Fluid and Mecahtronic Systems
Linköping university

Petter Krus
Fluid and Mechatronic Systems
Linköping University, Sweden

Sweden 9.5 million people

Linköping Municipality 140 000 people

Linköping University 27 000 students

Linköping, Sweden

Fluid and Mechatronic Systems at Linköping University

One full professor and three assistant professors

8 PhD students

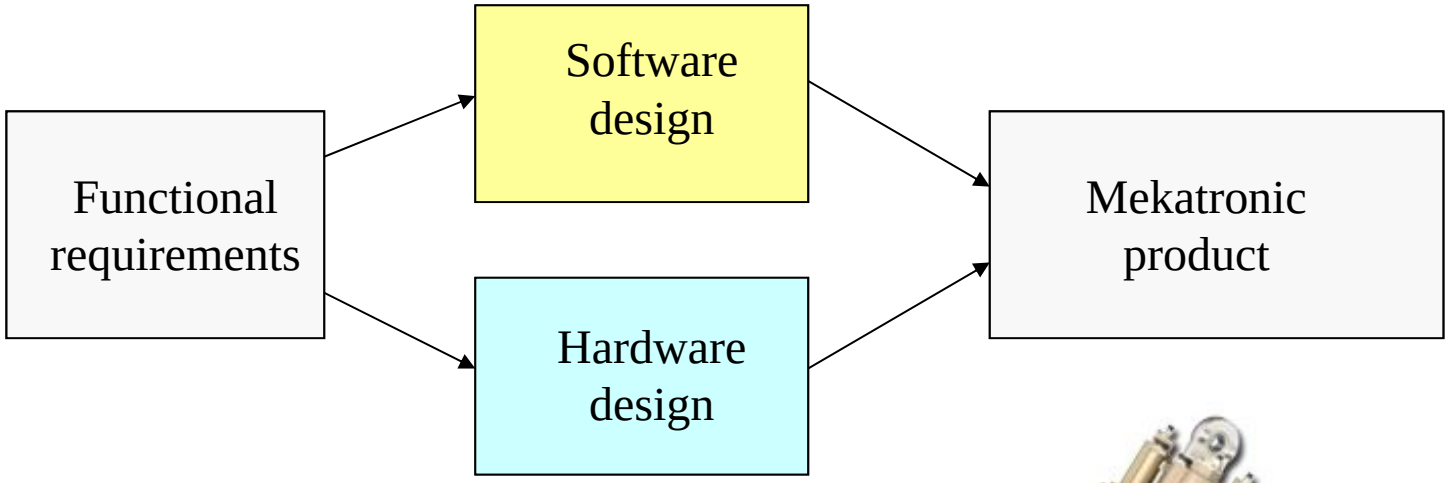
Systems that are characterized by a close coupling between:

- Mechanical system
- Power transmission/Actuation system
- Sensors
- *Control System*

This requires, *Multidisciplinary co-design,* i.e. Mechanical design and control system co-design where modelling and simulation are central

Fluid and Mechatronic Systems

Functions implemented in software

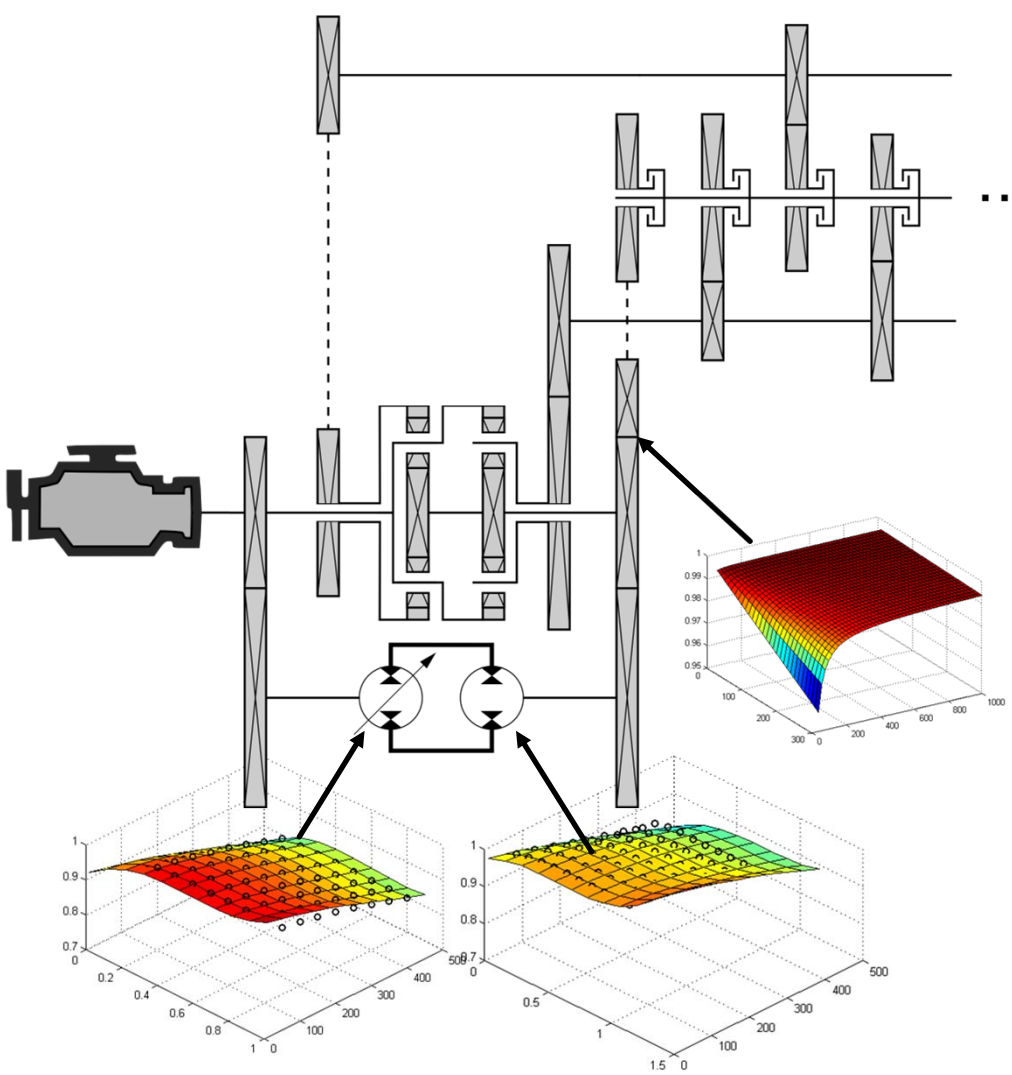


Functions implemeted in hardware

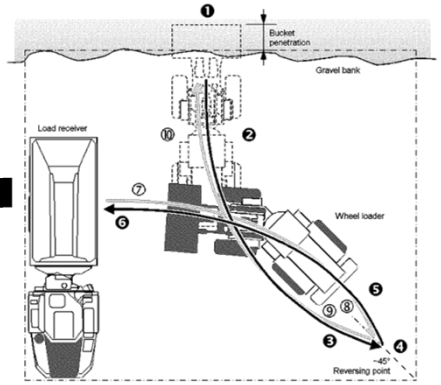

H480C

Karl Pettersson

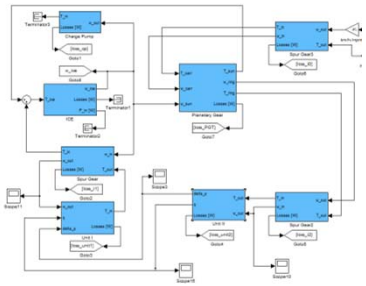
Hydromechanical Transmissions System Design



Load

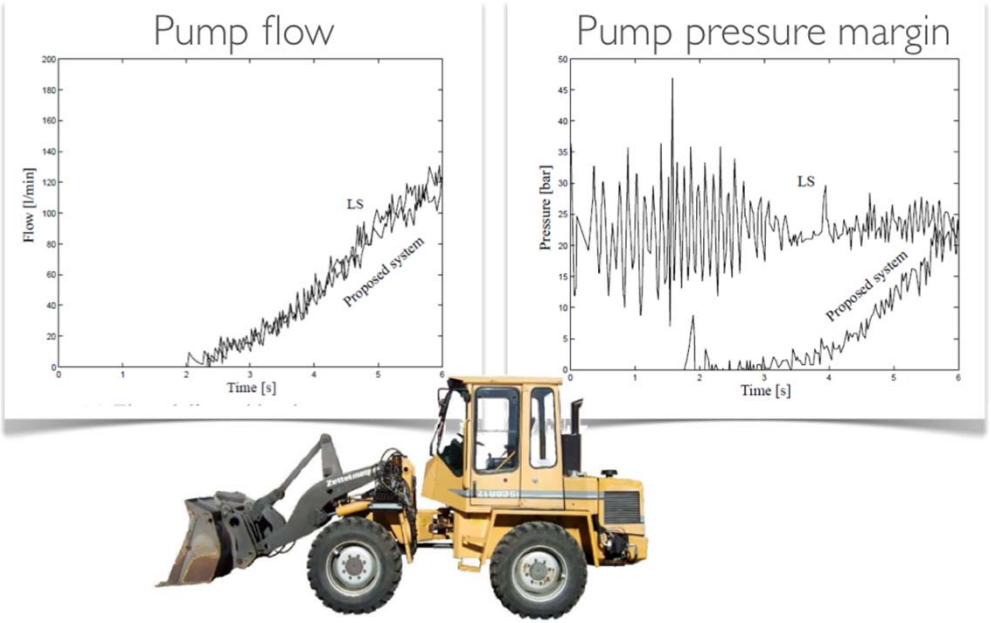


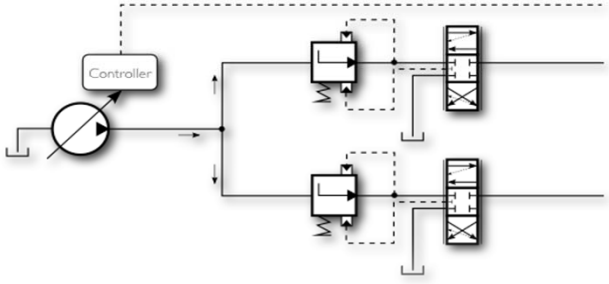
Implemented in Matlab/Simulink



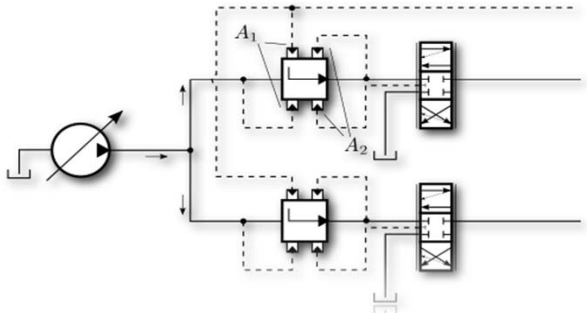
Energy Efficient Mobile Hydraulic Actuation Systems

Project sponsored by Parker Hannifin-Hannifin, USA



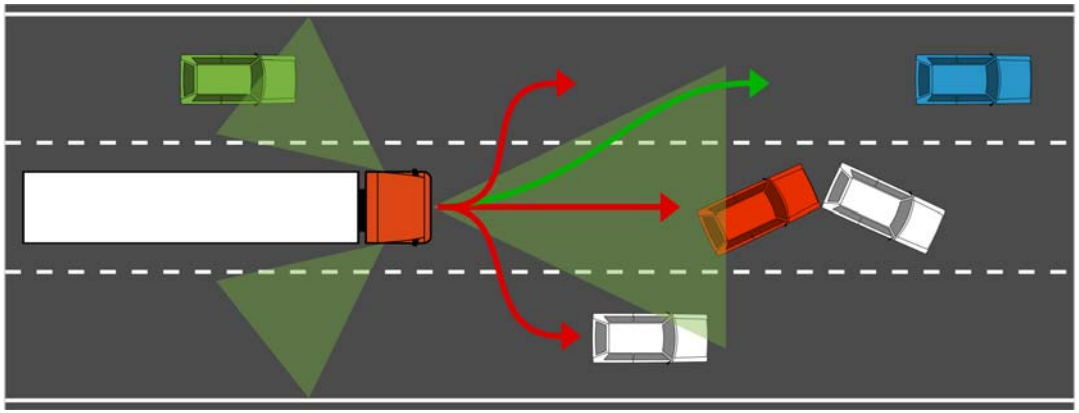


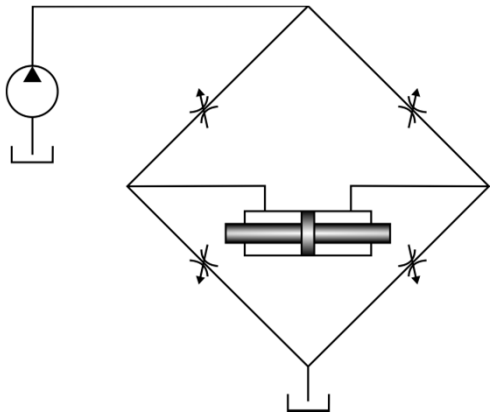
Original Load Sensing system (LS) with closed loop controlled pump



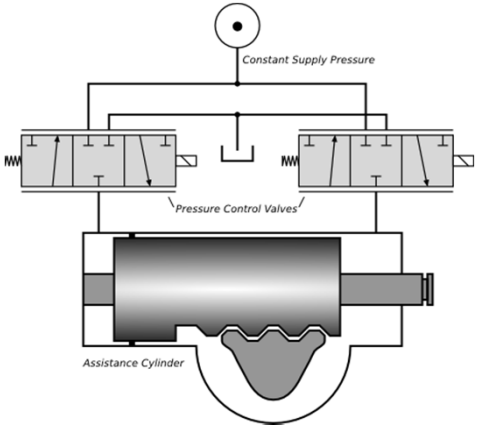
Flow sharing system with open loop controlled pump

Conceptual Design of a Closed-Centre Power-Steering for Active Steering



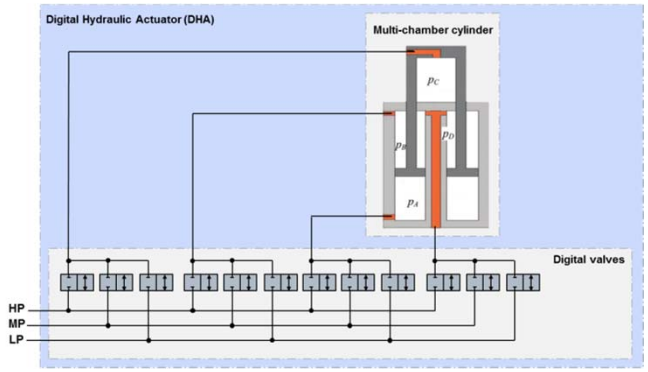


?

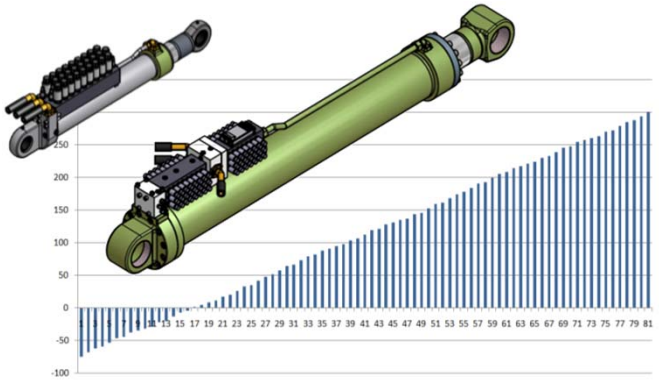


Magnus Sethson
Alesandro Dell'Amico

Digital hydraulics

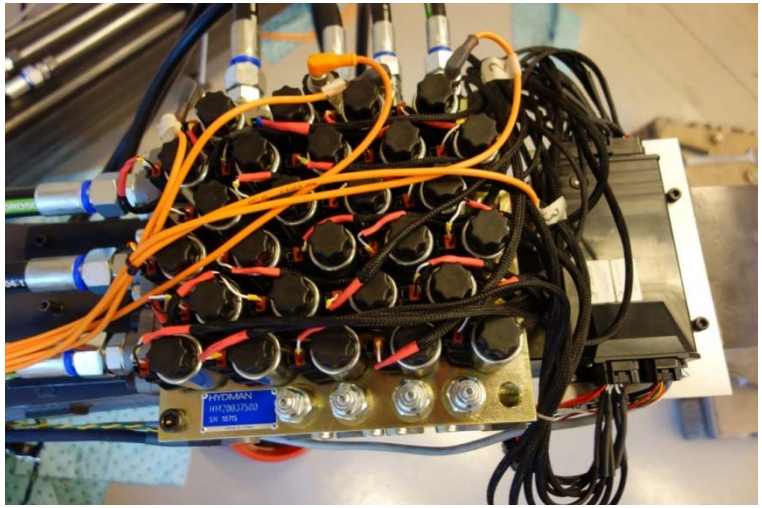


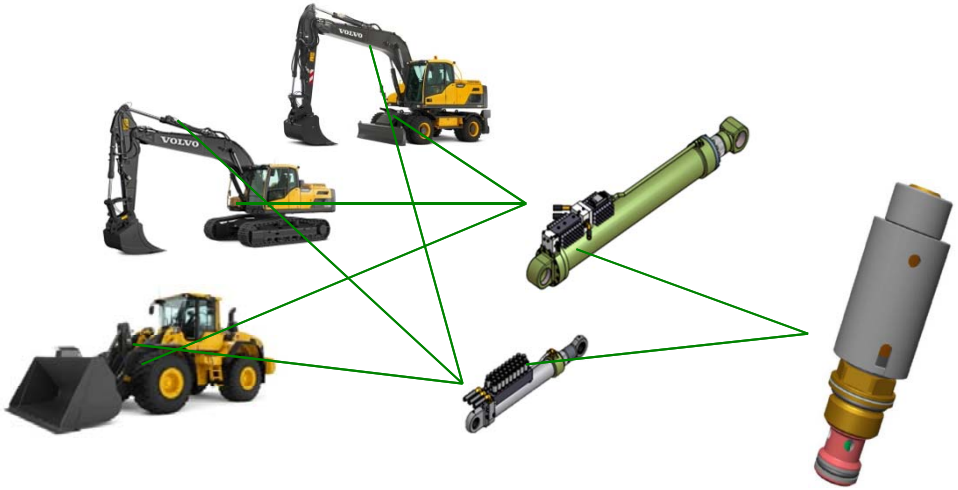
Multi-chamber cylinders



Discrete force spectrum

Digital valves



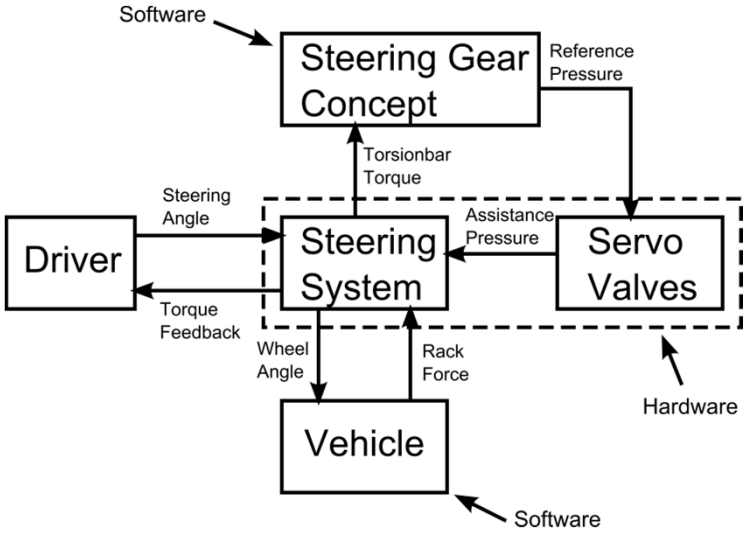


Conceptual Design of a Closed-Centre Power-Steering System using Hardware-in-the-Loop

Electrohydraulic closed-center valves for enabling active steering and reduced energy consumption

A generic test rig

A physical steering gear is in the loop



- The conceptual design is in the software
- Fast servo valves simulates the behaviour of each conceptual design

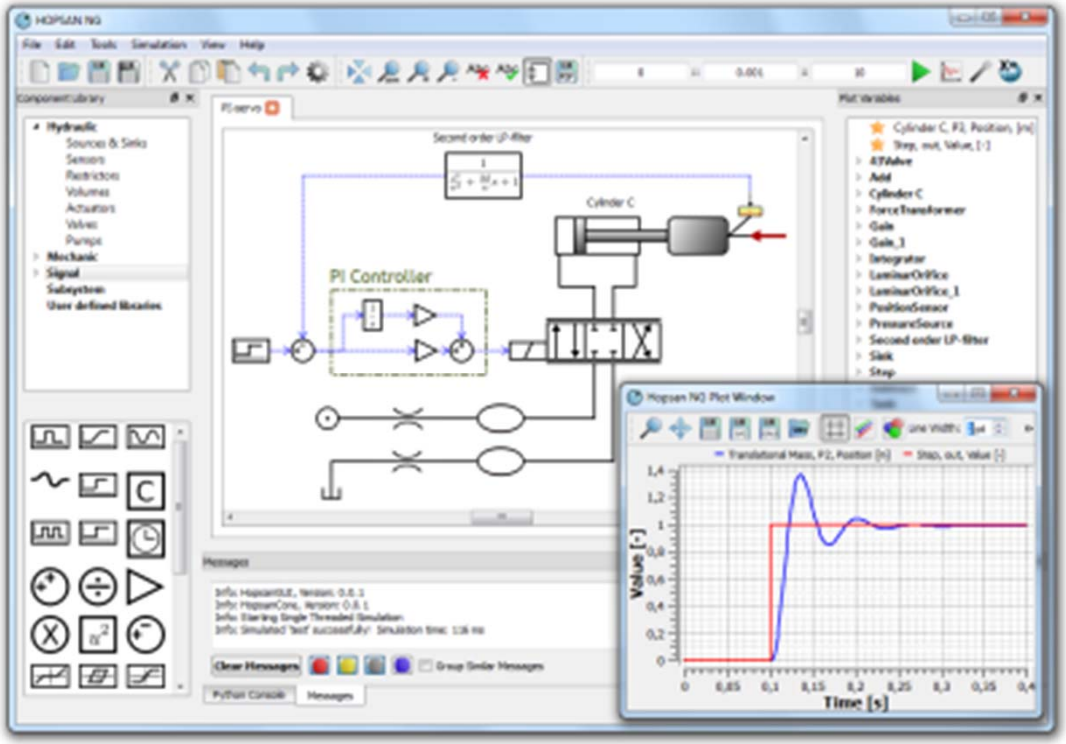
HOPSAN-NG (Next Generation)

Bidirectional delay-lines

Modelica support is under development

Genuine team work

Freeware that can be downloaded from
http://www.iei.liu.se/flumes/system-simulation/hopsanng



Atlas Copco: Rock drill Simulation and Optimization using the HOPSAN simulation package

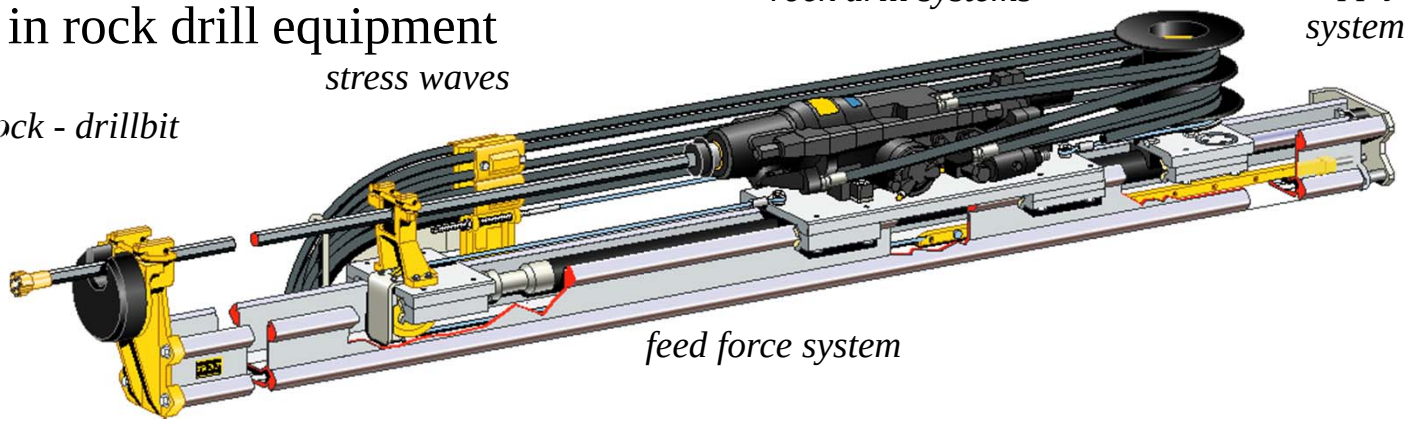
Atlas Copco has 45% of the world market in rock drill equipment

rock - drillbit

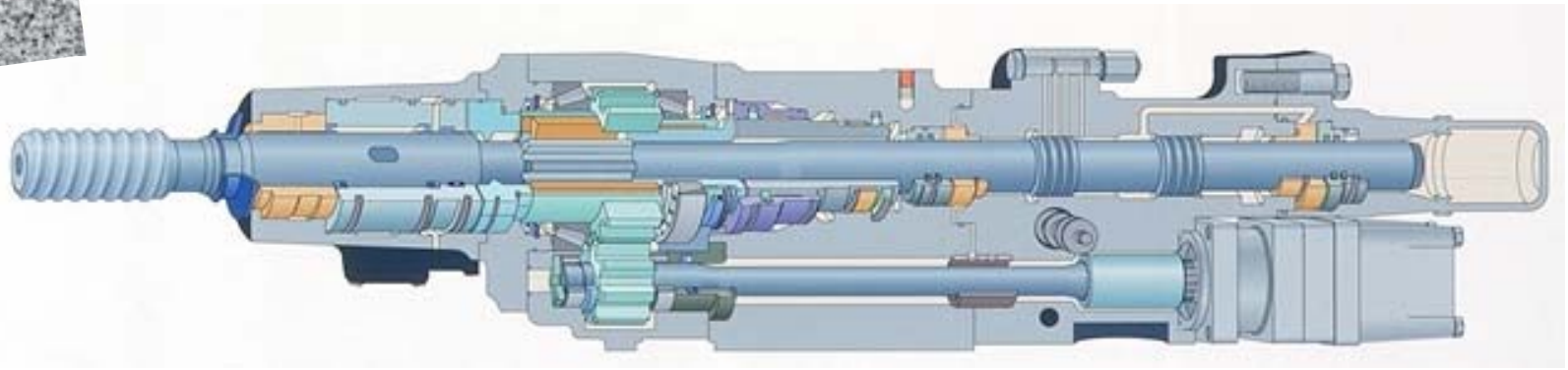
stress waves

rock drill systems

supply system



feed force system



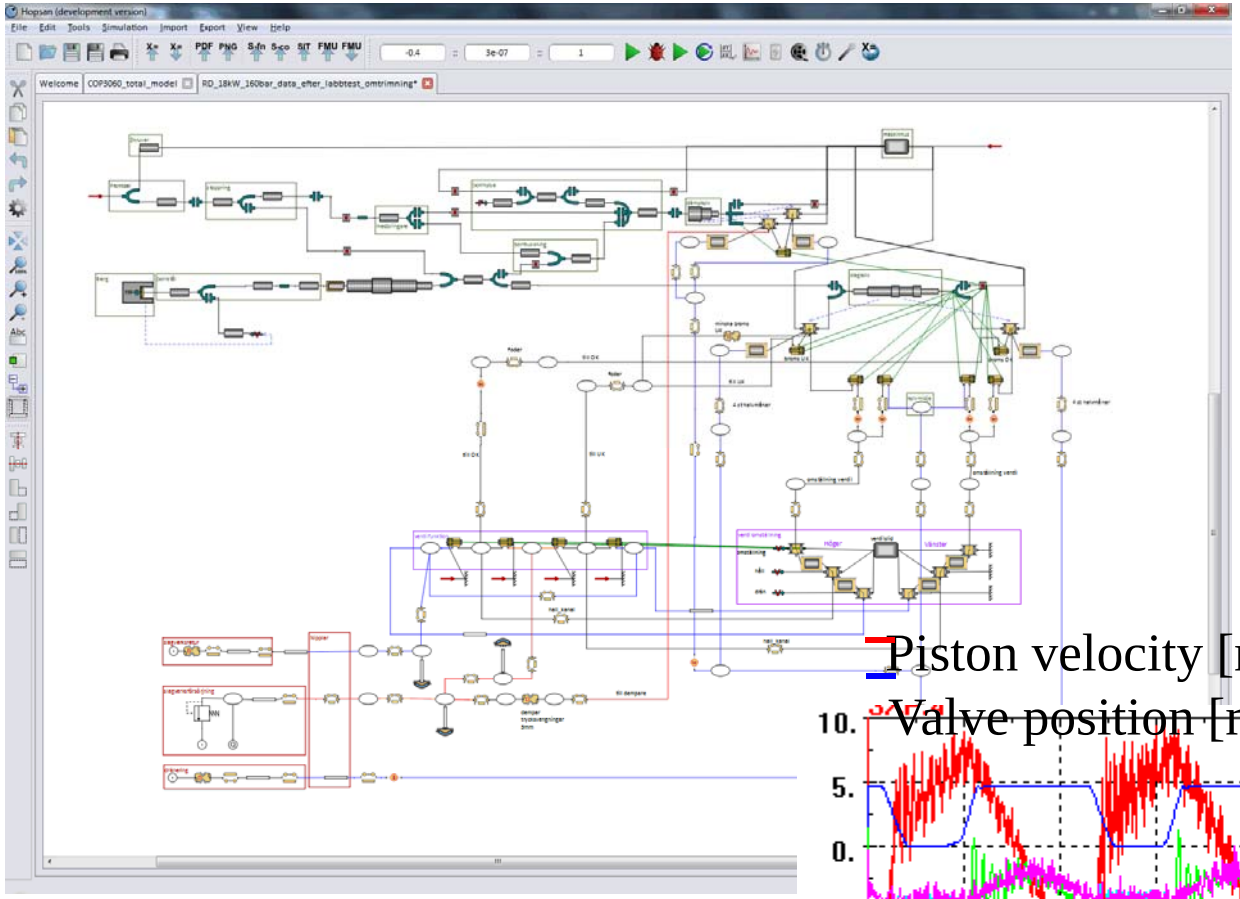
stress wave

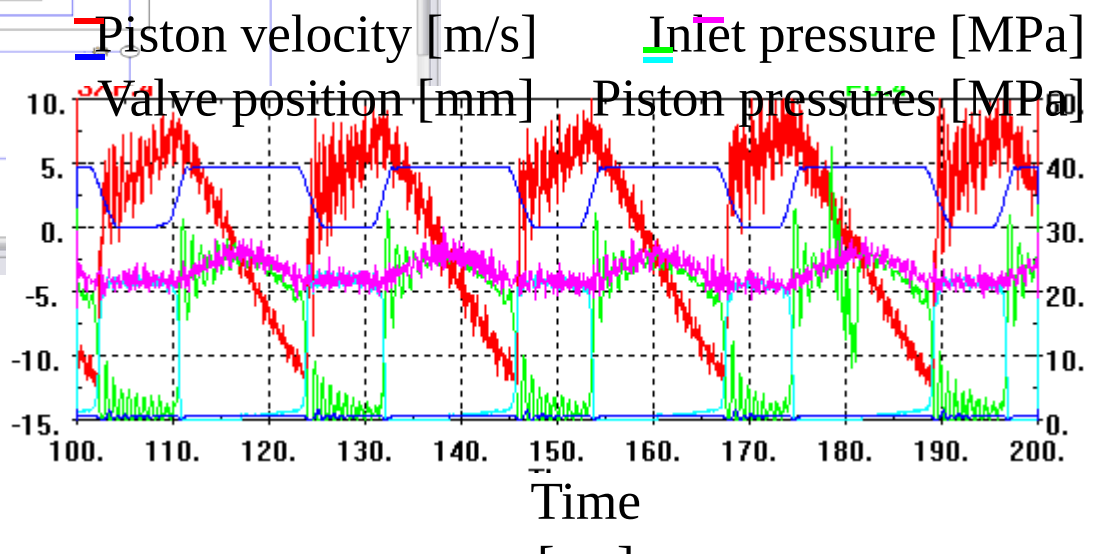
rotation

feed force tranfer and damping

percussion

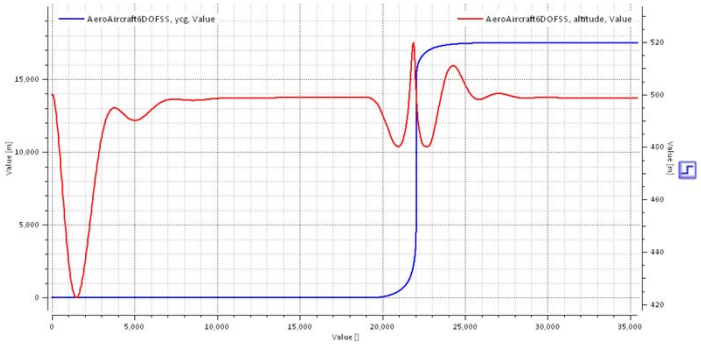
Atlas Copco: Rock drill Simulation



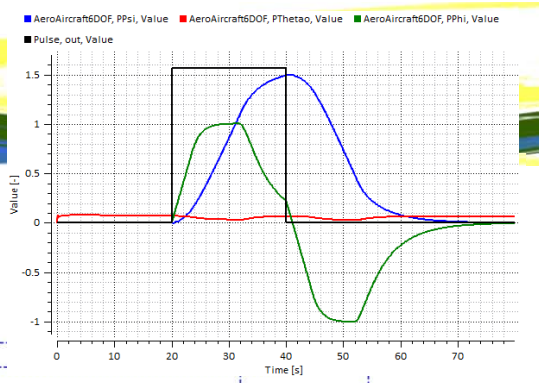


WIEFP 2014

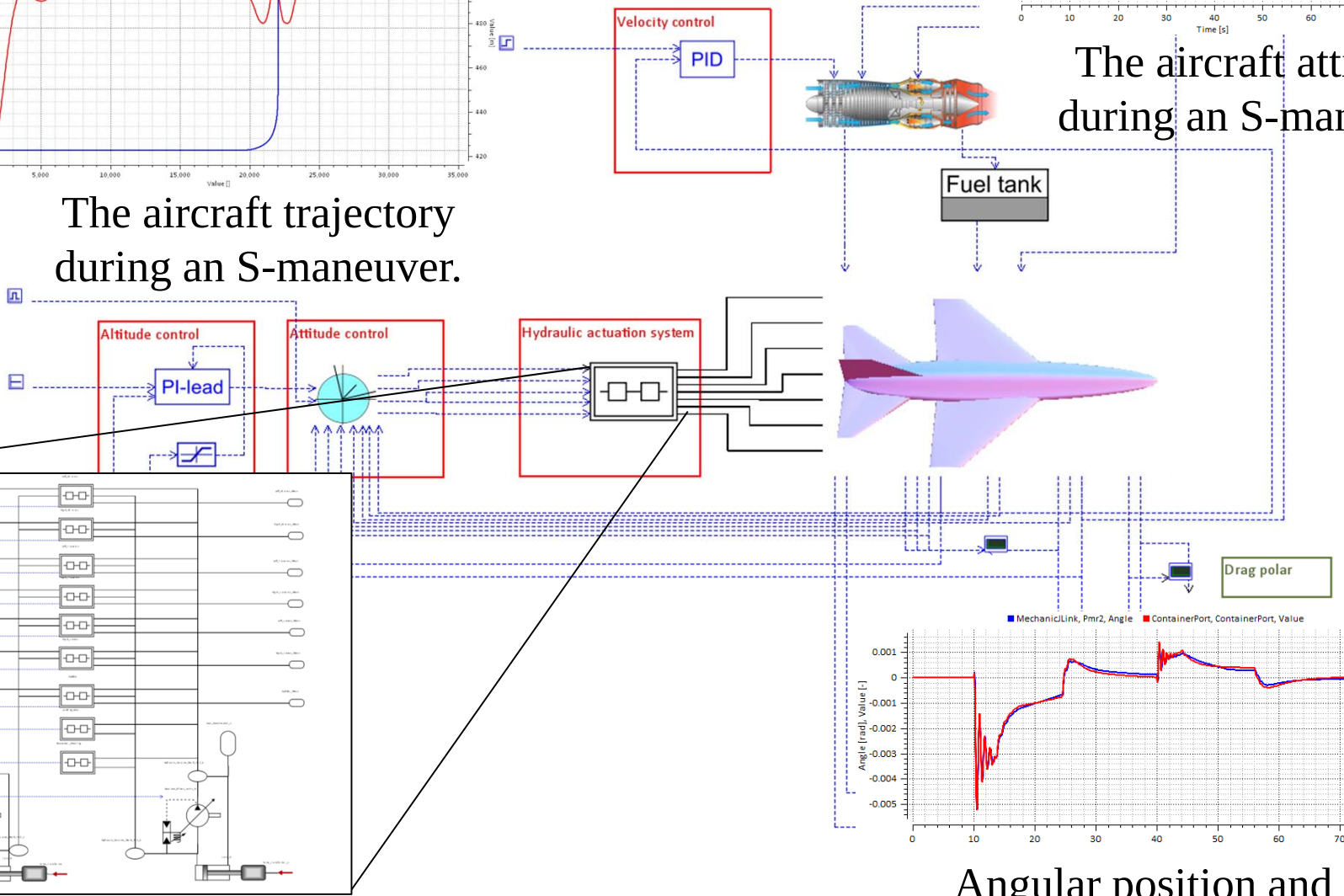
Integrated Aircraft System Simulation



The aircraft trajectory during an S-maneuver.



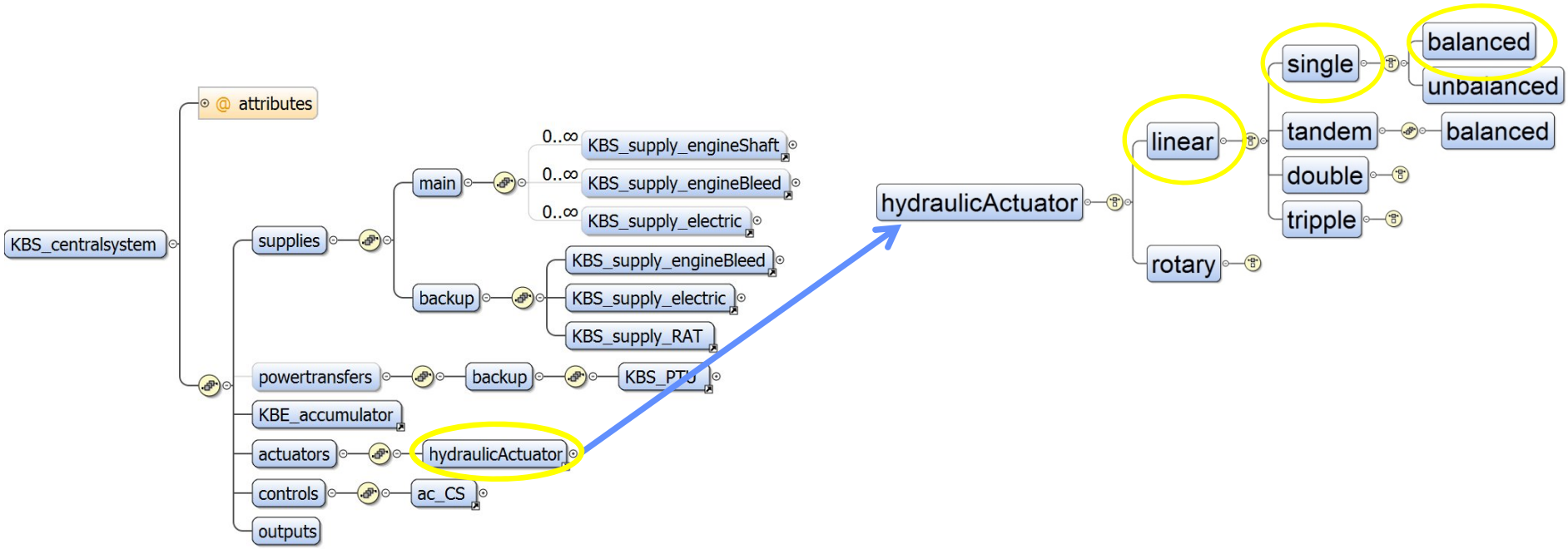
The aircraft attitude during an S-maneuv



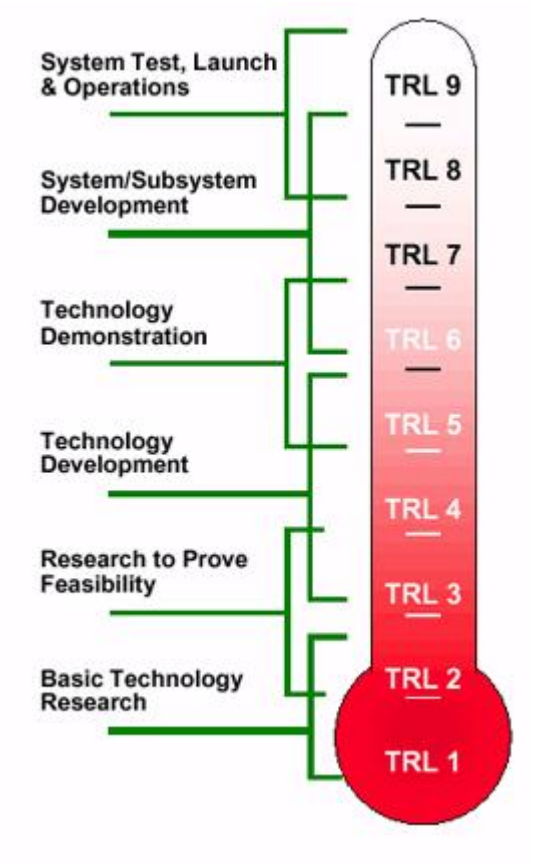
Angular position and

KBE for system

Knowledge modelling of aircraft hydraulic System



Technical Rediness Level

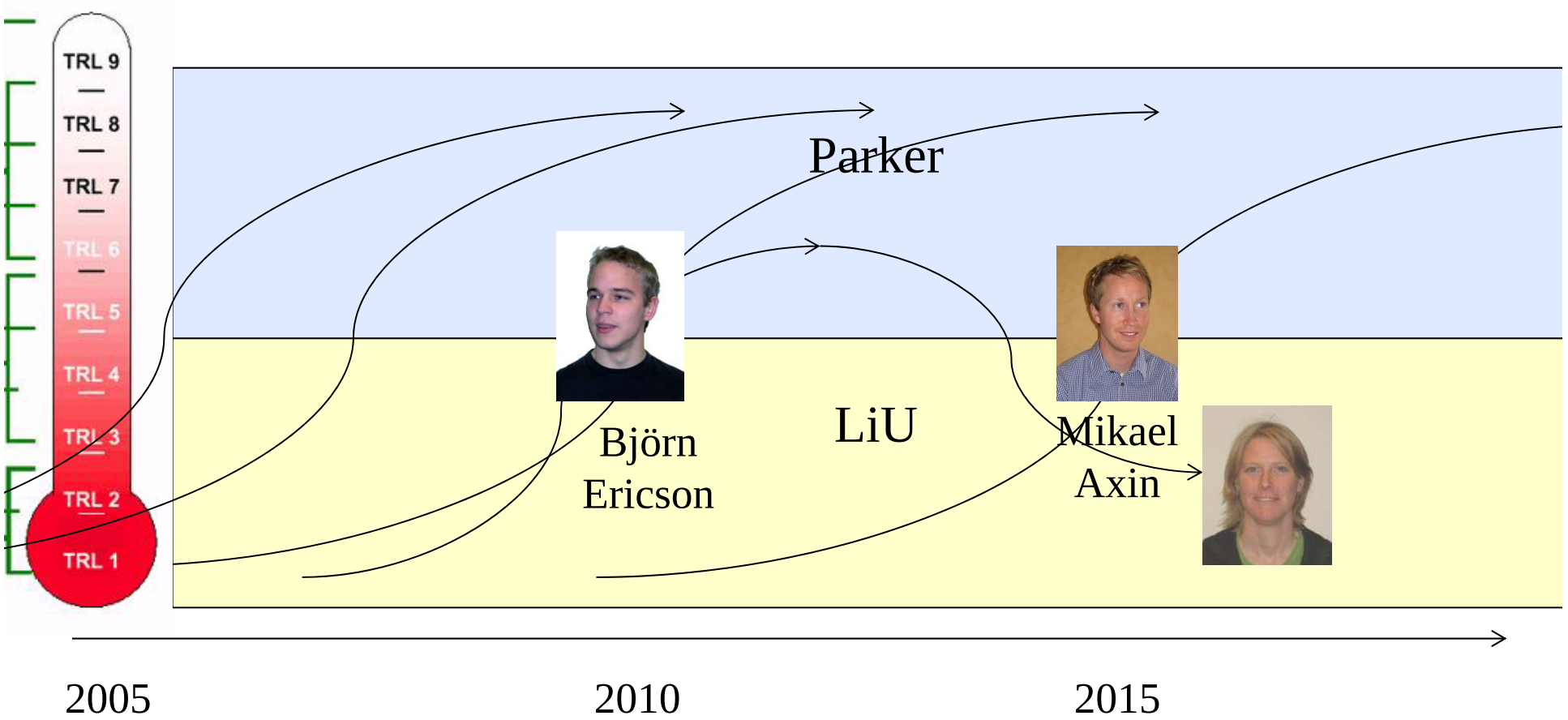


Technology Readiness Level (TRL) is a measure used by some United States government agencies and many of the world's major companies (and agencies) to assess the maturity of evolving technologies (materials, components, devices, etc.) prior to incorporating that technology into a system or subsystem.

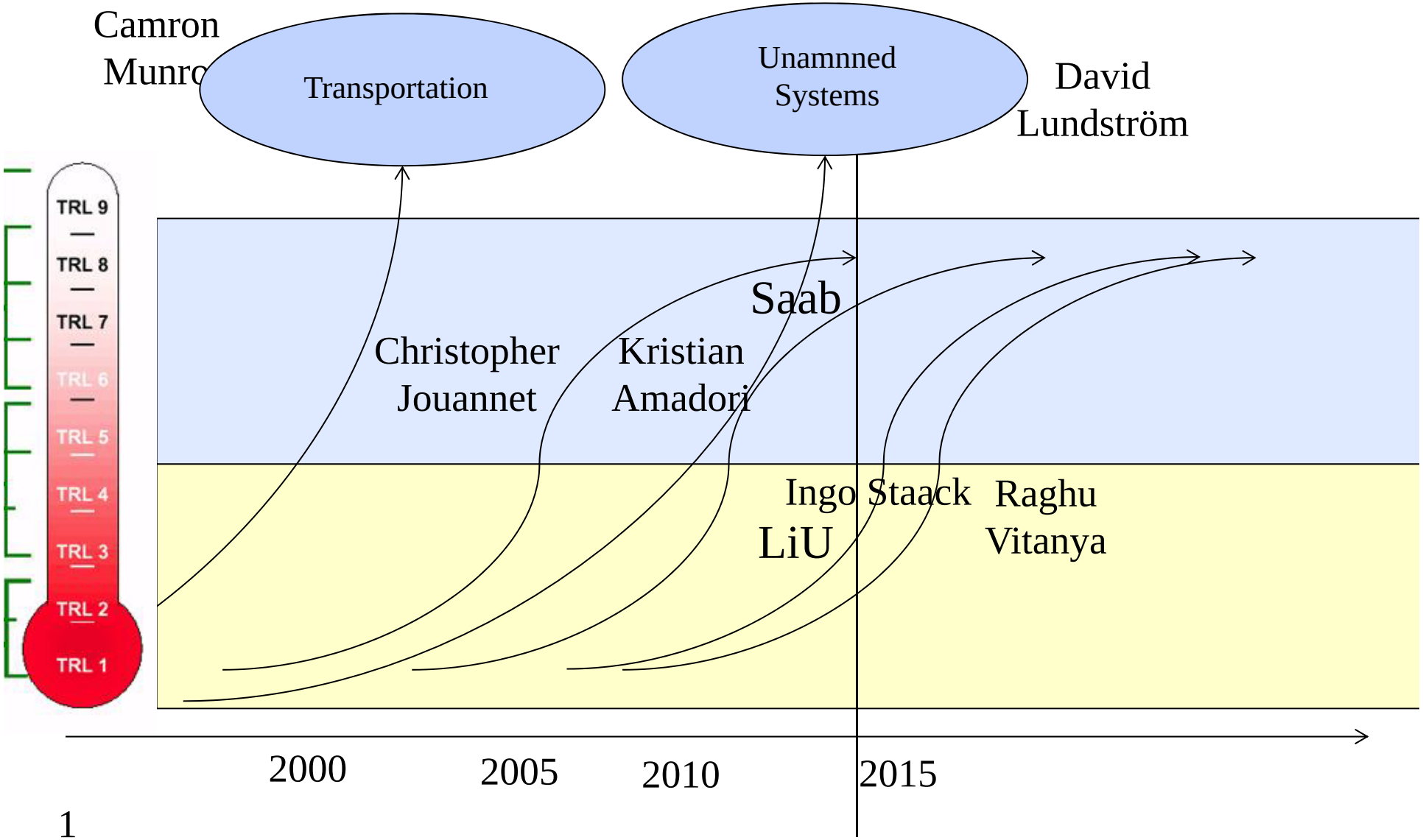
Universites belong on the lower end of the scale

Industry belong to the upper levels

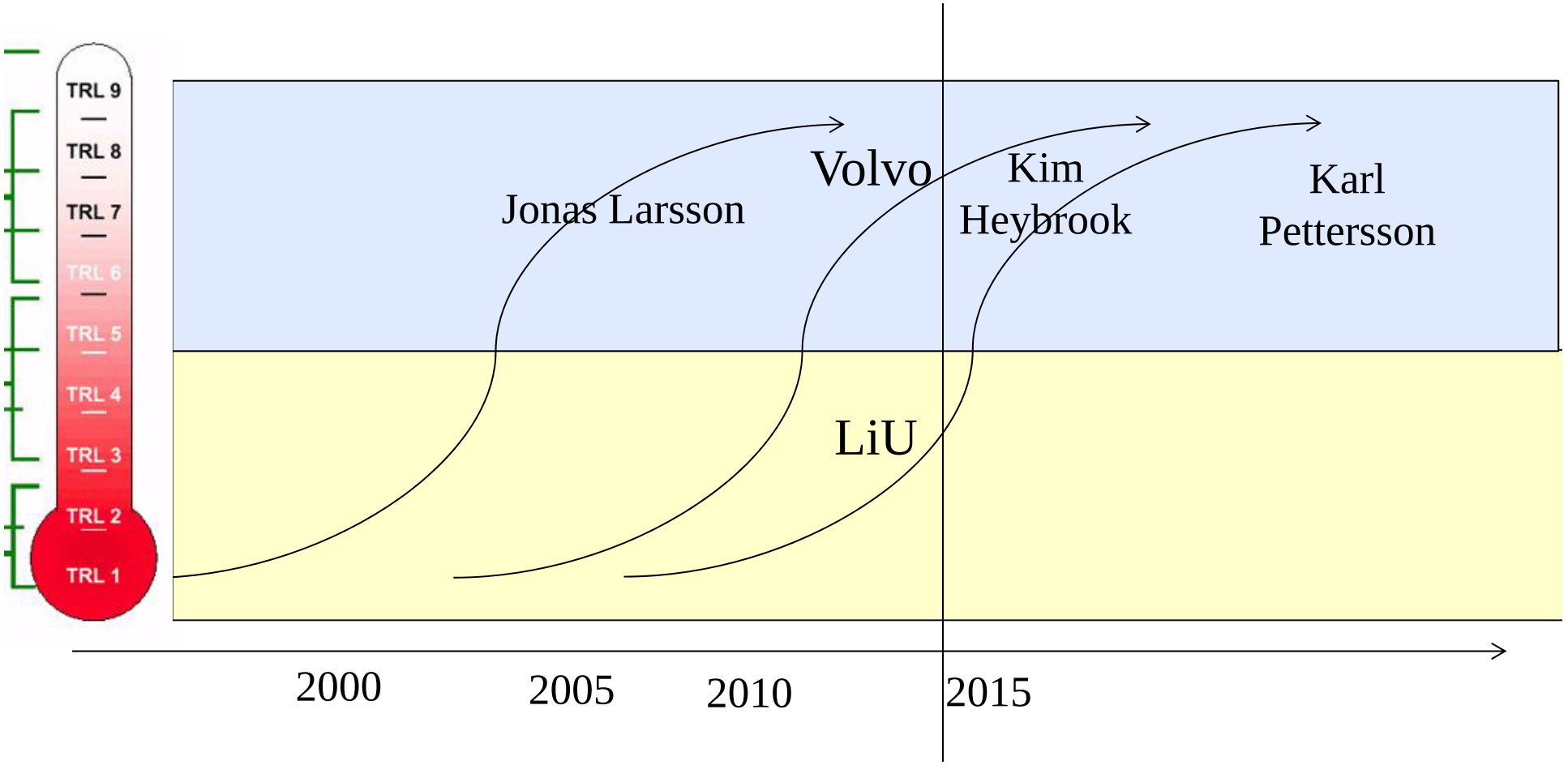
There must be an overlap


TRL 9
TRL 8
TRL 7
TRL 6
TRL 5
TRL 4
TRL 3
TRL 2
TRL 1
Parker
Björn
Ericson
LiU
Mikael
Axin
2005
2010
2015

Aircraft Conceptual design (Design tool development)



Volvo CE projects



Cross Fertilisation

System Optimization

With a good network methods developed in one area can be transfered to other application areas.

Simulation based optimization was implemented for hydraulic system optimization in 1991 at LiU Flumes.

Simulation based optimization in Hopsan is heavily used by Atlas Copco for Rock drill development.

Simulation based optimization was introduced for pump design with Parker.

System optimization was introduced in projects with ABB for industrial robots.

Oil hydraulics in Sweden

Sweden is a leading nation in hydraulics . The proportion of Swedish industrial hydraulics are among the highest in the world, more than three times higher than for the United States and Germany .

Sweden's successful exploitation of hydraulics has resulted in the Swedish company has taken a leading role in several industrial sectors where hydraulics is a key technology in the products. Several world leading Swedish company that manufactures hydraulic components and systems .

Hydraulics is currently used in the automotive, mining, paper / pulp and machine tool industry for aircraft, U- boats , trucks, tracked vehicles, construction equipment and forestry equipment .

Commodity exports are estimated at 100 billion SEK or 10% of the commodity value of Swedish industrial exports . Swedish hydraulics manufacturers have a significant market share (~ 5%) of the world market for hydraulic system of over 200 billion SEK.

The Potential of Fluid Power

The importance of oil hydraulic is due to its unique ability to produce large forces, with great control, and the ability to efficiently store energy. The market for hydraulic components and systems are expected to triple turnover to 1000 billion in the next 15 year period. Few technologies today can compete with hydraulics. In the United States Department of Energy estimated that the hydraulics and pneumatics industries account for 2-3% of energy

Aviation is responsible for about 2% a CO2 footprint

The Potential of Fluid Power, cont

Approximately 79% are losses. Technically it is possible to reduce them to 10%. The commercial "upside" is gigantic. R & D investment can quickly be made profitable by a major product diversification across many industry sectors.

The new innovative hydraulic system has already fulfilled many expectations. Caterpillar launched this year a new hybrid excavator (336EH) that saves up to 25% fuel by hydraulic recovery of braking energy of the swing movement. It pays back within a year.

Bridgeing the gap

Jochen Pohl had a PhD at LiU/*Flumes* in 2001

He then worked for another ten years as 20% assistant professor and 80% in his company.

Co-supervisor of PhD students.

Access to university network for informal discussions.

Did control system that is licensed for ”Volvo Dynamic Steering”

The Epic Split - most watched automotive commercial on Youtube ever!! >72 million downloads

Pesquisa Aplicada para Geração de Engenheiros de Excelência