Autonomously Driving Trucks

Challenges and Opportunities

Reinhold Behringer
Knorr-Bremse GmbH
About Presenter and Talk

Reinhold Behringer
System Development Engineer, ADAS
Knorr-Bremse GmbH (since April 2019)
https://www.linkedin.com/in/reinholdbehringer/

Presentation:
• Background: Autonomous trucks and Advanced Driver Assistance Systems (ADAS).
• Specific challenges for autonomous technology for trucks.
• Outlook on future for autonomous trucks.
About Knorr-Bremse

• Leading provider of braking systems for trucks, buses, trailers, and agricultural machines.

• Also world leader in provider of equipment for rail vehicle systems.

• Decades of expertise in developing braking systems:
  • pneumatics, mechanics, electronics, control engineering.

• Now applying of domain expertise for developing autonomous driving systems for trucks.
Autonomous Trucks – Why?

• Improved safety: reducing the number of accidents.
• Improved efficiency: optimized driving, more driving hours.
• Coping with increasing shortage of truck drivers now and in future.
Trucks / Lorries: Case for Autonomous Operation

• Shortage of truck drivers:
  • Additional 45,000 truck drivers currently needed in Germany [1].
  • In US 2028: shortage of 160,000 truck drivers [2].

• Efficiency gains in logistics:
  • US anticipates 55% TCO savings in 2027 with fully autonomous trucks [3].

Trucks / Lorries on Public Roads

• In 2016 in Europe [1]:
  • 55.9M commercial vehicles, of those 12.6M trucks/lorries. 326.8M passenger cars.

• Fatalities [2]:
  • 5% of total in 2016.
  • Decrease from 1161 in 2007 to 674 in 2016.

Accident involving Trucks / Lorries on Public Roads

• In EU: Number of fatalities in truck accidents: 2% [1].
• In US: #of deaths in truck accident increase, while #of deaths in all other motor vehicle crashes are declining [2].

Trucks / Lorries Accidents

• Most fatalities of truck accidents outside urban areas [1].
• 50% of truck accidents (2015): collision at end of standing traffic [2].

[1] Fig. 20: European Road Safety Observatory (ERSO), 2018, https://bit.ly/2Wghrj4
Accidents with trucks
Legal ADAS Requirements for New Trucks in Europe

• Lane Departure Warning System (LDWS) since Nov 2009
• Advanced Emergency Brake System (AEBS):
  • Level 1: speed reduction to 30 km/h (moving obstacle) resp 70 km/h (standing obstacle).
  • Level 2 (since Nov 2018): speed reduction down to 10 km/h (moving obstacle) resp 60 km/h (standing obstacle).
  • Since Nov 2018 minimum reduction of speed by 20 km/h (vehicles > 8t).
  • Potential of ideal AEBS: avoidance of 25% of accidents, 45% of deaths [1]
• Detailed specifications by UN in Feb.2019 [2]:
  • E.g. warning to driver 0.8 sec before automatic emergency braking.
• Consequence:
  • Number of fatalities in truck accidents decreased from 1161 (2007) to 674 (2016) [3].

SAE Levels of Driving Automation

SAE J3016™ LEVELS OF DRIVING AUTOMATION

Graphical representation of the SAE levels of autonomous driving, revised by SAE in 2018.

Legal Requirements for Autonomous Vehicles

• Worldwide many publications by government agencies and insurers regarding autonomous vehicles.
• These are guidelines and requirements for
  • Minimum capability,
  • Takeover and handover times and processes.

History of Autonomous Trucks

2005: Komatsu, autonomous mining vehicles [1].
2016-2020: Starsky Robotics. First street legal fully-unmanned truck. “Supervised machine learning doesn’t live up to the hype.” Main concern: “safety not appreciated by investors”.
2019: first coast-to-coast commercial Level-4 system, by Plus.ai [4].

Currently Available Truck ADAS Technology

• Most current commercially available ADAS technology (including for trucks) is SAE-Level 2.
• Latest development efforts are targeted towards of SAE-Level 3+.

• BUT:
  • There is concern that SAE-Level 3 is unrealistic, requiring human drivers to be fully attentive while system drives “mostly” autonomously [1].
  • Takeover time (from system to driver) is recommended to be 5-7 seconds [2].
  • But full situational awareness of driver takes longer (>45 sec) [3].

• Therefore:
  • More focus on development of SAE-Level 4 autonomy.

Transitioning ADAS Technology from Cars to Trucks

• Simpler than cars:
  • Trucks have lower speed. Size and weight provide “stability”.

• More difficult than cars:
  • Different overall system behaviour of trucks:
    • Weight (e.g. 40 tons): low acceleration and deceleration.
    • Size (trailers and semi-trailers), more complex kinematics.
    • Length of trucks and semi-trailers. More difficult to manoeuvre.
  • Sensors mounted on truck driver cabin need to compensate for cabin motion: has its own motion characteristics (dampening for driver comfort).

• Trucks more dangerous than cars:
  • Larger weight (momentum) causes more serious impact in collisions.

• Sensor systems must be adapted to mounting on trucks. AI approaches need to be trained to take into account truck characteristics.

Truck Manufacturers with Autonomous Concepts

• Examples:
  • Volvo: Hub-to-Hub and SAE-Level 4 prototype.
  • Daimler (including Freightliner): aiming at SAE-Level 4.
  • MAN: networked platooning, self-driving trucks and safety vehicles (SAE-Level 4).
  • Scania: platooning, SAE-Level 4 (Scania AXL).
  • Iveco: driverless autonomous bus (SAE-Level 4).
Volvo

Daimler (in US: Freightliner)

• Series production of SAE-Level 2 technology: Active Drive Assist, Active Lane Assist, in all speed ranges.
• Next aim: SAE-Level 4 [1].


Video: https://bit.ly/2KX0ODD
Ford Otosan


Scania

Vehicle Technology Providers

- Peloton: platooning. [https://peloton-tech.com/](https://peloton-tech.com/)
- Locomation: platooning. [https://locomation.ai/](https://locomation.ai/)
- Aurora: fully autonomous system for trucks and cars (collaboration with Chrysler) [https://aurora.tech/](https://aurora.tech/)
- TuSimple: L4 autonomous shipments. [https://www.tusimple.com/](https://www.tusimple.com/)
- Plus.ai: [https://plus.ai/](https://plus.ai/)
- Knorr-Bremse.
- Continental: sensors.
Autonomous Trucks in Asia

• Inception Technology (China) https://bit.ly/2xsGrLD
Autonomous Truck Concepts

• Concepts:
  • Hub-To-Hub Transport
  • Platooning

• Technologies:
  • Lane-Keeping
  • Distance-Keeping
  • Lane-Changing
  • On-Ramp / Off-Ramp for highways
Hub-to-Hub Autonomous Highway Transportation

• Autonomous driving between depots.
• Is seen as a new overall inclusive logistics solution.
• Is challenging, because not only highway, but also depots.
• Fully autonomous driving would be dock-to-dock.
• Depots need to be near highways.
Platooning

• Is basically an SAE-Level 1 system, but can have also higher-level functions.
• Leading vehicle can be driven by human driver.
• Following vehicles keep automatically a close distance to preceding vehicle.
• Envisioned advantages:
  • Better fuel economy (4% leader, 10% follower) [1].

• OEMs are working on follower technology.
  • Next generation: Follower is SAE-Level-4.

Collaboration Continental and Knorr-Bremse

- **Continental**
  - Sensor hardware (radar, lidar, camera).
  - Vehicle-to-vehicle communication.

- **KNORR-BREMSE**
  - Vehicle integration in truck demonstrators.
  - Driving systems, actuators.

Knorr-Bremse / Continental Platooning Demonstrator

• Three trucks of different make.
• Demonstrated:
  • Platoon formation
  • In-sync driving
  • Auto emergency brake
  • Exit from convoy
  • Safe splitting of platoon
• Driver is present!

KB & Conti Platooning

• https://www.youtube.com/watch?v=bLnWUKWlNak
KB Highway Pilot

- https://www.youtube.com/watch?v=Dx5OLJdYvBc

LEVEL 4 DRIVERLESS OPERATION
Certification of Safety

• Standards for safety:
  • Functional Safety in event of system failures: ISO 26262.

• In USA: NHTSA publishes company “Voluntary Safety Self-Assessments” (VSSA) [2].

• Investigations of how to demonstrate reliability of Autonomous Systems [3].

Demonstrate Reliability

• Needed to demonstrate reliability in terms of fatalities and injuries.
• Driving alone is not feasible [1]:
  • Hundreds of billions of miles to be driven.
  • Tens / hundreds of years.
• Edge cases and dangerous situations / accidents not sufficiently addressed.
• Solution:
  • Systematic simulation of systems. OpenScenario, OpenDrive.

For Cars: PEGASUS

• Addressing safety of autonomous vehicles and how it can be assessed.

• Assessment of functionalities with robotic remote-controlled objects, for exact repeatability of testing scenarios.

• The Pegasus Method: framework for approval recommendation aimed at highly automated driving functions.
  • 20 steps, based on test cases, scenarios, and requirements management.

• Originally only for passenger vehicles, but could be modified for trucks.

Challenges for Future Autonomous Trucks

• SAE-Level-2 ADAS products: ensure that driver is fully alert at any time.
• SAE-Level-3 products: ensure that control takeover from system to driver is seamless.
  • Autonomous systems may consider longer handover time.
• SAE-Level3+:
  • AI approaches (e.g. deep learning) have been hyped, are reaching limits.
  • Robustness of situation and scenario recognition is not yet sufficient. 99% $\rightarrow$ 99.9999%
  • A lot of driving on public roads, but is still insufficient to prove reliability.
  • Insufficient data from edge cases (critical situations, accidents).
• Risk estimation and acceptance by automatic driving system. Literally following the traffic rules re. speed: will become obstacle.
• “Cooperation” with other non-autonomous vehicles.
Summary and Outlook

• The major breakthrough of autonomous truck deployment will most likely not be in SAE-Level 3, but in SAE-Level 4 systems.

• Strong emphasis on safety. Can only be achieved by taking into account more simulation, especially regarding edge case scenarios, to prove safety and robustness of technology.

• Autonomous trucks do have a strong business case, and it is very likely that in 10 years a significant percentage of autonomous trucks will be on highways.
Thank you!

Reinhold Behringer
System Development Engineer
Knorr-Bremse GmbH

https://www.linkedin.com/in/reinholdbehringer/
reinhold.behringer@knorr-bremse.com