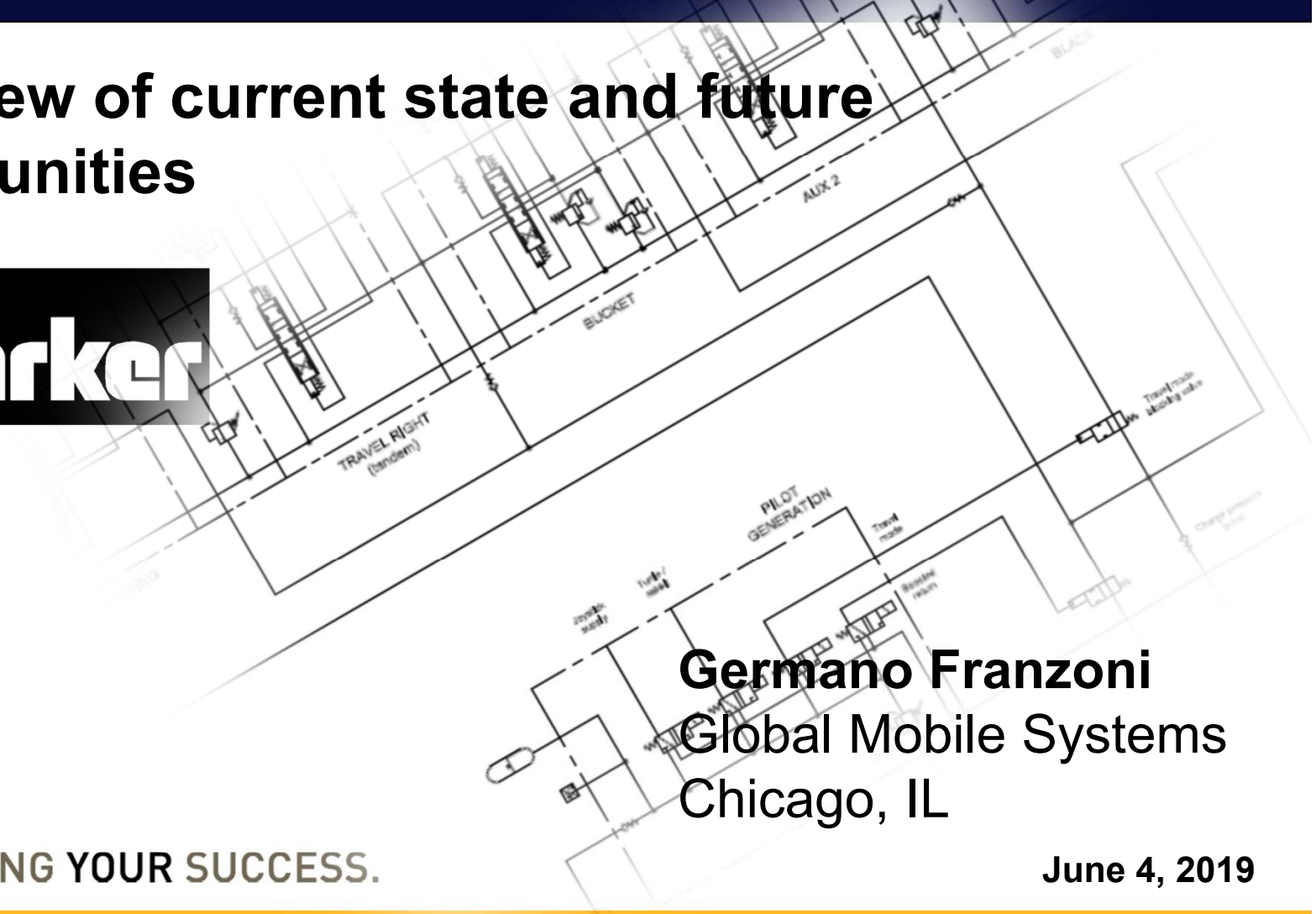
Systems Engineering and Electrification in Fluid Power

Overview of current state and future opportunities



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ENGINEERING YOUR SUCCESS.

June 4, 2019

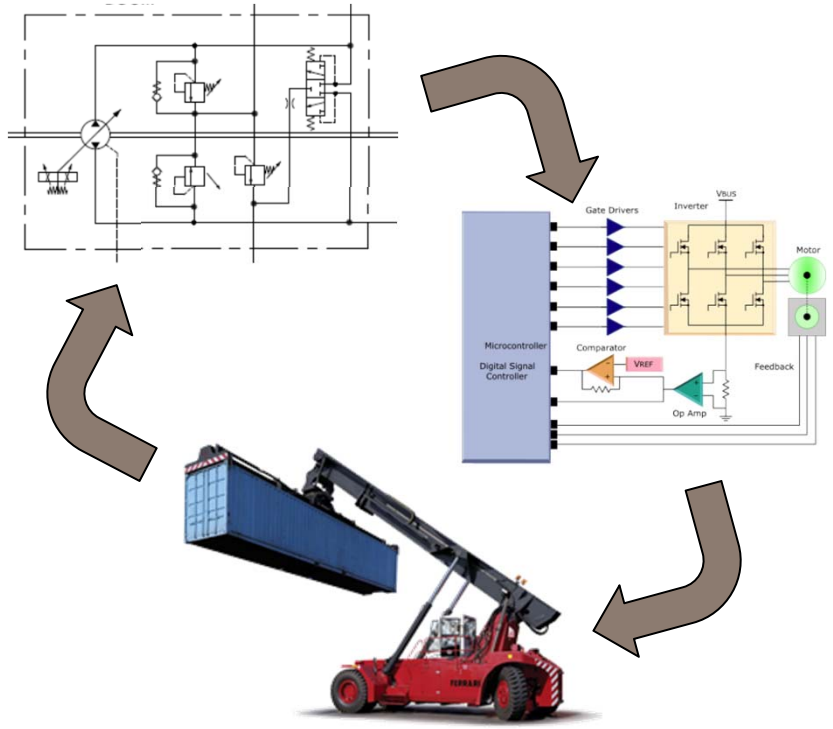
Outline

- Systems engineering overview
- Examples of traditional sys. engr. activity
  - Circuit generation
  - Simulation to support projects
  - Baseline and energy mapping
- Electrification of mobile equipment
  - Overview (mini construction)
  - Parker approach to electrification
  - Example
- Conclusion

Systems Engineering

- Discipline of Fluid Power Engineering
- Design and control of **hydraulic circuits**

- Knowledge of
  - Hydraulic components
  - Controls and programming
  - Machines, applications



Systems Engineering at Parker (GMS)

- Organization overarching multiple divisions and groups
- Represent multiple technologies
- Support customers (OEMs) for next generation systems
- Global organization
- US location: Chicago, 4000 m^2 test and development lab
- Outside GMS scope
  - Design components

Secular trends

- Consolidation of hydraulic suppliers
- Leaner engineering and testing resources at OEMs – help needed
- New trends develop cross technology applications (Electrification)

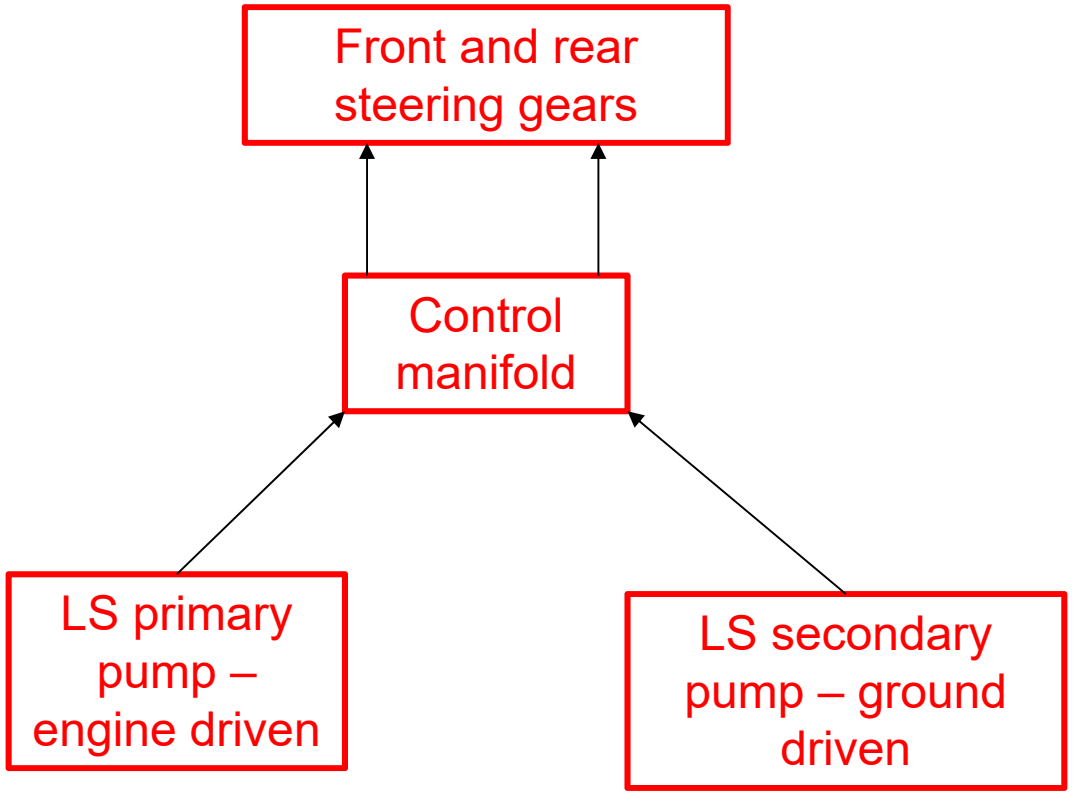
- Baby boomers are all retiring, new generations not attracted by hydraulics
- Lack of hydraulic engineering talent

Projects

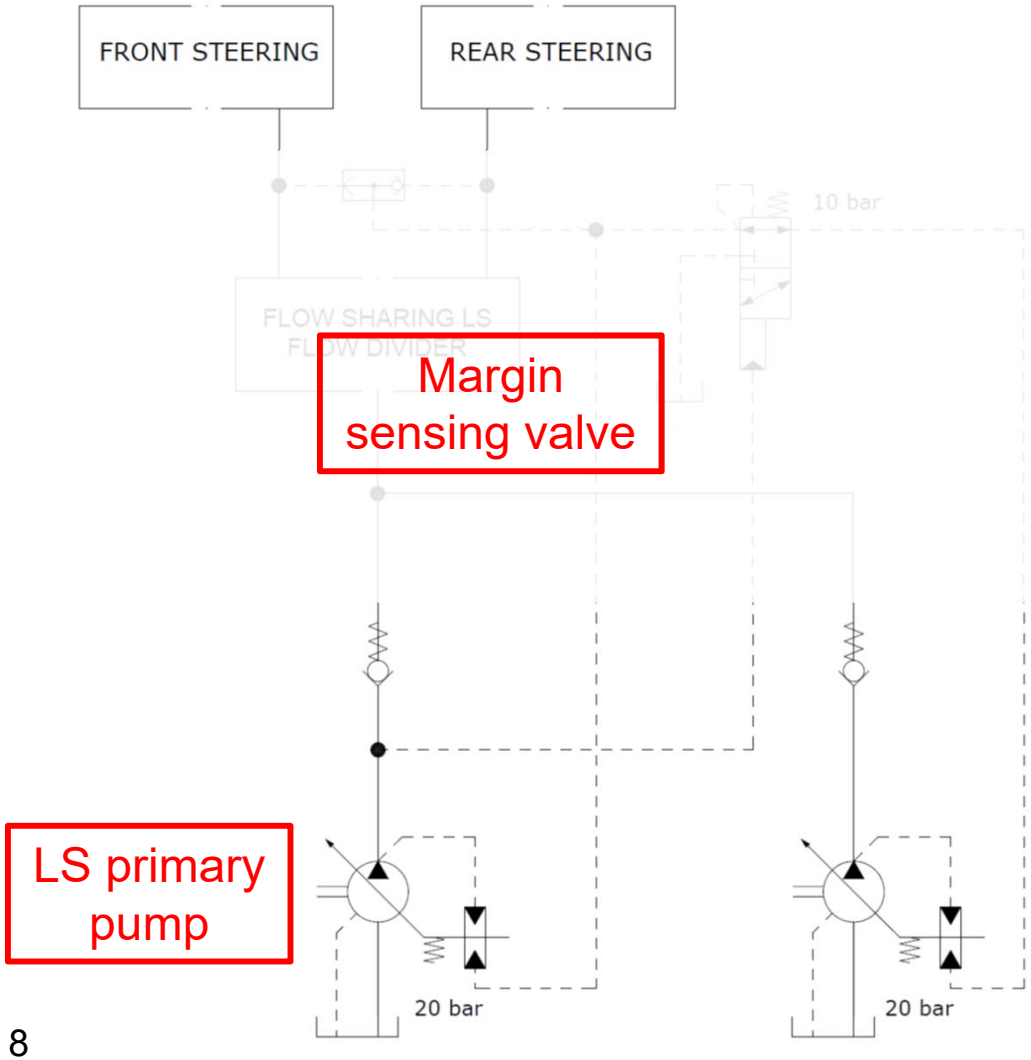
TRADITIONAL SYSTEMS ACTIVITY

Example of system project

GOAL: develop a front and rear steering circuit for a vehicle inclusive of emergency steering pump



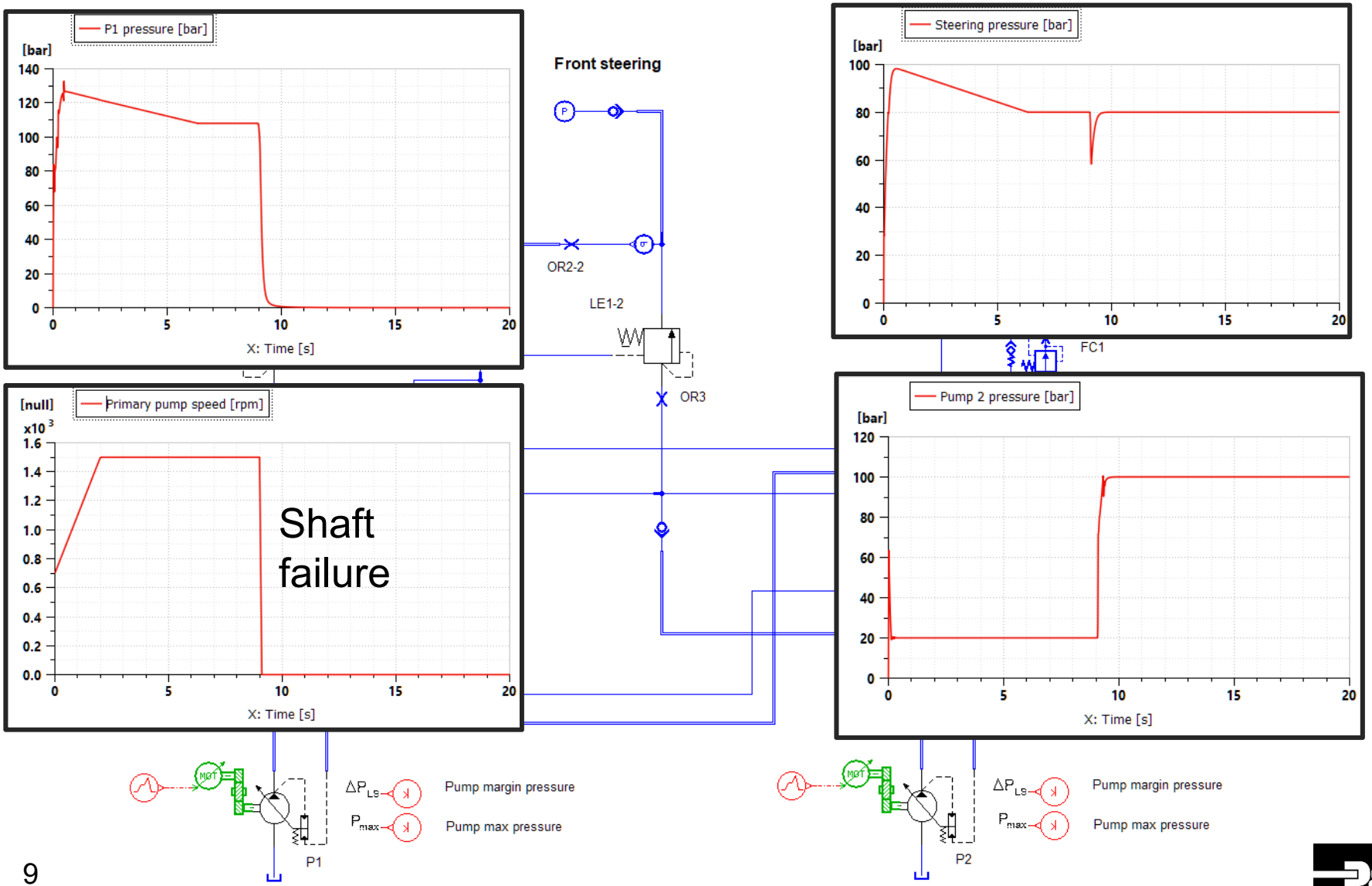
Secondary pump engagement



Margin sensing valve:

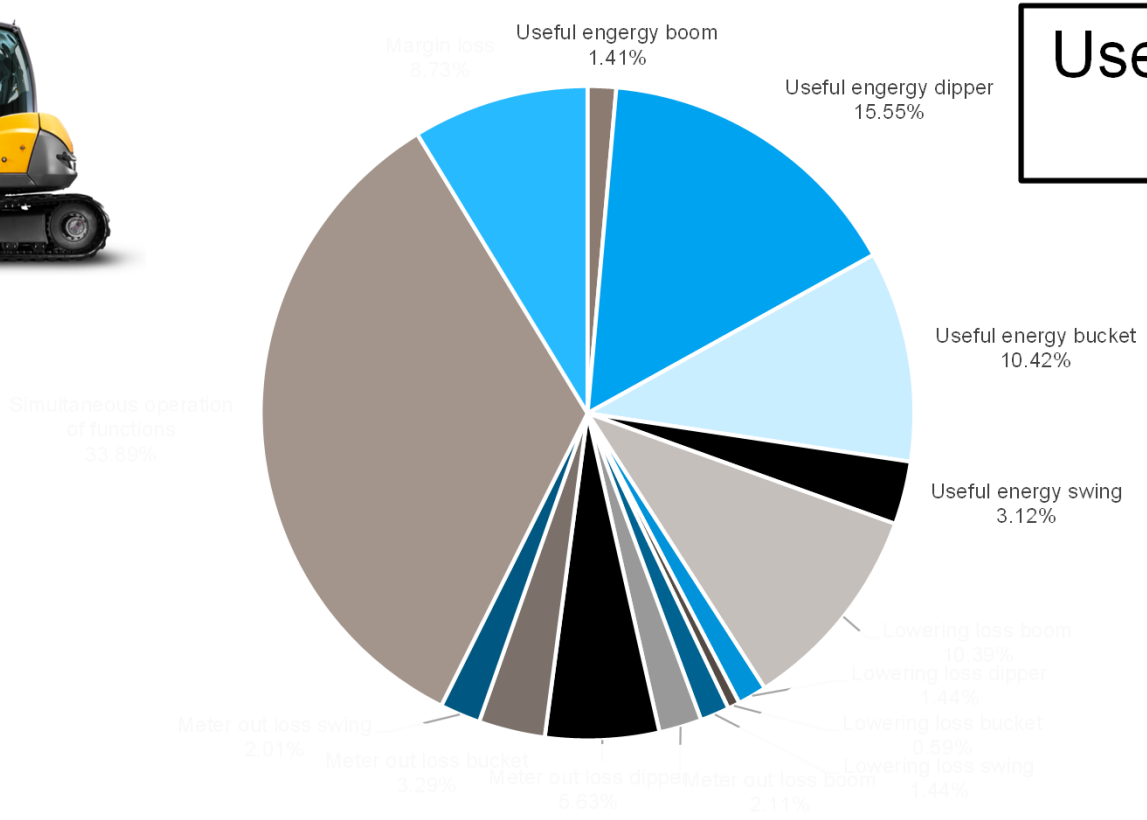
- If primary pump is OK
  → LS2 = 0
- LS2 engaged only if margin of P1 collapses

Simulation used to support OEM



Energy mapping – system optimization

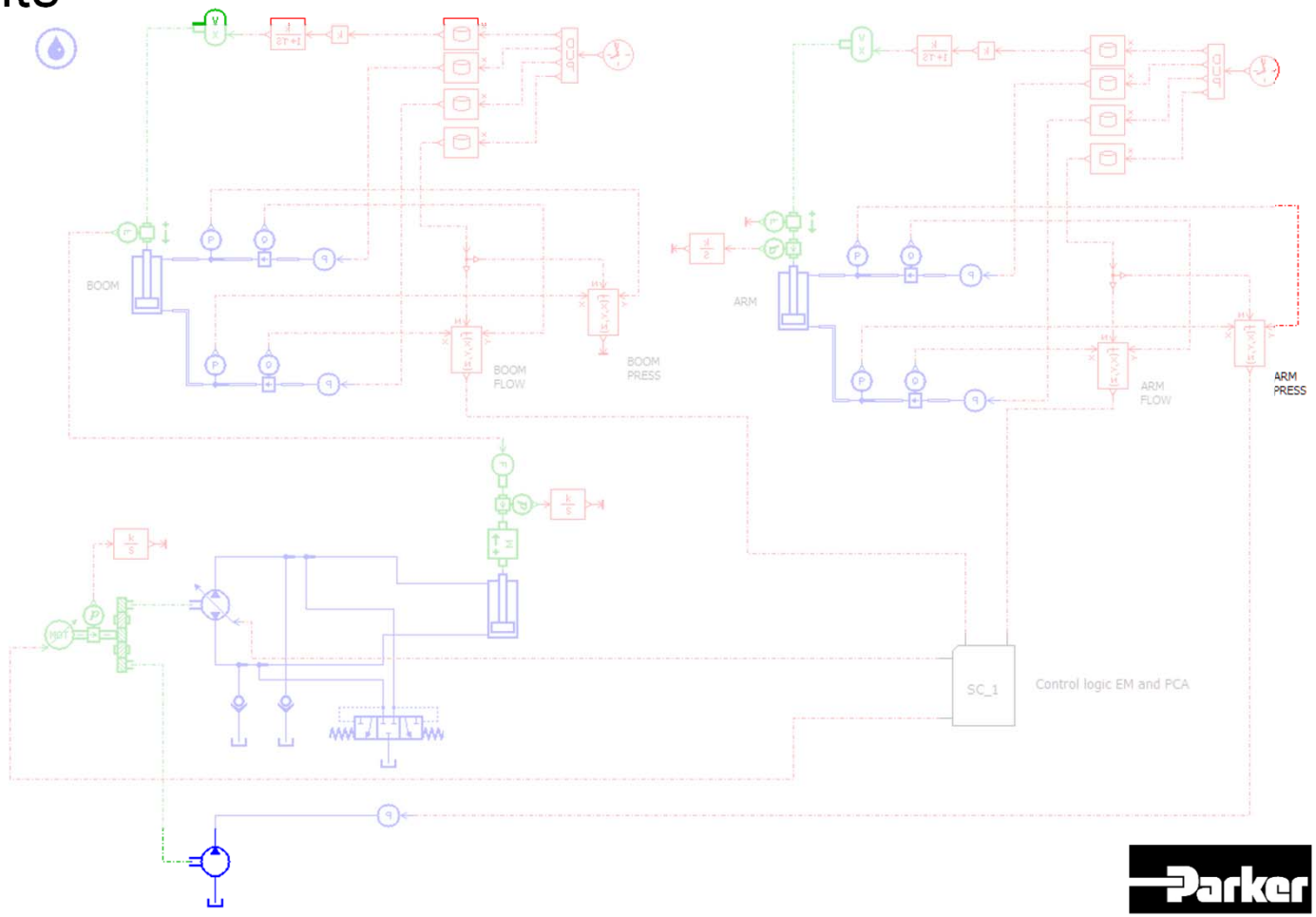
- Testing in our proving ground
- Baseline: analyze losses and suggest improvements



Useful energy: 30.5%

Energy mapping – system optimization

- Simulation is again used to propose system improvements



Innovative trend and opportunities

ELECTRIFICATION OF MOBILE EQUIPMENT

Compact construction equipment

- Why?
- Upcoming regulations:
  - Zero emissions (historical downtowns, indoor)
  - Low noise (no engine)
- Sweet spot for power density of Electric motors
- Battery is still affordable
- The Elon Musk factor….

Mobile Electrification

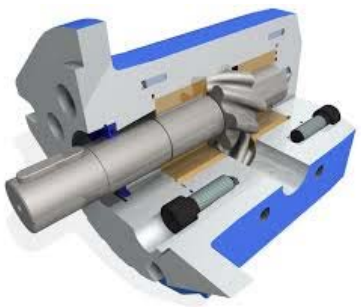
Engineering challenge with significant revenue potential

- Battery, Motors, Inverters are the **cost drivers**
- Need of efficient or smart systems
- Combination of multiple technologies requires skills
- Component Integration

Opportunity for Systems Engineering!

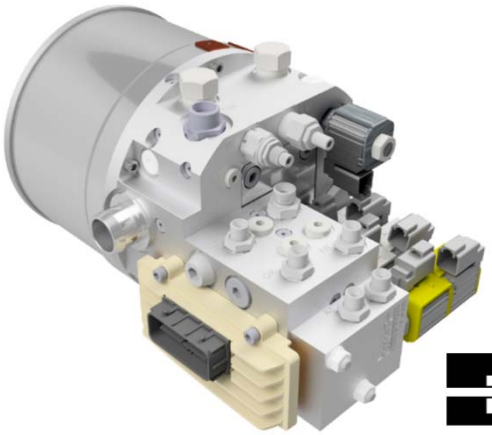
Electrification at Parker

- GVM PMAC Motors
  - Established market leader position
- GVI inverters (recently launched)
- Multiple pump technologies
- Cooling technologies

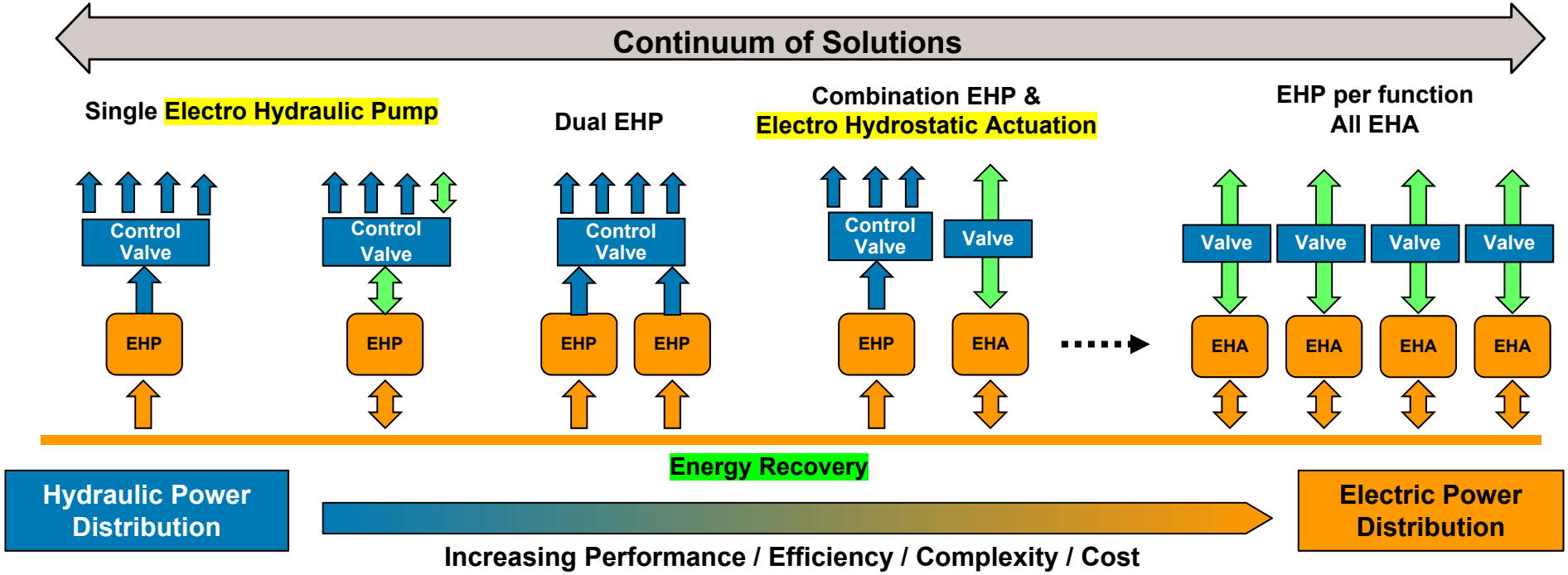


2 Parker teams:

- GMS: Machine testing, circuit design
- MTC: Technology development, component integration



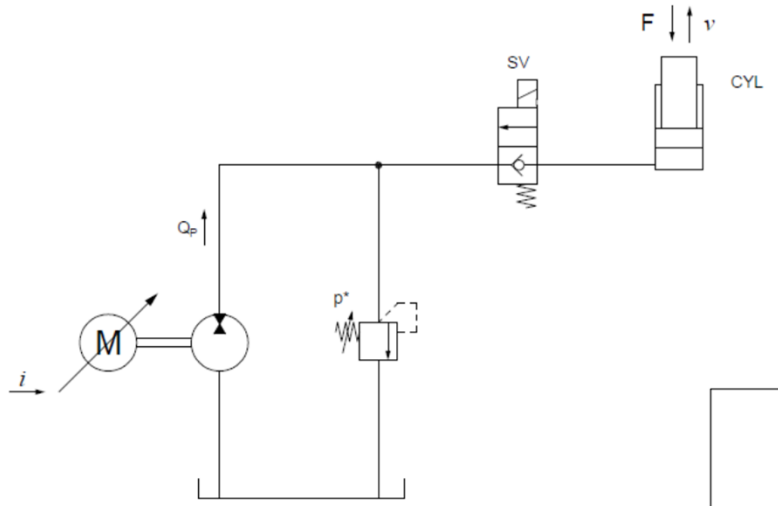
Mobile Electrification



- Different levels of impact on a system design
- Energy recovery is an opportunity
- What is the best solution?

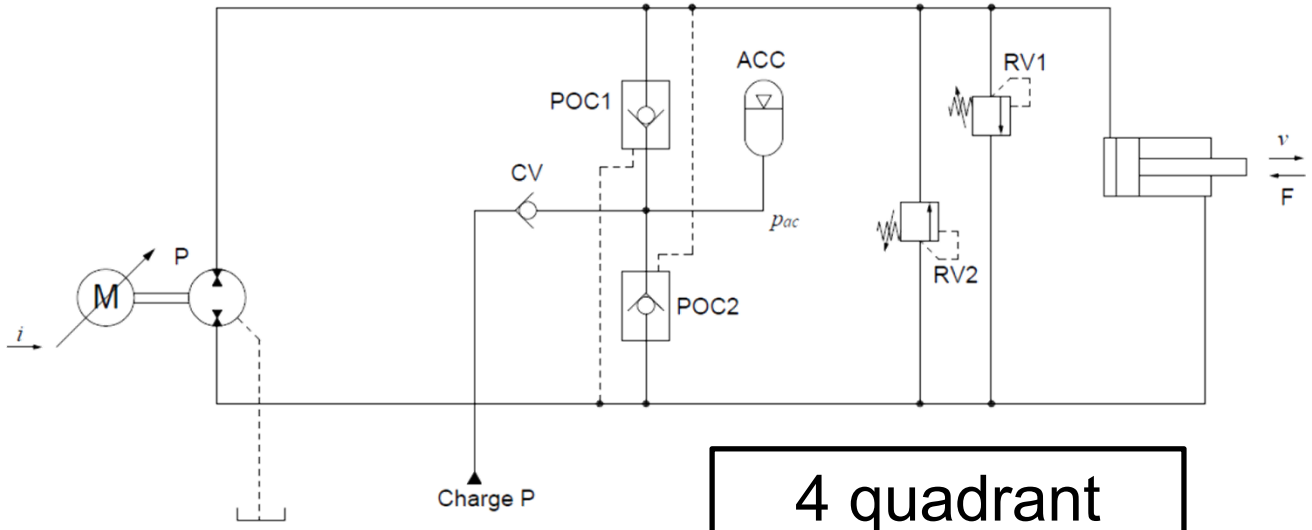
Parker Approach – two solutions

1) Electro Hydraulic Actuator (EHA)



- No metering losses
- No overproduction
- Energy recovery possible

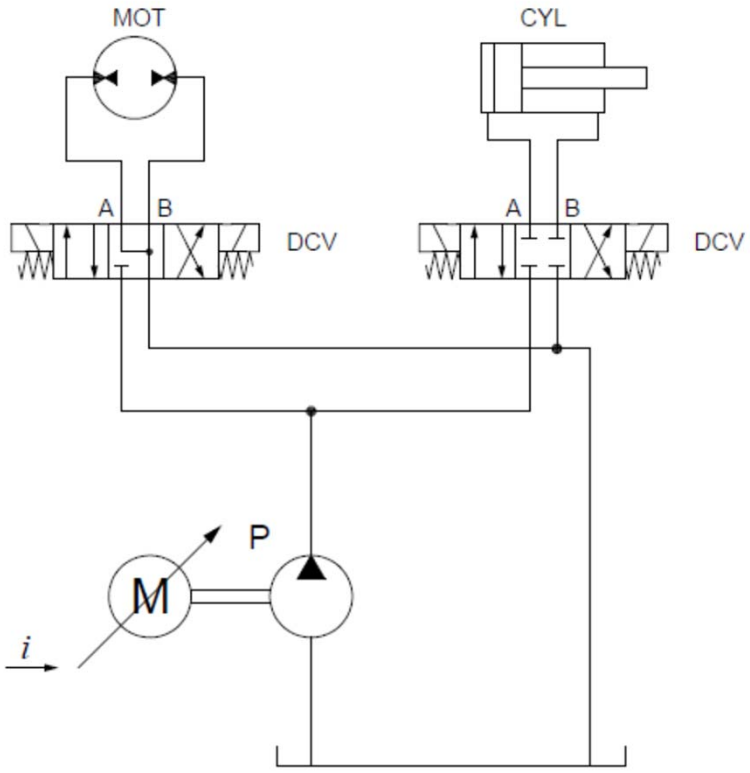
2 quadrant



4 quadrant

Parker Approach – two solutions

2) Electro Hydraulic Pump-Valve (EHP)



- Multiple valve technologies possible
- Less efficient than EHA
- No energy recovery
- No need to have 1 motor and 1 inverter per function

Example: skid steer loader

FCT	Currently	Observations
Drive	Tandem hydrostat	
Aux	Open circuit pumps Main control Valve	High demand function No energy recovery
Lift		Recovery potential Interference with bucket
Bucket		Interference with boom No energy recovery

Example: skid steer loader

FCT	Currently	Electric version
Drive	Tandem hydrostat	E. Motor with planetary
Aux	Open circuit pumps Main control Valve	EHP
Lift		EHA
Bucket		EHP

Electrification is not only power

Additional challenges:

1) Cooling: air, hyd. oil, water glycol

Different cooling types have pros and cons

2) Pilot generation

3) Other aux functions (AC, ….)

Conclusion

- Systems Engineering
  - Discipline focused on circuit design and controls
- Example of traditional approach
  - Simulation and baseline testing support
- New trends in electrification
  - Require cross-technology approach
  - New methods for system design

- Secular and recent trends in favor of Syst. Engr.