Platooning – challenges and opportunities

8th ETSI ITS Workshop 2016
March 10, 2016

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A *platoon* is a number of vehicles that are travelling closely together and are electronically connected (electronic towbar)!
ITS-G5 is the Enabler for Platooning

- ITS-G5/IEEE 802.11p is the wireless technology that can pull vehicles together in platoons (a.k.a road trains)
- No communication no platooning
- Wireless communication is regarded as a sensor with different characteristics compared to radar, lidar or camera
- First vehicle is driven manually or automatically
  - Following vehicles are controlled both laterally and longitudinally based on sensor information (including the wireless sensor)
Platooning – Proof of concept

- SARTRE
  - EU project 2009-2012
- Developed platoon application lead by a commercial truck followed by one truck and three Volvo cars
- Communication between vehicles used ITS-G5/IEEE 802.11p
- All following vehicles were automatically controlled
- Main objectives
  - Reduce environmental impact by reduced fuel consumption
  - Reduce congestion by more efficient use of the road network
EU project SARTRE

Reduced fuel consumption leads to reduced amount of CO2 emissions.
Japanese project JARI

Measurement result
(3 trucks platooning - no payload)

FC improvement (%)

Distance between two trucks (m)
The source to stops can be, e.g., red lights and shock waves in dense traffic scenarios, affecting the overall road traffic efficiency.

VDA = German Association of the Automotive Industry
Connected Vehicle Concept

V2V, V2I = ITS-G5/IEEE 802.11p
Road traffic efficiency

- Short-range wireless communication ITS-G5/IEEE 802.11p closes the gap between line-of-sight technologies (e.g., radar, camera) and cellular technology providing long-range communication

- Better utilization of existing road infrastructure (less road traffic congestion)
  - ACC requires a time headway of at least 2.8 sec to be stable
  - Cooperative ACC using C-ITS can reduce this to at least 0.9 sec
  - 2000 vehicles/lane/hour to 4000 vehicles/lane/hour if 100% CACC penetration (research conducted in the US)

A string of vehicles is said to be stable if any disturbances introduced into the string is absorbed!
Challenges

- The road topology influences the performance of the platoon
- The platooning application needs to address the road topology
- Restrictions on weights on certain parts of roads (e.g., bridges)
  - Geofencing
- Different vehicle types
- Permission to operate platoons on public roads
Platooning is a system-of-systems

- Operational independence
- Managerial independence
- Evolutionary development

Emergent behaviour
New safety approach
Control and communication challenges

- Should the platoon control be centralized or distributed?
  - How much control has the leader?
- Separate security solution for the platoon to reduce overhead
  - C-ITS security has much overhead and introduce communication delay
- Can current developed protocols for C-ITS (CAM and DENM) be used for platooning?
  - No, information is missing and CAM and DENM do not support creation and maintenance of the platoon

Minimum delays to avoid string stability issues!
Standardization needs for platooning – Communication aspects

- Common definition of platooning and CACC between SAE, ISO and ETSI is needed
- New facilities layer protocol (or extension of existing ones)
  - Supporting both platooning and CACC
- Separate frequency channel for CACC and platooning
Standardization on platooning in Europe

- TR 103 298 "Intelligent Transport Systems (ITS); Platooning; Pre-standardization study"
  - Rapporteur: Katrin Sjöberg, Volvo
- TR 103 299 "Intelligent Transport Systems (ITS); Cooperative Adaptive Cruise Control (CACC); Pre-standardization study"
  - Rapporteur: Lan Lin, Hitachi
- Time plan
  - June 2015 (early draft), June 2016 (stable draft), February 2017 (approval), March 2017 (publication)
Standardization on platooning worldwide

- SAE DSRC Tech Cmte has established "Cooperative Vehicle Task Force" treating both CACC and platooning
  - SAE J2945/6 – message sets for platooning and CACC
- ISO TC204 WG14 "Vehicle/Roadway and Control Systems"
  - PWI 20035 Intelligent Transport Systems – Cooperative Adaptive Cruise Control (CACC) – Performance Requirements and Test Procedures
  - Extends the already available "ISO 15622 Adaptive Cruise Control Systems"
  - Excerpt from scope: classification of the types of CACC, performance requirements, state transition diagrams, test procedures, etc.
  - CACC does only longitudinal vehicle speed control, uses time gap control strategy similar to ACC and has similar engagement criteria as ACC
Summary

- ITS-G5/IEEE 802.11p is closing the gap between LOS sensors (e.g., radar, lidar and camera) and the long-range cellular technology
  - No subscription needed to operate ITS-G5
- ITS-G5/IEEE 802.11p provides real-time ad hoc networking
  - No coverage by base stations required to operate ITS-G5
  - Congestion control has been developed to maintain network stability in high density vehicle scenarios
- ITS-G5/IEEE 802.11p enables platooning
  - Opportunities
    - Major gains for road traffic can be achieved
    - Better utilization of current road infrastructure
    - Reduced CO2 emission due to reduced fuel consumption
  - Challenges
    - Functional safety
    - User acceptance and human machine interface (HMI)
    - Legal framework and liability
Thanks for listening!