Connected and Cooperative Vehicles

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Strategies for Future Traffic

**Avoid**
- Minimizing travel distances
- Reconstruction of existing cities

- Long-term Effect
- Restricted potential (Growth of leisure traffic)

**Shift**
- Mass transportation vehicles through main lines
- Public Transport Network
- Freight transport through rail systems

- Restricted infrastructure
- Need for high investments

**Improve**
- Vehicles are more efficient
- Traffic flow is better
- Connected Vehicles
- Cooperative Vehicles

Action Field of Vehicle Manufactures
Where are we today?

- Day-1 Specifications completed
  - Basic System Profile (BSP) v1.0.5
  - Triggering Conditions
- Finalizing the Compliance Assessment documents
- Testing - Cooperative ITS Corridor in Europe
100% Ausstattung der Neuzulassungen
100% Ausstattung der Typenneuzulassungen
Hochlaufzeit 10 Jahre bis 100%
Ausstattung der Typenneuzulassungen
der Ober- und obere Mittelklasse-
Fahrzeuge

Volkswagen – Deployment Phases of Car2Car Communication Technology and Functions

ETSI ITS Workshop 2013

How does the future looks today?
Deployment Phases of Vehicle2X Communication Technology and Functions (Examples)

**Phase 1:**
- **Basic V2V Communication**
  - e.g. Roadwork Warning
  - Emergency Vehicle Warning
  - Traffic Jam Warning
  - Post Crash Warning

**Phase 2:**
- **Fusion of V2V and Sensor Data**
  - e.g.
    - ACC-Adjustment
    - Lane Change Warning
    - Simple Merge-In Warning

**Phase 3:**
- **Fully-developed Situation Analysis**
  - e.g.
    - Advanced Merge-in Assistance
    - Hazardous Area Warning

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**Deployment Phases:**
- **V2X-Basis**
- **Data Fusion**
- **Collective Perception**

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**Timeline:**
- 2015
- 20xx
- 20xx
- 20xx
Collective Knowledge through Collective Perception

“seeing what the others see“

Knowledge

- Local Status
  - Speed
  - Acceleration
  - Yaw-rate
  - ...

- Local Environment
  - Vehicles
  - Pedestrians
  - Street
  - ...

Enhancement

Remote Status

- Speed
- Acceleration
- Yaw-Rate
- ...

Tactical Environment

- Intention
- Traversable Area
- Concealed Objects
- ...

Collective Knowledge

Collective Perception allows us to „see through the eyes of the other“
Deployment Phases of Vehicle2X Communication - Technology and Functions

- **Basic V2V Communication**
  - e.g. Roadwork Warning
  - Emergency Vehicle Warning
  - TrafficJam Warning
  - PostCrash Warning

- **Fusion of V2V and Sensor Data**
  - e.g. ACC-Adjustment
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- **Fully-developed Situation Analysis**
  - e.g. Advanced Merge-in Assistance
  - Hazardous Area Warning

- **Active Coordination (Rules + Decisions)**
  - e.g. Cooperative Merge-In Assistance
  - Overtaking Assistance

**Deployment Phases**

- **Phase 1**: V2X-Basis
- **Phase 2**: Data Fusion
- **Phase 3**: Collective Perception
- **Phase 4**: Cooperative Agreements
Vehicle2X Communication
Cooperative Agreement

Example Cooperative Merging

- The merging vehicle distributes an information about its intended manoeuvre*.

* Adequate messages still have to be defined.

I am going to merge shortly*
Vehicle2X Communication Cooperative Agreement

Example Cooperative Merging

- The peripheral vehicles analyze, whether the intended manoeuvre is relevant for themselves and how they could assist.
- The white car indicates relevance and recognizes that it is not possible to change the lane. It also calculates that it is possible to enlarge the gap to the car driving ahead in a comfortable manner.
Vehicle2X Communication Cooperative Agreement

Example Cooperative Merging

I am going to enlarge the gap and thus assist the manoeuvre.*

- The intended cooperative behavior will be communicated* and thus accomplished planning reliability for the merging vehicle.
  * Adequate messages still have to be defined.
Vehicle2X Communication Cooperative Agreement

Example Cooperative Merging

- The merging vehicle permanently controls the manoeuvre with its sensor system and checks its plausibility.
Vehicle2X Communication
Cooperative Agreement

Example Cooperative Merging

- When the point of time or place is reached for lane changing, the merging vehicle executes the merging manoeuvre.
Benefits of a Cooperative Driver Assistance System (C-DAS)

**Traffic Dimension (collective)**

- Increased traffic safety due to a more anticipatory and amicable driving behavior and by avoiding potential dangerous situations
- Increased traffic efficiency as a result of a smoother traffic flow.

**Individual Dimension**

- Enhanced driving assistance systems (ACC, Blind Spot Warning)
  - Better handling complex driving situations, e.g. assistance during merging-in on the highway
  - Increased comfort, e.g. fewer driver interventions
- Win-Win-Situation, Community mindset
  - “Grant and be granted” through cooperation

Driving will be simpler and safer
V2X Applications Roadmap

100% installation of new vehicle sales

100% installation of new vehicle platforms

10 year ramp-up to 100% installation of new vehicles

Installation on select new vehicle type of luxury and upper middle class vehicles

Take-over of the driving functions

- Fully Automated Driving
- Optimal Traffic Flow

Status Data
- GLOSA 1.0
- In-Vehicle Information
- Roadworks 1.0
- Traffic-Jam W
- Pre-/Post-Crash W
- Hazardous Location W
- Adverse Weather W
- Roadworks 1.0

Sensor Data
- GLOSA 1.0
- In-Vehicle Information
- Roadworks 2.0
- Connected ACC
- Intersection Collision W
- ...

Intention Data
- GLOSA 2.0
- Roadworks 3.0
- Lane-Merge Assistance
- Area Reservation
- Cooperative ACC
- VRU Warning
- Platoon
- Probe Traffic Data

Coordination Data
- Cooperative Merging
- Overtaking Assistance
- Intersection Assistance
- Dynamic Platooning
- VRU Assistance
- ...

Dissemination

Cooperation

Phase 1
Awareness Driving

Phase 2
Sensing Driving

Phase 3
Cooperative Driving

Phase 4
Synchronized Cooperative Driving

Phase 5
Accident-free Driving

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WG Roadmap
V2X Technology Roadmap

Phase 1
- Single-channel
  - Day1 CC
  - G5A-CCH
  - Day1 PKI
  - GN-GBC
  - GN-SHB

Phase 2
- Multi-channel CC
  - GN-Groupcast
  - GN6
  - GN-BTP + QoS
  - GN-Unicast
  - Data Streaming
  - Advanced FWD
  - Segmentation/Reassembly

Phase 3
- Multi-channel CC
  - Segmentation/Reassembly
  - Misbehaviour detection
  - Sec-Maintainability
  - PC-change rules

Phase 4
- Automatic-driving Messages
  - I2V Coop. Messages
  - V2V Coop. Messages
  - PTD
  - Coop. Sensing
  - VRU
  - SAM
  - MAP
  - SPAT
  - IVI

Channel Management
- Simultaneous multi-channel
  - G5D-SC5
  - G5B-SC4
  - G5B-SC3
- Simultaneous dual-channel
  - G5A-SC2
  - G5A-SC1
- Switched-mode
- Single-channel

Networking
- Day1 CC
- G5A-CCH

Security
- Day-1 PKI

Messages
- DENM
- CAM

Dissemination
- Cooperation
Thank You!
Questions?

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