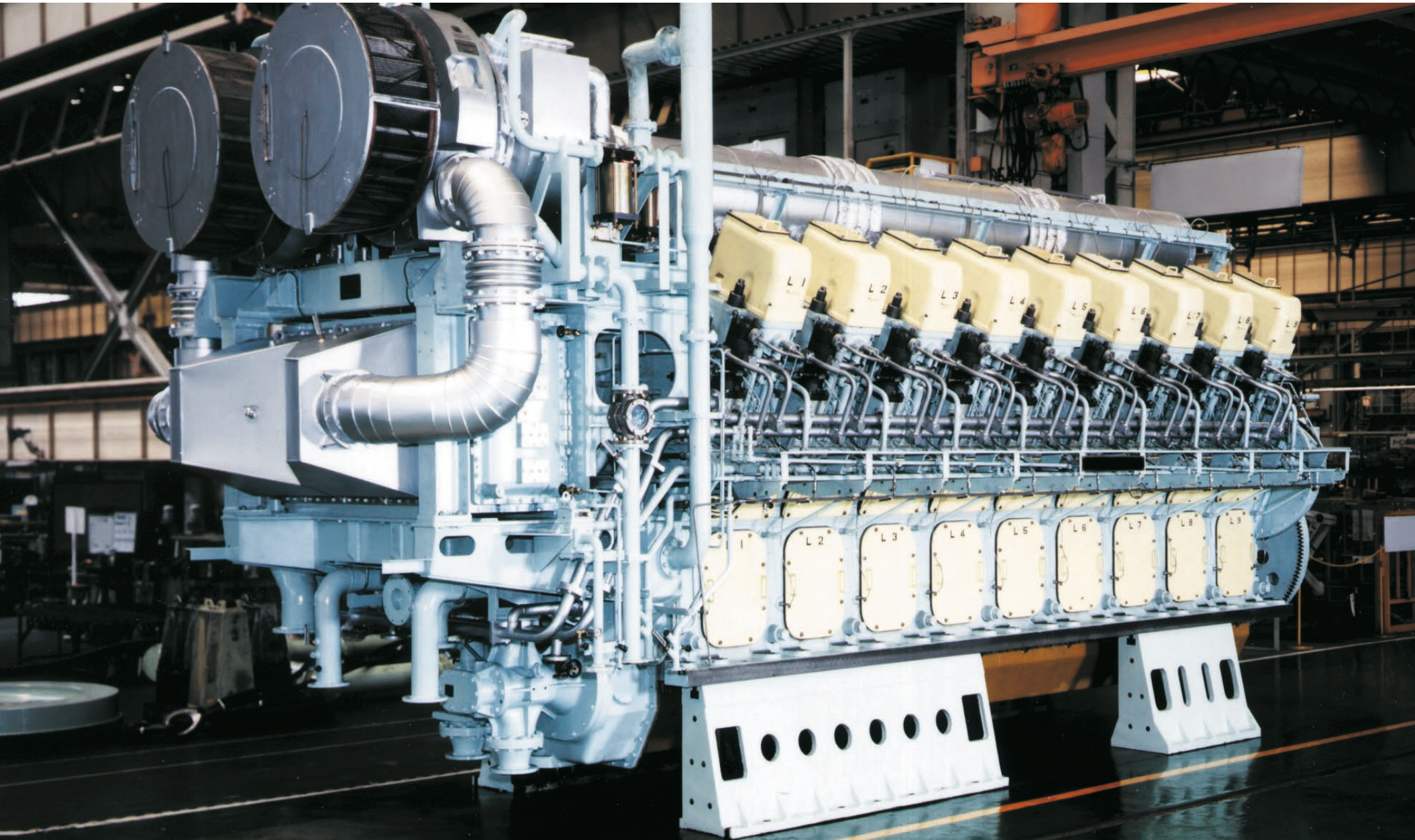


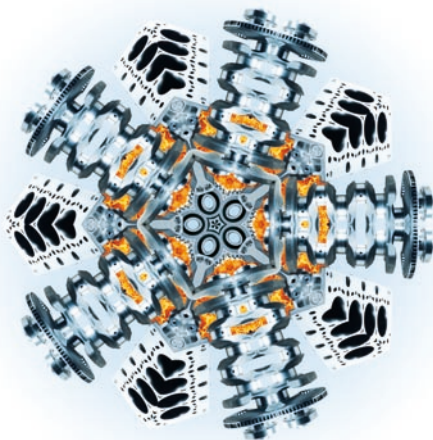
AVL LARGE ENGINES STRATEGY - PRODUCTION - FIELD OPERATION

Engineering - Technologies - Products



AVL





AVL LARGE ENGINES. FROM STRATEGY TO PRODUCTION TO FIELD OPERATION.

Our aim is to collaborate with our customers and to support them in creating a successful business position by leveraging AVL's unique strengths:

Specialist Engineering Expertise for Large Engines

AVL has played a major role in the development of around 100 large engines (diesel and gas). AVL has the most experienced independent engineering team in the industry, which combined with a unique frontloading process and two single cylinder engine testing systems, enables AVL to design large engines from strategy all the way to production.

Technology Innovation and R&D Tools

Higher product efficiency and quality are dedicated goals for the large engines industry, and AVL achieves these goals with advanced simulation expertise, experimental methods and innovative technologies.

Development, Simulation, Testing and Integration under One Roof

AVL is the only engineering company in the world that provides simulation, development, testing and system integration as a "one-stop-shop" competence center.

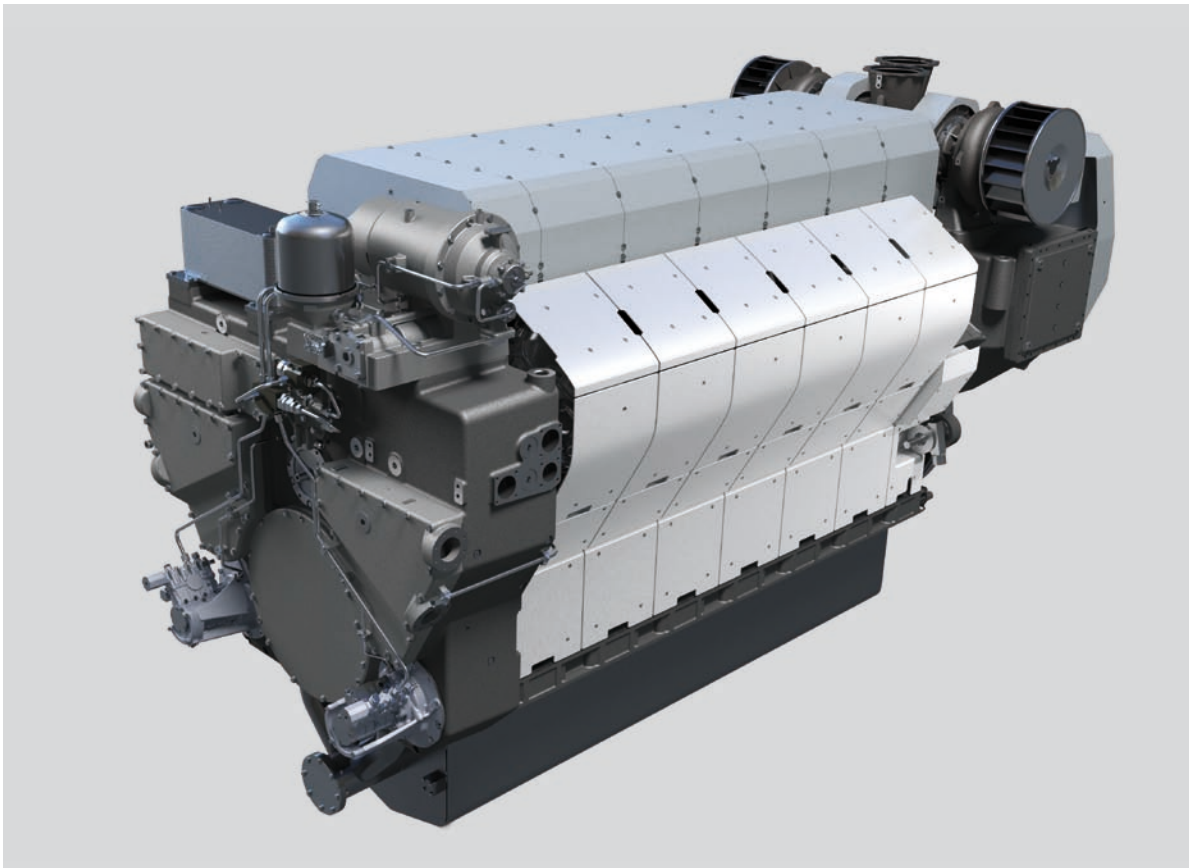
Industry Knowledge, Market and Application Expertise

AVL is highly experienced in developing competitive products that are optimally tailored to fit targeted markets and applications.

Global Presence

AVL has Engineering Tech Centers in Europe, Asia, North and South America and Australia. Local support is provided with the back-up of an international network of experts and technologies.

MARKET DRIVERS AND APPLICATIONS



Multiple Application Environment

- Marine propulsion and auxiliary power
- Power generation and cogeneration
- Locomotives

Rapid Technological Evolution

- Fuel systems, turbocharging, electronic controls, etc.
- Superior system integration

Environmental Sustainability

- Reduction of greenhouse gases (GHG)
- Compliance with emission regulations

Economic Imperatives

Life cycle cost balanced for each application

- Fuel efficiency
- Initial cost
- Reliability, availability and service costs

AVL APPROACH, AVL PORTFOLIO

AVL aims to be the industry's preferred partner throughout the entire life cycle of large engine products – from strategy all the way to production and field 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:

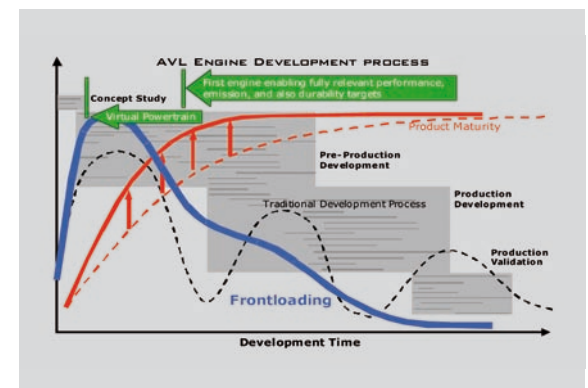
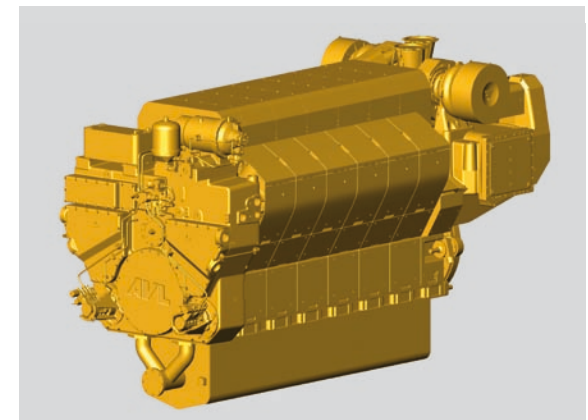
- High flexibility
- Creative solutions
- Fast problem solving
- Low product cost solutions

AVL Business Principles

- Rigorous project management, strong customer participation and collaboration
- Leverage the global AVL experience

AVL Product Portfolio

- Strategic services: Developing the product/market strategy
- Feasibility study: Technology selection, basic concept and layout, manufacturability, supplier identification, cost evaluation, risk assessment
- Design and development: From advanced simulation to comprehensive product design
- Testing and validation: From component testing to engine testing and optimization, from field validation to full production release
- System integration: Integration of engine with aftertreatment and complete power systems
- Product support: Field support, troubleshooting, emission reduction, performance improvements and adaptation for new applications

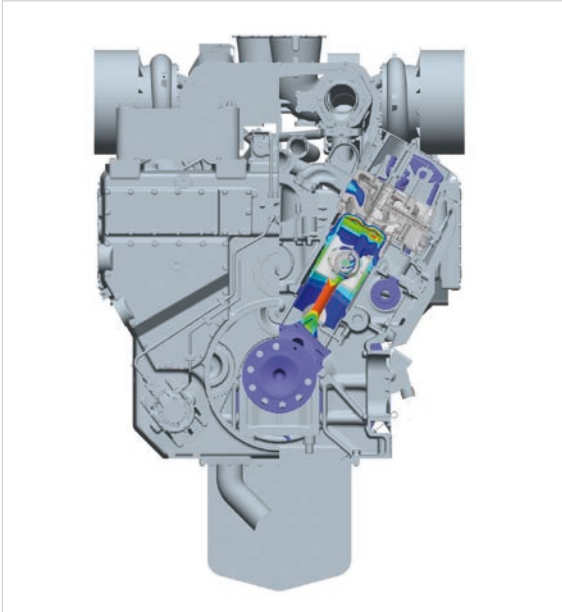


Product/market
strategy

Feasibility
study

Product
development

Mature
production



FROM FEASIBILITY STUDY TO DESIGN AND DEVELOPMENT

AVL Solution Portfolio

Feasibility Study

- Position the intended product in the product/market matrix
- Develop a technical feasibility study
- Layout the product architecture
- Establish a preliminary manufacturing and sourcing concept

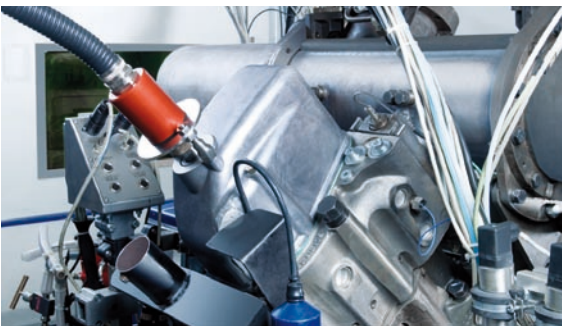
Design and Development

- Layout design of components and systems
- Verification of design in a first step with comprehensive frontloading simulation
- Detailed design

- Establishment of manufacturing structures and development of the supply base
- Support in sourcing and QA for components and subsystems
- Prototype building support
- Thermodynamic development and mechanical validation
- Assistance in the final iteration based on field experience

Product Enhancement Services

- Enhancement of existing products for new applications or for performance improvements
- Application of advanced emission technologies for meeting stricter regulatory limits



Customer Perspective

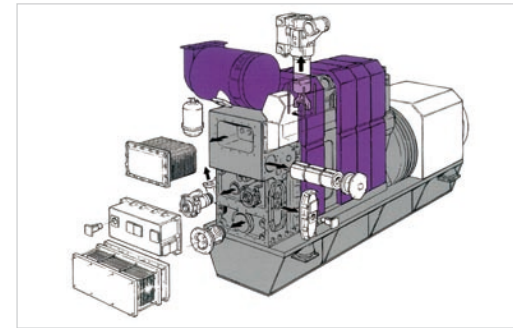
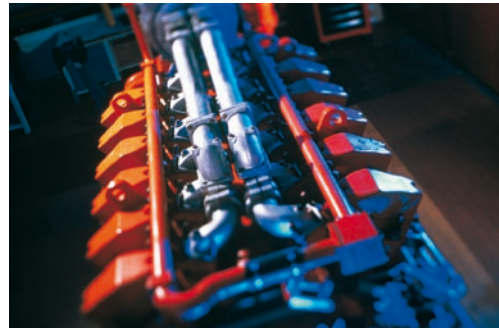
In the current very competitive economic environment, products must perfectly match the customer's needs:

- Strategic fit to the customer's profile and to its business objectives
- Optimum performance at targeted cost and reliability standards

- Operation and maintenance practices tailored to the specific application
- Design aligned to the OEM manufacturing resources
- Technical solutions leverage the accessible supply chain

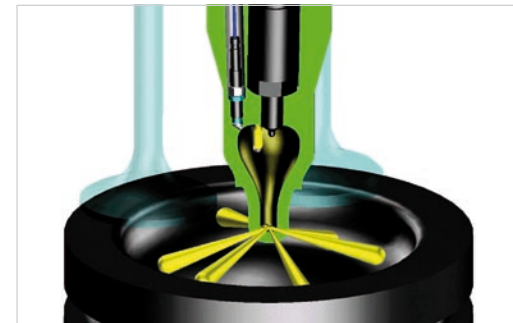
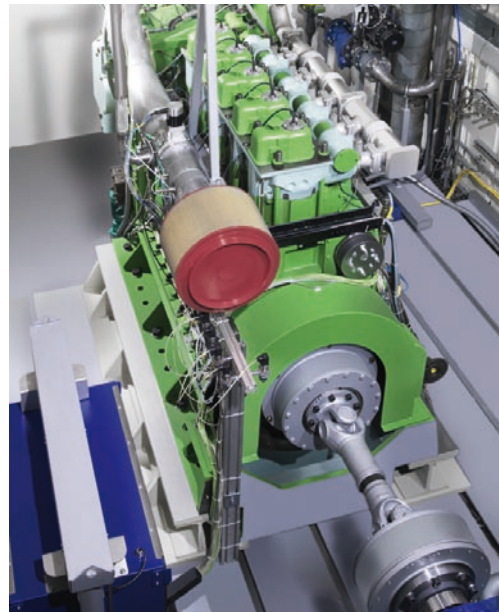
AVL Strengths

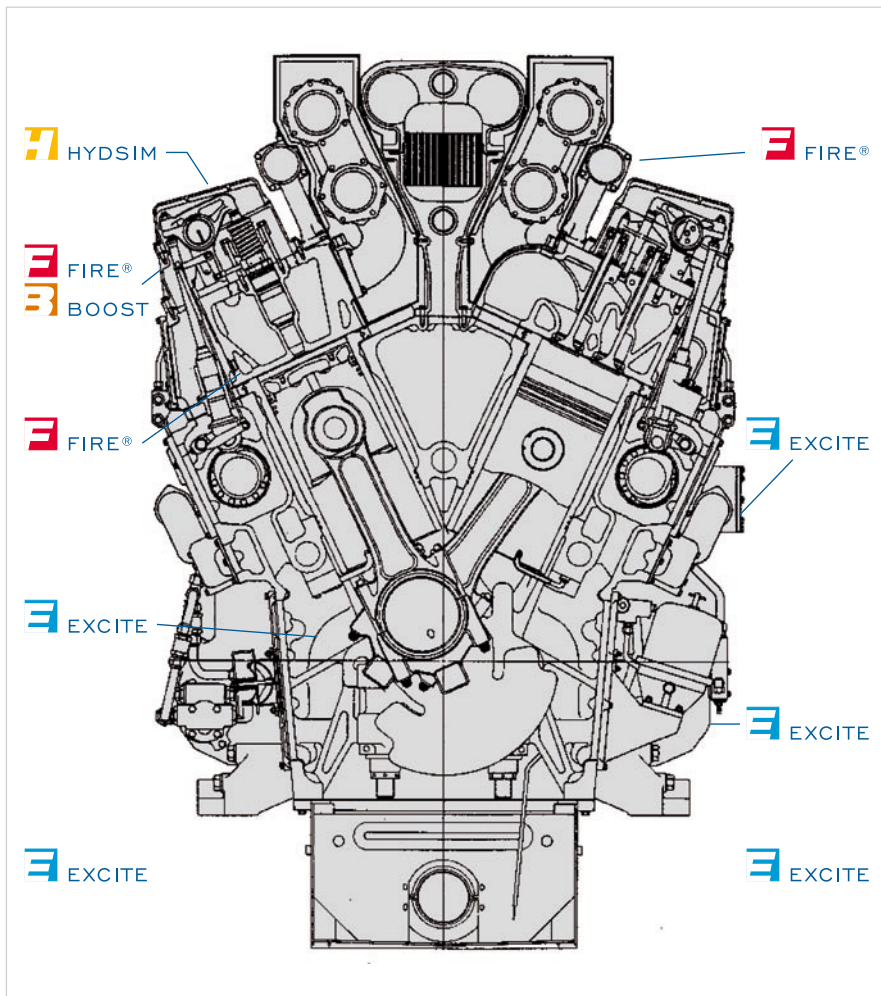
- High level of market and application knowledge
- Leading development competence for diesel and gas engines
- Advanced virtual product development methodology
- AVL proprietary development process
- Technology expertise from thermodynamics and combustion to structures, noise and vibrations all the way to complete systems
- Close collaboration with customers through worldwide presence



Customer Benefits

- World-class product design tailored to the performance and business goals
- Competitive product with a clear USP through highly innovative technologies
- Efficient alignment of the product design to manufacturing and supply requirements
- Support throughout the product life cycle





ADVANCED SIMULATION

AVL Simulation Solutions

The AVL approach is to replace physical prototypes with virtual prototypes by applying frontloading in order to reduce development time and costs. AVL's simulation workflows address application tasks that cover all aspects of the product creation process and guide the user through to practical solutions.

Thermodynamics and CFD

AVL BOOST and AVL FIRE® are the industry's first choice for reliable thermodynamic and combustion simulation and performance prediction. They feature the industry's only 1D, 2D, 3D seamless integration of exhaust aftertreatment systems.

Hydraulic Simulation

AVL HYDSIM is an efficient tool for the hydraulic simulation of fuel injection systems and the hydraulics of valvetrains.

Dynamic Calculations

AVL EXCITE is the perfect tool for the dynamic and acoustic analysis of power units and for piston and ring dynamics, camshaft drives and valvetrains.

Customer Perspective

- Right product for the market
 - Short time to market with a minimum of iteration
 - Acceptable cost to market at minimum risk
-

FE Simulation, Bearings and Tribology

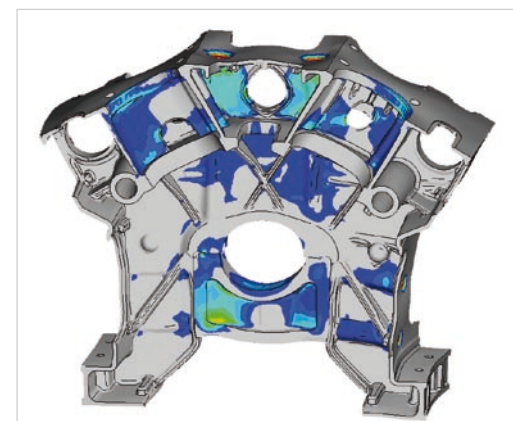
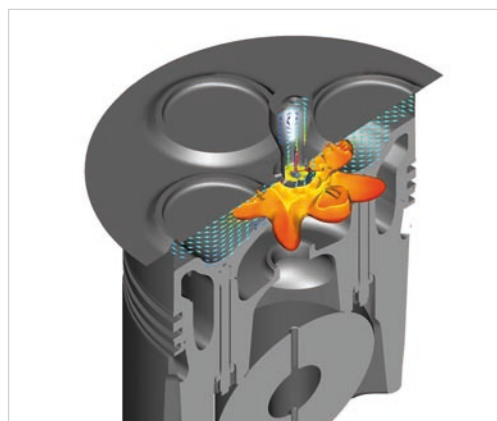
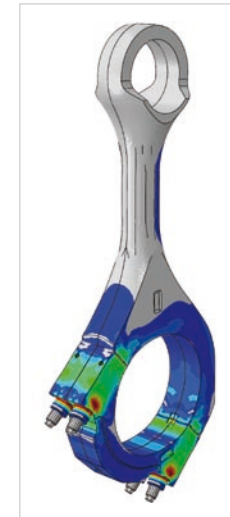
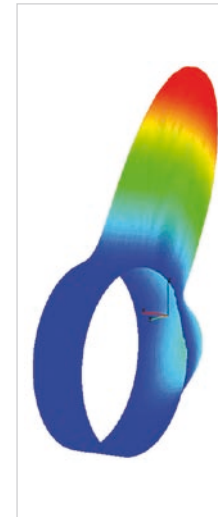
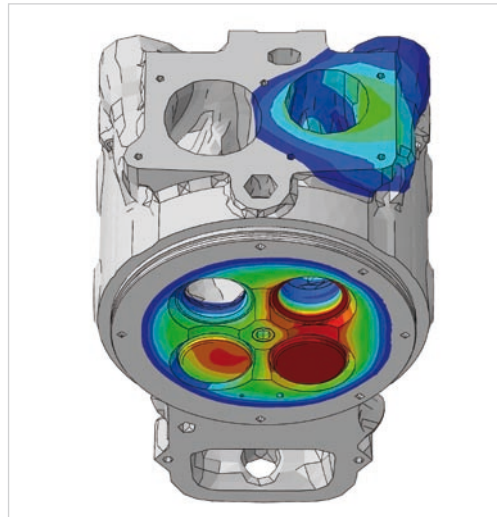
Our proprietary software can be used in combination with the most advanced numerical tools for FE analysis and bearing calculations available in the industry.

AVL Strengths

- High-fidelity system simulation models
- Robust, easy-to-use and complete physical models
- Fully interactive and integrated simulation tool chain
- Solutions guided by seamless simulation workflows
- Multidimensional simulation platforms based on AVL's deep engineering know-how

Customer Benefits

- Shorter overall development time
- Fewer test cycles
- Lower overall costs
- Proven validation for high accuracy and confidence
- Simulation and training support worldwide





AVL TESTING AND VALIDATION

AVL Testing Solutions

Component Testbeds

For critical subsystems such as fuel injection valve-trains, turbochargers, pumps, cooling and lubricating circuits and aftertreatment components.

Single Cylinder Engine System (SCE)

Unique development platform with high modularity and flexibility in a wide range of parameters (BMEP up to 35 bar, cylinder pressures up to 300 bar) for technology evaluation, combustion development, performance assessment and component validation. Additionally, a single cylinder engine system including the necessary measuring systems is available at the Large Engine Competence Center in Graz.

Testing Facilities for Multi-Cylinder Engines

Modern testbeds for testing engines up to 25 MW

Advanced Data Recording and Processing Systems

PUMA Open Testbed Automation: Application-oriented, scalable management system for increased productivity – capable of integrating best-in-class software and hardware by means of an open interface with cutting-edge functionality. F-FEM: High-precision data acquisition hardware. SESAM: Measurement system suitable for low emission engines

Customer Perspective

- The increased flexibility of fuel injection systems, valve timing, air systems and electronic controls drives the need for multi-parameter optimization
- Engines with “near zero emissions” require high measurement accuracy
- The development cost for multiple application engines is high
- The response time for meeting emerging market needs is short



Advanced Testing Methodology for Complex Multi-Parameter Systems

- Design of Experiments (DoE) used for complex performance optimization
- Self-learning algorithms rationalize and shorten the optimization process
- Performance optimization and design validation occur by combining the advantages of the Single Cylinder Engine and Multi-Cylinder Engine platforms

AVL Strengths

- Global market leader in developing and supplying testing equipment for diesel and gas engines
- Broad experience in the testing of reciprocating engines

- Leveraging the sophisticated technology developed for the testing of automotive and heavy duty engines for large engines

Customer Benefits

- Efficient multi-parameter optimization for performance, reliability and emission goals by using world-class tools and methods
- Reduced time and cost to market due to
 - Frontloading development process
 - Single Cylinder Engine for rapid technology evaluation (prior to design freeze)
 - Multi-Cylinder Engine for system validation



SYSTEM INTEGRATION AND FIELD SUPPORT

AVL Solution Portfolio

- Engine and plant diagnostics
- Regular checks of engine and systems “health”
- Optimization of operation management
- System modification and optimization
- Resolution of operational problems
- Consultancy services in conjunction with maintenance and service contracts
- Solutions for reduction of engine emissions to comply with new regulatory limits
- Conversion to gas, biogas

AVL EPOS™ – Engine Performance & Optimization System

- Open diagnosis system for monitoring the operation of large combustion engines and their auxiliaries
- Support system for fuel minimization during operation of various fuel qualities and changing conditions
- Decision support system helps customers in their efforts to implement condition-based maintenance

Customer Perspective

Superior system integration is vital for optimizing increasingly complex engine environment

- Aftertreatment
- Waste heat recovery
- Auxiliary drives
- Supporting systems for cooling, lubrication

Efficient field support is vital for owners and operators of ships, power plants, and for other applications.

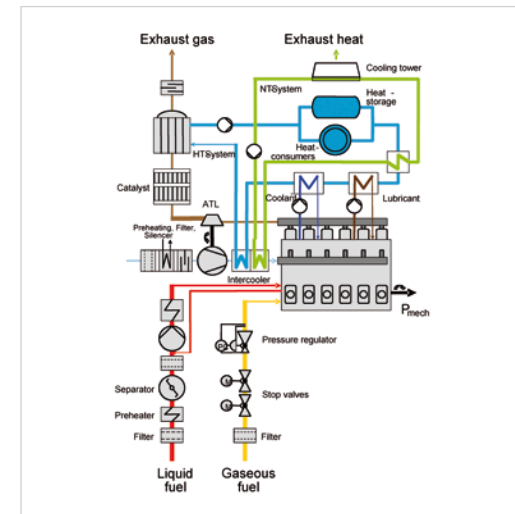
- Reliable, safe and efficient plant operation
 - Adaptation to changing requirements such as regulatory, fuels, maintenance resources, etc.
-

AVL Strengths

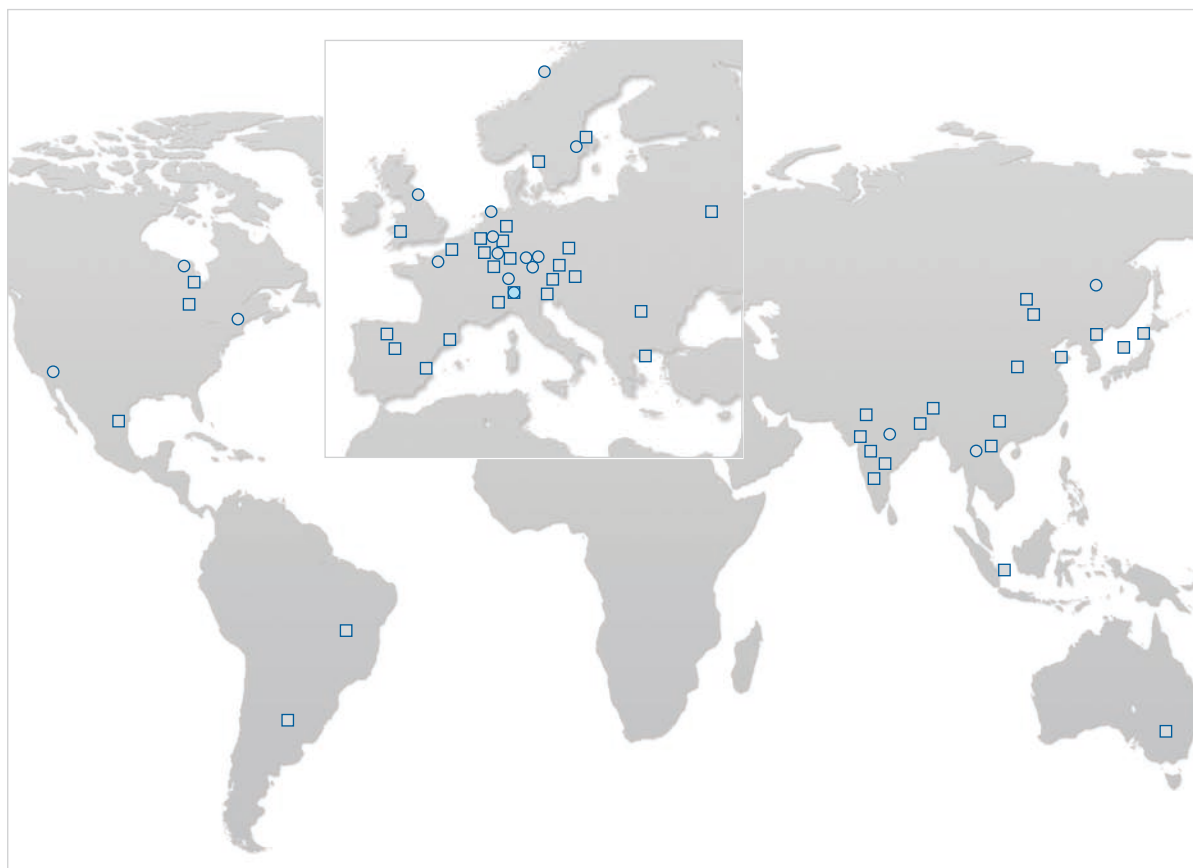
- High technical competency in large-bore engines and their auxiliary systems
- Comprehensive knowledge of the regulations covering diesel and gas engines as well as exhaust emissions and aftertreatment
- Quick availability of technical specialists near the customer sites worldwide
- Synergy between the expert teams and the AVL instrumentation division
- Professional project management
- Objectivity of an independent company

Customer Benefits

- Assurance of optimized, reliable and safe engine and installation operation
- Extension of product's usable life through problem resolution and/or upgrades
- Reduction of operating costs
- Improved economics through optimization of fuel energy use
- Accurate and efficient problem investigation
- Confidentiality in dealing with field problems



AVL – A WORLDWIDE PARTNER



EUROPE

- Great Britain
 - Dunton-Basildon
- France
 - Palaiseau
- Germany
 - Ingolstadt
 - Munic
 - Regensburg
 - Remscheid
 - Stuttgart
- Italy
- Austria
 - Graz, Headquarters
 - Steyr
- Poland
- Romania
- Russia
- Sweden
 - Stockholm
 - Södertälje
- Slovenia
- Spain
- Czech Republic
- Turkey
- Hungary

NORTH AND SOUTH AMERICA

- USA
 - Lake Forest, CA
 - Ann Arbor, MI
 - Plymouth, MI
- Argentina
- Brazil
- Mexico

ASIA

- China
 - Shanghai
- India
 - Delhi
- Indonesia
- Japan
- Korea
 - Seoul
- Thailand

Key:

- AVL Affiliate
- AVL Tech Center (TC)
- Graz location (AVL Headquarters) and AVL Tech Center

For further information please contact:

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