



C-ITS SOLUTIONS FOR SAFE TUNNELS

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Research Institutes of Sweden

RISE Viktoria



ONE RISE, SERVING ALL



RISE VIKTORIA

Cooperative Systems



Electromobility



Sustainable Business

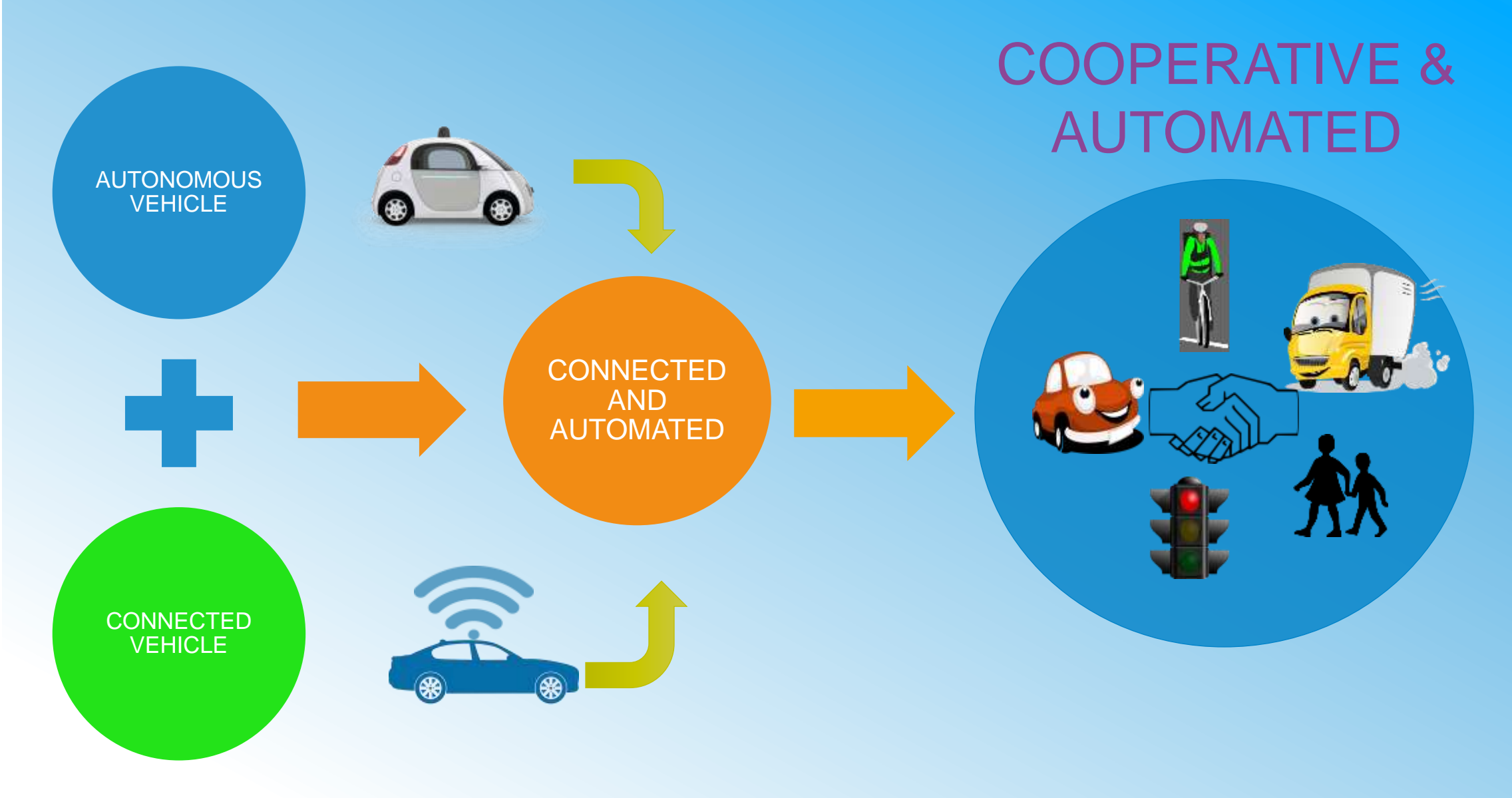


Digitalization Strategy



Sustainable Transport

TRANSPORT EVOLUTION



WHERE ARE WE?



- Automation

Mercedes: Partly automated production model tested



ZF: Fully automated remote truck docking



Kamaz: Partly automated production model



Royal Truck & Equipment: Fully automated impact protection



Volvo: A refuse truck in urban environment



Caterpillar: Fully automated mining truck



Freightliner: Fully automated Inspiration Truck.



Peterbilt: Advanced driver assistance system



Scania: Highway truck platooning



- Goods transportation

Uber: Automated mobility service on highways



Peloton: Aftermarket solution for platoons on highways



tuSimple: Automated mobility service on highways



Embark: Single truck driving on highways



Mercedes Benz: A nest for delivery drones



- Goods transportation

This isn't just a company. It's a movement.

Einride is installing the world's first completely emission-free, road-based transportation system. We are rethinking the entire transport infrastructure from the ground up, creating the transport solution of the future.

[Learn more](#)

Tesla: Automated highway driving & autonomous parking for existing models.



Ford: No steering wheel for taxi services by 2021. Start selling to ordinary customers by 2025.



Volvo Cars: Automated highway driving in Sweden, China, the UK.

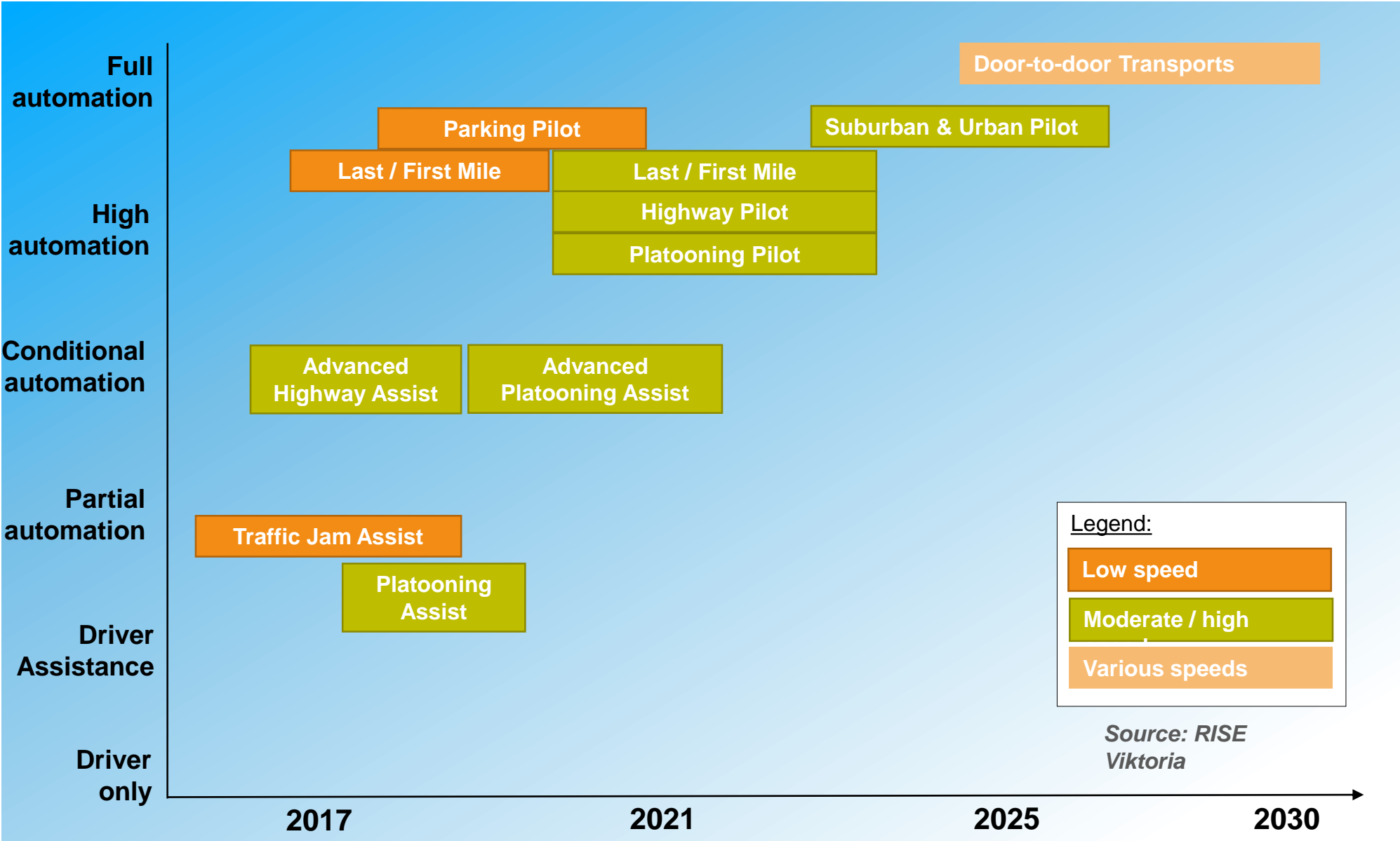


Toyota: Automated highway driving, to be commercialized in 2020.



- People transportation

AUTONOMOUS FUNCTIONS



AV AT TUNNELS

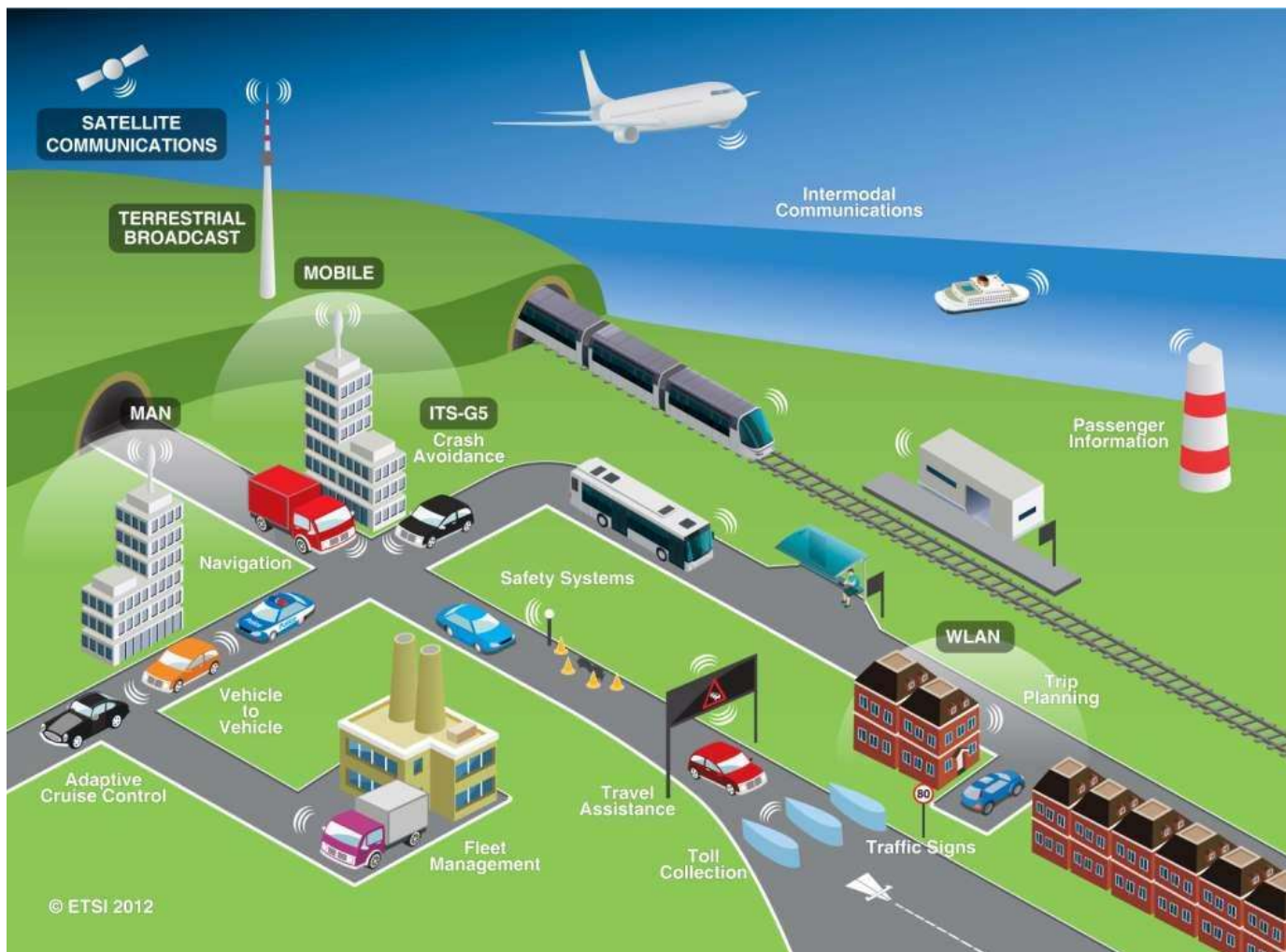
- Road markings
- Lighting conditions (especially at the entrance and exit)
- Positioning
- Testing miles and conditions
- Emergency response process
- Fire and smoke detection/recognition
- Batteries for Hybrid and electrical vehicles
- Corner scenarios



The Mercedes-Benz Future Bus

- Significant challenges

COOPERATIVE INTELLIGENT TRANSPORT SYSTEMS



■ Connectivity

C-ITS R&D

interactive 

 CyberCars

 HAVEit

 COSMO

 Nordic WAY

 SAFESPOT

 eur FOT
Empowering drivers with the road

 CVIS
CONCEPTS FOR VEHICLE INTERACTIVE SYSTEMS

 KIPAS

 CoCarX

 CONVERGE

 CityMobil

 coopers

 SARTRE
Safe Road Trains for the Environment

 DRIVE+

 Compass 4D

 game

 C-ROADS

 COM Safety

 eCoMove

 AUTONET
2030

 Cooperative ITS Corridor
Joint deployment

 simTD

 FOTsis

 AdaptiVe

 INTERSAFE2

 TEAM
Transportation
Education
Action
Mobility

- Significant research efforts
- Large scale trials
- Ready to deploy

COMMUNICATION TECHNOLOGIES

GSM

- Up to 90%
- best effort
- 2 – 5 s

UMTS

- 75 – 90%
- Various QoS (3.5G)
- 300 – 500 ms
- Broadcast (3.5G)

LTE

- Urban coverage
- Various QoS
- 50 – 150 ms
- D2D (no ITS)
- broadcast

LTE-A

- Rolling
- High QoS
- 10 – 20ms
- D2D (ITS)

5G

- 2020 beyond
- Ultra High QoS
- 1 ms
- D2D
- broadcast

- Cars are already connected through cellular
- ITS-G5 is expected to be deployed as of 2019
- 5G V2X complement with ITS-G5, business model is yet to come

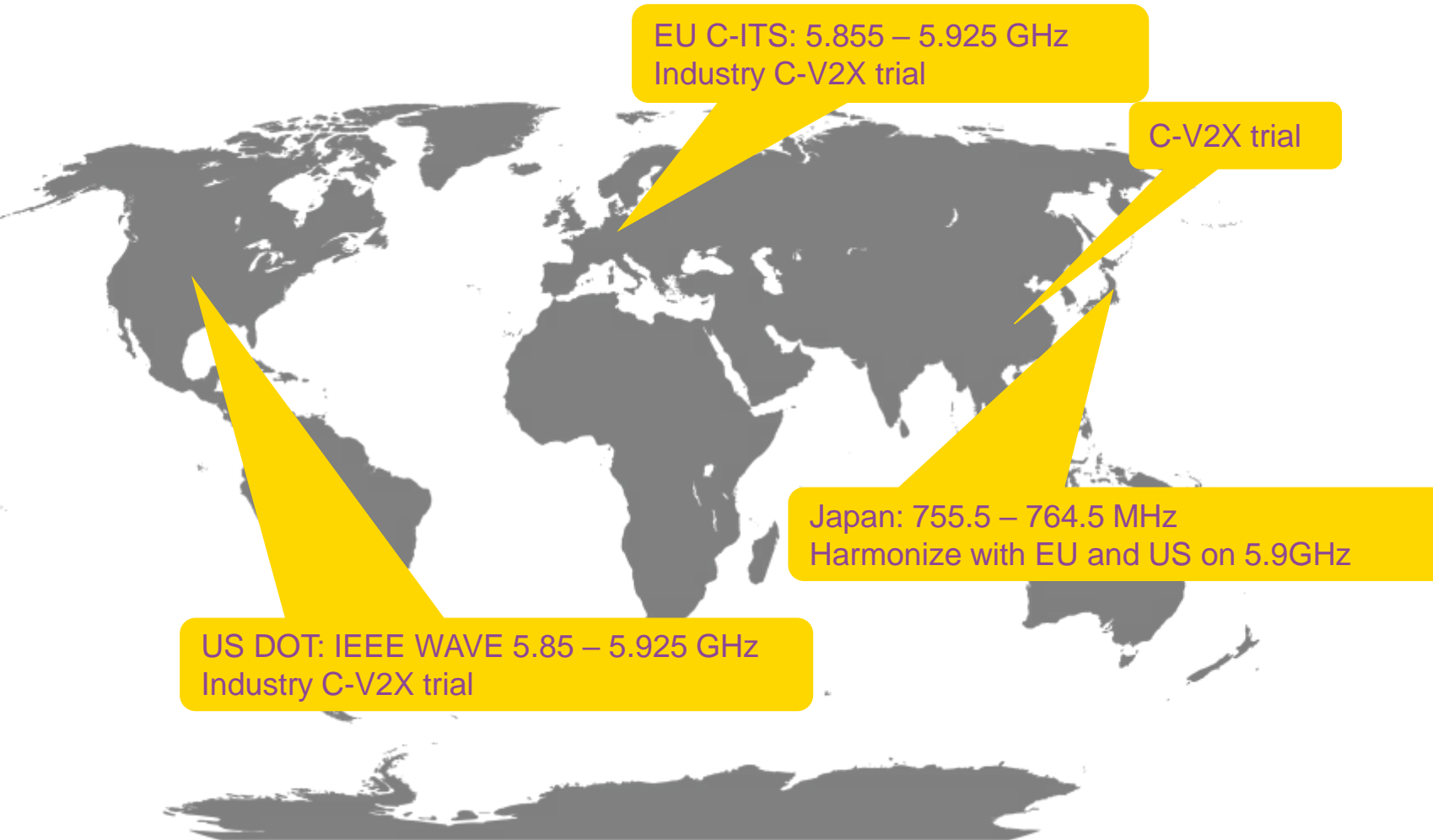


connectivity

ITS-G5

- Up to 1km,
- 300 – 500m
- High QoS
- < 100 ms
- Ad-hoc

GLOBAL STATUS



- EU-US-Japan harmonization on ITS frequency band
- 3GPP is catching up with LTE-based solutions
- 5G is on the way

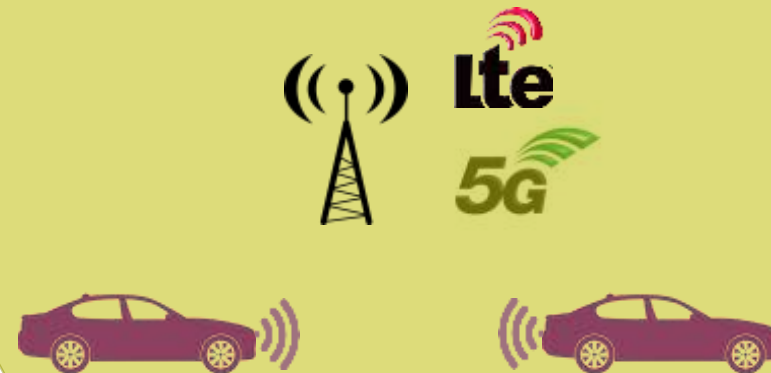
CELLULAR AND ITS-G5 DEBATE

ITS-G5/DSRC




- Safety critical situation
- Low latency communication
- Many years research and pilot
- Ready to go
- Congestion problem
- Not really future oriented, maybe

- Future oriented
- Support more advanced functions
- Backed by telecom and most OEMs
- Still at the starting point
- Business models
- Spectrum



WHILE WE DEBATE



€100 Billion

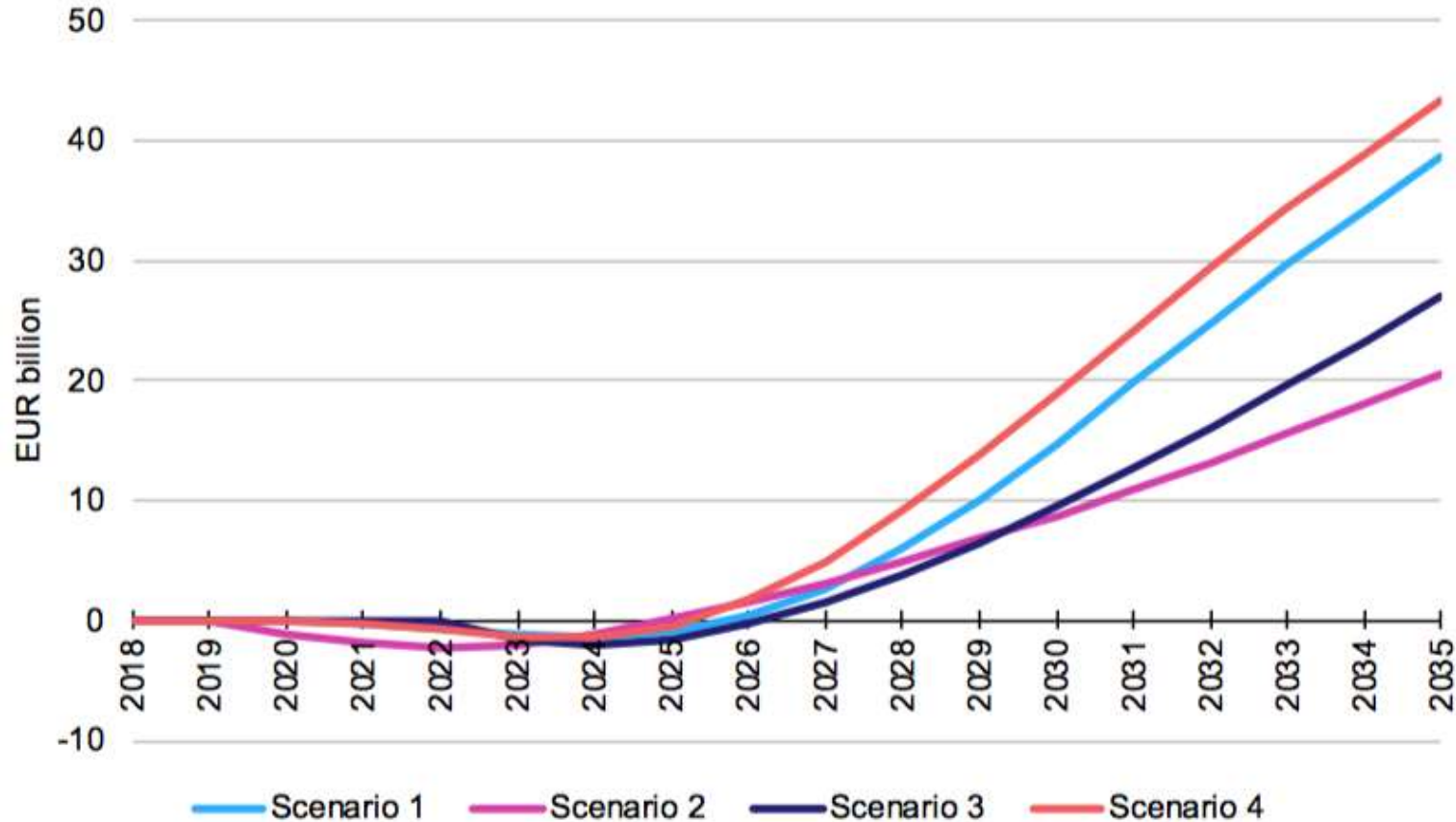
EU C-ITS Platform

- Benefits positive somewhere 2022 to 2026
- Benefits dominated by e.g., reduced travel time, reduced accident rates, reduced fuel consumption
- Costs dominated by vehicle equipment and are service independent

3:1

- Cost benefits

5GAA ON NET BENEFITS



- Scenario 1: no mandate, let industries solve (€39B)
- Scenario 2: 2020 Mandate 802.11p (€20B)
- Scenario 3: 2023 Mandate LTE PC5 (€27B)
- Scenario 4: Co-working on 5.9 GHz (€43B), equal bandwidth

STOP WAITING, DO IT

ITS-G5/DSRC



- Safety critical situation
- Low latency communication
- Time is NOW



Deploy



Hybrid

- Future oriented
- Support more advanced functions
- At the starting point



Trial

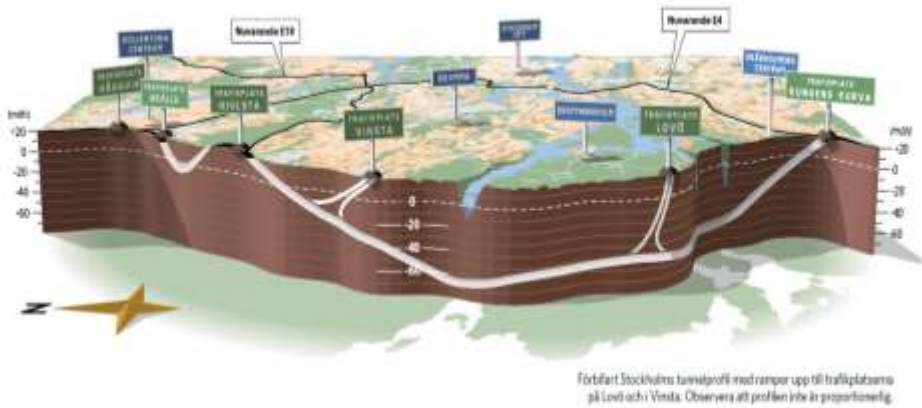
NORDIC WAY



- Weather information
- Road hazardous warning
- Slippery road warning
- ITS-G5 and Cellular
- Nordicway2 starts

STOCKHOLM BYPASS TUNNEL

Length: ca 21 km
Tunnel: ca 18 km
Travel time: ca 15 minutes



Cooperative ITS for Safer Road Tunnels: Recommendations and Strategies FINAL REPORT

AUTHORS: Azra Habibovic, Måhdere Amanuel, Lei Chen, Cristofer Englund
PROJECT: ITS Solutions for Safe Tunnels (initiated by Swedish Road Administration and co-financed by Trans-European Transport Network (TEN-T))
DATE: 2014-11-17



Co-financed by the European Union
Trans-European Transport Network (TEN-T)



TRAFIKVERKET

The sole responsibility of this publication lies with the author. The European Union is not responsible for any use that may be made of the information contained therein.



C-ITS ESSENTIAL FOR TUNNEL SAFETY

- C-ITS will help improve tunnel safety, both DSRC and Cellular

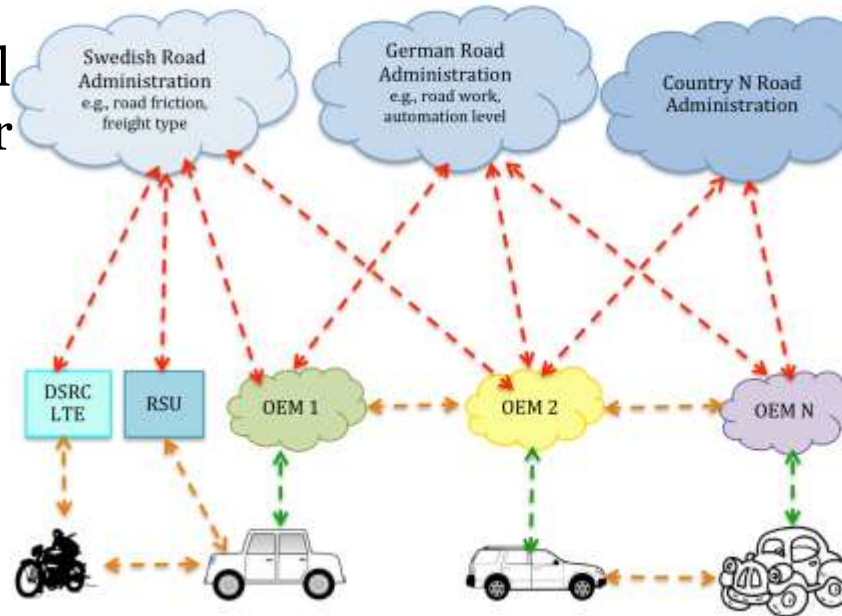
- Situational awareness
- Emergency response
- Information sharing
- Cooperative positioning

- Certain information needs to /must be communicated

- C-ITS data sharing platform

- Emerging technologies

- Autonomous vehicle
- 5G



- Green: already available
- Orange: in the near future
- Red: need to be developed

- DIGITAL INFRASTRUCTURE



- **Accelerate** real-life implementation of cooperative driving
 - Based on C-ITS Release 1 and contribute to Release 2
 - Multi-vendor approach and close-to market implementation
- Joint **development** and **demonstration**
 - Environmental perception
 - Wireless communication (V2V)
 - Vehicle automation
- **Realistic** scenarios
 - Highway: Platoon merge
 - Urban: Cooperative intersection
 - Demo: Emergency vehicle

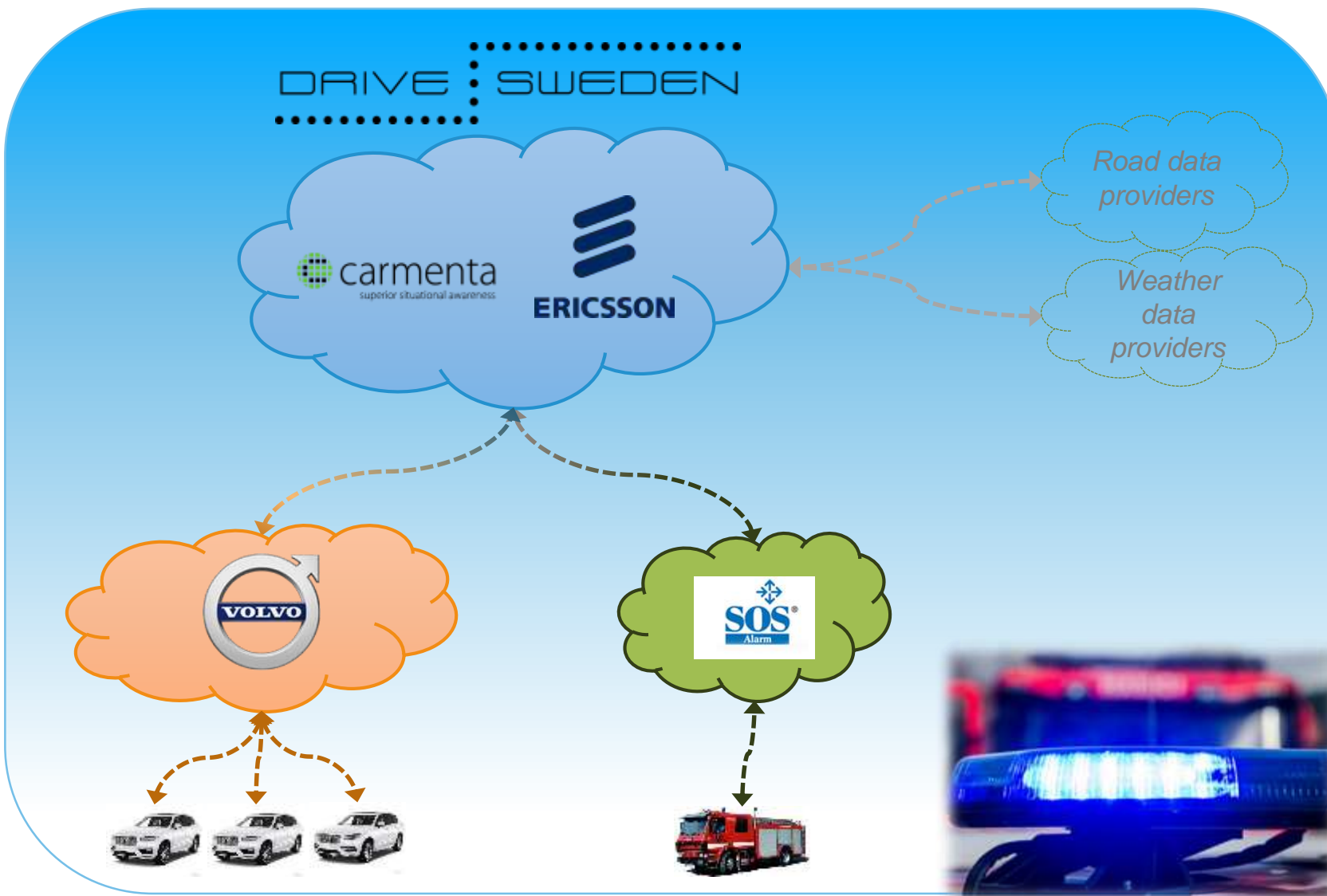


IGAME- EMERGENCY VEHICLES



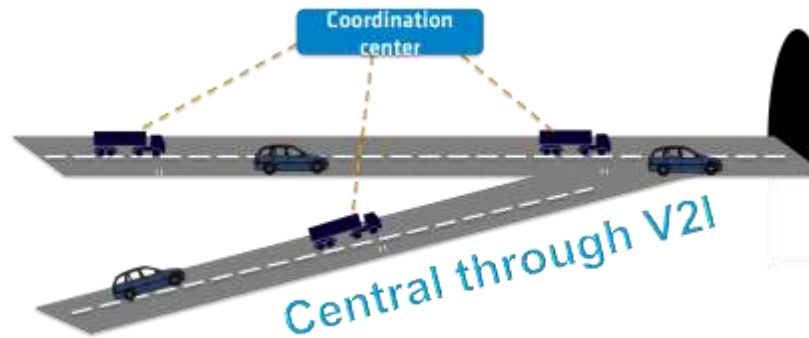
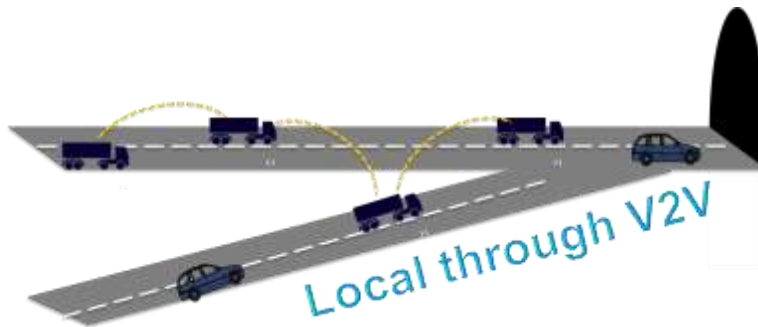
- EV communicate with other vehicles through V2V
- Other vehicles give way automatically
- Tunnels?

AD AWARE TRAFFIC CONTROL – EMERGENCY VEHICLES



- Traffic cloud
- Different stakeholders
- Emergency vehicles information to other road users for priority
- Tunnel?

DANGEROUS GOODS VEHICLES



*Paper: Chen et al., 2015.
Coordinating dangerous goods
vehicles: C-ITS applications for safe
road tunnels.*



- Coordinating dangerous goods vehicles (DGV)
 - Minimizing risks through coordination
 - Share information with operators
 - Warn other road users about the DGVs
 - Potential C-ITS application

DIGITAL RULES FOR GEO-ZONES

- Tunnel traffic rules apply within the zone
- Communicate with vehicles before entry and exit
- Detailed geometry and traffic information
- Instructions during emergency response
- Digital instructions for AV



Digital runway incursion warning (RISE)

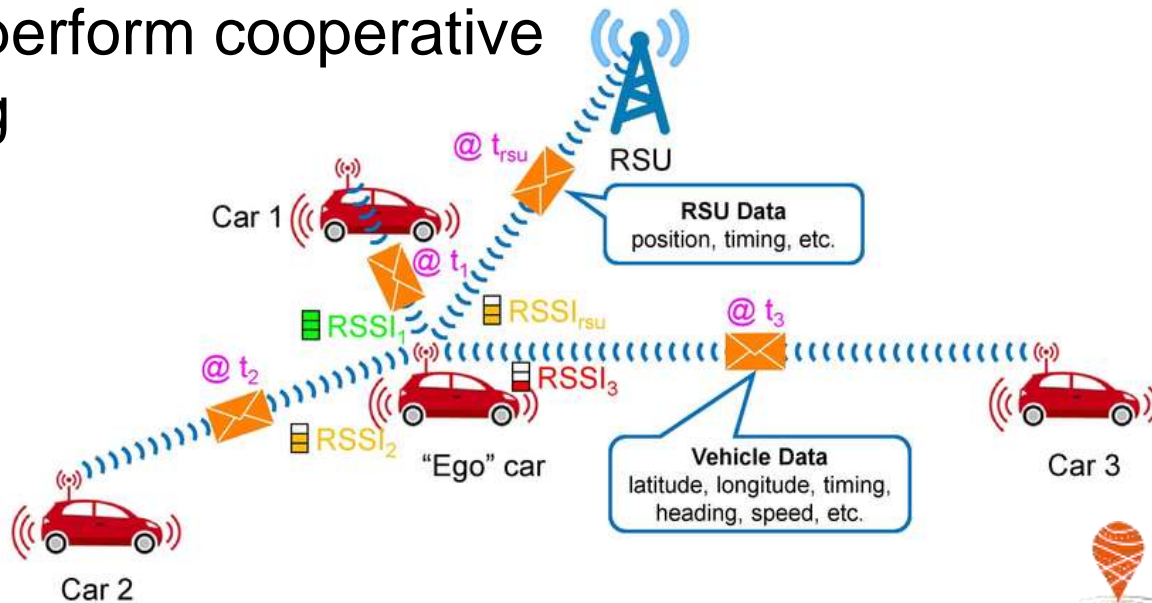


Geo-fencing demo (Trafikverket)

- GEO-FENCING

COOPERATIVE POSITIONING

- GNSS + ITS-G5 + on-board Sensors (Inertial, camera, etc.)
- Cooperative cars exchange information through V2V link
- Ego cars perform cooperative positioning



- POSITIONING

WHAT WE DO NOW

- C-ITS integrated with tunnel planning and operation
 - V2X in tunnel test and pilot
 - Use cases and requirements for V2X at tunnels
- Autonomous vehicles in tunnels
- Digital infrastructure, with focus on tunnels
 - Tunnel traffic rules
 - Evacuation instructions
- Vehicle data sharing platform
 - Clear definition on data requirements
 - Facilitate the business case
- Systematic thinking
 - Engage stakeholders
 - Proactive

■ SUMMARY



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