Connected Vehicles

the Role of Infrastructure

AJPS Conference | 17 – 18 October 2016 Andreas.Schmid@swarco.com

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Content

- Vision
- Technology - State of the art
- R&D: In development
- From Vision to Technology to Implementation: Key steps?

Andreas Schmid:
"when I mention V2X or cooperative systems
I'm referring to the function set as
it is presented in the following 10 minutes

Cui bono – Why V2X?

C-ITS Platform 2015 – final report:

http://ec.europa.eu/transport/themes/its/c-its_en.htm

A first overall conclusion is thus that the benefits of deploying C-ITS services are very large indeed but they will not appear in the short-term.

Dominant benefits

- Reduced travel times/ increased efficiency (66%)
- reduced accident rates (22%)
- Fuel consumption savings (11%)

Source: WG1 final report p38

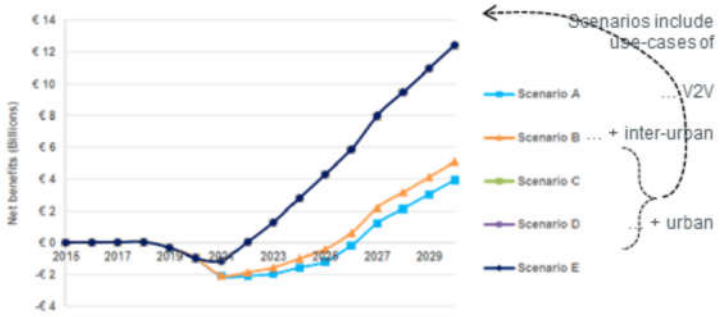


Figure 3: Net Benefits from C-ITS

June 2015: Rupert Stadler, Berliner Wirtschaftstag: *"If all traffic lights in Germany would be connected, 900 million litre fuel could be saved per year. This equivalents more than two million t less CO2."*

Compared with in-vehicle-only based optimisation efforts “V2X” approaches seem overwhelming in effectivity

There is no doubt about global benefits can are reached. Certainly this doesn’t mean for an individual business case that it is positive…

The more applications being implemented early, the smaller the valley of invest will be. Or: the more ‘software’ use cases can be used by the same hardware invest, the faster benefits are reached.

A real raise can be observed by adding “urban” use cases with scenarios C and further. The “V2V”-scenario A shows the lowest benefits when standalone – even when infrastructure (inter-urban) is added (scenario B)

Quis solvit – Who pays?

- C-ITS Platform 2015 – final report

http://ec.europa.eu/transport/themes/its/c-its_en.htm

Dominant costs
- Hardware in vehicles (86%)
- Aftermarket devices (10%)
- Rest - inkl. Infrastructure (4%)

Soure: WG1 final report p38

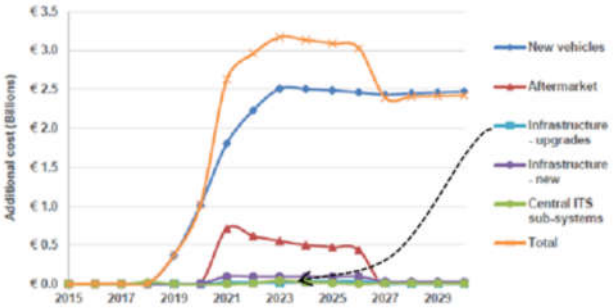


Figure 4: Costs for C-ITS deployment

i.e.
- Vehicle Industry will have to bear main extra-costs …and therefore be a key driver

The fairly largest invest is with the vehicles (high volumes!)
Infrastructure must invest, too – otherwise the benefits are severely rescued (see previous slides). Yet the infrastructure costs are not visible as high because within the cyclic re-invest for modernisation V2X will have a comparably small extra add on to costs.

Cooperative Systems – SWARCO Vision for an enabler technology

We expect the future to look like:

- Real Time Traffic **data is shared** between vehicles, roadside infrastructure, traffic management centres and information services.
- Information include Safety and Emergency data, followed by global connected services and finally cooperative management as a new information type.
- Traffic Management extends **from physical to virtual space**. Information and advice disseminated in virtual space has same legal requirement as physical signs. Investment in physical dynamic signs is reduced, but not stopped.
- Connectivity and multiple sources overtake classic detection. Vehicle based data and phone based data are a reliable data source. Investment in classic detection is reduced significantly – alternatives are cheaper.
- Infrastructure is **protected** against virtual attacks and is **projected robustly and safe** into the **virtual environment**
- **'Cooperative' functions** are required in 'classic' products to stay in the market, including centers as well as road side controllers, detectors and signs.
- SWARCO has "virtual" extensions in its infrastructure portfolio to complement the physical equipment

- Do you share the view?
- Where would you suggest a different position?
- What do you think is missing?

Technology – state of the art
I: Defined content: Standard messages

Standard Message Sets
From “Cooperative Systems” / V2X a series of standardises messages are fixed

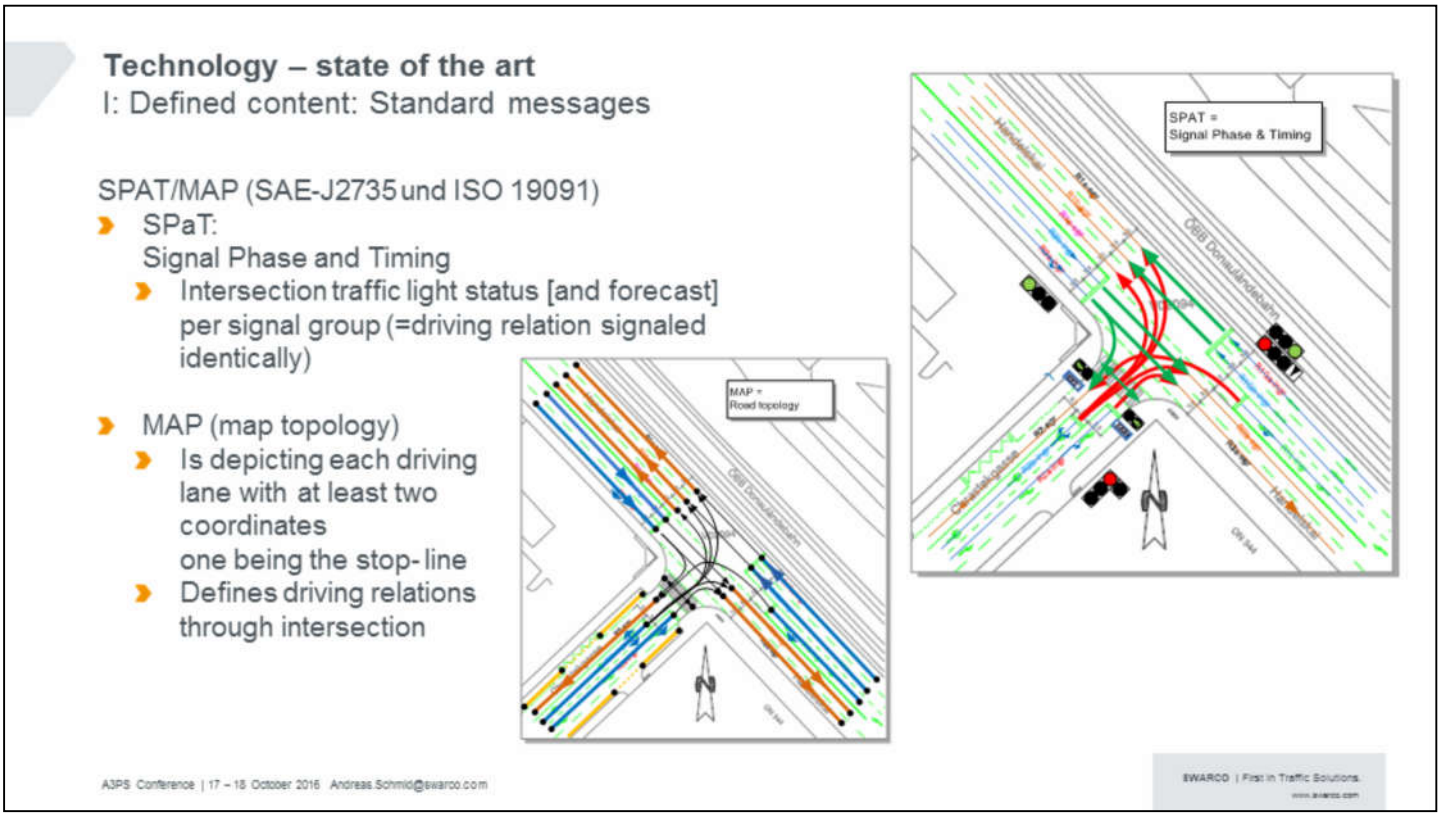
- CAM
  Cooperative Awareness Message (ETSI EN 302 637-2)
  - Position, speed, direction of a vehicle, 1..10 Hz; optional content for prioritisation
- DENM
  Decentralized Environmental Notification Message (ETSI EN 302 637-3)
  - Warning messages

CAM: Position, Direction, Speed, veh. Type, [other] @1..10Hz

DENM: Warning @event

Part of more or less ANY implementation so far.

Also because CAM message has a key function in ETIS ITS G5



Used in two separate architectures:

In direct communication between traffic light controller and vehicles for safety relevant applications (e.g. red-light violation) and prioritisation.

In Central & Service Provider communication setup for GLOSA/TTG use cases (see slide 10) to reach a large scale initial service coverage on day one.

Technology – state of the art
I: Defined content: Standard messages

- IVI
  In Vehicle Information (ISO/TS 19321)
  - Content of [dynamic] road signs

Images: ECo-AT ECo-AT_SWP2.1_InVehicleInformation

Used in some implementation initiatives – not all infrastructure operators could find a usage that benefit/cost ratio would justify this implementation. Some do not support a local / direct communication, but foresee central based information provision.

Technology – state of the art

II: Defined applications

"On air standard message are not enough"
How are we using them?

- Roadworks Warning (RWW)
  - Allow vehicles to "see" warning trailers
- General (safety) warnings
  - Mark upcoming area to be driven with care
  - Local Hazards
  - Share information on slippery road, jams ends, accidents,…

Image: drive-c2x.eu

Cooperative Warning

- Is precise 'on the spot'
- Injects "electronic knowledge" on risks to our safety systems

Image: https://www.afas-online.de/

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Fully agreed use case in C-ITS corridor countries and beyond

Technology – state of the art
II: Defined applications

"On air standard message are not enough"
How are we using them?

- Greenlight Optimal Speed Advisory (**GLOSA**)
  - Show the driver at which speed the next intersection can be passed
  - Drive without need to rush for green
- Time to green (**TTG**)
  - Show the driver when green is back
  - Take a relax at red / be prepared for green in time
  - Start-stop engine ignites just before green
  - drive-train / energy management and vehicle comfort functions
  - ACC/ Gear-shift et al. energy functions adapt to traffic flow

Juni 2015: Rupert Stadler, Berliner Wirtschaftstag:
"If all traffic lights in Germany would be connected, 900 million litre fuel could be saved per year. This equivalents more than two million t less CO_2."

Cooperative Greenlight functions

- Save fuel & reduce pollution
- Bring comfort and "Wow" to drivers
- Increases throughput
- Enhance safety
  Relaxed drivers are a safety plus!

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Presented in several cities (Berlin, Verona, Trondheim, Ingolstadt. Stockholm, …)
Audi announce market introduction in US.

Technology – state of the art
II: Defined applications

“On air standard message are not enough”
How are we using them?

- Intersection safety: red light violation

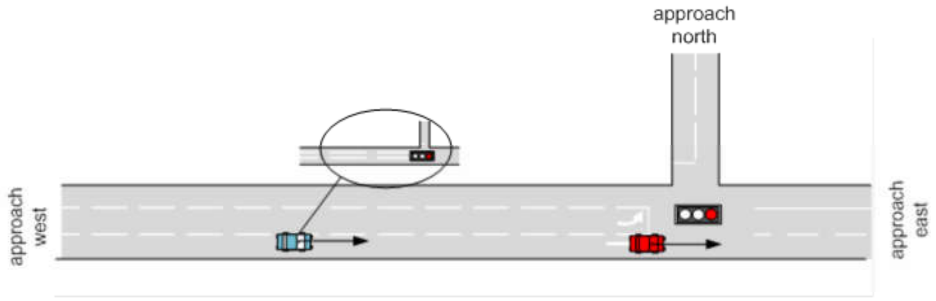


Image: ECo-AT SWP 2.1 Use Cases Intersection Safety

Part of several R&D / deployment implementations

Technology – state of the art
II: Defined applications

"On air standard message are not enough"
How are we using them?

- Prioritisation
  - Use "cooperative vehicle - standard CAM" messages to see the vehicle approaching your intersection every second
    E.g. R09.16 part of the European profile
  - Allow different vehicle type specific prioritisation
    E.g.
    i) trams & buses,
    ii) police & emergency services,
    iii) heavy vehicles
  - Use V2X built-in security mechanisms to flexibly add & remove usage permissions;
    E.g. use buses from neighbour city for special event

Cooperative Prioritisation

- Saves fuel & reduces pollution
- Saves cost
  (no further technology added / V2X technology can be used for several use-cases)
- Is based on mass (V2X) technology
- Is flexible
- Comes with state-of-the-art security

Can replace todays technologies for prioritisation.

In DACH old technology needs a successor!

Has more potential (since many synergies with other V2X use cases using same technology and hardware) than alternatives.

Technology – state of the art
II: Defined applications

"On air standard message are not enough"
How are we using them?

- Dynamic Sign Content: Speed limits
- Shockwave damping
  - Avoid creation and propagation of jam ends due to oversaturated traffic flow
    - Already shown in A58, NL
    - To be deployed in C-ROADS, Hessen, Germany

Image: drive-c2x.eu


Image: trafficwaves.org

Increasingly taken up by (inter-urban) road operators

Technology – state of the art
III: Communication Technology

ETSI ITS G5 aka "WiFi-P"
5.9 GHz 802.11p based communication

- Availability
  - Commercial of the shelf (Cots) chipsets and units from various vendors on the market available
  - Tested in integrated scenarios with functions as mentioned prior
  - Integrated in Infrastructure "extensions" from many infrastructure vendors (Traffic Light controllers, Roadsigns, warning trailers)
- Features
  - Direct, Free to air (no provider / provider network required)
  - Low latency (sufficient for safety / highly automated functions)
  - Several 100m communication range (up to 1 km line of sight)

Foto: Cohda Wireless

Technology – developments
What we will have next?

Communication technology
Mobile network suppliers include connected and highly automated driving requirements into next generation developments

Mobile Edge Computing
- Low latency
- Local, fast "computing" resources as 'cloudlet'

V-LTE
- Low latency
- Device-to-Device (D2D) functions allow communication in case no centrally managed network is available

Bild: http://inside5g.com/mobile-edge-computing-used-to-support-assisted-driving/

27.09.2016: Gründung der 5G Automotive Association (5GAA):
"Today AUDI AG, BMW Group, Daimler AG, Ericsson, Huawei, Intel, Nokia and Qualcomm Incorporated, announce the formation of the "5G Automotive Association".

5GAA Meldung im Handelsblatt und bei Volkswagen

Handelsblatt:

„5G ist noch in der Versuchsphase, eine weltweite Übereinkunft über Details fehlt noch. Der Mobilfunkturbo soll Daten zehn Mal so schnell wie der gerade schnellste Standard 4G/LTE transportieren."

„Die Reaktionszeit bei Eingaben soll gegen Null gehen. „

Technology – developments
towards automated driving

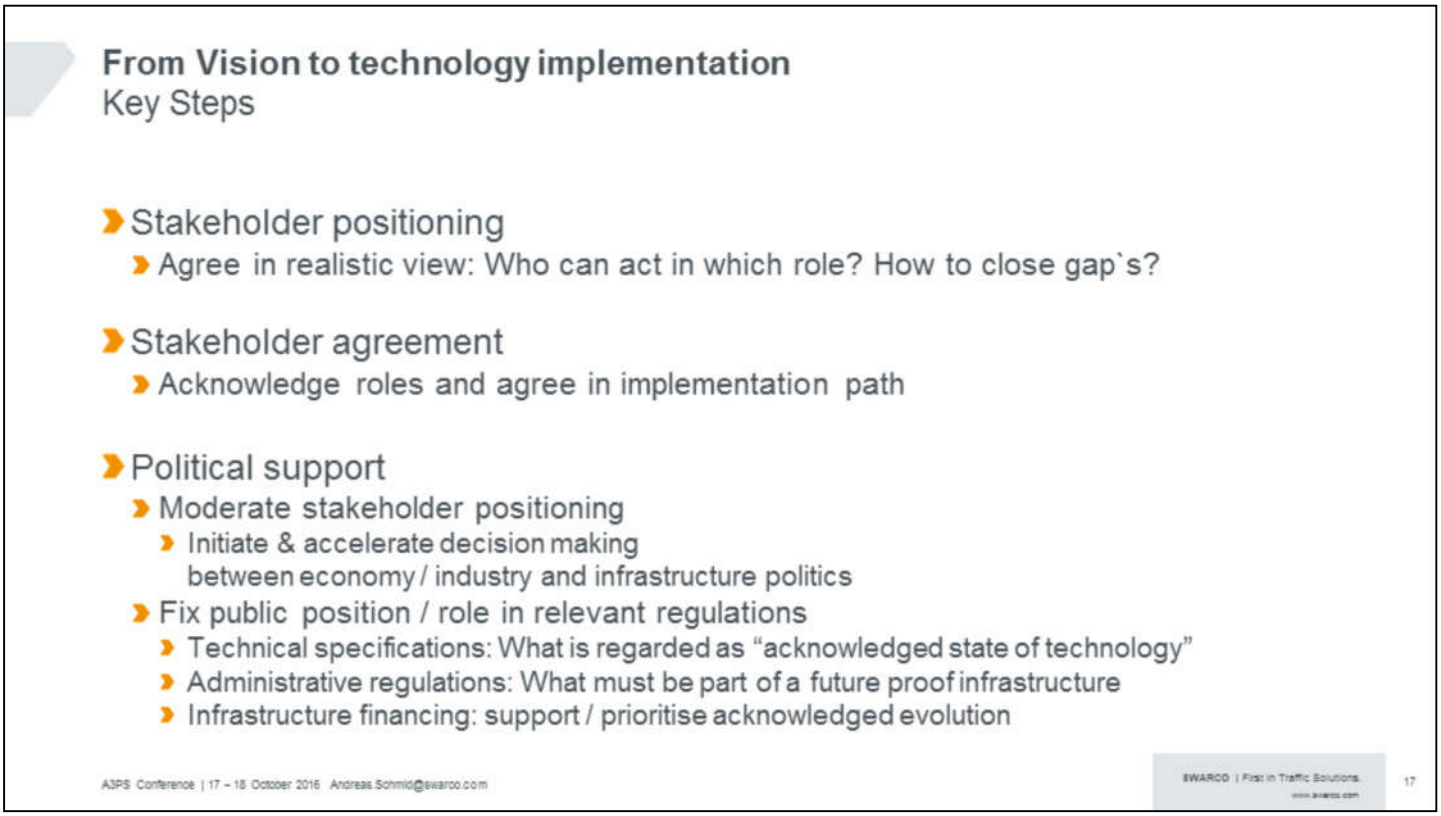
From Information towards reliability for safety
complete system view: Vehicle + Infrastructure

- How must the technical design of the functions be changed from a **functional safety** consideration?
  - How reliable are traffic-lights / speed-limits / warnings in the air?
  - Does infrastructure check for failures and what is the **safe reaction in case of failures**?
    (how to extend safety functions inside traffic-light controllers or speed limit gantries)
- Which new functions are required by Highly Automated Functions (HAF)
  - What additional functions must be agreed to enable highly automated driving?

Vehicle Industry so far did not commit to an acknowledged set of requirements towards infrastructure for automated driving.

Still experts developing for highly automated vehicles clearly indicate that a safe vehicle requires infrastructure support once the driver is taken out of the loop.

There is a notion that introduction for infrastructure support is not required “full coverage” but that there is a migration path “route-by-route”.



e.g.:

- Infrastructure will provide safety relevant data such as rules given by signals (traffic lights, speed limits) and hazard warnings via V2X in legally binding way (same as optical)
- It will start with using 802.11p and be prepared for adding next generation cellular once standardised and agreed and implemented
- Rollout
  - Infrastructure supports "step by step" rollout on dedicated routes and corridors.
  - Industry does not expect "area coverage" and can cope with "city-by city" and "route-by-route" rollout
- Infrastructure will use V2X standard technology prior to alternative variants for achieving a single use case
  - If new prioritisation for public transport or rescue is equipped, V2X technology is chosen

Thank you for listening

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Questions and feedback explicitly welcome!

Now and after the meeting – don't hesitate to contact me!

Some key points on my CV:

In my entire professional work life I dealt with traffic information and –control systems. Both in Research and development as well as in implementation.

1999 Dipl.-Ing. **Bauingenieurwesen (Civil Engineer), Technische Universität München (University of Technology, Munich)**

1999 Heusch/Boesefeldt München

- Introduction of RDS-TMC (FORCCE ECORTIS)
- Introduction of DATEX (INFOTEN) (first Traffic Management Centre Network in Europa)
- Tender preparation DATEX2 (Standard for traffic Management Centre information interchange)
- MOBINET (Traffic information and management centre Munich)

2004 PTV Group Karlsruhe

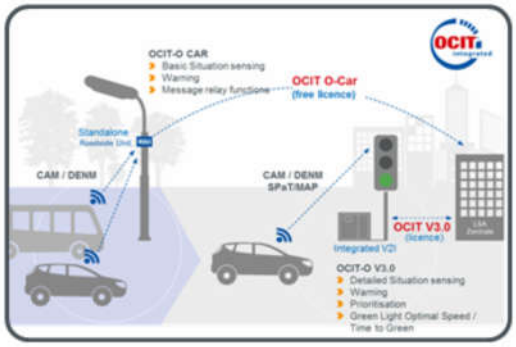
- Consulting Toll Collect – part of the team to setup Germanys first electronic fee collection system (function set Basis Data)
- BayernInfo: Project Management Service Platform
  First intermodal Real-time traffic information and planning system (before Google Maps existed!)
- ERTICO:TISA Founding (after Mobile Info / GST projects) – Organisation for Standardising Traffic and Traveller Information Services technology
- **CVIS: Core Architecture Group (today: ETSI Cooperative Systems Architecture** is based on this work)
- Chairman TPEG Application Working Group (up to today): Chair technical team to maintain and create standards, defining how traffic and traveller information reaches drivers (digital broadcast and Internet)

2013 SWARCO Traffic Systems

- Product Manager "Integrated Traffic Management"
- Member of SWARCO Innovation Team:
  Leader of „Cooperative Systems" program. Mission: Make SWARCO „V2X Ready".
- Member or DG MOVE "C-ITS Platform"

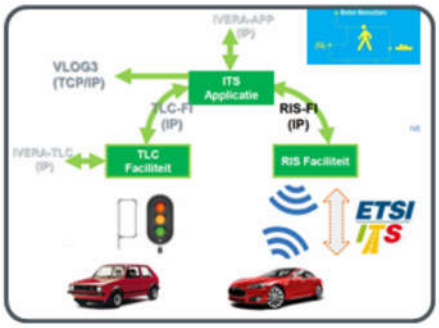
Backup

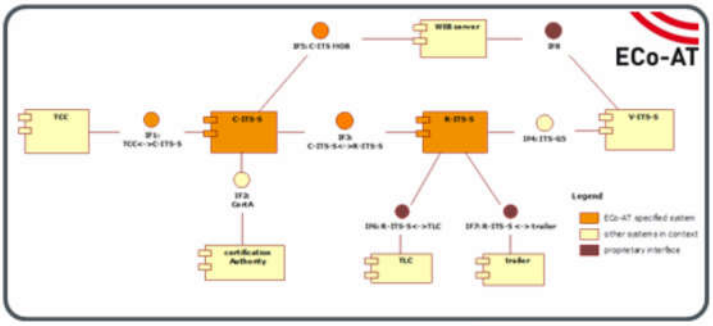
Implementation Status
IV: legacy architecture linkage



"On air standards are not enough"
How is the standard function achieved through the existing backend-infrastructure

- National specifications required
  how to serve the use-cases along chain





Traffic Situation sensing
Use vehicle movement data

Every second a probe
V2X CAM messages as resource

- Collect sample data on intersection traffic movements
  - Stops (per lane; before/after stop line)
  - Waiting times & travel times
  - Start & end positions (origin-destination)
- Detect with one sensor at a range of several 100m
  - Speed / travel time samples on various (slip-) roads
  - Jams / jam resolution

Cooperative Situation sensing

- Allows traffic analytics on different scale, as it is based on (free) floating vehicle data

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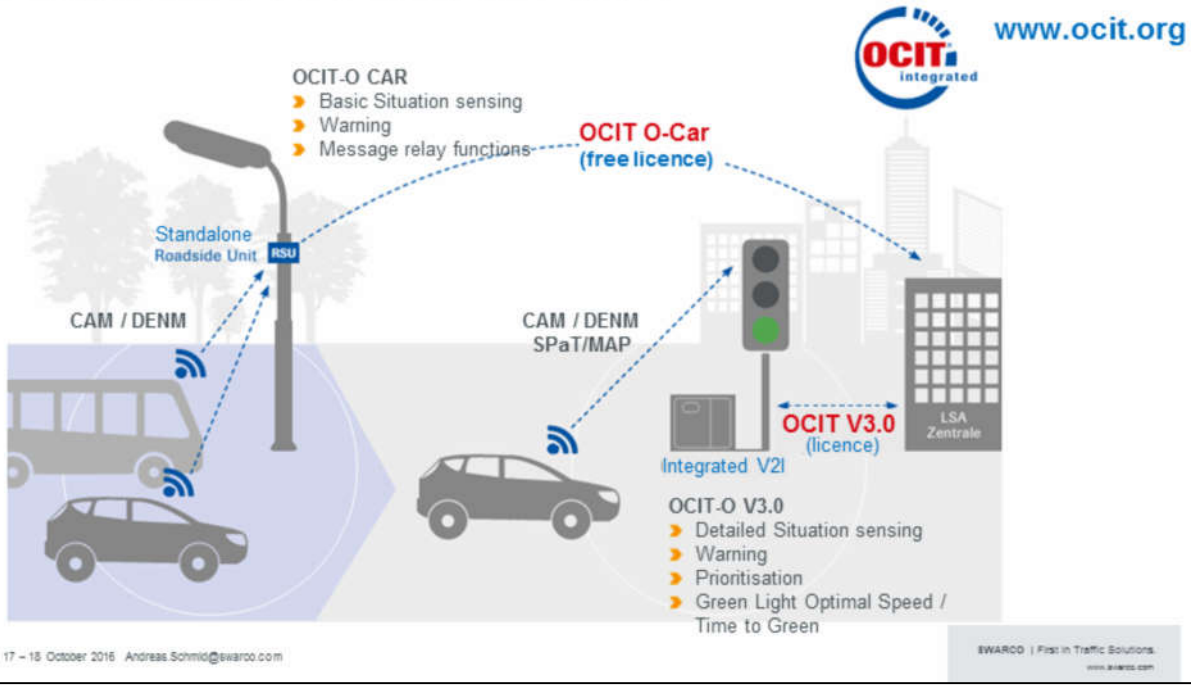
Industry Standardised V2X data inside infrastructure




References
SWARCO participation
R&D funded projects
C-ROADS
2016 - 2020
ECo-AT
iKoPA
2015 - 2018
TESTFELD TELEMATIK
2011 - 2013
TEAM
Tomorrow's Elastic Adaptive Mobility
2012 - 2016
ITeM
(ITS Testfield Merzig)
2013 - 2015
INTER SAFE 2
2008 - 2011
KOLIBRI
2012 - 2013
INTERSAFE
a PReVENT Project
2005 - 2007
Ko-FAS
2011 - 2013
Contracted projects
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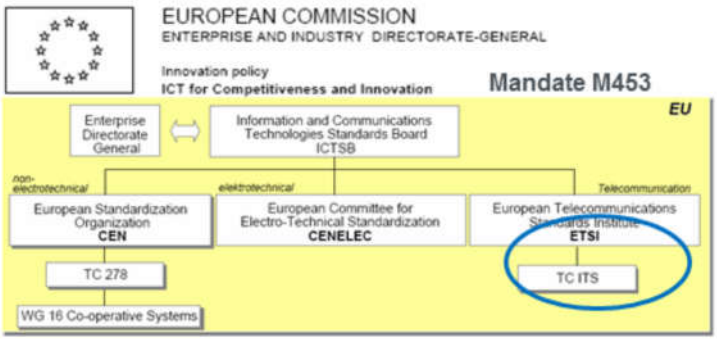
References
SWARCO in stakeholder groups & standardisation



Standardisation at ETSI TC ITS WG 1 .. WG 6

- Communication Layer (physical, GeoNet, …)
- Mobile Applications (V2V)
- Message Telegrams: **CAM, DENM**

Standardisation at CEN TC278 WG 16/ISO TC204 WG 18

- Infrastructure Applications
- Architecture
- Message Telegrams: **SPaT, MAP, IVI**

OCIT®

CAR 2 CAR COMMUNICATION CONSORTIUM

DIN

CEN

ISO International Organization for Standardization

SAE International

ETSI

ETSI ITS Standards on the move

TISA

ERTICO

AMSTERDAM GROUP

European Commission

DG MOVE C-ITS Platform

Applications

- How to start?
  - 25 Services already in C-ITS Platform
- Infrastructure-focus:
  - C-ITS Corridor:
    - (Roadworks) Warning
    - In-Vehicle Signature
    - Shockwave damping / „Cooperative Line Control“
  - Urban:
    - Traffic Light Assist / green wave (GLOSA/TTG)
    - Prioritisation with V2X
    - Hazard-warnings (DENM)
    - Traffic situation (use Cam vehicle data)

Service name	Bun
Emergency electronic brake light	
Emergency vehicle approaching	
Slow or stationary vehicle(s) warning	
Traffic jam ahead warning	
Hazardous location notification	
Roadworks warning	
Weather conditions	
In-vehicle signage	
In-vehicle speed limits	
Probe vehicle data	
Shockwave damping	
Green Light Optimal Speed Advisory/Time to Green (GLOSA/TTG)	
Signal violation / Intersection Safety	
Traffic signal priority request by designated vehicles	
Information on alternative fuelled vehicle charging and fuelling stations	
On-street parking information and management	
Off-street parking information and management	
Park & Ride information	
Traffic information & Smart routing	
Loading zone management	6
Zone access control management	6
Vulnerable road user protection (pedestrians and cyclists)	7
Cooperative collision risk warning	8
Motorcycle approaching indication	8
Wrong way driving warning	9

Inter-urban EU initiatives create focus on day-one services.

Urban global connected services on GLOSA/TTG based leveraging on central architecture can make the start. An (independent) special case: Prioritisation with “V2X” (already today prices can compete with classic solutions on infrastructure).

- (Roadworks) Warning: Vehicles emit “traffic messages” and are able to receive these directly, too. Content as known of “RDS-TMC” or better of its successor “TPEG” can be exchanged fast and spontaneously in form of DENM messages. Particularly at local hazards (work zones, accidents, ice, emergency breaking,…) a key win.
- IVS: Important information and advisory regulations of signs can be directly communicated to vehicle assistant functions in electronic format (even where is no physical sign).
- Line Control: the vehicle knows the imposed control function of the traffic centre and supports with its assistant systems fluent and safe driving.
- GLOSA/TTG: driver AND vehicle know about expected signal control transitions – and can proceed relaxed (driver) and energy efficient in traffic and be prepared to proceed exactly in time respectively when waiting. And it is sooo cool….
- Collect traffic data (use CAMs) is more or less a “free FCD add-on” … just starting with an initially low sample rate.
- Prioritisation → next slide