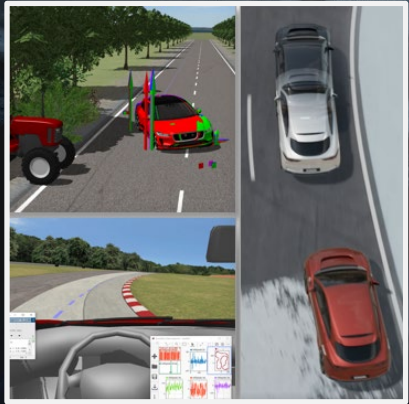
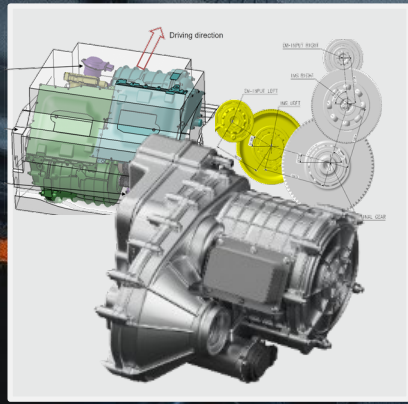


Product Engineering

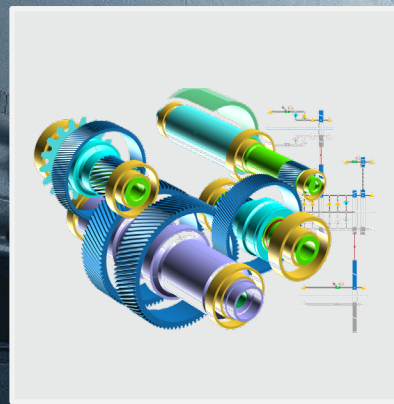
Mechanical System Engineering



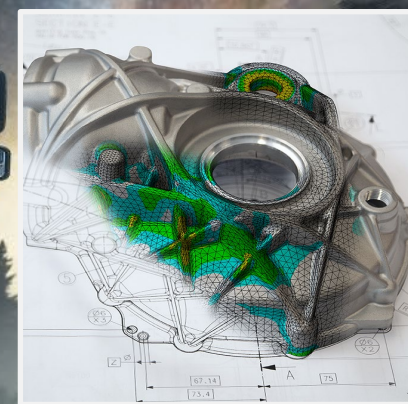
Mechanical System
Architecture (VMSA)



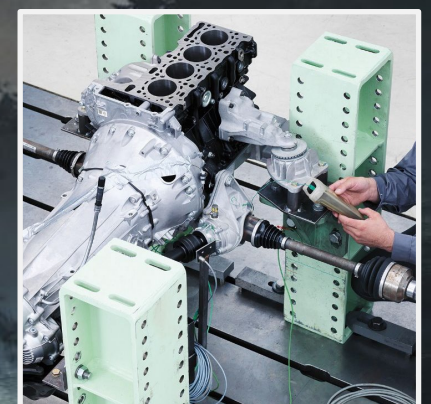
Mechanical System
Design (VMSD)



Virtual Verification
(VMSV)



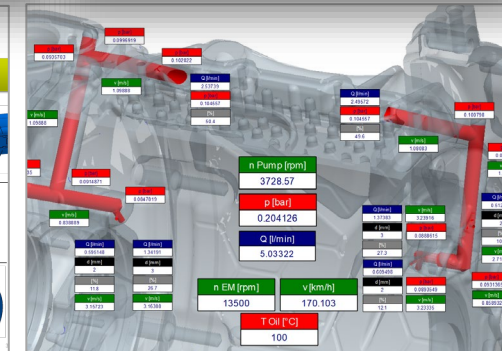
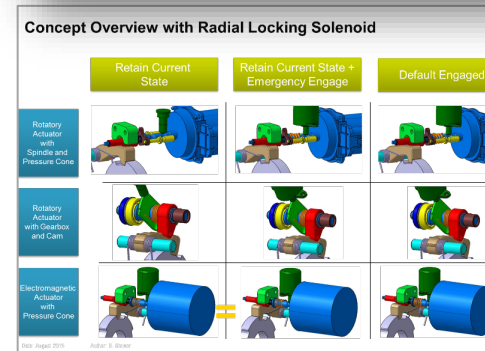
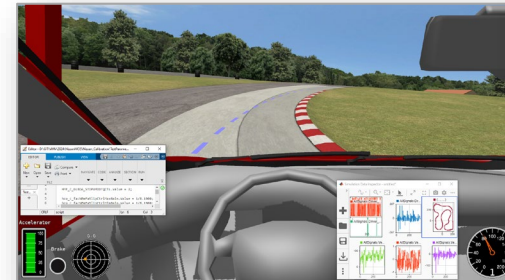
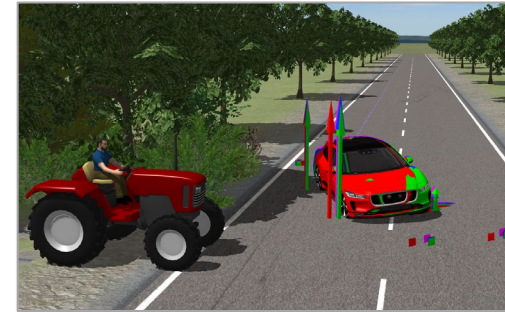
Mechanical
Component
Engineering (VMSC)



Mechanical System
Verification (VMST)

Mechanical System Architecture (VMSA)

- **System engineering (sub-system eGBX)**
 - Requirements engineering (eGBX SOW responsibility)
 - Link to system level requirements (upward) and component level (downward)
 - „Left side“ of the engineering V-Model acc. Automotive Spice
 - System architecture
 - Definition of system components (clutches, actuation systems,...)
- **System simulation**
 - Function simulation (park lock, shifting,...)
 - Lubrication networks
 - Load data & driving cycles
 - Vehicle dynamics



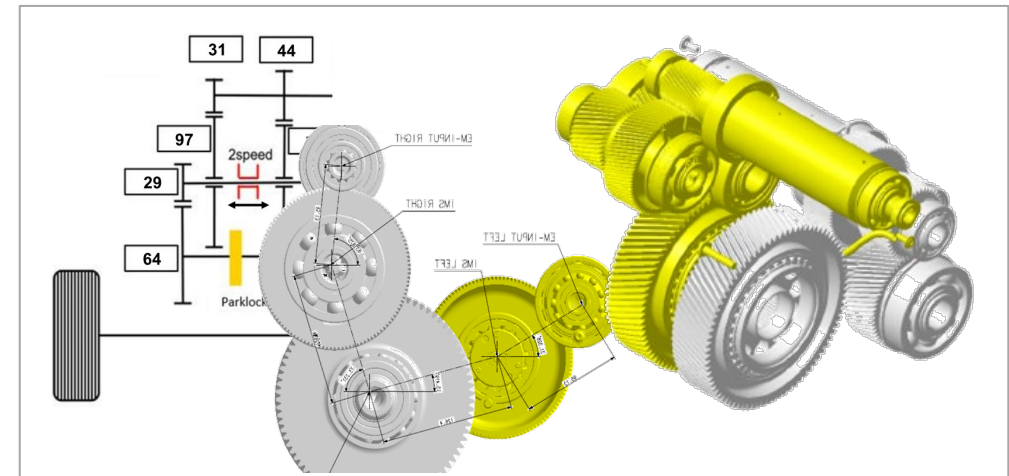
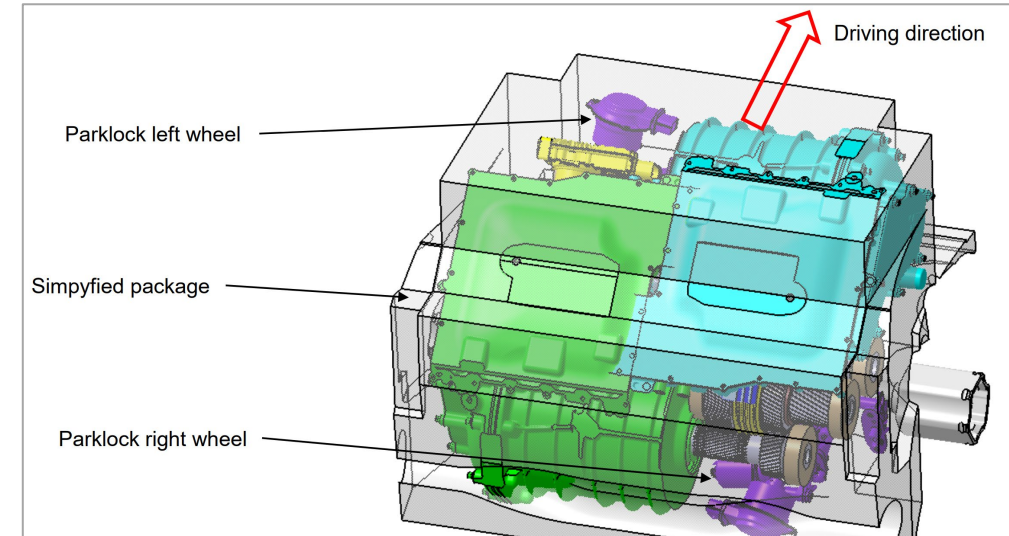
Mechanical System Design (VMSD)

- **Geometrical integration**

- Package studies for the customer applications under consideration of the mechanical customer requirements
- Interface coordination within the mechanical subsystems (eMotor, inverter, gearbox and add-on components) (EDU)
- Package & interface alignment with customer (OEM)

- **Mechanical system design (EDU)**

- First concept design studies (quotation) for the mechanical system
- Generate PLM-BOM for the quote concept and PLM-BOM coordination during product design phase
- Serviceability and assembly ability
- System (EDU) stack up analyses (tolerancing)
- Integration & coordination of system add-on components like
 - NVH covers
 - Mounting brackets
 - HV/LV-wiring
 - Cooling routing incl. connectors
 - Protection components
 - Labels
 - Customer provided parts (rubber mounts, side shafts, etc.)



Virtual Verification (VMSV)

- **Load data analysis**

- „Translation“ of customer load data for further tasks (gbx dimensioning and testing)

- Maximum/Misuse loads for gearbox
- Lifetime relevant load data

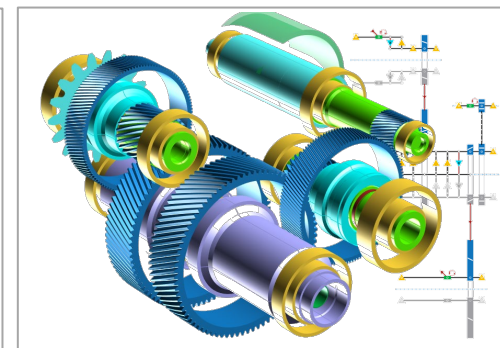
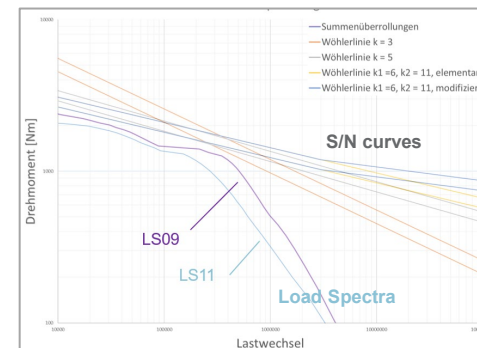
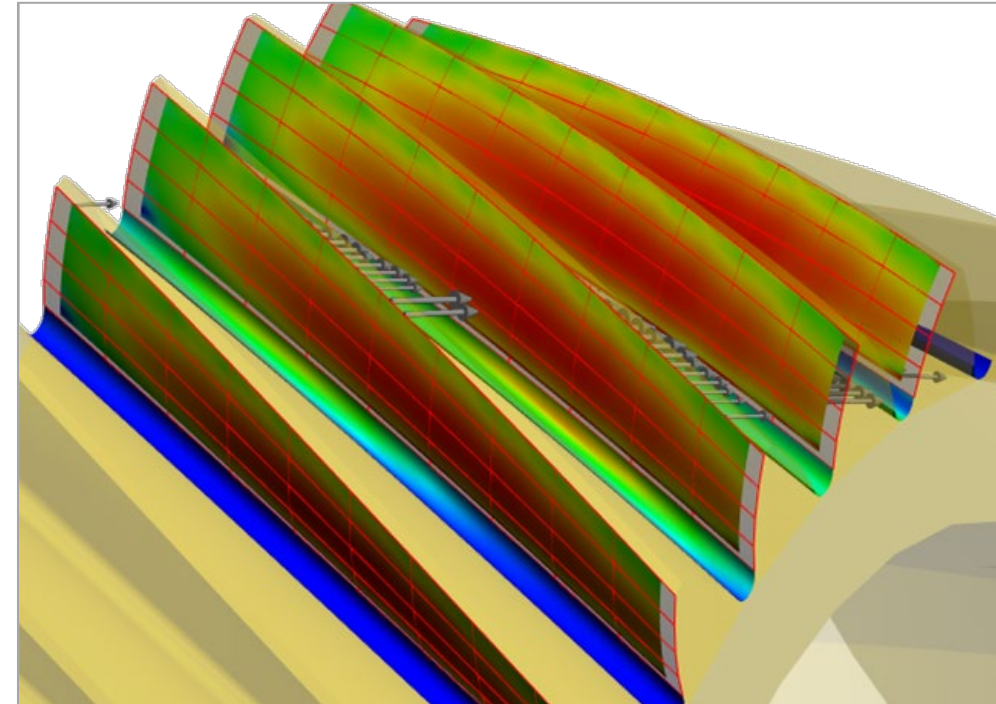
- **Analytical analysis**

- Gears, bearings, shafts, bolts

- Lifetime, static loads, efficiency, NVH
- Definition of macro & micro geometry of gears
- Alignments with supplier and manufacturing

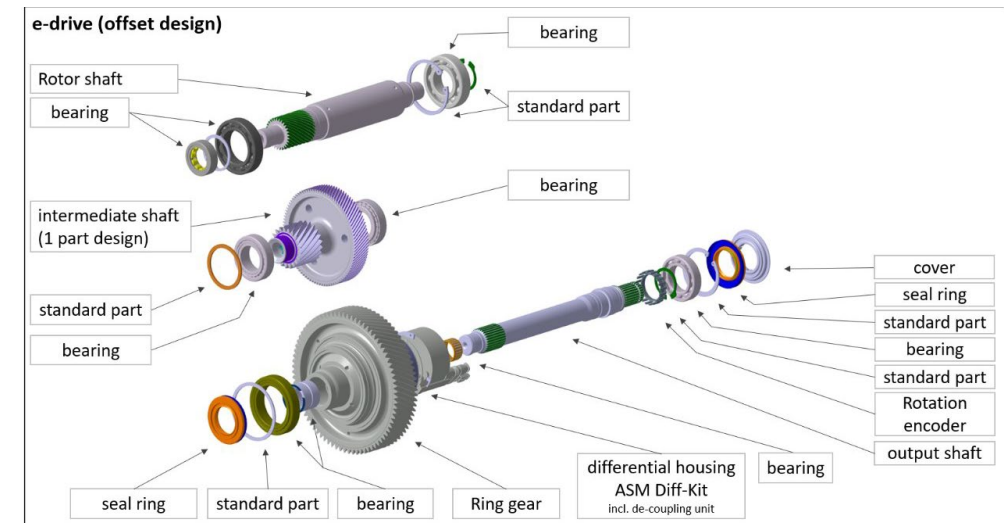
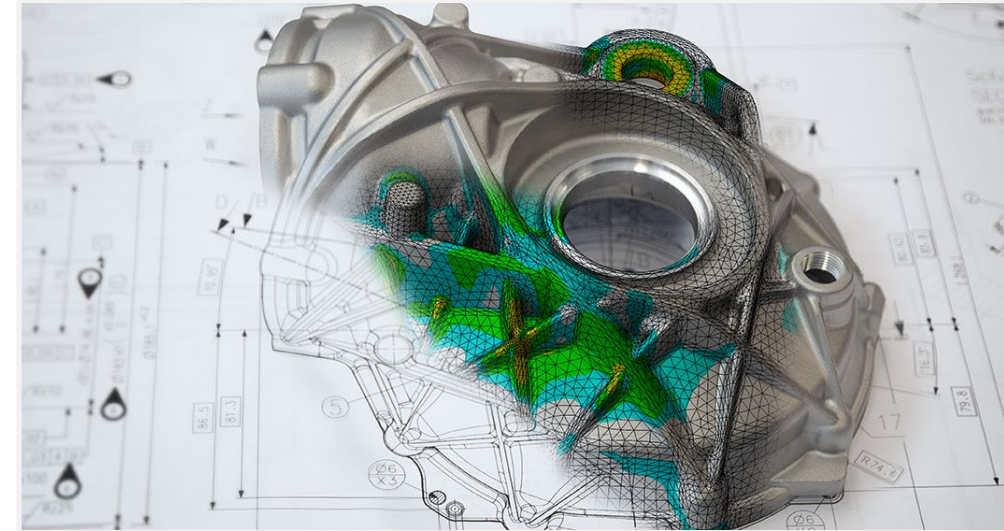
- **Efficiency simulation & optimization**

- **Coordination of FEA tasks** (to be performed in separate department out of engineering services)



Mechanical Component Engineering (VMSC)

- **Mechanical subsystem design gearbox**
 - Gearbox concept design, packaging & product design for customer applications
 - Integration of existing gearbox components & subsystems
 - Gearbox PLM-BOM responsibility
 - Gearbox assembly (3D models & 2D drawings)
 - Gearbox stack up (tolerancing)
 - Integration of gearbox relevant functions acc. PFG's & SOW
- **Design & development of gearbox components & subsystems**
 - Development & CAD design (3D, 2D & SORs) of gearbox housings, covers, seals, oil & cooling routing components
 - CAD design (3D, 2D) of gears & shafts
 - Application development & CAD design of gearbox components like
 - Shifting systems
 - Clutches & decoupling
 - Parklock
 - Hydraulics
 - Supplier alignment till SOP of components & subsystems
 - Alignment with AME (Manufacturing) & cost engineering (purchasing)



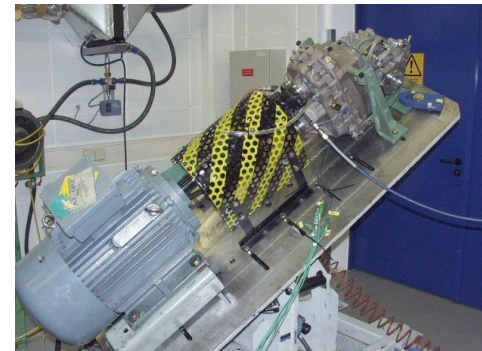
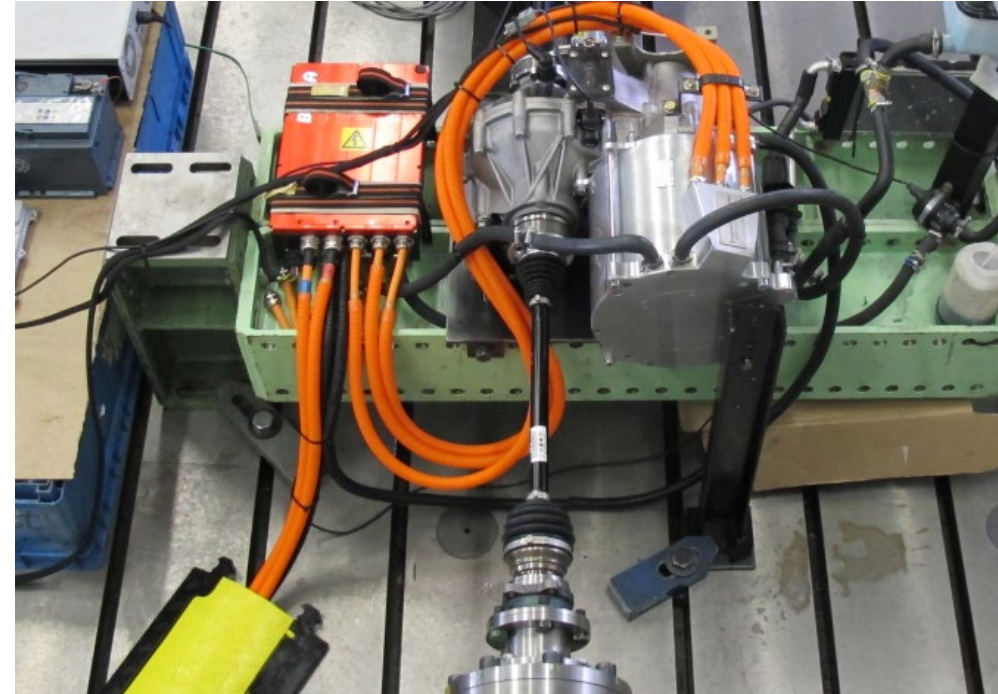


Mechanical System Verification (VMST)

- **GBx or eGBX sub-system test strategy**
 - Define master test plan -> definition of test levels
 - Balance between test levels
 - Tracking of KPI's
- **Design verification plan & report**
 - Identification/analysis of test requirements
 - Bundling of requirements to tests
 - Planning of tests
 - Report
- **Testing**
 - Definition of specimen (measured parts, special characteristics, sensors)
 - Check of test worthiness
 - Test cycle definition
 - Work instruction definition
 - Tear Down with VPTS, rating of test
- **Release recommendation**
 - Traceability
 - Documentation
 - Rating if results are adequate for release

Mechanical System Verification (VMST)

- Lubrication & ventilation testing
- Functional testing
 - Bearing adjustment
 - Contact pattern
 - Shifting of gears
 - Engagement of locks
 - Clutch characteristics
 - Temperature behavior loaded
 - Efficiency measurement
 - NVH measurements
- Durability Testing
 - System life test
 - Gears, bearings, differential
 - Seal rings
 - AWD clutch (high / low power)
 - Actuation system
 - Park lock
- Ultimate strength testing
 - Static ultimate strength testing
 - Dynamic ultimate strength testing
 - Chain jump test
- E-drive-system testing
 - Functional and durability testing of electric drives (motor, inverter)
 - Testing of hybrid systems, range extenders, ...



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