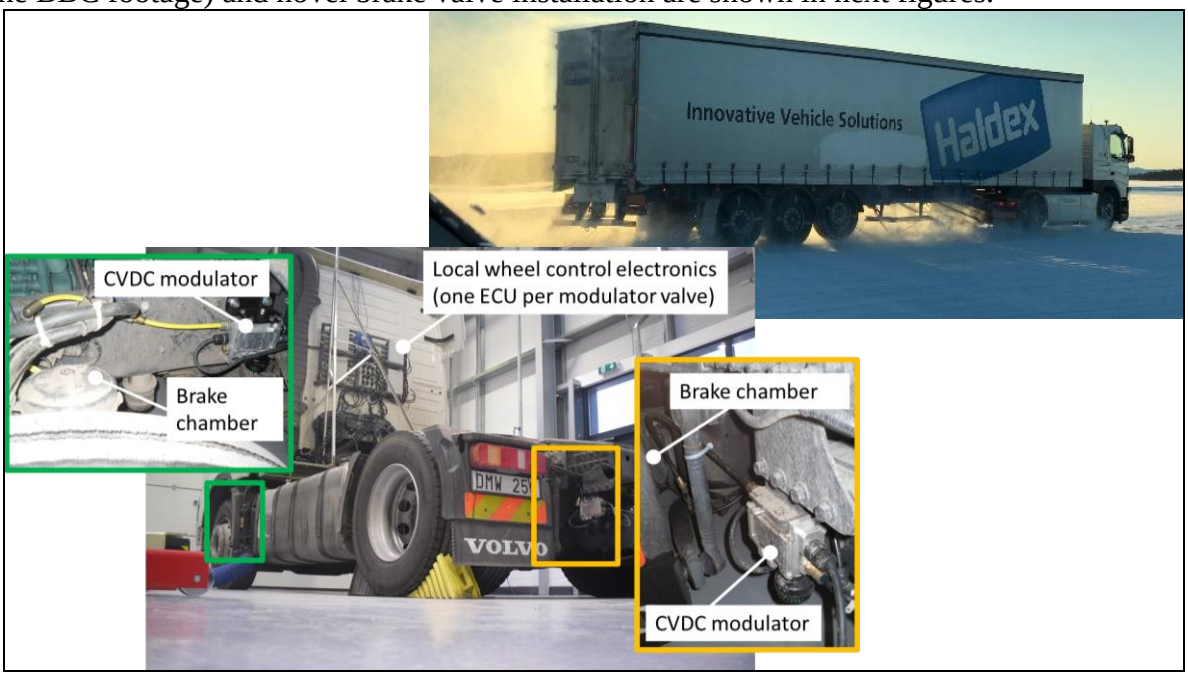
MSc Thesis proposal:

Virtual Verification of Complete Vehicle Requirements for Heavy Vehicles for Development of Brake Systems

Background

Heavy vehicles (such as trucks and buses) operate an electronically controlled, pneumatically actuated braking system. This type of system is commonly known as an electronic brake system (EBS). Recent work by Cambridge University, Haldex Brake Products, Volvo Trucks, and Chalmers University has resulted in the development of a novel fast-acting braking system that enables stopping distances to be reduced by up to 17% in low friction conditions. Vehicle demonstrations of the prototype system were shown on the BBC, [1]. A research project is now run at Haldex, Volvo GTT and Chalmers, see [2]. The test vehicle (featured in the BBC footage) and novel brake valve installation are shown in next figures.



The research project investigates if vehicle control and wheel brake actuator control can be developed in a modular way, with strict standardised signal interface between the controls. Chalmers participates in project and develops tyre characteristics estimator for actuator controls. Two concepts are investigated, “recursive estimator” and “extreme-seeking estimator”.

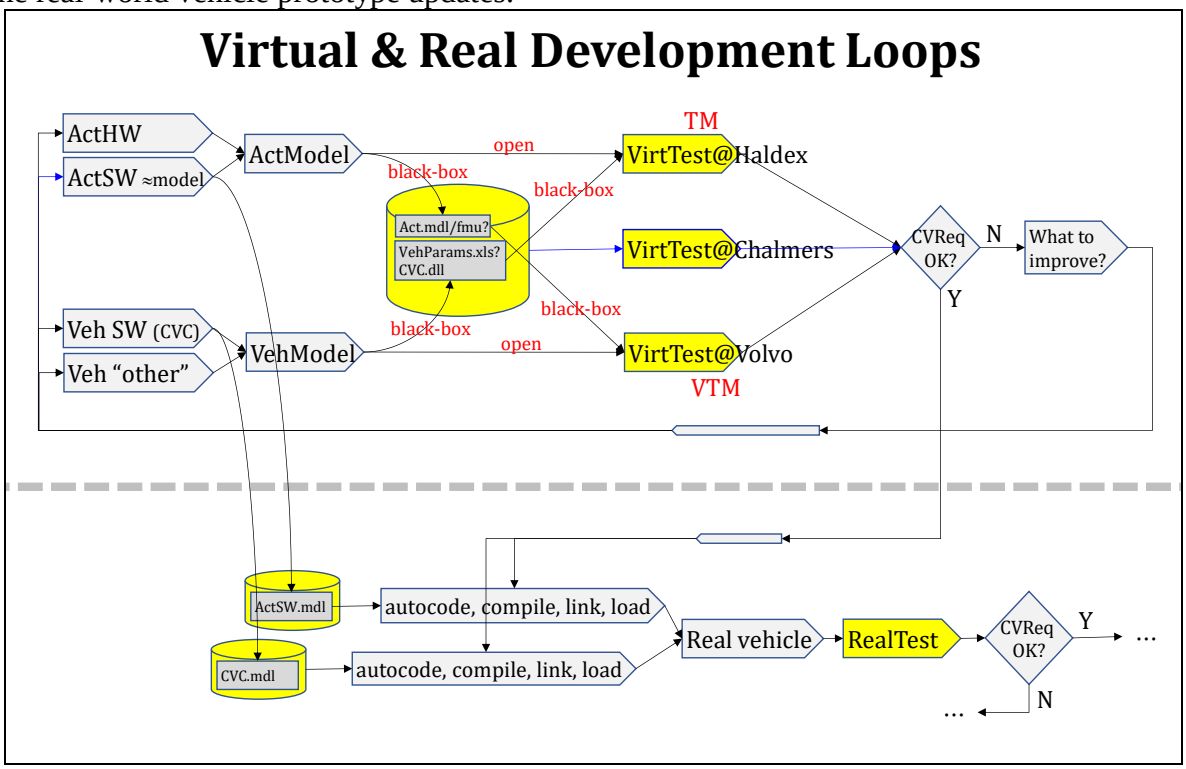
Opportunity motivating the project

Traditionally, vehicle manufacturer and subsystem supplier cooperate and build real-world vehicle prototypes in subsequent development loops. A real-world prototype takes often relatively long time to build, even if modern rapid-prototyping tools are used. For brake systems, the long loop time is accentuated since brake systems have a complex interaction with so many other subsystems in the vehicle. Complex interaction requires same understanding of interfaces (physical and signal) by several engineers in at least two

companies. With modern modelling and simulation techniques it is possible to share models and efficiently develop, using virtual verification.

Envisioned solution

Virtual verification (simulation) enables quicker development loops and better understanding. It will also speeds up the development by improving the quality (less misunderstandings) in the real-world vehicle prototype updates.



Objective <or Research Question>

- How should vehicle manufacturer and brake system supplier utilize simulation models to improve quality and speed of development?
- How much tool/environment independence can be utilized, such as Modelica and FMI standards?

Overall, the challenges and the learning objectives, is not on modelling the parts, but to design good test manoeuvres, including pre- and post-processing.

Deliverables

- A truck model with at least this modularity: Vehicle, Vehicle controls, Brake actuators, Brake actuator controls.
- Test scripts for some 3-10 relevant complete vehicle manoeuvres.
- Working demonstration environment which supports both vehicle manufacturer's and brake supplier's complete vehicle simulation tool. (This should answer Research questions above by demonstration.)
- The work is tool/environment independent, which will be demonstrated by, at least 2 tools/environments to be used: Haldex Brakes environment "TruckMaker" and Volvo GTT's environment "VTM".

Sketch of activities

- **Information search** and
  - Identify interesting 3-10 complete vehicle manoeuvres, such as: straight-line braking, brake in curve, evasive lane change with ESC intervention, tyre characteristics estimation by "recursive estimator" and vehicle control usage of the estimate, friction estimation by "extreme seeking" and vehicle control usage of it, ...
  - Learn TruckMaker, VTM, (possibly Modelica? FMU?)
- **Collect models**:
  - Vehicle (collect from Haldex and Volvo GTT)
  - Vehicle control (from Volvo GTT)
  - Actuator (from Haldex, probably a Modelica/fmu model)
  - Actuator control (from Haldex and Chalmers)
- **Build integration environment**, probably in TM, possibly using [3], [4].
- **Develop scripts** for the relevant manoeuvres and assessment scripts, on complete vehicle level. This is the main work of the thesis.
- **Demonstration/Dissemination** to project [2].

Academic subject:

Requirement on student background:

Automotive, Mechanical, Mechatronics or Physics engineering

Supervision and examination:

Vehicle dynamics

Administrative

- Suitable number of students: 1 or 2
- Number of credits: 30 points per student
- Starting date: During spring 2019
- Stakeholder: Haldex Brakes, Volvo GTT
- Support persons for student(s):
  - Examiner: bengt.jacobson@chalmers.se
  - (Academic) Supervisors: fredrik.bruzelius@chalmers.se, alireza.marzbanrad@chalmers.se (also representing stakeholder, with a need for a complete vehicle model for tyre characteristics estimation and extreme seeking)
  - TruckMaker support at Haldex: Edo Drenth
  - VTM support at Volvo GTT: TBD
- Application to: bengt.jacobson@chalmers.se with CV and transcripts or to web announcement of same thesis at Haldex web, to be or is announced also at http://corporate.haldex.com/en/work-at-haldex/job-opportunities
- Physical location: Chalmers

References:

[1] R. Wescott, "New HGV braking could save lives with quicker stops," BBC, May 2015. [Online]. Available: http://www.bbc.com/news/business-32845386

[2] https://research.chalmers.se/en/project/7113

[3] http://studentarbeten.chalmers.se/publication/233463-a-truck-dynamics-model-for-driving-simulators
[4] https://research.chalmers.se/publication/251269
[5] https://www.linkedin.com/pulse/simulation-better-than-real-thing-edo-drenth/