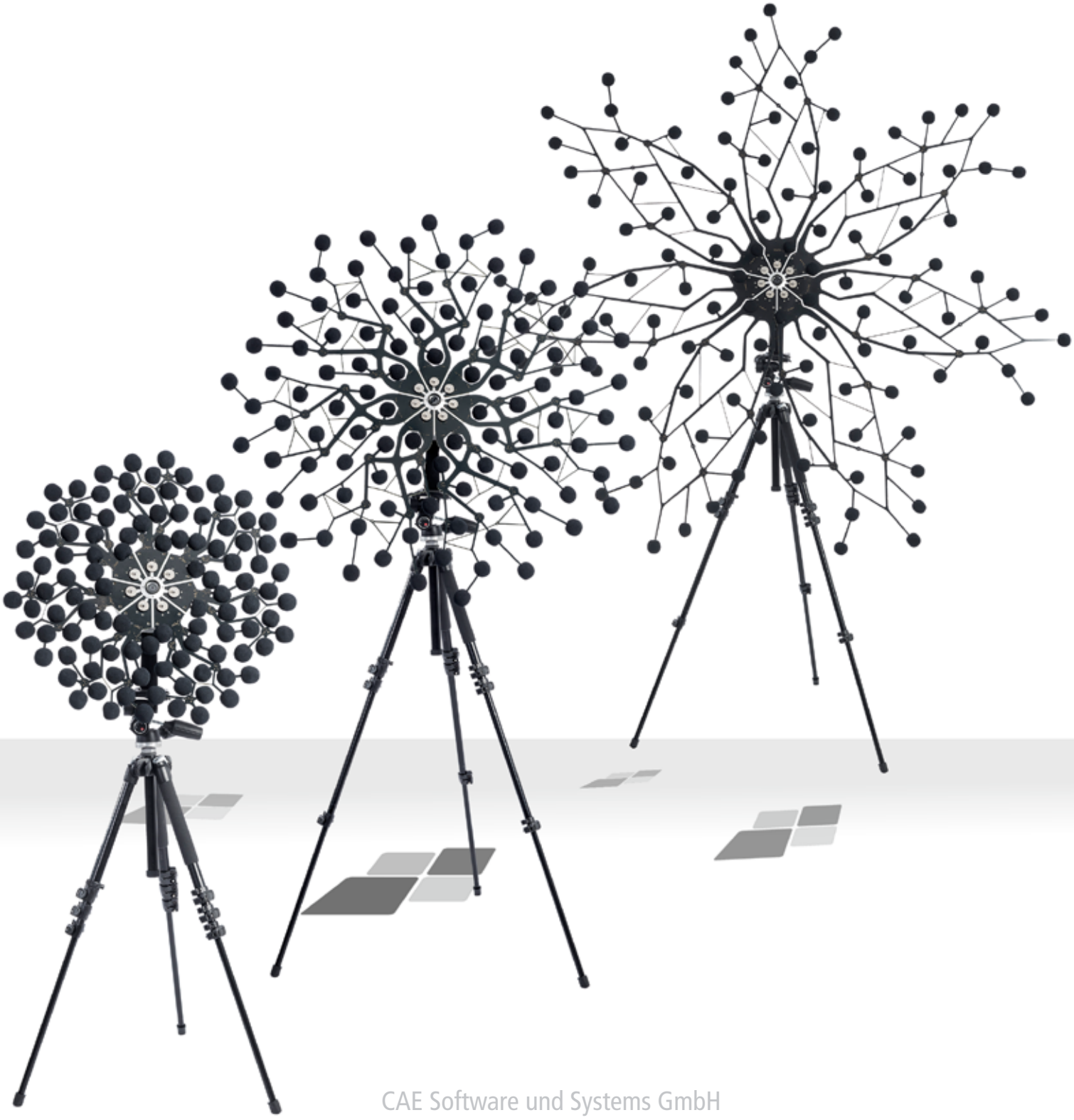
Noise Inspector

Innovation leader in acoustic cameras



CAE Software und Systems GmbH

See Sound and Vibration

During the last years new technologies for the visualization of sound sources "acoustic cameras" became extraordinary relevant in the industry due to its practical and intuitive use. Acoustic design of a product is an important aspect of product development. Ease of use and obvious results give engineers a new sense - "See sound sources with your eyes". This accelerates product development, quality control and environmental measurements.

Therefore CAE Software & Systems develops powerful and flexible measurement systems. Our acoustic camera "Noise Inspector" improves continuously to provide you the advantages of an accurate, fast and smart technology. With this system sound and vibration becomes visible in real-time. Furthermore the software is easy to use for non-experts and offers great functionality for experts. The results are easy to interpret for everybody. Noise Inspector is an important product to improve your product quality, minimize development time and to save your resources.

It can be adopted to your needs due to its flexibility in array design, number of microphones and state of the art algorithms. The smooth transition between beamforming, holography and sound intensity measurements makes nearly all acoustic problems analysable.

Noise Inspector - Everything is designed to result in a very high performance. More advantages – less costs!

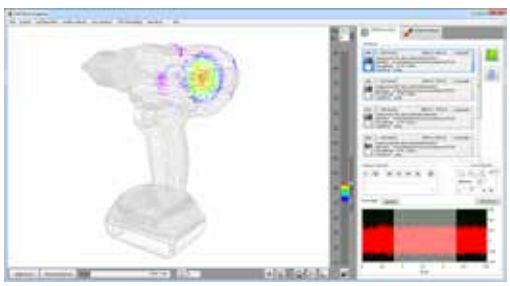
Features

Hardware

- One system for near and far field
- 24 bit synchronous sampling
- 8 - 1000+ channels
- High resolution results on optical picture
- Integrated data acquisition system
- Battery operation (low power consumption)
- Trigger and RPM channel
- Light weight and small packaging dimensions
- Flexible and mobile

Software

- Real-time sound imaging for quick results
- Postprocessing for high accuracy results
- Powerful HD algorithms
- Easy reporting including AVI and WAV export
- Localization from 40 Hz upwards
- Dynamic range more than 40 dB possible
- Acoustic weighting filters
- LabVIEW and Matlab interface for algorithms
- Batch or manual processing
- Unique real 3D beamforming
- Intuitive and easy to use



Noise Inspector is a Solution

The Noise Inspector is designed for quick setup to save time and start immediately with measurements. Therefore we designed a system which can be setup by only one person in about one minute. Immediately after setting up the hardware, the first acoustic pictures are only one mouse click away.

NVH measurement inside of a car. Shaker excitation underneath the steering wheel. (Photo Julian Kehne).

Four Important parts of acoustic cameras:

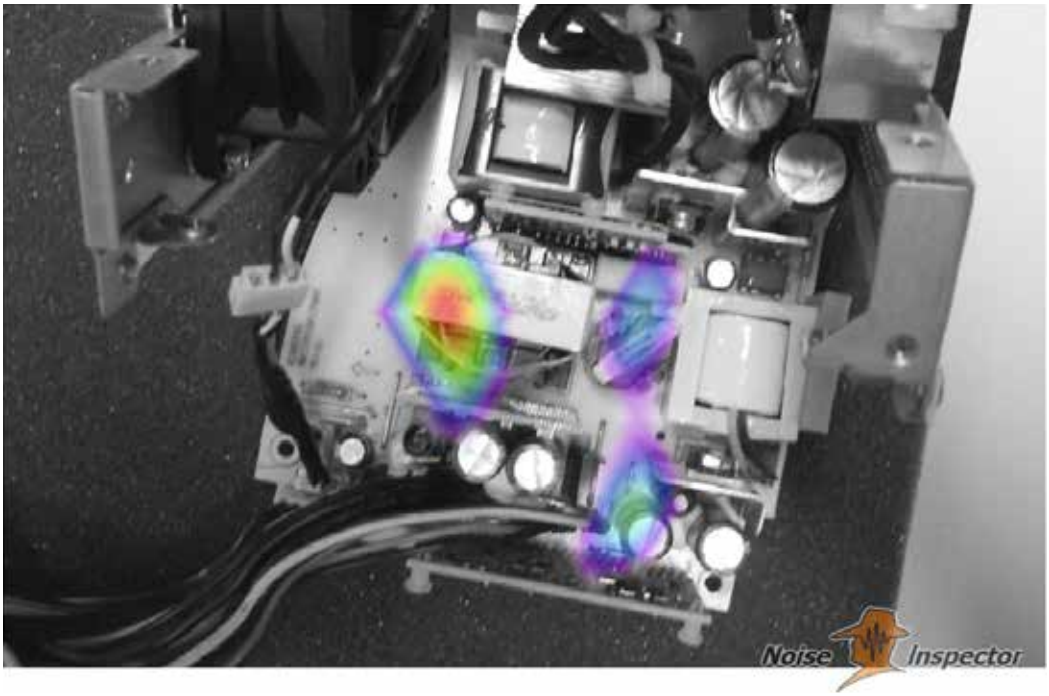
- Microphone array: It is very important to have a well-designed array.
- Data acquisition (analog or digital): 24 bit resolution, anti-aliasing filters and simultanious sampling.
- Camera: USB or IP cameras are used for visualization.
- Computation Software: Our software is made to be for high resolution acoustic pictures and movies.

Measurement of the room acoustics of the Golden Hall in Vienna, Austria.

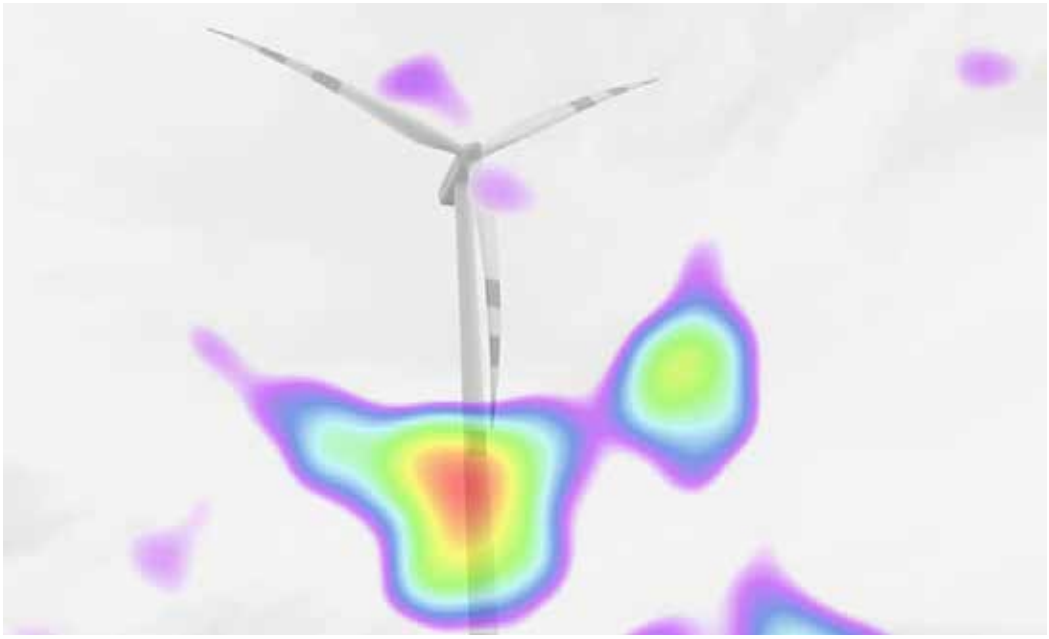
Endless Applications for Acoustic Cameras

Our Noise Inspector is optimized to deliver best performance and most accurate results for every possible application. It is a system for very low to very high frequencies.

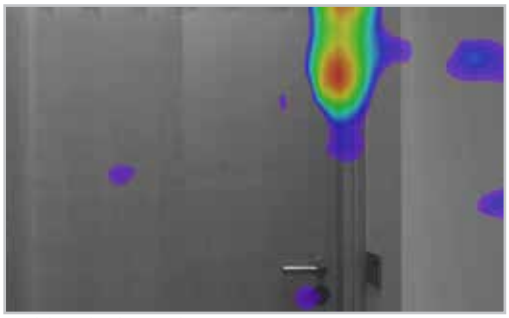
Whining of a power supply



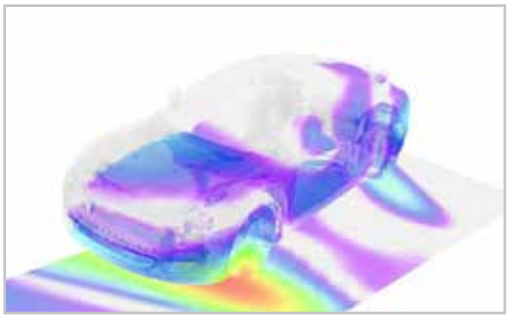
Airborne noise of wing tip

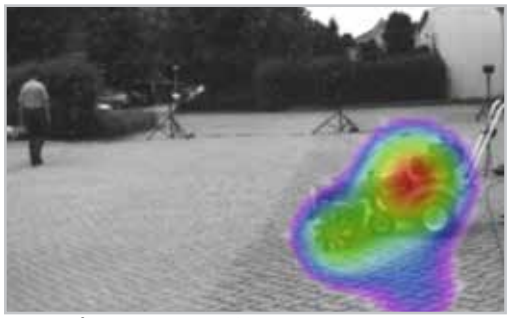


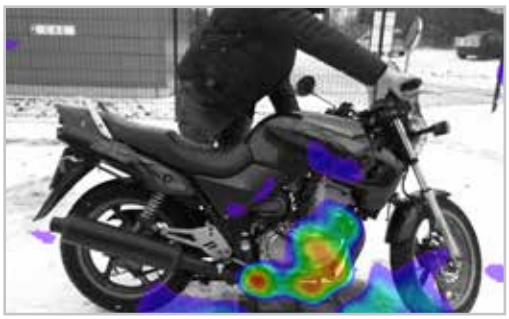
Endless applications

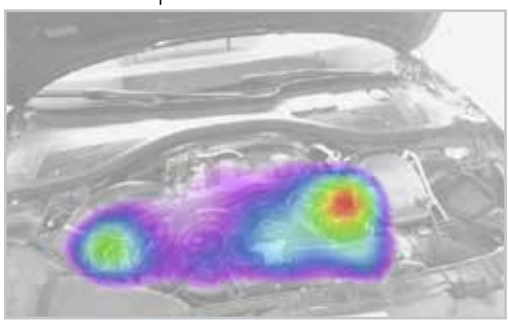

Building leakage detection


Building acoustic (project with HEBO)

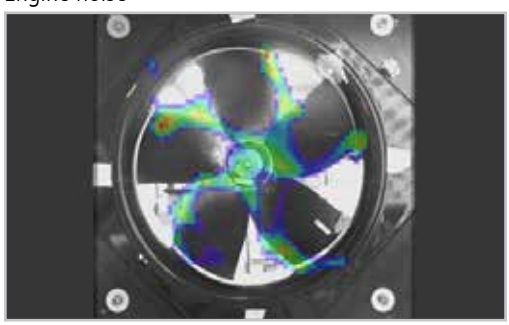

Aero acoustic noise in wind tunnel


Noise of a sweeper machine


Motorcycle noise


Engine noise

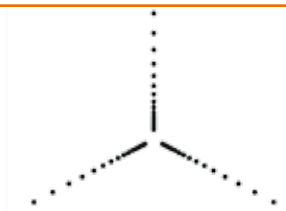
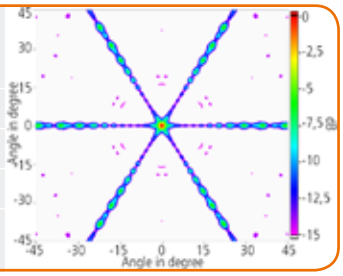
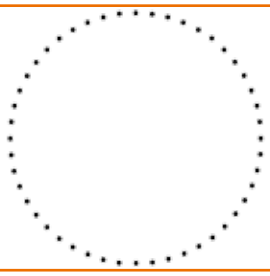
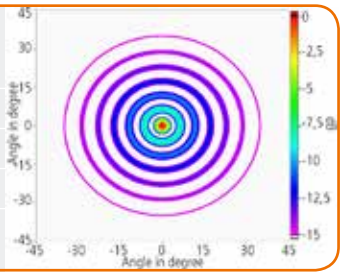
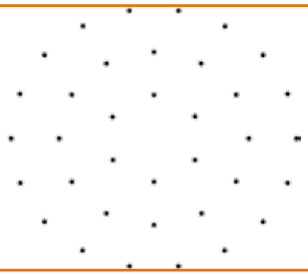
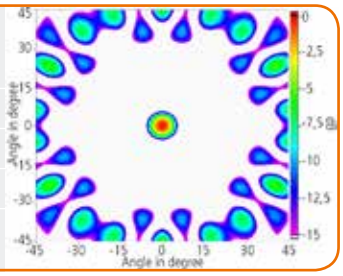
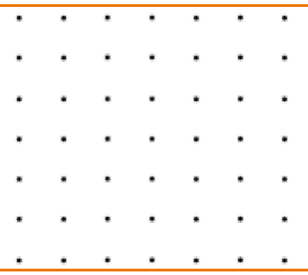
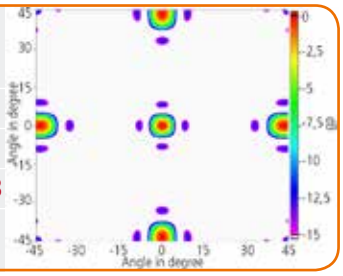

Drill noise


Fan noise

Common Arrays

The array design is an important physical property to deliver very high resolution results. Therefore we put a lot of engineering know-how into the shape of the arrays. Standard designs give results with poor resolution and/or poor dynamic range.

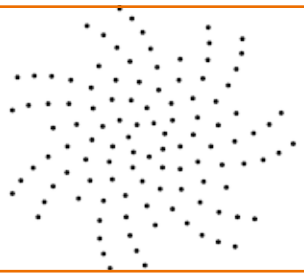
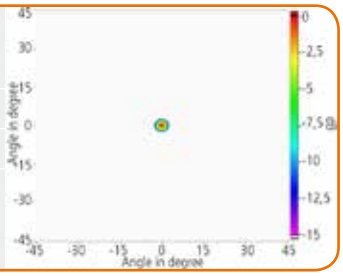
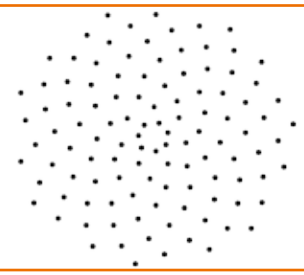
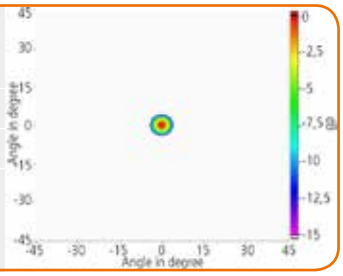
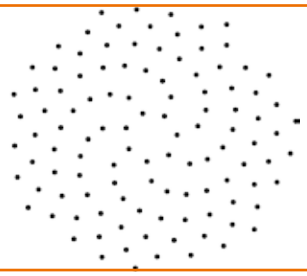
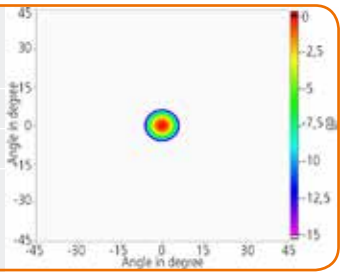
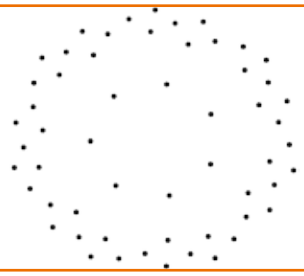
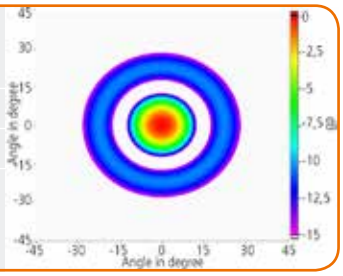
Common array designs

Star Array Microphones: 48 Diameter: 1.6 m		**Beampattern** -3dB width: ±1.07414 ° max side lobe: -5.53551 dB Simulation at 5 kHz	
Ring Array Microphones: 48 Diameter: 0.75 m		**Beampattern** -3dB width: ±1.92012 ° max side lobe: -7.89909 dB Simulation at 5 kHz	
Concentric ring Array Microphones: 36 Diameter: 0.6 m		**Beampattern** -3dB width: ±2.96055 ° max side lobe: -5.49043 dB Simulation at 5 kHz	
Chess Array Microphones: 49 Diameter: 0.6 m		**Beampattern** -3dB width: ±2.59681 ° max side lobe: -0.0001821 dB Simulation at 5 kHz	

Array Technology - The Key for good Results

Because the influence of the array designs is that significant, we created a portfolio of good microphone distributions (see below). Furthermore it is absolutly possible to create customized array designs to fulfill the customers needs.

Our array designs

Bionic L-112 Array		**Beampattern**	
Microphones:		-3dB width:	
112		±1.33044 °	
Diameter:		max side lobe:	
1.7 m		-15.4284 dB	
		Simulation at 5 kHz	
Bionic M-112 Array		**Beampattern**	
Microphones:		-3dB width:	
112		±2.13321 °	
Diameter:		max side lobe:	
1 m		-21.7749 dB	
		Simulation at 5 kHz	
Bionic S-112 Array		**Beampattern**	
Microphones:		-3dB width:	
112		±3.30846 °	
Diameter:		max side lobe:	
0.6 m		-16.2920 dB	
		Simulation at 5 kHz	
Bionic XS-56 Array		**Beampattern**	
Microphones:		-3dB width:	
56		± 6.6501 °	
Diameter:		max side lobe:	
0.27 m		- 10.4825 dB	
		Simulation at 5 kHz	

Excellent Software - Makes the Difference

The Noise Inspector software is a turn key solution to visualize sound sources. Acoustic pictures and movies show the user fast and directly where the noise is coming from. The user friendly interface guides the user through the whole process from data aquisition through analysis to reporting. Many well-known and new algorithms for getting detailed pictures are implemented in the software. A comprehensive reporting tool allows the user a fast documentation and visualization of the results.

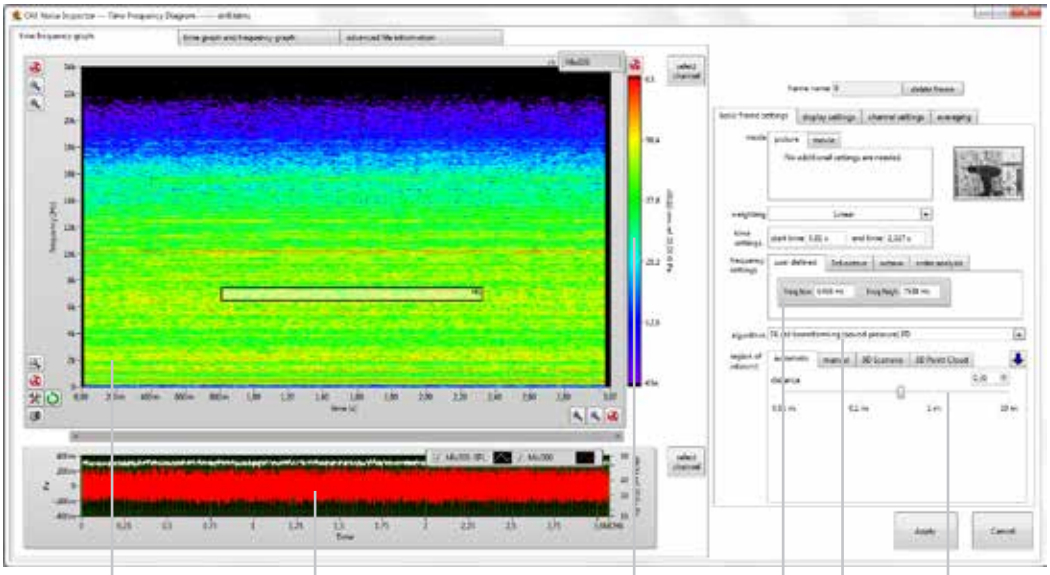
With the acoustic pictures and movies the next necessary development steps can be started.

The Noise Inspector Software is not a closed software solution, the export capability allows the usage of the results and measurements on different software platforms. The raw data files and the result files are stored on the hard disc in the TDMS-fileformat from National Instruments and can be read in external software easily.

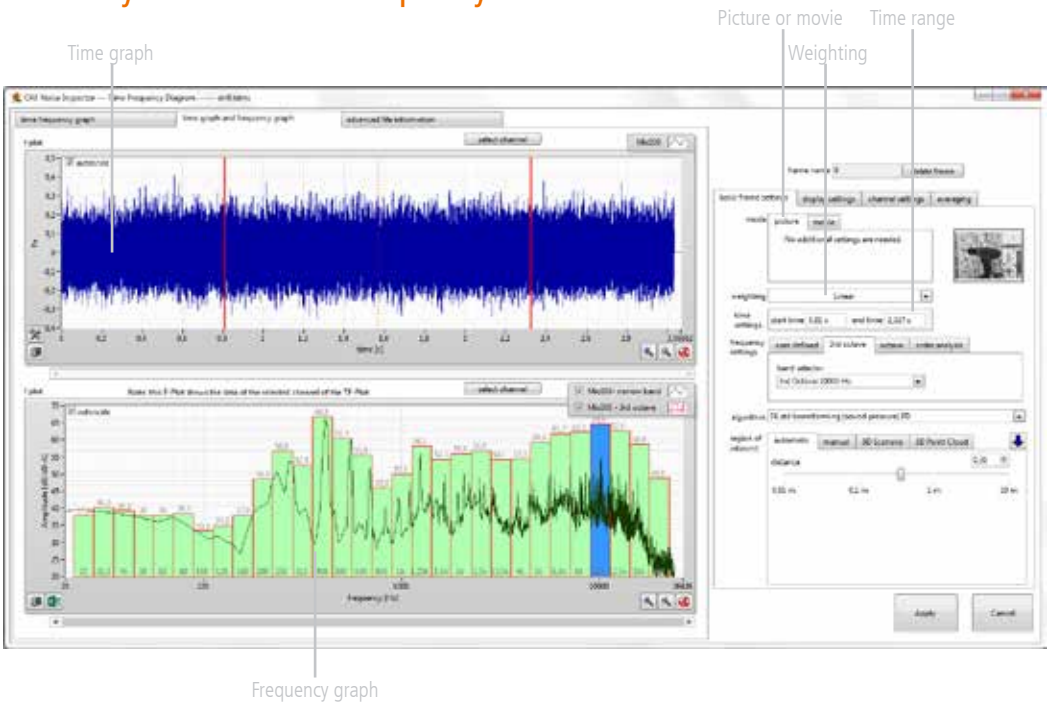
The open LabVIEW and Matlab interface provides a simple way for our customers to develop their own algorithms and to integrate these into the Noise Inspector, which is often used for research properties.

Main interface of the Noise Inspector

Pre-analysis in time-frequency domain



Pre-analysis in time and frequency domain



Wide Selection of Algorithms

The Noise Inspector software comes with the largest range of algorithms available on the market. You can choose between standard beamforming or high resolution beamforming algorithms for far field measurements.

If you are facing lower frequency sources the Noise Inspector can be used for acoustic holography measurements or intensity mapping tasks. Also the user is able to design own analysis algorithms and implement them via the LabVIEW interface for plugins.

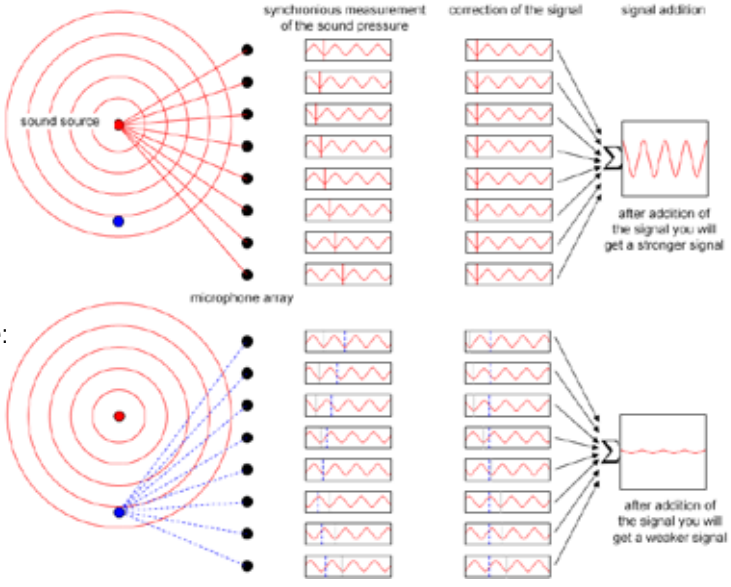
Features

Algorithms for best results

from 40 Hz
- SONAH - statistically optimized near field acoustic holography
- Online-Intensity
- Offline-Intensity
- Online 3D Intensity

from 350 Hz
- Standard Beamforming - very fast and robust
- EVOB (EigenValue Optimized Beamforming)
- Deconvolution algorithms
  - CLEAN SC
  - MUSIC - Multiple Signal Classification
  - Capon
  - DAMAS
  - Orthogonal Beamforming
  - And others
- Real 3D beamforming - object is inside of the microphone array
- Rotating beamforming - for fast rotating parts e.g. fans
- user - interface for your own methods

Focusing on a sound source: After correction of the time of flight between the focus point and the microphone positions all signals will be in phase.

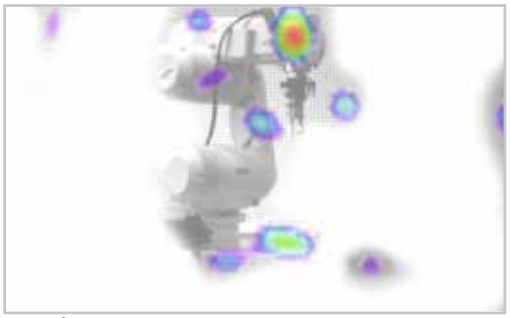


Focusing beside a sound source: After correction of the time of flight between the focus point and the microphone positions all signals will have a different phase.

Theory of Beamforming

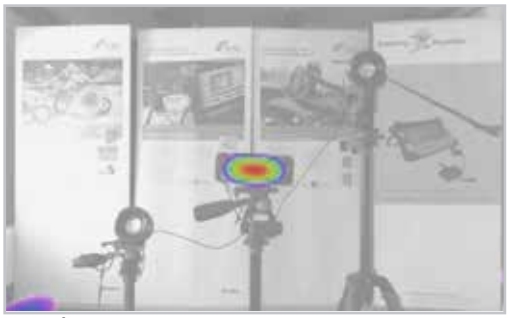
Advanced HD Algorithms

Comparison



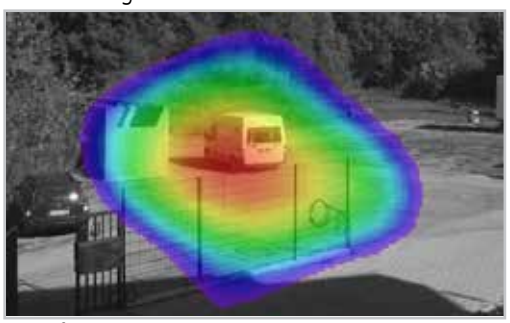
Beamforming

EVOB (EigenValue Optimized Beamforming)



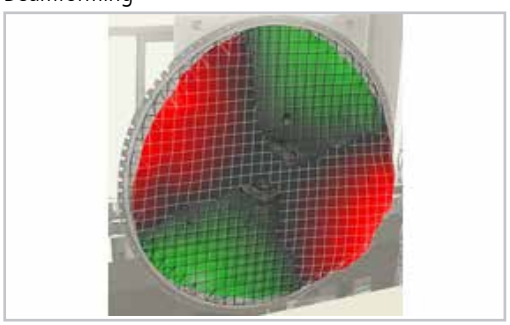
Beamforming

MUSIC

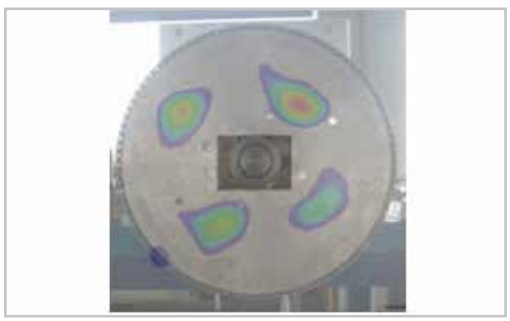


Beamforming

Clean SC

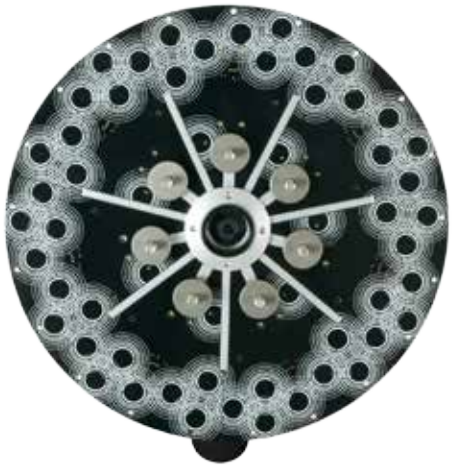


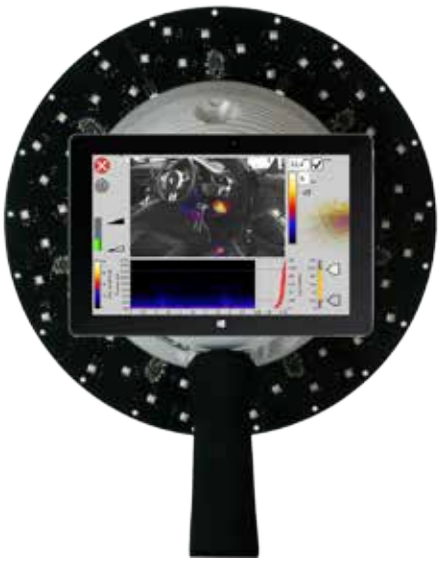
Laser scanning vibrometry



Acoustic holography (SONAH)

Acoustic Camera
Bionic XS-56 Array





Features

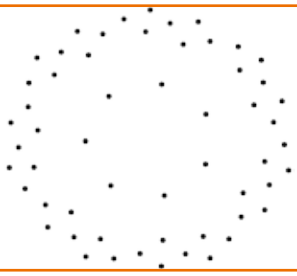
- Portable measuring instrument (sensors, data acquisition, analysis and visualisation in one unit)
- online results with up to 100 fps (acoustically)
- Far field analysis (beamforming)
- Fully integrated design (no frontend necessary)
- High dynamic range and resolution
- Very small package volume
- 40° resolution at 2000 Hz with beamforming

Application

- NVH
- Squeak and rattle
- Noise leakage detection
- Engine noise
- Automotive (interieur and exterieur)
- Quality assurance
- Product developement
- For transient and stationary noise sources

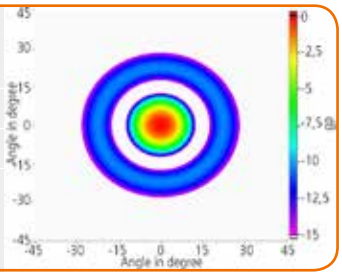
Bionic XS-56 Array	
Array Size	Diameter 270 mm
Array Material	Composite Material
Weight (excl. Tripod)	2.6 kg
Microphones	56
Sample Rate	48 kHz
Mic. Frequency Range	10 Hz to 24 kHz
Operating Range	< 33 dB to 120 dB
Analysis Dynamic Range	up to 40 dB
Measurement distance	0.1 m to ∞
Resolution	24-Bit
Interface	Ethernet
Operating Temperature	-40 °C to +60 °C
Operating Humidity	Non Condensing

Bionic XS-56 Array	
Microphones:	56
Diameter:	0.27 m



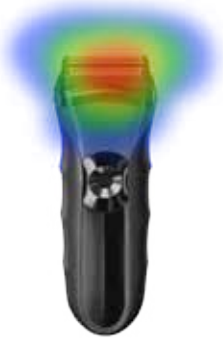
Beampattern	
-3dB width:	± 6.6501 °
max side lobe:	- 10.4825 dB

Simulation at 5 kHz



Acoustic Camera

Bionic S-112 Array



Features

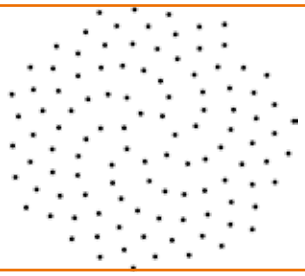
- Far field analysis (beamforming)
- Near field analysis (holography)
- Fully integrated design (no frontend necessary)
- High dynamic range and resolution
- Very small package volume
- 40° resolution at 1000 Hz with beamforming
- From 40 Hz with holography
- Handheld

Application

- NVH
- Squeak and rattle
- Noise leakage detection
- Environmental and building acoustics
- Engine noise
- Automotive (interieur and exterieur)
- Product developement
- For transient and stationary noise sources

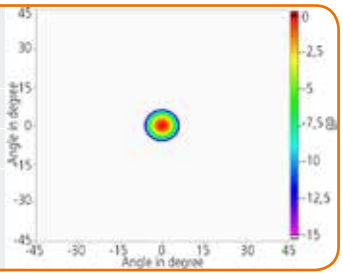
Bionic S-112 Array	
Array Size	Diameter 600 mm
Array Material	Composite Material
Weight (excl. Tripod)	3.1 kg
Microphones	112
Sample Rate	48 kHz
Mic. Frequency Range	10 Hz to 24 kHz
Operating Range	< 33 dB to 120 dB
Analysis Dynamic Range	up to 40 dB
Measurement distance	0.2 m to ∞
Resolution	24-Bit
Interface	Ethernet
Operating Temperature	-40 °C to +60 °C
Operating Humidity	Non Condensing

Bionic S-112 Array	
Microphones:	112
Diameter:	0.6 m



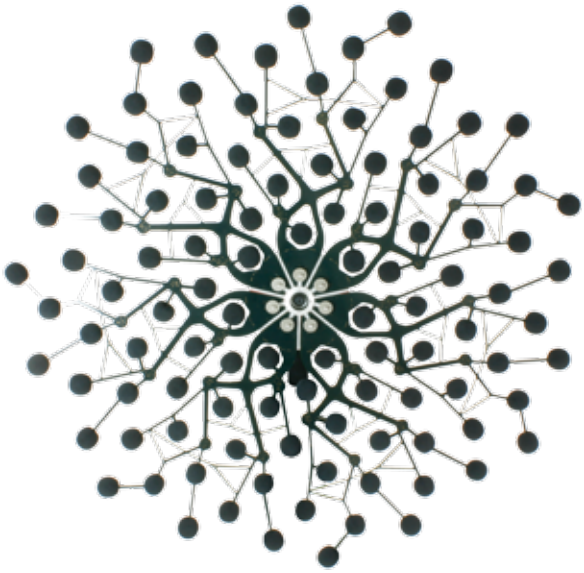
Beampattern	
-3dB width:	±3.30846 °
max side lobe:	-16.2920 dB

Simulation at 5 kHz



Acoustic Camera

Bionic M-112 Array



Features

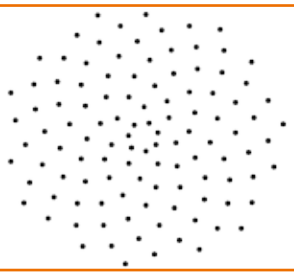
- Far field analysis (beamforming)
- Near field analysis (holography)
- Fully integrated design (no frontend necessary)
- High dynamic range and resolution
- Very small package volume
- 40° Resolution at 600 Hz with beamforming
- From 40 Hz with holography
- Handheld

Application

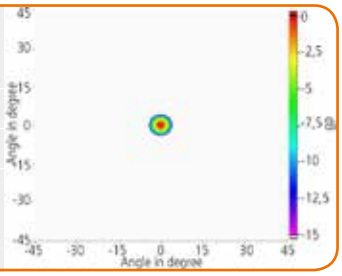
- NVH
- Squeak and rattle
- Noise leakage detection
- Environmental and building acoustics
- Engine noise
- Automotive (exterieur)
- Machine acoustics
- For transient and stationary noise sources

Bionic M-112 Array	
Array Size	Diameter 1000 mm
Array Material	Composite Material
Weight (excl. Tripod)	3.3 kg
Microphones	112
Sample Rate	48 kHz
Mic. Frequency Range	10 Hz to 24 kHz
Operating Range	< 33 dB to 120 dB
Analysis Dynamic Range	up to 40 dB
Measurement distance	0.2 m to ∞
Resolution	24-Bit
Interface	Ethernet
Operating Temperature	-40 °C to +60 °C
Operating Humidity	Non Condensing

Bionic M-112 Array	
Microphones:	112
Diameter:	1 m

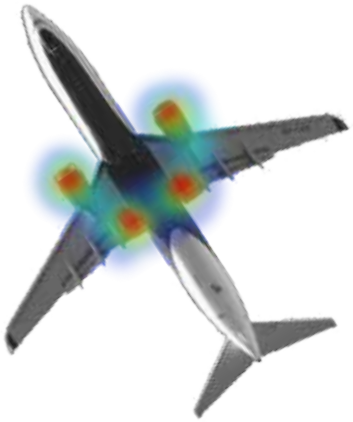


Beampattern	
-3dB width:	±2.13321 °
max side lobe:	-21.7749 dB



Simulation at 5 kHz

Acoustic Camera
Bionic L-112 Array



Features

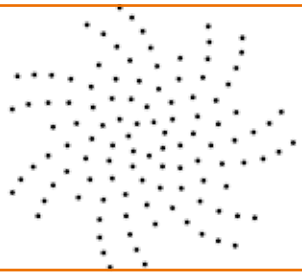
- Far field analysis (beamforming)
- Fully integrated design (no frontend necessary)
- High dynamic range and resolution
- Very small package volume
- 40° resolution at 350 Hz with beamforming
- Large diameter for good spatial resolution

Application

- Automotive
- Machine acoustics
- Noise leakage detection
- Environmental acoustics
- Building acoustics
- Wind energy
- Wind tunnel
- For transient and stationary noise sources

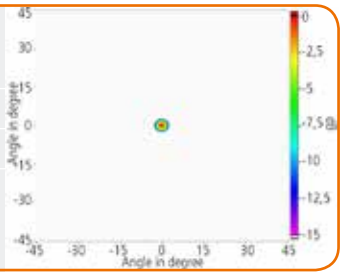
Bionic L-112 Array	
Array Size	Diameter 1700 mm
Array Material	Composite Material
Weight (excl. Tripod)	3.5 kg
Microphones	112
Sample Rate	48 kHz
Mic. Frequency Range	10 Hz to 24 kHz
Operating Range	< 33 dB to 120 dB
Analysis Dynamic Range	up to 40 dB
Measurement distance	0.8 m to ∞
Resolution	24-Bit
Interface	Ethernet
Operating Temperature	-40 °C to +60 °C
Operating Humidity	Non Condensing

Bionic L-112 Array	
Microphones:	112
Diameter:	1.7 m



Beampattern	
-3dB width:	±1.3044 °
max side lobe:	-15.4284 dB

Simulation at 5 kHz



Digital Real-Time Integrated Hardware

The powerful data acquisition hardware is integrated into the acoustic camera hub and is robust and lightweight. The onboard real-time processor and FPGA guarantee the highest accuracy of the measured data. By synchronizing frontends the system can be extended to more than 1000 channels. Furthermore it can record the RPM of a rotating system. A trigger channel can be used to start the measurement with an external signal.

The frontend streams the acquired data of the microphones and the camera through high speed ethernet in real-time to the host computer.

Features

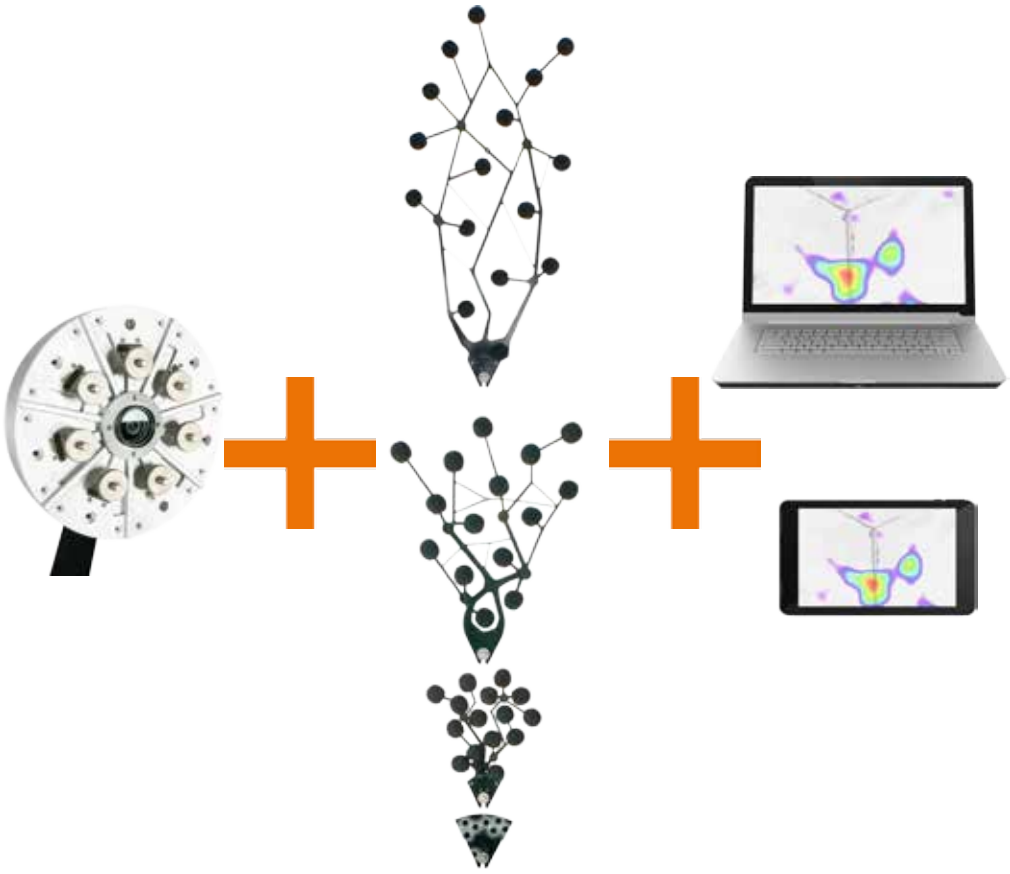
- Lightweight
- Robust
- Expandable
- Trigger channel
- RPM channel
- Battery option
- Fanless
- Low power consumption
- Synchronized multi chassis applications
- Up to more than 1000 microphone channels

Hub-Frontend	
Channels	112
Sample rate	48 kHz
Resolution	24 bits
Simultaneous sampling	Yes
Interface to PC	Ethernet
Fanless	Yes
Additional inputs	Trigger, Tacho (RPM)
Battery option	Yes
Power supply	12 V DC
Power consumption	< 14 W
Dimension	180 x 180 x 100mm
Weight	2,2 kg

Modular Design

The Noise Inspector is a new generation of acoustic cameras. The unique modular acoustic camera system makes it an optimal solution. Besides it is possible to expand the acoustic camera with an additional microphone array to open up new fields of application. For very fast troubleshooting an upgrade with an intensity array or an acoustic compass (3D acoustic intensity probe) offers you a high performance acoustic camera for every application. The IEPE Breakout Box offers you a connection to the analog world.

Take your choice



Optional Extensions

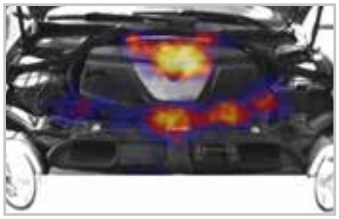
IEPE Breakout Box

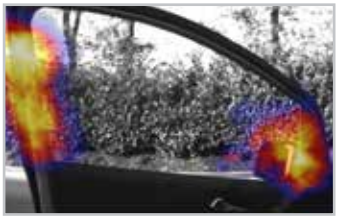
Acoustic Compass

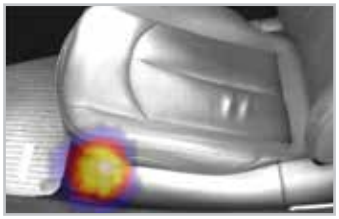
Intensity Array

Smart Vision - Stand Alone Operation

By using a tablet the acoustic camera can be turned into a very smart and mobile system. It is mounted on the backside and will be plugged into the acoustic camera. Acoustic pictures will directly displayed on the tablet in real-time. The simple software interfaces allows the user to start immediately acoustic investigations.


Engine noise


Noise of a closing side window


Electronical seat adjustment

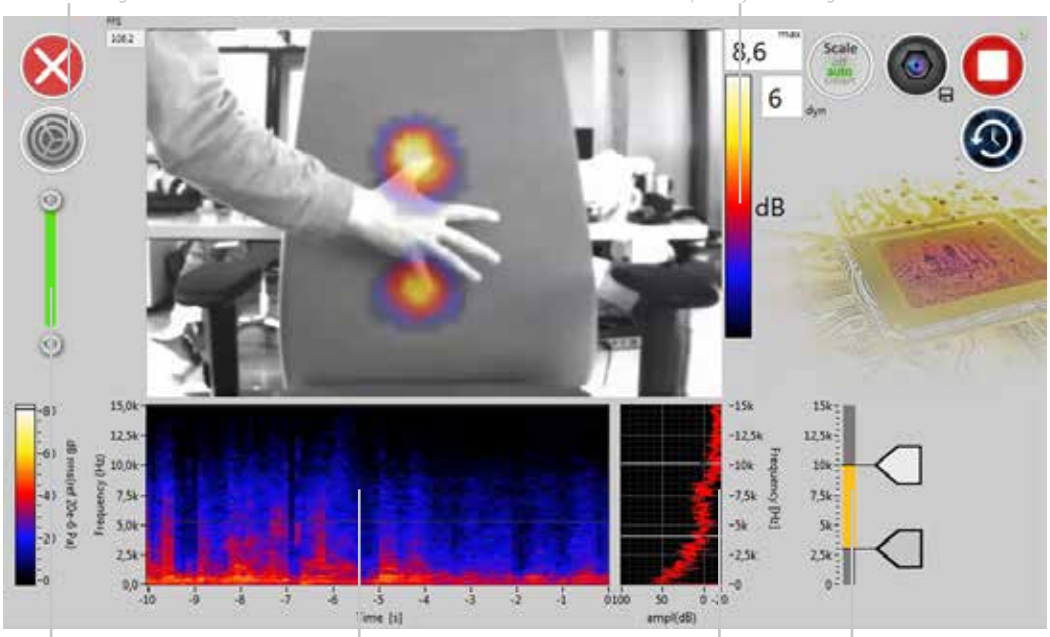
Features

- Up to 100 acoustic pictures per second over a broadband frequency
- Up to 60 optical pictures per second
- Real-time processing with high definition acoustic pictures
- No analysis hardware (PC/Notebook) needed
- No cables needed
- Optimized array shape for high dynamic range
- Online local sound
- Exporting acoustic pictures
- Recording acoustic videos
- Easy-to-use
- Ultramobile
- Flexible
- Robust

Smart Software - Perfect for Newcomers

On/Off and Setup of Beamforming

Maximum Soundpressurelevel and setup for dynamic range



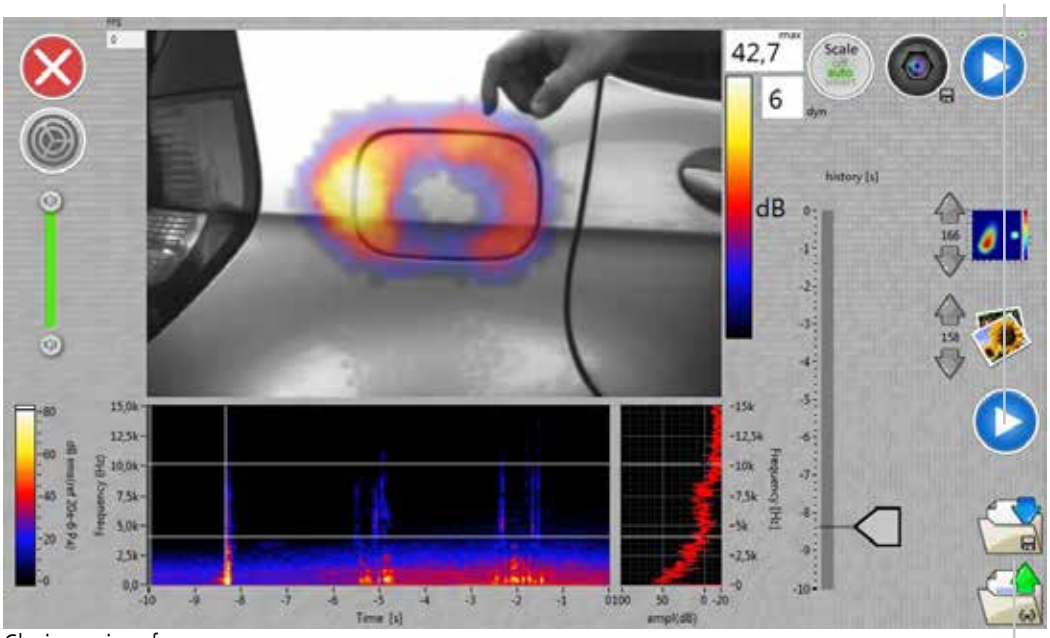
Volume of local sound

Time-frequency graph

Frequency graph

Frequencyrange sliders for beamforming

Play recorded video with sound



Closing noise of a gas cap

Save or open measurement

3D Acoustic Camera

3D Array

Features

- 3D beamforming
- 3D results on 3D objects
- One measurement for the complete acoustic emission in 3D
- Array size: small cube or complete room or combine our standard arrays to a 3D array
- Acoustic photos and videos

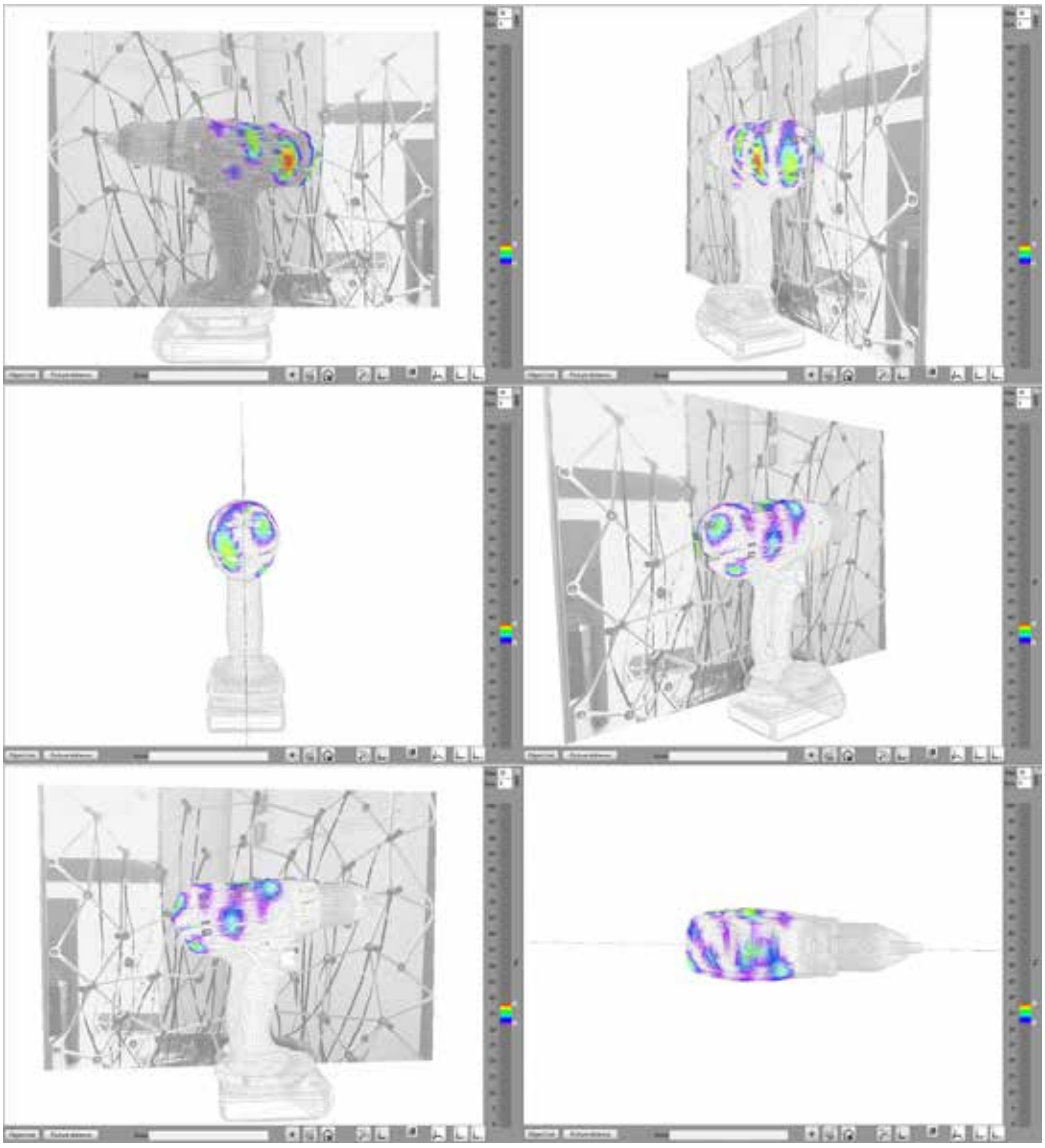
Application

- NVH
- Squeak and rattle
- Machinery acoustic
- Product developement
- Wind tunnel
- Quality assurance
- Noise leakage detection
- Test stand
- For transient and stationary noise sources

3D Array	
Array Size from	0.8m x 0.8m x 0.8m
Array Material	Aluminium
Weight	10 kg
Microphones	40 and more
Sample Rate	48 kHz
Mic. Frequency Range	10 Hz to 24 kHz
Operating Range	< 33 dB to 120 dB
Analysis Dynamic Range	up to 40 dB
Measurement distance	Inside of array
Resolution	24-Bit
Interface	Ethernet
Operating Temperature	-40 °C to +60 °C
Operating Humidity	Non Condensing

What is Real 3D Beamforming?

Worldwide unique 3D beamforming. The object is surrounded by microphone arrays and is therefore measured from all sides. The results are real 3D measurement results which are projected on the 3D model. Only one measurement shows the complete acoustic emission of the measured object. There is no limit in the microphone array size - from a small cube of 800 mm x 800 mm x 800 mm up to a complete anechoic chamber. High resolution in all dimensions.



3D Intensity Camera
Acoustic Compass

The CAE Acoustic Compass is a 3D sound intensity probe that is able to measure from low frequencies to high frequencies in 3D. The output of the analysis is a spectrum with amplitude and direction of incidence for each frequency line. The Noise Inspector software shows the direction and the intensity on the 3D display.

Intensity measurement systems have a very high dynamic range as there is no algorithm and no beampattern limiting this range.

Features

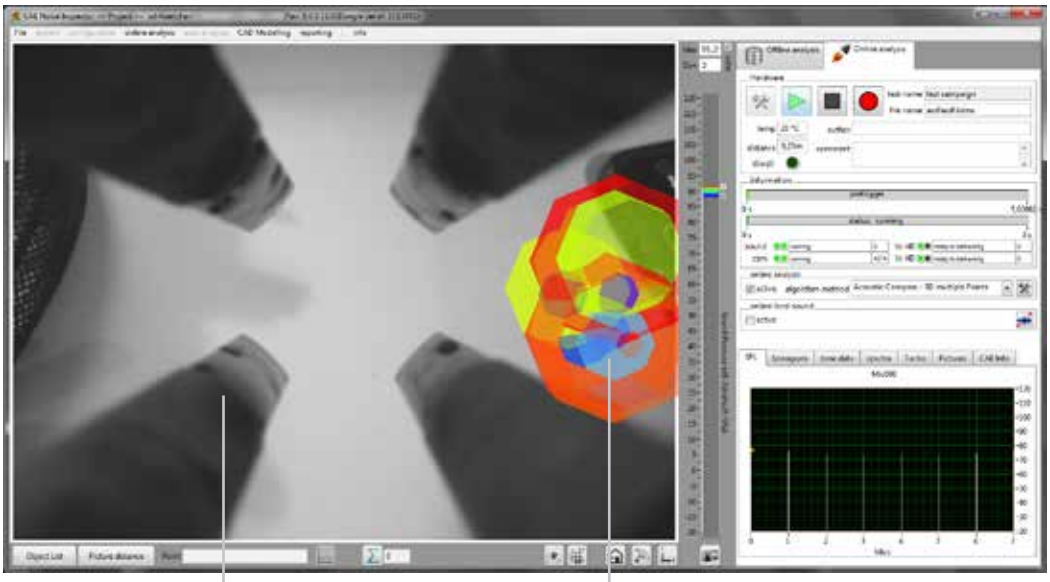
- Online analysis
- Localization in small spaces
- Ultramobile
- Easy to use - like a compass
- 3D intensity measurement
- Usage from 40 Hz to 4 kHz

Application

- Noise leakage detection
- Machinery acoustic
- Cabin acoustics
- Automotive (interieur)
- For stationary and quasistationary noise sources

Acoustic Compass	
Array Size	40 mm x 40 mm
Array Material	Composite Material
Weight (excl. Tripod)	0.5 kg
Intensity Probes	28
Sample Rate	48 kHz
Mic. Frequency Range	10 Hz to 24 kHz
Operating Range	< 33 dB to 120 dB
Analysis Dynamic Range	up to 30 dB
Source distance	0.01 m to ∞
Resolution	24-Bit
Interface	Ethernet
Operating Temperature	-40 °C to +60 °C
Operating Humidity	Non Condensing

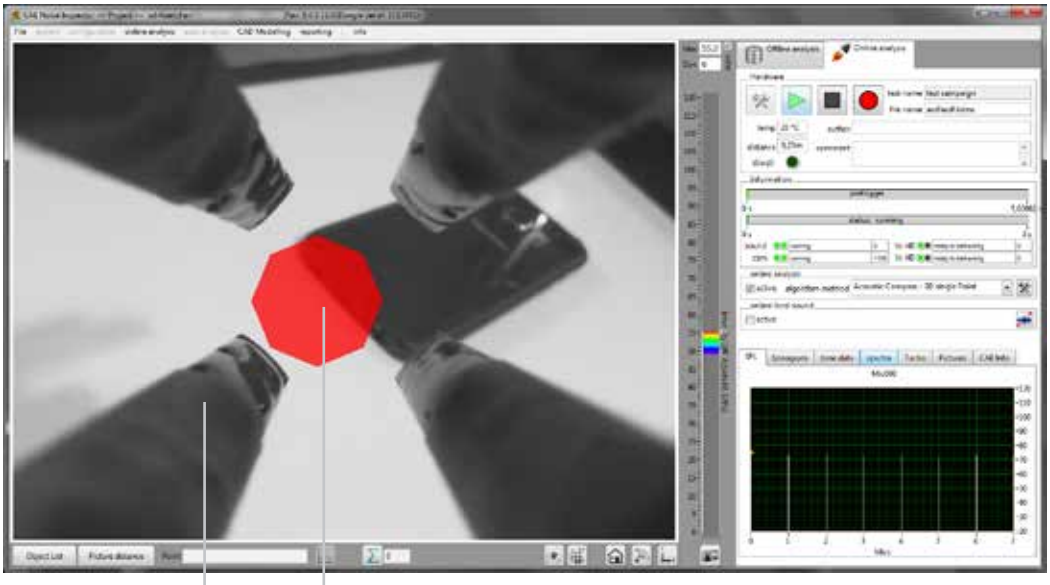
Noise source is to the right direction of the probe (3D multiple point)



8 microphones result
in 28 intensity probes

Localized sound source (3D multiple points)
Each point represents one frequency line, direction and amplitude (color)

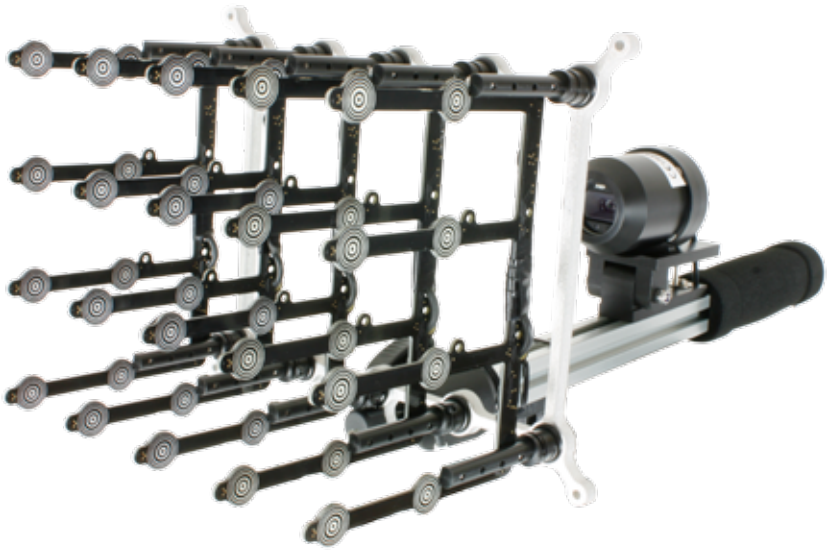
Noise source (cell phone) is in front of the probe (3D single point)



8 microphones

Localized sound source (3D single point represents average direction from 3D multiple points method)

Intensity Camera
Intensity Array



The CAE Intensity Array is an one dimensional sound intensity measurement system that is able to detect the source of very low frequencies. The output of the analysis is the sound intensity for each probe mapped on a picture. This measurement system is able to map stationary as well as transient noise sources.

Intensity measurement systems have a very high dynamic range as there is no algorithm and no beampattern limiting this range.

Features

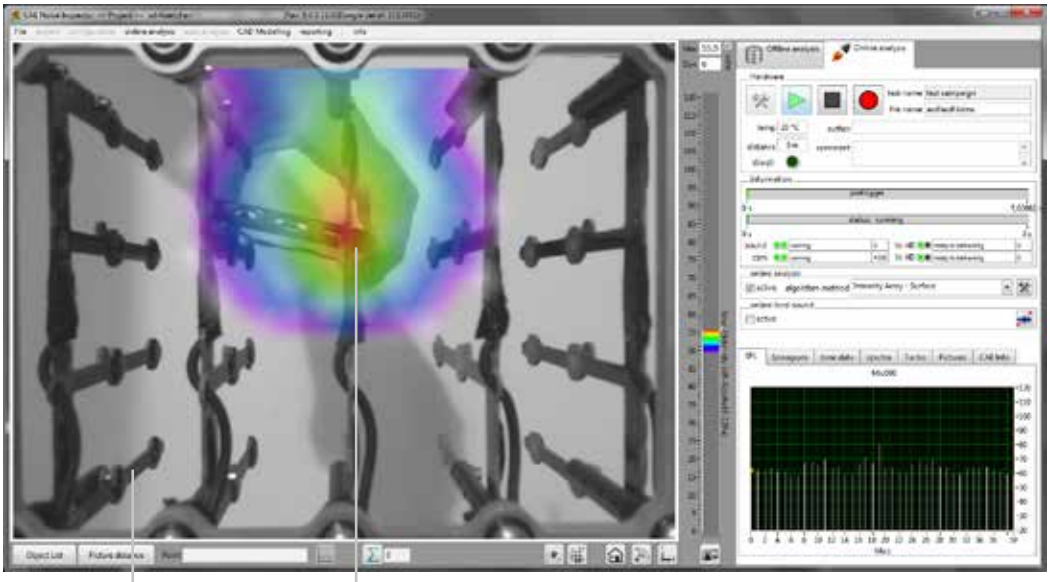
- Online and offline intensity analysis
- Localization in small spaces
- Ultramobile
- Easy to use
- Intensity measurement
- Usage from 40 Hz to 4 kHz

Application

- Noise leakage detection
- Engine noise
- Machinery acoustic
- Cabin acoustics
- Automotive (interieur)
- For transient and stationary noise sources

Intensity Array	
Array Size	160 mm x 120 mm
Array Material	Composite Material
Weight (excl. Tripod)	0.8 kg
Intensity Probes	20
Sample Rate	48 kHz
Mic. Frequency Range	10 Hz to 24 kHz
Operating Range	< 33 dB to 120 dB
Analysis Dynamic Range	up to 30 dB
Source distance	0.01 m to ∞
Resolution	24-Bit
Interface	Ethernet
Operating Temperature	-40 °C to +60 °C
Operating Humidity	Non Condensing

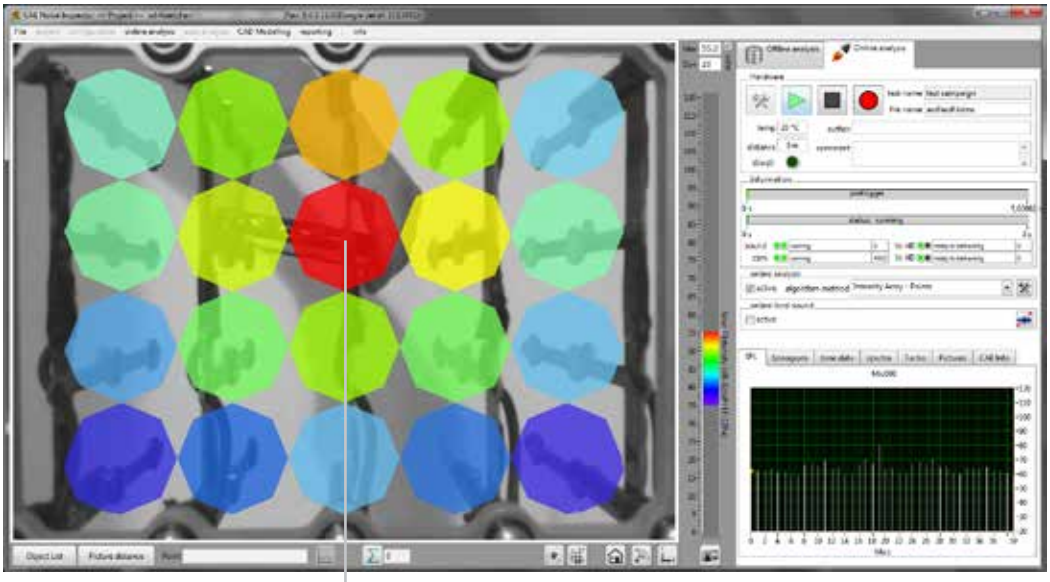
Typical intensity map for a point source (surface view)



2 microphones result in 1 intensity probe

Surface View for easier detection of sound sources

Typical intensity map for a point source (points view)



Intensity amplitude is shown for each probe (color)

Acoustic Camera
Wind Turbine

Features

- Far field analysis (beamforming)
- High dynamic range and resolution
- 40° Resolution at 120 Hz with beamforming
- Large diameter for good spatial resolution
- Accurate spatial resolution for low frequencies

Application

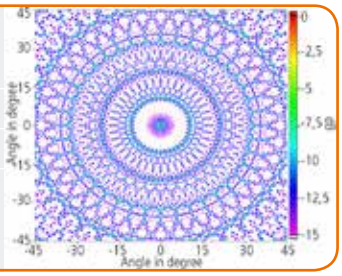
- Wind turbines
- For transient and stationary noise sources

Wind Turbine Special	
Array Size	Diameter 5000 mm
Array Material	Aluminium
Weight	75 kg
Microphones	40
Sample Rate	48 kHz
Mic. Frequency Range	10 Hz to 24 kHz
Operating Range	< 33 dB to 120 dB
Analysis Dynamic Range	up to 40 dB
Measurement distance	2.5 m to ∞
Resolution	24-Bit
Interface	Ethernet
Operating Temperature	-40 °C to +60 °C
Operating Humidity	Non Condensing

Wind Turbine Speical	
Microphones:	
40	
Diameter:	
5 m	

Beampattern	
-3dB width:	
±0.299082 °	
max side lobe:	
-5.06477dB	

Simulation at 5 kHz



Extension to Analog World
IEPE Breakout Box

The IEPE Breakout Box is a powerful extension for the I²S Frontend. It connects the analog world to the digital I²S-Frontend. With the Breakout Box it is possible to connect IEPE and analog sensors to the hardware. Every channel is seperately switchable between IEPE mode and normal mode.

The Noise Inspector can be used for data acquisition and for analysis if you want to build your own analog acoustic camera. If you want to go on and connect different types of sensors you can use our Sound and Vibration Inspector software for data acquisition and complex analysis of dynamic signals.

I²S-Frontend	
Channels	40 and more
Sample rate	48 kHz
Resolution	24 bits
Simultaneous sampling	Yes
Interface to PC	Ethernet
Fanless	Yes
Additional inputs	Trigger, Tacho (RPM)
Battery option	Yes
Power supply	12 V DC
Power consumption	< 7W
Dimension	230 x 185 x 58 mm
Weight	2 kg

Breakout Box	
Channels	8 and more
Sample rate	48 kHz
Resolution	24 bits
Simultaneous sampling	Yes
Interface to PC	via I²S-Frontend
Fanless	Yes
Input	Analog or ICP/IEPE
Battery option	Yes
Power supply	12 V DC
Power consumption	< 1W
Dimension	140 x 75 x 50 mm
Weight	0,5 kg

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