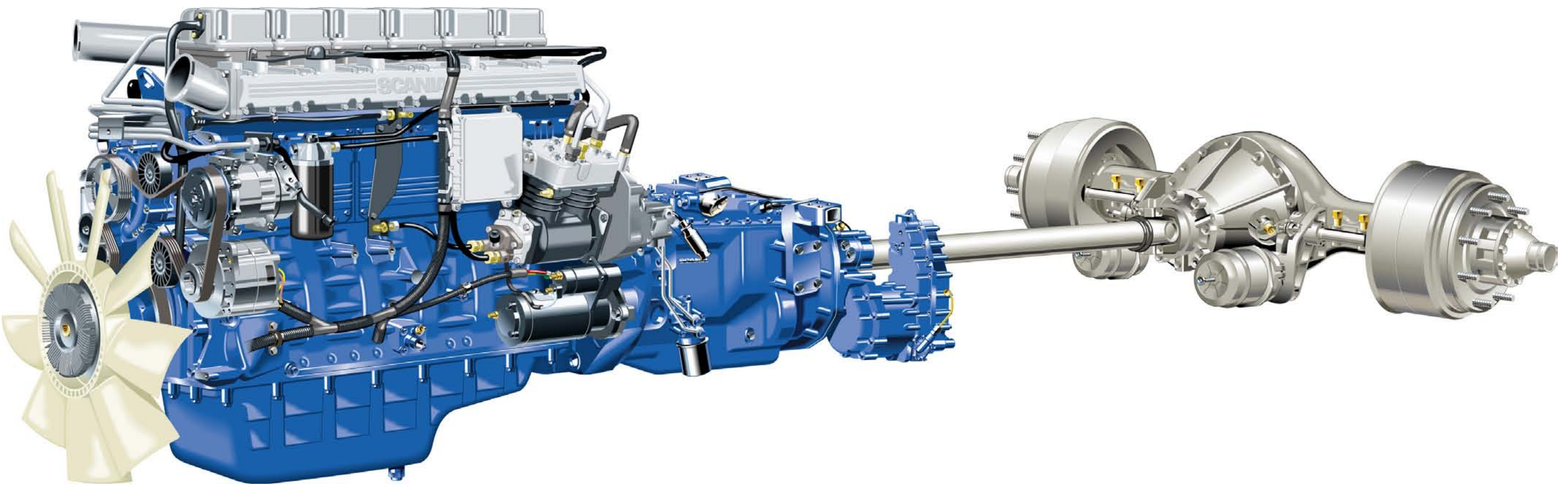
Control of a Driveline with a Slipping Clutch

Lars Eriksson, Andreas Myklebust, Lars Nielsen (Vehicular Systems, LiU)
Henrik Flemmer (SCANIA CV)

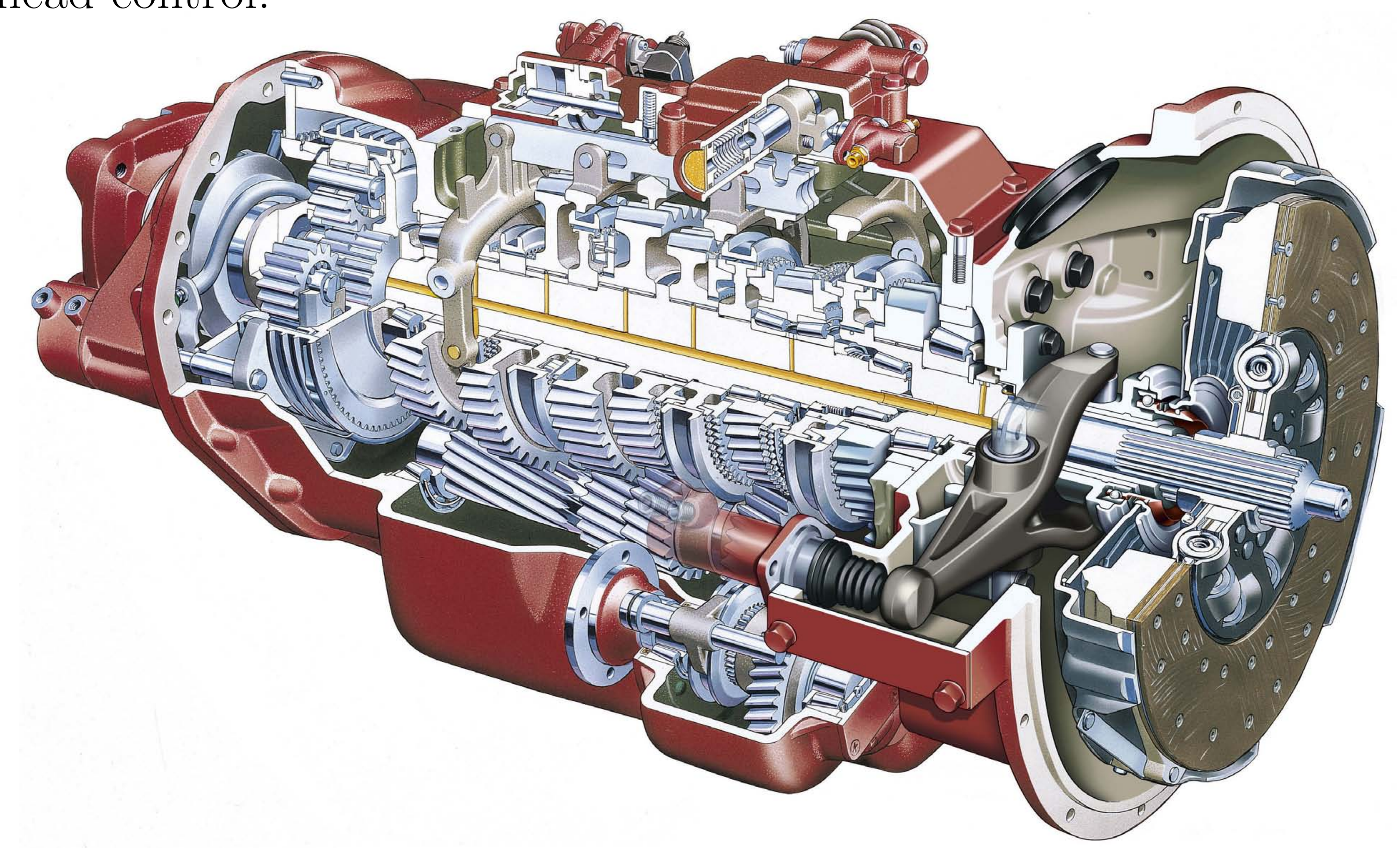
Integrated Powertrain Control

The goal of this part of the project is to study modeling of and control principles for integrated control of the driveline that consists of an engine, automatic clutch and AMT (Automated Manual Transmission). The specific selection of problems will be done together with Scania. The main guideline is that models should aim at control and that control principles studied should aim at the next step to be used in actual control systems.



Control of a Driveline with a Slipping Clutch

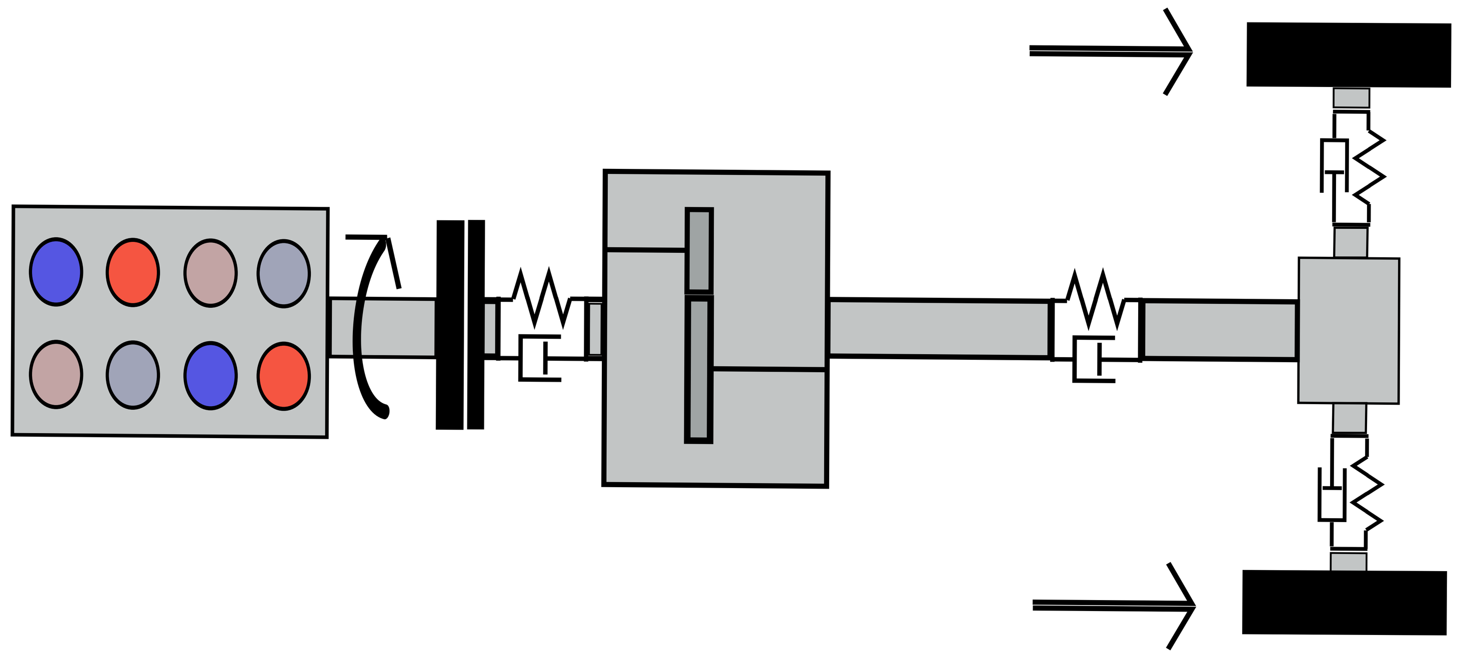
The introduction of a new automatic actuator for the clutch opens up new opportunities for controlling the engine and driveline, and new strategies that can improve the driveline performance are predicted. Several applications would benefit from advanced clutch control. For example start and stop strategies for heavy trucks can be employed and in addition the clutch control can be utilized in AMTs to reduce the time for gear changes, which is a crucial parameter for preventing stall in heavy trucks during hill climbing. Furthermore clutch control is also a factor in look ahead control.



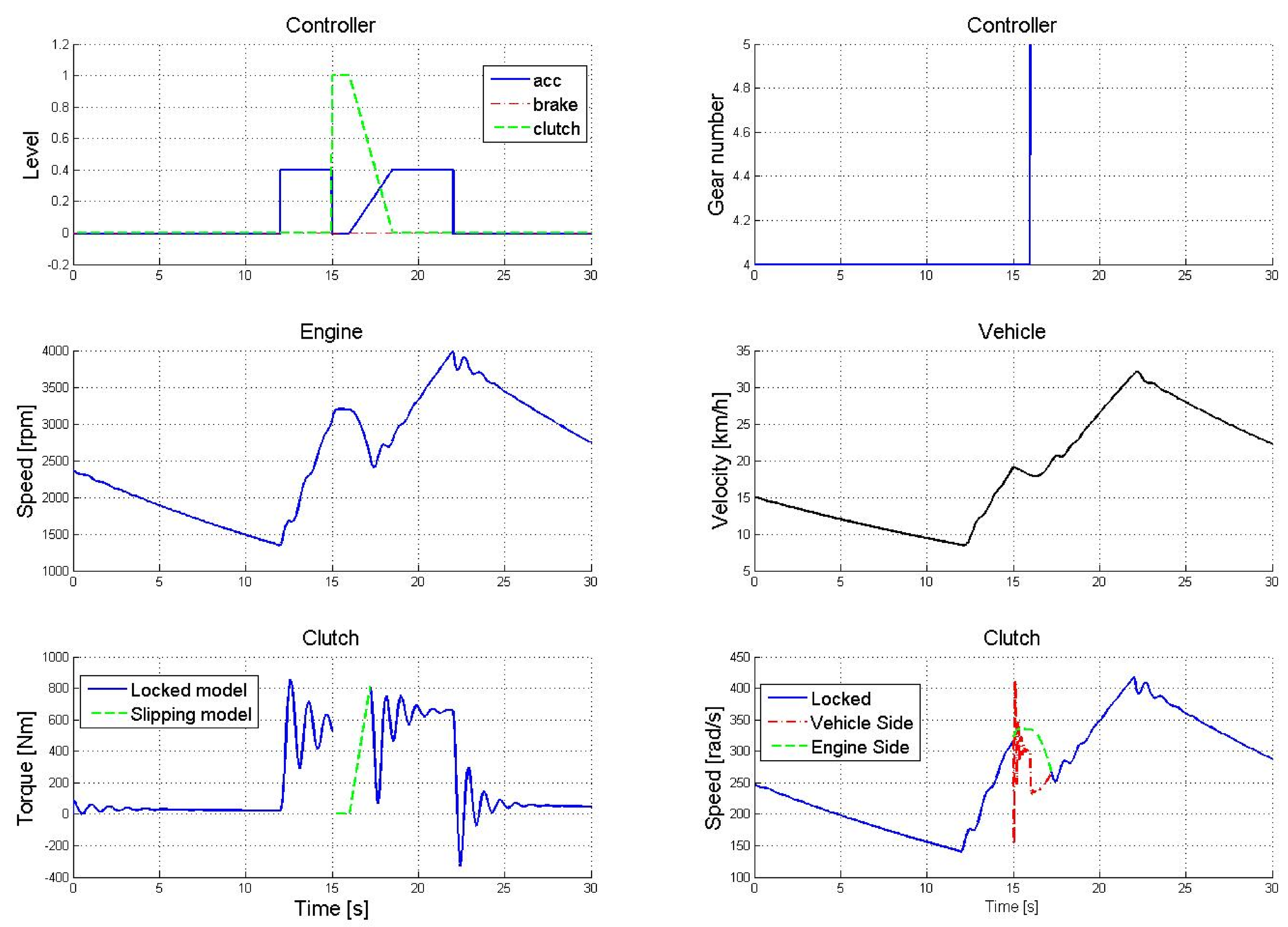
It is also possible to use the clutch to damp oscillations in the driveline, but to handle this more research is necessary. An important first step is to gain the fundamental knowledge about the important characteristics of a driveline with a slipping clutch, and the starting point will focus on modeling for control.

Clutch and Driveline Model

A clutch model has been incorporated in a larger driveline model. The model is implemented in Matlab/Simulink and contains an engine, a gearbox, torsional effects in the driveline and a longitudinal vehicle model. It is fairly simple but contains most parts of the driveline.



A gear shift using the clutch and the requested torque signal is illustrated in the below plots for a vehicle with typical truck data It can be seen that the qualitative behavior of the truck is good.

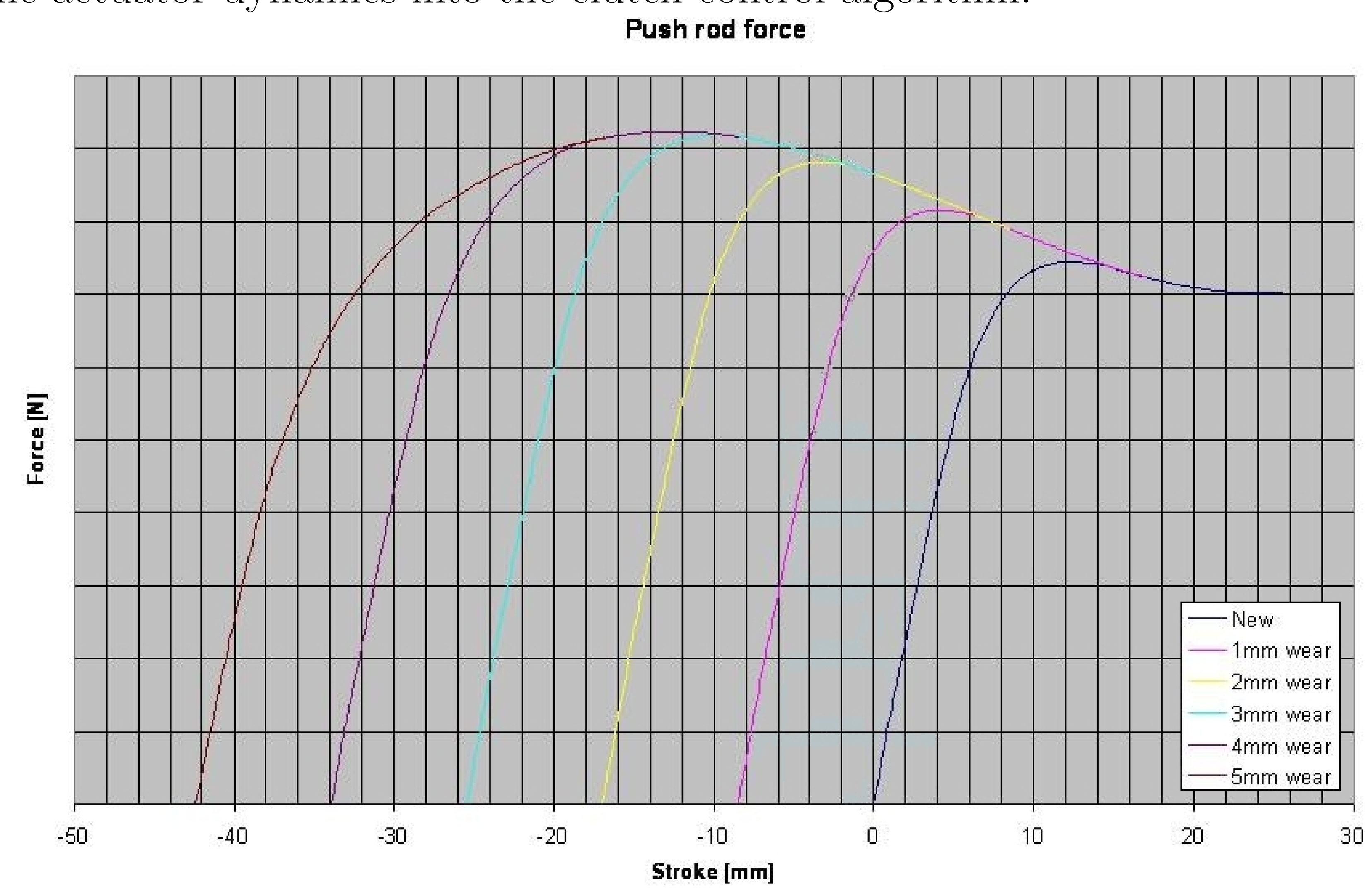


The clutch is modeled as two plates with inertias that can be pushed together. Pushing them together leads to a friction torque that is transmitted both ways in the clutch. The transmitted torque is proportional to the clamping load. When the rotational speeds of the two plates match they lock together and a second clutch model take over the simulation. In this model there is one degree of freedom less and the transmittable torque is modeled through static/dynamic friction.

Future Work

The next step is to validate the model using Scania truck data acquired on a system with the new clutch system. This includes tuning of the model.

The next extension of the model concerns the new electro-mechanical-hydraulic actuator. The actuator receives the computer control signal, starts the electrical motor that through a worm gear actuates the push rod that clamps or releases the clutch. These dynamics set the time constant for how fast the clutch position, and thereby the transmitted torque, can be altered. It is therefore of great importance to incorporate the actuator dynamics into the clutch control algorithm.



Future extensions of the model will aim to give better control during different driving scenarios. If the clutch is new or worn has a large effect on how much clamping load is necessary for giving a certain transmitted torque. The clutch ageing profile can be seen in the figure above. The clutch is also likely to change behavior depending on its working temperature depending mainly on the amount of dissipated energy in the clutch during slipping. To capture this, the model has to be extended with a thermal mass.