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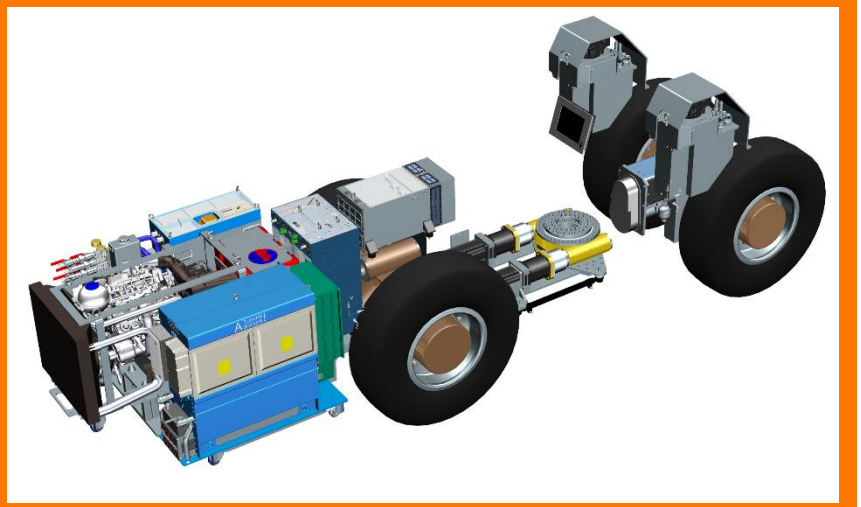
Full-scale series hybrid mining loader with zonal hydraulics



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ECV seminaar 11.5.2016

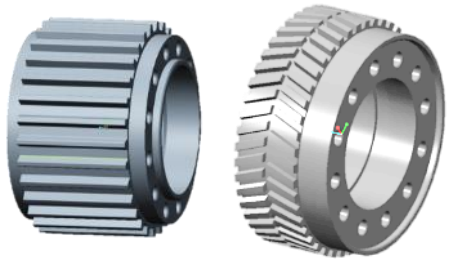
Undergroud mining load haul dumber

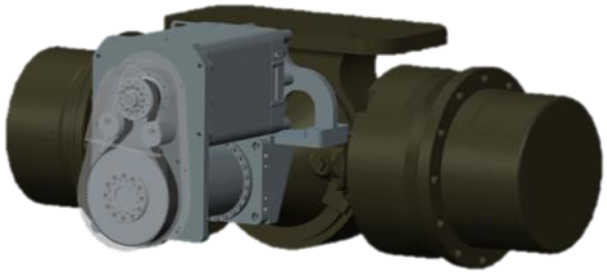
- ”Research by engineering” approach
- We will make drivable hybrid loader – the great challenge
- Loader represents surprisingly general machine for Finnish NRMM industry, originally it was
  - Power class 90kW
  - Articulated steering
  - Hydraulic drive in front and rear axles
  - Lifting/lowering of the bucket i.e. big hydraulics
  - Heavy enough
- We had Experience from SPPA 2004-2008 and HybLab 2008*-2012 projects.

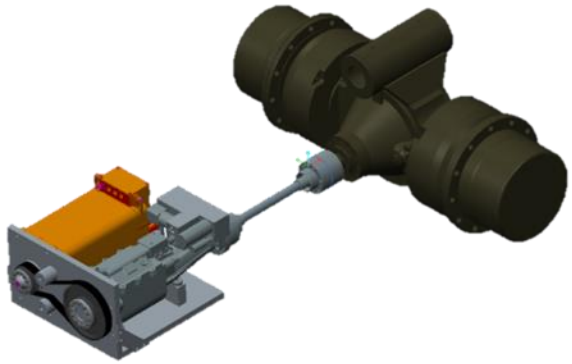
**1$ fuel → 2$ fresh air down the mine today, tomorrow it will be 3$...*

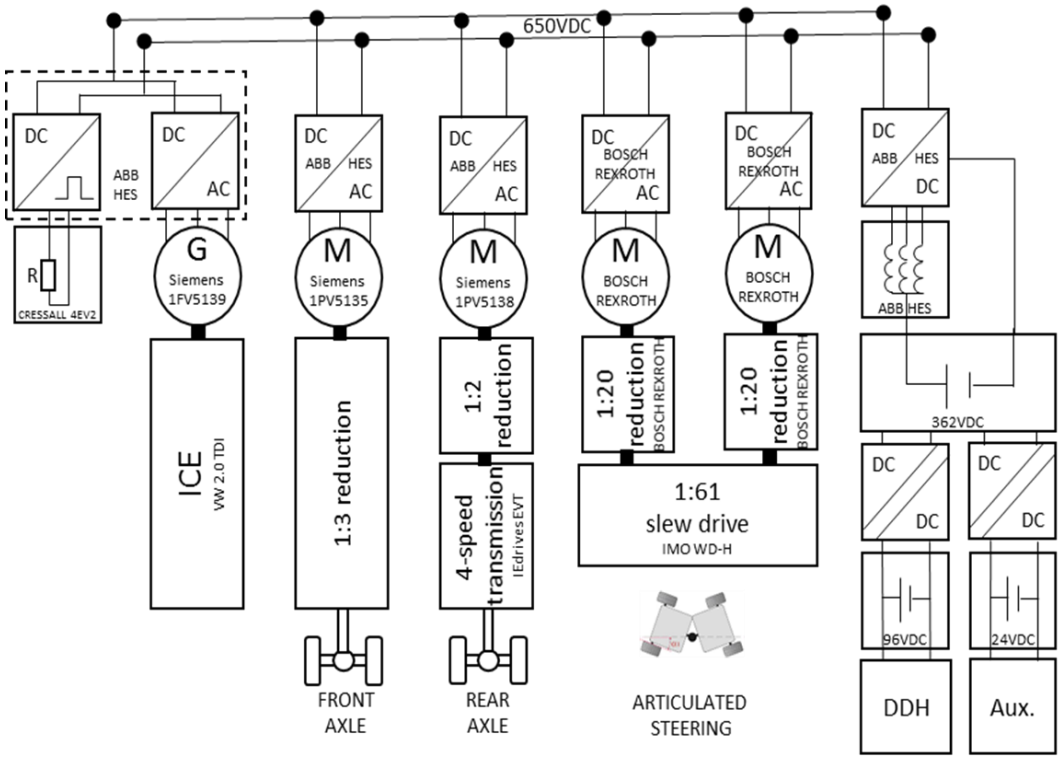
Sub system highlights

Expect life time 10 000h	Front axle	Rear axle
Gearing	3:1	2:1
Continous power / moment	67kW / 160Nm	85kW / 220Nm
Max power / moment	150kW / 430Nm	150kW / 530Nm
Speed range	+-10 000 rpm	+-10 000 rpm
Belt drive components	Gates, direct teeth	Goodyear, V-shape









Electromechanical actuation: Motivation

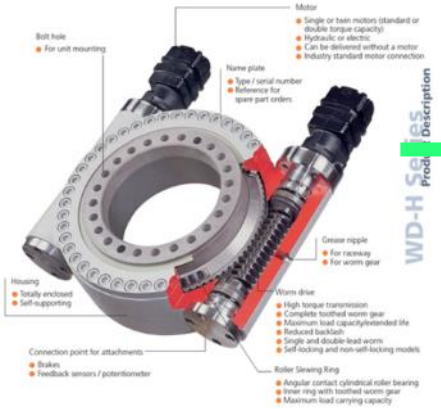
Conventional solutions done by 1-2 hydraulic cylinders

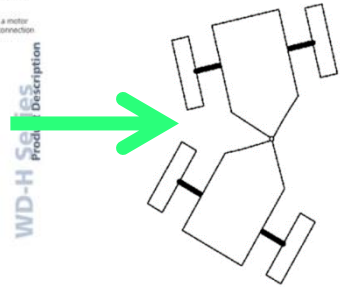
EM-actuator brings along new opportunities for controllability & accuracy & sensitivity adaptation

- ✓ Soft and slow movements vs. very fast and sharp performance if needed
- ✓ Self straightening can be implemented
- ✓ Steering degrees can be adapted by driving speed, direction and bucket position / load

New possibilities to layout

Does not continuous demand hydraulic flow i.e. for full electrical machines

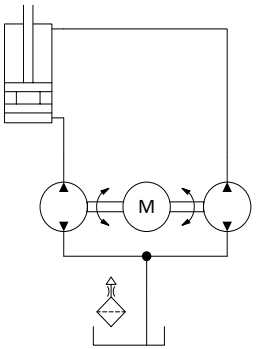


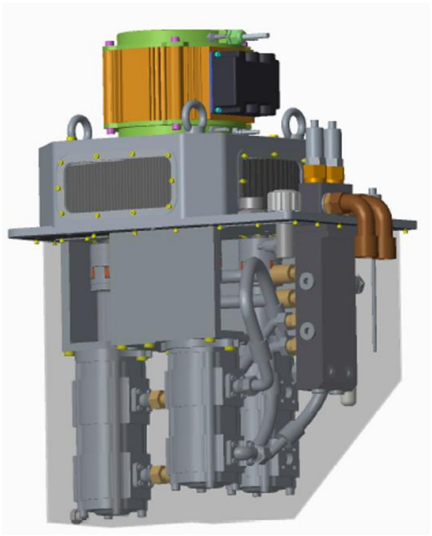


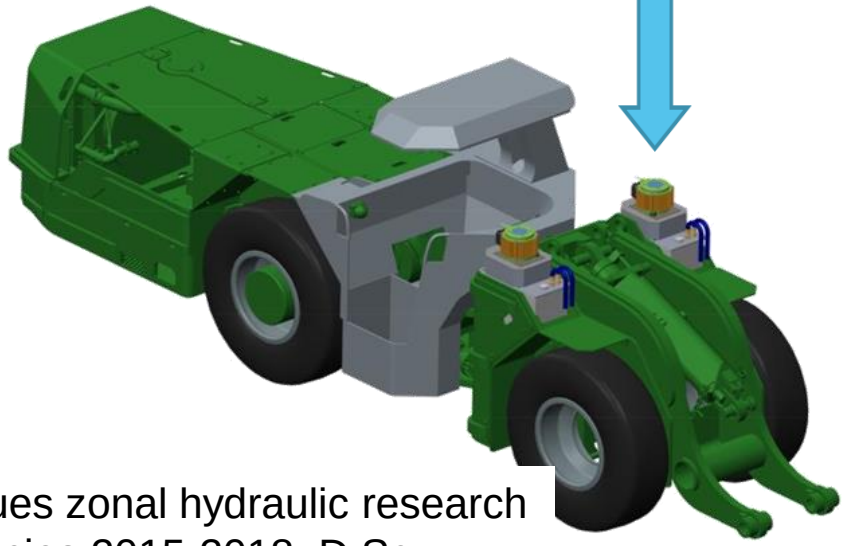
Direct driven hydraulics (zonal hydraulics)

Novel Power Pack for Electrification of NRMM applications

- Reliable
- Robust
- Efficient
- Tankless
- Sensorless







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EL-Zon project continues zonal hydraulic research with Tekes and companies 2015-2018, D.Sc. Tatiana Minav tatiana.minav@aalto.fi

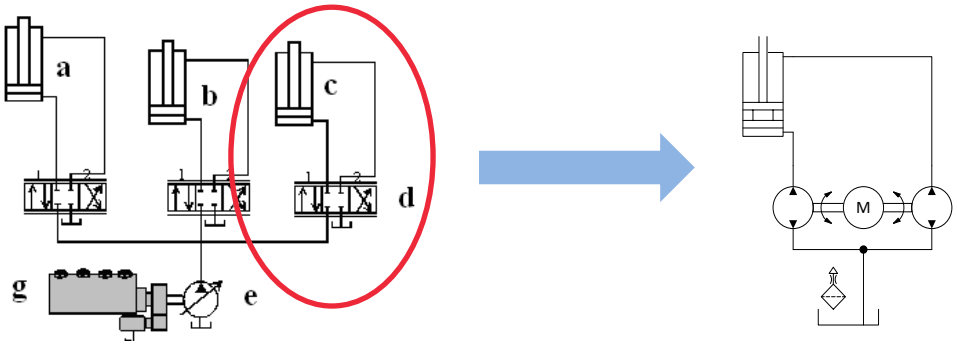
Some highlights related of the subject

- Electrification of Agricultural Machines, M.Sc.-thesis Otto Tammisto, 2014
- The hybridization of powertrains in the mobile heavy machinery industry and changes in industry architecture, M.Sc.-thesis Ilkka Kaikkonen, 2012
- Yearly updated i.e. 4 times during the project Road Map of electrification of non-road mobile machinery with VTT and LUT
- LUT simulation work – dimensioning of the components and possibility to use professional driver or customer before physical prototype

Summary and future opportunities

What new businesses are arising from this research?

- ✓ Automation and remote control of machines will become much more common. Electromechanical steering is one technology to enable no-driver-on-board or even robotized non-road-mobile-machines
- ✓ New business models and rent/leasing are all hungry for information. Electric solutions will bring more intelligence on board



Consept of zonal hydraulics (direct driven hydraulics)

As a teaser please see http://www.moreelectricaircraft.com/

Summary and future opportunities

Key findings of the research

- ✓ Electromechanical movements – control is a challenge but it brings benefits
- ✓ Get yourself familiarized with modern belt drives
- ✓ Hydraulic is developing all the time – good engineering is valued here. When you need a huge cooler ask yourself why…
- ✓ Direct driven hydraulic or zonal hydraulic – what ever we call it now will come.

Exploiting this research for business

- ✓ Less waste heat (cooling and exhaust) for under ground & indoor operations, also lower fuel consumption
- ✓ Tier V will come 2019/2020 = down size your diesel and improve the performance at the same time by hybridization