Technology Advances in Vehicle Control & Braking

09/29/16
For almost 100 years braking was based on robust mechanical systems for trains and trucks...

...These systems can stop, but not control stopping distance or stability
In the beginning of the AV future, there was ABS...
5-I’s of Active Safety & Future Autonomy

- **Information**: More sensors; outside inputs = more information
- **Intelligence**: Analyze information to determine appropriate response
- **Intervention**: Speed & direction variation to mitigate situation
- **Insight**: Driver & system performance data available from system
- **Integrity**: In order to allow DAS systems going forward to mitigate larger amounts of crash energy, evolution of all elements are required

- More, enhanced cameras & radars
- Object and situation arbitration
- Much stronger decleration & steering intervention
- Telematics, data for driver education
Why vehicle control and braking is important...

Truck rollover video
Individual WHEEL control

Wheel Speed Sensors (Information) + Electronic Control Unit (Intelligence):

Deliver information to the ABS system to avoid skidding and loss of control

Truck wheel ABS’ing Video
Individual VEHICLE control

Lateral acceleration, Yaw Rate and Steering Angle sensors are the foundation for Electronic Stability Control (ESC)....
Information + Intelligence = Intervention

Doubles on Ice Video

No Full Stability (ESC) System

Full Stability ESC System
Control VEHICLE in Relation to ENVIRONMENT

Early Vehicle Radar Systems (1980’s)

Frequency Shift Keying (FSK)

Linear Frequency Modulation (FM)

Both FM and FSK (FMFSK)

Radar + Cameras

Passive Camera

Lane Detection

Object Detection
More information into the system....

... more robust interventions earlier, with less false activations
Radar and Camera – Complementary Technologies

Radar is accurate in:
- Distance
- Relative velocity
- Independent of visibility

But, limited resolution of:
- Lane relevance
- Object size
- Object elevation
- Object classification

Video is accurate in:
- Relevant lane recognition
- Object size
- Object elevation
- Object classification

But limited in:
- Distance triangulation
- Relative velocity
- Poor weather/visibility

When you make a decision, it’s better to have more than one source of information!
Radar + Camera = More Robust Interventions Earlier

Sensor Fusion video
Insight from Systems – Actionable Safety

Inputs

Data

Consolidation

Use

Benefits

ESP

Wingman

SmarTire

AutoVue

ABS / ATC

Vehicle

SDP

Telematics

Web Site

SafetyDirect®

Severe Event Info w/ Video

Tire, System & Vehicle Alerts

Driver Scorecards

Diagnostics

ATC

Roll

Yaw

ABS

System Status

Tire conditions

Driver alerts

Speed

GPS

Odometer

Collision Mitigation

Collision Warning

Stationary Object Alert

Impact Alert

Lane Departure

Lane Change

Excessive Curve

...
“…They claimed under oath that the hood flew up because we hit them first. At the conclusion of the proceeding, we revealed that we had a video showing that not to be true….. “

-- Director of Safety, SafetyDirect Customer
Path to Autonomous Commercial Vehicles

**Platooning**
- Automatic following
- Optimization of air-resistance (cv) under safe traffic conditions

**Autonomous control of select maneuvers / functions**
- Controlled, monitored lane change, executed by the system per driver demand
- Automatic rear docking & coupling
- Automatic vehicle positioning in a lane

Bendix Trucks Platooning Video
The path to autonomous vehicles involves sensors + communication

Increasing communication between vehicles and infrastructure
Intelligent Transportation Systems (ITS)

Increasing levels of on-vehicle assistance / automation
Advanced Driver Assistance Systems (ADAS)

Level 0  Level 1  Level 2  Level 3  Level 4  Level 5
Driver Only  Driver Assistance  Partial Automation  Conditional Automation  High Automation  Full Automation

*SAE Levels of Driving Automation for On-Road Vehicles
Roadmap to Autonomous Driving

Today

Driver Assistance Systems:
- Full Stability + Collision Warning & Mitigation + Lane Departure Warning + Vehicle & Driver Data

Tomorrow < 2021

ADVANCED Driver Assistance Systems:
- Driver Supported Platooning Lane Keeping
- Select Traffic Applications
- Predictive Vehicle & Driver Data

Future >2021

Semi-Autonomous Applications
- Highway Auto-Pilot
- Advanced Auto-Pilot Platooning “Trains”
- V2X Connectivity

Longitudinal Control

Lateral + Longitudinal Control

Redundancy = Fail Safe

Need for Data will further increase on the road to Autonomous Driving
Challenges for future Autonomous Vehicle development need to be resolved before commercialization

Legal & Societal challenges
- Vienna convention for Europe and signatory countries
- Product liability – law of least probable risk vs. Transition of responsibility to OEMs and DAS suppliers
- Societal acceptance of autonomous vehicles

Data security & integrity
- Loss of communication (V2I, V2V, slow safety relevant, real time safety relevant)
- Integrity of data and software (failures, sabotage/manipulation, distortions)

Functional safety
- Mitigation of transition of control from system to driver

Commercial
- ROI for Investment stakeholders
- Amortization of running cost (data, maintenance, service)
Keys to a safer future...

- Driver will remain an integral part of the safety equation for the foreseeable future but fully supported in critical situations
- Active & Supportive Systems work together to deliver fleets an integrated, optimal approach to safety
- ESP is prerequisite for DAS systems;
- Current DAS (FCAM) systems are efficient in addressing collisions and lane departures
- Further enhancements based on sensor optimization until 2018
- Expanded AEB (Autonomous Emergency Braking) implementation
- Support driver without requiring takeover in emergency situations
- Advanced systems will need more information input – other vehicles, traffic environment
- V2V and V2I necessary for closing information gaps and create system redundancy
- Regulation/legislation needed to develop standards and expand adoption rates
- Parallel to active safety technologies are telematics and data to support fleets in risk mitigation efforts
Thank you