MÜLLER-BBM

Acoustics Management – Predictions – Measurements – Analysis

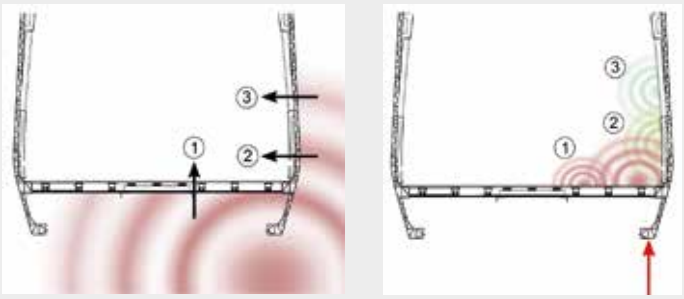
Rail vehicle acoustics

Know-how and experience in vibro-acoustics

www.mbbm-ind.com

Our competence

The engineering company Müller-BBM is active in all sectors of acoustics and vibration technology and has been involved in railway and vehicle acoustics for decades. As an established partner of the railroad industry, we understand our customers and their needs and thus, we can offer custom-made services and solutions.



Calculated prognosis of airborne (left) and structure-borne (right) noise generated by floor ①, lower ② and upper ③ sidewall

Calculative prediction of the interior noise level

Experimental study

Vibro-acoustic know-how and long-term experience for your vehicle development

The development of rail vehicles is a complex process in which diverse – partly even contradictory – requirements have to be met. Next to safety, fire protection, weight, energy consumption and maintainability, vibro-acoustic requirements play an important role in the development process.

Interior and exterior noise as well as speech intelligibility inside the train are significant criteria for the planning and the construction of new rail vehicles.

Müller-BBM brings in vibro-acoustic know-how in all phases of development.

In the concept phase, we support manufacturers of rail vehicles in the definition of acoustic goals and in working out unambiguous descriptions of detailed acoustic specifications for components and tender documents.

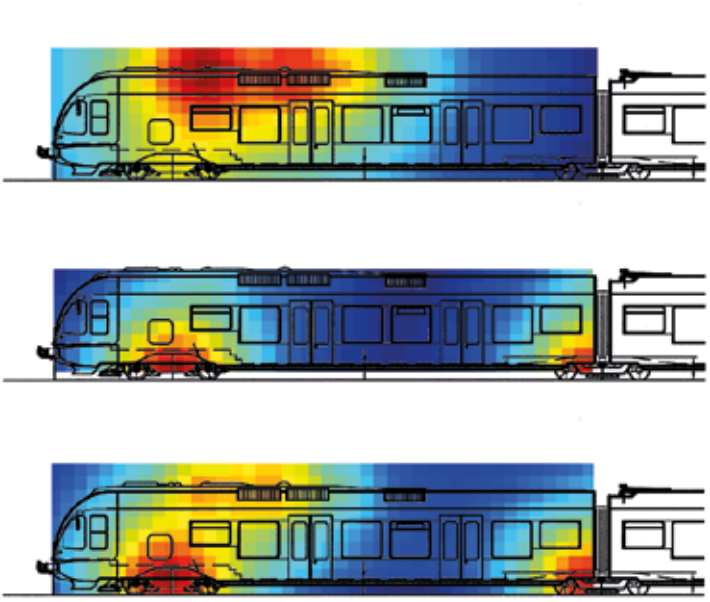
Within the scope of what is generally called “acoustics management”, we carry out calculative predictions while continuously checking compliance with acoustic requirements. With our in-depth knowledge of acoustics we will be at your side for designing the appropriate acoustic measures.

Our extensive, measurement-based experience on trains enables us to continuously check the results for plausibility in the planning phase. With advanced and effective measurement and analysis techniques, such as transfer path analyses, we gain insight into the dynamic and acoustic behaviour of rail vehicles.

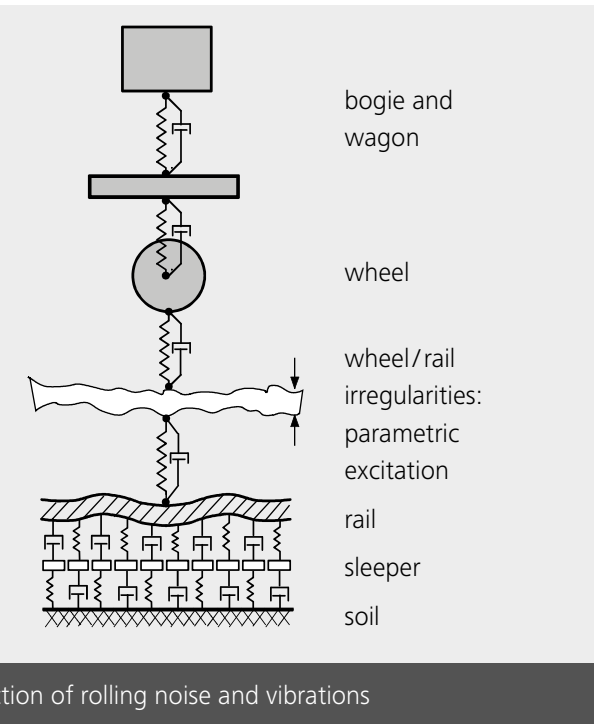
In our accredited testing laboratory, we continuously examine the components of rail vehicles such as doors and gangways as well as noise sources such as gearboxes and ventilation systems.

Together with the Deutsche Bahn AG (German Railways – DB), we have developed a computational procedure for the prognosis of rolling noise and vibration in trains and beneath railroad tracks (RIM).

m|wheel: measurement of wheel roughness



Prediction of exterior noise



RIM: calculative prediction of rolling noise and vibrations

At the same time we have fostered the development of special measuring devices for the railroad industry such as roughness measurement systems for rails and wheels. And, Müller-BBM has established a highly effective tool for the prediction of interior noise, which is still used in all acoustics management projects.

Research projects in the sector of rail acoustics are a good opportunity for Müller-BBM to share knowledge and to gain new insights. As an active member of the relevant committees and associations, we also promote the state of the art in standardisation.

An overview of our expertise:

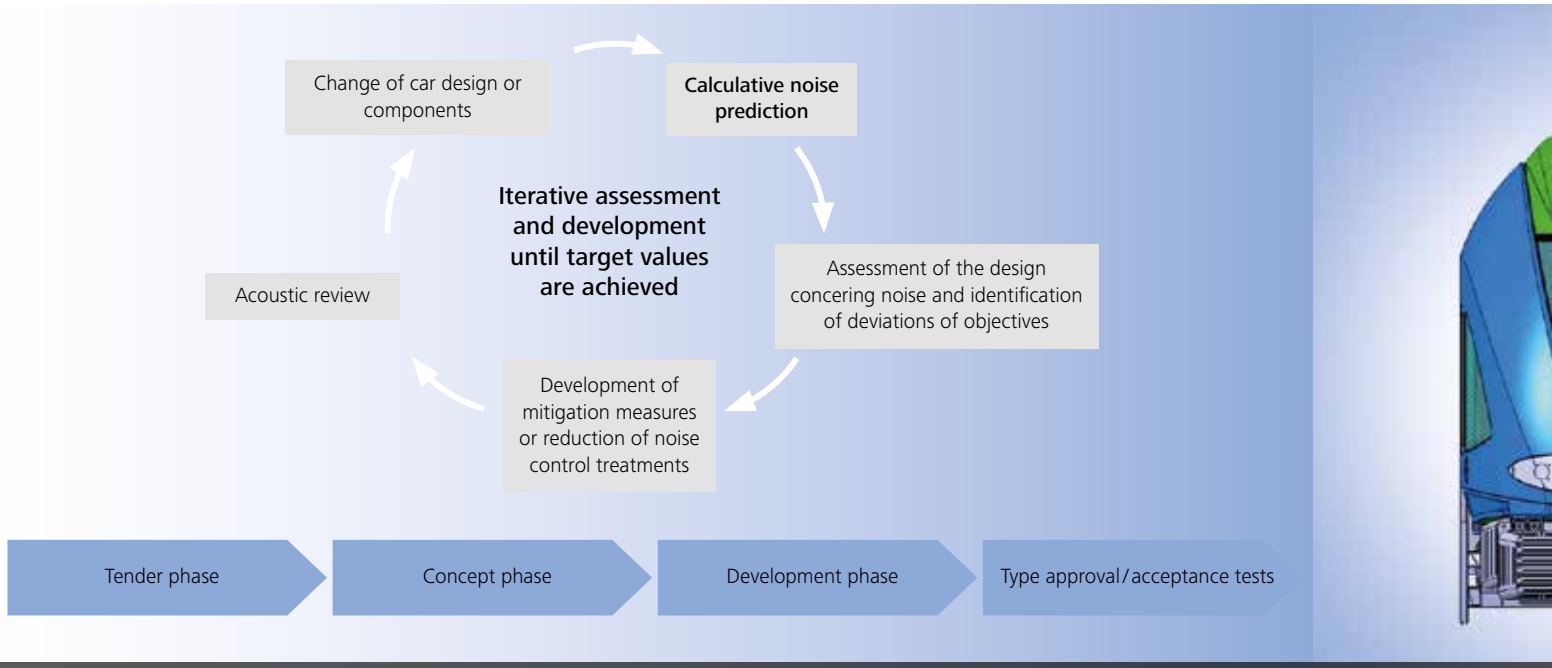
- Vibro-acoustic consultation during the entire vehicle development: from the concept and development phase up to the acceptance tests and the type approval
- Calculative acoustic prognosis based on the respective stage of construction
- Analyses in structural dynamics
- Our extensive measurement equipment allows the application of a multitude of different analysis methods
- Müller-BBM provides consulting for all types of rail vehicles: locomotives, main line vehicles, high-speed trains as well as trams, metro and underground vehicles.

The Müller-BBM testing laboratory "sound and vibration" is accredited according to ISO/IEC 17025 for all relevant investigations and assessments concerning acoustics and vibrations in rail vehicles and on railroad tracks.

In addition, Müller-BBM operates its own DAkkS-accredited calibration laboratory for acceleration and acoustic measurands.

Our services

Müller-BBM is at your side in all phases of your project: from the vehicle concepts over the actual development to acceptance tests and homologation of the vehicles, our expertise will help you to solve vibro-acoustic problems.



Acoustics management in the development of rail vehicles

Acoustics management

Careful acoustics management is a guarantee that acoustic goals are achieved. Special constructional solutions that are customized to the requirements allow for systems and components, which are best both technically and commercially.

Our goal is a consistent overall concept which also meets all other requirements besides acoustics.

"Acoustics management" means:

- Evaluation of the rail vehicle's concept regarding the achievement of the customer's acoustic requirements
- Continuous check, whether the agreed target values have been reached
- Identification of critical operating conditions as well as of their respective sources and transmission paths
- Definition of acoustic target values for individual components

Calculative prediction of

- Interior sound pressure levels (passenger compartment, driver's cab)
- Airborne and structure-borne sound contributions for the typical test cases standstill and traveling with constant speed on open track or in a tunnel
- Exterior sound pressure level
- Speech intelligibility

m|wheel: measurement of wheel roughness

Assessment of exterior noise at standstill

Consultation

Consulting regarding acoustic and low-vibration constructions:

- Selection of materials, components and possible mitigation measures
- Proposals for acoustic optimised solutions and low-vibration constructions
- Calculative and experimental elaboration of mitigation measures

Component tests

Performance of component tests, be it in your company, in our test stands or directly in the vehicle:

- Sound power level of individual components
- Force level (operational force, blocked forces)
- Sound reduction index of components such as access doors, windows or transition systems
- Machine vibrations

Type approval of rail vehicles

Acceptance tests on rail vehicles:

- Exterior noise
- Interior noise
- Speech intelligibility of annoucement systems (RASTI, STIPA)
- Ride comfort
- Ground-borne vibrations of rail vehicles
- Force density spectrum of rail vehicles
- Determination of roughness of wheel treads

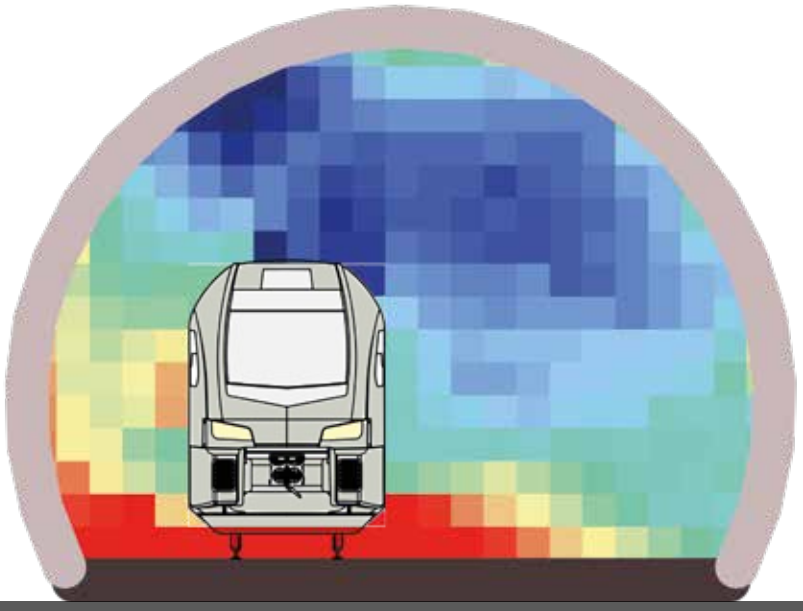
Acceptance test of the test track concerning:

- Track decay rate
- Rail roughness

Our procedures

Our long-term experience in rail vehicle acoustics has influenced the development of our own effective methods and tools positively. Furthermore, we have an extensive acoustic database of rail vehicles and rail vehicle components of all types at our disposal.

Measurement on a resilient mounted wheel tread



Ray-tracing: simulated sound level distribution in a tunnel

Finding answers to your questions and the elaboration of acoustic measures is the focus of our work. Therefore, we work out an effective concept of analysis which suits the specific conditions of your project.

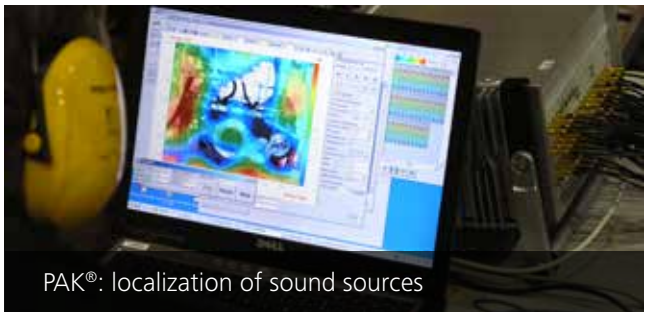
At Müller-BBM, we have a multitude of different experimental, computational and numerical analysis methods at our command. In our test stands, we can examine materials, components or devices.

Measurement technology

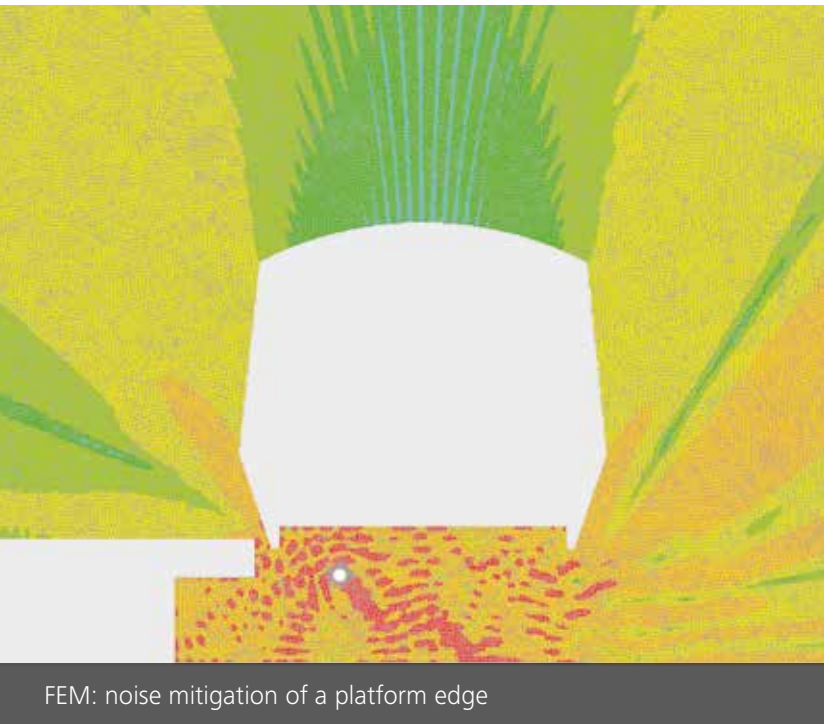
- Modern and extensive equipment for multichannel measurements:
- Sundry measurands and sensor technology (pressure, strain, deviation, force, speed, rotational speed etc.)
- Multichannel: typically 16–48 channels; measurements with 200 or even more channels are possible, too
- Time synchronisation of different measuring systems
- Laser-scanning
- Array measurement technology
- Sound intensity measurements
- Continuous measurements during regular operation can be performed

Modern analysis techniques:

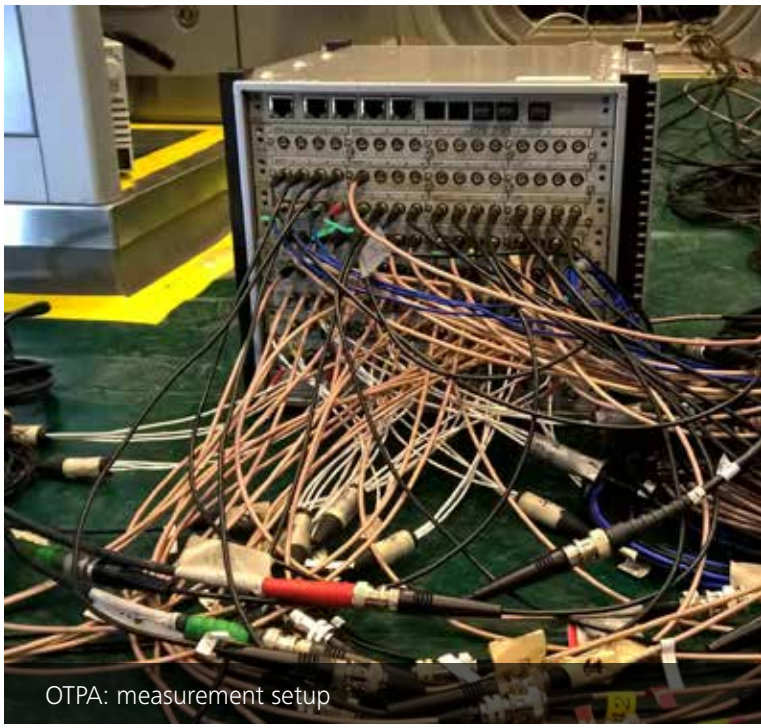
- Transfer path analysis (classic TPA) and operational transfer path analysis (OTPA)
- Operational deflection shape analysis
- Modal analysis
- Localisation of sound sources (array measurement technology)
- Analysis of rotational vibration
- Psychoacoustic methods and analyses
- Model updating with FEMtools



PAK®: localization of sound sources



FEM: noise mitigation of a platform edge



OTPA: measurement setup

Labs and test stands (selection)

- Test stand for the determination of the dynamic stiffness of resilient elements (e. g. for bearings or sub ballast mats)
- Floor/wall test stand for the determination of the sound reduction index of complete floor structures or other components such as access doors
- Echo chamber for the determination of the sound absorption coefficient
- Hemi-anechoic room with low background-noise for the determination of the sound power level of components
- Test stand for structure-borne sound damping

Calculative tools

- Hybrid model NOMAC prediction tool developed by Müller-BBM for the calculation of airborne and structure-borne noise contributions to the interior noise of a vehicle
- Ray-tracing for the calculation of speech intelligibility and of the local sound pressure distribution in the vehicle interior
- Statistical energy analysis (SEA) for calculation of sound insulation
- Methods according to ISO 9613-2 for calculating the exterior noise
- Boundary element method (BEM) for the calculation of radiated sound
- Wheel-rail-impedance model RIM for the prediction of pass-by noise levels, vibration levels and sound contributions of the components wheels, rails and sleepers as well as for the prediction of ground-borne vibrations

MÜLLER-BBM

Consulting and Assessment
for Industry, Infrastructure and Trade

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Müller-BBM Industry Solutions GmbH is a subsidiary of Müller-BBM AG, with headquarters in Planegg near Munich. Since 1962 Müller-BBM has been advising clients nationally and internationally and is now one of the world's leading engineering firms. More than 350 highly qualified employees form an interdisciplinary team of scientists and engineers in the most diverse specialist fields. The company currently has twelve offices in Germany as well as a branch office in Austria.

Notifications
Müller-BBM Industry Solutions GmbH is notified as an expert authority in accordance with § 29b of the German Federal Pollution Control Act (BImSchG).

The notification comprises
- determining emissions and immissions of air pollutants, noise and vibration
- verifying the correct installation and function in addition to the calibration of continuous emission measurement systems (CEMS)
- checking combustion conditions

Accreditations
Our testing and calibration laboratories are accredited according to DIN EN ISO/IEC 17025:
- Test laboratory for sound and vibration, electromagnetic fields and light, air pollution control, measurement of hazardous sustances
- Calibration laboratory for acceleration and acoustical quantities

Müller-BBM Industry Solutions GmbH has a significant number of employees with competency certificates that were awarded to them on an individual basis. They include publicly appointed and sworn experts, state-recognised experts and otherwise appointed and notified experts.

Detailed information on the scope of our accreditation, its international validity and the corresponding certificates can be found on http://www.mbbm-ind.com/about-us/quality

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