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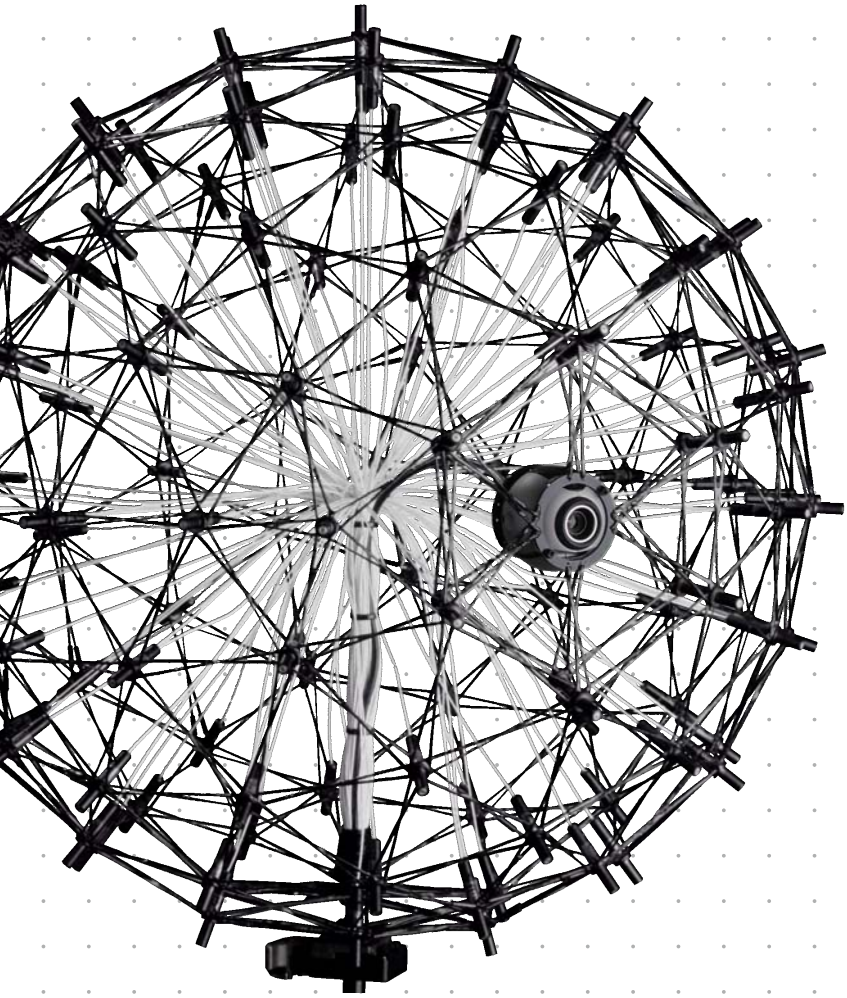
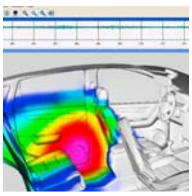
acoustic **camera**

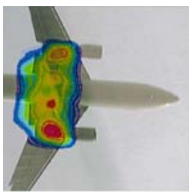
The original.



acoustic **camera**.
Listening with your eyes.







We are the pioneers in acoustic imaging systems – and world market leader!

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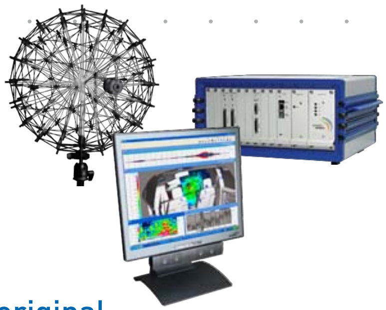
Company profile.

The Society for the Promotion of Applied Computer Science **(GFaI)**, where the **acoustic camera** was designed, was founded in 1990 with its head-quarter in Berlin. The institution offers custom R&D services. The list of references of successful projects ranges from small and medium sized enterprises to research establishments and major corporations.

gfai tech GmbH is a wholly owned subsidiary of GFaI and is responsible for the production and marketing of the GFaI product line.

acoustic
camera



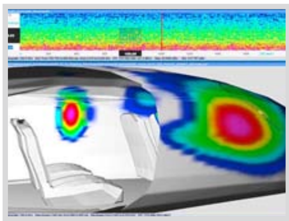
acoustic camera – The original.

The **acoustic camera** of GFaI was the first commercially viable system to localize acoustic emissions. Brought to market in 2001 as a pioneer technique, the **acoustic camera** has become a metaphor for beamforming systems over the years.

However, GFaI's **acoustic camera** remains "The Original" and continues to surpass any competitor products both technically and when applied 'in the field' – proven by the trust and steadily growing number of customers from various industries, ranging from automotive and aerospace to engineering and consulting.

Our success is built upon three pillars: innovative power, strict quality standards and the solid engineering capabilities of our team. We are in constant contact with our customers from all over the world and use their feedback to develop the **acoustic camera** further and adapt the system to our clients' needs.

This brochure shall give an impression of the wide field of applications for the **acoustic camera** and introduce the system itself with a selection of its most interesting features. However, there is much more to discover!



Measurement examples from various industry sectors.

The acoustic camera. Intelligent problem solver – universally applicable.

Measuring a mining bridge
with the Star Array.

acoustic camera – Listening with the eyes.

Using their eyes, human beings can gather information more quickly and with more flexibility than with any other sense organ. This is why complex processes are "visualized" and great technical effort is made to extend vision to fields that the eye usually cannot see. X-ray machines, magnetic resonance imaging devices and infrared cameras are only a couple of examples for technical instruments visualizing the invisible.

As far as sound is concerned, the developments are less advanced. What would be the advantages if sound was visible?

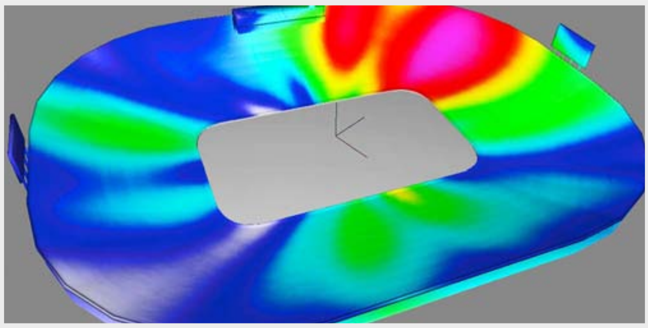
Noise – Environmental sound pollution.

Sound and noise are omnipresent in our everyday life. Unlike your eyes you can never close your ears. Increasing traffic on the ground and in the air, more powerful machinery and tools are only a few examples contributing to an increasing noise level which affects people's everyday life and pollutes the environment.

The first step in making the environment quieter and more comfortable is to perform a detailed analysis of the undesired noise sources in a fast and efficient way.

Designers and engineers can take effective measures to reduce noise only if the sources of noise emission are exactly known. But this is where the problems usually start: Which components, assemblies or installations are really responsible for noise emissions? How is it possible to measure and document the successfully identified noise?

acoustic **camera**



Noise measurement of 110,000 people in large sports stadium.

Product sound – Product quality.

Sound is an important quality aspect. Year after year, the automotive industry invests tremendous amounts of money to locate and analyze noise sources and to reduce their intensity if not their occurrence. The characteristic sound of a car has always been a very important marketing argument. A sports car must be distinguishable by its characteristic sound when it passes by. Any type of side tone is undesired and must be eliminated. How is it possible to achieve these aims faster and more effectively than ever before?

Acoustic quality assurance.

Faults in machinery and plant installations can often be detected by a change in their noise emissions. An experienced mechanic can actually hear a fault. Some manufacturers rely on the excellent hearing skills of a few staff members to identify faulty products in the final quality control. How can tests like these be automated and made more objective?

The solution: making sound visible – Fast and easy

The **acoustic camera** delivers a groundbreaking tool to solve these types of problems. For the first time, a portable system can be used to visualize sounds and their sources. Maps of sound sources that look similar to thermographic images are created within seconds. Noise sources can be localized rapidly and analyzed according to various criteria.

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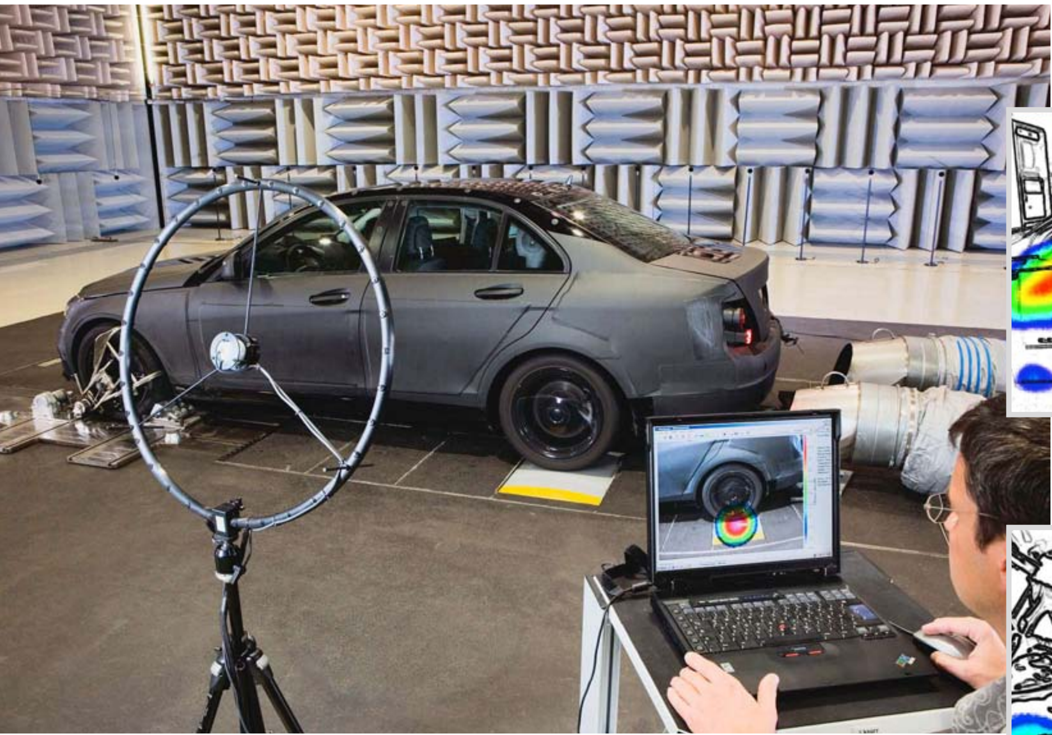
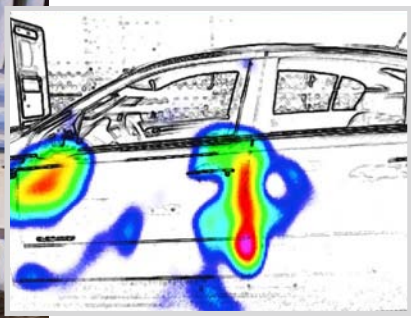
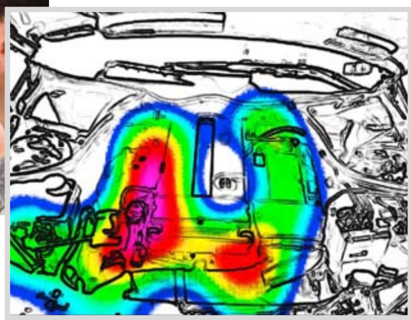
Fast results. Visualization in real-time or as acoustic fingerprint.



Ring Array for exterior measurements visualizing acoustic sources in 2D mode.





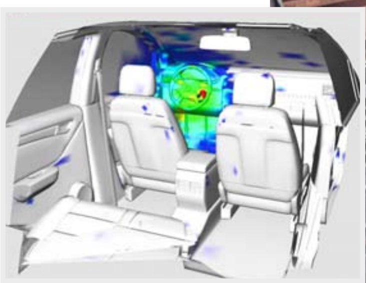
Photographing and filming sound.

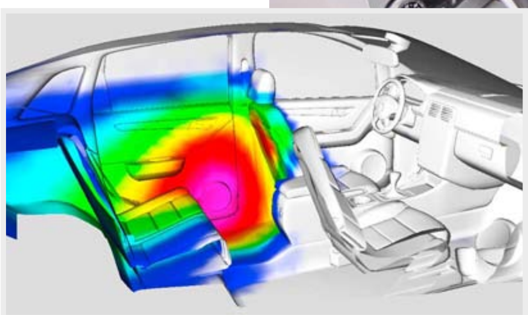
There is a simple, yet ingenious idea behind this revolutionary solution. A digital camera is used to acquire an image of the noise-emitting object. At the same time an exact defined array of microphones records the sound waves emitted by the object. Dedicated software then calculates a sound map and combines the acoustical and the optical images of the noise source.

The handling and operation of the **acoustic camera** is almost as easy as with a common camera. You can monitor the target object in real time on-screen in a preview window. When you are done with the setup you just press the "shutter release button" – and that's it! The acoustic "fingerprint" of the target object has been acquired.

The computer can calculate various sound maps, i. e. acoustic still images or videos. The complete soundscape which usually consists of a combination of many sound sources can be broken down into individual sources which are displayed through different coloring. The map visualizes the distribution of the sound pressure. It is now possible to identify the relevant sources of high sound levels.

Up to now, this has never been done within a short time frame. The **acoustic camera** has established itself as an indispensable tool whenever fast and reliable answers are needed.





Above: Sphere Array for interior or room measurements.

Left: Visualization in 3D mode mapping acoustic information onto a 3D model.

Intelligent system concept.

Engineers in the industries work under immense pressure with respect to time and money. They need tools helping them to identify and to solve problems without creating new difficulties. Thus, the design of the **acoustic camera** is built upon modularity, ease of use and intuitive operation of the software.

The system comprises the microphone array with the implemented camera, a data recording device and a notebook. The customized arrays are designed for different fields of application. The array setup is done within minutes. The system is immediately ready to use.

In addition to the sound recording it is possible to acquire parameters like revolutions per minute, angle of rotation, voltages and currents. This facilitates a temporal and spatial allocation of sound sources to the operating state of the measured object.

High precision noise investigation. Exact localization and identification of noise sources.

Set-up for acoustic measurement of industrial plant and Acoustic Photos 2D.

Noise reduction – A compelling task for industrial societies.

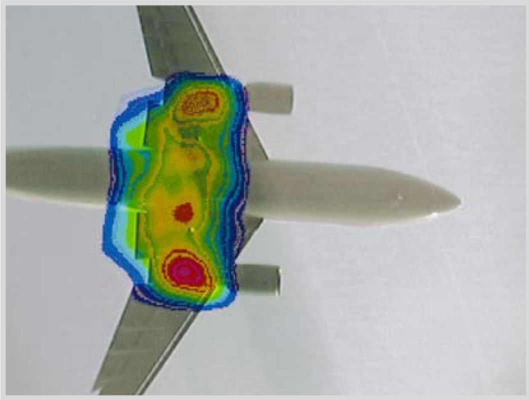
Noise – an often underestimated pollutant. The human heart rate increases when exposed to sound levels above 65 decibels. At night, when cars and other vehicles only penetrate the subconsciousness, traffic noise can disturb human's health by affecting the quality of sleep.

Legal requirements for the operation of technical devices are becoming more and more stringent. This is the case not only for planes and industrial installations but also for a lot of electrical equipment. In addition, lower noise level is a good sales argument. However, machines and equipment must become more and more powerful, faster and lighter which leads in many cases to increased noise emissions. Also eco-friendly wind turbines can become a factor of annoyance. To meet these conflicting demands enormous investments have been mandatory in the planning and development stages.

When traditional technology is used to measure a wind turbine, for example, data from numerous measurement points must be acquired using microphones or vibration transducers. This is certainly not an easy task taking into account the size of the object and the rotation of the blades. Afterwards it remains questionable whether the sources that are found to be especially loud are responsible for the elevated noise emissions.

There is always the risk of taking the wrong measures to reduce the noise emissions since these measures would be based on insufficient (and sometimes inadequate) data. When the true origins of noise exposure are not exactly known, it becomes harder or even impossible to correctly assign the responsibilities. Vast amounts of money could easily be spent without the desired effects.

acoustic **camera**

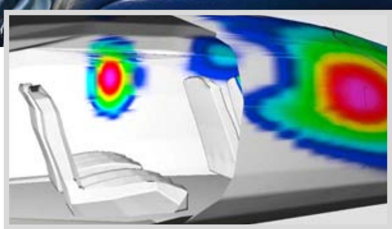


Noise radiation from aircraft engines, gear and flaps and Acoustic Movie 2D.

Accurately identifying and documenting sources of noise – In best time.

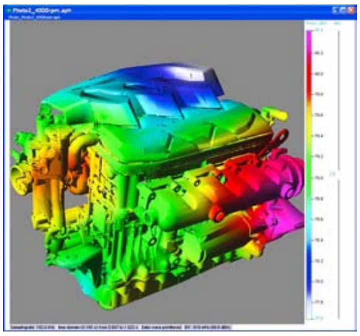
The **acoustic camera** can save an immense amount of time and corresponding money. Noise sources can be localized rapidly and very precisely from the position of the listener – even at distances of several hundred meters.

The method has numerous advantages. Instead of placing microphones in a machine or plant and strenuously looking for noise sources, the object as a whole can be surveyed in only a few measurements from the relevant perspectives. Moreover, documenting the success of the noise reduction is much easier with the **acoustic camera** system. Gathering two acoustic images – one "before" and one "after" – can clearly show the effectiveness of a modification.



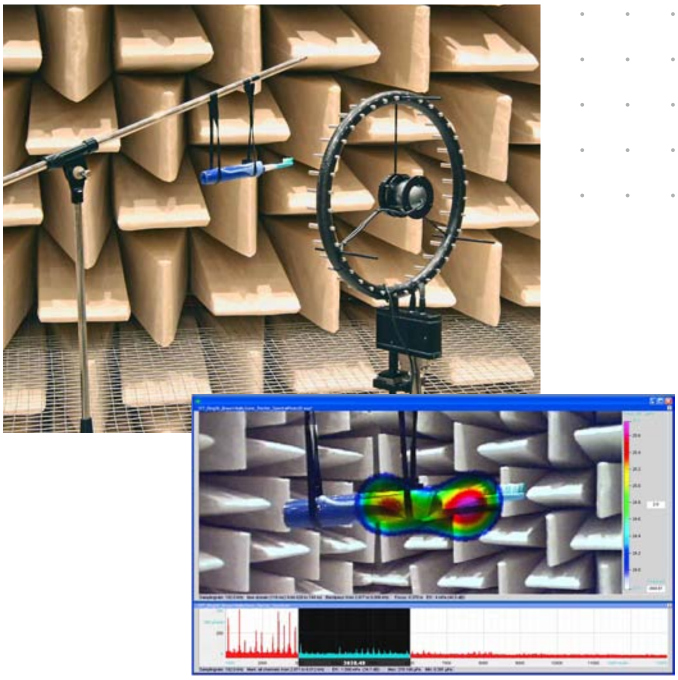
Position of Sphere Array in aircraft cabin and Acoustic Photo 2D.

Optimized spectrum of analysis. Enhanced and extended analysis methods in product design.



Above: Underhood measurement using Ring Array.

Left: Acoustic Photo 3D of an engine.



Measuring acoustic emissions from toothbrush – set-up and result.

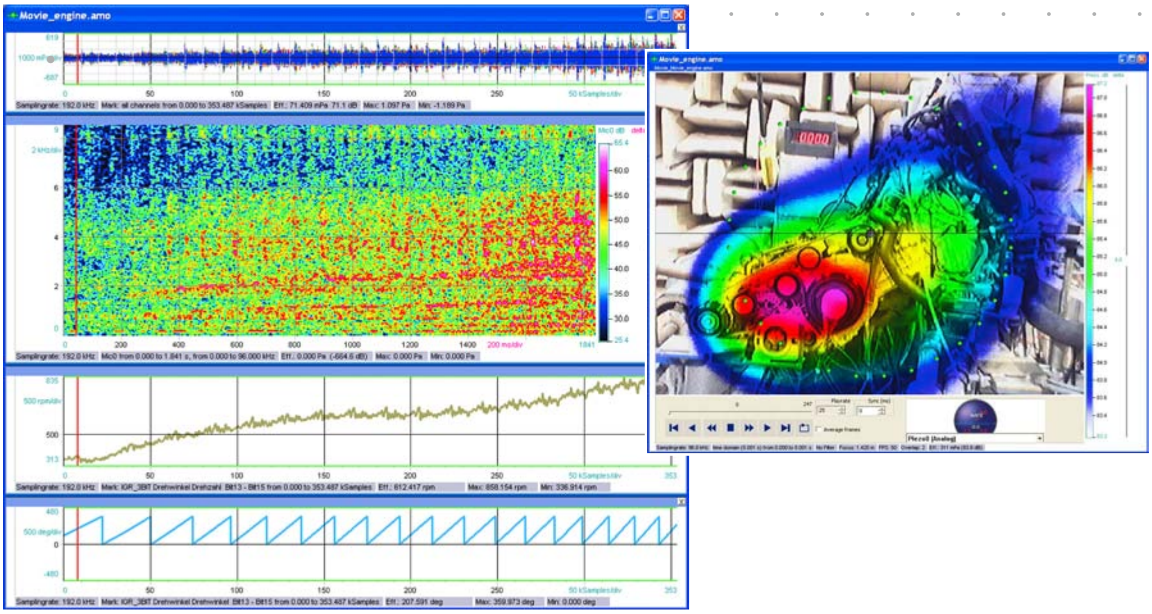
High-quality sound brings high-quality product.

Sounds do not necessarily have to be loud to cause discomfort. In many cases there are sources far quieter than the dominant sound that seem to be psychoacoustically dominating. Some of the most significant examples for this phenomenon exist in the automotive industry where the **acoustic camera** has already been applied with great success.

Rattling, hissing or clicking noises are undesired in any vehicle. Even at high speed the pianissimo parts of classic music should not be drowned by driving noise. Shutting the door, however, must produce a solid sound despite the lightweight construction. There are similar requirements for the sound of car engines. The roar of a sports car or the smooth and refined sound of a sedan are typical distinctive characteristics of car brands.

This is why a lot of effort is put into modeling the desired sound and eliminating disturbances. Sound issues are also playing an increasingly important role when it comes to household appliances. Some high-value products can already be identified by their "high-value sound". Noises that are usually associated with faults, like clicking, crackling or whistling sounds, can irritate customers and frequently lead to unnecessary complaints.

Time, frequency and modal analyses have been the means of choice so far to trace undesired noises. But these methods have a decisive disadvantage: The spatial resolution is limited if not missing.



Engine sound relating to crankshafts angle and rpm.

Space-, time- and frequency-selective measurements.

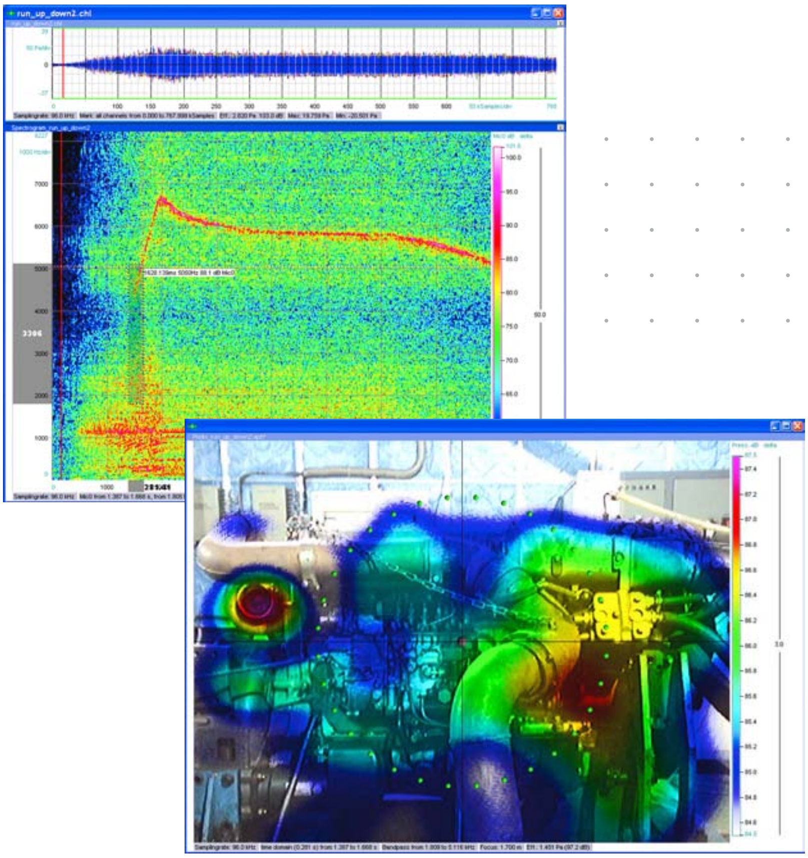
The **acoustic camera** can extend the known standard time- and frequency-selective analysis and add a location-selective component. With this method not only the progression of the sound signal is shown but a sequence of acoustic images can be acquired: Acoustic films are generated. The analysis clearly shows which sound sources are active in time and location. Extreme slow motion is possible – up to a resolution of 192,000 images per second if required. Noise paths become visible, active sound sources and passive reflections are isolated. Entirely new insights and perceptions about the development of sound and noise are offered. It is also possible to analyze sounds from moving objects.

The **acoustic camera** extends and enhances existing analysis methods.

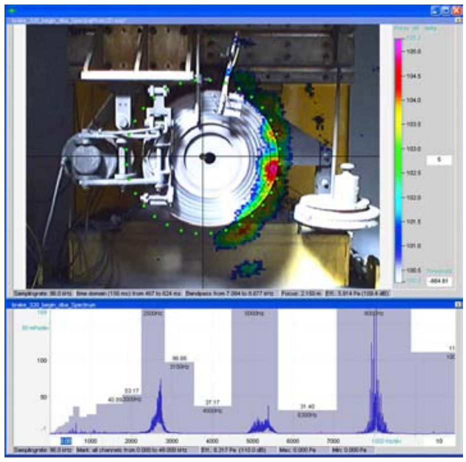
The **acoustic camera** comprises traditional analysis methods like A-weighting, one-third octave band analysis, narrow band analysis, filters, and many more. Based on these methods far more detailed research becomes possible.

In a spectrogram, for example, sounds can be highlighted in the time and frequency domain. The **acoustic camera** then shows the exact origin of this sound. The approach can also be made from the other end: After selecting a spot on the measured object, the sound originating from that spot can be reconstructed, visualized and broken down into its spectral components. It is also possible to replay the sound via speakers – any time after the measurement has been completed.

Profitable quality assurance. Save time and money by professional quality control.



Time- and frequency-selective images (as highlighted in spectrogram).



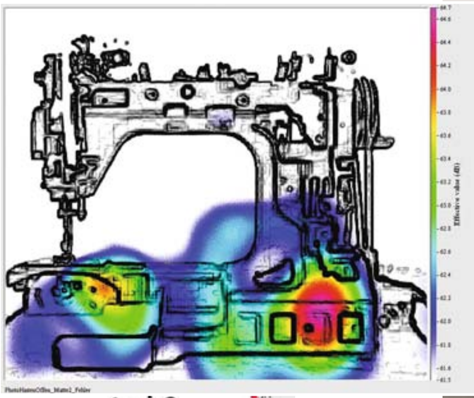
Virtual scanning of a brake showing the location-selective spectrum of mouse cursor.

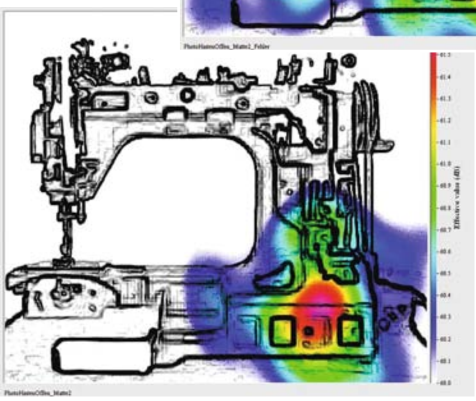
Multi sensor technology – Virtual sound studio.

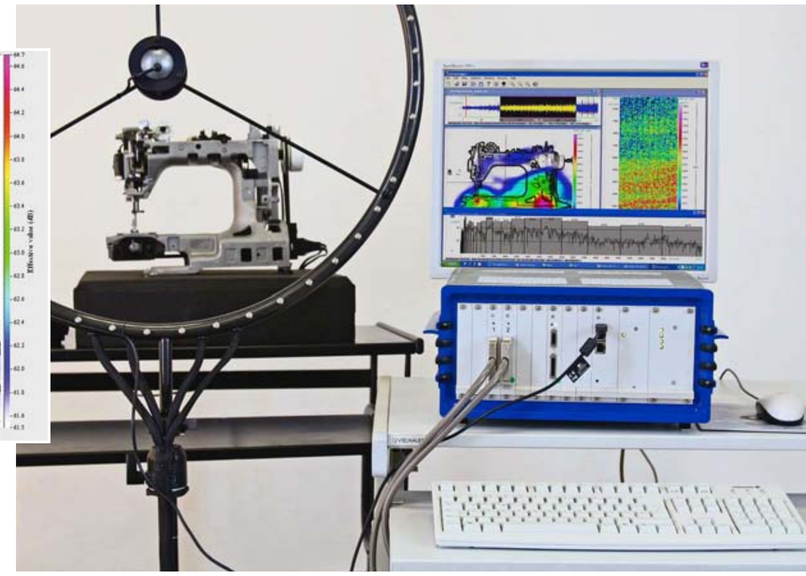
The more senses are used to gather information, the better human beings can recognize complex situations and act accordingly. This is why acoustic and visual signals are used in aircraft cockpits to present information.

The **acoustic camera** acts according to the same principle in order to show interrelations between heard and "seen" sounds. When the measurement is complete the acoustic image or the acoustic film can be virtually replayed – as if the running machine was scanned in real-time using a directional microphone. The sound originating from the predefined spot will be replayed using the speakers of the computer system. Sound sources that are usually drowned by louder sources become audible. The image can be animated by the software resulting in an acoustic film. The spectrum of the spot can be displayed if required.

One convincing advantage of this method is that all the calculations can be done anytime after the measurement is completed. Neither the measured object nor the camera needs to be mounted in place. All data required for these functions is recorded and saved during the measuring session. The analysis of the data acquired can be performed any time using a standard computer.







Above: Ring 48 Array measuring sewing machine.

Bottom Left: Normal soundscape of a sewing machine.

Top Left: Fault in bobbin mechanics.

The **acoustic camera** facilitates identification of faults and defects.

Many of us have already experienced the following situation: The car engine is running but something sounds differently. An experienced driver can hear that something is wrong with the car even before any warning light on the dashboard comes up. The same is true for many industrial applications: Numerous faults can be detected just from variations in the sound emission. In quality control experienced staff can often identify faulty products just from their abnormal sound.

The **acoustic camera** can find faults resulting in variations in the sound field as an objective instrument without depending on the disposition of quality assurance staff. Two acoustic images can be placed side by side in the software to perform a simple comparison of nominal and actual values. The same value range is applied to both images with a click of a mouse button. Any variations become obvious and the visual presentation also reveals where exactly the fault is located.

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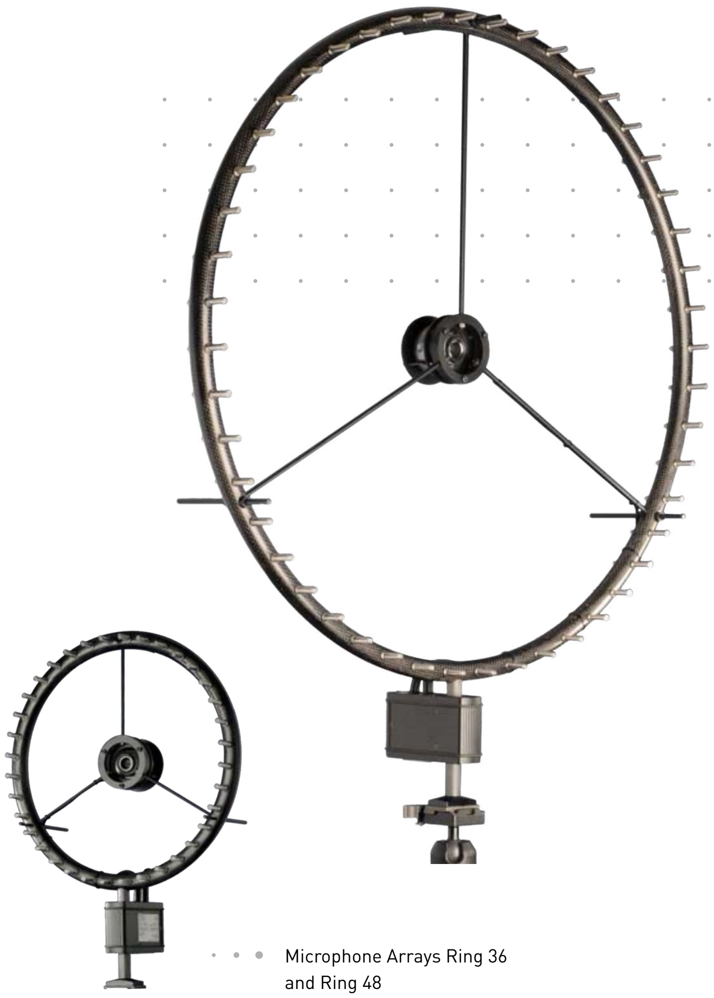
Individually configurable system.

Microphone Arrays.



Microphone Arrays Ring 36 and Ring 48

Ring Arrays for acoustic labs. Star Arrays for open-air applications. Sphere Arrays for interiors.

Since the **acoustic camera** is using beamforming technology the following arrays are designed to serve the specific needs of the user and its application. However, if the mentioned arrays do not serve your special case you can use some of our freely configurable microphone bundles to design your own array.

All arrays include a video camera and microphones which are advanced disturbance tolerant with 1/4˝ symmetrically buffered electret pressure receivers. The material used for the microphone ring is carbon fiber and carbon mesh for the spherical array.

GFaI's partnership with SenSound (USA) allows GFaI to offer a comprehensive acoustic imaging package. The existing **acoustic camera** Beamforming hardware platform now seamlessly integrates with SenSound's Nearfield Acoustic Holography software by using the free configurable microphones. For more information on Holography please see also: www.sensound.com

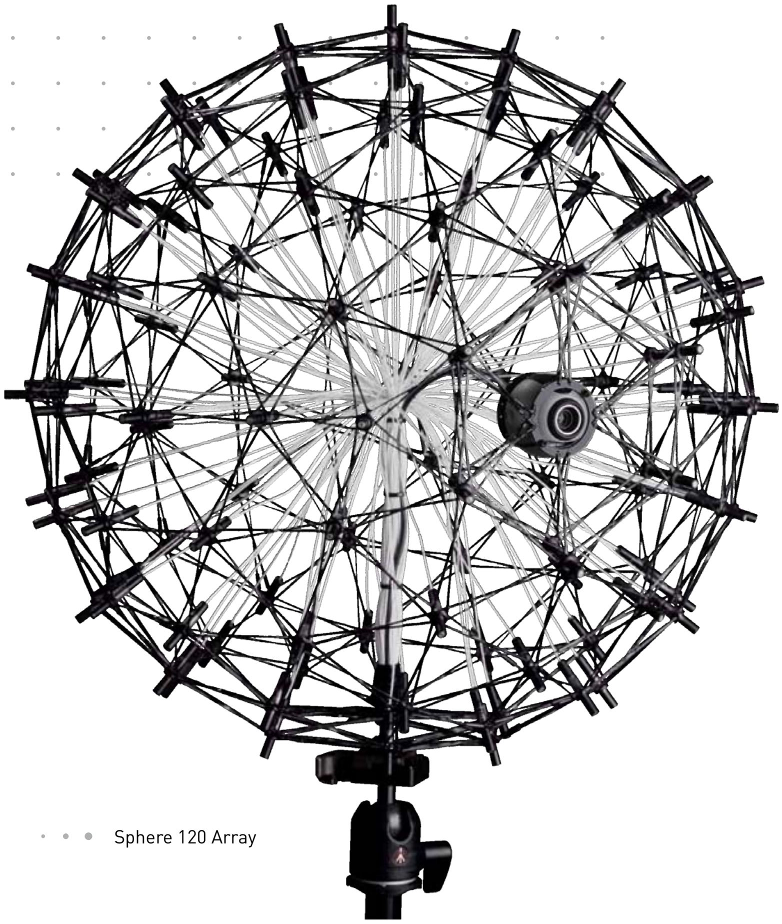
Type	Ring 36	Ring 48
Size	Ø 0.35 m	Ø 0.75 m
Recommended measurement distance	0.4 m to 2 m	0.7 m to 5 m
Number of 1/4˝ electret pressure microphones	36	48
Maximum sound level	130 dB (standard)	130 dB (standard)
Recommended mapping frequency	1 kHz to 20 kHz (50 kHz)	400 Hz to 20 kHz

Ring 36/48 Array for the acoustic lab.

The Ring 48 Array is the preferred choice for a broad range of applications.
When measuring higher frequencies and smaller components an array of smaller diameter with 36 microphones may be favored.

Free configurable 24 channel microphone bundle (10Hz-10kHz) acoustic camera

Sphere 48 Array



Sphere 120 Array

Sphere 48/120 Array for measurements in interiors.

The sphere design is a 48 to 120 channel measurement system for small devices, for measurements in very confined spaces and for high frequencies. The microphone construction is made from carbon fiber material and guarantees maximum acoustic transparency. The design minimizes aliasing effects and partial reflections. The array has extremely small microphones to reduce distortions of the wave field.

The array can be set up at the optimum angle on the included tripod. Backward attenuation is high enough to allow an all-around mapping. This makes the system ideally suited for measurements in vehicle interiors and all applications in the room and building acoustics.

Type	Sphere 48	Sphere 120
Size	Ø 0.35 m	Ø 0.6 m
Recommended measurement distance	0.3 m to 1.5 m (longer distances possible for frequencies >3kHz)	0.3 m to 1.5 m (longer distances possible for frequencies >3kHz)
Number of 1/4' electret pressure microphones	48	120
Maximum sound level	130 dB (standard)	130 dB (standard)
Recommended mapping frequency	1 kHz to 10 kHz	600 Hz to 10 kHz

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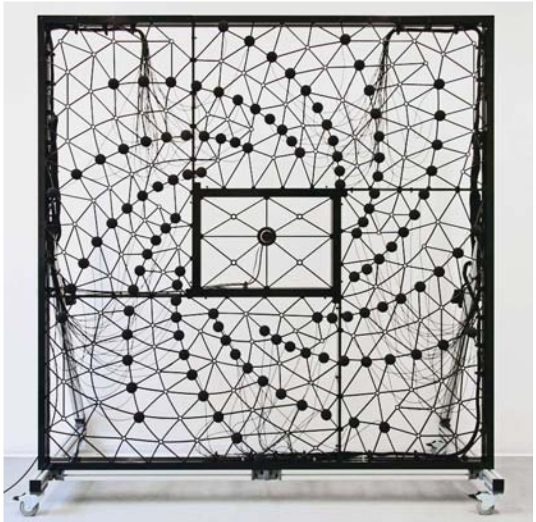
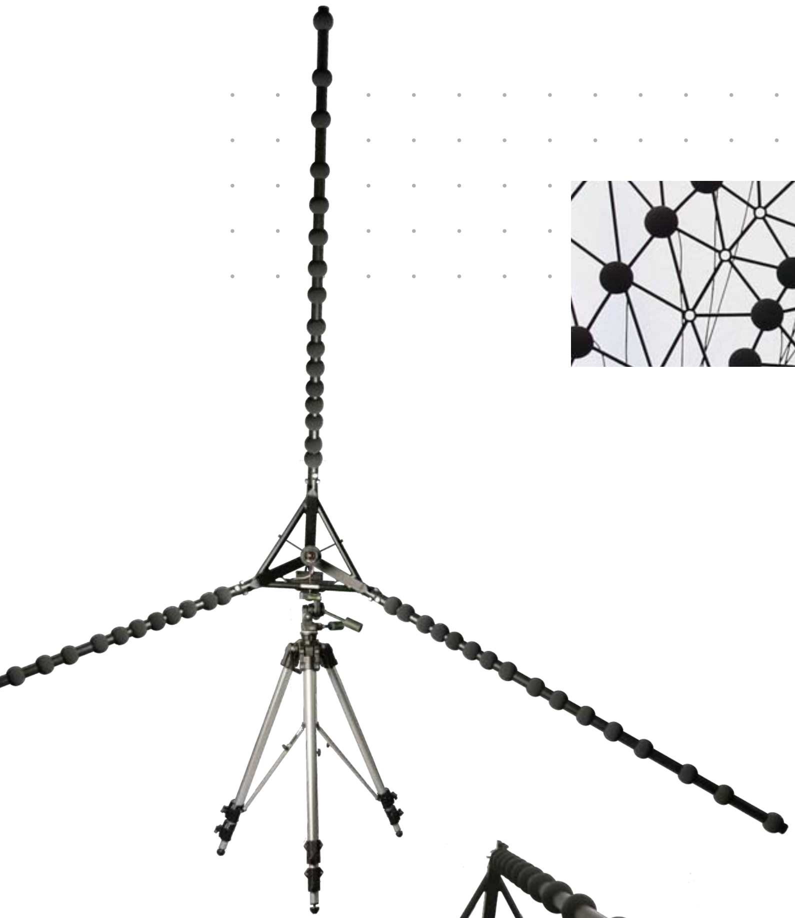
Individually configurable system.

Microphone Arrays.



Spiral 120 Array



Star 48 Array

Star 48 Array for long distances and low frequency application.

The star-shaped array with 48 measurement channels has been designed for measurements over longer distances. The maximum span width is 3.40 m. Thanks to the folding mechanism the entire system can be easily transported in a standard station wagon and quickly set up within a few minutes.

The Star 48 Array is non-planar and the patented construction guarantees a maximum backward attenuation which is a prerequisite for measurements in environments that are not disturbance-free. Pass-by measurement is featured. The included 3 m tripod is fitted with a 3-way head and allows for a setup at the optimum angle.

Spiral 120 Array for wind tunnel application.

The Spiral 120 Array has been developed for the measurement of large objects and special applications, e.g. in a wind tunnel. It achieves an excellent acoustic dynamic range.

Type	Star 48	Spiral 120
Size	Max span width 3.4 m	2 x 2 m
Recommended measurement distance	3 m to 300 m	3 m to 150 m
Number of 1/4' electret pressure microphones	48	120
Maximum sound level	130 dB (standard)	130 dB (standard)
Recommended mapping frequency	100 Hz to 7 kHz (>6dB)	200 Hz to 20 kHz

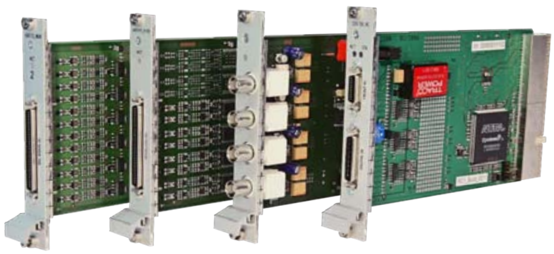
Individually configurable system.

Data Recorder.

Data Recorder mcdRec

Data Recorder mcdRec 721.

The newest generation data recorder has been designed especially for high channel count application and harmonizes best with the **acoustic camera** in any laboratory and in the field. Featuring a modular system configuration it provides a remarkably high data transfer rate and a high level of interface connectivity, e. g. Ethernet. With its newly developed design the data recorder can easily be adapted to changing requirements or new technical developments.



Measurement cards

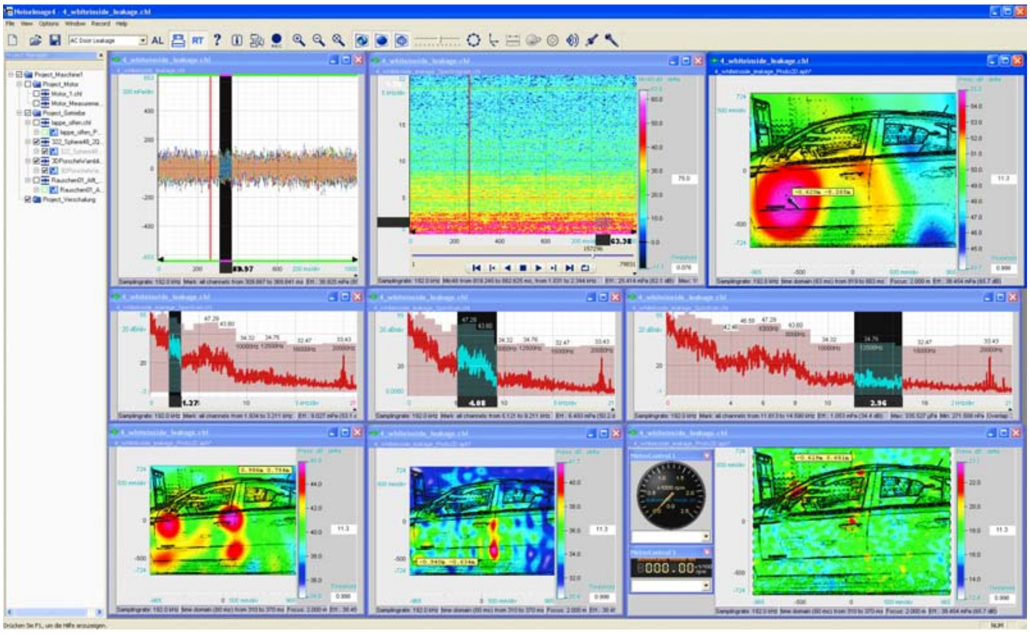
Technical details mcdRec

- 48 to 144 microphone channels in a 10" rack (24 channels per card)
- sampling frequency from 48 kHz to 192 kHz for each analog channel and up to 6 MS/s
- Embedded PC with Windows XP (embedded)
- Network capability
- Gigabit Ethernet Interface, transfer rate 20 MByte/s

From left to right	Type of card	Number of channels	Input
1	cPCI Analog Measurement Card for microphone arrays	24 analog	diff. 2.5 ± 1 V
2	cPCI Analog Measurement Card for AC/DC measurements	8 analog	diff. ± 10 V
3	cPCI Analog Measurement Card for TEDS sensors, 30 bit adc	4 analog	4.7 mA / 1 to 23 V
4	cPCI Digital isolated Measurement Card with Remote Connector	12 digital	-7 V to + 12 V

Individually configurable system.

Software NoiseImage.



NoiseImage enables you to freely choose and display a variety of analyses simultaneously: time-, frequency-, rpm- and space-selective.

Software NoiseImage: acquisition, evaluation and storage of data, acoustic images and movies.

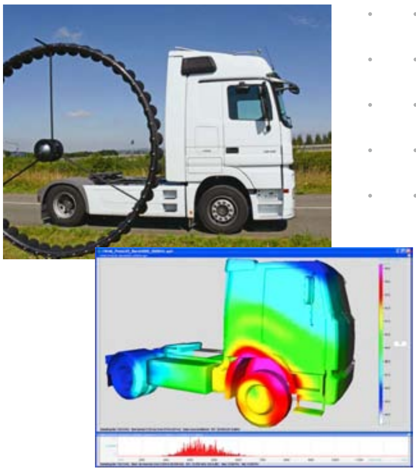
When developing the software great attention has been paid to ease of use, to covering the important questions the user has to answer and to the overall quality and stability of the software. The basic, intuitive and graphically oriented user interface has been continuously upgraded. User experience and recommendations resulting from more than eight years of practical application have influenced the development of NoiseImage and led to many new features within the software architecture.

The complete software is now based on a plug-in concept. Extending the basic module every functional plug-in brings along its own graphical interface and its own tools. The users can decide which functions they really need and can thus arrange a tailor-made software system.

Analysis methods and special features.

- Extended preview in record module
- Oscilloscope for time and spectral functions
- A-, B-, C-standard weightings
- Freely configurable Butterworth filter bank
- Acoustic photos 2D and 3D
- Acoustic movies 2D and 3D (including automatic overlay of optical video)
- Frequency-selective acoustic photo (SpectralPhoto2D and 3D)
- Space-selective spectrum and spectrogram
- Space-selective order spectrum and ordergram
- Channel data export into ArtemiS from HEAD-Acoustics and MATLAB® from The MathWorks, TXT, WAVE etc.
- Maximum buffer time at 48kHz sampling rate is 173s
- Broadband, short time analysis using time/ frequency domain beamforming
- Additional methods like zero-padding, MAX-method, “delete Autocorrelation”, coherence filtering

acoustic **camera**



Measuring acoustic emissions from truck with Ring Array – set-up and 3D result.

Acoustic Movie 2D of a wind turbine and Acoustic Photo 3D of car interior including spectral analysis.

All modules of NoiseImage enable you to map onto 2D optical photo or 3D-CAD-model of the measured object

Acoustic Photo 2D/3D

- High resolution acoustic map (more than 20MPixel)
- Location-selective listening into the acoustic map
- Frequency-selective Acoustic Photo using band filter
- Frequency- and time-selective Acoustic Photo directly from selected region in the spectrogram
- Adjustable contrast of Acoustic Photos (colour palette and pressure- or dB-range)
- Export of Acoustic Photos to Text, JPG, PNG or BMP-format
- To AVI-Format in slow motion (without sound) and in realtime (including sound) in 2D and 3D

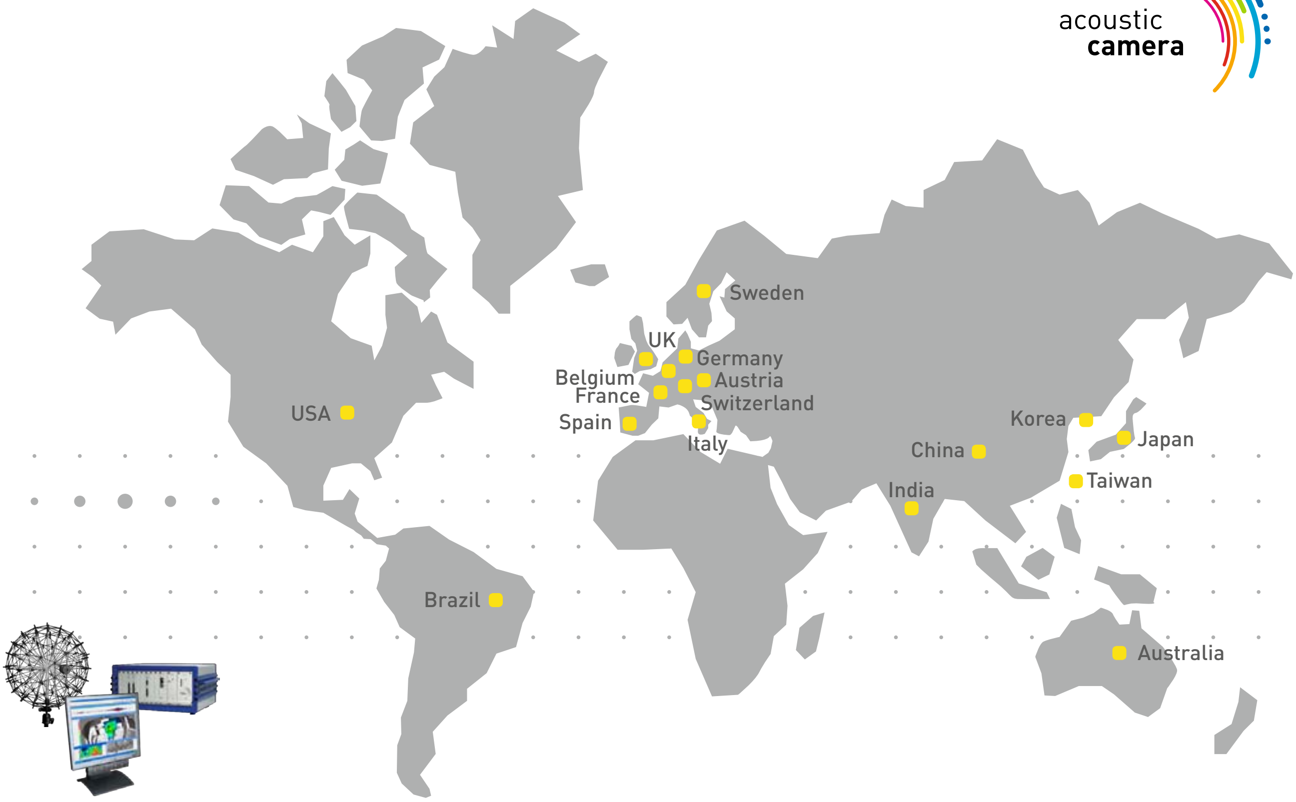
Acoustic Movie 2D/3D

- High time resolution, acoustic ultra slow motion up to several thousand acoustic frames per second
- Mapping of acoustic frames onto the recorded optical video (movie on movie-function)
- Location-selective listening into the Acoustic Movies
- Adjustable contrast of Acoustic Movies (colour palette and pressure- or dB-range)
- Export of individual frames from the Acoustic Movie to Text, JPG, PNG or BMP-format
- To AVI-Format in slow motion (without sound) and in realtime (including sound) in 2D and 3D

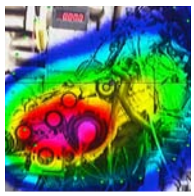
Spectral Photo 2D/3D

- Manual selection of a frequency band and immediate update of Photo2D and 3D
- Easy manipulation of the width of the selected frequency band using the mouse
- Continuous shifting of individually marked frequency band
- View of frequency and amplitude axis in linear as well as in logarithmic scalings
- Simple and fast visual evaluation of third octave bands
- Sound pressure level display for individual third octave bands
- Export of the Acoustic Photo to Text, JPG, PNG or BMP-format
- To AVI-Format in slow motion (without sound) and in realtime (including sound) in 2D and 3D

gfai tech - going for advanced innovation technologies!



For more information about our local distributors please visit us at: **www.acoustic-camera.com**



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