CONNECTED AND AUTOMATED MOBILITY FROM A ROAD OPERATOR'S POINT OF VIEW

IEEE Standards Meeting

Munich, 2/3 December 2019

Stefan Ruehrup

ASFINAG

- Mobility as a Service
- Connected Vehicles
- Automated Driving

About ASFINAG

- The Austrian motorway and expressway operator
  - Planning
  - Construction
  - Operation / Maintenance
  - Tolling

100% financed via tolling

30 billion km
driven per year

2.223 km
network length

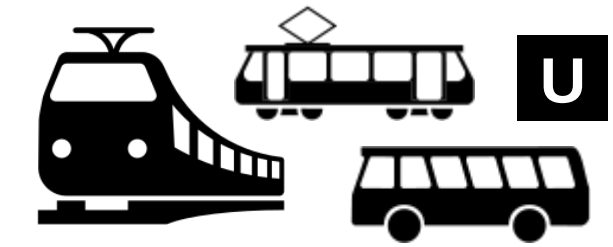
ASFINAG Vision

ASFINAG is one of Europe's leading motorway operators with a special focus on:

- road safety
- availability
- traffic information
- traffic management
- technological innovations

Mobility as a Service

- is end-user oriented
- involves all modes of transport
- combines existing services
- requires data sharing → interfaces and interoperability



Public transport

Individual mobility

On-demand transport

Sharing mobility

MaaS made in Austria

- Strategic framework
- Definition of Readiness levels

ITS austria

https://www.austriatech.at/en/its-austria/

"Mobility as a Service" (MaaS) is an end user-oriented, intermodal service that claims to combine the offers of existing mobility providers in all modes within the framework of the core components

- intermodal travel information and
- use of the travel offer under consideration of
- booking, reservation, payment and billing
- including new forms of mobility (e.g. sharing mobility)

in an integrative service (e.g. one-stop-shop principle) and at the same time act as a basis for new services.

Source : ITS Austria – MaaS made in Austria – National framework conditions for the realization of MaaS in Austria

Data Exchange

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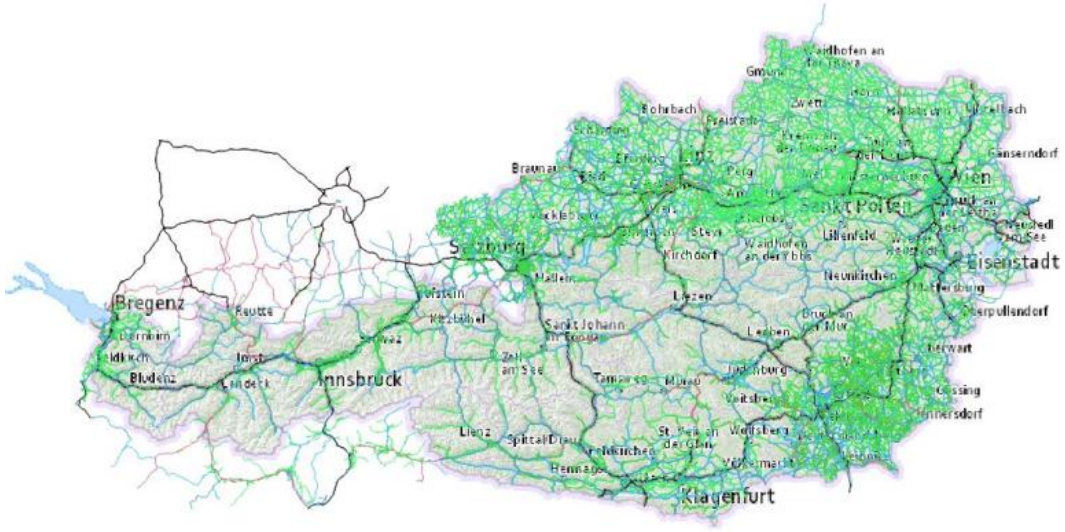
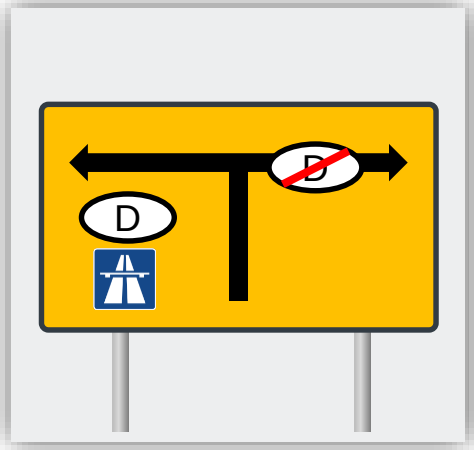
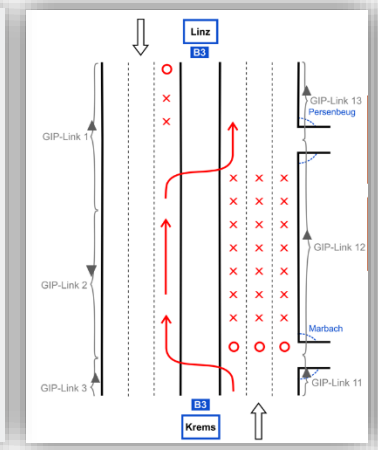
Other road networks

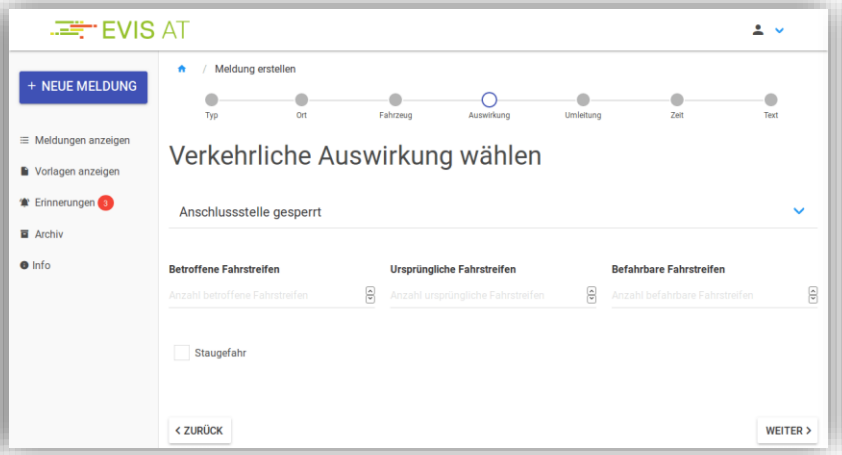


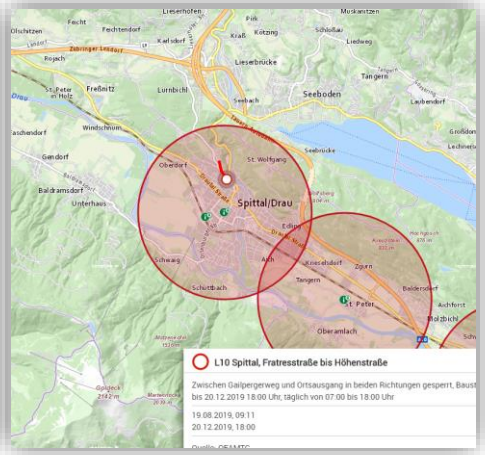
Neighbouring countries

Public transport providers

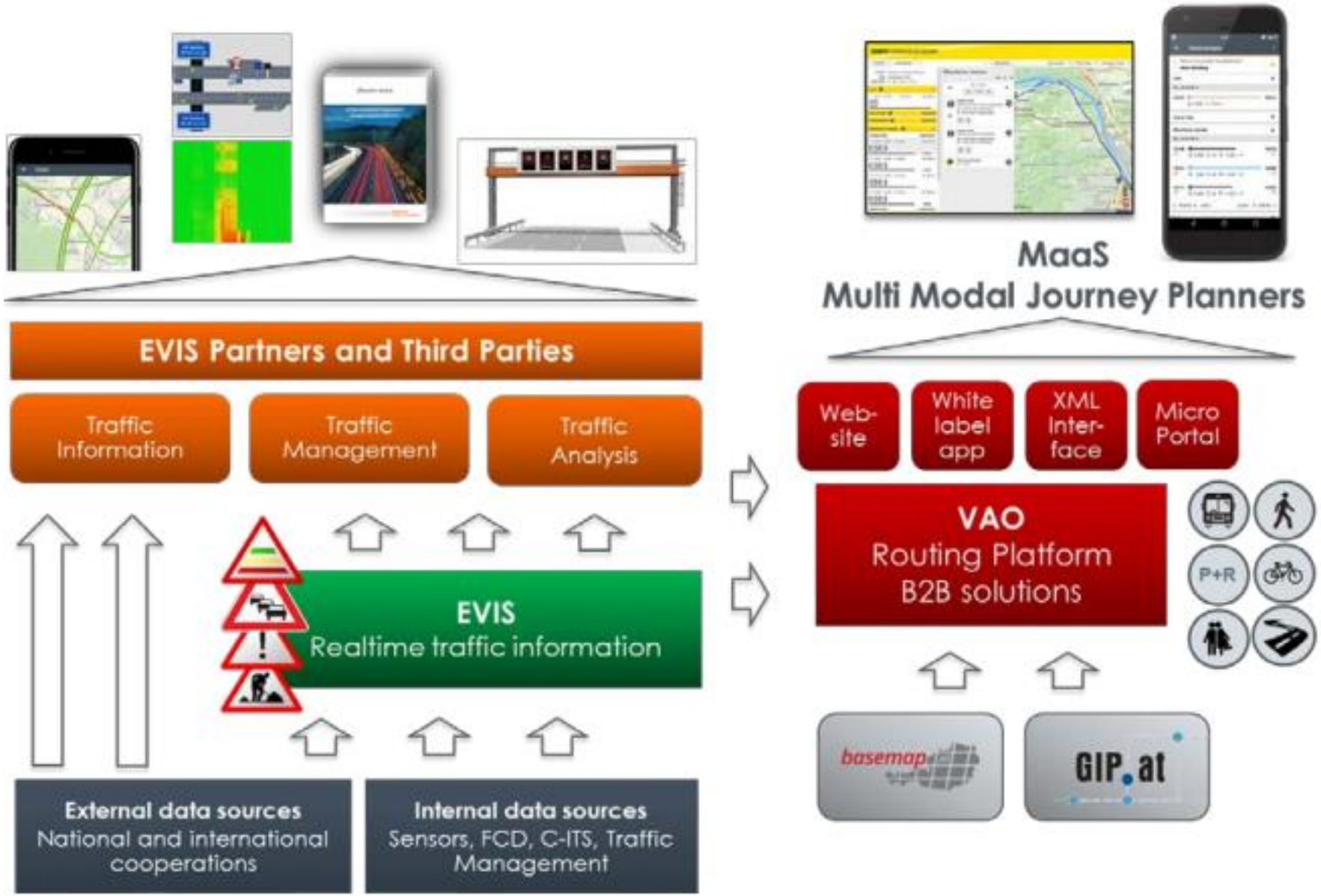








MaaS and its Contributors



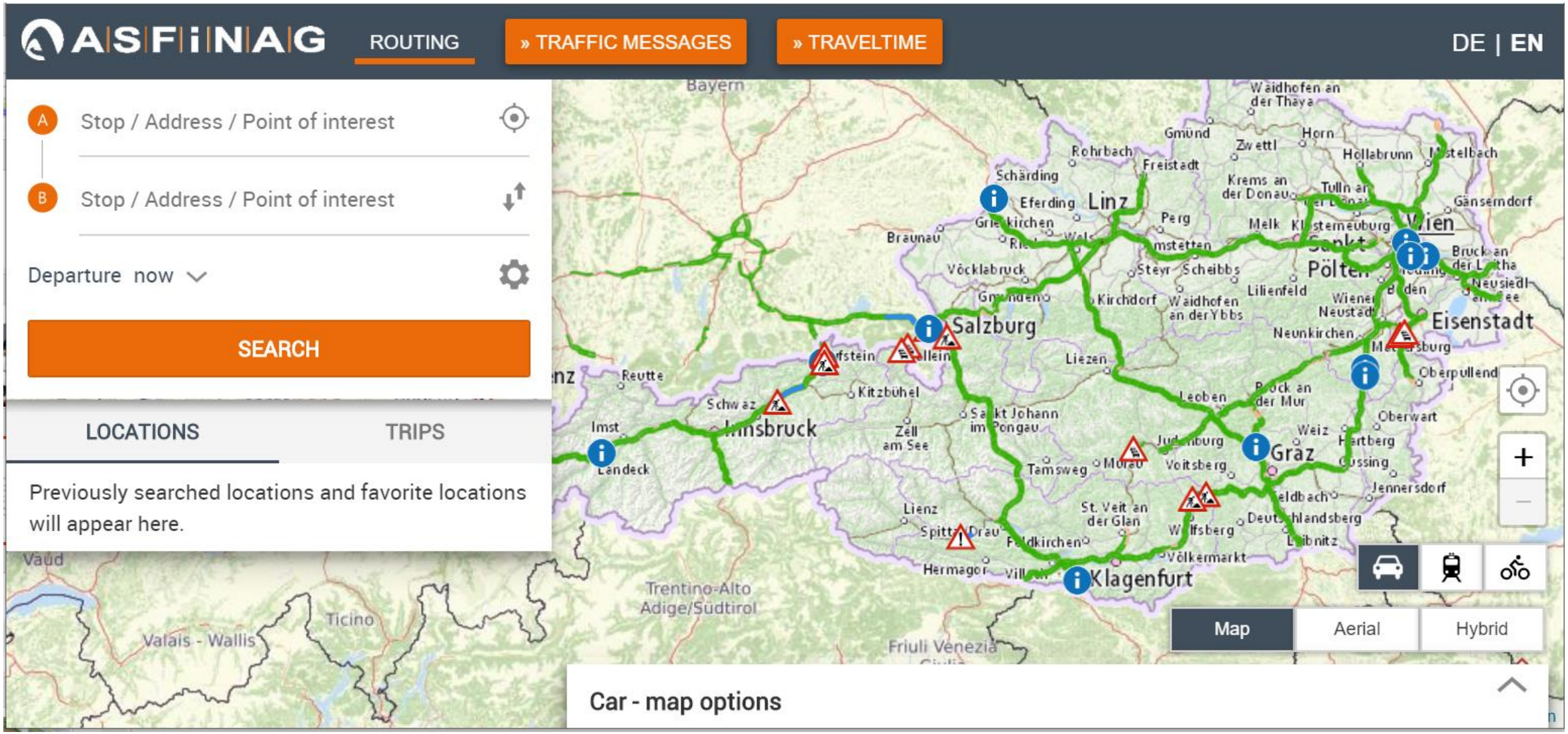
evis.gv.at

verkehrsauskunft.at

www.gip.gv.at

www.basemap.at

Routing based on common platform



ASFINAG App

Stay informed with the **ASFINAG App**! Now in 14 languages.

Routeplanner

Traffic Info

e.g. Webcams, Kompagnon, Travel Times

GET IT ON Google Play

Download on the App Store

Standardisation aspectcs

- DATEX II is an important toolbox: CEN/TS 16157 series
  - Adaptable, allows profiling for a specific application
  - Modular: separate schemas for common elements, locations, VMS, traffic situations
  - Modeled in UML, presented in XML; JSON possible.
- Important standards for public transport
  - Network and Timetable Exchange (NeTEx), CEN/TS 16614 series
  - Standard Interface for Real-time Information (SIRI), CEN/TS 15531 series

CONNECTED VEHICLES

ITS services until now

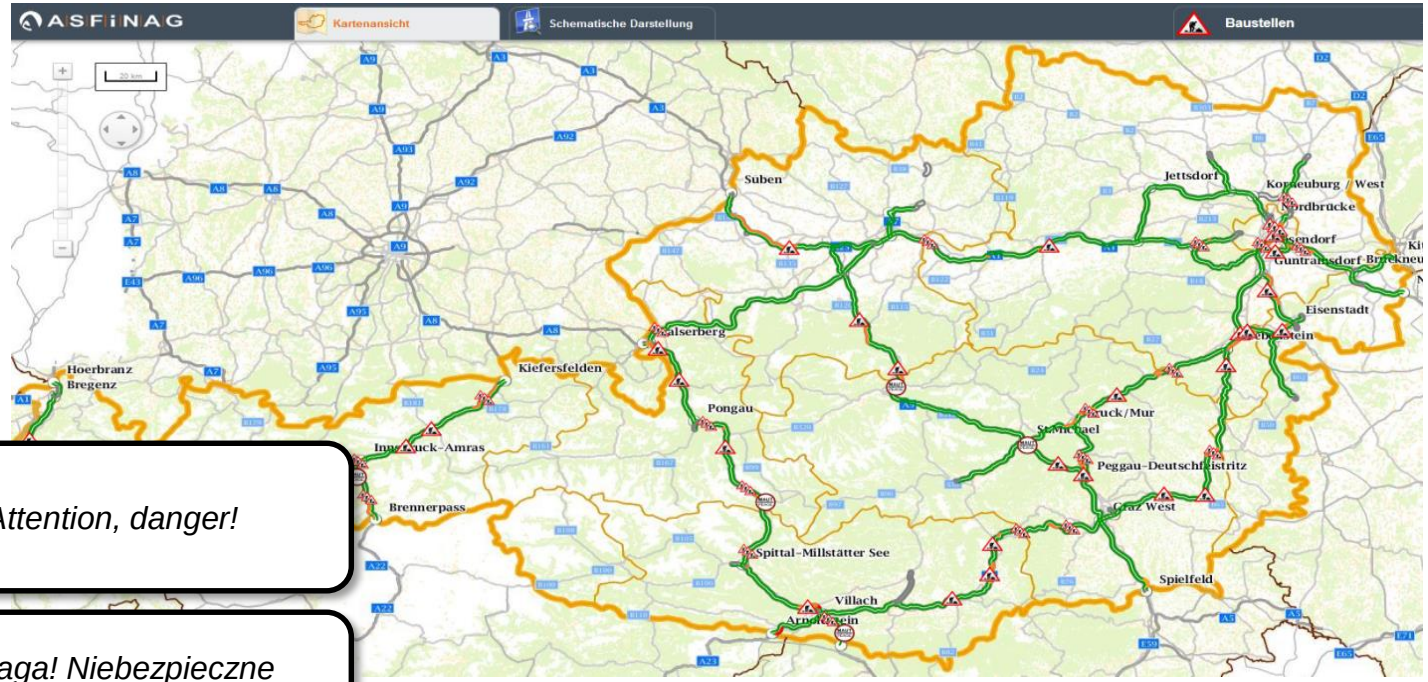
VMS on trailers or gantries, CB radio

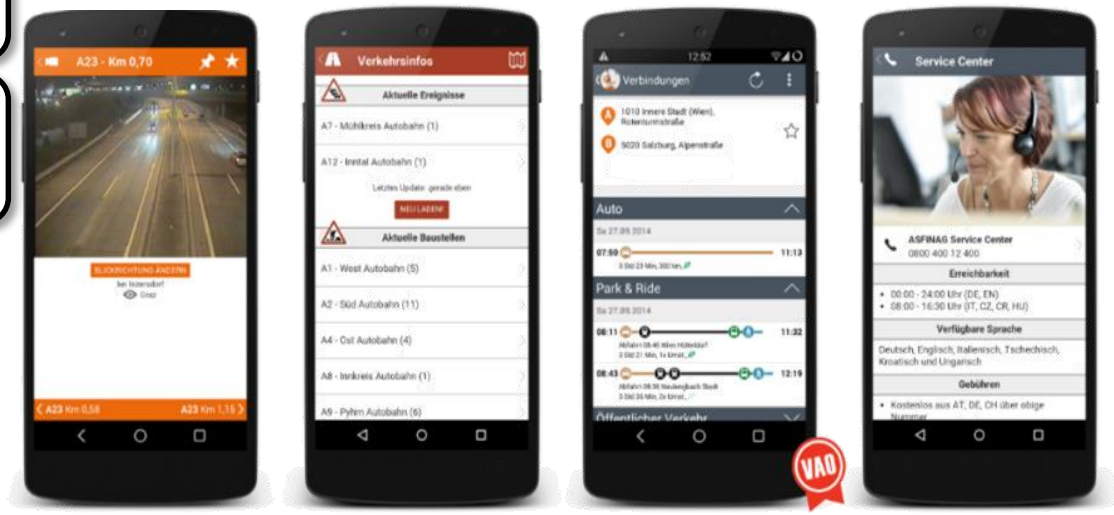
Attention, danger!

Uwaga! Niebezpieczne miejsce.

Achtung, Gefahrenstelle!

Websites, Maps





FM Radio (RDS-TMC), Apps, Navigation Systems

WE NEED MORE THAN THAT …

… to increase
traffic safety

Cooperative ITS is the Answer

- First generation of C-ITS services is available
- Implemented and fully tested in a multitude of pilots and early deployments
- Based on open standards and freely available specifications
- Interoperable between vehicles and infrastructure throughout Europe
- Using a “hybrid” communication approach
  - ad-hoc short range
  - long range

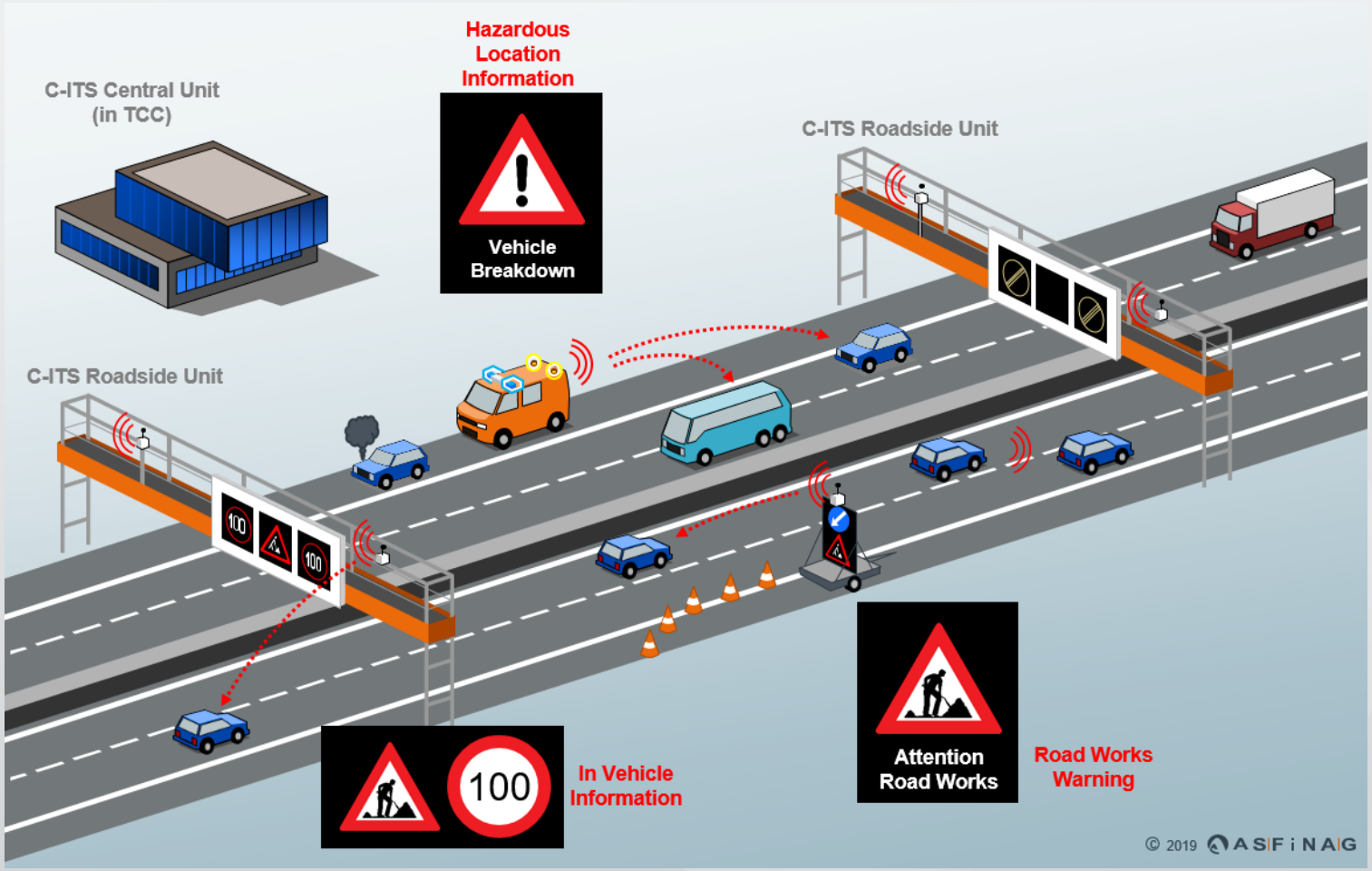
IEEE 802.11p

C-ROADS

https://www.c-roads.eu

CAR 2 CAR COMMUNICATION CONSORTIUM

https://www.car-2-car.org



C-ITS becomes reality

Vehicles:

- Europes best selling vehicle gets WLANp
  - → C-ITS hits the mass market
  - → Day 1 C-ITS services are not an exclusive feature, but reach many road users

WLANp (DSRC/ITS-G5) production equipment demo, Austria, 2019

Infrastructure in Austria:

- Austrian tenders opened 12/2018 (ongoing)
- New series of C-ITS equipped road works trailers (contract awarded)
- Long-term contract for a **central station** and **several hundreds (500+) of roadside stations** (ongoing)
- Day 1 C-ITS services specified
- Day 2 extensions for automated driving

IEEE 802.11p

C-ITS deployment takes off

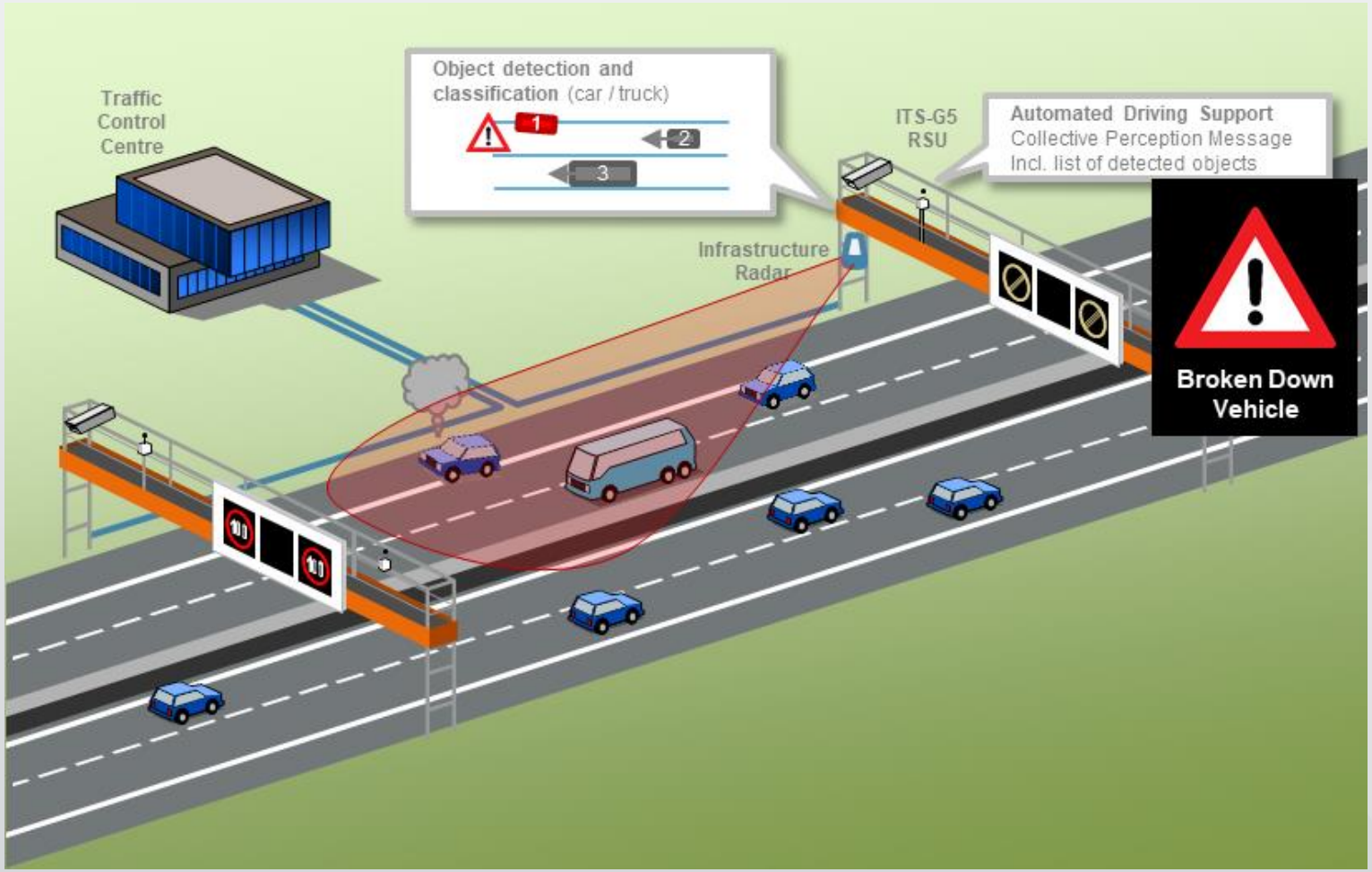
C-ITS Deployment Group

Standardized C-ITS services are key to addressing increased road traffic congestion and reduce fatalities.

This is why European C-ITS stakeholders such as road authorities, road operators, vehicle manufacturers, ICT industry and the agriculture machinery and railway equipment sector are jointly committed to C-ITS based on available and proven interoperable harmonized specifications, standards and technologies.

Contact: Paul Spaanderman
ps@InnoMo.EU

ASFINAG is already testing the Next Generation of C-ITS



Background

Infrastructure-based Collective Perception Message demonstrated 2019 on Austrian A2

Highways England:
18% - 48% improvement in fatal weighted injuries (FWI) rate through Stopped Vehicle Detection
Highways England 2019 annual report

Hybrid Approach – Short range and long range communication

- Redundancy is important for infrastructure services
- Short range communication (IEEE 802.11p) works decentralised,
  e.g. every safety trailer works autonomously → avoids single point of failure

- Mobile networks are expected to cover large areas
- Using both ways of communication increases availability,
  instead of relying on mobile cellular networks alone

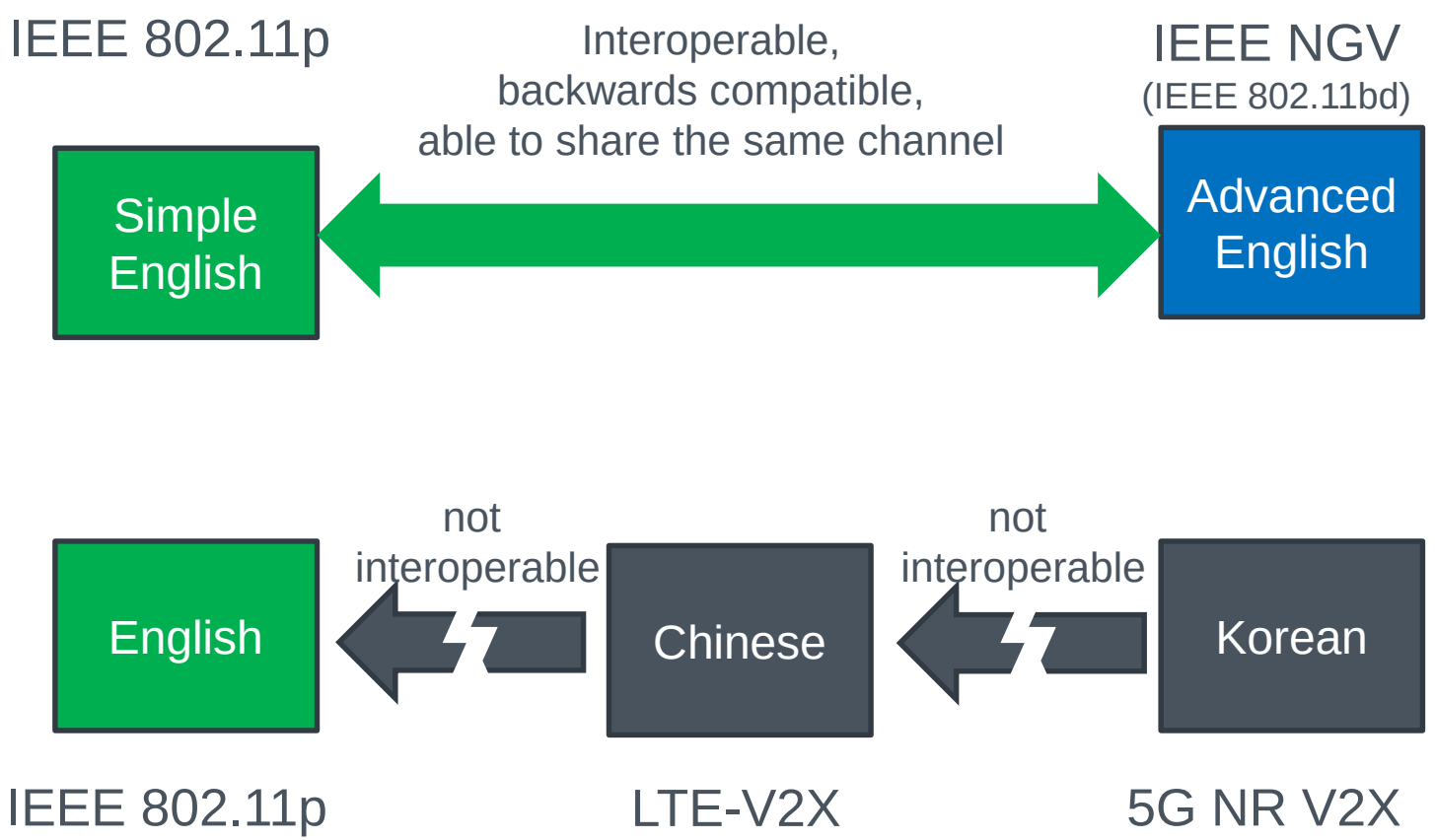
- Additional long range option: DAB+ mandatory in new vehicles by end of 2020

Standardisation Aspects

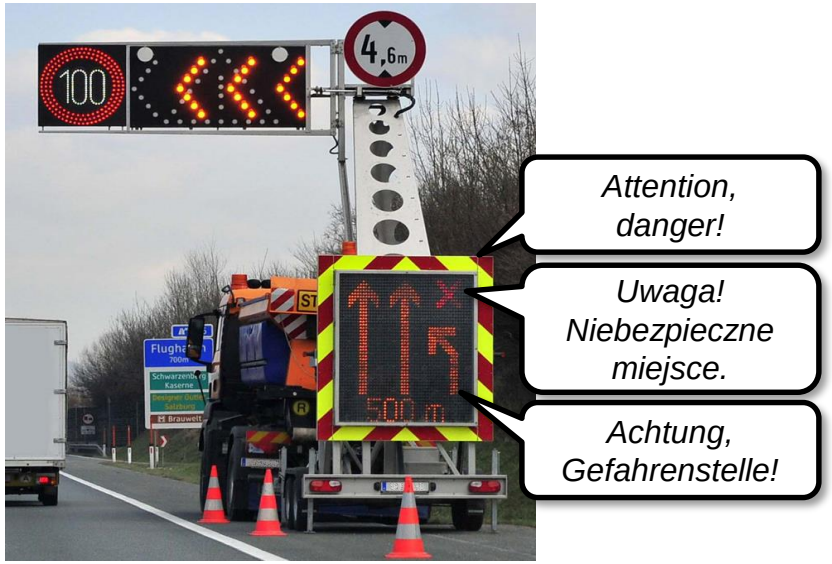
Since this is a Meeting of IEEE Standards Association:

- IEEE 802.11p has evolved “under the hood” (1km range, NLOS, …)
- What is next: **IEEE Next Generation V2X (NGV)**
- Desired properties:
  - Interoperable and backwards compatible with IEEE 802.11p (ITS-G5 / DSRC / WLANp)
  - True interoperability on radio access layer
  - Make new features available while being compatible with currently deployed technology

Analogy of Interoperability and Backwards Compatibility



Reality: 4 languages,
no guarantee that it is understood



→ Interoperability is much more important than marginal performance gains

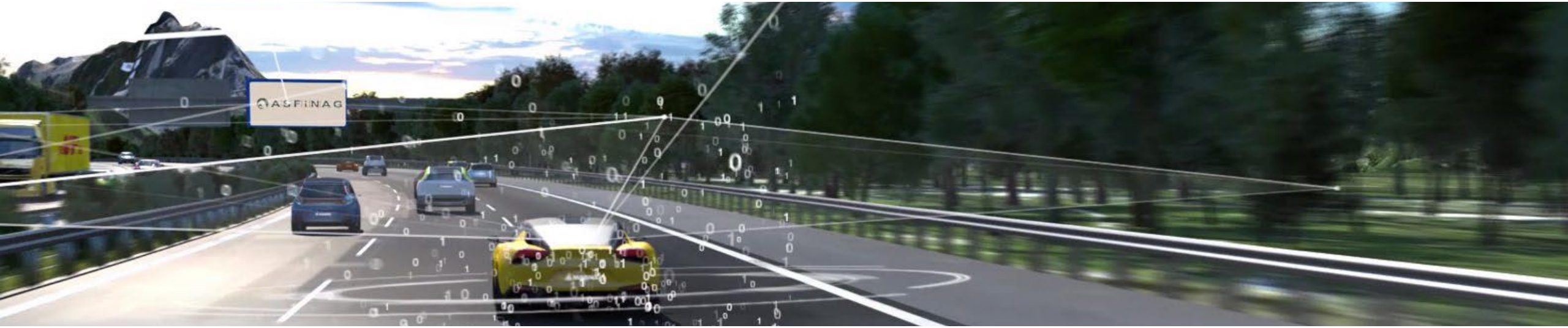
[Kenney, Update on V2X in the US, ITS World Congress, Singapore 2019]

Standardisation aspects (2)

- **True interoperability desired:**
  systems that speak the same language at their interfaces, not somewhere else

- True interoperability preferred over „system-level interoperability“ where a system has to be built around to compensate for incompatibilities

- **Backwards compatibility** is important for ITS services over long lifetimes of vehicles and infrastructure elements



AUTOMATED DRIVING

SAE Levels of Automated Driving

0	1	2	3	4	5
No Automation Zero autonomy; the driver performs all driving tasks	**Driver Assistance** Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design	**Partial Automation** Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment all times	**Conditional Automation** Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.	**High Automation** The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.	**Full Automation** The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

[SAE J3016 Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles]

SAE Levels and Design Domains

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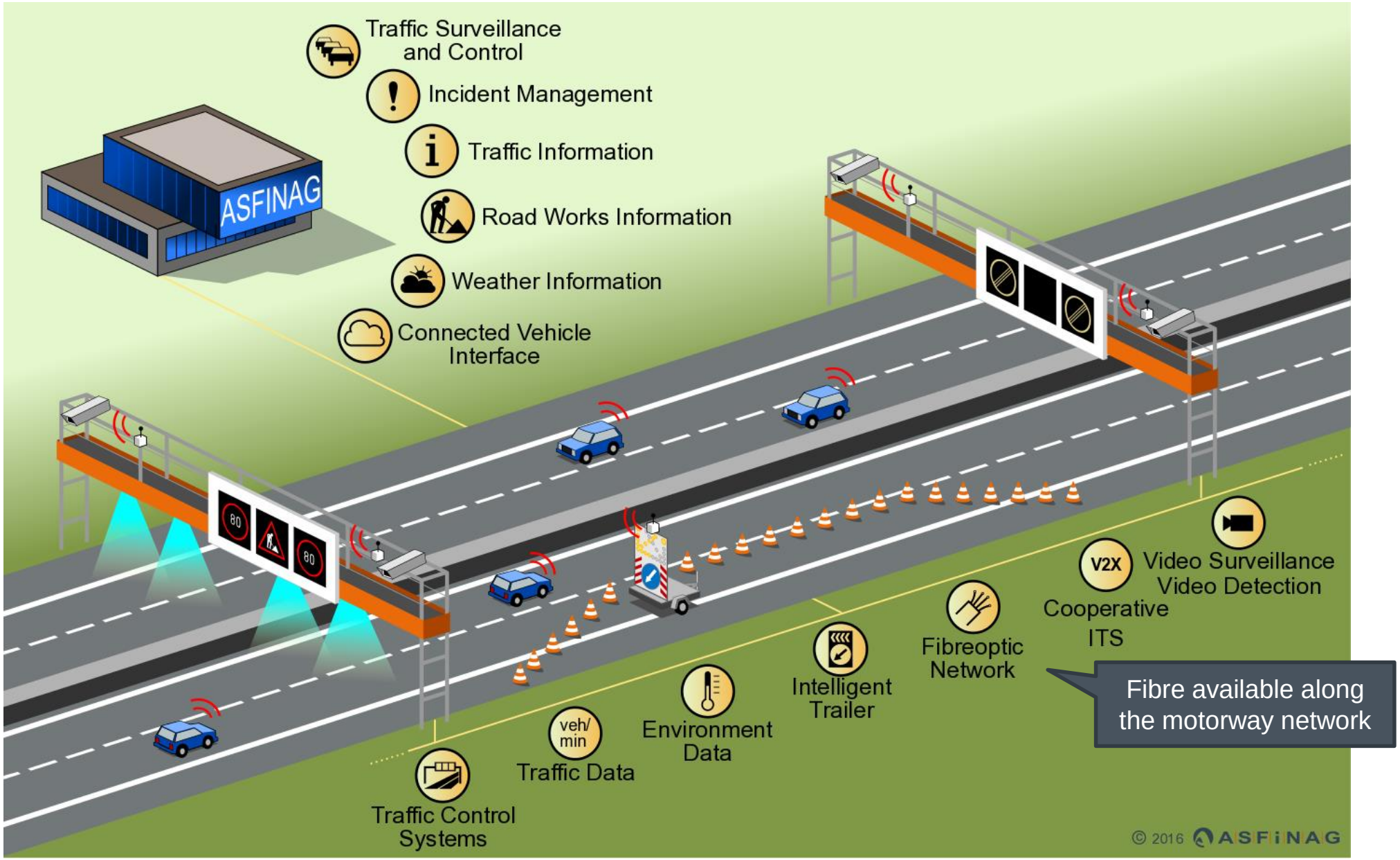
ODD limitation	Level 1 ACC	Level 2 ACC **and** Lane keeping	Level 3 „hands off“, driver must be ready to take over **all** times	Level 4 **All** driving functions under **certain** conditions	Level 5 **All** driving functions under **all** conditions
Segregated areas / limited speed				„People mover“	(N/A, L5 means all conditions)
Controlled-access Motorway, traffic jam			Traffic jam pilot*		
Controlled-access motorway, free flow			Highway pilot*		
Everywhere			(N/A, L3/L4 have conditions)		Hardly feasible in near future

Available | Feasible, needs time | Very hard

*with speed limit / under certain environment conditions

[cf. Shladover, “Practical Challenges to the Implementation of Automated Driving Systems”, ICCVE 2019]

How can Infrastructure help?



Infrastructure Support for Automated Driving

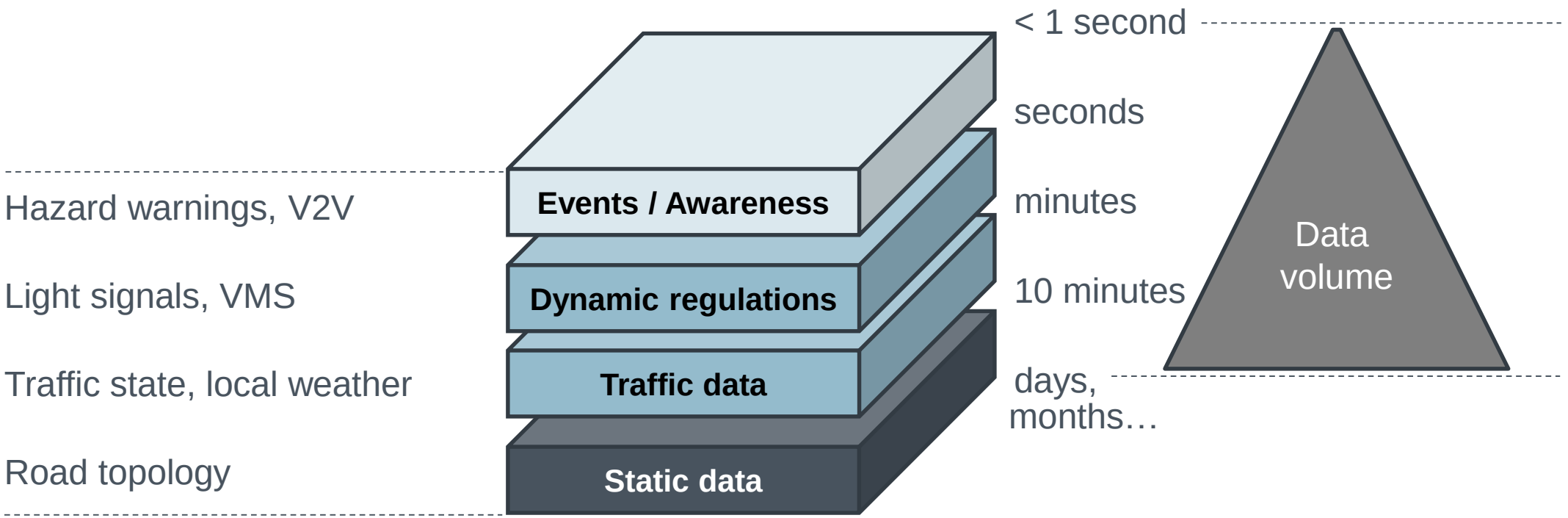
ISAD

	Level	Name	Description	Digital information provided to AVs			
				Digital map with static road signs	VMS, warnings, incidents, weather	Microscopic traffic situation	Guidance: speed, gap, lane advice
Conventional infrastructure	E	Conventional infrastructure / no AV support	Conventional infrastructure without digital information. AVs need to recognise road geometry and road signs.				
	D	Static digital information / Map support	Digital map data is available with static road signs. Map data could be complemented by physical reference points (landmarks signs). Traffic lights, short term road works and VMS need to be recognized by AVs.	X			
Digital infrastructure	C	Dynamic digital information	All dynamic and static infrastructure information is available in digital form and can be provided to AVs.	X	X		
	B	Cooperative perception	Infrastructure is capable of perceiving microscopic traffic situations and providing this data to AVs in real-time.	X	X	X	
	A	Cooperative driving	Based on the real-time information on vehicle movements, the infrastructure is able to guide AVs (groups of vehicles or single vehicles) in order to optimize the overall traffic flow.	X	X	X	X

[Carreras et al.: Road infrastructure support levels for automated driving. ITS World Congress, Copenhagen 2018]

Level C/D – Static and Dynamic Data

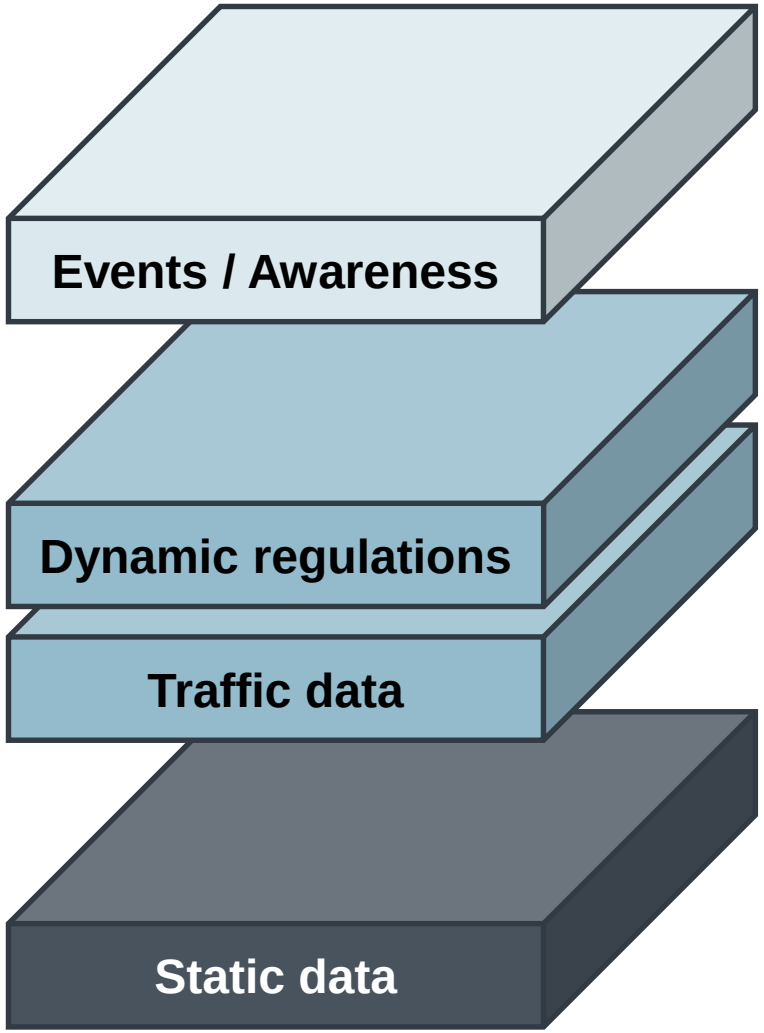
- Road topology does not change every day - VMS data does, but is very small.
- There are several criteria (update rate, locality, timeliness etc.)



More demand for entertainment → not road operator business.

[cf. DIRIZON Digitalisation and Automation]

V2V / V2X needs for Automated Driving



Local interaction (awareness, coordination)
→ few hundred bytes every ~100ms
(vehicle response time 50-150ms*)
→ well-suited for IEEE 802.11p
short range communication

Local and wide area scope
→ Local signaling by IEEE 802.11p
→ Wide area by Mobile Internet (3G/4G)

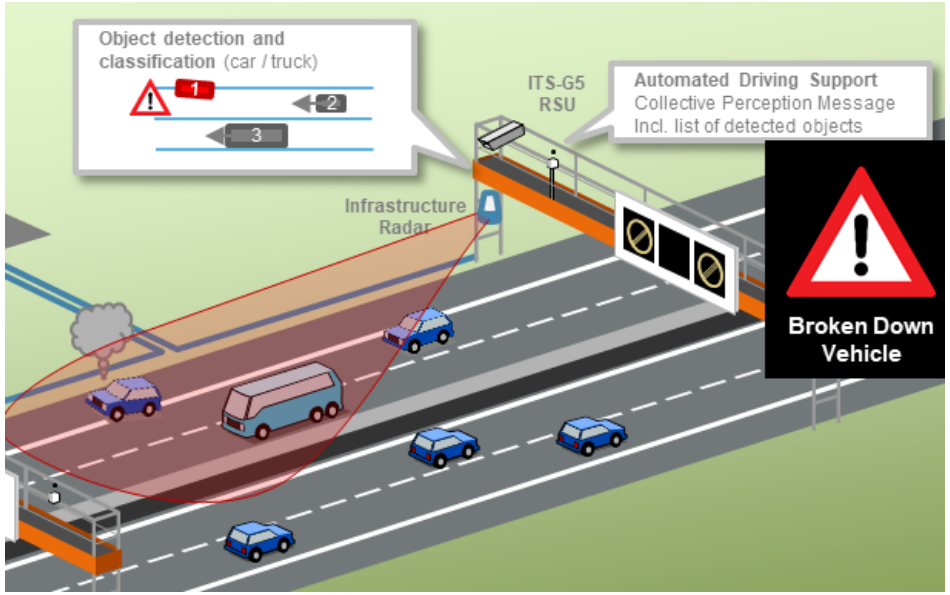
Background data download
→ Mobile Internet / Wi-Fi
when parking, charging, …

Technology available today!

* [Lay, Handbook of Road Technology, CRC Press, 2009]

Level B – Cooperative perception

- Sharing of object data
- NOT sharing of real-time streams from infrastructure video cameras
- NOT showing real-time images ahead of the vehicles driving in front („see through“)



- **Beware of a rebound effect of video/„see-through“**:
  - Could lead to more (dangerous) overtaking maneuvers
  - Could lead to driver distraction
- Video sharing might soon become obsolete with automated driving: vehicle can share object data instead of raw images

Level A – Cooperative Driving is not Remote Control

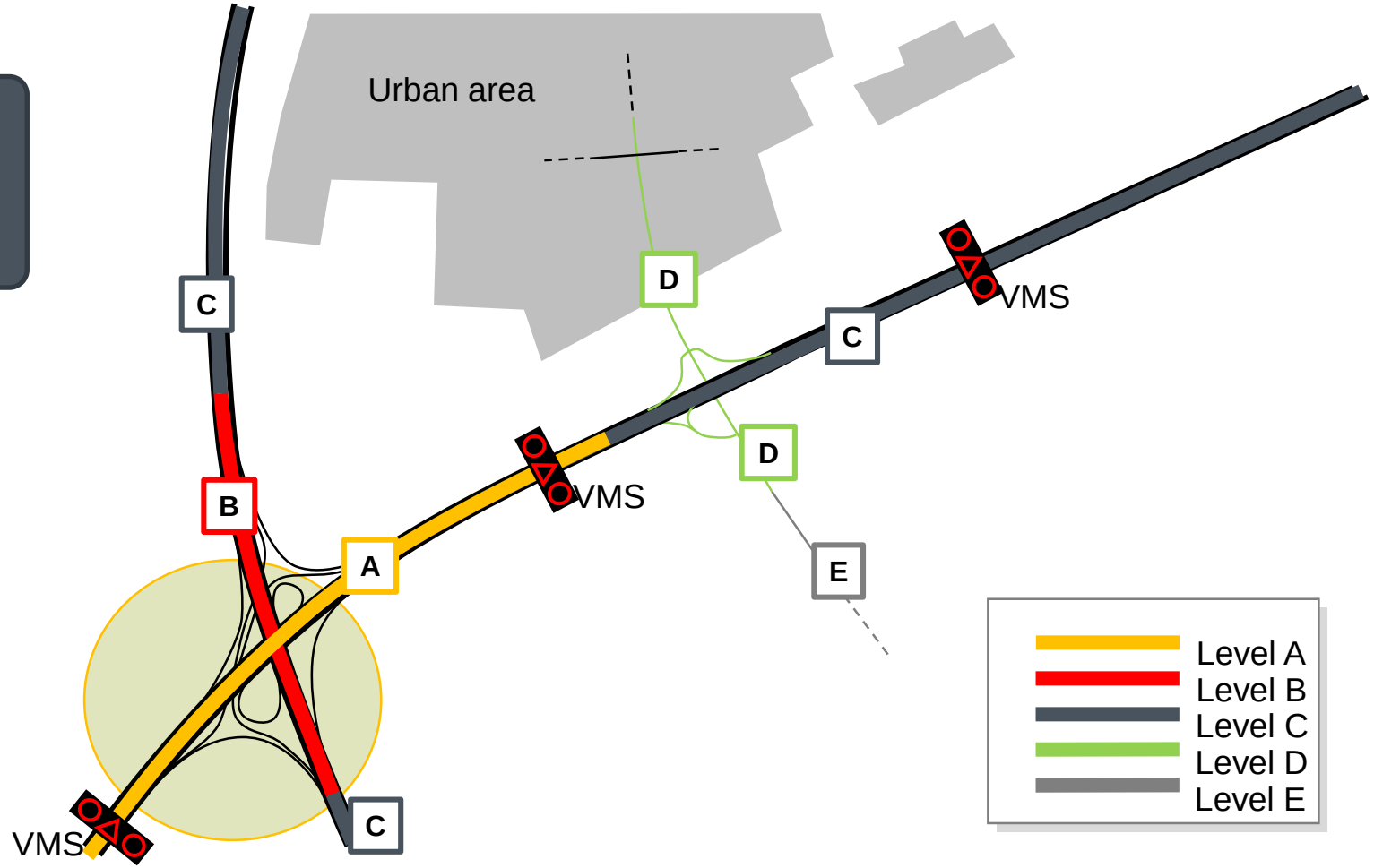
- Guidance means: giving advice on lane changes, inter-vehicle gaps, but decisions are made by the vehicle.

- NOT a remote control service, where the road operator takes over the steering of the vehicle.
- **Remote control service is NOT realistic!**
  - Does Air Traffic Control steer airplanes by remote-control?
  - Why should road operators do?

Infrastructure view - ISAD

ISAD levels can and will differ from one road segment to another

- Based on ISAD Level, certain on-board vehicle decisions can be supported
- AVs will have to be able to drive on E-level, but the additional possibilities of higher levels might increase availability of driving functions



[Carreras et al.: Road infrastructure support levels for automated driving. ITS World Congress, Copenhagen 2018]

The real challenge: Sensor perception and sensor data sharing

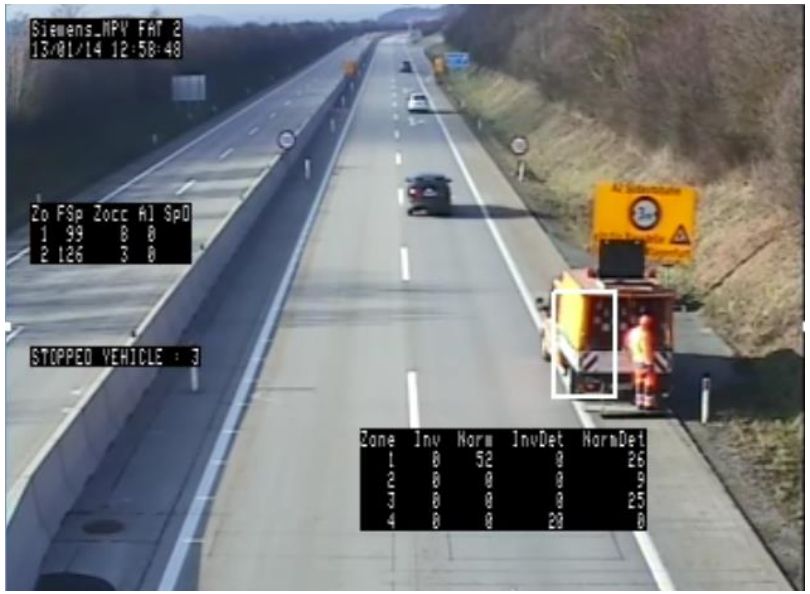
- Sensor perception uses machine learning approaches
- Large training sets, intensive testing → ability to identify objects of a known class

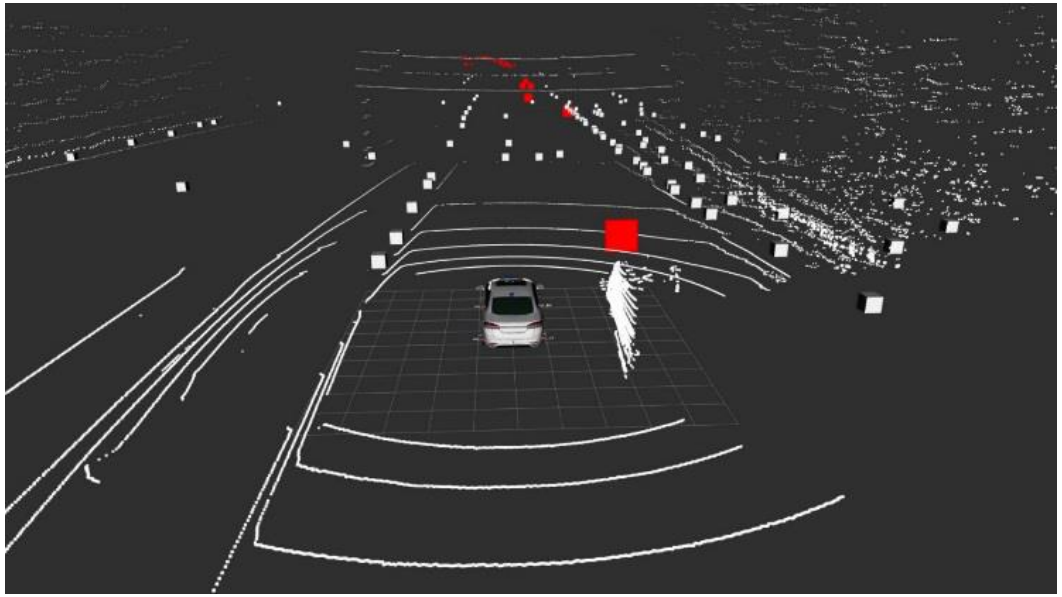
- What about edge cases, previously unknown types of objects?
  - Some situation might be classified wrongly
  - Situation might be reproducible

- When sharing sensor/object data, what is the impact of edge cases?

Sensor fusion

- One sensor alone will probably not be sufficient …
- Sensor fusion usually based on precise knowledge of the involved sensors
- What about sensor fusion involving external sensors?





Radar detections

Infrastructure data

[Seebacher et al., Infrastructure data fusion for validation and future enhancements of autonomous vehicles' perception, IEEE ICCVE 2019]

Standardisation aspects

- ISAD classification aims at categorising the (digital) environment
  - Will ODDs and ISAD align?
- ISAD relates to sharing data of the physical world
- Sensor perception is a key element
- Quality and performance criteria for automotive sensor perception are important
  - Initiatives such as IEEE P2020* welcome!
  - Some aspects also relevant for road operators

*IEEE Standards Association P2020 - Automotive Image Quality Working Group

Summary and Conclusion

- MaaS is a multi-stakeholder environment, where interoperability is a key aspect
- Cooperative ITS is being rolled out, both vehicles and infrastructure
- Connectivity supporting Automated Driving is available today!
- There is no „5G for automated driving“ prerequisite (first the needs, *then* the technology)
- Infrastructure support has several aspects → ISAD categories
- Challenges are in sensor perception and sensor data sharing

www.asfinag.at