CHASSIS
FEV Chassis
Reliable Partner in Chassis Development

Founded in 1978, FEV is an internationally recognized leader in the design and development of internal combustion engines and supplier of advanced test and instrumentation systems. FEV has consistently expanded its range of expertise into other vehicle systems. Engine integration, NVH integration and driveline development are now a part of that expertise; however, chassis integration and vehicle dynamics are also expanding FEV’s field of expertise.

The chassis team consists of qualified engineers, who have gained valuable experience working for FEV, OEMs and Tier1 chassis/vehicle dynamics teams. The FEV Chassis experts have proven their competence to many satisfied customers.

In order to help facilitate chassis development, FEV has defined its own test procedures to complement the existing international test standards.

Integration of a chassis into a new vehicle (derivative), with regard to classical vehicle dynamics, is a core competence for our team of engineers. The integration of modern active mechatronic systems, such as ABS, ESP and EPS, is a logical step that has been implemented in several projects.

FEV also offers the capability and corresponding experience to integrate tires into a new or existing vehicle, including all subsequent supplier-related activities.

Working with FEV Chassis means:

- Open partnership
- Completely customer oriented
- Utilizing customer’s methods
- On site work as needed
- Quick access to our competent experts
- Access to our knowledge-base and database
FEV Chassis Applications and Activities

- Concept Layout
- Design
- Kinematics and Compliance
- Prototype Workshop
- Vehicle Dynamics Evaluation
- Tuning and Measurement
- Validation
- Chassis Electronics
The primary resource of the FEV Chassis team is its homogeneous mix of competent engineers and experience. State-of-the-art vehicle dynamics measurement equipment and the availability of other necessary measurement facilities allow them to perform development and testing work in a professional manner.

FEV also offers its engineering service competency in the form of placement of resident engineers within your company, working directly with your teams and procedures. The diversity of our team members also allows us to provide the following services:

**Chassis Analysis for:**
- Kinematics
- Packaging and layout
- Elasto-kinematics
- Strength and stress

**Subjective Tuning (Supported by Objective Tests) of:**
- Tires
- Springs and anti-roll bars
- Shock absorbers
- Steering systems
- Brake systems
- Active systems

**Objective Testing**
- Handling (open and closed loop)
- Ride comfort (road and rig)
- Braking performance

**Subjective Testing**
- Steering
- Handling
- Ride comfort
- Brake performance and comfort
- ABS and ESP performance and comfort
- Wet performance
- Winter performance
- Off-road performance

**People are the main resource of FEV Chassis. Other resources include:**
- CAD and CAE tools
- Workshops
- Test tracks
- Measurement equipment
- Commercial and in-house analysis tools
Test Facilities:

- Workshop with divided areas, allowing confidentiality for each customer
- Private test track for initial evaluation of test vehicles
- Measurement equipment for all relevant vehicle dynamic parameters, such as:
  - Steering wheel angle
  - Steering wheel torque
  - All 6 DOF for the complete vehicle (position, speed and acceleration)
  - Brake pedal force and travel
  - Additional equipment for measuring force, displacement or acceleration regarding any desired component or system of the vehicle

CAE:

- ADAMS/ADAMS Car, Motion View
- Nastran, Ansys
- Hypermesh, I-DEAS
- Matlab/Simulink
- Design Of Experiments (DOE)
- In-house code for quick and easy set-up
Appropriate target selection is a prerequisite for developing excellent vehicle dynamic behavior. FEV’s rapidly growing database can be the basis for target setting. A comprehensive database, consisting of both objective and subjective data describing the vehicle dynamics, is used to generate FEV’s unique scatterbands. These scatterbands represent the current and future state-of-the-art.

FEV is experienced in performing benchmarking investigations of all magnitudes, including a range that starts with dedicated studies and continues through to the analysis of complete vehicles.

Vehicle dynamics benchmarking may contain the following:

- Vehicle selection
- Vehicle procurement
- Acquiring static data
- Subjective tests
- Objective tests
- Target setting for new development

FEV’s extensive database includes:

- Approximately 50 vehicles
- Objective metrics
- Subjective evaluation based on FEV’s rating standard
FEV Chassis
Market and Customer Adaptation

A vehicle’s chassis is typically developed to provide optimum performance for a broad range of customers. This optimization is not sufficient or possible for certain markets or customer classes. In those instances, specific adaptation is required to meet the customer’s needs.

The following are special cases where further chassis development is required:

- Circumstances in certain markets require specific developments
- Customers in certain markets have different expectations
- Special purpose vehicles for police, armor protection, high speed or rough road conditions
- Local sourcing of chassis components can require new compromises in chassis development

Development of chassis systems and components for specific customers or markets:

- Analysis of market needs
- Definition of modification program
- Supplier management
- Test program
- Release for OEM or local market

Typical projects of FEV's chassis development experience:

- Analysis of market needs
- Analysis of competitor’s vehicle
- Development of chassis set-ups
- Tire release programs
- Damper release programs
FEV offers a high level of experience in the field of tire integration and testing to car manufacturers, tire manufacturers and other interested parties (e.g. automotive trade publications and race teams).

**FEV is capable of conducting a complete development program, including:**

- Supplier choice and management
- Vehicle tests
- Rig tests

**In addition, we are an ideal solution to address:**

- New tire sizes
- New suppliers
- Localizing

To support these efforts, a variety of test tracks and general purpose roads are located near Aachen, Germany, including the German Autobahn and the famous Nürburgring.

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**FEV’s tire testing competence includes:**

- Test drivers with long term experience
- Well proven test procedures
- Fundamental tire knowledge for making the right decisions

_Nürburgring – “The green hell”_
FEV is an experienced partner that can support your company in the development of chassis systems, starting with the basic layout and concept considering:

- Packaging and layout
- Kinematics and compliances
- Vehicle dynamic effects
- NVH effects
- Strength and stress
- Integration of mechatronics

In addition, we also support our customer’s efforts during the subsequent design phase, where our integrated approach of Vehicle Dynamics and NVH provides a key benefit.

For the right decisions for your concept-development FEV provides:

- Experienced concept engineers
- Commercial and in-house CAE tools
- Concept decision based on experience and CAE
- Well proven test procedures
- Advanced knowledge of interdisciplinary impacts

Concept Matrix for a Non-driven Rear Suspension

<table>
<thead>
<tr>
<th>Suspension Type</th>
<th>Handling</th>
<th>Ride comfort</th>
<th>NVH</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid axle with coil springs</td>
<td>+/0</td>
<td>-</td>
<td>0/-</td>
<td>+</td>
</tr>
<tr>
<td>Semi trailing arms</td>
<td>-</td>
<td>+/0</td>
<td>0/-</td>
<td>+</td>
</tr>
<tr>
<td>Twist beam axle</td>
<td>0/-</td>
<td>0</td>
<td>0</td>
<td>++</td>
</tr>
<tr>
<td>MacPherson strut</td>
<td>+</td>
<td>+/0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Double wishbone</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Multiple linkage</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>--</td>
</tr>
<tr>
<td>Control blade suspension</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>-</td>
</tr>
</tbody>
</table>
The cornerstone of each chassis development project is objective testing. Whether performed for model validation or as a part of final release testing, objective results represent a proof of all of the virtual and subjective tuning that has been accomplished.

FEV uses all of the available tools that are needed in completing these objective tests:
- State-of-the-art measuring and data acquisition systems
- Various data analysis software packages
- Test procedures according to specific ISO standards
- Experience with many OEM test procedures
- FEV test procedures
- Access to and experience on all major test tracks

FEV utilizes a wide range of scatterbands for frequently used test procedures. This allows a direct comparison of the test vehicle’s performance to competitor vehicles.

FEV’s objective testing competence is based on:
- State-of-the-art measuring equipment
- The right test procedures in combination with:
  - The right objective metrics

Methodology to develop objective parameters (example)

Driving Maneuvers

- 10 Vehicles
- Subcompact to luxury class, sports cars and SUV

Signal Analysis

- Measurement platform
- Measurement steering wheel
- Objective values

Subjective Ratings

- 10 Experts
- Ratings from 1-10
Furthermore, FEV has developed objective parameters that provide an excellent correlation to the subjective impressions. It has delivered valuable models for vehicle dynamics, which determine objective ratings (on a scale from 1 to 10) for handling, braking and ride comfort aspects. The methodology for objective parameter development, internally developed at FEV, has proven its value in many other vehicle aspects, such as NVH and engine drivability. The number of parameters is constantly increasing, with the goal of covering all of the main items that are defined in our subjective evaluation catalog.

Ride comfort objective parameter development

Objective measurement tools:
- Experienced test drivers
- Methodology
- Scatterbands
- Objective metrics correlated with subjective impression
- Reliable models

Regression Analysis

- Combination of objective values
The use of mechatronics in active chassis systems has become an increasing part of our development projects. The tuning of active chassis systems is a task that FEV is quite adept at handling.

The FEV Chassis team can combine their strengths with the FEV Mechatronics department to include the following tasks:

- ECU prototyping
- Software development
- Function development
- Testing (HIL)

In this manner FEV can offer complete new developments in the field of chassis mechatronics from the concept phase through the Start of Production (SOP).

FEV Chassis Mechatronics

FEV is the right place for automotive mechatronic development:

- Chassis tuning
- ECU calibration
- New developments
In addition to chassis tuning for ride and handling, NVH plays an important role in chassis development at FEV.

FEV uses an integrated approach, where NVH and ride and handling engineers work closely together. A well-known example is the development of wheel suspension bushings with its potential conflicts between handling and NVH properties. NVH optimizations at FEV are always performed with ride and handling in mind and vice versa, resulting in optimally balanced solutions.

FEV’s Chassis-VINS (Vehicle Interior Noise Simulation) is a superior tool that provides an analysis of all of the single contributors to the overall noise that is experienced by the customer. Additionally, many other tools are readily available to FEV’s highly qualified NVH engineers.
At FEV, simulation has become an integral part of our chassis development projects, following our philosophy of simultaneous engineering. This technique in chassis development has become an attractive solution, because it reduces development time and the number of prototypes that is required at the start of a project. Using simulation in this manner provides a strong and flexible tool for creating further improvements.

FEV utilizes the following software for chassis simulations:

- ADAMS Car is the standard software package for the development of Vehicle Dynamics
- Matlab/Simulink with a simplified vehicle model or a hybrid approach with an ADAMS model and Matlab based controllers for the development of active systems
- FEV's chassis-VINS software or commercial software packages like Nastran for simulating chassis noise

FEV also offers a wide range of experience with various alternative software packages. Over many projects we have utilized software that has been specified by our customers.

In addition to full chassis development projects, FEV offers its simulation services to complete specific tasks. Typical examples of the types of projects FEV has conducted include:

- Wheel and suspension kinematic analysis
- Wheel and suspension elasto-kinematic analysis
- Full vehicle handling analysis
- Full vehicle ride comfort analysis
- Active system controller development
FEV Chassis
Workshops and Training

**Workshops are a special category of services that are performed by FEV**

FEV has developed a variety of workshops and training programs, which can be tailored to meet your specific needs.

The following is just a sample of the many workshops and training sessions available through FEV:

- Driver training (different skill levels)
- Subjective evaluation – ride and handling training
- Tire assessments
- Vehicle Dynamics benchmarking
- High speed and extreme testing (incl. race tracks)
- Winter testing
- Wet handling

FEV offers long term partnerships to train your test engineers, especially in the field of driver training.

**FEV Racing**

FEV engineers enjoy excellent driving performance. A group of FEV enthusiasts donate their weekends to support Scheid Motorsport, a traditional race team based near the famous Nürburgring.

Based on deep knowledge of vehicle dynamics and market requirements, FEV organizes workshops under a variety of conditions that are suited to fit your company’s needs.