MSc thesis proposal: Performance assessment of electrified converter dolly combinations

Background

The HELPED project is a research project within the vehicle dynamics group at Chalmers. This project aims to evaluate aspects of introducing an electrified converter dolly (e-dolly) with propulsion. A converter dolly is a small vehicle intended to convert the connection of a trailer from a drawbar to a fifth wheel, see figure below.

![Figure 1 An example of a dolly converter vehicle. From Wikipedia. By Teppo Lainio - Own work, CC BY-SA 2.5, https://commons.wikimedia.org/w/index.php?curid=456523](https://commons.wikimedia.org/w/index.php?curid=456523)

Introducing an (electrically) propelled axle on a dolly converter vehicle is motivated by a flexibility argument, where existing vehicles in a vehicle combination can be used without modification. But the main argument is that an electrified axle can increase the fuel efficiency of the internal combustion engine of the primary mover (the first one in the combination).

![Figure 2 Example of an A-double combination in LEGO, consisting of a (from right to left) tractor, semi-trailer, dolly converter (single axle), and last another semi-trailer.](image-url)

Assessing the performance of vehicles in a realistic operation is a challenging problem. The typical approach is through simulation/test drive of a specific route following a predetermined speed profile, often called a driving cycle. Previous research at Chalmers, [1,2] has proposed a way to assess performance (e.g. energy efficiency) that separates the factors that contribute to the energy consumption and also deals with the variation of operating conditions in a structured manner. The main idea of this thesis proposal is to utilize this assessment method (operating cycles) in vehicle combinations that have an electrified dolly converter in the combinations, for example, an A-double like in figure 2. The energy gain will depend on the control strategy between the leading vehicle’s combustion engine and the electrified axes on the converter dolly.

With predictive control, there is a great potential to save fuel using the extra energy buffer that the electrified axle and its battery provide and allowing some deviation of the longitudinal speed. However, with actuation on more axles in the vehicle combination comes the risk of creating dangerous situations. Energy efficiency and traffic safety can be dealt with simultaneously using optimal control strategies, see [3].

The project will investigate how such a holistic predictive control strategy performs compared to heuristic control strategies and with combinations without any electrification. This assessment will be performed in a simulation environment and the evaluation will be done using a statistical framework developed in [1] and [2].

Problem description
The core problem to investigate in this thesis project is the problem and complexity associated with assessing the performance of a hybrid electric vehicle combination containing an electrified converter dolly. The challenge is to handle both the variation in use, e.g. range of missions and locations, and also the variation in the same kind of use, e.g. preventing what is called cycle beating. The environment should be rich enough to describe major factors (elevation, curves, wind, etc).

Research question
Questions that should be considered in the project are,

- How do we find some representative use cases of an A-double combination?
- How can we quantify performance using the proposed cases?
- Can we estimate the influence of model error to the performance measure?

Deliverables
- Models suitable for the problem at hand
- Test cases, grounded in empirical data or other experience and predictions and forecasts.
- A study revealing the performance gain of using an edolly and a predictive controller strategy.

Tentative plan
- Literature study
- Inventory models for the purpose of the project and possible develop new ones if required
- Formulating test cases
- Simulation study,

Administrative
- Number of credits: 30 points per student (nominally 20 weeks).
- Starting date: any time
- Requirements:
  o Good understanding of system dynamics
  o Good understanding of modeling (vehicle dynamics preferable)
  o Knowledge and skill in a modeling and simulation tool (e.g. Modelica, Simulink/Matlab, etc)
  o Good understanding of statistics and stochastic process.
- Resources/Stakeholder: Chalmers and Volvo (the thesis will be strongly connected to the HELPED project and the partners within this consortium.).
- Responsible subject/research group at Chalmers: Vehicle dynamics
  o Examiner: Fredrik Bruzelius
  o Supervisor
    ▪ Fredrik Bruzelius
    ▪ Toheed Ghandriz
- Application to Fredrik Bruzelius, fredrik.bruzelius@chalmers.se, with CV and transcripts.
- Physical location: Chalmers and possibly also at Volvo GTT

References