What it is about

This project is about how to get enhanced driving dynamics and energy management in future electrified vehicle concepts. Electromechanical propulsion, steering and suspension give more degrees of freedom available for control input. This will further enhance the outer limit of the vehicle performance, as well as enables optimal control of the vehicle with respect to driving safety and energy management.

Over actuation

In an over-actuated system there are more control inputs than degrees of freedom (DOF) i.e. more control inputs than required to control the system.

Wheel corner modules

A wheel corner module is mechanically separate from the other wheels of the vehicle. The propulsion and braking torque, steering/camber angles and suspension deflections are controlled with separate actuators.

Energy management

With individually controlled wheels the need for static wheel alignment, needed for vehicle stability, is reduced. This will enable the steering and suspension to adapt the steering angles for all driving situations so that the rolling resistance and tyre wear is reduced, without sacrificing vehicle stability and safety.

Future work

The next step in the in this research project is to implement some of the findings in the KTH Research Concept Vehicle (RCV).

Wheel force allocation

To study the potential of wheel force allocation several approaches are used. A down-scaled prototype vehicle was built and implemented with wheel slip and chassis controllers. Furthermore a simple, cost-effective force allocation algorithm was developed, implemented and evaluated in simulations and experiments. Straight line braking tests were performed for the three different controller settings; individual anti-lock brakes (ABS), yaw-torque-compensated ABS and force allocation using both wheel torque and steering angle control at each wheel. The results show that force allocation is possible to use in a real vehicle, and will enhance the performance and stability even at a very basic level, utilising very few sensors with only the actual braking forces as feedback to the controller.

Active suspension to aid braking performance

This work presents how to utilise vertical loading on individual wheels in a vehicle in order to improve vehicle performance during straight line braking. Through numerical optimization, solutions on how active suspension should be controlled and coordinated together with friction brakes to shorten the brake distance are found. The results show that the brake distance can be improved by more than 1 m in 100 km/h by lowering and rising of the chassis. These results provide valuable guidance on how active suspension can be used to give significant improvements in vehicle performance with reasonable complexity and energy consumption.

Active camber control

Numerical optimisation is used to find solutions on how the active camber should be controlled and coordinated in cooperation with individual braking and front axle steering. Based on the characteristics of a multi-line brush tyr model, a Simple Magic Formula description is developed where camber dependency, load sensitivity and first order speed dependent relaxation dynamics are included. The vehicle is analysed during an evasive manoeuvre when the vehicle is running at the limit. It is evident from the results that active camber control can improve safety and performance during an avoidance manoeuvre.