

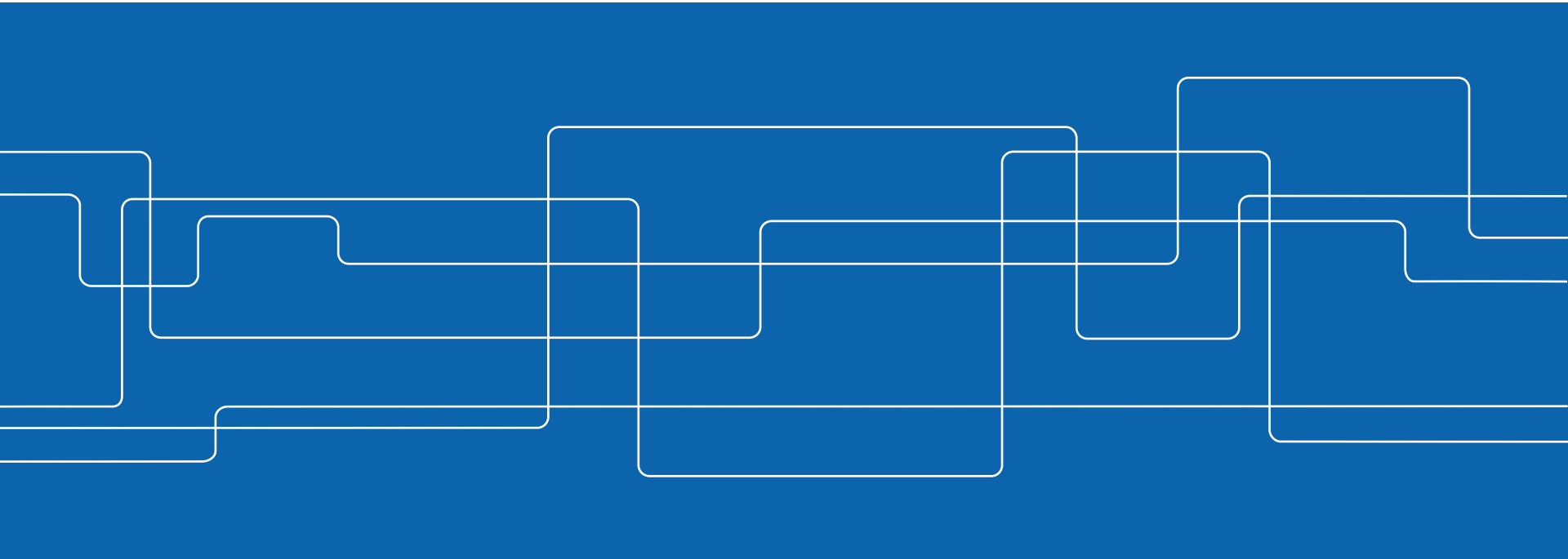


Research Concept Vehicle (RCV) – Research platform for future vehicle concepts

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KTH Research Concept Vehicle

- Modular design to include research results from several disciplines
- Developed to validate and demonstrate current and future research
- Versatile in its design and its functions
- Full access to and control of all units

Functions:

- Drive-by-wire technology
- 4 in-wheel electric motors
- Active electric individual steering, camber and traction/braking on each wheel
 - FWS, RWS, 4WS
 - FWD, RWD, 4WD
 - Torque Vectoring, Adaptive Steering, Active Camber
 - Etc.
- Light-weight design with carbon-fiber sandwich
- New battery management technology



KTH Research Concept Vehicle

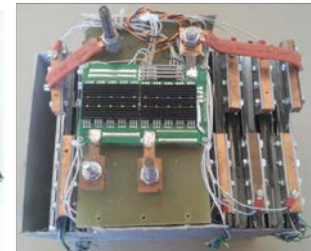
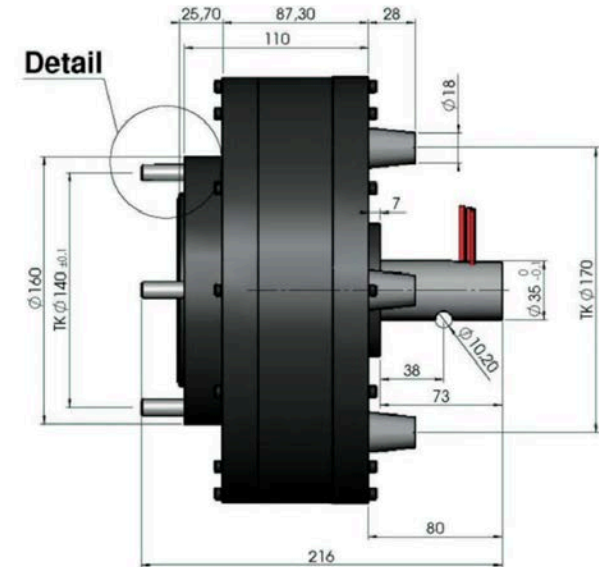
Numbers:

- Weight: 400 kg
- Unsprung mass: 25 kg
- Track width: 1.5 m
- Wheel base: 2 m
- Tyres:
 - Dual compound Michelin Pilot Sport 3 170/60 R17
 - Bridgestone Potenza 175/55 R17 81W
- 17 kW drivetrain (peak)
- 52 V 42 Ah Lithium-battery for 30 min drive full activity
- Top speed: 70 km/h



Powertrain parts

- Electric motor
 - Heinzmann PRA-230
 - Permanent-magnet synchronous type
 - 36 pole 2kW nominal
 - Develops 150 Nm during a short interval
- Motor converter
 - Kollmorgen ACD 4805 converter
 - @ 33 Nm and 520 rpm it has efficiency of 94.4 %
- Battery
 - In-house designed 52V/40Ah Lithium-ion battery pack
 - + commercial 24V/10Ah Lithium iron phosphate battery
 - Drives the steering and camber actuators



Steering & camber actuators

- Thomson MX24- B8M10E0-51

Actuator Voltage:	24 VDC
Max Stroke Lengths (mm):	100
Max Dynamic Load (N) :	800
No Load Speed (mm/sec):	60
Max Load Speed (mm/sec):	30

- Thomson PR2405-4A65D15DCS

Actuator Voltage:	24 VDC
Max Stroke Length: (mm)	150
Max Dynamic Load: (N)	2250
Max Static Load: (N)	4500
No Load Speed: (mm/s)	28
Max Load Speed: (mm/s)	23

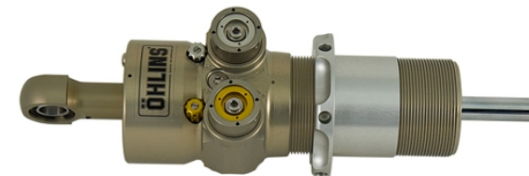
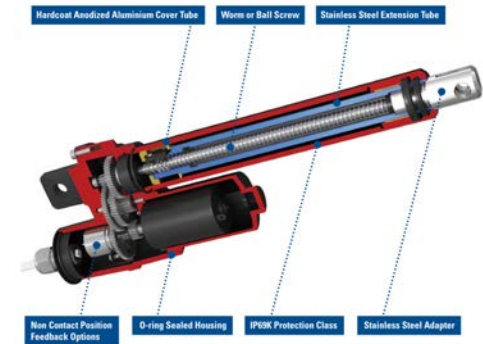
- Actuator converter

- ESCON 70/10
- Built-in PID control



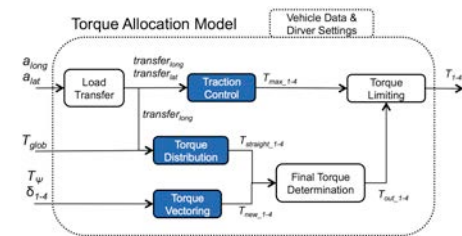
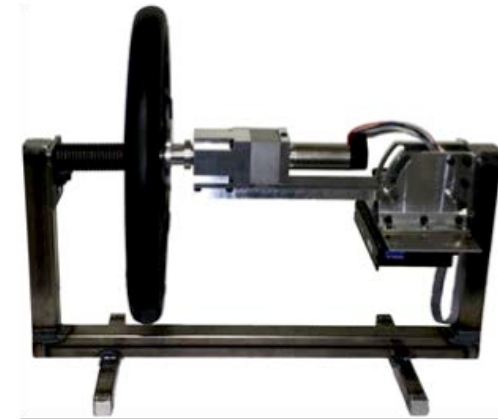
- Öhlins TTR Dampers

- Adjustable Bounce/Rebound high-/low speed
- Possible to enable active adjustment

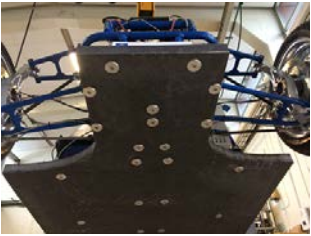


Steering wheel & control

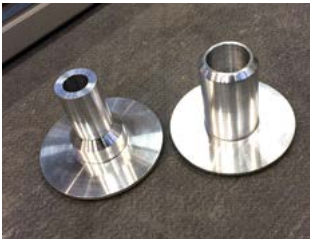
- Steering wheel
 - Haptic force feedback steer-by-wire
 - Can give 8 Nm of torque feedback
 - Can handle rotational rate of 20 rad/s (1146 deg/s)
- Torque allocation and steering control
 - Torque allocation algorithm is being implemented
 - 100% Ackerman for both 2WS and 4WS mode
 - 4WS speed dependent steering model is added
 - Toe-sweep for tyre slip curves
 - Camber gain on steering angle
- Tie-rod force sensors
 - Force sensors added to the four tie-rods for measuring road disturbance and tyre forces
 - Used for feedback model to the driver
- dSPACE – MicroAutoBox
 - Linking to the main Simulink Architecture



Chassis & Driver interface



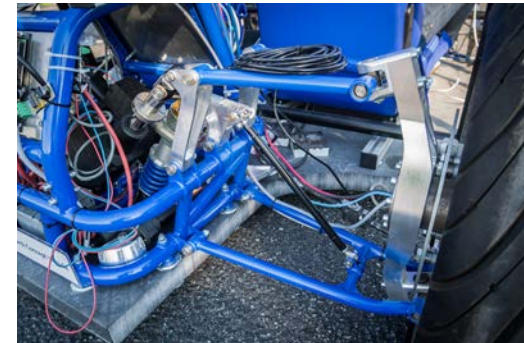
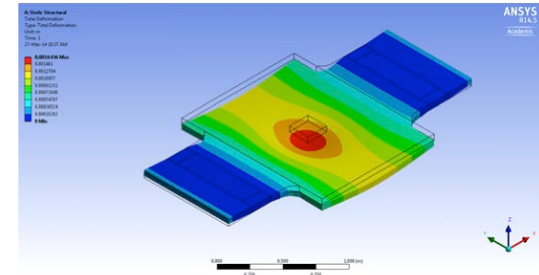
(a)



(b)

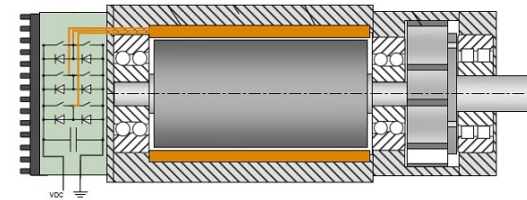
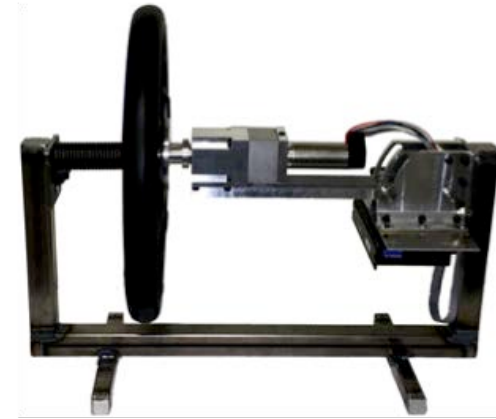


- Light-weight base plate
 - Carbon-fibre sandwich structure
 - Fibre lay-up 0° and $\pm 45^\circ$ fibres
 - Local core reinforcements with inserts at mounting points
- Driver interface
 - 4 point seatbelt
 - Throttle and hydraulic brakes
 - Mode switch to enable selection of up to 11 different vehicle settings, 2WS, 4WS, active camber etc.
- Other
 - Own developed Arduino based IMU + GPS



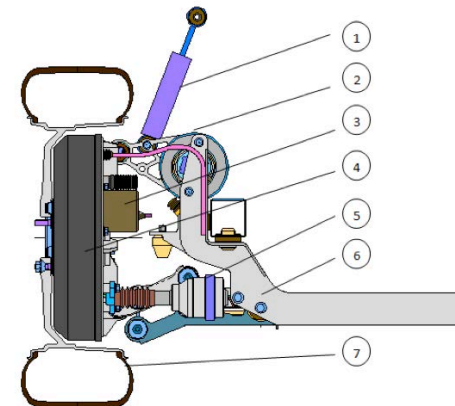
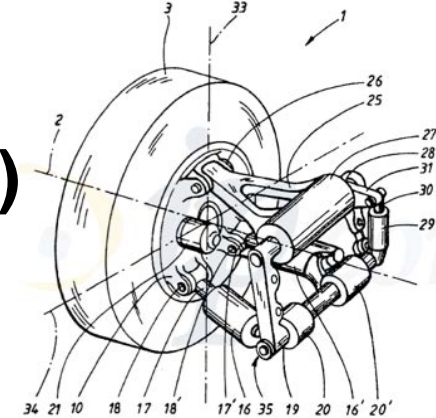
Steer-by-wire system

- The steer-by-wire system is a result from the research project IDIOM - Integrated Design and Optimization of Mechatronic Products
- Involved researchers:
 - Jan Wikander (Professor Mechatronics)
 - Daniel Malmqvist (PhD Student)
 - Daniel Frede (PhD Student)



Autonomous Corner Module (ACM)

- The ACM concept builds on a Volvo Cars patent by the inventor Sigvard Zetterström Patent No. EP1144212, 1998.
- The ACM concept has been a research area for the Vehicle Dynamics group at KTH for over 10 years.
- Involved researchers:
 - Mats Jonasson (Volvo Cars and KTH)
 - Annika Stensson Trigell (Professor Vehicle Dynamics)
 - Lars Drugge (Associate Professor Vehicle Dynamics)
 - Jenny Jerrelind (Associate Professor Vehicle Dynamics)
 - Mikael Nybacka (Assistant Professor)
 - Sigvard Zetterström (Volvo Cars and KTH)
 - Johan Andreasson (Modelon)
 - Johannes Edrén (PhD Student)
 - Daniel Wanner (PhD Student)
 - Mohammad Mehdi Davari (PhD Student)



ACMs gives an over-actuated vehicle

- ✓ Has more actuators than degrees of freedom that are to be controlled, i.e. we can choose to steer the vehicle in multiple ways by software controlled functions

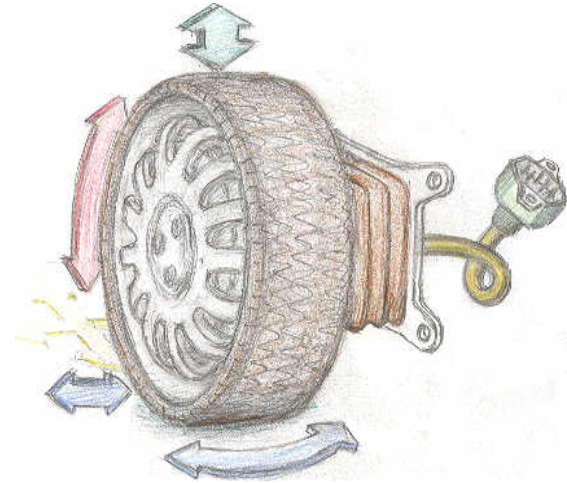
Actuators located close to the tyres and individual control of each wheel;

- propulsion/braking
- alignment/steering
- vertical wheel load

Enable a chassis design that is possible to reuse in the development process for new vehicle platforms

New styling possibilities, “sofa” for autonomous vehicle

Reduced need of a number of traditional chassis components



Energy relevance

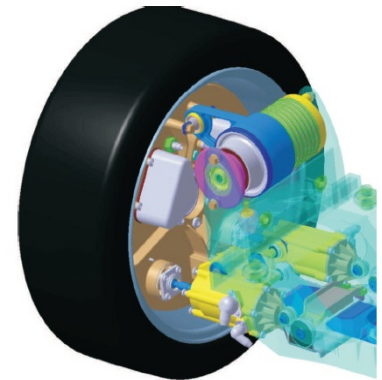
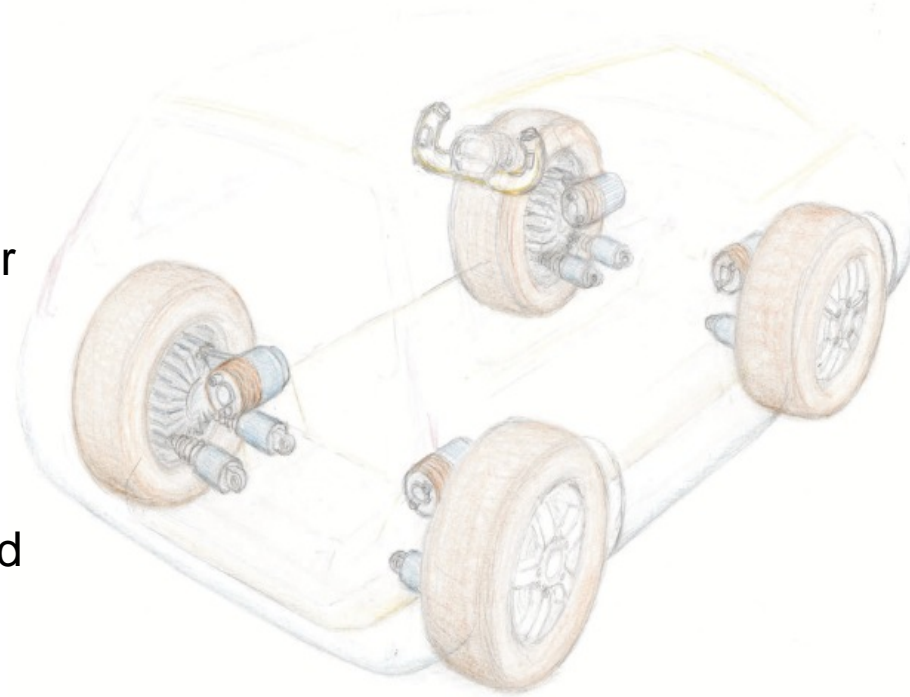
Electric motors can give higher efficiency for the propulsion

- Lower energy losses
- Control of traction, yaw motions
- Individual regenerative brakes

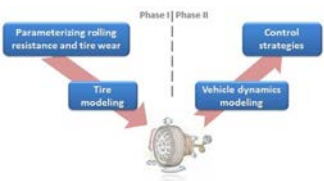
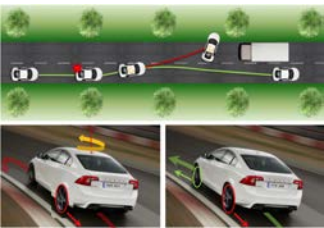
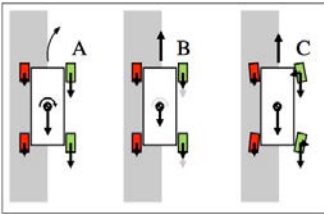
Lightweight chassis design, no gear box and drive shafts

Continuously controlled wheel alignment contributes to low tyre rolling-resistance and wear

Enabler for low aerodynamic drag, flat underbody and leveling control



Planned work with the RCV



- Generic vehicle motion modelling and control for enhanced driving dynamics and energy management
 - Validate and gather data for simulation model
 - Vehicle and tyre models
- Fault-tolerant over-actuated hybrid electric vehicles
 - Validate and gather data for fault simulation model
 - Capture driver reactions to different simulated faults
 - Fault-tolerant force allocation
- Innovative lightweight vehicle concept with wheel corner modules
 - Validate and gather data for tyre model
 - Run a number of experiments with different vehicle settings and tyre types
 - Characterize/optimize rolling resistance and tyre wear
- Driver vehicle interaction
 - Evaluate different vehicle characters and their influence on driver perception
 - Design drive-by-wire steering model for realistic and adjustable force feedback

Generic vehicle motion modelling and control for enhanced driving dynamics and energy management

A project at Swedish Hybrid Vehicle Centre

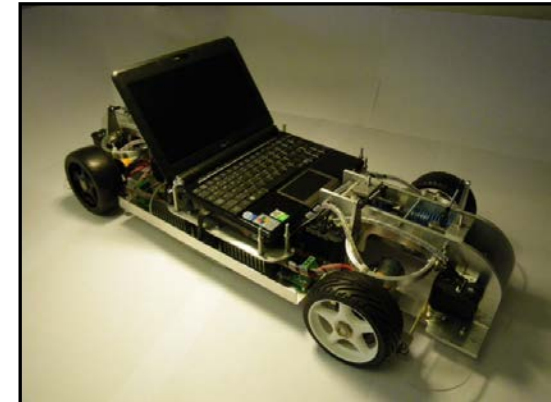
J. Edrén, A. Stensson Trigell, J. Jerrelind, M. Jonasson

How can force allocation be utilised in a real vehicle to improve vehicle dynamics and safety?

Findings:

- Reduced brake distance
 - Split- μ with Hjulia 8.5%
 - Level control 60km/h 3.8%
- Increased performance
- Reduced curve resistance

Hjulia, 1/6 scale, full ACM functionality



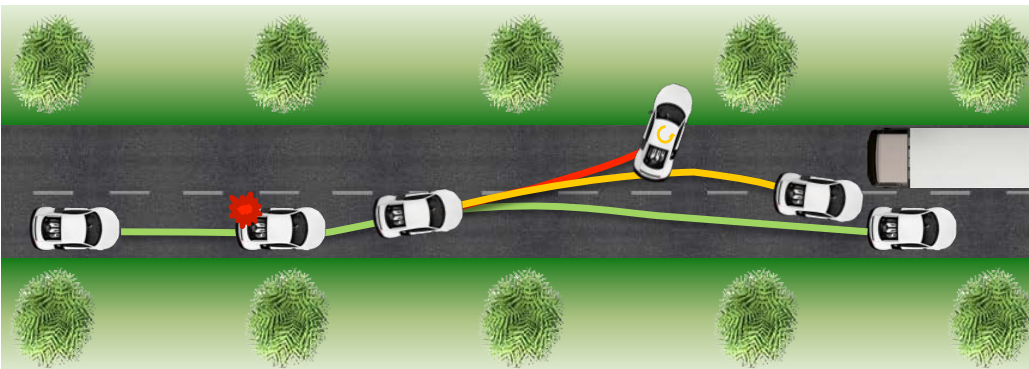


Fault-tolerant over-actuated hybrid electric vehicles

A project in Swedish Hybrid Vehicle Centre

D. Wanner, A. Stensson Trigell, L. Drugge, M. Jonasson, O. Wallmark

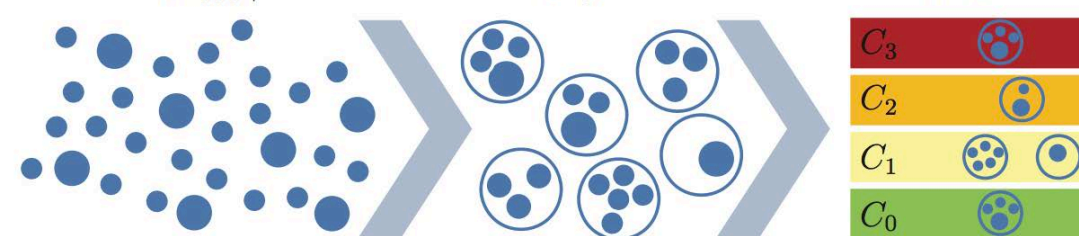
- What happens if electrified vehicles fails when driving?
- Analyze the impact of failure modes and the degree of in-built fault-tolerance for different vehicle control strategies in electric and hybrid-electric drivelines



Fault collection
N=600+

Fault grouping
N=31

Fault classes
N=4

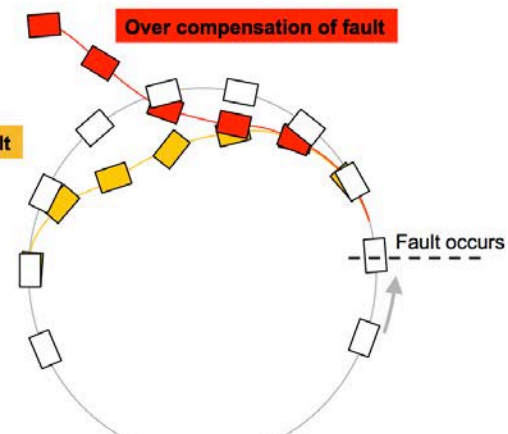


Vehicle with fault

Fault-friendly
vehicle design

Fault-tolerant control
for active safety

Under compensation of fault

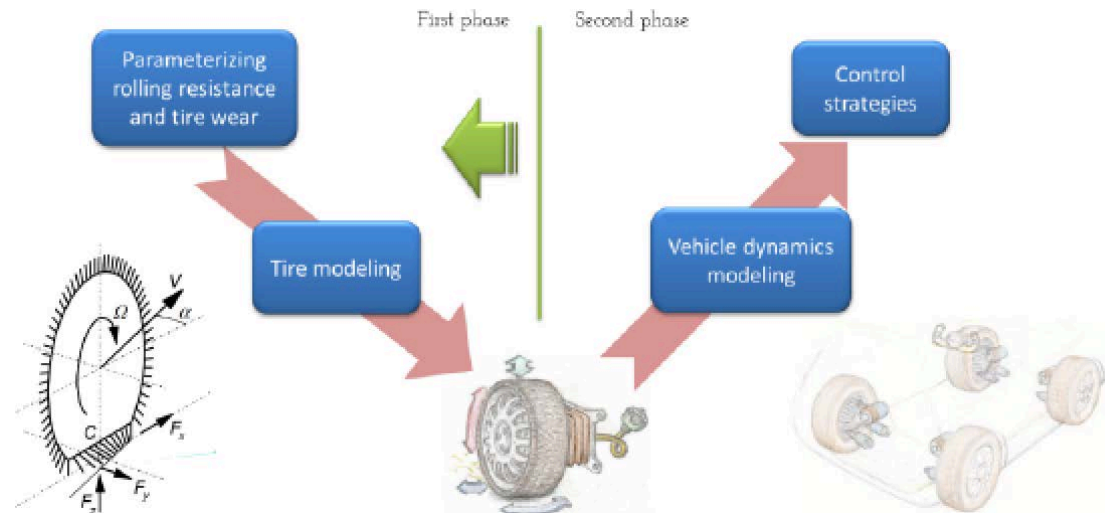
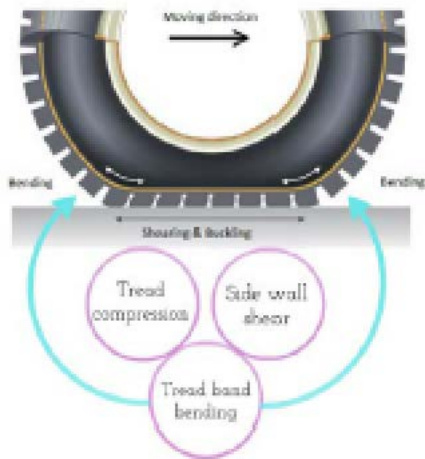


Lightweight vehicles with corner modules

A project in Centre for ECO² Vehicle Design

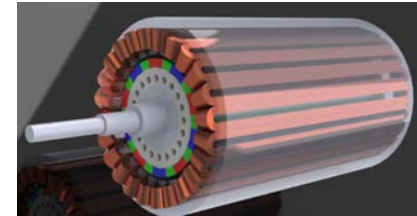
M. Mehdi Davari, J. Jerrelind, A. Stensson Trigell, L. Drugge

Minimize rolling resistance and tire wear, while maintaining handling, comfort and safety using the advantage of wheel corner modules in a lightweight vehicle concept



Future developments to the RCV

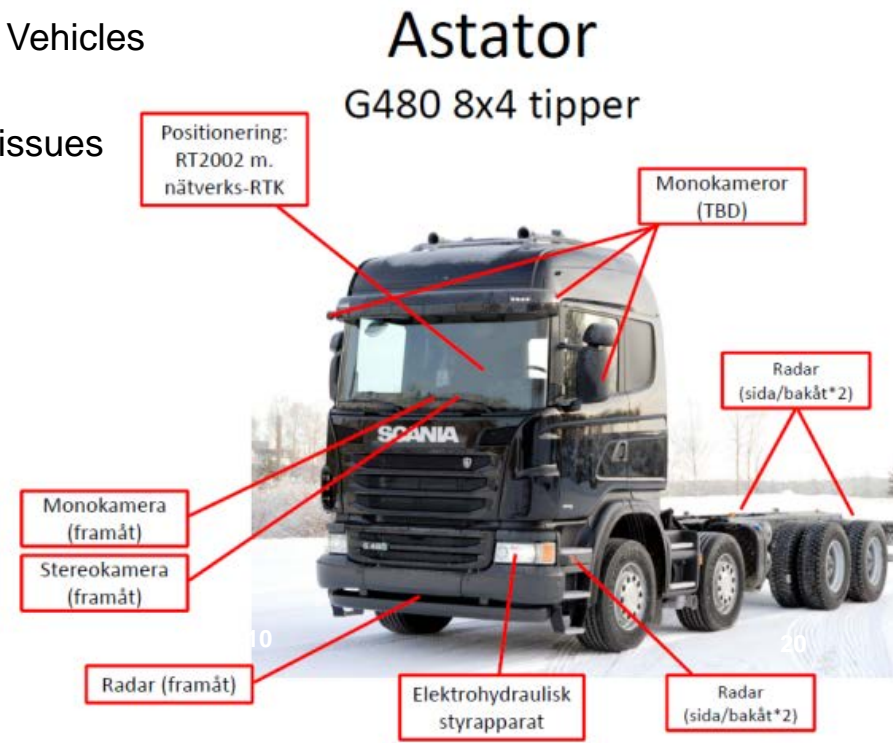
- Since the RCV is modular it is easy to exchange parts like the suspension assembly for another type
- A transversal leafspring is being developed by a shared MSc student Wilhelm Johannisson
 - Supervised by Magnus Burman, Mikael Nybacka and Lars Drugge
 - Will be manufactured this summer
- New rear electrical motor with differential and drive shafts
 - A research project at Electrical Energy Conversion
 - Oskar Wallmark is responsible
 - Currently in design



Future developments to the RCV

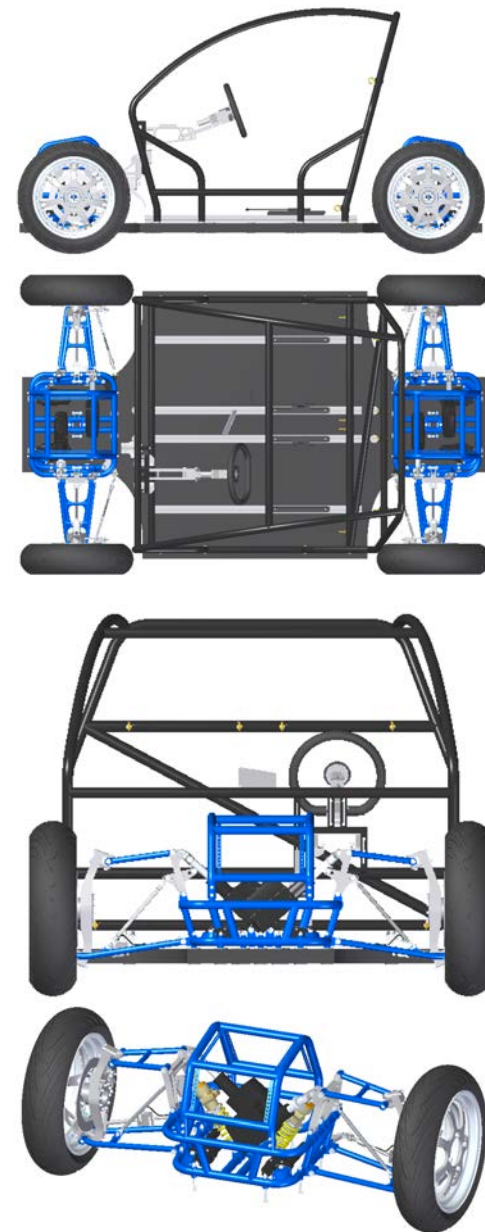
- Autonomous driving
 - Project has started to equip the RCV with sensors
 - Jonas Mårtensson (KTH Automatic Control, responsible)
 - Near goal:
 - Drive autonomously on the parking outside Transport Lab before snow comes
 - Identify and evade obstacles
 - Next goal:
 - Create a platform for research on Autonomous Vehicles
 - Modular and extendable
 - Support projects like iQMatic studying specific issues

RESEARCH CONCEPT VEHICLE (RCV) – RESEARCH
PLATFORM FOR FUTURE VEHICLE CONCEPTS



KTH Research Concept Vehicle

- Number of people involved so far:
 - Project management from Transport Labs
 - 20 senior staff
 - 8 MSc thesis and internship projects
 - 25 students in projects
- Groups involved so far, applying CDIO process:
- ITM:
 - MMK / Mechatronics (Senior, PhD, MSc Students)
 - MMK / SKD (MSc Students)
 - MMK / Verkstaden (manufacturing staff)
 - IIP / XPRES (Students and manufacturing staff)
- SCI:
 - AVE / Vehicle Dynamics (Senior, PhD, MSc Students)
 - AVE / Lightweight Structures (Senior, MSc Students)
- EES:
 - Electrical Energy Conversion (Senior, MSc Students)
- CHE:
 - Applied Electrochemistry (PhD)



KTH Research Concept Vehicle

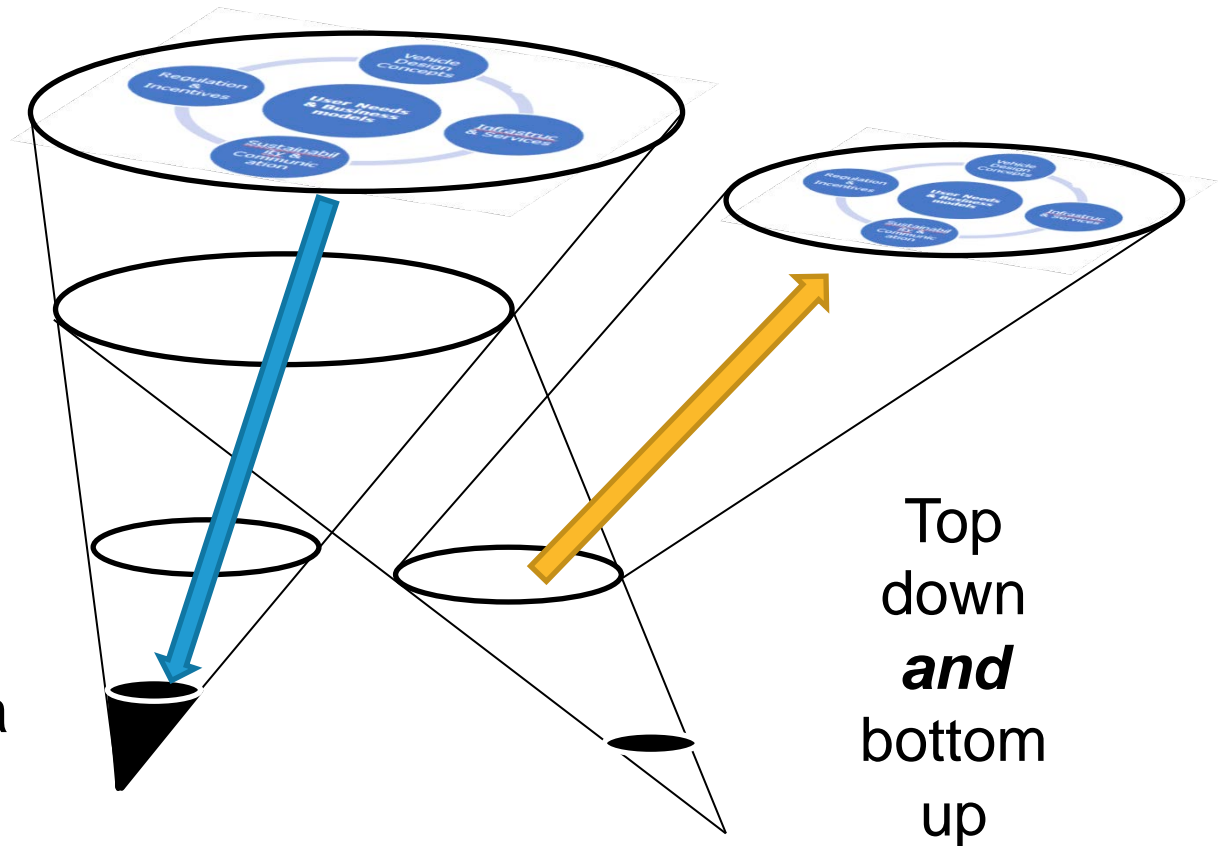
- Developed with funding from:
 - KTH Transport Platform
 - KTH Transport Labs
 - Which is funded by:
 - KTH Transport Platform
 - ITM
 - SCI
 - ABE
 - CHE
 - STandUP
 - TRENoP
 - Centre for ECO² Vehicle Design
 - SHC (Swedish Hybrid Vehicle Centre)
- Interested divisions
 - Both man-hours and parts
- Sponsors
 - Öhlins, dampers
 - Lesjöfors, springs



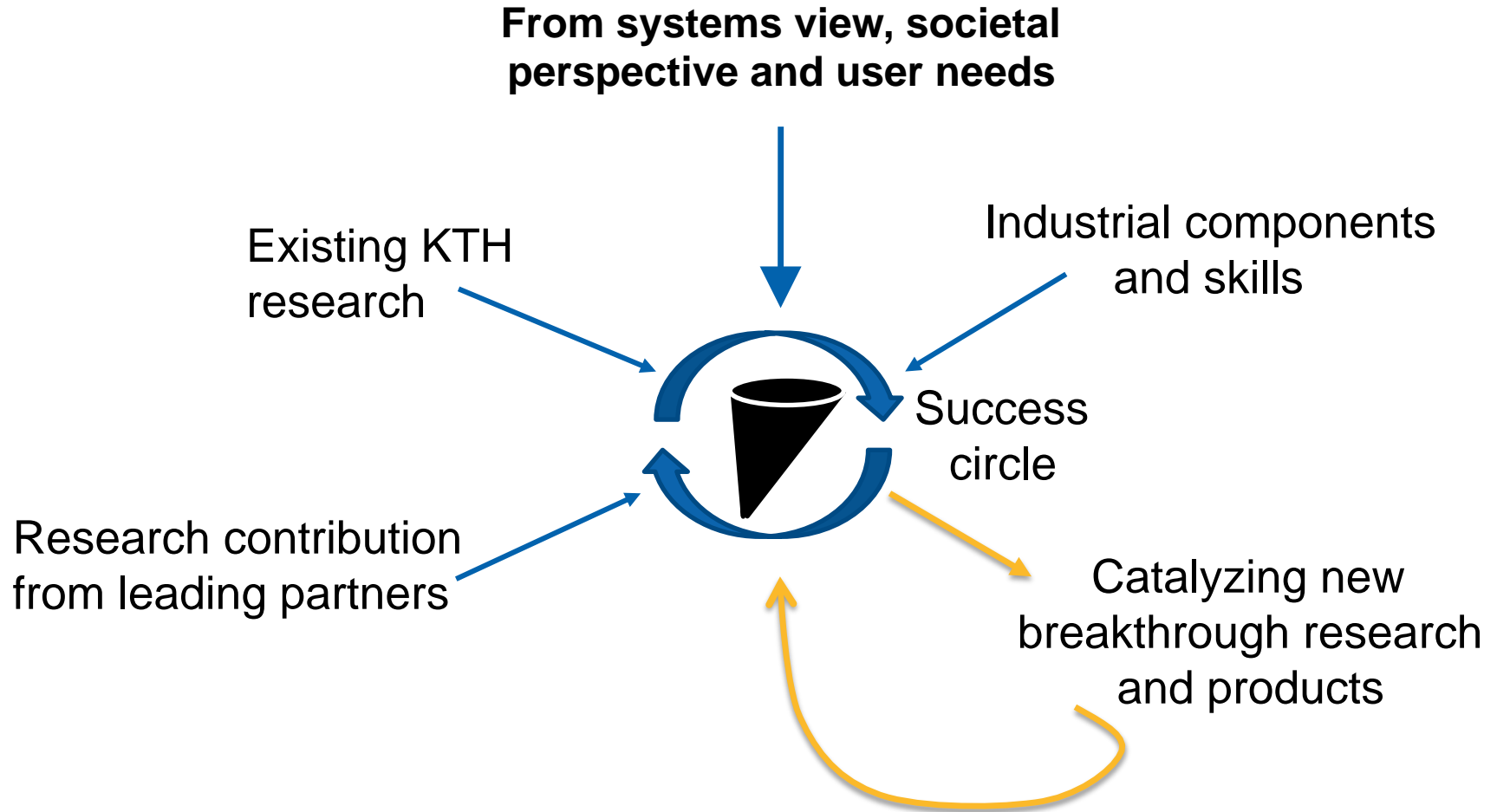
Systems view and integrated research @ KTH Transport Lab

Holistic
level

Demonstra
tor level



Research and innovation @ Transport Lab





Thank you!!

<http://www.kth.se/en/sci/institutioner/ave/avd/fd>

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