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*Automated Driving Applications and
Technologies for Intelligent Vehicles*

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AutoNet2030

Towards the improvement of V2X standards for automated driving

Technical Workshop

Athens, Greece
21-22 APRIL 2016



// Automated Driving

Some characteristics of Automated Driving...



// Need for Cooperation

- Automated vehicles in Stand-Alone mode operate in isolation using only on-board sensors to sense their environment
- Decreased road capacity due to increased inter-vehicle distance and lack of coordination.

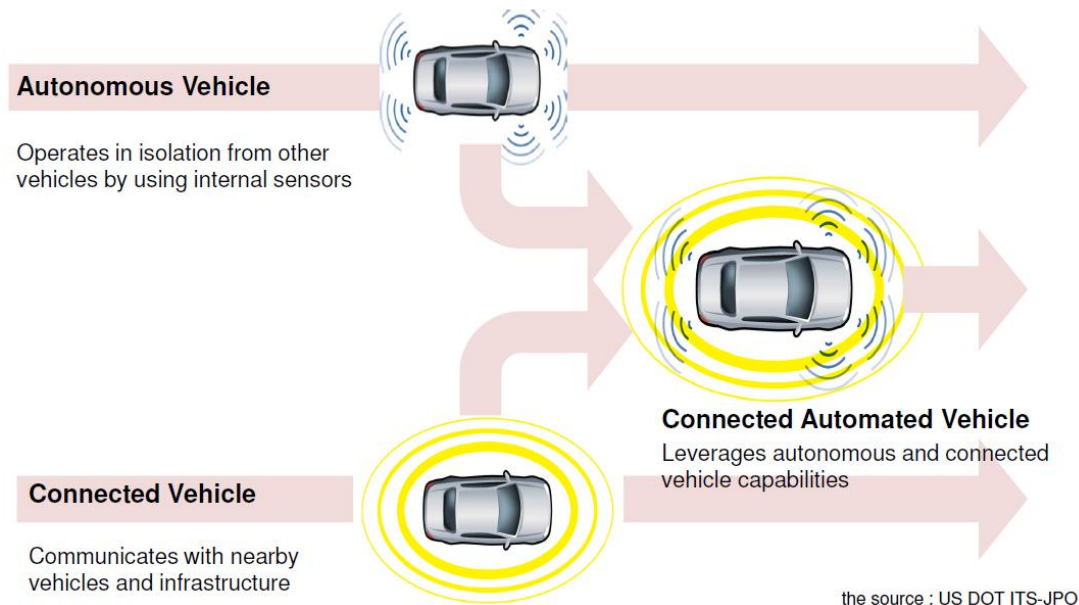


- Communication between vehicles (and infrastructure) can make automated vehicles smarter
 - Coordinated trajectories and higher awareness can improve safety, comfort and traffic efficiency

// AutoNet2030 Motivation



- **Convergence** between *stand-alone* vehicle automation and cooperative *V2X communications*

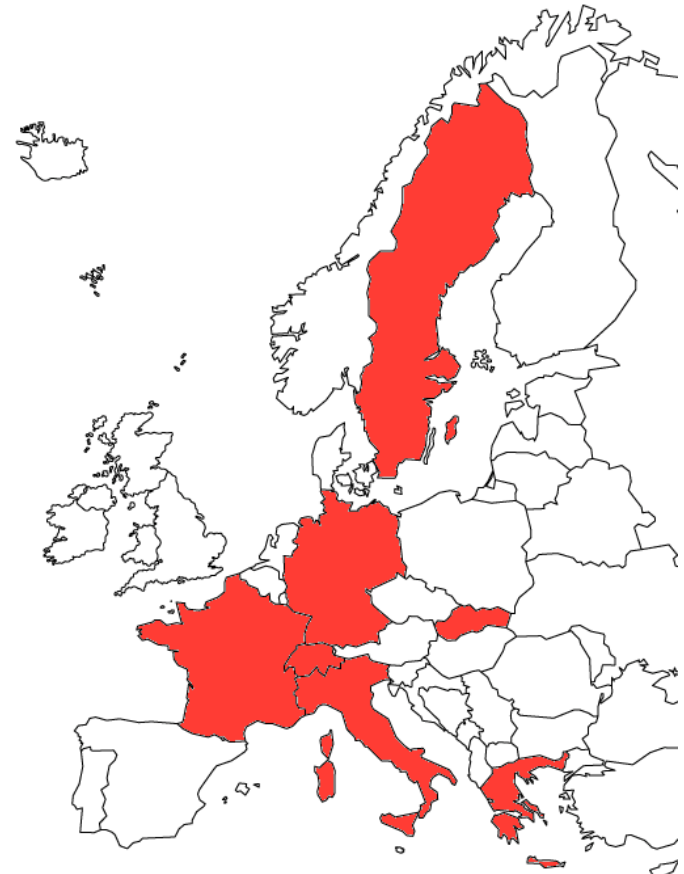


- Key to develop the right concepts for mutually useful convergence of these trends, demonstrate improved **cost-efficiency** and **performance** as opposed to pure sensor-based solutions
- Keep overall system **complexity** as **low** as feasible
 - stand-alone automated driving is already complex enough

// AutoNet2030 Project Facts



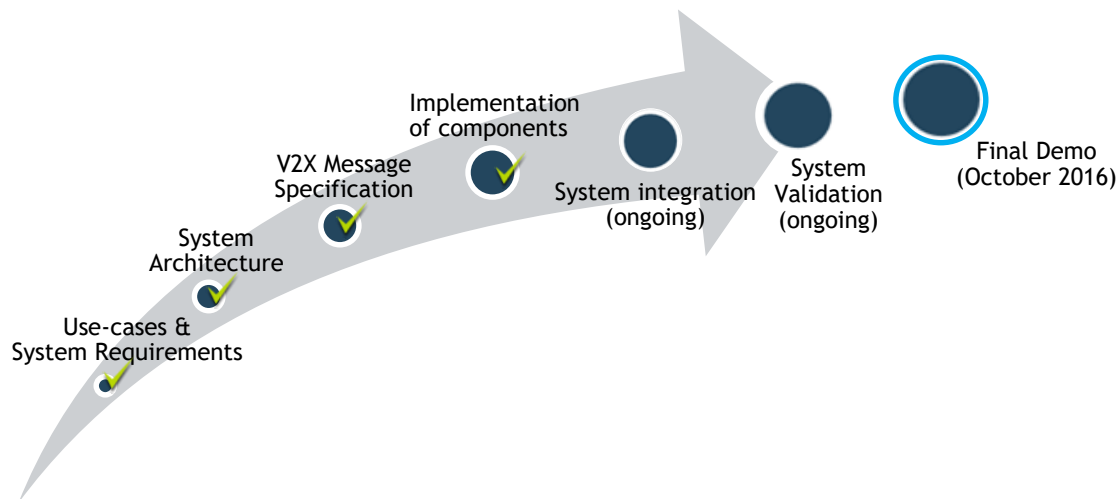
- **Project duration:** November 1, 2013 - October 31, 2016
- **Project budget:** 4.6M Euro
- **EC contribution:** 3.35M Euro
- **Partners:** ICCS (coordinator)
 - BroadBit
 - ARMINES
 - BaseLabs
 - Fiat Research Center
 - EPFL
 - Hitachi Europe
 - Technical University of Dresden
 - Scania Trucks



// AutoNet2030 Objectives



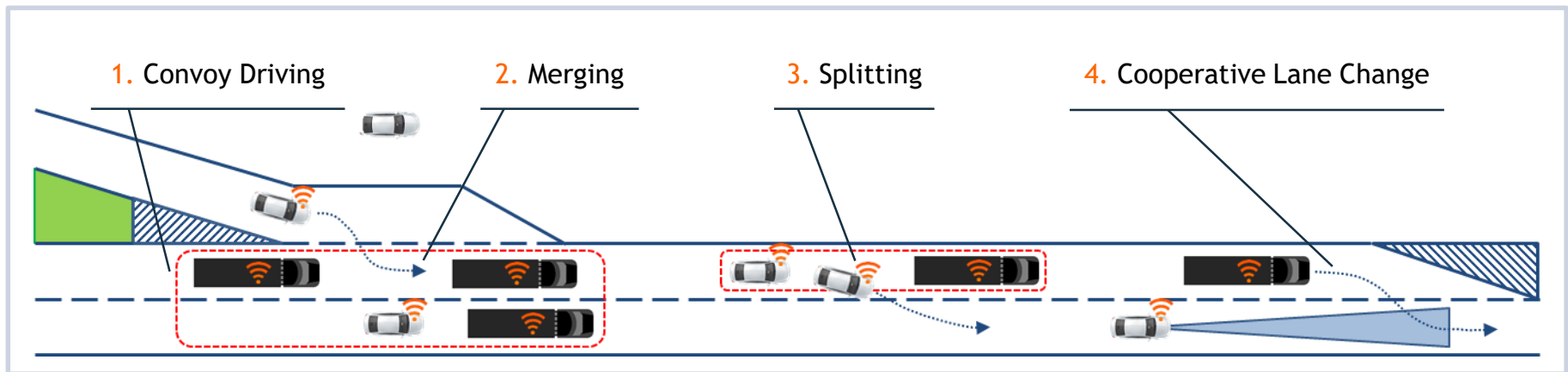
1. Specifications of V2X messages for automated driving, also feeding ETSI ITS standardization
2. Development of maneuvering control algorithms for cooperative automation
3. Development of cost-effective on-board architecture for integrated sensing and communications
4. Development of a new HMI system facilitating the interaction between manual driven and automated vehicles



// AutoNet2030 Highway Use-cases

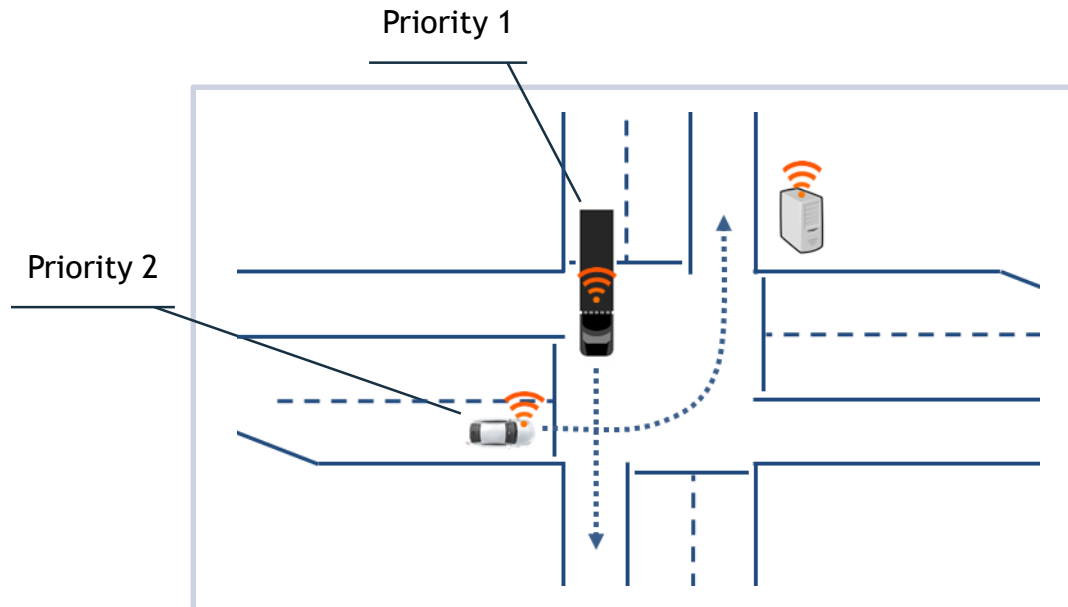


- 4 cooperative AD freeway use-cases
 1. Convoy Driving: Multi-Lane Platoon under Distributed Control i.e. no *leading* vehicle
 2. Merging: Joining a convoy
 3. Splitting: Leaving a convoy
 4. Cooperative Lane Change: Lane change agreement between neighbor vehicles



// AutoNet2030 Urban Use-cases

- 1 cooperative AD *urban* use-cases:
 1. Cooperative Intersection Control: Infrastructure-based coordination of vehicle entry on intersections using relative priorities



// Communication Requirements

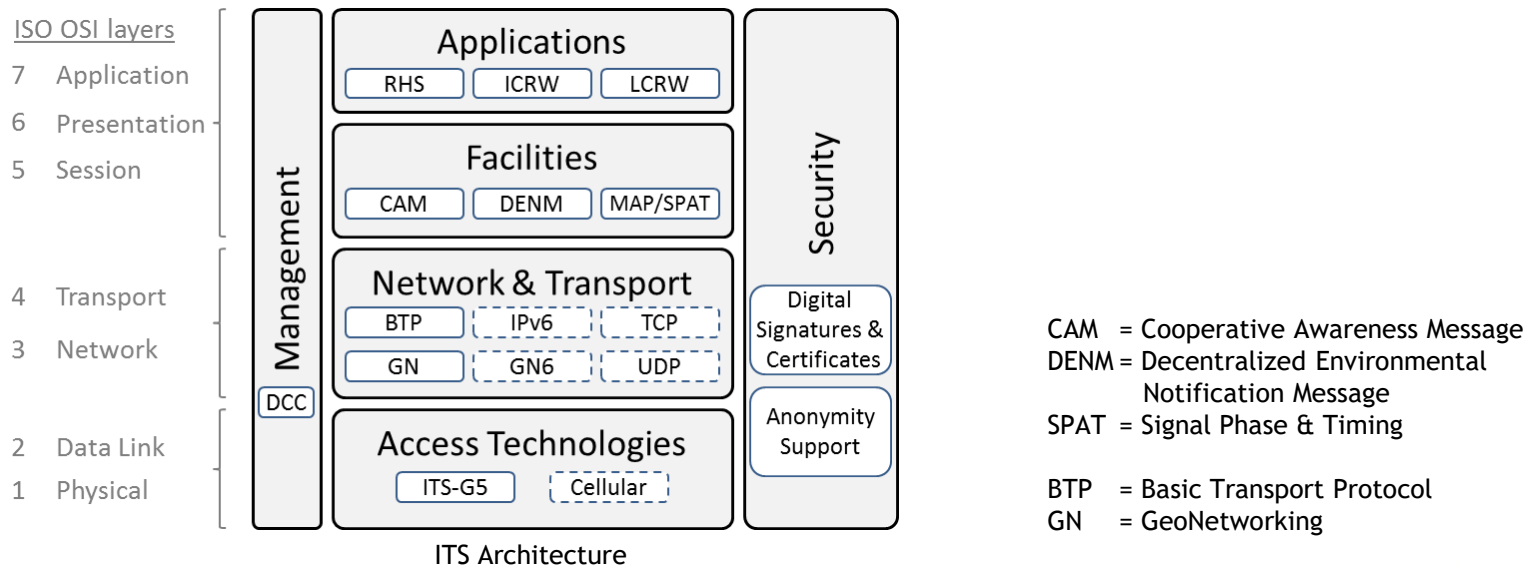


- Functional Requirements
 - *Cyclic* broadcast of data for **cooperative sensing**
 - Sensors: position, speed, acceleration, etc. (10Hz)
 - Perception: occupancy grid (2Hz)
 - Control: target trajectory, speed & acceleration, group composition (2Hz)
 - *Event-based* uni-/broadcast of data for **cooperative maneuvering**
 - Ad-hoc lane change negotiation
 - Intersection priority request / assignment
- Data Quality Requirements
 - Absolute localization accuracy (< 0.5m)
- Delay Requirements
 - End-to-end delay < 100ms. for high dynamic data
 - End-to-end delay < 500ms. for maneuver negotiation

// European V2X Standards



- ITS Architecture defined by ETSI TC ITS follows OSI layered architecture and contains several V2X protocols & messages.
- Well fit for **convergence** with Autonomous Driving:
 - Perception, HMI in *Facilities*-layer
 - (Cooperative) Automated Vehicle Control in *Applications*-layer
- Current V2X standards in EU like the Cooperative Awareness Message (CAM) partly satisfy AutoNet2030 use-case requirements. **Need for extensions.**

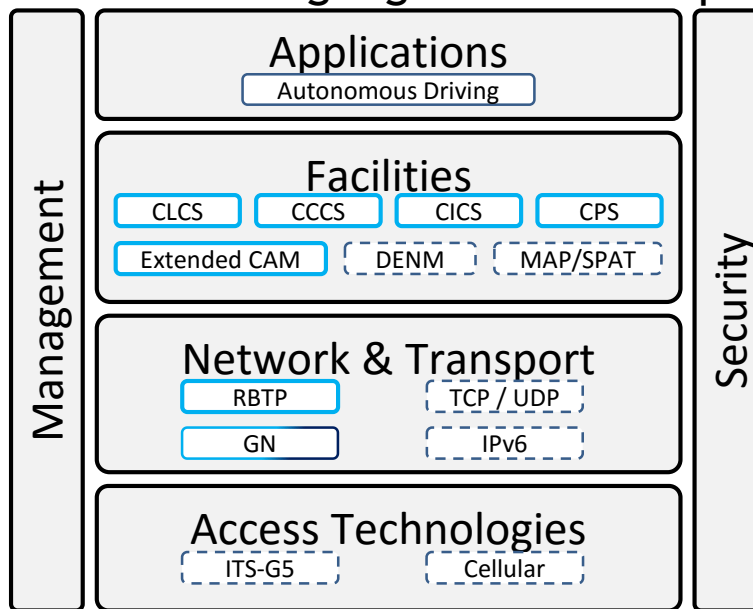


// AutoNet2030 V2X Extensions



Joint effort between *AutoNet2030* and *AdaptIVe* resulted in:

1. New and extended Facilities-layer messages
 - CLCS (Lane Change), CCCS (Convoy), CICS (Intersection) to satisfy *Cooperative Maneuvering* requirements
 - CPS (Occupancy Grid) and Extended CAM for *Cooperative Sensing* requirements
2. Reliable BTP to support Cooperative Maneuvering
3. Innovative GN routing algorithms to improve uni-/broadcast communication



Full specification available at:
<http://www.autonet2030.eu/>

- CLCS = Cooperative Lane Change Service
- CCCS = Cooperative Convoy Communication Service
- CICS = Cooperative Intersection Control Service
- CPS = Cooperative Perception Service
- RBTP = Reliable BTP

AutoNet2030 V2X extensions standard V2X components

// ETSI TC ITS activities on Automated Driving



- 2 Work Items in WG1 (Application Requirements and Services)
 - Definition, use cases, requirements, recommendation on technical specifications targeting at extending the release 1 standards (CAM, DENM, GN, ITS-G5 etc.) to support Platooning & C-ACC applications
- 1. TR 103 298 - Platooning pre-standardization study
 - Rapporteur: Ms. Sjöberg (Volvo Technology Corporation)
 - Status: WI Adopted by Technical Committee.
- 2. TR 103 299 - C-ACC pre-standardization study
 - Rapporteur: Ms. Lan (Hitachi Europe)
 - Status: Early draft of Technical Report

AutoNet2030, AdaptIVe and i-GAME
are contributing to the above work items.

// Conclusions



1. *Cooperative* Automated Driving can further improve safety, comfort and traffic efficiency
2. AutoNet2030 has defined use-cases and communication requirements for Cooperative Automated Driving
 - Convergence between V2X and stand-alone AD
 - Communication complements on-board sensors, no replacement
3. Current V2X Standards in EU are insufficient to meet *Cooperative Maneuvering* and *Cooperative Sensing* requirements of AutoNet2030
4. AutoNet2030 has defined extension to EU standards for V2X communication and contributes to ongoing standardization activities in EU



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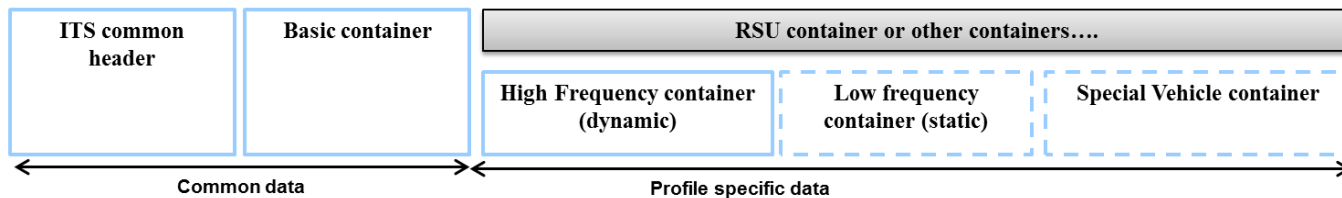
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Thank you.



// Extended CAM content

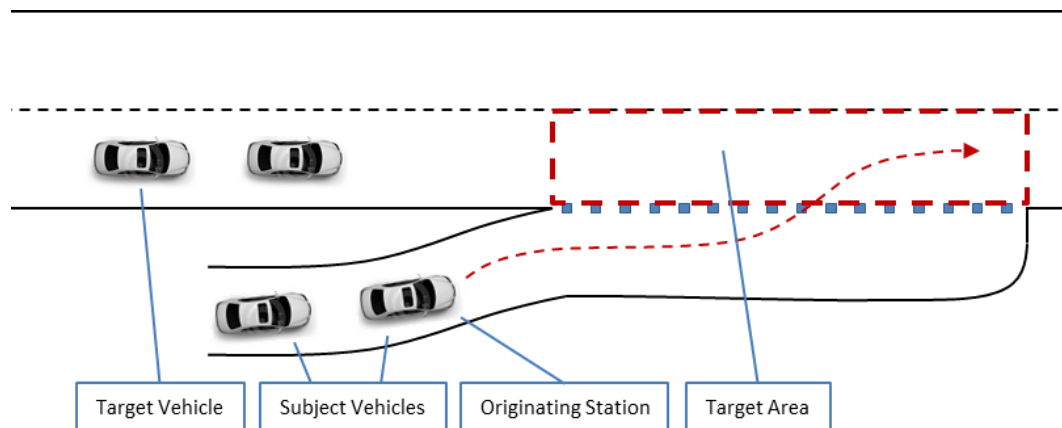
Field	Description	Transmission Frequency
Driving Mode	The driving mode engaged by the vehicle that sent the CAM.	2 Hz
Automated Control	Lists the automated vehicle control systems engaged by the vehicle that sent the CAM.	2 Hz
Braking Capacity	The maximum braking capacity and its confidence of the vehicle that sent the CAM.	2 Hz
Target Speed	The target speed of the vehicle that sent the CAM.	2 Hz
Target Longitudinal Acceleration	The target longitudinal acceleration of the vehicle that sent the CAM.	2 Hz
Target Distance to Preceding Vehicle	The target distance between the front bumper of the vehicle that sent the CAM and the rear bumper its preceding vehicle in the same lane.	10 Hz
Target Distance to Following Vehicle	The target distance between the rear bumper of the vehicle that sent the CAM and the front bumper of its following vehicle in the same lane.	2 Hz
Predicted Path	The predicted future trajectory of the vehicle that sent the CAM.	2 Hz
Group Identifier	The platoon of convoy identifier in which the vehicle that sent the CAM is driving.	2 Hz
Group Speed	Target speed of the convoy or platoon the vehicle is driving in	2 Hz



// Cooperative Lane Change Coordination

Communication facility to support a cooperative lane change of a single or group of vehicles. A Cooperative lane change is executed in three phases:

- **Search Phase (optional):** finding the right target vehicle in case awareness of potential target vehicles is insufficient.
- **Preparation Phase:** longitudinal adjustment of subject and target vehicles.
- **Execution Phase:** lateral lane change of subject vehicles.



// Cooperative Lane Change Service cont'd

