Evaluating Traffic Efficiency and Safety by Varying Truck Platoon Characteristics in a Critical Traffic Situation

Timo Faber, TU Delft; Salil Sharma, TU Delft (S.Sharma-4@tudelft.nl); Maaike Snelder, TU Delft and TNO; Gerdien Klunder, TNO; Lóránt Tavassy, Professor, TU Delft; and Hans van Lint, Professor, TU Delft

Introduction

- Truck platooning is the application of cooperative adaptive cruise control where multiple trucks are electronically linked using V2V communication.
- Truck platoons might bring fuel savings and emission reductions. However, their interactions with surrounding traffic and resulting impact on traffic operations and safety are not fully understood.
- Research is needed to assess the impacts of truck platoons especially in critical traffic situations. One of these situations lies around merging sections.

Research objective

- To evaluate the effects of varying truck platoon characteristics on traffic efficiency and safety around a merging section

Modeling of truck platoons

- Longitudinal controller
  - Preliminaries
  - Cooperative Adaptive Cruise Control (CACC)
  - Adaptive Cruise Control (ACC)
  - Cruise Control (CC)
- Lane changing controller
  - Last vehicle first principle
  - Last vehicle in a platoon starts blinker and changes lane first
  - Rest of vehicles in a platoon change lanes
  - Trucks in a platoon may also decelerate to shorten the lane changing process

Experimental design

- Interchange Benelux on A15, The Netherlands
- OpenTrafficSim
- Java-based which uses IDM+ and LMRS
- Trucks: 15%
- On-ramp demand is 25% of mainline demand

Scenarios

- Base case: No platoons
- Scenario 1: Truck platoons on mainline carriageway
- Scenario 2: Truck platoons merging onto mainline carriageway

Local (one-at-a-time) sensitivity analysis

- We change one characteristic of a platoon at a time by keeping others fixed at reference configuration and observe its effect on the output.
- Useful to select some of the best performing platoon configurations in a situation

Conclusions

- Truck platooning on the mainline carriageway seems to be detrimental to traffic efficiency and safety in high traffic intensity.
- Truck platoons merging onto mainline carriageway has limited effects on traffic efficiency and safety.
- Uncertainty in traffic efficiency and safety strongly depends on the interactions among platoon characteristics, traffic demand, and considered traffic scenarios.

Impact of reference platoon configuration

- Platoon characteristics
  - Market penetration rate: 0% (Base case), 25%, 50%, 75%, and 100%.
  - Platoon length: 2 trucks, 3 trucks, 4 trucks, and 5 trucks.
  - Headway in a platoon: 0.3 s, 0.9 s, and 1.5 s.
  - Desired platoon speed: 80 km/h and 100 km/h.
  - Gap creation deceleration: 0 m/s² (off), 1.5 m/s², and 3.0 m/s².

- Lane changing: only mandatory lane changing is allowed
- Cut-ins: only if intra-platoon headway allows for that

Efficiency

- Average travel time (TT)
- Maximum flow (Flow)

Safety

- Time to collision (TTC<0.5)
- Required Braking rate (RBR<2.1m/s²)

Low traffic intensity

- Base case (no platoons): 117.12
- Reference platoon on mainline carriageway: 119.65
- Reference platoon merging onto mainline: 117.51

High traffic intensity

- Base case (no platoons): 127.93
- Reference platoon on mainline carriageway: 149.04
- Reference platoon merging onto mainline: 132.16

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