

# Electric Bus

## Development and Integration of the Electric Drivetrain

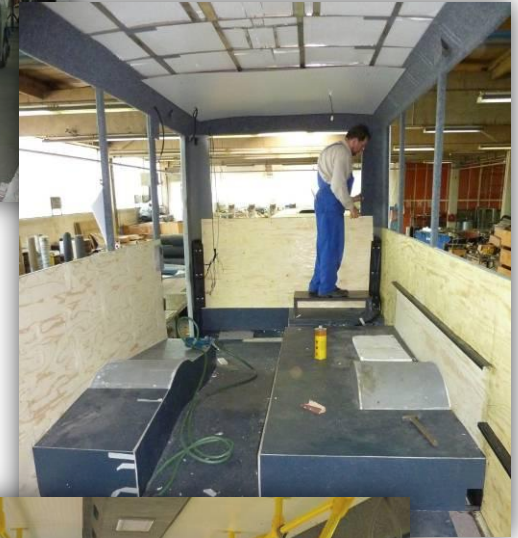
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# Outline

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- Electric Machine and Transmission
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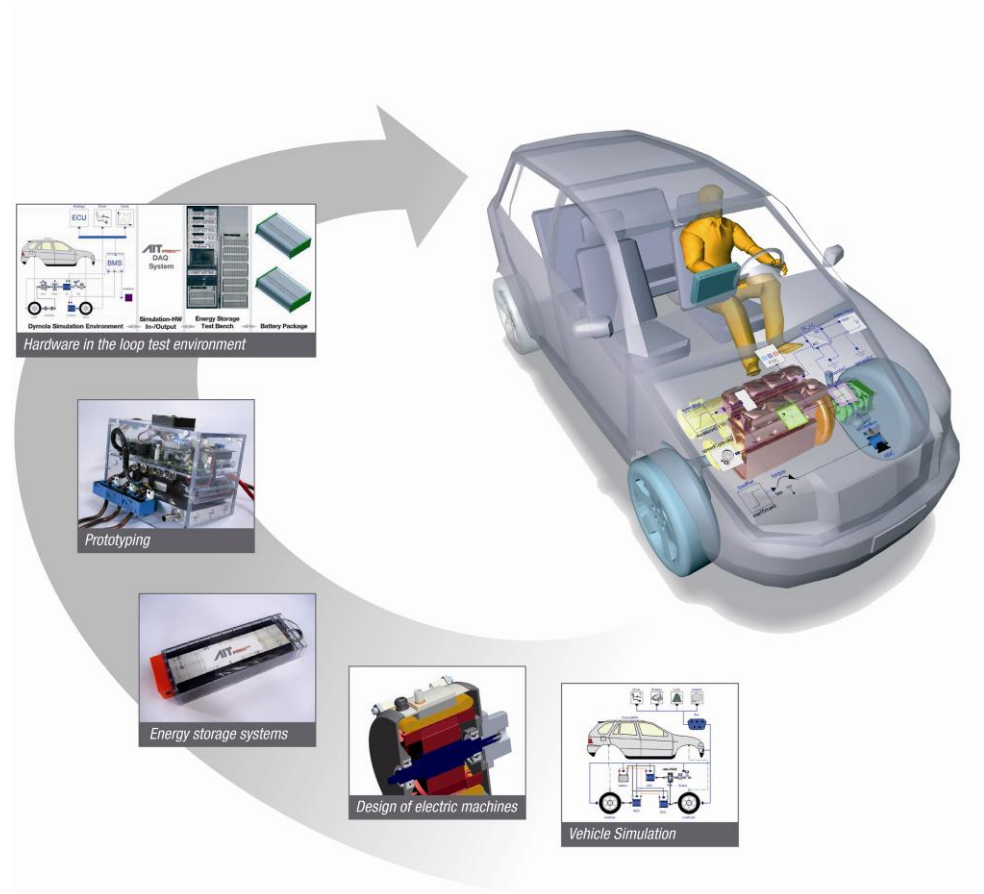
# Electric Bus

- public traffic in small cities
- 7.2 t curb weight
- 8 m length
- based on Iveco Daily
- max. 35 persons
- 250 km/day



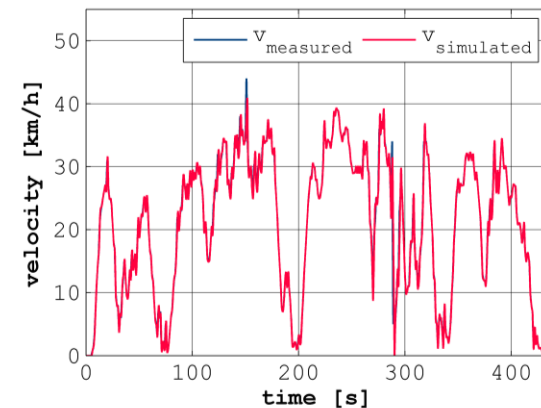
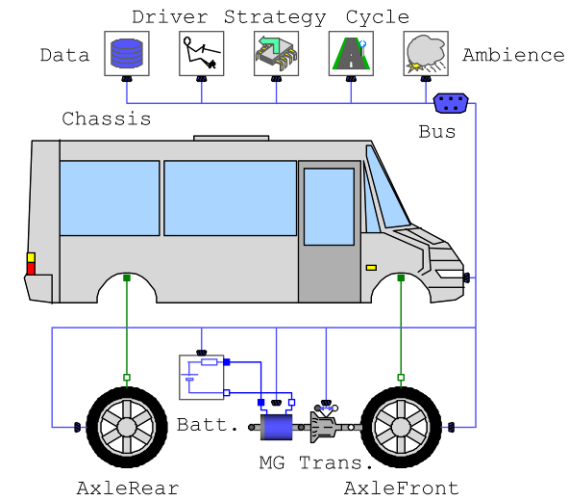
# AIT Approach

- Modeling
- Entire vehicle simulation
  - electrical
  - mechanical
  - thermal
- Optimization
- Dimensioning
- Design
- Prototyping
- Hardware in the Loop (HIL)
- Integration

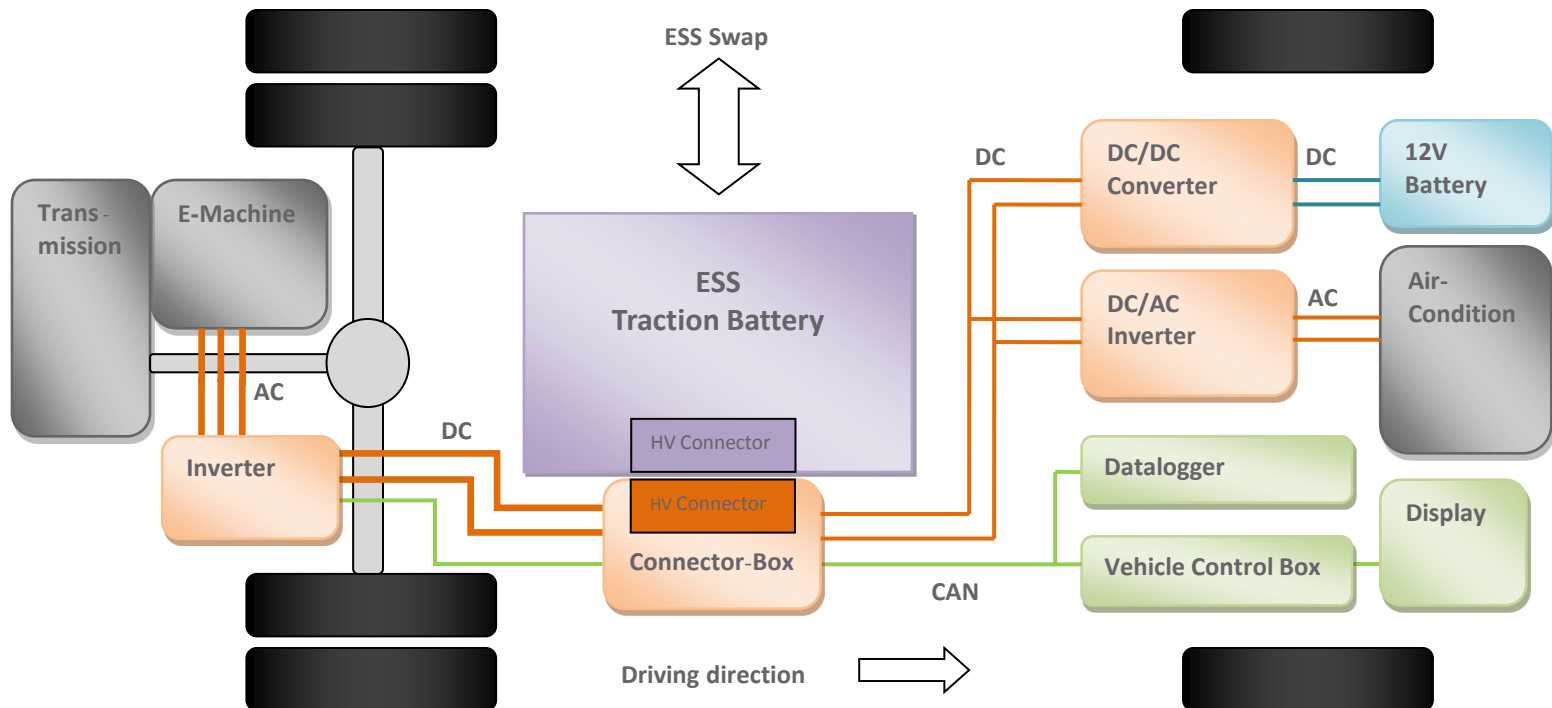


# Vehicle Simulation

- Input:
  - parameters from vehicle measurement
  - real life cycles
  - different types of machines, transmissions, batteries
  
- Output
  - power requirement vs. performance
  - battery size vs. range, weight
  - impact of auxiliaries
  - operation strategy



# System Overview

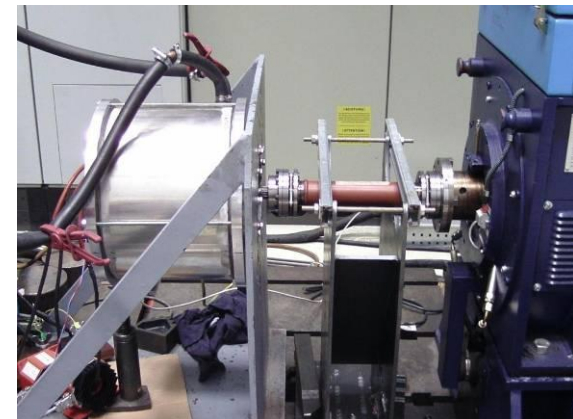


## Technical Data

- Speed 1. Gear                      50 km/h
- Speed 2. Gear                      80 km/h
- Automatic transmission actuation
- Rear wheel drive
  
- Range (one battery)              > 65 km
- Battery swap time                < 1 min
- Charge time                        90 min
- Battery lifetime                   > 1000 Cycles

# Electric Machine

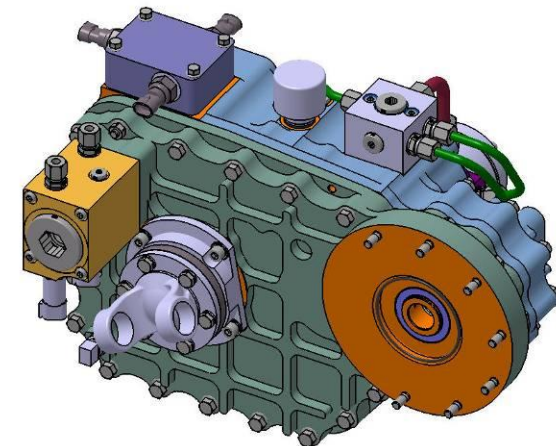
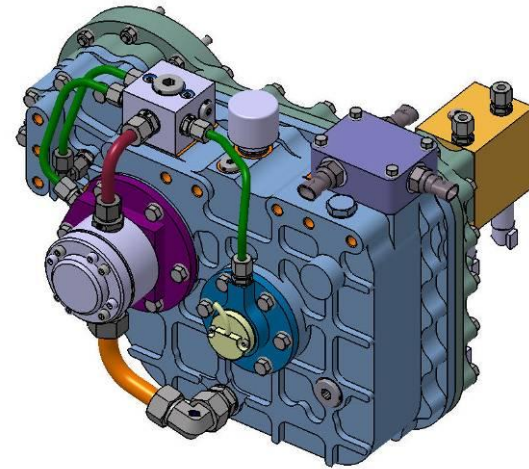
- asynchronous induction machine
- water-cooled
- high torque at small diameter
  
- 70 kW                      nom.
- 165 Nm                    nom.
- 4000 U/min            nom.
- 6400 U/min            max.
  
- mass 120 kg





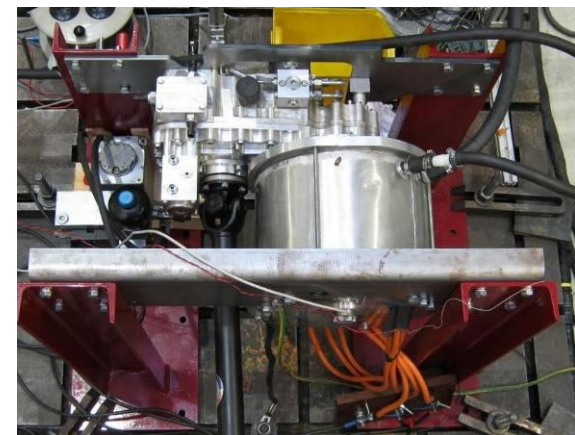
## 2 Speed Transmission

- 2-stage gear reduction
- 2 gears
  - 1st gear reduction: 3.71
  - 2nd gear reduction: 2.35
- shifting time < 1 s
- mass 41 kg
- clutchless shifting
- electro-hydraulic actuation
- electronic synchronization



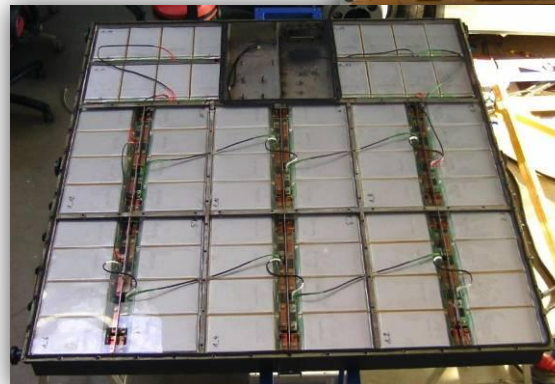
# Powertrain Validation (E-Machine, Transmission, Inverter)

- proof of concept
- different controller parameters
- validation of
  - electrical-
  - mechanical-
  - thermal characteristics
- proof of safety and protection methods



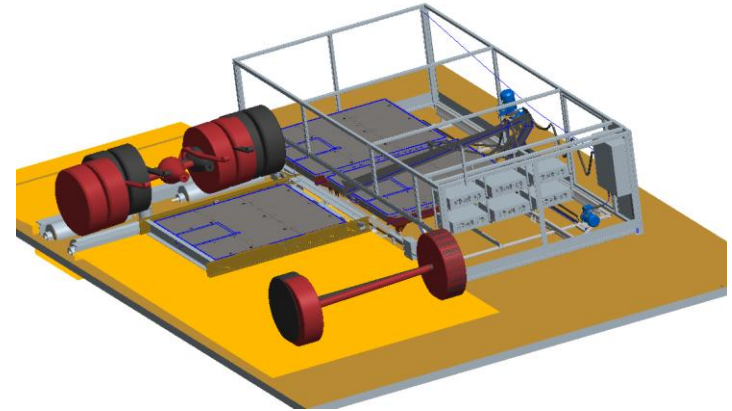
# Energy Storage System (ESS)

- removable underfloor battery
- crash test simulation
- 700 VDC nominal voltage
- 80 Ah capacity
- 50 kWh capacity
- 16 single modules
- 43.8 VDC nominal voltage
- internal BMS
- mass < 450 kg



# Battery Swap System

- fully automatic
- communication with vehicle
- handles two traction batteries
  - one in the vehicle
  - one is charged
- self connecting power connector
- changeover time < 1min

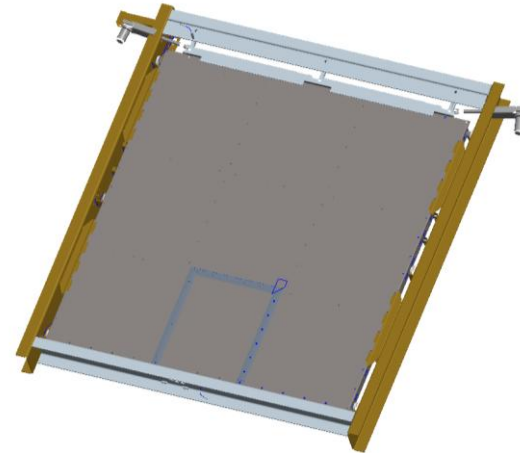






# Integration

- Underfloor battery box
  - low floor concept
  - battery height only 15 cm
  - solid frame around battery box
  
- Motor, gearbox, inverter
  - behind rear axle
  - underfloor
  
- Air Cond., DC/AC, DC/DC
  - in the front end
  - combustion engine removed



# Conclusion and Outlook

- accelerated development process
  - determination of optimum vehicle concept
  - dimensioning of vehicle components by multiphysical simulation
  
- unique electric bus concept
  - lowfloor
  - 2-gear
  - battery swap system
  
- start of operation
  - spring 2011
  - Perchtoldsdorf



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