Your Innovative and Reliable Partner
for **Precision Engineering Services**

Dr.-Ing. Valerius Boxberger

Precision Engineering Department

Advanced Precision Engineering Services

Your Innovative & Reliable Engineering Partner
…our expertise and flexibility - your advantage!

8 +
Years of Experience

50+
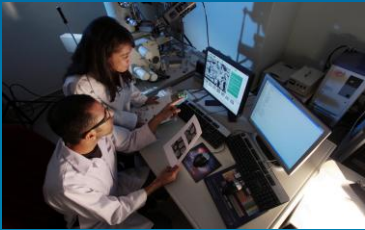Experts for Precision Engineering

50+
Executed Projects

500+
Engineers from various technical department, ready to support

AVL Group at a Glance

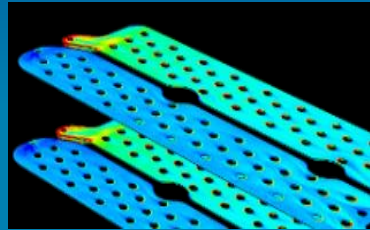|			
1948 Founded	**29** Countries Represented	**12,200** Employees Worldwide	**10 %** Of Turnover Invested in Inhouse R&D
75+ Years of Experience	**50+** Global Tech and Engineering Centers	**68 %** Engineers and Scientists	**2,200** Granted Patents in Force

AVL Service Portfolio – Precision Engineering

Development of high-precision components and systems **from concept** to **manufacturing**. Project scopes include, for example, (virtual) **concept design** and **development**, **material science**, **customized test setups**, **data analysis** and **evaluation**.

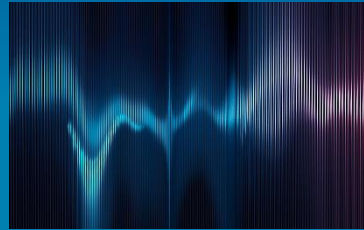## High Precision Mechanical Design

- Precision Bearing-, Frame-Design and Integration
- Vacuum spec. Design

Simulation/Numerical Analysis

- Thermal & Flow Analysis (CFD/CHT)
- Thermomechanical /Dynamic / Mechanical Analysis (FEA)

Acoustics and Vibration

- Waterline Acoustics
- Flow-Induced Vibration
- Acoustic Measurement Chamber

Material Technology/ Reliability

- Material Selection
- Material Analysis

Supplier Management

- Supplier Sourcing and Selection
- Supplier Qualification and Auditing

Production Engineering

- Cost (Reduction) Studies
- Industrialization Support

Software, AI and Data Intelligence

- Imbedded Software Development
- Machine learning
- Predictive Maintenance etc.

Recycling and Sustainability

- Material Selection
- Design for Recycling

Design and Manufacturing of special test setups

- Procurement, welding, build etc.
- Testing and Evaluation

Failure Mode and Effects Analysis (FMEA)

- Potential error identification
- Failure effect evaluation
- Definition of countermeasures

Mechanical Design for Precision – AVL Service Portfolio

Nav: Mechanical Design · Simulation/Numerical Analysis · Acoustics and Vibration · Material Technology/Reliability · Supplier Management · Cost Engineering/Series Production Support · Software, AI and Data Intelligence · Recycling and Sustainability · Design and production of special test setups · FMEA

- **Concept design** – Architecture definition; Thermal architecture; Cooling system design
- **Bearing systems** – Dev. of stress-free bearing supports (isostatic, comp. of manufacturing tolerances and thermal deformations)
- **System integration** – Subcomponents; Measuring Devices
- **Numerical verification** – CFD-Simulation; FEA-Simulation *(Erdel, 09.05)*
- **Tolerances** – Tolerance chain analysis; Reproducible positioning *(<15μm passive, <1μm active)*
- **Engineering consultancy** – Engineering judgment; Design optimization
- **Project management** – Project management support; Time and technical progress management
- **Production engineering** – Detailed production support (machining)
- **Measurement concepts** – Selection/development of measurement concepts
- **Others** – Please ask for further demands

The precise and repeatable positioning of components is a challenge. Manufacturing tolerances, dead weight, thermal and dynamic influences are just a few examples that can have a negative impact on accuracy

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System Architecture Definition

- Lean and agile processes, **optimizing efficiency** and effectiveness
- Capturing important **requirements**
- Defining the **system integration strategy**
- Linking the **requirements** to key drivers
- Functional and non-functional or **quality requirements definition**
- **System partitioning** and decomposition
- **System integration** incl. strategy definition

Planning and designing components of a system and their interactions to ensure the systems functions efficient and effective…

Thermal System Design

- **Thermal system design**
- **Thermal compensation &** sensor placement
- **Requirements management** and the creation and negotiation of defect budgets
- **Design, analysis and evaluation of thermal stability** (thermal cancelling, shielding, insulation)
- **Optimization of thermal properties**
- **Heat conduction in** diluted gases (xPa)
- **Ensuring temperature stability** to a few mK
- **Control of thermoelastic deformation** of components in the nm range
- **Model-based development/lumped mass 0D/1D simulation**
- **Thermal management**

(TCR=0.0001 [mK/W])

Temperature differences of just a few mK can lead to significant losses in optical performance. We ensure the thermal stability of optical systems in a challenging environment (vacuum, materials, etc.).

Acoustics, Vibration and Dynamics

Vibration of Fluid (Acoustics)	Vibration of Solids (Structural Dynamics)	Measurement and Testing	Mitigation Measures
Waterline acoustics (WLA) – 1D simulation method to predict pressure waves in waterlines and test countermeasures virtually.	**Transfer Path Analysis** – Analysis and minimisation of vibration in mechanical components.	**500 μN-Test-Setup** – Measurement of the exciting pressure fluctuations for analysis of internal and external flow-induced vibration (FIV). Measurement of extremely small flow-induced forces.	**Optimisation** – Optimising structural stiffness and frame architecture. Acoustic and vibration performance optimisation. Minimisation of disturbance forces on optical equipment.
Flow-Induced Vibrations (FIV) – CFD method to predict flow-induced vibration and assess the impact of mitigation measures.	**Vibration Prediction** – Finite Element Method (FEM) to predict and remedy the vibration of mechanical components, e.g. silencers.	**Transfer-Matrix-Test-Setup** – Experimental determination dynamic behaviour for silencers, hoses and similar components.	**Suppression** – Development and optimisation of acoustical and mechanical suppression systems. Active suppression. Passive suppression: Silences and hoses; Material damping; (Structural damping)
Noise Radiation – Calculation and prediction of the resulting sound emissions into the environment.		**Acoustic Chambers** – Half-space cells, 19 Hz and 100 Hz cutoff frequency. Class 1: ISO3745/DIN45635(100Hz Testbed). Incl. low-noise water supply..	

Materials Technology / Reliability

Research & Development
- Materials R&D
- Material Characterization
- Benchmark Studies
- Data Analysis
- Guidelines & Reports
- Certification
- Development of test plans
- Test management

Design & Simulation
- Decision support data
- Material Input Data
- Material Specs Assessment
- Drawing Check
- Preferred Materials
- Restricted Substances

Production Engineering
- Process Quality
- Batch Testing
- Prototype Validation
- Comparison with Specs
- Process Improvement
- Supplier Assessment

Service & Recycling
- Materials performance
- Failure Analysis
- Materials Substitution
- Task Forces
- Materials Aging
- Recycling & Disposal

Seamless Integration Between Product and Process Engineering

Product Development Process: Product Feasibility · Concept Design · Prototype Development · Development & Series Preparation · Product Validation · SOP · Product Life Cycle

- Business Case
- Supply Chain (Forward Sourcing, RfQs/Audits, Supplier Negotiation, SQA APQP/PPAP, Supplier Dev.)
- Simultaneous Production Engineering (Target Cost, DfM / DfA, Manufacturing Tests, DtQ/Special Characteristics, Design to Cost, Material Technology, Product PPAP, Product & Process Optimization)
- Cost Engineering (Make or Buy Analysis, Localisation Study, Cost Audit, Cost Reduction Study, Cost Analysis, Cost Benchmarking, Cost Optimization)
- Product Quality & Documentation (Product Structure, Product FMEA, Virtual Prototype, Change & Concern Management, Process FMEA, Release Management, Product Visualization, Supplier)
- Manufacturing and Factory Planning (Initial Planning, Detailed Planning, Realisation)
- Product Life Cycle

Comprehensive development process tailored to specific project requirements. We consider all accompanying topics and incorporate them into the planning.

Software, AI and Data Intelligence

Embedded Software Development
- E/E platforms and integration
- Advanced Driver Assistance Systems (ADAS) and Automated Driving (AD)
- Functional safety and cybersecurity
- ASPICE compliant development

Cloud Software Development
- Customized data pipelines
- Scalable analytics
- Automated CI/CD pipelines

Simulation, Test Software and Methodology
- Design and simulation solutions
- Functional testing (MiL, HiL, SiL)
- Lab and process management
- Test automation and virtualization

Artificial Intelligence Solutions
- LLM utilization for Requirements
- Data analytics for development
- Anomaly Detection
- Failure prediction
- Root Cause Analysis

All software solutions contain our innovation, engineering legacy and application insight.

Design to Cost in product development

Feasibility · Concept · Design · Validation · Production

Target definition → Affordable
- Top down from corporate view
- ESG strategy
- Localization, Make or Buy
- Risk assessment

Design to Cost → Achievable
- Material selection
- Manufacturing and assembly process selection
- Design for X balancing
- Target verification

Supplier Nomination → Actual
- Request for quotation
- Cost & CO₂e break down
- Production implementation
- Target offsetting

Cost and optimization
- Production optimization inhouse and supplier
- Variant management

Bottom-up production process simulation
Secondary data — Primary data

* QG… Quality Gate; ESG… Environmental, Social, Governance

Failure Modes and Effect Analysis (FMEA)

1. Planning and Preparation	2. Structural analysis	3. Functional Analysis	4. Failure analysis	5. Risk Assessment	6. Optimization
Scope definition/Document evaluation	System structure setup; System element definition; Organization of subsystems in an evaluation structure	Assign functions and features; Form function	Derive malfunctions and error; Characteristics form error network	Define prevention and detection measures; Assess risks	Plan optimization; check the effectiveness of measures

- Identification of potential failures in systems, products, or processes at an early stage
- Systematically evaluation of error impact and countermeasures
- Cost reduction
- Structured and preventative approach to improve quality, safety, and reliability

Method applicable to:
- Product development
- Identification of deficiencies in the design phase
- Process planning
- Analysis of production processes
- Quality assurance
- Verification of the robustness and reliability of a system

Thank you

AVL ✦

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