



Standardization of Wireless Vehicular Communications within IEEE and ETSI

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CERES

CENTRE FOR RESEARCH ON EMBEDDED SYSTEMS

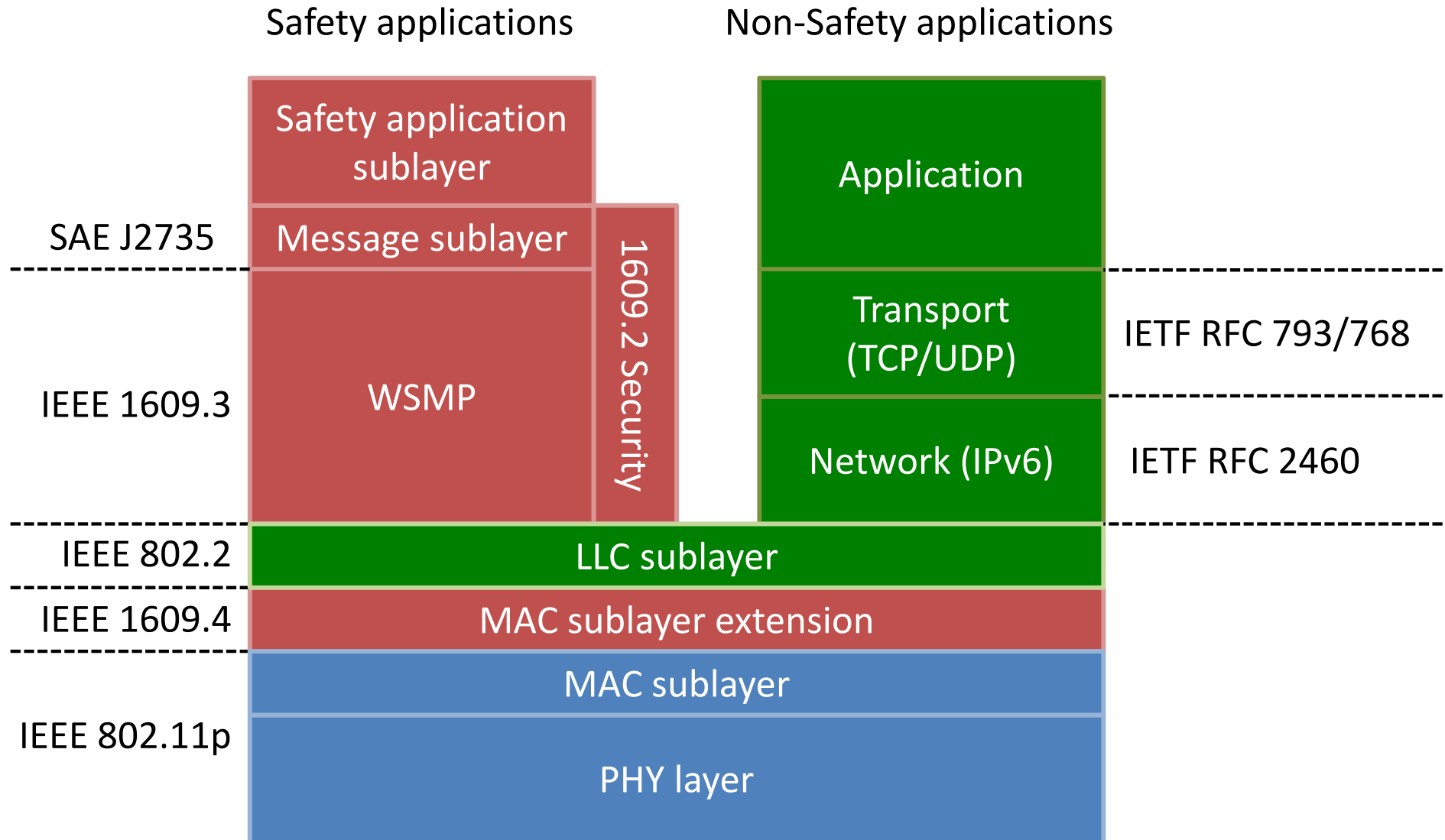
Cooperative ITS

- Traffic efficiency, traffic safety and value-added services
- Can be realized through different wireless access technologies
- Focus here is on road traffic safety using ad hoc networking through IEEE 802.11p
- Two types of messages: time-triggered position messages and event-driven hazard warnings

Frequency bands for cooperative ITS

- North America
 - 5.850-5.925 GHz Intelligent Transportation Systems Radio Service
 - 75 MHz
 - 7x10 MHz channels
 - 1 control channel and 6 service channels
- Europe
 - 5.875-5.925 GHz (30 MHz + 20 MHz)
 - Road traffic safety
 - 1x10 MHz control channel and 2x10 MHz service channels
 - Traffic efficiency
 - 2x10 MHz service channels

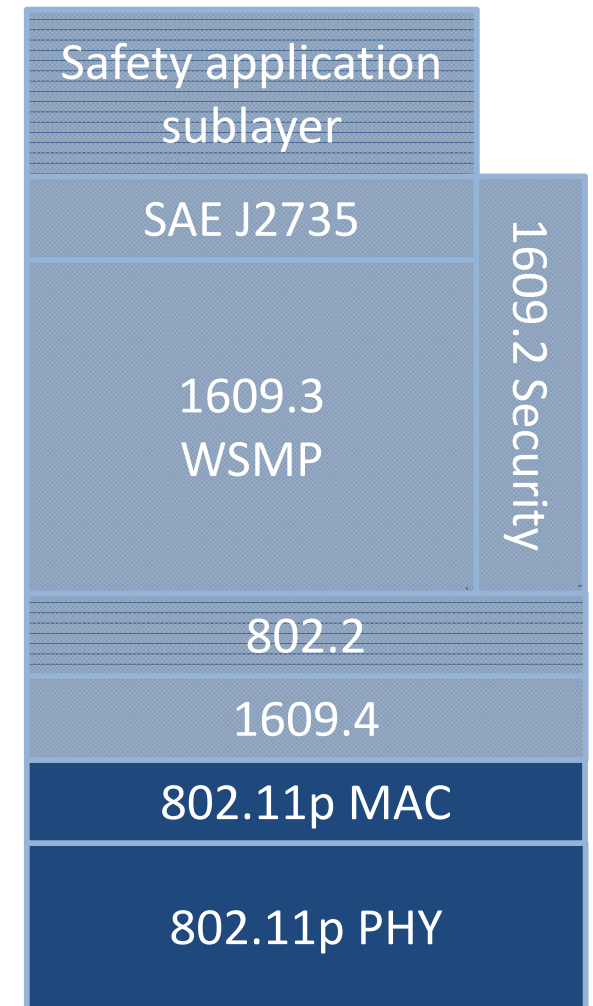
IEEE WAVE/802.11p



WAVE = Wireless Access in Vehicular Environment

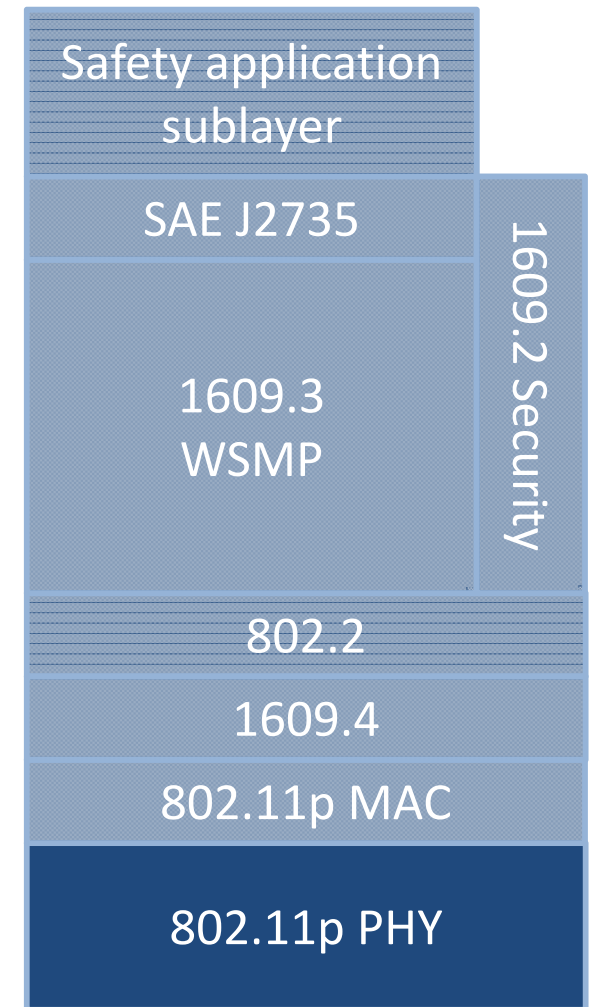
IEEE 802.11p

- An amendment to the WiFi standard IEEE 802.11
- Ratified in July, 2010
- No access point functionality
 - No authentication or association procedures
- Medium access control (MAC)
 - Carrier sense multiple access with collision avoidance (CSMA/CA)
 - Support for Quality of Service (802.11e)



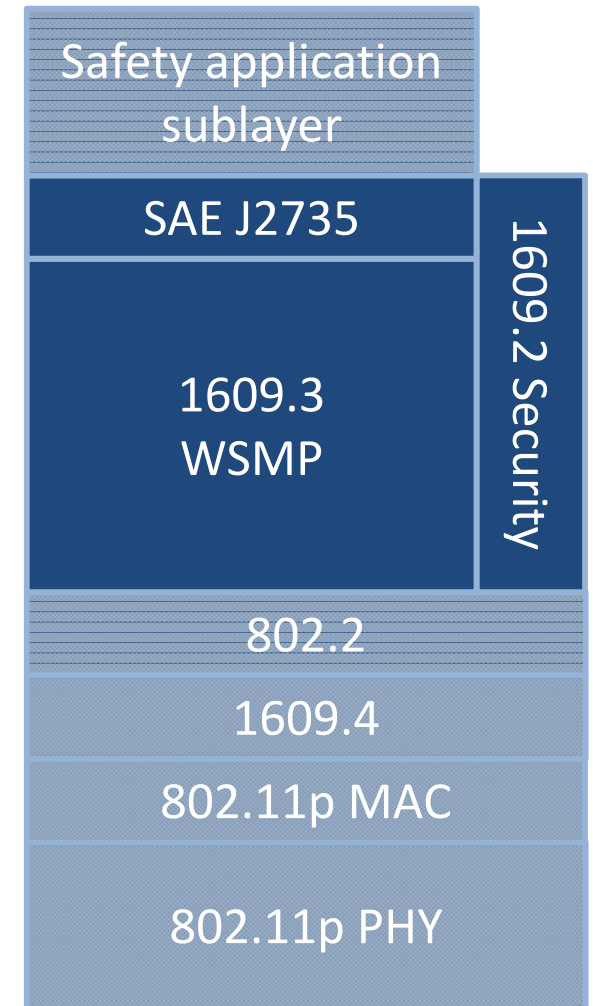
IEEE 802.11p

- Physical layer of 802.11p
- Derived from the 802.11a
 - Defines 3 different channel widths: 5, **10**, and 20 MHz
- Orthogonal Frequency Division Multiplexing (OFDM)
 - 48 data carriers and 4 pilots
 - Subcarrier spacing of 156.25 kHz
 - Symbol interval $8 \mu s$ (GI of $1.6 \mu s$)
- 8 different transfer rates
 - 3, 4.5, **6**, 9, 12, 18, 24, 27 Mbps
 - BPSK, QPSK, 16-QAM, 64-QAM



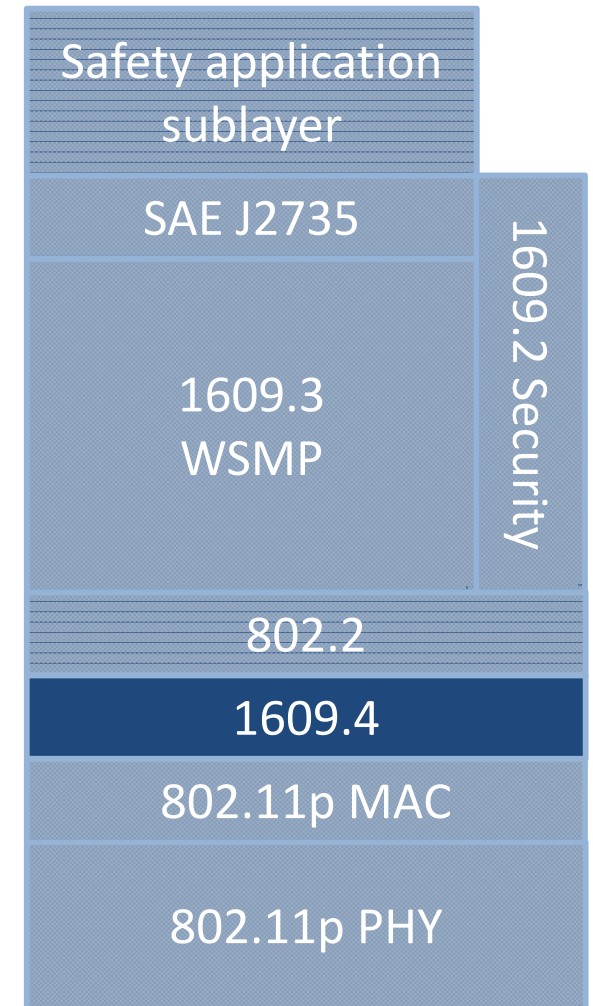
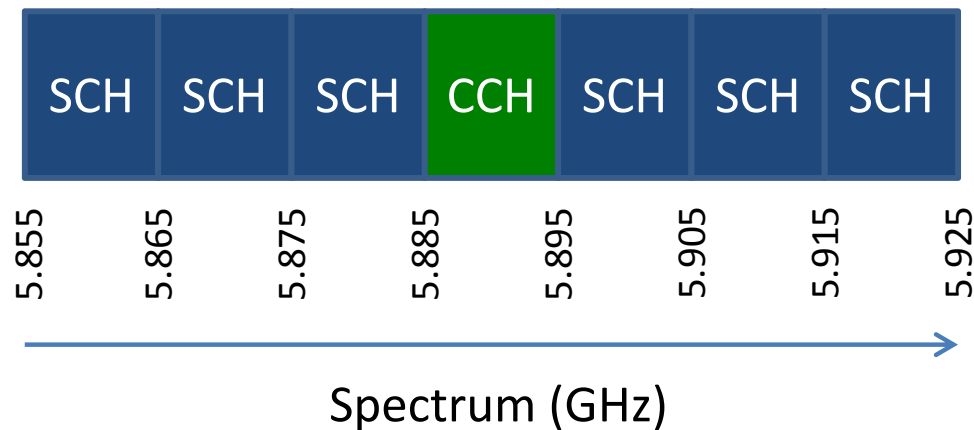
IEEE WAVE/802.11p

- 1609.3 WSMP
 - WAVE short message protocol (WSMP)
 - Developed to avoid excessive overhead
 - WAVE Short Messages (WSM)
 - WAVE Service Advertisements (WSA)
- SAE J2735 DSRC message set dictionary
 - 15 message types
 - Basic Safety Message (BSM)
 - ~300B, 10Hz
 - Conveys state information about the sending vehicle
 - Periodic "Here I am" messages
- 1609.2 Security



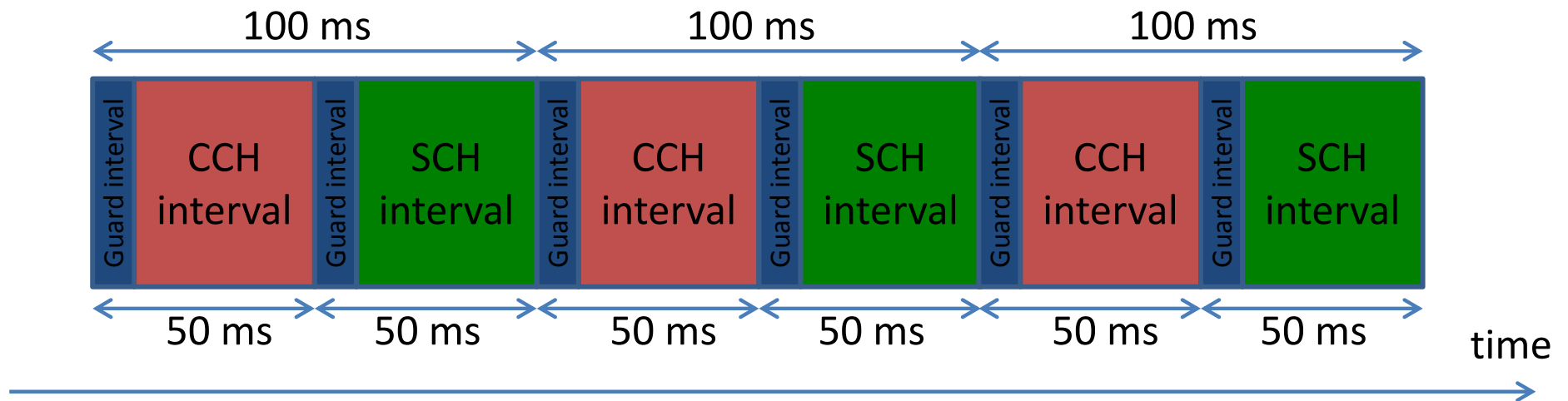
IEEE WAVE/802.11p

- 1609.4 Multichannel operation
 - One Control channel (CCH)
 - Six Service channels (SCH)

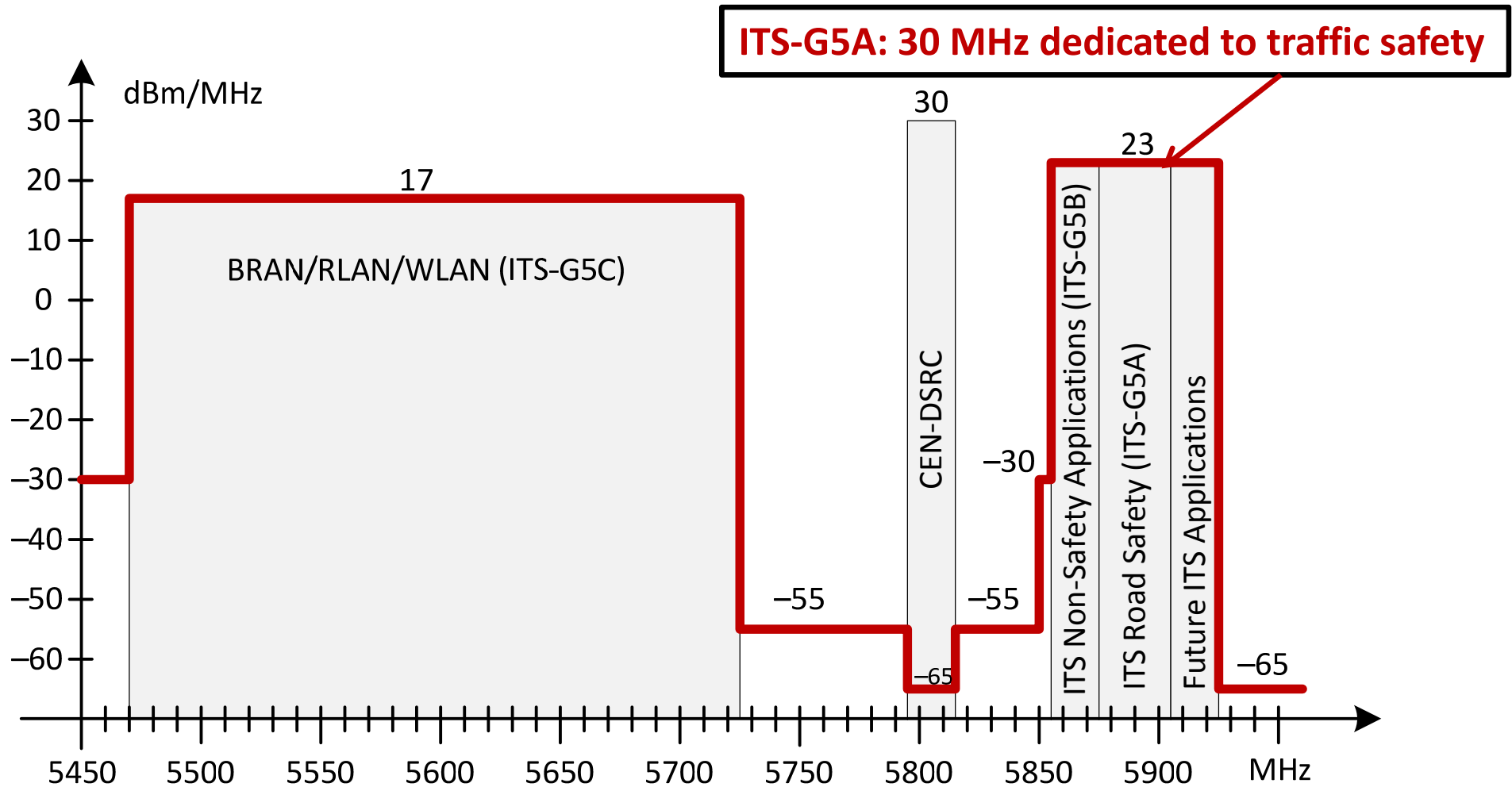


Ongoing work in the US

- SAE J2945.1 Minimum Performance Requirements
 - To ensure interoperability between nodes
 - E.g., define BSMs sending rate, transmit power control, adaptive message rate control
- Update of 1609.4 multichannel operation
 - Move all road traffic safety data to one SCH



Frequency bands in Europe



ETSI ES 202 663 (V1.1.0): “Intelligent Transport Systems (ITS); European profile standard for the physical and medium access control layer of Intelligent Transport Systems operating in the 5 GHz frequency band”

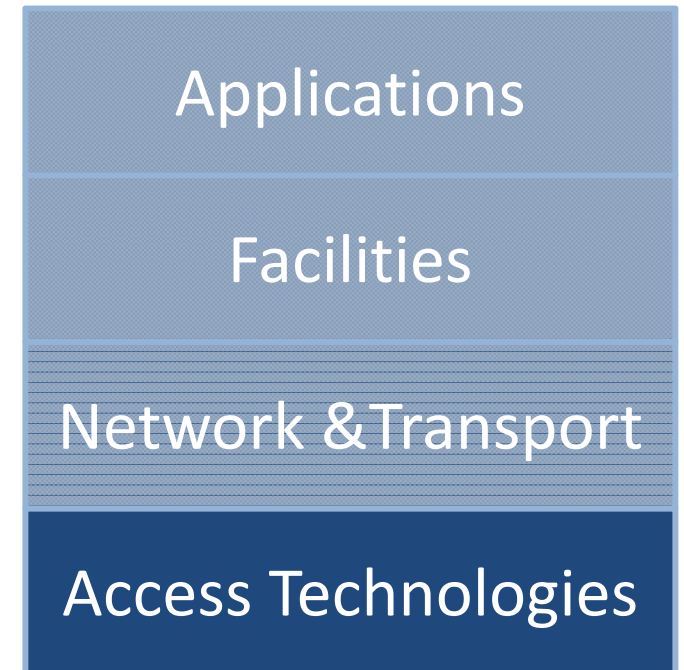
ETSI TC ITS protocol stack

- Adds a facilities layer in-between transport and applications
- The access technologies do not only focus on *ad hoc* networking



ETSI – Access technologies

- Profile standard of IEEE 802.11p
 - Termed **ITS G5**
 - MAC and PHY
 - ES 202 663
 - Adapting 802.11p to the European spectrum
- Requirement on Decentralized Congestion Control (DCC)
 - TS 102 687

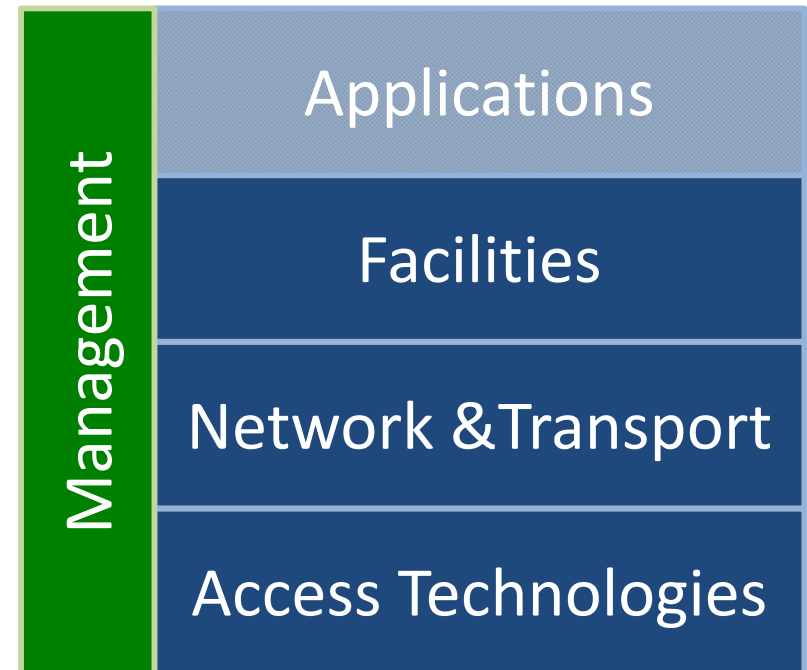


Motivations for DCC

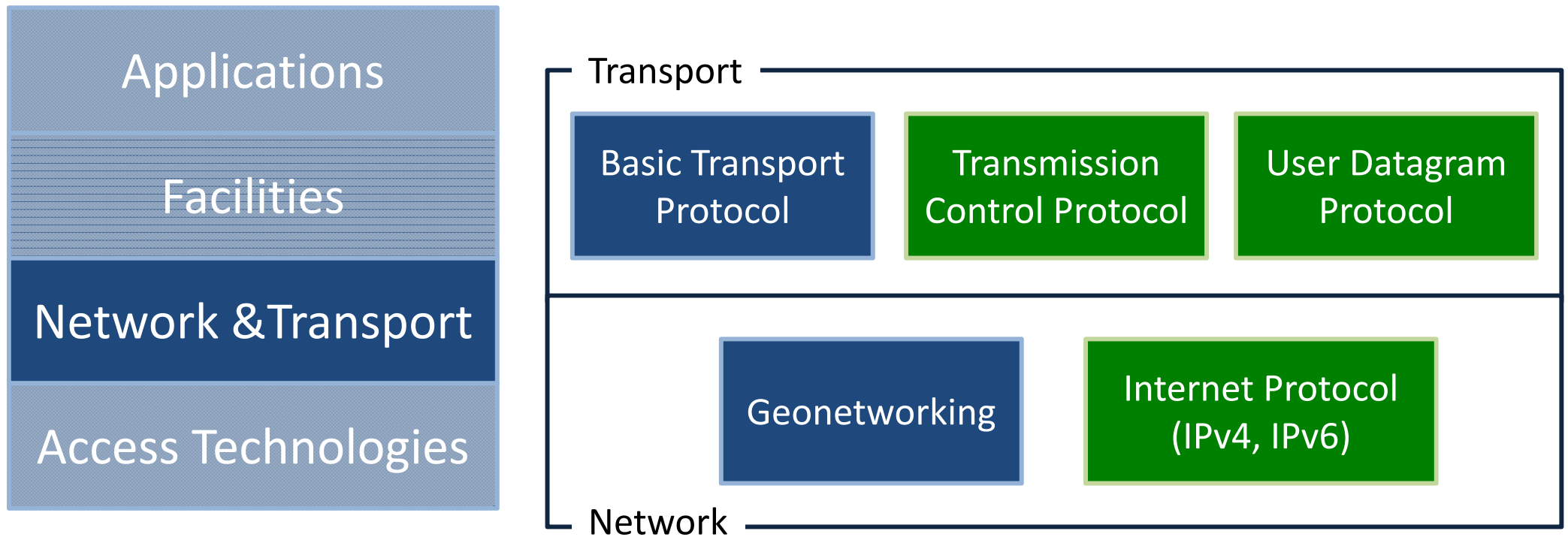
- Adapt the transmit power through transmit power control (TPC) algorithms
- Adapt the packet generation in each node through transmit rate control (TRC)
- The number of nodes in a VANET cannot be restricted
- CSMA as MAC method will have trouble when the number of nodes increases within radio range
 - Unbounded channel access delay (nodes will not be able to transmit packets)
 - Affects the performance of the road traffic safety applications

DCC

- DCC influences three parts of the protocol stack
 - Access technologies
 - Network & Transport
 - Facilities
- Management plane plays a central role
- Cross-layer problem



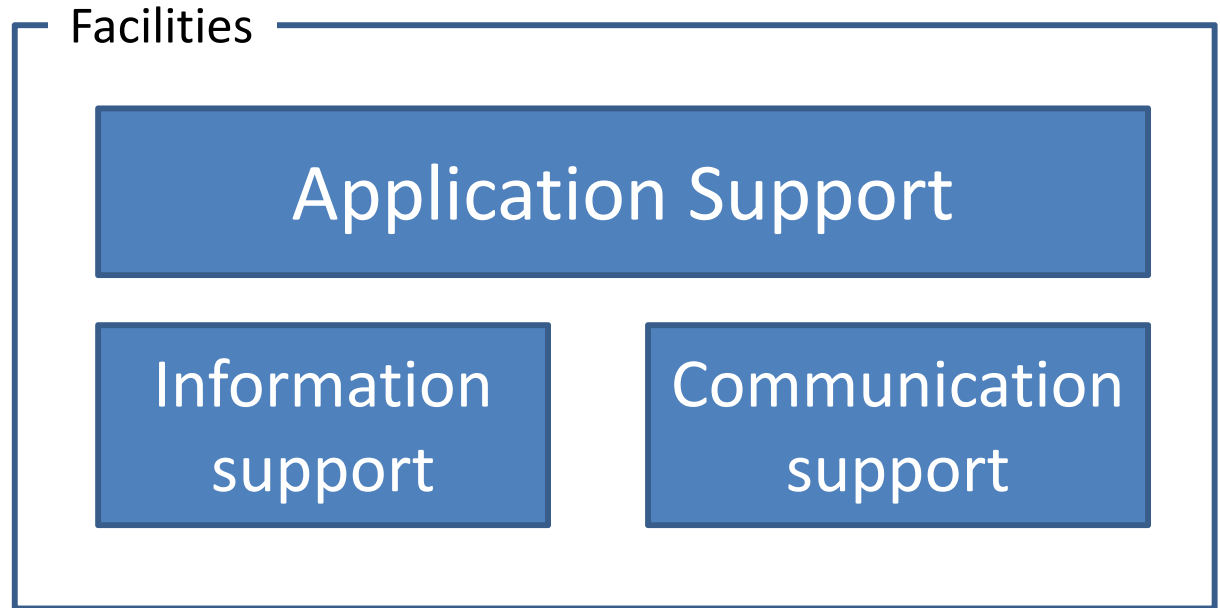
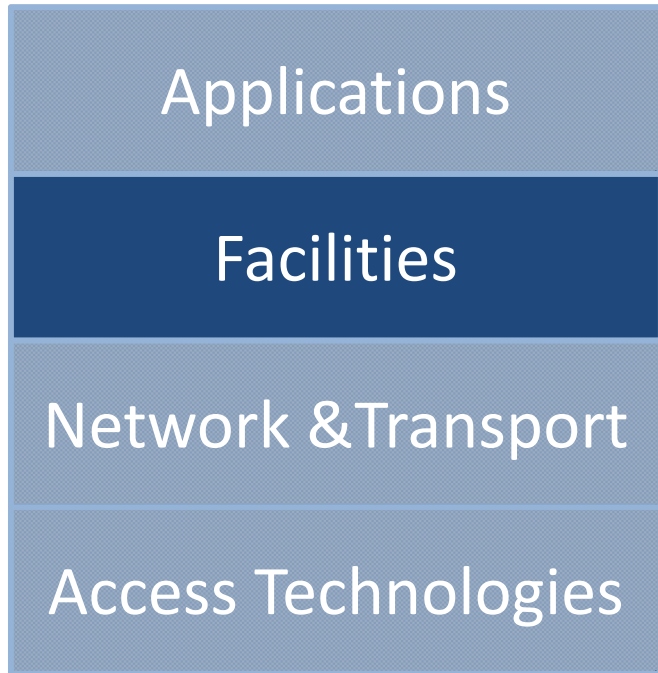
ETSI – Network and transport



ETSI – Network and Transport

- Geonetworking
 - Media-independent functionality
 - TS 102 636-4-1
 - Does not rely on a specific access technology
 - Media-dependent functionality
 - TS 102 636-4-2
 - Supporting the DCC part
- Basic Transport Protocol (BTP)
 - TS 102 636-5-1
 - Connection-less (best effort delivery)
 - Low overhead

ETSI – Facilities



Application support

- E.g. Station positioning, Service management, Message management, Mobile station dynamics, LDM management, Security access

Information support

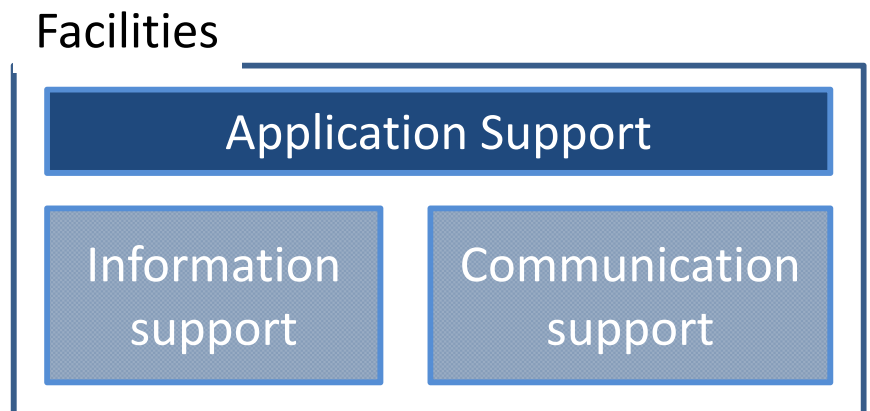
- E.g. LDM database, Data presentation, Location referencing, Station type/capabilities

Communication support

- E.g. Addressing mode, Mobility management, GEONET support, Session support

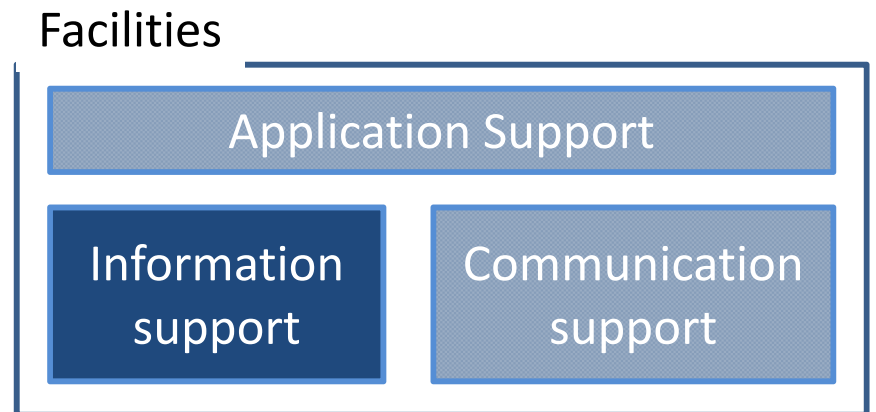
ETSI – Facilities cont'd

- Two central message types
- Cooperative Awareness Messages (CAM)
 - TS 102 637-2
 - Periodic time-triggered position messages
 - "Here I am"
 - 1-10 Hz, packet length including security up to 800 bytes
- Decentralized Environmental Notification Messages (DENM)
 - TS 102 637-3
 - Event-driven hazard warnings

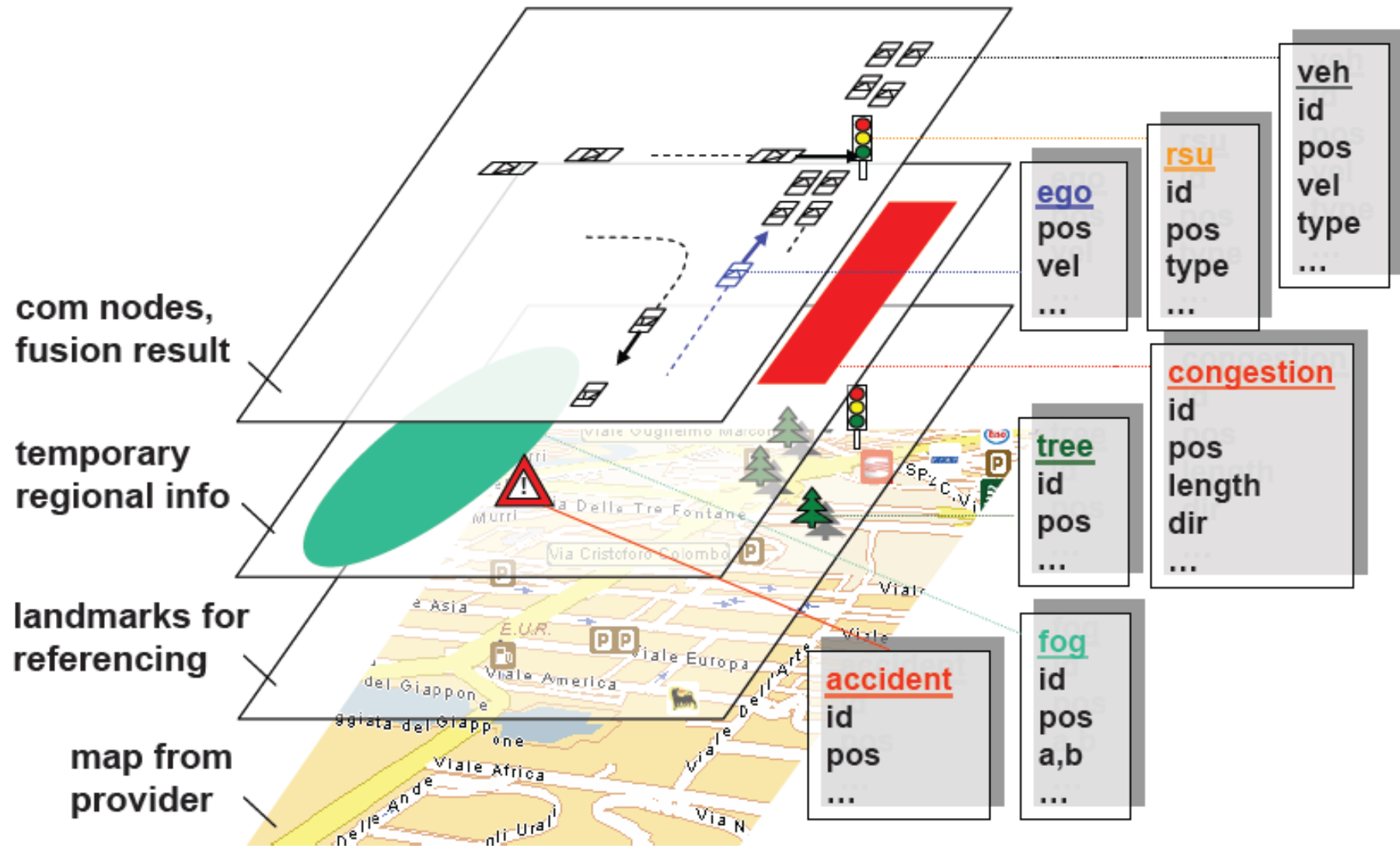


Local Dynamic Map (LDM)

- The LDM is a database storing and maintaining data
- TR 102 863
- Dynamic data received from other ITS stations through CAM and DENM
- Applications retrieve relevant data from the LDM

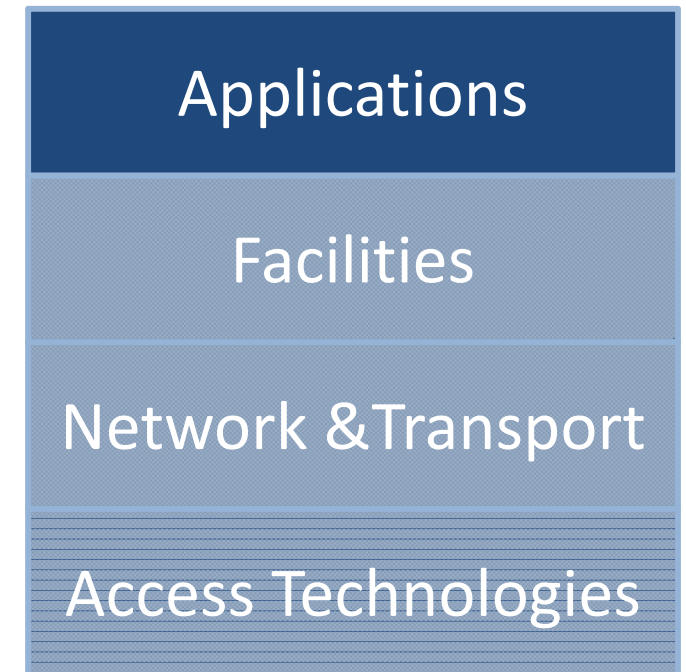


LDM



ETSI – Applications

- Basic set of applications
- TR 102 638
- Road safety (driving assistance)
 - Emergency vehicle, slow vehicle, wrong way driving, traffic condition, roadwork, etc.
- Traffic efficiency
 - Speed limits notification, enhanced route guidance



Ongoing activities within ETSI

- Revision of CAM and DENM specifications
- Channel specification of the ITS band at 5 GHz
 - How to use the different available frequency channels for cooperative ITS
 - TS 102 724
- Minimum set of standards to be finished mid 2012 to ensure interoperability

Wrap up

- IEEE and ETSI have selected the same MAC and PHY layers for road traffic safety applications
 - IEEE 802.11p
 - ETSI ITS G5 (profile of 802.11p) with requirements on DCC
- Beacons/Hello messages
 - Basic Safety Messages (BSM) defined in SAE J2735
 - Default: 10 Hz, approx. 300 byte
 - Cooperative Awareness Messages (CAM) defined in TS 102 637-2 (revised for the moment)
 - Default: 2 Hz, approx. 800 byte

Wrap up cont'd

- ETSI added a facility layer in-between transport and application layers containing
 - Application-, communication and information support
 - Local Dynamic Map (LDM) concept
- In the US the BSMs will contain path history and path prediction of the transmitting vehicle
 - No map as a foundation
- In Europe the LDM in each vehicle will keep track of the vehicles through the CAMs
- SAE J2945.1 Minimum Performance Requirements
 - Amongst many other things there will probably be an outline of application requirements

An aerial photograph of a multi-lane highway with heavy traffic. The highway is filled with cars, and the surrounding area includes green hills, trees, and some buildings. Three semi-transparent text boxes are overlaid on the image.

Thank you!

Questions?

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