AVL Commercial Driveline and Tractor Engineering

Commercial On- and Off-Road Expertise from Concept to SOP

AVL

COMMERCIAL DRIVELINE & TRACTOR ENGINEERING

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PA3062E, Classification Public

AVL Commercial Driveline & Tractor Engineering

AVL is the world's largest independent company for the development, simulation and testing of powertrains (combustion engines, transmissions, electric drives, batteries, control software, hybrids) for all kind of vehicles and machines as well as for complete tractors.

AVL offers all services supporting the whole life cycle of the products leading to the following success stories:

- Development of the complete vehicle
- Global presence with local support
- Present in all industries and applications
- Leading edge technology & senior expertise
- Unique tools, methodologies & processes
- Various series production projects for commercial powertrains every year
- Numerous significant transmission development programs every year
- Several significant hybrid system development programs every year
- Vast amount of engine development projects for tier/stage III/IV.

Due to the unique and challenging requirements of the commercial vehicle market, AVL dedicated an entire competence center to commercial drivelines and tractor engineering.

The driving factor for this competence center within AVL's global network is the need to meet the highest requirements and customer expectations regarding functionality, performance, efficiency and technology. So AVL is able to satisfy the needs of vehicle manufacturers as well as their customers.

Key fields of competence:

- Commercial drivelines for trucks & construction machines
- Complete development of agricultural tractors.

Product / Market Strategy → Feasibility Study → Product Development → Testing / Validation → Homologation → SOP Support

AVL COMMERCIAL DRIVELINE & TRACTOR ENGINEERING SUPPORTS ALL INDUSTRIES

AVL APPROACH

AVL aims to be the industry's preferred partner throughout the entire life cycle of commercial vehicles – from strategy all the way to the production and operation. Unique synergies deriving from the interaction between AVL's competences in design, simulation, engineering and testing lead to the following main advantages for customers:

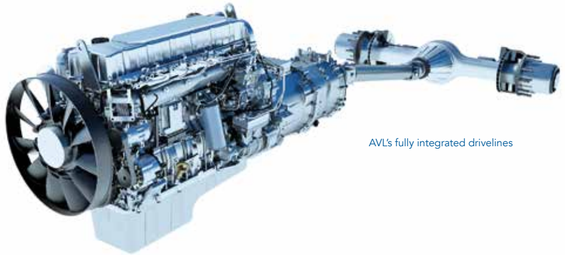
- High flexibility
- Creative solutions
- Fast problem solving
- Custom made solutions fulfilling market requirements.

AVL ENGINEERING EXPERT SERVICES

- Market studies and portfolio consulting
- Requirement engineering and product specification
- Benchmarking and technical/technological assessments
- Styling and ergonomic layout studies
- Feasibility & concept studies
- Front loading, target setting, Load Matrix
- Simulation of system and functions
- Transmission and driveline development
- Cabin and component development
- Software, functions and control systems development
- System integration
- Build of demonstrators and functional prototypes (mules)
- Noise Vibration Harshness (NVH) analysis and assessment
- Functional safety
- Electrification and hybridization
- Precision farming
- Testing, calibration and validation
- Reliability & risk engineering
- Technical services & homologation
- Supplier assessment and recommendation
- Plant and production engineering
- Training and process development/enhancement.

COMMERCIAL DRIVELINE – TRANSMISSIONS FOR ON- AND OFF-ROAD APPLICATIONS

Every year there are increased demands for both driveline efficiency and driver comfort. The main requirements are competitive product costs and high reliability for conventional and new driveline concepts such as hybrid drivelines. Transmissions have become a fully integrated component in a commercial vehicle's driveline. Due to the vast amount of different transmission concepts on the markets it is necessary to consider the whole driveline as one system. AVL's extensive engineering experience and the use of efficient development, simulation and testing tools are the basis for AVL's innovative and efficient solutions.



AVL's fully integrated drivelines

AVL DCT concept for Trucks / Bus applications

Axle optimization

INNOVATIVE TRANSMISSION TECHNOLOGIES

- Development of most efficient MT, AMT, AT, CVT and DCT transmissions for all applications.
- Development of power shift transmissions.
- Advanced shift strategies and controls.
- Development of complete transmissions and axles or components.
- Simulation and evaluation of new technologies or new solutions.
- Automation of existing manual transmissions including software and control systems.
- Testing of transmissions and axles.
- Design assessments and consultancy.

AVL STRENGTHS

- Long experience in transmission development especially for commercial vehicles.
- Expertise to develop and optimize the transmission as a vital part of it.
- Key competences in hybridization, hydraulics, mechanics and electronics to secure the optimum output for every single customer project.
- New technologies and development methodologies are consequently generated by AVL's internal R&D projects.

TRACTOR ENGINEERING

The rapid growth of the global population is leading to increased productivity and quality demands. A higher degree of mechanization and system optimization is needed to meet the new challenges.

AVL Simulation Soft Soil Tier Interaction

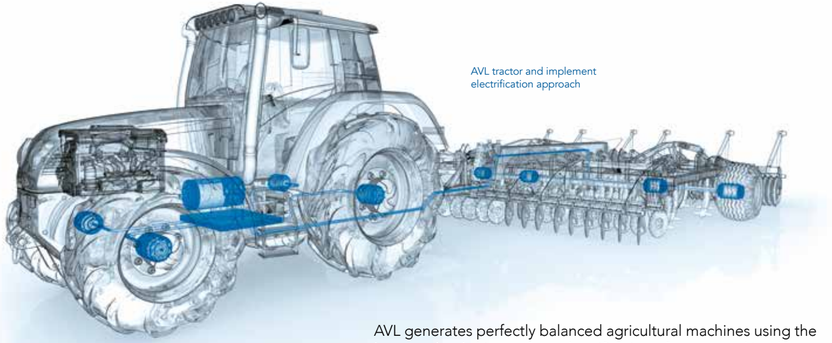
TARGETS OF TRACTOR OEMS:

- Increased working precision due to more productivity, cost of ownership reduction and environmental restrictions.
- Higher efficiency and improved ground coverage by optimized power distribution in terms of tractive force and working speeds.
- Favorable dispersed power to improve driving force and decrease soil compaction.

AVL SERVICES

AVL has rich expertise in agricultural and tractor engineering supported by model based real time simulation of agricultural machinery and implement in field. This, in combination with a high level of innovation enables AVL to generate optimized solutions meeting current and future market requirements. Together with advanced measurement techniques and system know-how, AVL

- offers support throughout the whole life cycle of the tractor
- supports the customer from market /product study till the start of series production and after sales support.



AVL tractor and implement electrification approach

AVL generates perfectly balanced agricultural machines using the latest technologies such as electrification of tractor and implement. Electrification and hybridization enable optimized performance and efficiency levels due to the early evaluation of the components interactions through simulation.

Driveline agricultural tractor

AVL DCT concept for tractor application

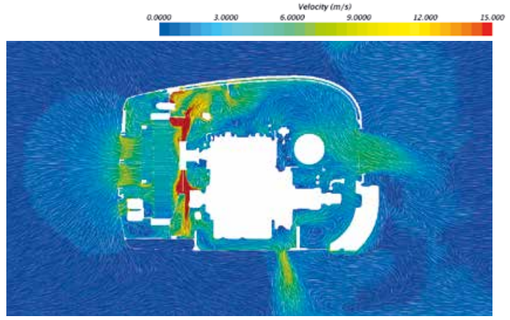
AVL STRENGTHS

- Dedicated team of high level tractor experts
- Advanced technology solutions
- Clearly defined development time and costs
- A competent project partner
- Qualified capacity on demand
- Use of most modern development tools and methods
- Global presence
- Solutions are based on the wide experience available
- Absolute confidentiality.

CONSTRUCTION MACHINERY ENGINEERING

MARKET DEMANDS

- Increase of world population leads to a higher need for building and optimization of living environment.
- Trend towards urbanization, increased level of living standards as well as comfort and future safety regulations at working places.
- High demand on new innovations due to increased need of productiveness of construction vehicles by improving efficiency, life time and safety for users.



CFD – Under bonnet air-flow simulation

AVL STRENGTHS

- Advanced construction machinery solutions that reduce development risk and duration.
- Use of most modern development tools such as simulation and methods to provide future solutions.
- Present in markets across the world.
- Absolute confidentiality.

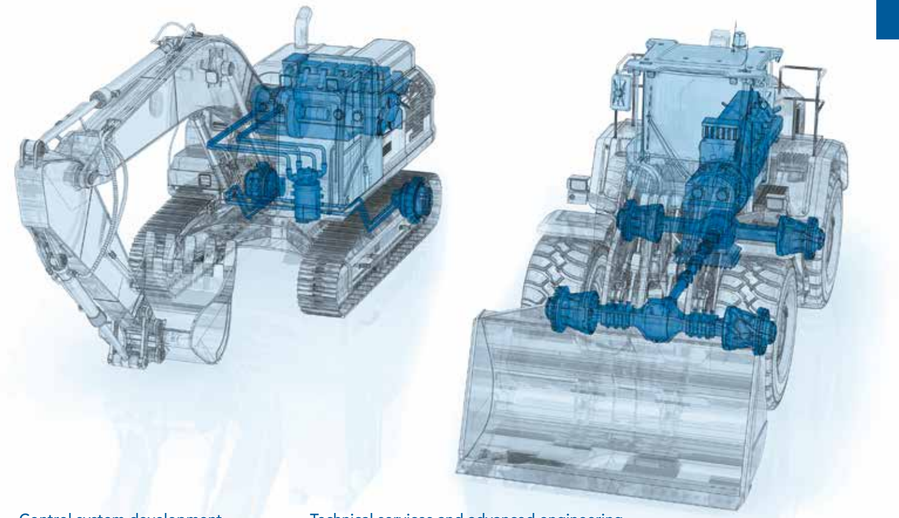
AVL SERVICES

Development and optimization of powertrains and their components:

- Drivelines (transmissions and transfer gearboxes)
- Engines
- Heavy duty axles
- Hydrostatic transmissions
- Hybridization, electrification
- Reliability & risk engineering.

Cabin construction including

- Ergonomic layout studies
- Simulation of the concept (NVH analysis).



Control system development

- Hardware
- Software

Assembling of prototype and demonstrator

- Testing, calibration, validation
- Functional safety

Technical services and advanced engineering

- Benchmarking technical/technological assessments, feasibility and concept studies.
- Market analysis, portfolio consulting and product specification, creation and development of future machinery and powertrain concepts.
- Process enhancement and optimization.
- Plant and production engineering.

AVL SERVICES – FROM CONCEPT TO SOP

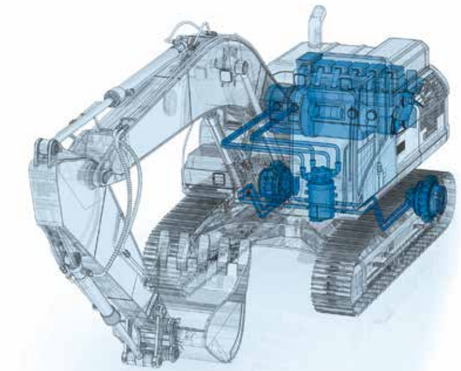
Product Portfolio Consulting
- Requirement definition based on detailed market analysis and know-how.
- Definition of future product portfolios and consequent portfolio modifications and extensions.

Benchmarking
- For the individual components as well as the full powertrain up to the whole vehicle.
- From design to product cost, performance and driveabiltiy.

Requirement Engineering
- Transfer of market requirements into complete vehicle systems.
- Definition of components and (sub-) system requirements & targets.
- System specification of system functionality no matter if hardware or software.

System Simulation
- Detailed investigations of component & entire vehicle system performance.
- Vehicle system optimization by parameter, trade-off and sensitivity analysis.

Concept Design, Detailed Design & Development
- Design and development of the whole vehicle including all components (transmission, powertrain till the whole driveline).
- Supported by unique simulation methodologies (CAE – front loading).
- Performance testing and optimization through testing on rig, test bed and in the field.



Plant & Production Engineering
- Vehicle, component & system optimization with respect to mass production.
- Product cost analysis & design to cost.
- Support for localization of products in all markets.
- Planning of required manufacturing facilities and infrastructure.

Software, Functions & Control Systems Development
- Development of software suitable for mass production – for all vehicles.
- Flexible development process tailored from prototyping to serial production projects to ensure best quality results.
- Algorithm development in close cooperation with in-house component and system experts.
- High modularity for easy integration into your system.

System Integration
- Mechanical, thermal, electrical and functional integration.
- Prototype procurement and assembly.
- Vehicle, component & system testing on rig, on test bed, in field as well as on MIL, SIL and on HIL environment.

Functional Safety
- Safety assessment – identification of risks & hazards
- Safety concept specification & development
- Safety testing & verification and validation.

System Calibration
- Calibration of engines, transmissions, electric & hybrid systems
- System calibration considering sub-system interactions
- Vehicle / powertrain driveabilty calibrations
- Most efficient calibration process.

Reliability Engineering & System Validation
- Reliability engineering & risk management
- Systematic design & optimization of the validation plan
- Quantification of validation risk
- Functional & durability development of component as well as on vehicle system level.

Powertrain Certification & Homologation
- Certification consulting incl. negotiation support with authorities
- Certification testing on accredited facilities (test bench & chassis dyno)
- In-use emissions compliance testing.