USE OF KULI FOR ELECTRIC VEHICLES

KULI user meeting

M. Bergmans, 23 May 2019

ALTRAN

CONTENT

01

INTRODUCTION
ALTRAN NETHERLANDS

Altran is the undisputed global leader in Engineering and R&D services (ER&D)

45,000
EMPLOYEES

€ 2.9 bn
2017 REVENUES*

30+
COUNTRIES

ALTRAN

** Based on combined LTM Jun-17 revenue pro-forma of €2.9 billion: for Altran pro-forma for full-year impact of acquisitions and for Aricent pro-forma for full-year impact of software deals*

AN INTERNATIONAL COVERAGE IN E-MOBILITY

3 EXPERTISE CENTERS & STRONG SATELLITES

- Expertise centers for Passengers Cars
- Expertise center for Commercial and Special vehicles
- Expertise centers satellites

A DEEP EXPERIENCE WITH AUTOMOTIVE PLAYERS

BMW, MAN, FIAT GROUP, BOSCH, BRUSA, Porsche, 2getthere, Panasonic, Renault, PSA GROUPE, LEAR CORPORATION, Volkswagen, Mercedes-Benz, Dräxlmaier, Continental

E MOBILITY EXPERTISE

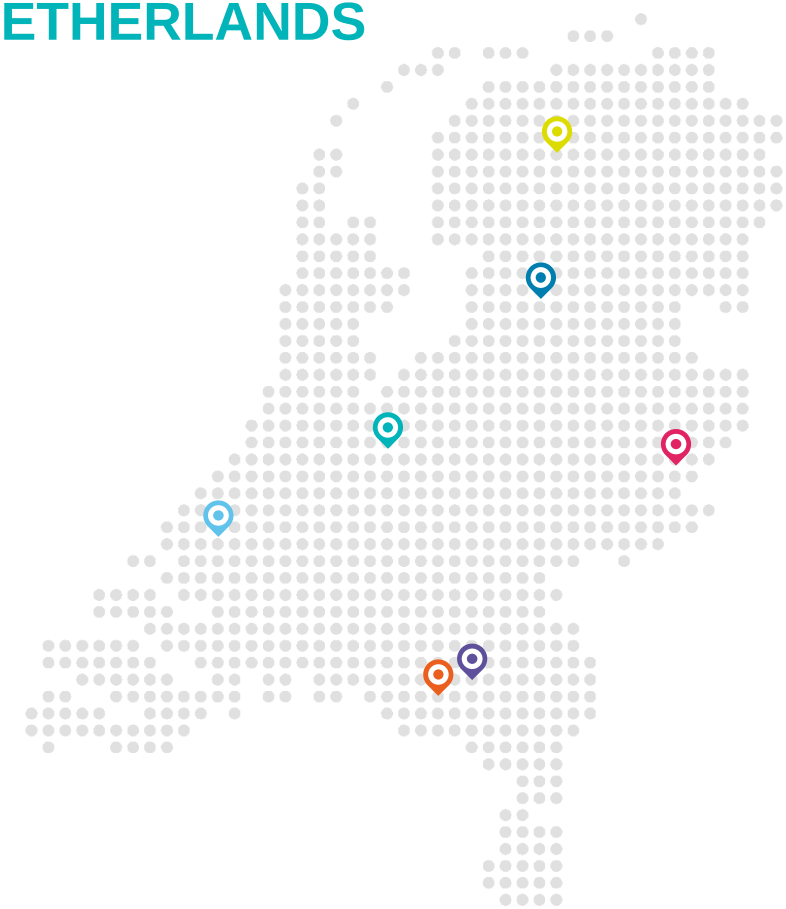
- Body & Chassis design
- SW & Controls
- Electronics
- System Engineering
- Functional Safety
- EMC Compliance
- Reliability
- Simulation
- Testing
- Homologation

KEY FACTS ALTRAN NETHERLANDS

€95 million Revenues (2017)

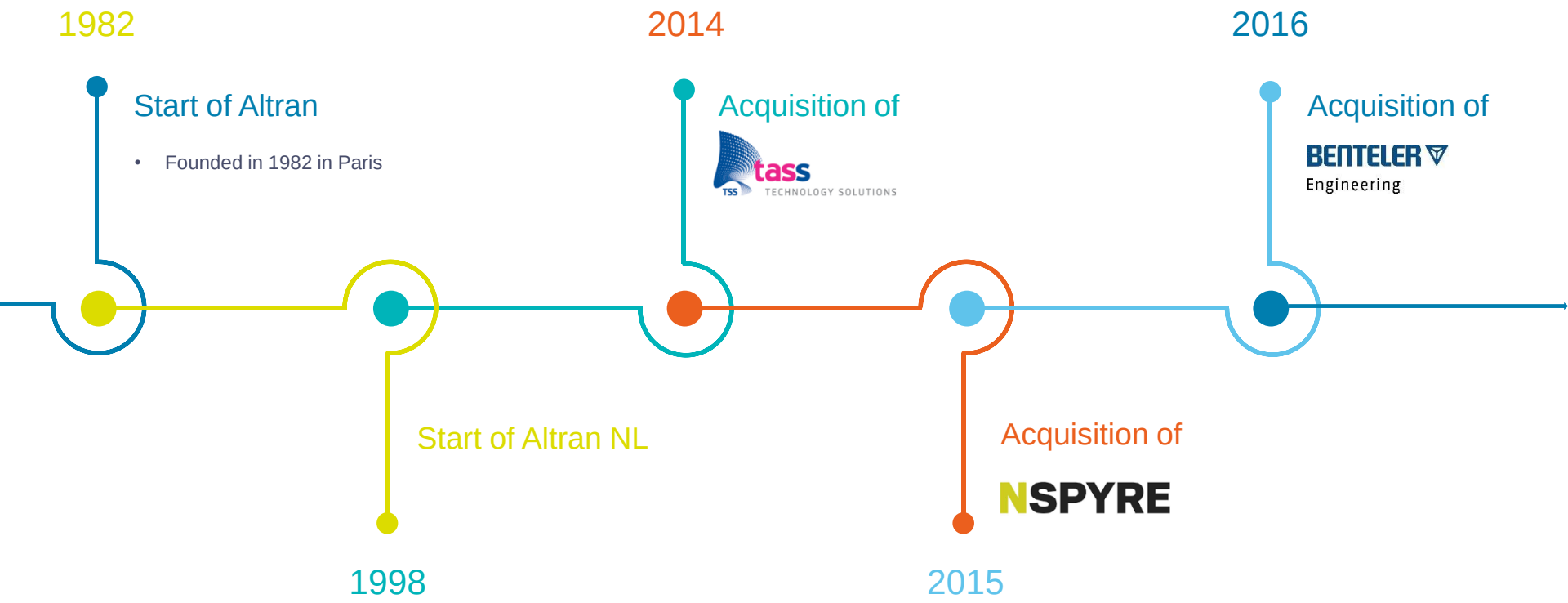
>900 employees

7 locations



- Utrecht
- Eindhoven
- Helmond
- Hengelo
- Leek
- The Hague
- Zwolle

HISTORY ALTRAN NETHERLANDS



ALTRAN STRENGTHS AROUND E-MOBILIT

1. Our expertise

- A strong track record for e-commercial and e-passenger cars
- Good customers references (MAN, BMW, Renault, Fendt, Porsche, APTS, 2getthere)
- R&D program to innovate and anticipate the market needs (Columbia- EMOC)
- Co-innovation program (2getthere)
- Several technologies (BEV-HEV-PHEV)
- Compliance with standards like ISO-26262

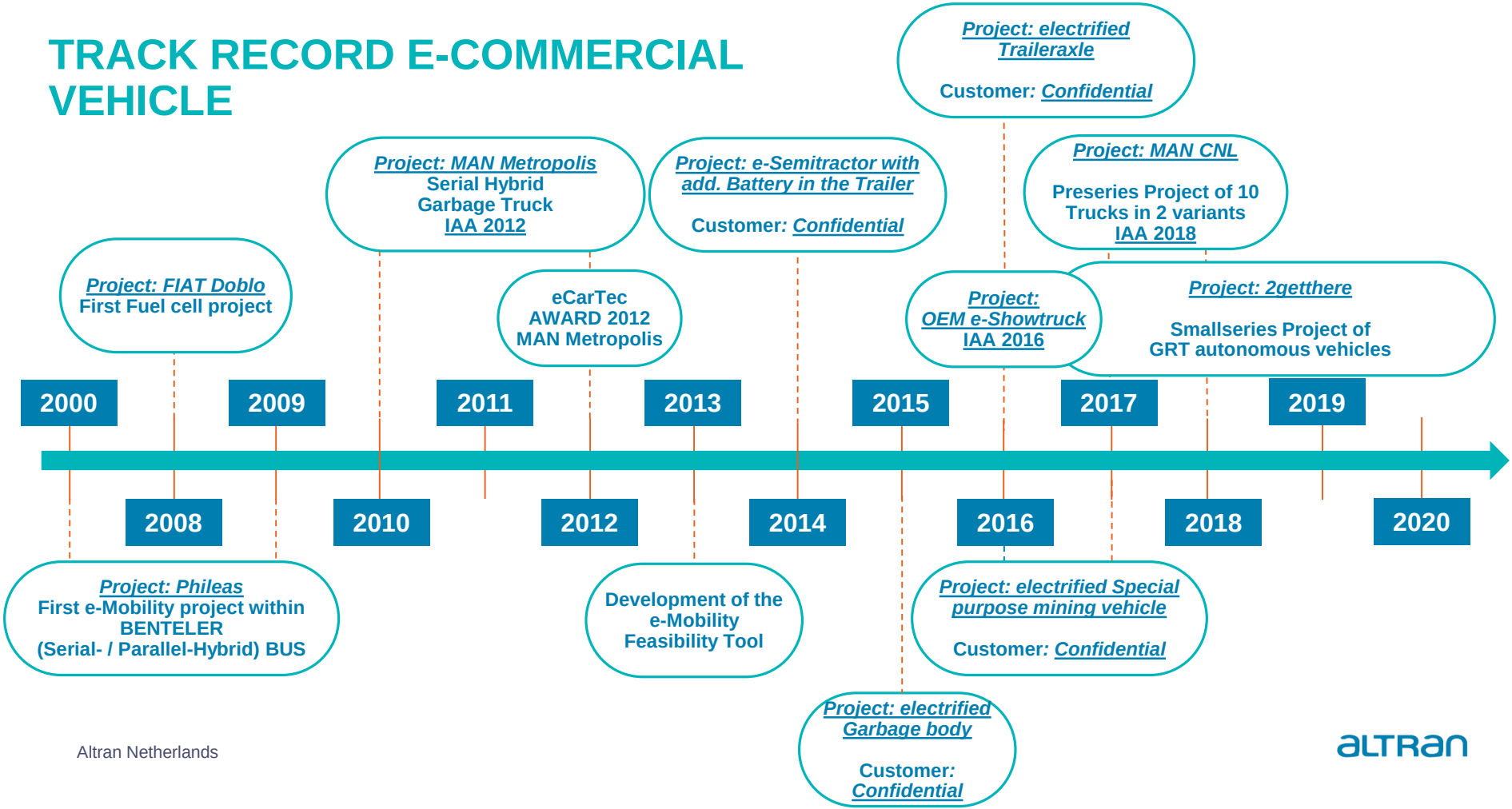
2. Our network

- International Experts and specialists with technical skills recognized, providing State-of-the-art technical solutions
- Project Management skills approved and shared with the OEMs
- Partners with skills recognized by the OEMs

3. One stop shop approach

- Deliver a complete project from design to prototyping testing and homologation

TRACK RECORD E-COMMERCIAL VEHICLE



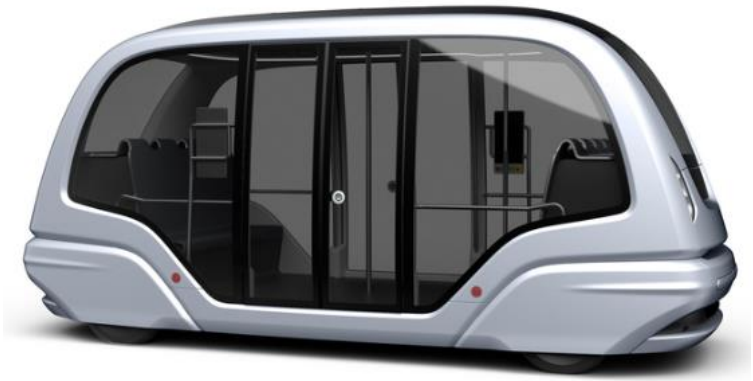
02

VEHICLE INTRODUCTION

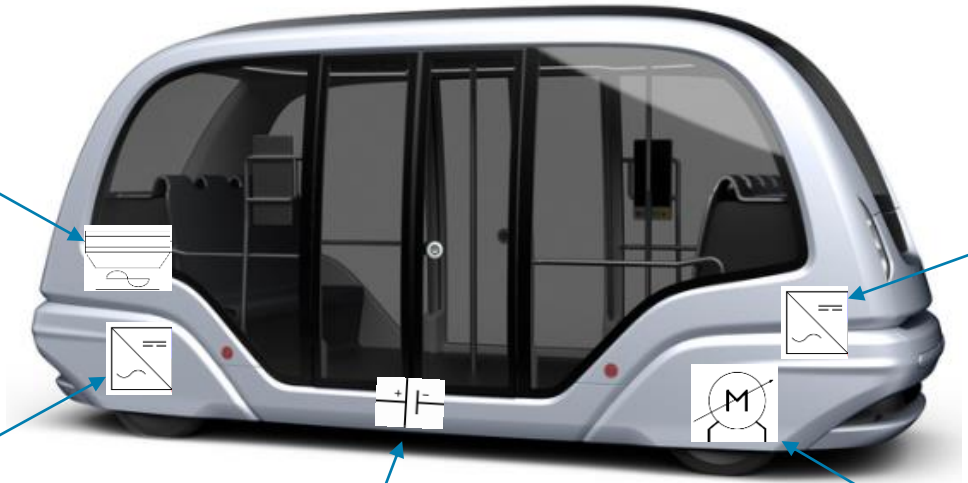
VEHICLE INTRODUCTION

- Electric people mover
- 24 passenger capacity
- 40 km/h
- Hot (desert) climates

- Full vehicle engineering by Altran:
  - Chassis
  - Body
  - Driveline
  - Electrics
  - Cooling
  - Proto build

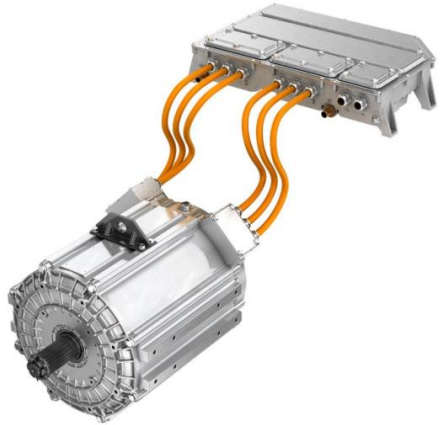


COOLED COMPONENTS



DIFFERENCES BETWEEN COMBUSTION ENGINE COOLING AND ELECTRIC VEHICLE COOLING

- Lot of heat generation
- Efficient at high temperatures
- 1 main component to be cooled



- Small heat generation
- Efficient at low temperatures
- Multiple components to be cooled

COOLED COMPONENTS

Component	Required flow	Maximum input pressure	Coolant temp. range
HV battery pack	17 l/min	1 bar	15 – 35 ^{0}C
Traction motor	6.7 l/min	2 bar	-40 – 85 ^{0}C
Traction inverter	6.7 l/min	2 bar	-40 – 85 ^{0}C
Multi-inverter	15 l/min	2 bar	-40 – 65 ^{0}C
Heat exchanger	5 l/min	2 bar	0 – 45 ^{0}C

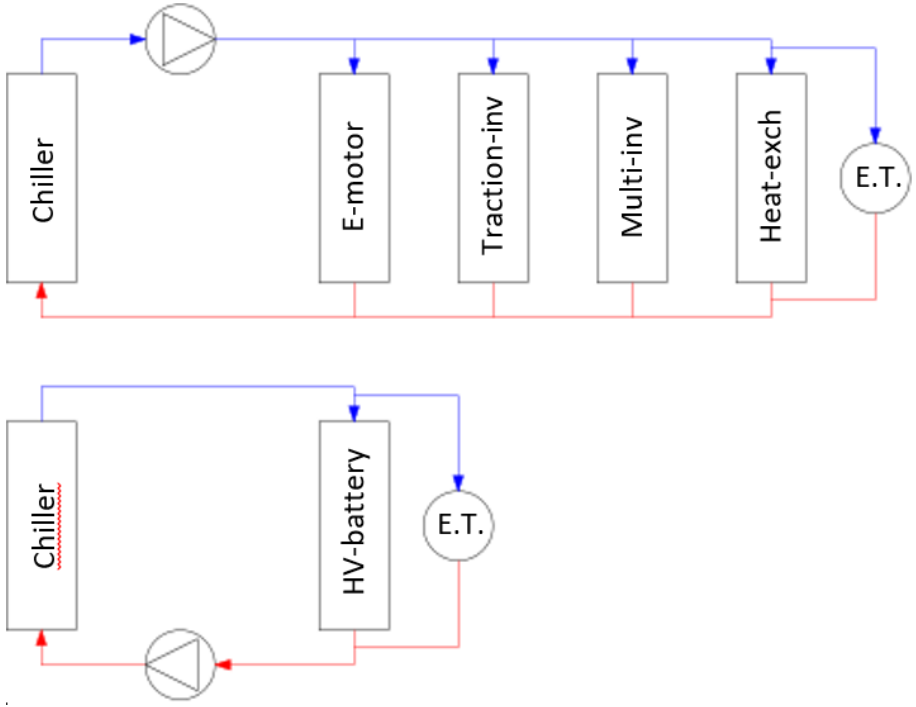
- Radiator cooling not sufficient, chiller cooling needed
- 2 separate cooling circuits
- Passenger cooling

COOLING SCHEMATIC

Components placed in parallel

Challenges:

- Pump selection (high flow vs. small back pressure)
- Right flow deviation over components
- Low maximum input pressure components



03

INTEGRATION COOLING SYSTEM IN KULI

ALTRAN

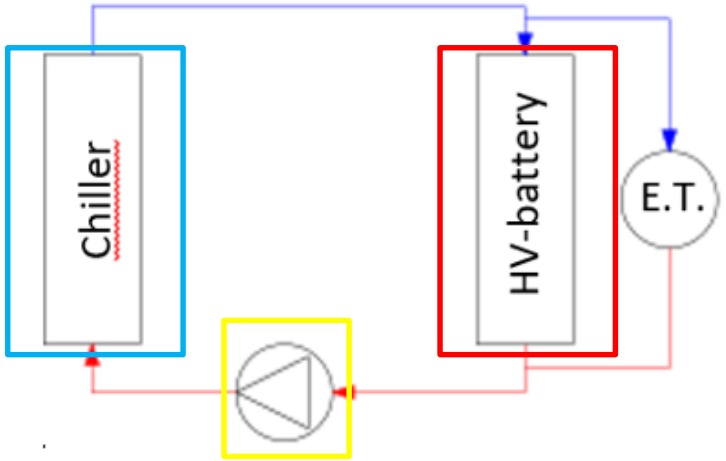
INTEGRATION

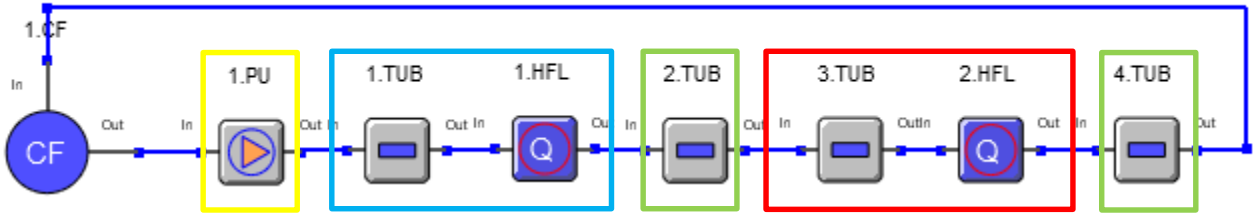
- Current model:
  - Steady state model
  - Main focus on flow and pressure losses
  - Drive cycle and powertrain calculations performed by Altran PT simulator
  - No vehicle speed dependency (constant vehicle speed), so constant heat generation
  - Constant cooling power from chillers, on/off switching strategy

- Future improvements:
  - Heat generation from Altran PT simulator imported into KULI
  - Chiller switch-on procedure based on coolant temperature

BATTERY COOLING

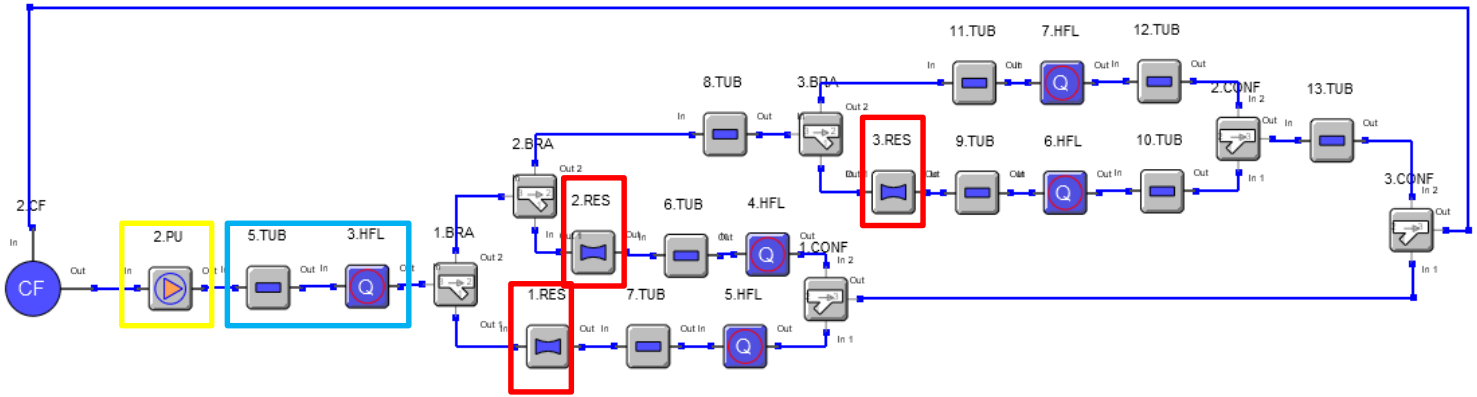
- Pressure loss and heat generation battery pack
- Pressure loss and cooling power chiller
- Pressure loss in tubing
- Coolant pump





COMPONENT COOLING COOLING

- Pressure loss and heat by individual components
- Pressure loss and cooling power chiller
- Pressure loss in tubing
- Coolant pump
- Restrictions to divide flow



RESULTS

Component	Required flow	KULI flow
HV battery pack	17 l/min	23.2 l/min
Traction motor	6.7 l/min	6.9 l/min
Traction inverter	6.7 l/min	7.2 l/min
Multi-inverter	15 l/min	14.5 l/min
Heat exchanger	5 l/min	6.0 l/min

- No measurements were performed to validate the KULI results for this vehicle
- Measurement results were used to verify KULI results at other projects

04

SUMMARY

SUMMARY

- Basics of KULI used for simulation of flows and pressure drops in our cooling systems
- KULI used for pump selection
- KULI used for flow deviation over components
- Altran’s powertrain simulator used for drive cycle and powertrain calculations

- Future implementations in Altran’s KULI models:
  - Heat generation from Altran PT simulator imported into KULI
  - Chiller switch-on procedure based on coolant temperature