MSc Thesis proposal Volvo Group Truck Technology and Chalmers Vehicle Dynamics:

Modelling the Motion and Energy Usage of Multi-trailer Vehicles and Different Motion Support Devices in Modelica

About us

Advanced Engineering & Vehicle Concepts is organized within Vehicle Engineering at Volvo Group Trucks Technology. We are responsible of preparing future trucks and transport solutions for all Volvo Group's brands and markets by managing and driving Advanced Engineering at Vehicle Engineering & Vehicle Technology. We develop the future competitive trucks to ensure the transport and energy efficiency for our customers and the society. We are open-minded and performance-oriented and honour to deliver tangible results.

Thesis Background

Environmental issues, consumers expectations and the growing demand for freight transport have created a competitive environment in providing better transportation solutions. Conceptual and optimization-based vehicle design using mathematical models help finding cost- and energy-efficient solutions and eventually faster market adaptation. Therefore, mathematical models with acceptable levels of fidelity must be developed to facilitate the conceptual design and performing optimization, for example, to understand what vehicle components are suitable for US transport fleet market and how they are different from Asia and Europe applications.

Modelica language offers modular physical modelling. It is tool-independent and there are many open-source libraries which make building models with different levels of fidelity possible. In addition, models are open, so that the mathematical equations are visible to users, providing a good autonomy for updating the existing libraries and developing new models.

Problem motivating the project

Most of the existing multi-trailer mathematical models are not modular and the level of fidelity of the models cannot be changed in a straightforward way. However, those properties of the mathematical model (modularity and flexible change of fidelity) are necessary for vehicle conceptual design and optimization for different design targets, applications, optimization cost and constraints.

Envisioned solution

The envision solution is mathematical models in Modelica that can be used to simulate motion of multi-trailer vehicles and energy usage of the entire system together with different motion support devices. The models should be modular, i.e., it should be possible to change a low fidelity subsystem model with a high fidelity one to capture the physical phenomena needed for the given application.

Objective <or Research Question>

Define different typical simulations where the model should be useful.

How to model the multi-trailer vehicle in Modelica with the purpose of component and fleet transport missions optimization?

How to make the model modular?

How to model different subsystems and motion control devices, e.g. brake actuators, suspension, electrically driven axles, steering, cooling systems, etc, with lowest reasonable fidelity levels with reasonable computational loads but with interface (variables, signals, parameters) extendable to higher?

What are the important phenomena and physical behaviours that change or cannot be captured by altering the model fidelity?

Deliverables (flexible)

- Modelica models of multi-trailer road vehicles. It should be possible to change number of units, e.g., add/remove semi-trailers to/from the models.
- Models of powertrain and longitudinal dynamics.
- Models for lateral and roll motion.
- Simple modular models of motion support devices (with one or two acceptable levels of fidelity). Motion support devices include but not limited to brake system, electric driven axles, steerable axles, and suspension system.
- The Modelica model should be automatically parameterized reading a model-independent vehicle parameter file.
- Making the comparison of the simulation results with other available in-house tools as well as the available real-world test data, both in terms of energy consumption and motion.
- Several of performance bases standard measures [1] should be analysed. Challenges, and potentially proposed development steps should be listed.
- Some of the models should be exported as functional mock-up units to another environment (such as Matlab or Python) and re-parametrization and change of model fidelity should be tested in the new environment.

Limitations

- The level of fidelity of subsystems' models should be limited.

Academic subject:

Requirement on student background:

Talented master students in Automotive, Mechanics, Mechatronics or Engineering Physics, with some knowledge of Modelica and programming.

Please send your application (CV and transcript) by email to toheed.ghandriz@chalmers.se or apply through https://www.volvogroup.com/en/careers/job-openings/119492BR.html.

Supervision and examination:

Volvo Group Truck Technology, Advanced Vehicle Engineering.

Chalmers University of Technology, Department of Mechanics and Maritime Sciences, Vehicle Engineering and Autonomous systems, Vehicle Dynamics.

Administrative

Link to VGTT application: https://www.volvogroup.com/en/careers/job-openings/119492BR.html

- Suitable number of students: one or two.
- Number of credits: 30 points per student (nominally 20 weeks)
- Starting date: January 2022
- Resources: The student(s) will be provided with similar available Modelica models and real-world test data, Modelica tools and student licenses.
- Stakeholder: Volvo Group Truck Technology (VGTT)
- Responsible subject/research group at Chalmers: *Vehicle Dynamics*
    - Examiner: Bengt Jacobson, bengt.jacobson@Chalmers.se
    - Academic and industrial supervisor: Toheed Ghandriz, toheed.ghandriz@volvo.com
- Physical location: Mainly Chalmers University of Technology, but students are welcome to sit also at VGTT occasionally.

References:

[1] Research project , *Performance Based Standards II,* https://research.chalmers.se/project/8350