard from various deployments)
- Start with V2N2X kickstarts overall V2X deployment



Thank all for tuning in!

Q&A

If you have any further questions, please contact the 5GAA marketing and communications team: marcom@5gaa.org