

# CASE STUDY

Carcoustics Tech Center GmbH

Germany

Automotive

Automotive NVH Testing Using PULSE

PULSE™, Software applications, Transducers

*Carcoustics International GmbH is a global leader in the design, development and manufacture of total vehicle acoustics solutions for the automotive industry. Focusing on the mid- to high-range passenger car market, Carcoustics' customers include many of the world's leading automotive manufacturing companies.*

*A PULSE data acquisition and analysis system, together with noise source mapping and acoustical holography techniques, are widely used in the development of cost-effective and efficient noise-reducing solutions and for the validation of acoustic simulation models based on statistical energy analysis.*

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The above illustration is a graphical display from Spatial Transformation of Sound Fields (STSF) Software Type 7688. A digital picture of the test object (in this case, a complete vehicle dashboard) has been superimposed on the contour plot. Areas of special interest have been mapped and named, and are defined by the green and red rectangles. The averaged sound power of each area is displayed. In the graph of sound power vs. frequency, the black curve shows the integrated sound power of the whole test area. The green and red curves denote the partial sound power contribution of their defined areas.

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## The Power of Silence

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**Fig. 1**

*Christine Völker is Head of Acoustics at Carcoustics' Leverkusen Tech Center*

Originally founded over 50 years ago, today Carcoustics has 18 facilities in 12 countries, and employs some 2200 people. The company focuses on the development and production of air-borne absorbing, insulation and damping solutions for complete cars, systems and components. Carcoustics mid- to high-range automotive customers include such prestigious names as VW, Daimler Chrysler, BMW, Ford, Audi, GM, Fiat, Jaguar, Renault, Nissan, to mention just a few.



Carcoustics' Tech Center, located at the company's head quarters at Leverkusen, 20 km north-east of Cologne, Germany, has impressive test and measurement facilities including semi-anechoic rooms, a transmission loss suite, material testing equipment, test tracks and a large two-axle dynamometer test cell. Independent of wind and weather, this test facility enables the

acoustic characteristics of a complete vehicle to be analysed under simulated driving conditions.

Carcoustics is globally accredited to ISO 14001 and ISO 16949 (the automotive quality standard).

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## Acoustic Expertise

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Christine Völker is responsible for the acoustic department with 15 people. Christine has a degree in Physics. Christine says, "Forty people work at our Tech Center here at Leverkusen. The departments included are Predevelopment, Acoustics and the Material Laboratory. We also have a Tech Center at our site in Novi, Michigan to support our American customers and a Competence Center in Liechtenstein that develops aluminium heat shields and thermal insulation systems".

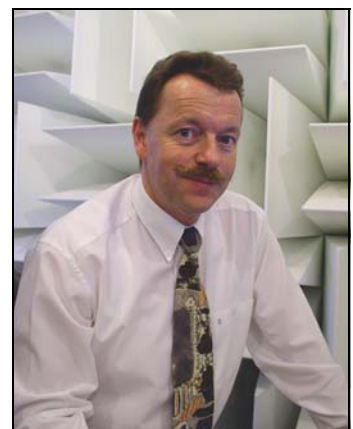
She continues, "The NVH specifications for components are driven by the market – the vehicle manufacturer and their customers – the strategies for providing optimal solutions, and the testing methodology, are driven by Carcoustics".

**Fig. 2**

*Ralph Bungenberg has worked at Carcoustics' Tech Center for nine years. He has been responsible for the design of many of the test facilities, including the impressive two-axle dynamometer test cell*

Ralph Bungenberg, an acoustics expert, has worked at Carcoustics Tech Center for nine years and was responsible for the design of many of the company's test facilities. Ralph has degree in Mechanical Engineering from Cologne University.

Ralph says, "I have broad experience in acoustic engineering, and my hobby is the design and construction of loudspeakers and enclosures. I had always wanted to build an acoustics lab and so it was an easy decision to come to Carcoustics when I was offered this opportunity. These days, my main focus is on acoustic simulation using statistical energy analysis techniques, although I still do plenty of practical testing, often to verify the mathematical models".



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## Acoustic Simulation

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Carcoustics' products range from large blow-moulded panels, components using foam composites, through to moulded carpets specially developed for the automotive industry.

**Fig. 3**

*Carcoustics Tech Center extensively uses mathematical modelling software to simulate the acoustic performance of its solutions*

The company is building up a huge internet-based database of complete cars and components, and the effects of damping, insulating, absorbing and heat-resisting materials. This database provides an initial specification for the design of components, specification of materials, and enables an accurate prediction of the acoustic parameters of vehicles in combination with simulation tools like AutoSEA.



In former times there was a special focus on noise and heat reducing solutions in the engine compartment. But today Carcoustics' strategy is the development of complete car acoustic packages.

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## Demands for Quieter Vehicles

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Ralph says, "On walking into a showroom, a customer's first impression is visual but the second is sound when the door is opened. In Germany, more than 60% of complaints on new cars are related to noise and vibration".

**Fig. 4**

*Carcoustics' two-axle dynamometer test cell. This state-of-the-art facility enables the acoustic characteristics of a complete vehicle to be analysed under simulated driving conditions*

He explains, "The demands for quieter, more comfortable vehicles constantly increase. Our customers are our partners and together our goal is to develop innovative, cost-effective solutions to reduce airborne noise. We are frequently involved in the design of acoustic solutions for a vehicle at the very earliest stages of its design. We extensively use mathematical models to simulate the acoustic parameters of a new vehicle and this substantially reduces the number of prototypes and tests, and shortens the time to market".



Once the specification for a component, based on optimal cost, weight and performance, has been agreed, prototypes are built and extensively tested.

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## Acoustic Measurements

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### Facilities

Carcoustics Tech Center has an impressive range of NVH test facilities. These include a very large two-axle dynamometer test cell that enables the acoustic characteristics of a complete vehicle to be analysed under simulated driving conditions. Vehicle can be tested with road load simulation, braking and acceleration at speeds up to 200 km per hour, and can accurately simulate road/street noise. The dyno can either be passive or active and, in passive mode, can calculate the load for a specific car. In active mode, it can be used to generate noise source for us with mathematical models. STSF techniques are used in this test cell to investigate the results of components applied to the vehicle, for example, engine noise damping solutions.

There are small semi-anechoic rooms for testing components and complete systems, and several transmission loss test setups. There is also a mid-size semi-anechoic room, large enough to accommodate a complete vehicle. It includes exhaust extraction facilities, enabling the engine

to be run without a load, and a water arch that simulates the sound of water splashing on the vehicle body.

Ralph says, “We have developed a unique multi-dimensioned homogeneous-field noise point source for use within the vehicle cabin (patent pending). We measure once inside the vehicle and then outside using NSI or STSF techniques, and correlate the results

Carcoustics has also developed a special test facility for measuring on the floor pans of vehicles. This uses six broad band loudspeakers driven by white noise. This setup is especially useful for measuring the noise insulation characteristics of carpets, with the benefit that the component being tested lies in-situ – the carpet is flat on the floor pan, and the roof lining hangs down from roof panel. Measurements are made from 315 Hz to 10 kHz.

### Data Acquisition

Carcoustics’ relationship with Brüel & Kjær goes back more than 20 years. A 24-channel PULSE data acquisition and analysis system was purchased in 2002, mainly for noise source identification and acoustical holography testing. PULSE is also used to measure vibration using a laser doppler vibrometer. Carcoustics also has its own ISO 362 pass-by test track facility.

**Fig. 5**

*Left: In a transmission loss facility, a complete vehicle dashboard is installed in the aperture. The sound intensity probe, attached to its robot control system can be seen in the lower left-hand corner  
Right: Close-up view of Sound Intensity Probe Type 3548*



Ralph explains, “The use of simulation tools reduces the development time, increases the number of variants and puts emphasis on the need for practical testing to validate the acoustic performance of our solutions. With large modules such as vehicle front ends, floor pans or doors in our transmission loss test setups, we use PULSE, Sound Intensity Probe Kit Type 3599, Rotating Microphone Boom Type 3923, a positioning robot and noise source mapping software to determine the acoustic properties of the complete component”.

**Fig. 6**

*The noise source in the reverberant room of the transmission loss suite is OmniPower Sound Source Type 4296 driven by Power Amplifier Type 2706*

He comments, “Brüel & Kjær’s quality is excellent, and PULSE is a very good standard platform for NVH testing – from basic sound level measurements to advanced structural and acoustic holography applications – and it enables us to make instant reports in our own templates”.



The first step is to test the component without any noise damping material. The Carcoustics solution is then added. Depending on the component or assembly, between five and thirty measurements can be made and the test data compared during post-process analysis. The NVH parameters of the test object are either defined by Carcoustics, based on its great experience, or specified by the customer in relation to NVH targets for a complete vehicle or component.

White noise from the built-in PULSE generator, via Power Amplifier Type 2706, drives a OmniPower Sound Source Type 4296 (12 loudspeakers in a dodecahedral configuration).

Up to 3200 test points can be made to build a contour plot of the test object over a frequency range from 200 Hz to 10 kHz.

Ralph says, “Each test takes two to three hours. Depending on the object being tested, we may make between five and thirty different measurements and the data is compared with previous test results during the post-processing analysis. Our test data is extremely valuable”.

Ralph continues, “The results from noise source identification measurements are correlated with the results from material testing. Of course we also make a lot of sound power measurements using PULSE and CPB analysis. We have about 100 measurement microphones and most of these are from Brüel & Kjær. We calibrate the microphones before and after each test using Sound Level Calibrator Type 4231.

### Material Testing

To test the mechanical and acoustic characteristics of raw materials, Carcoustics has a Brüel & Kjær Impedance Tube Kit Type 4206, Power Amplifier Type 2716 C and Complex Modulus Apparatus Type 3930 (Oberst). Data acquisition is made using a Brüel & Kjær two-channel analyzer Type 2035.

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## Spatial Transformation of Sound Fields

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**Fig. 7**  
*Ralph Bungenberg uses PULSE and Spatial Transformation of Sound Fields (STSF) Software Type 7688 in one of Carcoustics semi-anechoic rooms. The robot control system for the microphone array can be seen in the background*

Ralph continues, “We are expanding our use of PULSE and acoustical holography using Spatial Transformation of Sound Fields (STSF) Software Type 7688 and it is our intention to use STSF for this type of application in the future. We are constantly learning how to interpret the measurement results. It’s clear that STSF techniques will give us several benefits”



He continues, “Firstly, it will considerably reduce the measurement time. STSF will give us direct pictures and it is easy to superimpose a digital picture of the test object onto the contour plot. This is very useful in reporting results and discussions with customers. But perhaps the most interesting benefit is that it enables us to easily investigate damping at a local point and to target the solution”.

**Fig. 8**  
*Set of carpets for Jaguar’s XJ series*

We can then change the material, for instance by making a complete one piece foam-based component thicker or thinner in one specific place. This means we can target our solution and offer our customers the most cost-effective and efficient noise reduction”.



Carcoustics Tech Center in the USA also has PULSE. “Using our intranet, it’s very easy and convenient to share test data with our colleagues, and when required, we can exchange complete PULSE projects”, says Ralph.

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## Expanding Competence and Markets

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Carcoustics is constantly expanding its competence in total vehicle acoustics. For example, the company recently acquired a facility in the UK that manufactures automotive carpet materials, and a state-of-the-art carpet moulding machine has been installed at Leverkusen Tech Center.

Carcoustics continues to serve its customers, by providing innovative, and light-weight effective acoustic and thermal management solutions, but it is bringing these solutions to new market areas, including commercial vehicles and heavy trucks, and entry into the Asian market.

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## Key Facts

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**Fig. 9**  
*Spatial Transformation of Sound Fields (STSF) Software Type 7688 uses a large robotically positioned microphone array for data acquisition*

- Carcoustics International GmbH is a global leader in the design, development and manufacture of total vehicle acoustics solutions for the automotive industry
- The company focuses on the development and production of airborne noise absorbing, insulation and damping solutions for complete cars, systems and components
- Carcoustics' customers include many leading automotive manufacturing companies
- Carcoustics' Tech Center has impressive test and measurement facilities
- Carcoustics is globally accredited to ISO 14001 and ISO 16949
- "The demands for quieter, more comfortable vehicles constantly increase"
- Carcoustics' relationship with Brüel & Kjær goes back more than 20 years
- A 24-channel PULSE data acquisition and analysis system was purchased in 2002
- "Brüel & Kjær's quality is excellent, and PULSE is a very good standard platform for NVH testing"
- "We are expanding our use of PULSE and acoustical holography using Spatial Transformation of Sound Fields (STSF) Software Type 7688"
- "It's clear that STSF techniques will give us several benefits – it will considerably reduce the measurement time"
- Carcoustics is constantly expanding its competence in total vehicle acoustics
- Carcoustics continues to serve its customers, by providing innovative and light-weight effective acoustic and thermal management solutions, but it is bringing these solutions to new market areas, including commercial vehicles and heavy trucks, and entry into the Asian market

