



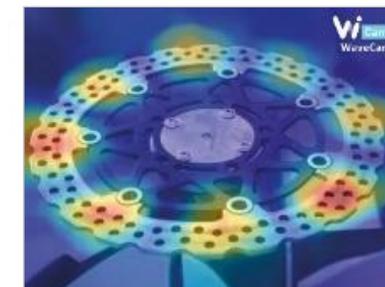
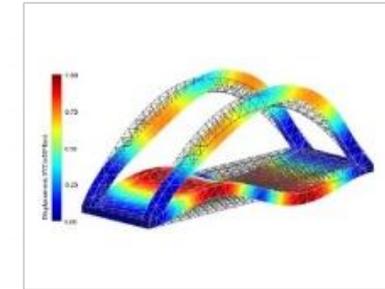
噪聲和振動可視化的新解決方案

New solutions for Noise and Vibration Visualization

Introduction to gfai tech's solution June 16th 2023

Milestones of gfai tech

- 2001** The Acoustic Camera - the worldwide first commercial system
- 2006** gfai tech GmbH was founded
- 2014** Wavelmage - a complete solution for structural dynamic analysis
- 2015** The first gfai tech wind tunnel is installed at Porsche
- 2019** Mikado - the mobile all-in-one sound camera
- 2021** WaveHit^{MAX} - the first intelligent modal hammer for experimental modal analysis
- 2022** WaveCam - software solution for video vibration analysis



噪聲和振動的創新產品 Innovated Products for Noise & Vibration

聲音定位和可視化 Sound Localization and Visualization



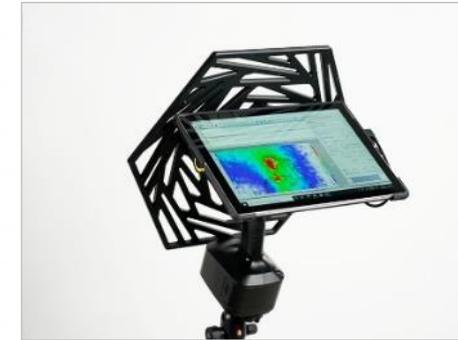
Acoustic Camera Pro
Microphone Arrays



Acoustic Camera Pro
Software NoiseImage



Acoustic Camera Pro
Datarecorder

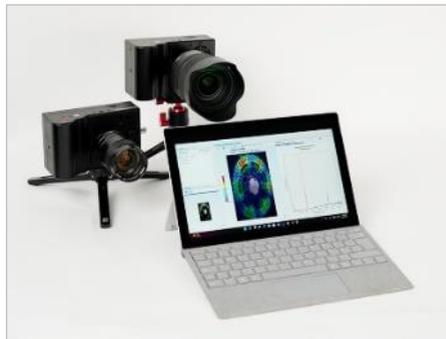


All-in-one Soundcam Mikado

振動和結構動力學 Vibrations and Structural Dynamics



Structural Dynamic
Software WavelImage



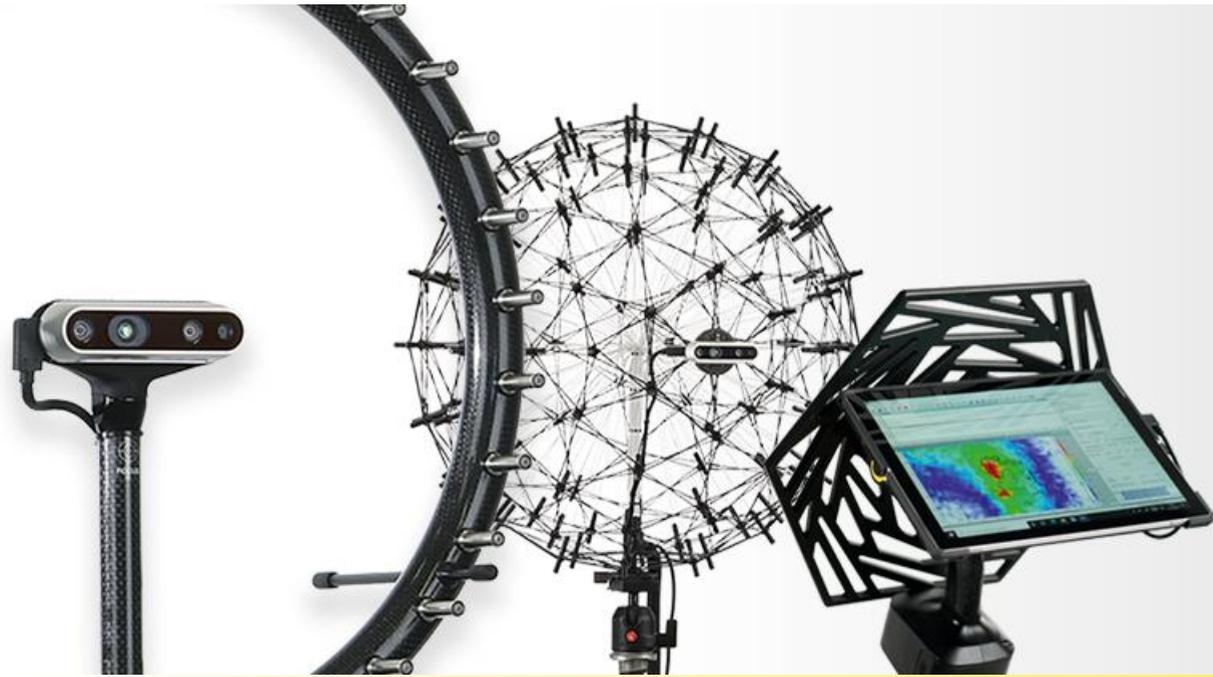
Vibration Analysis
with WaveCam



Mobile Data Recorder
gt-432-Series



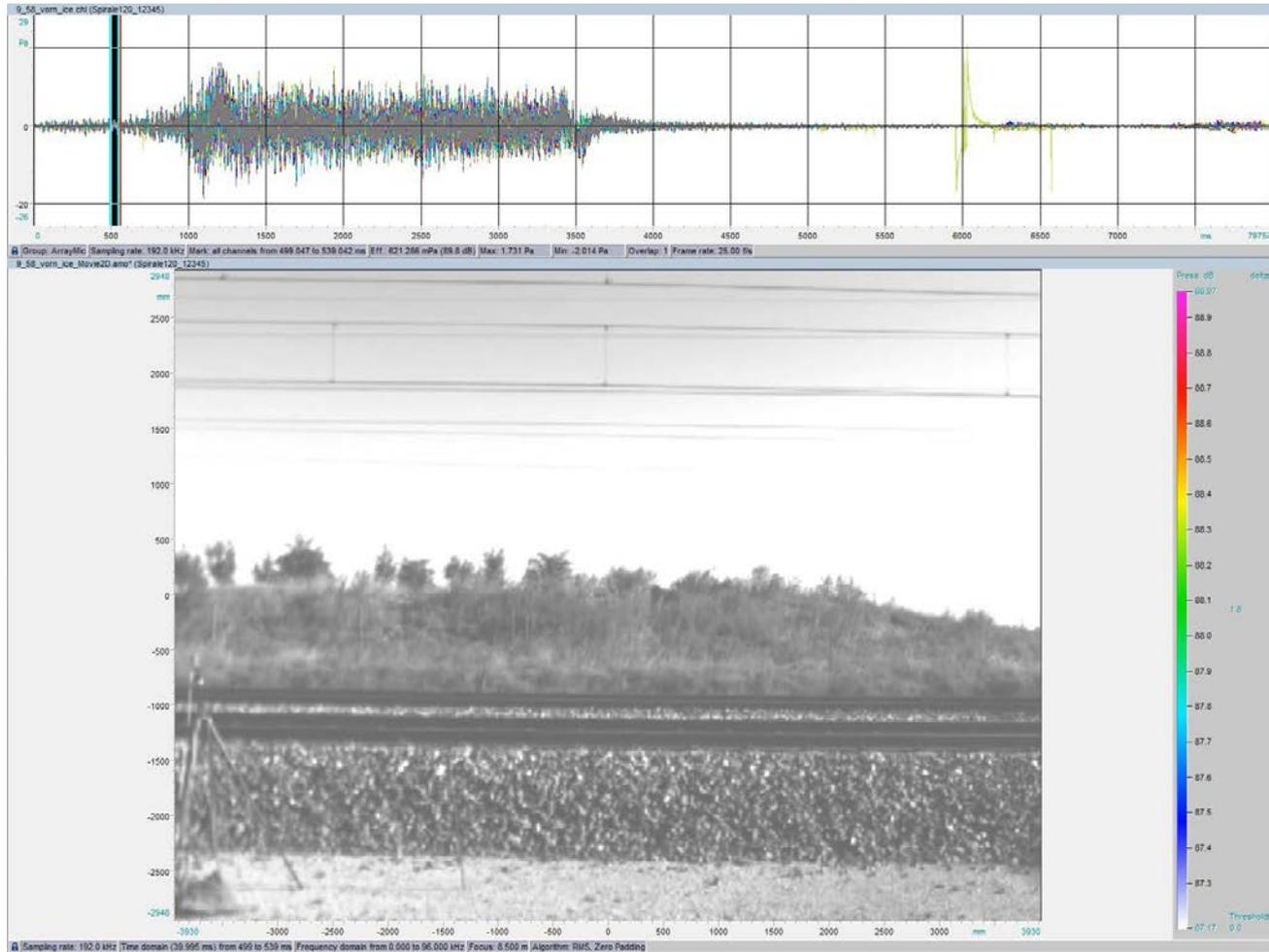
Impact Hammer
WaveHit^{MAX}



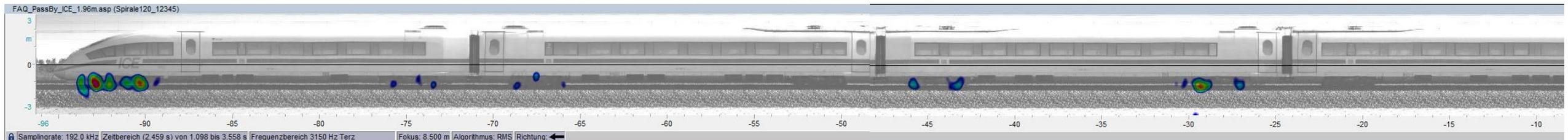
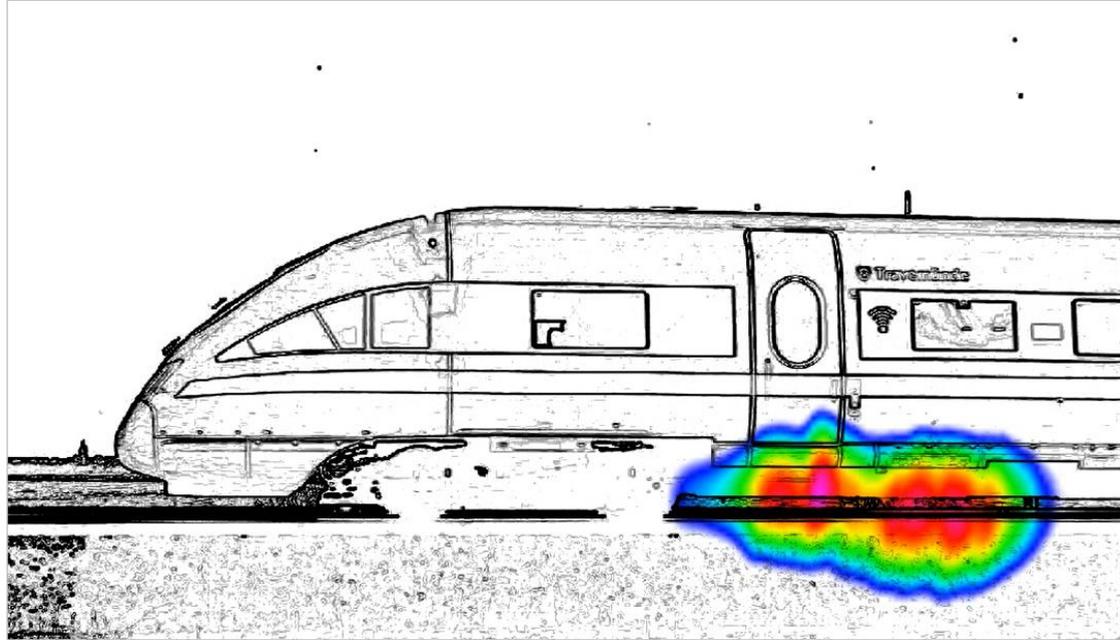
聲學相機 – 基礎知識 Acoustic Camera – Basics



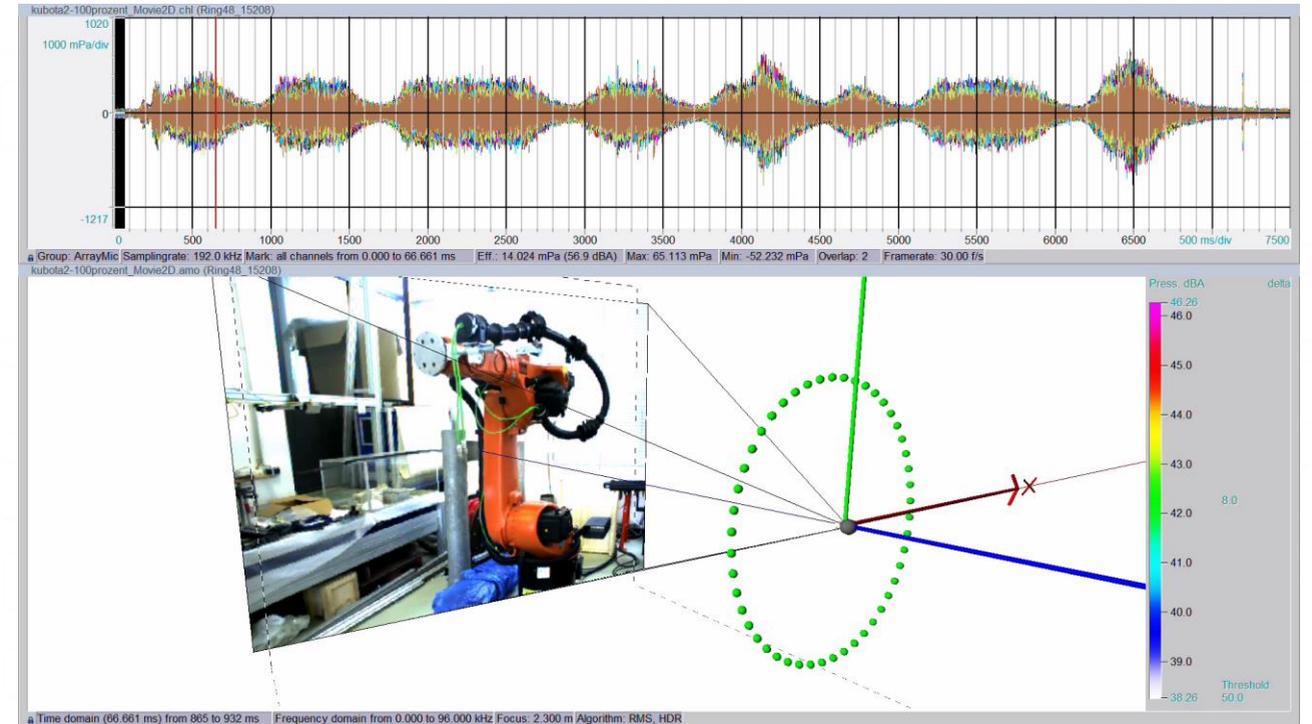
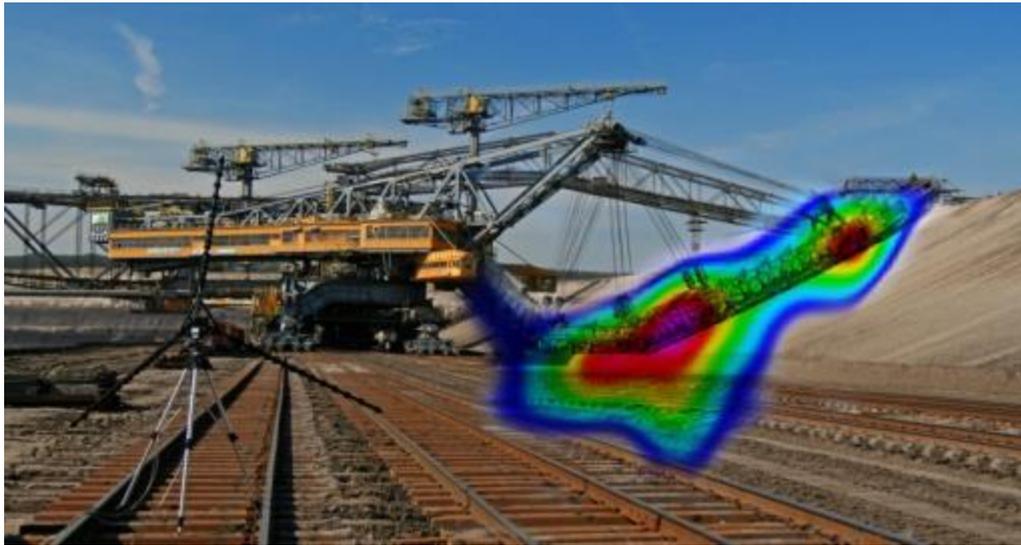
動機—聲音從哪裡來 Motivation – Where is the sound coming from?



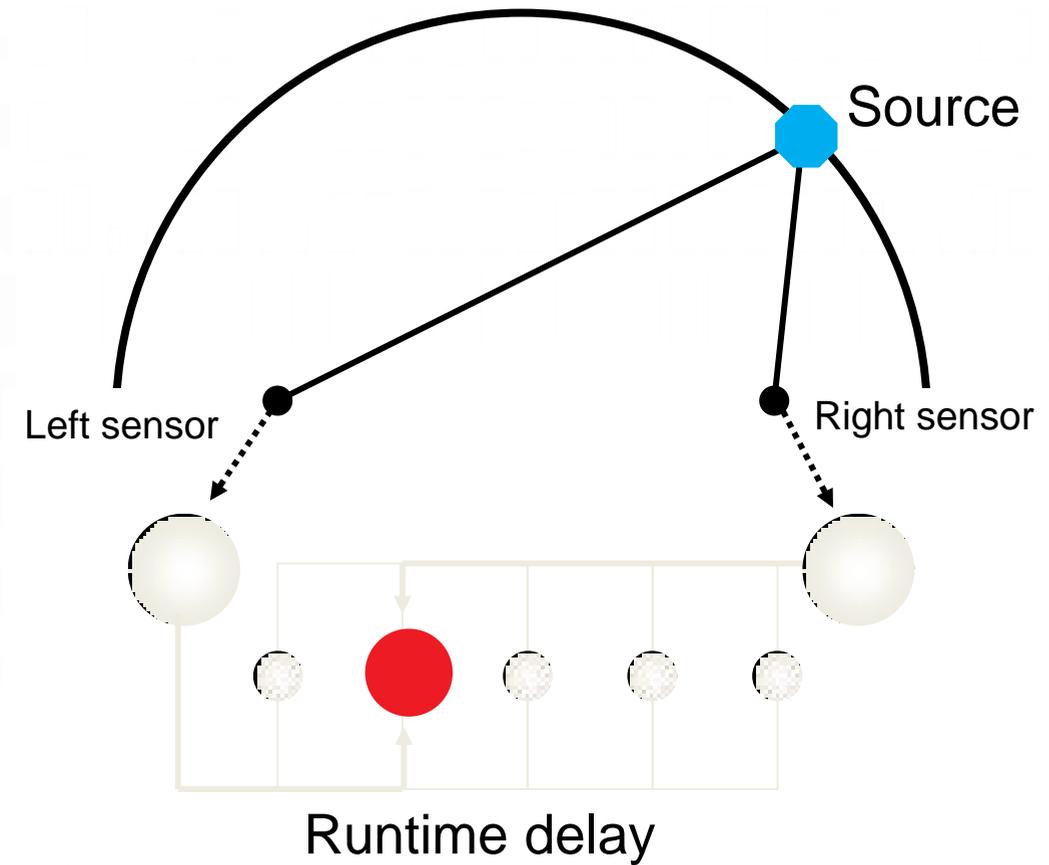
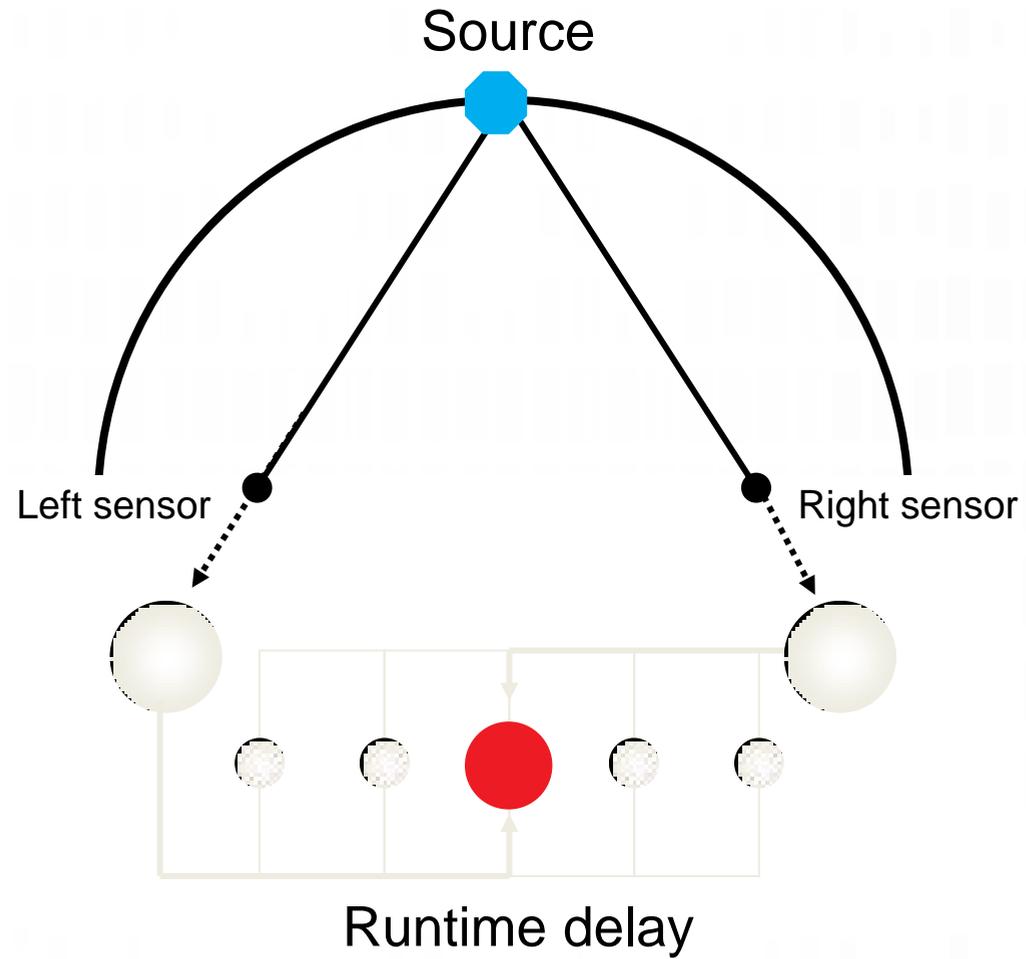
動機—聲音從哪裡來 Motivation – Where is the sound coming from?



動機—聲音從哪裡來 Motivation – Where is the sound coming from?

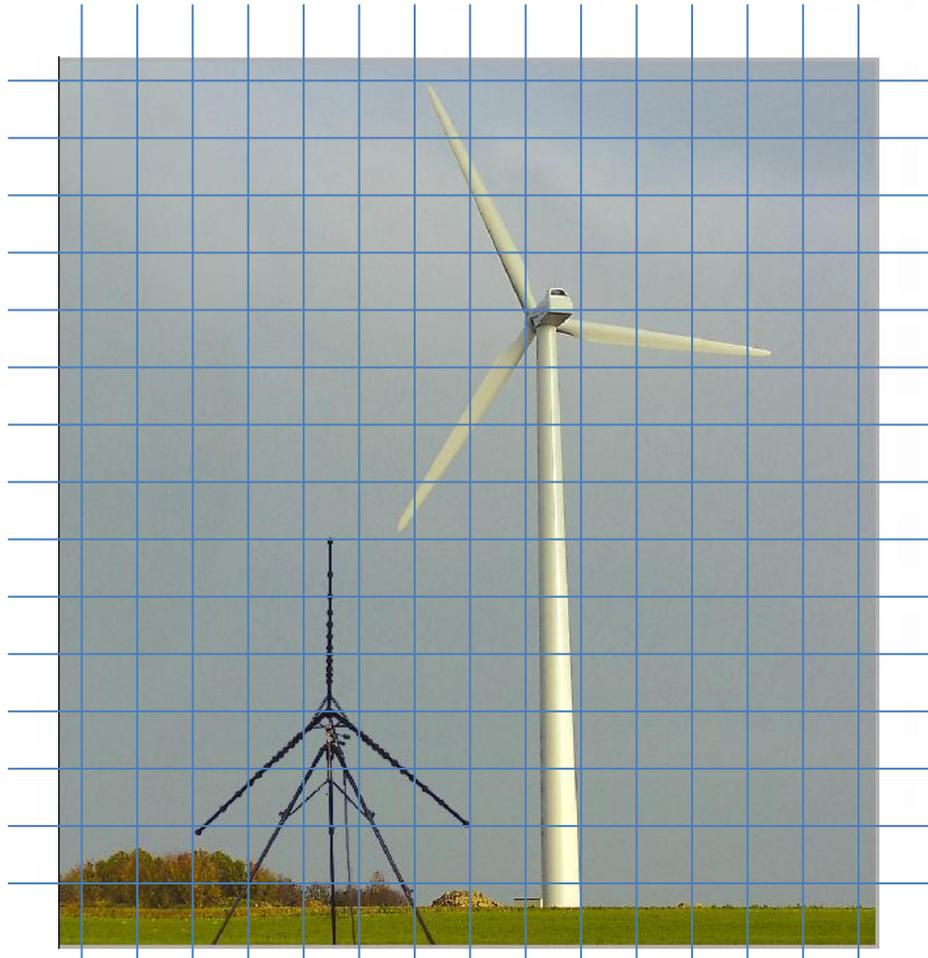


場域原則 Localization Principle



波束形成 3D Beamforming 3D

Picture



Picture & Acoustic Map





聲學相機 – 硬體 Acoustic Camera – Hardware



模組化測量設置 Modular Measurement set-up

聲學相機由 3 個組件組成

The Acoustic Camera consists of 3 components

- 麥克風陣列 Microphone Array
- 數據紀錄儀 Data Recorder
- 軟體 Software



數據記錄儀 gt-432系列 Data Recorder gt-432 series

模塊化數據記錄儀 gt-432 系列

The Modular Data Recorder gt-432 Series

- 多達 112 個通道 up to 112 channels
- 採樣率高達 192 kHz sampling rate of up to 192 kHz
- 模組化設計 modular design
- 綜合顯示 integrated display
- 使用電池供電和攜帶需求 Fully mobile with two Bosch batteries
- 96 個麥克風或 IEPE 通道 96 microphone or IEPE channels
- 12 個數位輸入 12 digital inputs
- 4 個獨立模擬輸入（電壓供應或電流供應）4 isolated analog inputs (voltage-supplied or current-supplied)



數據紀錄儀 Data Recorder

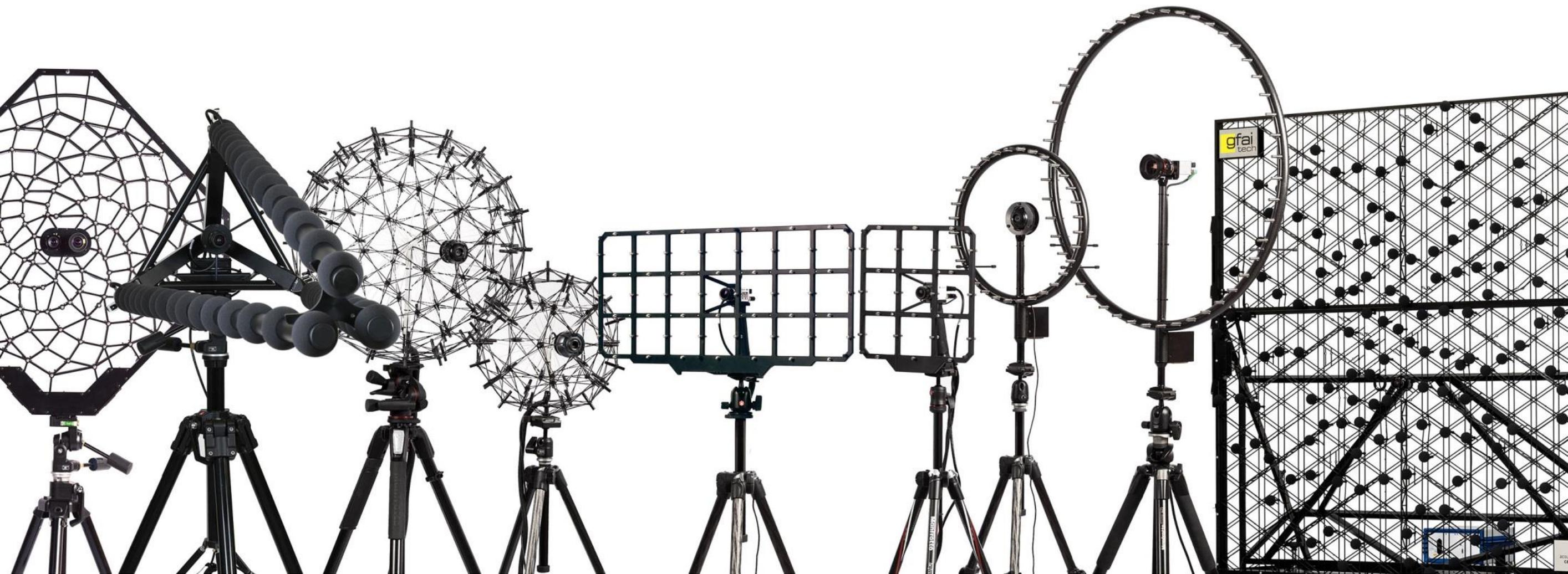
強大的多功能數據採集設備 Powerful and Multifunctional Devices for Data Acquisition



	gt-432 Series
Channels	up to 112 per recorder 1000+ with synchronized recorder
Sampling rate	up to 192 kHz
Recording	32 bit
Interface	1 Gbit Ethernet
Cards	analog, IEPE, digital, CAN Bus
Power supply	100 to 240 V or Bosch batteries
Weight / Dimensions	4060 g / 270 x 200 x 193 mm
Special features	mobile data recorder Integrated display-> autonomous operation

聲學相機麥克風陣列 Microphone Arrays of Acoustic Camera

Overview



聲學相機麥克風陣列 Microphone Arrays of Acoustic Camera

Ring – for 2D Beamforming

- 用於近場和遠場測量

For near field and far field measurements

- 對所有陣列的焦點變化最不敏感

Most insensitive to focus variations of all arrays

- 室內外測量

Indoor and outdoor measurements

			
	Ring 32 32 – 35 cm	Ring 48 48 – 75 cm	Ring 72 72 – 100 cm
Acoustic maps from	13 dB –130 dB	12 dB –130 dB	10 dB –130 dB
Recommended mapping frequency	354 Hz – 20 kHz (60 kHz)	164 Hz – 20 kHz (60 kHz)	105 Hz – 20 kHz (60 kHz)
Typ. measurement distance	> 0.3 m	> 0.5 m	> 0.5 m

聲學相機麥克風陣列 Microphone Arrays of Acoustic Camera

球體-用於3D 測量 Sphere – for 3D Measurements

- 波束成形結果映射到掃描的 3D 點雲或 3D CAD 模型上
Beamforming results are mapped on scanned 3D point clouds or 3D CAD models
- 碳纖維網
Carbon fibre mesh
- 針對內部測量進行了優化
Optimized for interior measurements



Sphere 32
48 – 35 cm



Sphere 80/120
120 – 60 cm

Acoustic maps from	12 dB – 130 dB	8 dB – 130 dB
Recommended mapping frequency	291 Hz – 20 kHz (60 kHz)	187 Hz – 20 kHz (60 kHz)
Typ. measurement distance	> 0.3 m	> 0.5 m

聲學相機麥克風陣列 Microphone Arrays of Acoustic Camera

Star – for 2D Beamforming

- 輕量化鋁陣列

Lightweight aluminium array

- 非常適合遠距離環境測量，尤其是戶外

Perfect for long range environmental measurements, especially outdoors

- 低頻的理想選擇

Ideal for low frequencies



Star 48

Acoustic maps from	12 dB – 130 dB
Recommended mapping frequency	66 Hz – 13 kHz
Dynamic range (Distance to the source: 7 m; calculation points: 90.000)	7 dB – 9 dB, up to 50 dB with advanced algorithms
Typ. measurement distance	> 4 m

聲學相機麥克風陣列 Microphone Arrays of Acoustic Camera

Fibonacci – Near Field, Far Field and Holography Measurements

- 從用於全息術的 30 Hz 到用於波束形成測量的 25 kHz 的應用範圍

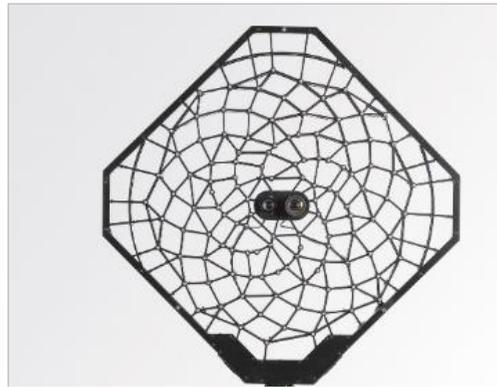
Application area from 30 Hz for holography to 25 kHz for beamforming measurements

- 鋁結構

Aluminum structure

- 全息術 (HELs 和 SONAH)

Holography (HELs and SONAH)

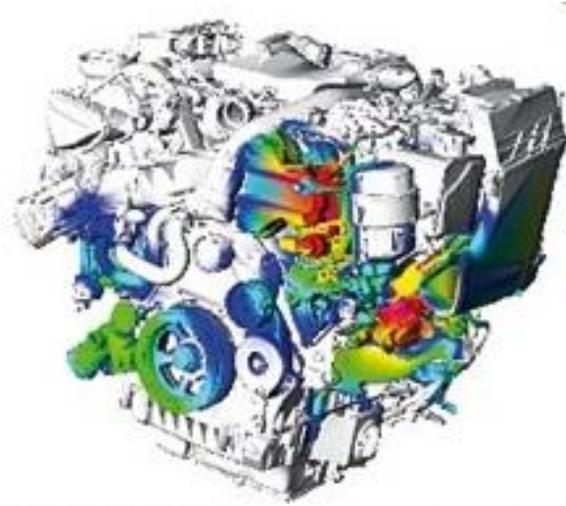


	Fibonacci 72 channels		Fibonacci 96 channels		Fibonacci 120 channels	
Acoustic maps from	9 dB – 130 dB		8 dB – 130 dB		7 dB – 130 dB	
Recommended mapping frequency	Beamforming Nearfield	285 Hz – 60 kHz 30 Hz – 2 kHz	Beamforming Nearfield	245 Hz – 60 kHz 30 Hz – 2 kHz	Beamforming Nearfield	262 Hz – 60 kHz 30 Hz – 2 kHz
Dynamic range (distance to source: 1 m, Calculation points: 90.000)	14 dB – 20 dB up to 50 dB with advanced algorithms		15 dB – 22 dB up to 50 dB with advanced algorithms		16 dB – 25 dB up to 50 dB with advanced algorithms	
Typ. measurement distance	SONAH: 10 – 20 cm, HELS: 0 – 10 cm, BF: > 0.8 m					

定制聲學相機麥克風陣列 Customized Microphone Arrays of Acoustic Camera

Dome

- 外部 3D 映射
3D-mapping from the outside
- 聲學圖：35 dB –130 dB
Acoustic maps from: 35 dB –130 dB
- 投影到 CAD 模型上
Projection onto CAD model
- 直徑達 1 m 的物體
Objects with a diameter up to 1 m
- 可擴展到不同尺寸
Scalable to different sizes



Your wishes

定制陣列的開發和生產沒有限制！ for customized array development and production have no limits!

陣列幾何形狀的優化始終以各自的應用為導向。

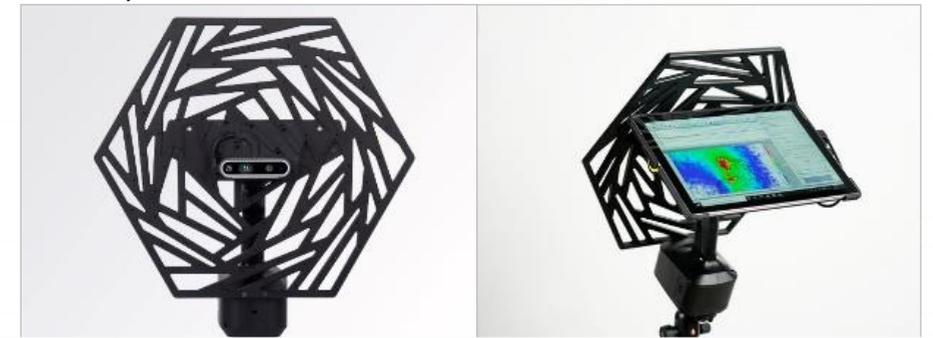
The optimization of the array geometry is always oriented towards the respective applications.



移動式一體化聲學攝影機 Mobile All-in-one Acoustic Camera

Mikado – for easy and fast troubleshooting of sound and vibration problems

- 多合一設計 Compact all-in-one design
- 透過充電電池實現完全可攜式 100 % autonomous through rechargeable Bosch battery
- 聲音分析軟體 NoiseImage MobileSond analysis software NoiseImage Mobile
- Microsoft Surface 可快速輕鬆地進行記錄和分析 Microsoft Surface for fast and easy recordings and analysis
- 使用 “DynaBeam” 創建 3D 模型 3D-model creation with „DynaBeam“

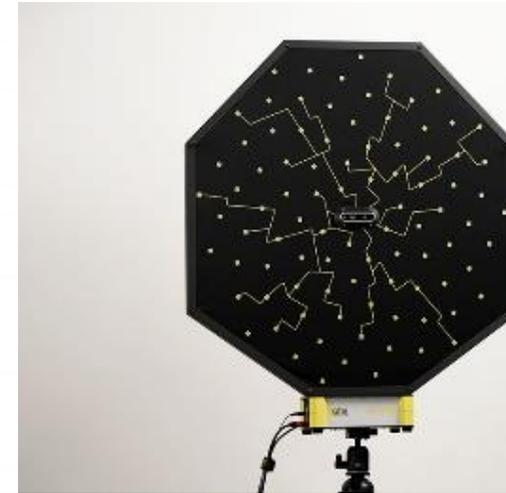


	Mikado	
Acoustic maps from	9 dB – 120 dB	
Recommended mapping frequency	Beamforming Nearfield	514 Hz – 24 kHz 30 Hz – 2 kHz
Dynamic range (Distance to the source: 1 m; calculation points: 90.000)	15 dB – 27 dB, up to 50 dB with advanced algorithms	
Typ. measurement distance	> 0.3 m	

移動式八角聲學攝像機 Mobile All-in-one Acoustic Camera Octagon

Octagon – for easy and fast troubleshooting of sound and vibration problems

- 多合一系統，包括數據記錄器 All in one system including data recorder
- 4 個模擬和 4 個數字輸入通道 4 analog and 4 digital input channels
- 優異的陣列特性 Excellent array characteristics
- 使用 “DynaBeam” 創建 3D 模型 3D-model creation with „DynaBeam“
- 192 個麥克風 192 microphones
- 直徑 80 厘米 80 cm diameter



	Octagon	
Acoustic maps from	9 dB – 120 dB	
Recommended mapping frequency	Beamforming Nearfield	170 Hz – 24 kHz 30 Hz – 2 kHz
Dynamic range (Distance to the source: 1 m; calculation points: 90.000)	15 dB – 27 dB, up to 50 dB with advanced algorithms	
Typ. measurement distance	> 0.5 m	



聲學相機軟體 NoisImageAcoustic Camera Software NoisImage

New features

New Software - DynaBeam

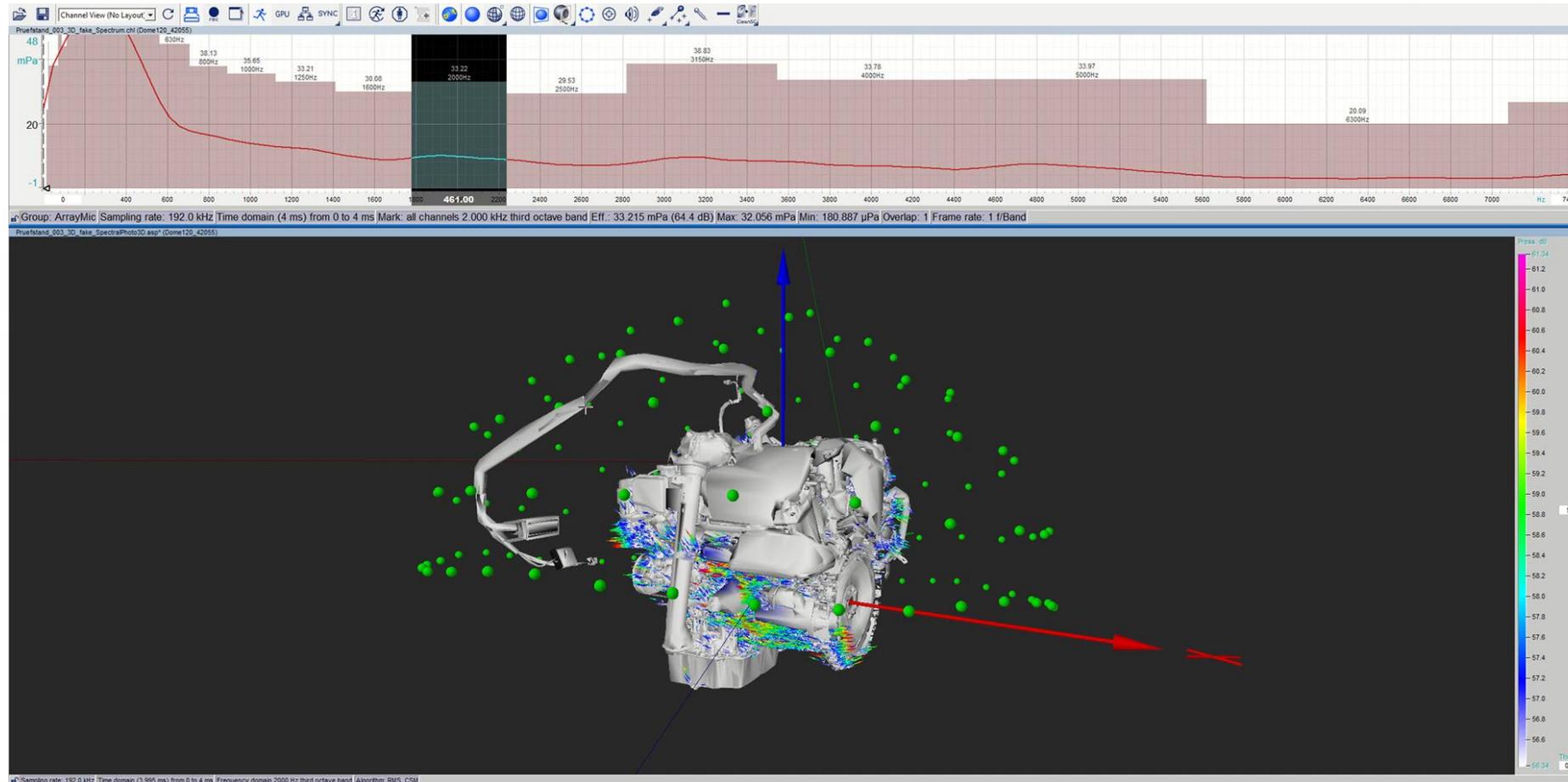
DynaBeam

- 使用聲學相機生成 3D 掃描
Generating a 3D Scan with the Acoustic Camera
- 幾乎增加通道數
Virtually increasing the channel count
- 波束形成 3D
Beamforming 3D
- 顯示最響聲源的方向性
Showing the directivity of the loudest sound source
- 更好的低頻聲源分離
Better sound source separation in low frequencies



New Software - DynaBeam

引擎測試 Engine test bench with DynaBeam





聲學相機 Acoustic Camera

Summary and measurement examples



應用 Applications



Automotive



Building & Structure



Energy



Rail, Marine & Aviation



Environmental Noise & Immission Control



Machinery & Plant



Consumer Products



Troubleshooting

應用-汽車 Applications – Automotive

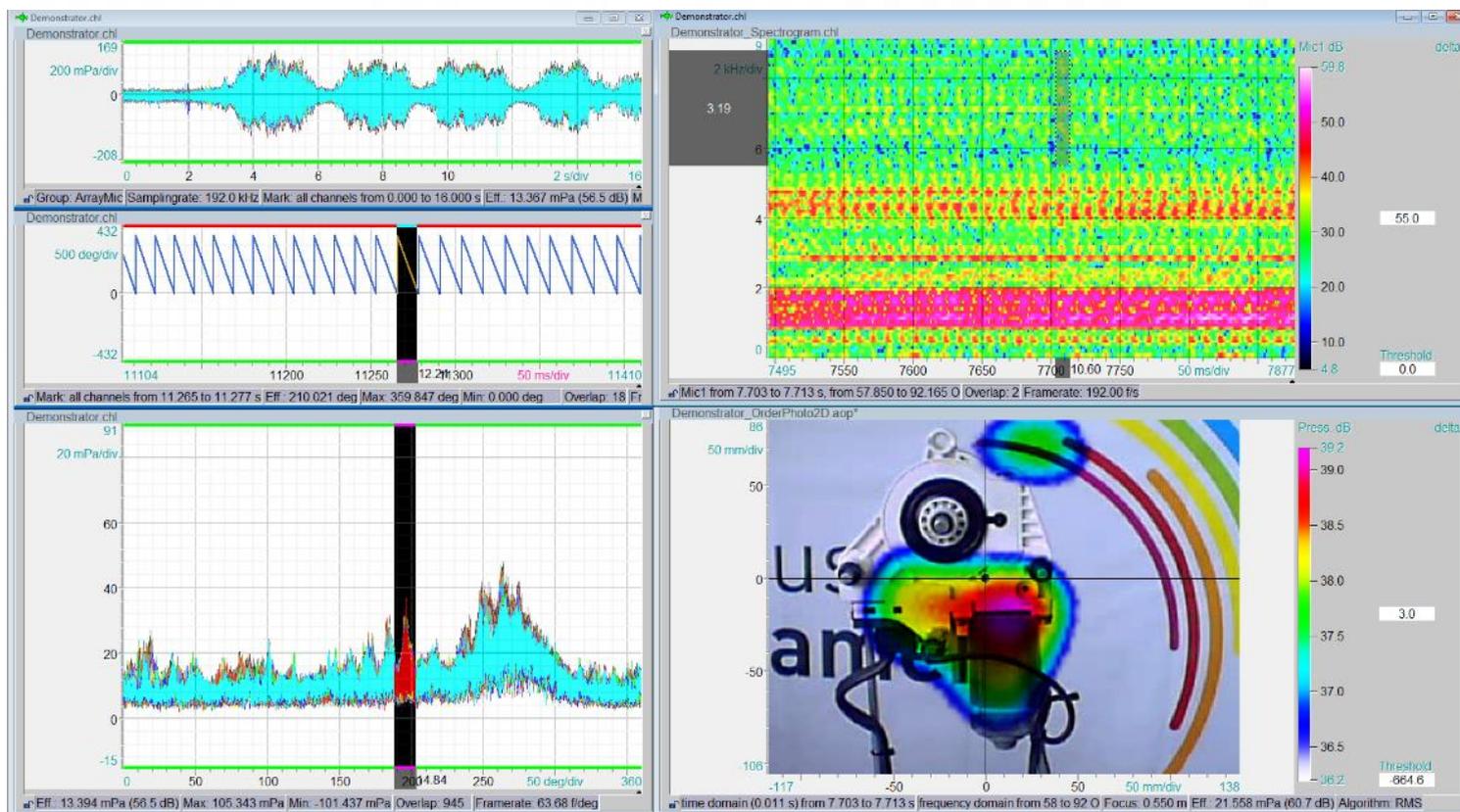
3D Analysis with DynaBeam



應用-汽車 Applications – Automotive

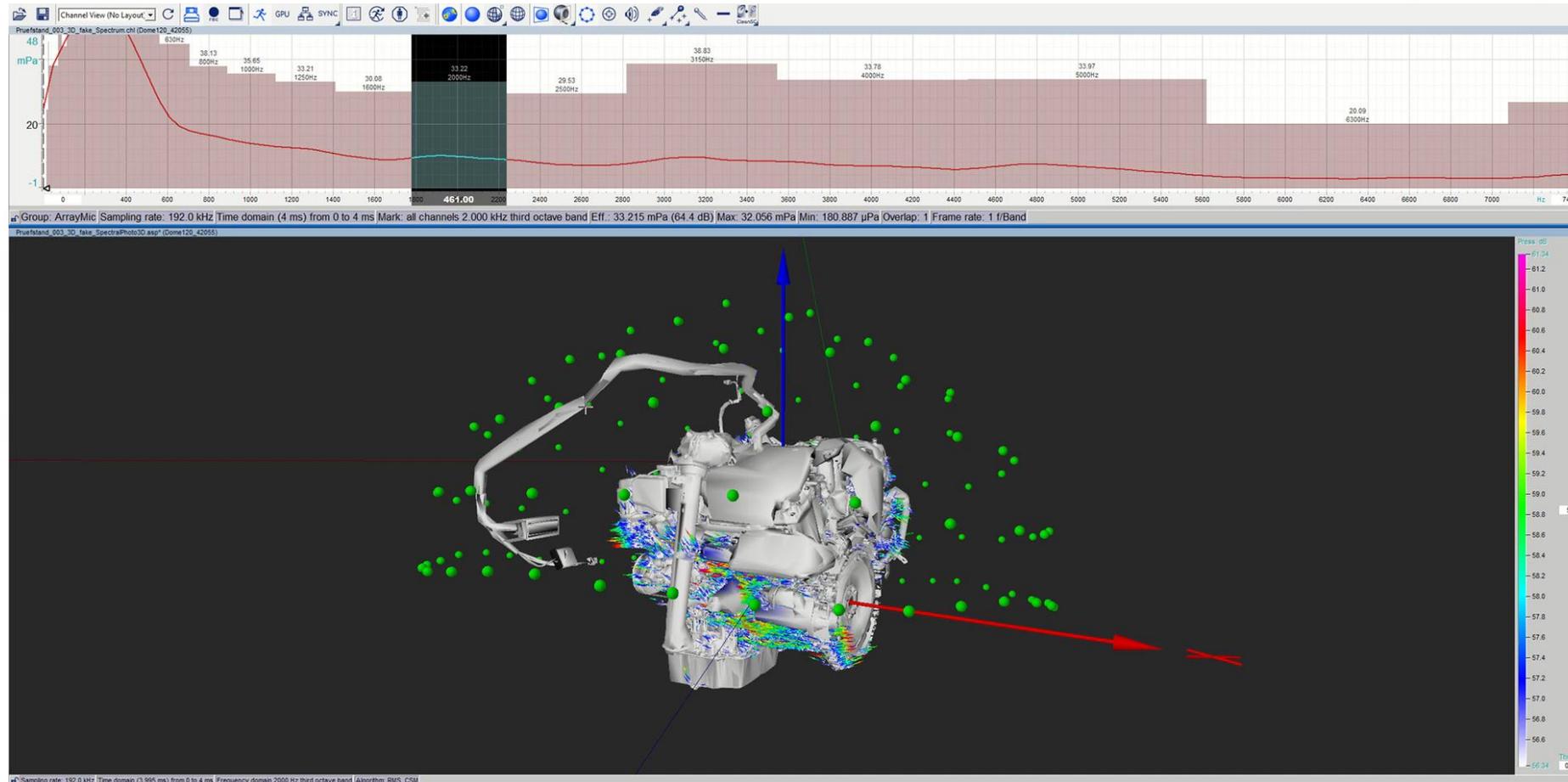
Automotive – Components:

- 用於車窗 for car windows,
- 用作參考信號的旋轉角度 rotation angle used as a reference signal



應用- 汽車Applications – Automotive

Engine test bench with Dome array

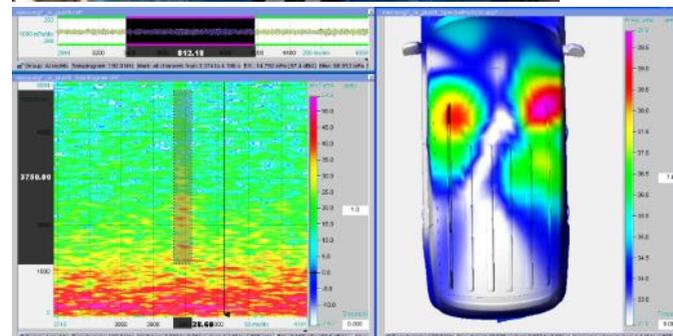


應用-汽車Applications – Automotive

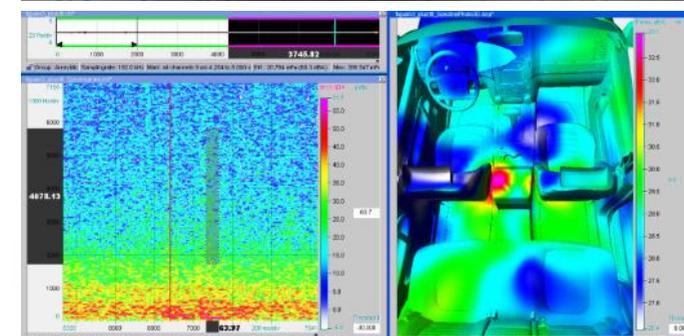
Automotive – Car Interior

BSR – Buzz, Squeak and Rattling

- Vehicle optimization and quality management for a VW Tiguan



Sunroof cracking



Stick-Slip-Effect at surfaces

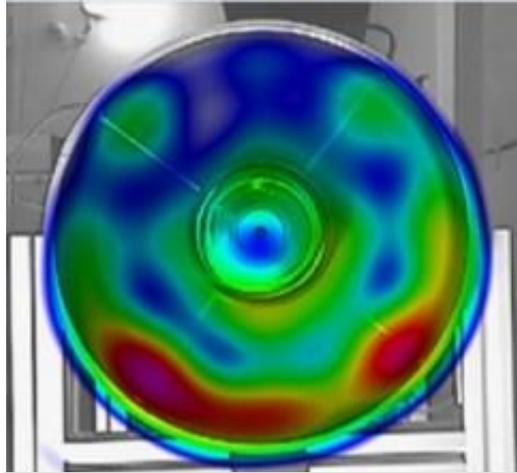
應用-汽車Applications – Automotive

Automotive – Seat structures at Johnson Controls

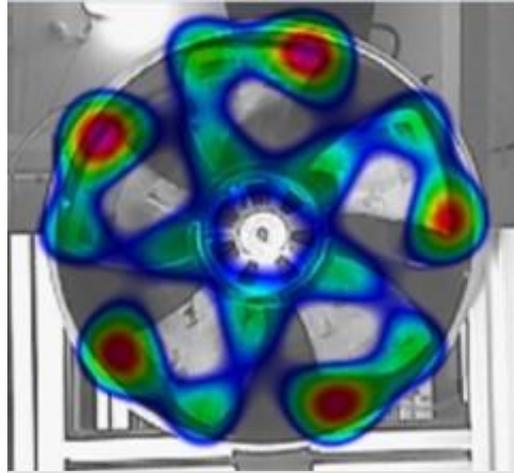


Source: <http://www.auto-medienportal.net/artikel/detail/18957>

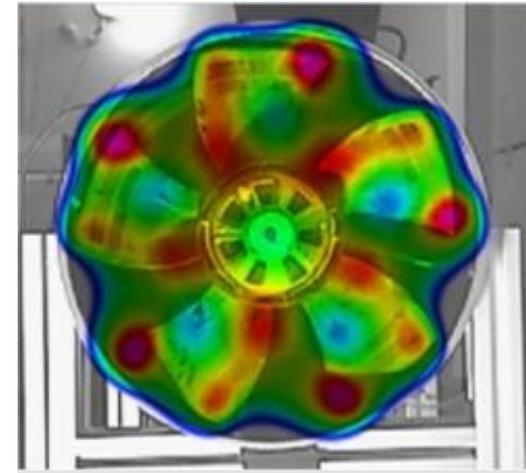
應用於風扇測量 Application Fan measurement



Without Rotational Beamforming

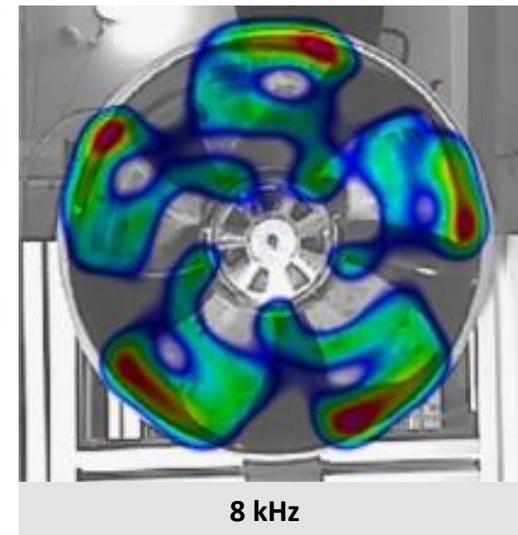
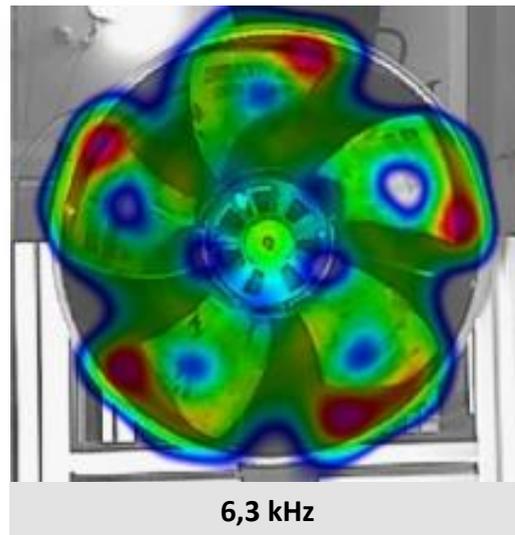
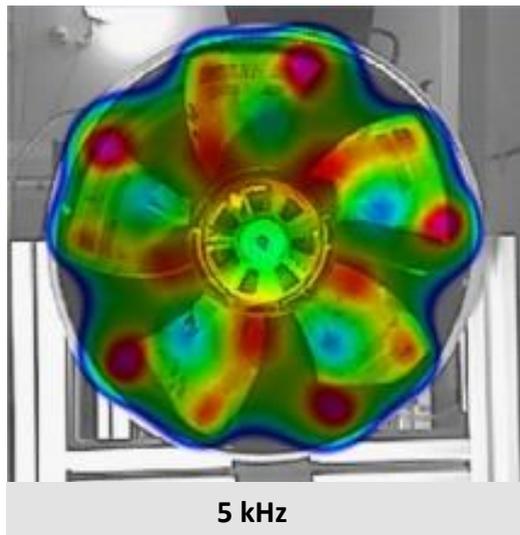
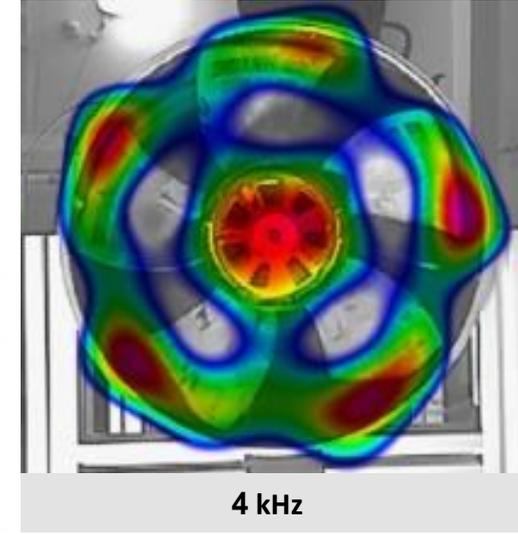
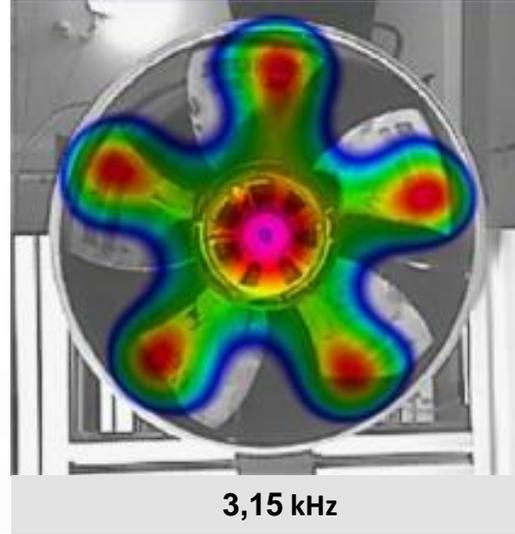


With Rotational Beamforming



With Rotational Beamforming,
orthogonal and functional BF

應用於風扇測量 Application Fan measurement



應用於聲音設計 Application Sound Design

聽覺心理 Psychoacoustics

參數 Parameters

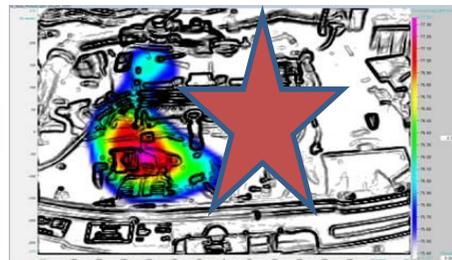
- 響度：基於 **DIN 45631/A1 FFT 算法 Loudness**: based on DIN 45631/A1 FFT-algorithm
- 清晰度：基於 **Aures 的 DIN 45692**，來自 **Bismarck Sharpness**: based on DIN 45692 by Aures, from Bismarck
- 粗糙度：**Sottek 的聽力模型**，標準 (70Hz)，R 粗糙度 (20Hz)，變化強度 (4Hz) **Roughness**: Hearing model by Sottek, Standard (70Hz), R-roughness (20 Hz), variation strength (4Hz)
- 色調：**DIN 45681**，特殊情況：無圖像計算，無時間相關計算

Tonality: DIN 45681, Special case: no image calculation, no time-dependent calculation

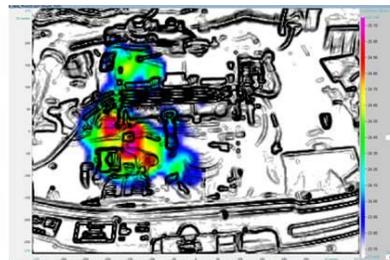
The standard filters of psychoacoustics are extended to include psychoacoustic images.



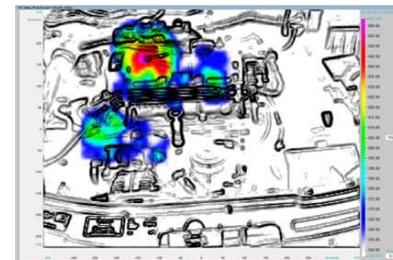
Sharpness (Cylinder Head)



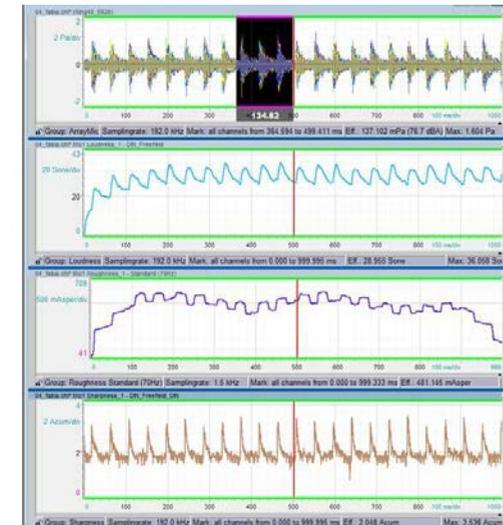
Tonality



Loudness

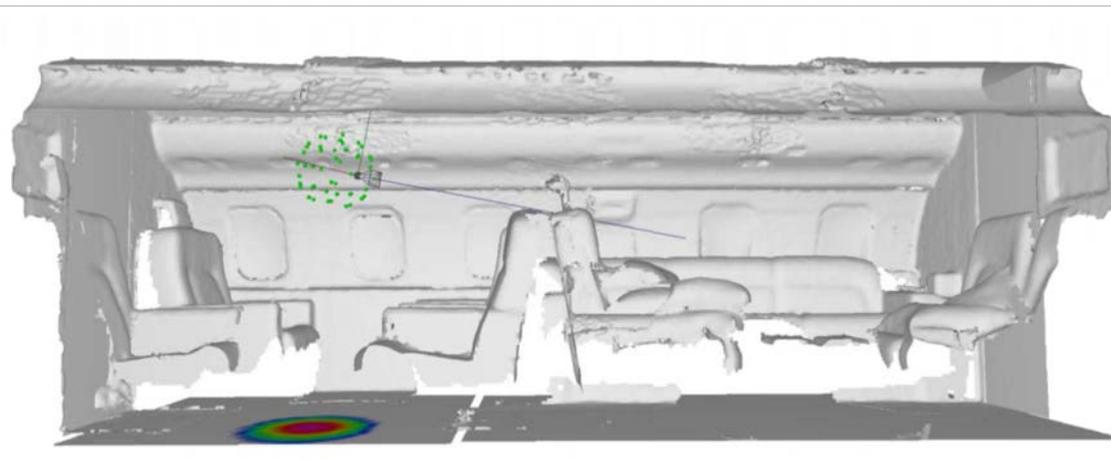
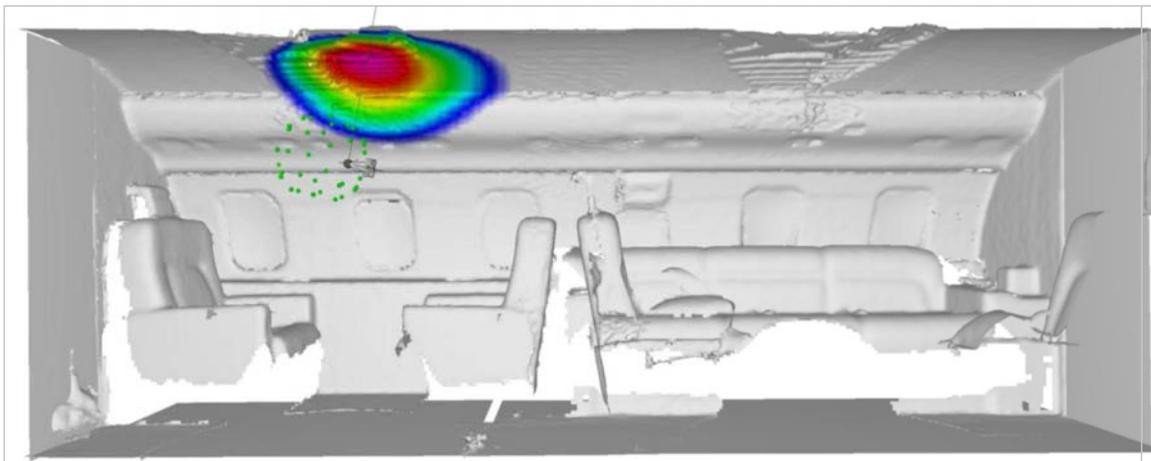


Roughness (EGR valve)

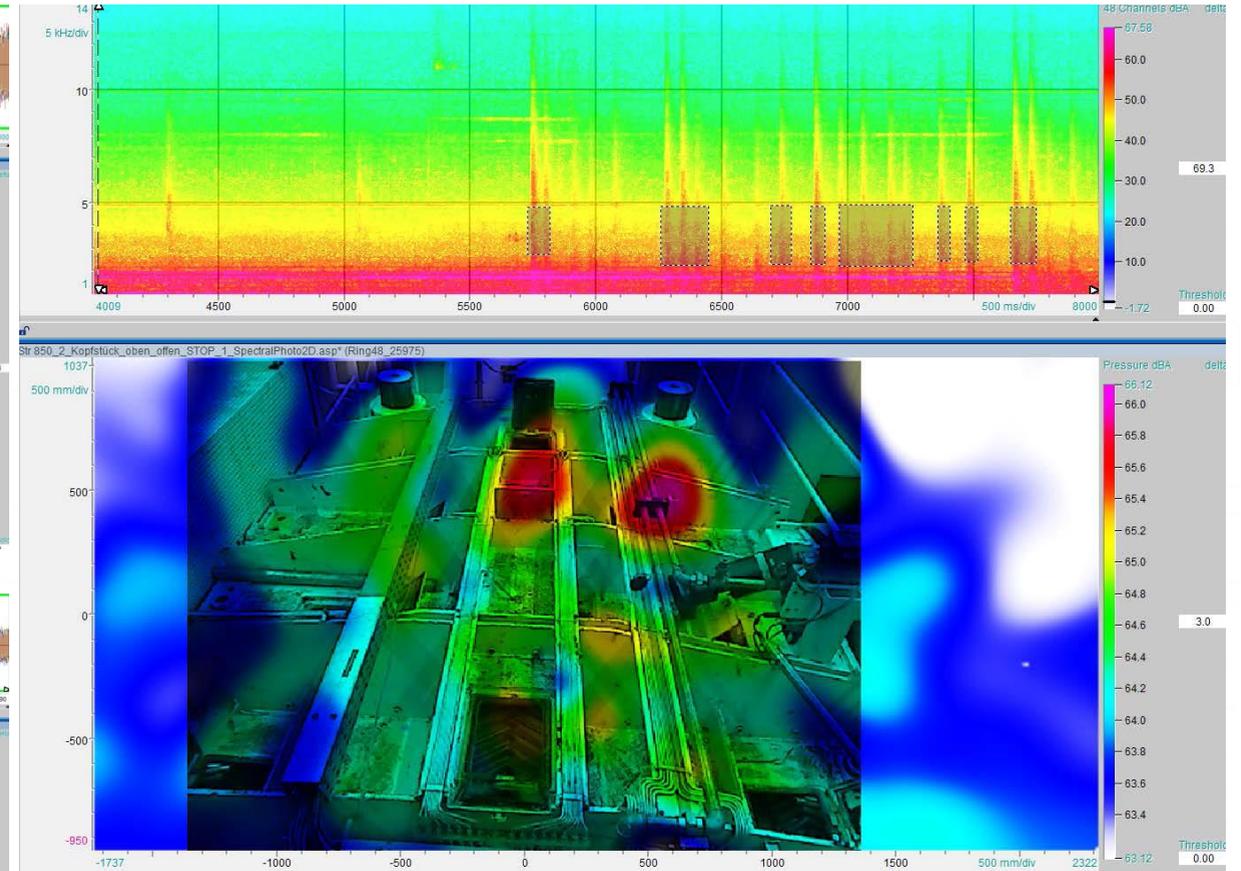
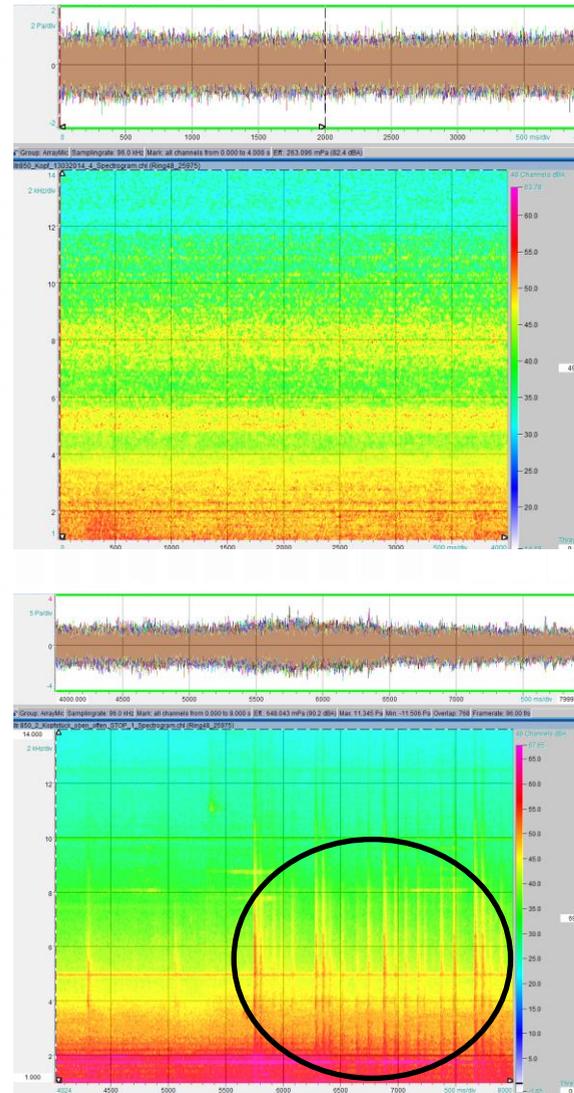
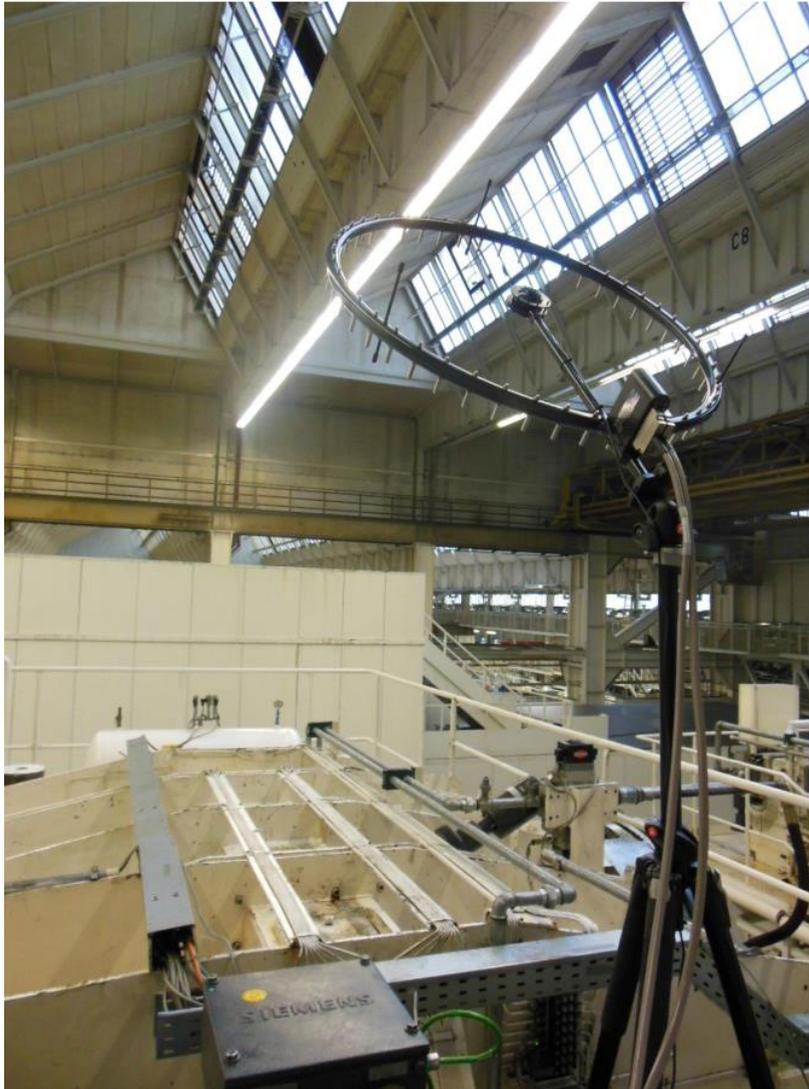


Microphone data of a combustion engine in neutral (according to psychoacoustic parameters)

應用於航空 Application – Aviation



應用於維護 Applications – Maintenance

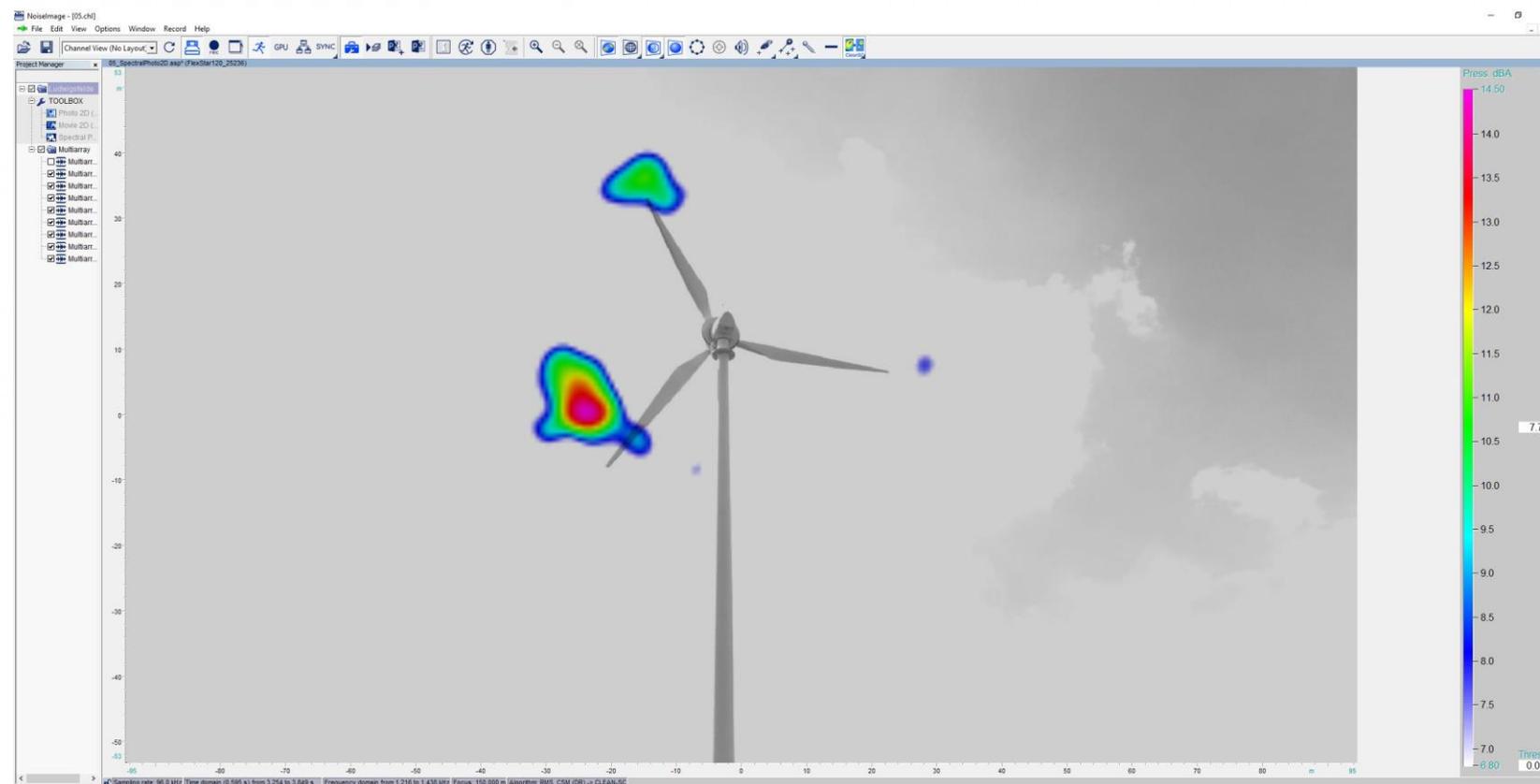


The Acoustic Camera as a tool for machinery maintenance, Inter.noise 9-12 August 2015, San Francisco.

應用於能源領域 Applications – Energy Sector

2D Outdoor Measurements of a Wind Turbine

- with Acoustic Camera Star AC Pro

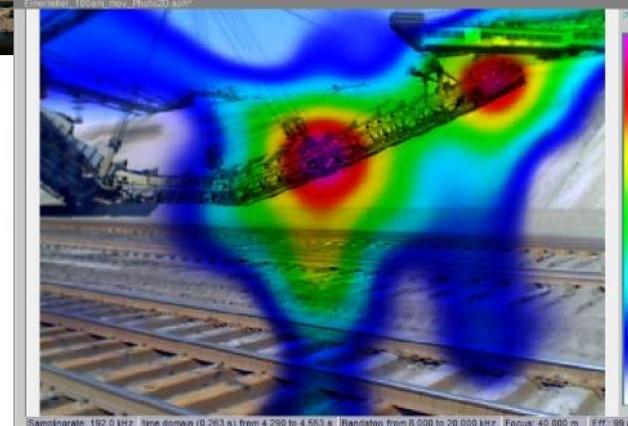
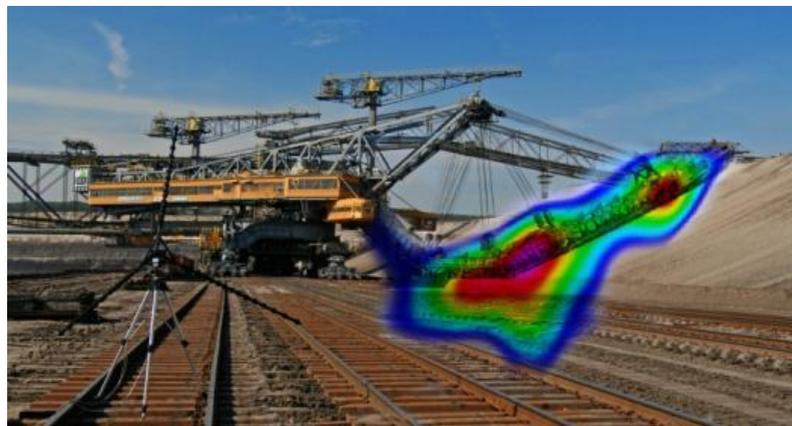
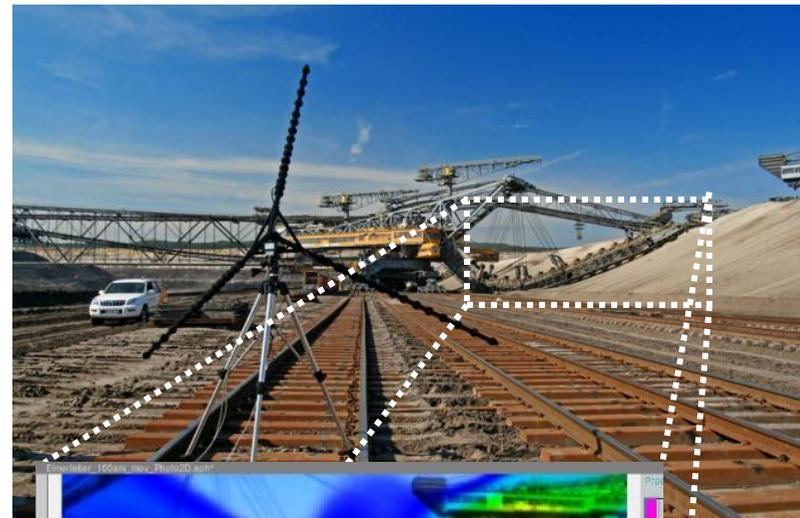


Stuart Bradley, Michael Kerscher, Torben Mikkelsen:
Use of the Acoustic Camera to accurately localize wind turbine noise sources and determine their Doppler shift, WTN Conference Rotterdam 2017

應用於環境量測 Applications – Environmental Measurement

Measurement of Strip Mining Excavator

Free field Measurement with Acoustic Camera Star AC Pro



Samplingrate: 192.0 kHz | Time domain (0.263 s) from 4.250 to 4.553 s | Bandstop: from 8.000 to 20.000 kHz | Focus: 40.000 m | Eff: 99 mPa

應用於環境測量 Applications – Environmental Measurement

Measurements of an Industrial Plant

with Acoustic Camera Star AC Pro for long distances



應用於建築結構 Applications – Building & Structure

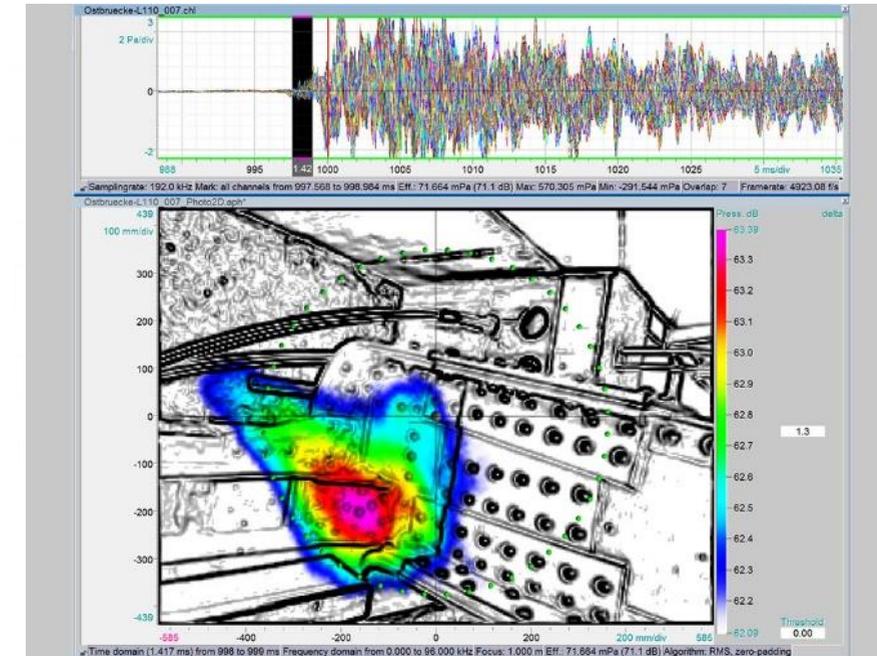
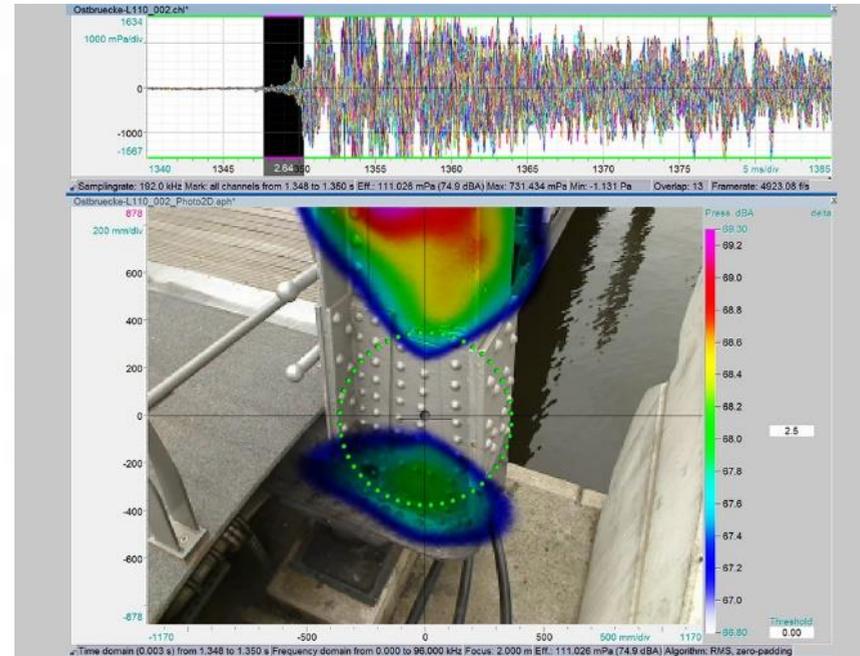
Sound Imaging in Colosseum Rom with Acoustic Camera Sphere AC Pro



應用於機械及設備 Applications – Machinery & Plant

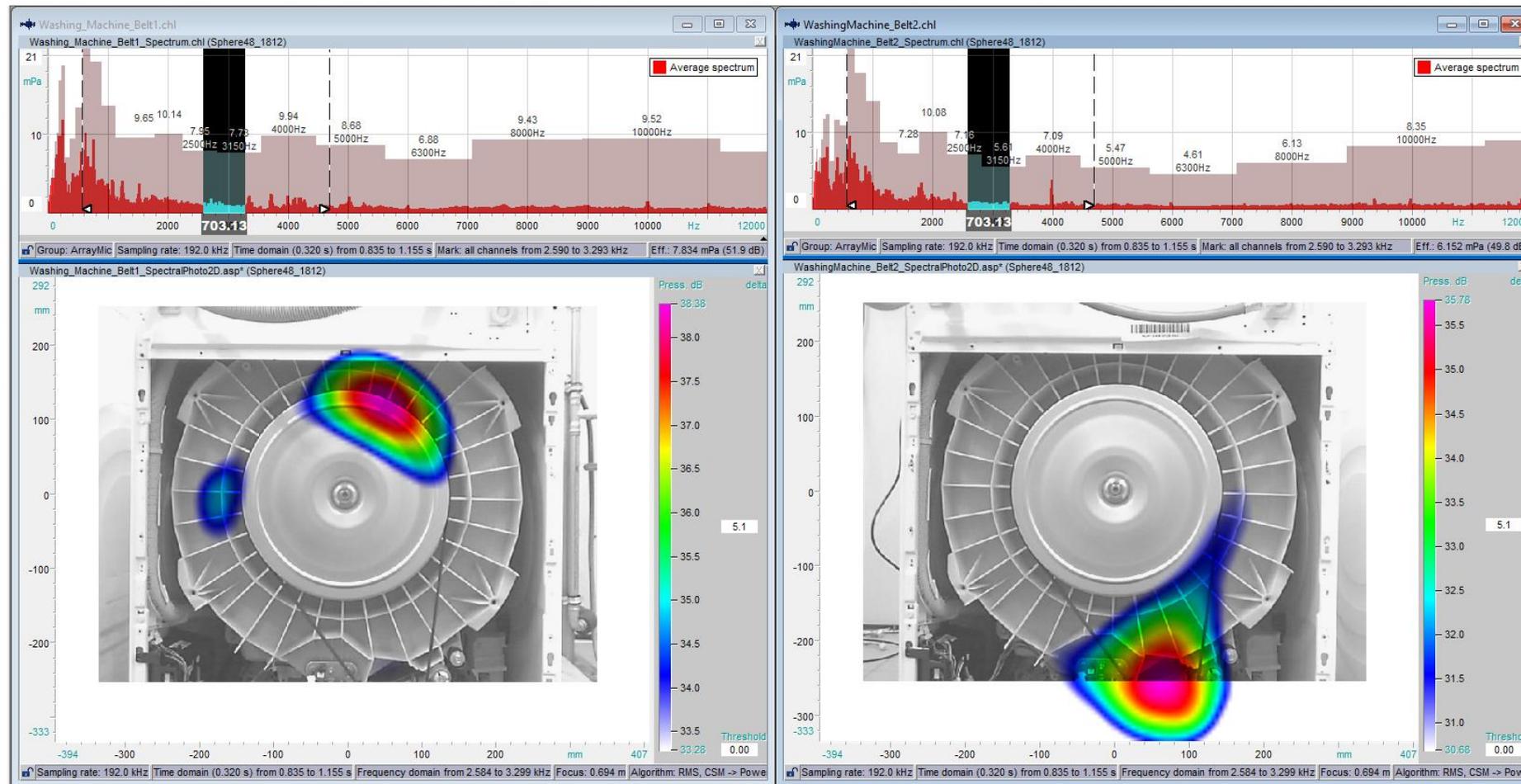
Localize Sound Sources on a bridge

with Acoustic Camera Ring AC Pro results with analysis software NoiseImage



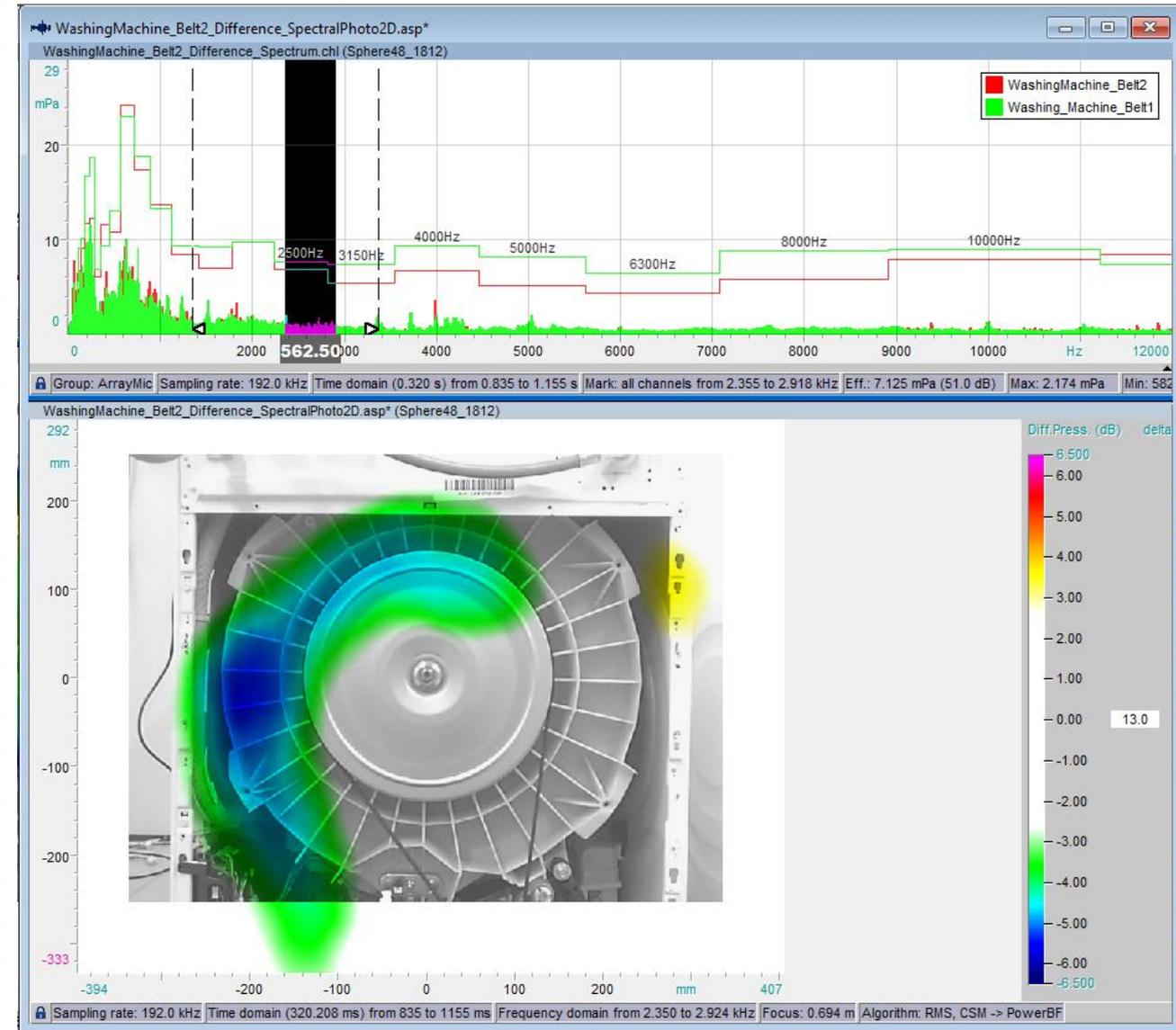
應用於消費商品 Applications – Consumer Products

Washing machine with two different belts
The differences can easily be visualised



應用於消費商品 Applications – Consumer Products

Washing machine with two different belts Differential image



應用於汽車產業 Applications – Automotive

Automotive – Underbody

Underbody drive train test with 50x60cm 72 channel intensity array moving along the entire exhaust system. Investigating various load conditions and its related relevant sound sources.

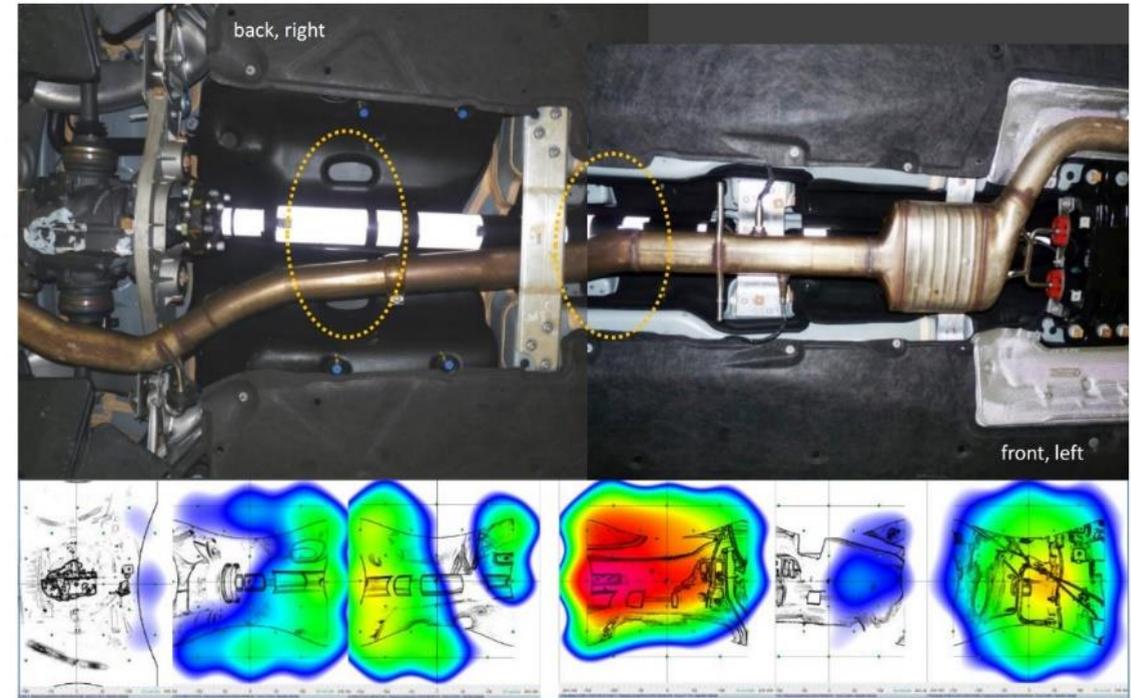
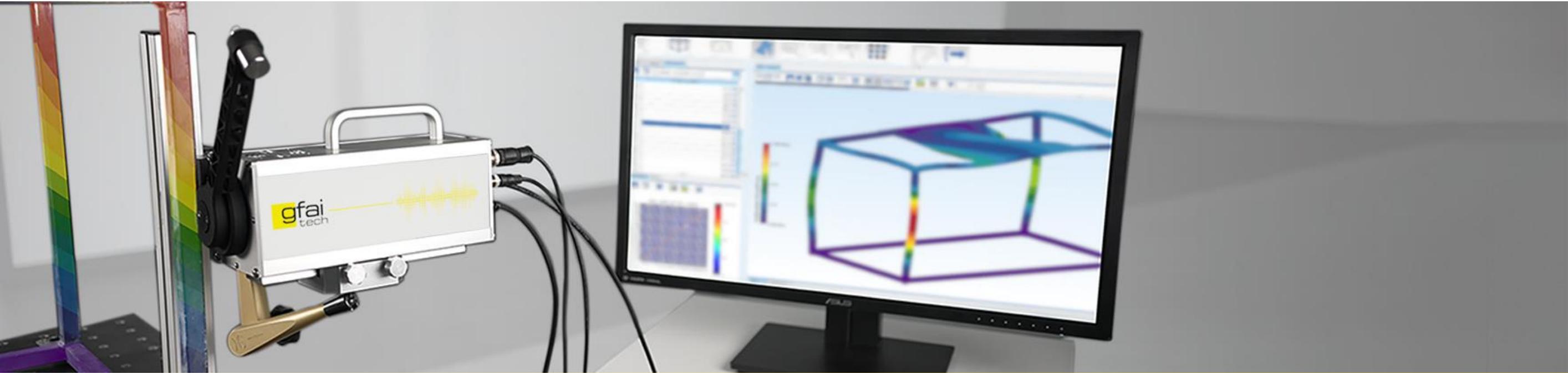


Fig. 8: Airborne noise emission of the cardan shaft detected with the Gfal intensity array

BeBeC 2014; Daimler Paper: Nau/ Moll >Extension of traditional measurement methods in vehicle acoustics to the method of source localization in the vehicle interior, Page 9



振動測試 Vibration Testing – WaveCam

WaveCam: Can you imagine doing this...



Source: https://www.dlr.de/content/de/bilder/2018/2/500-sensoren-messen-die-schwingung-direkt-am-rotorblatt_30632.html

WaveCam: ... only with a camera and Laptop

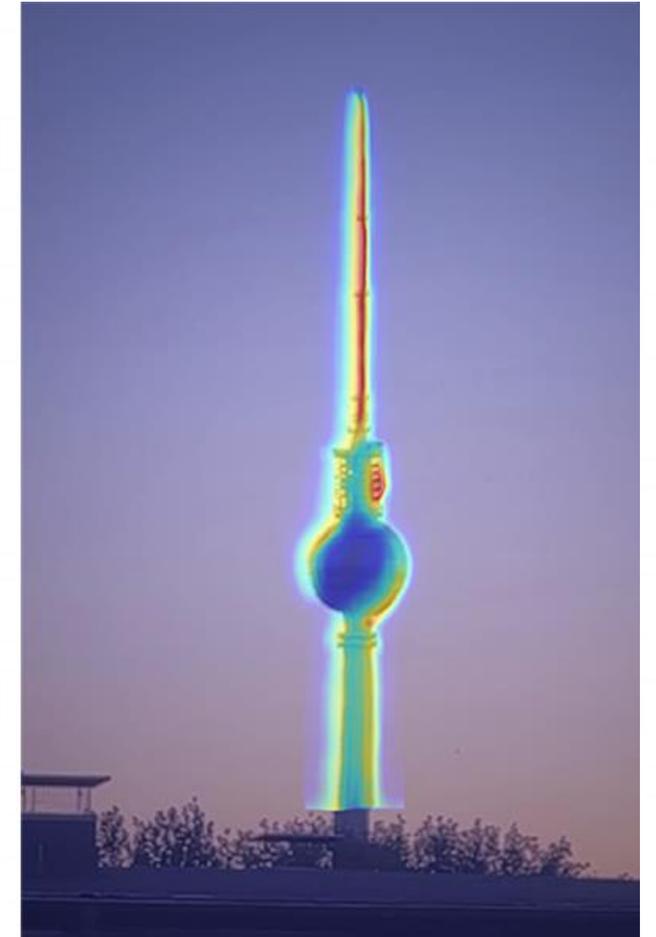
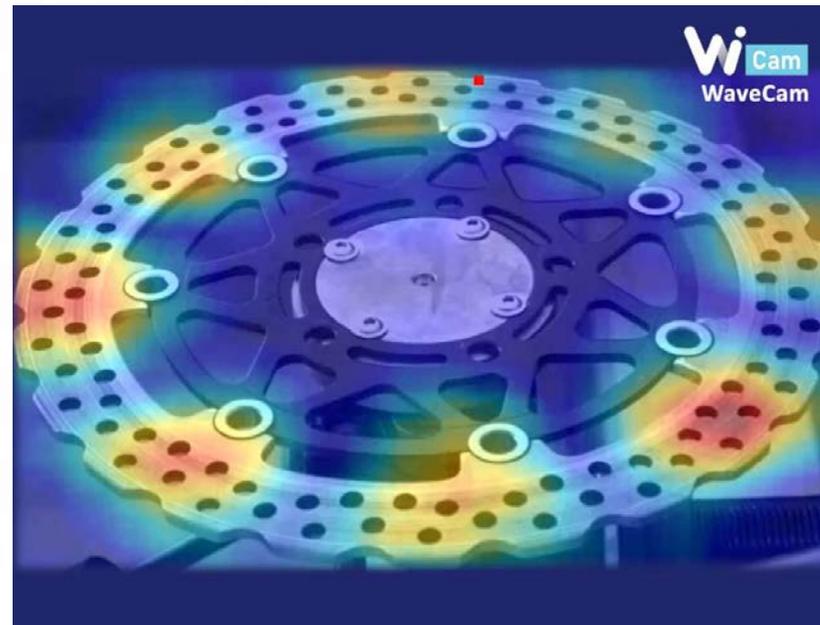


WaveCam

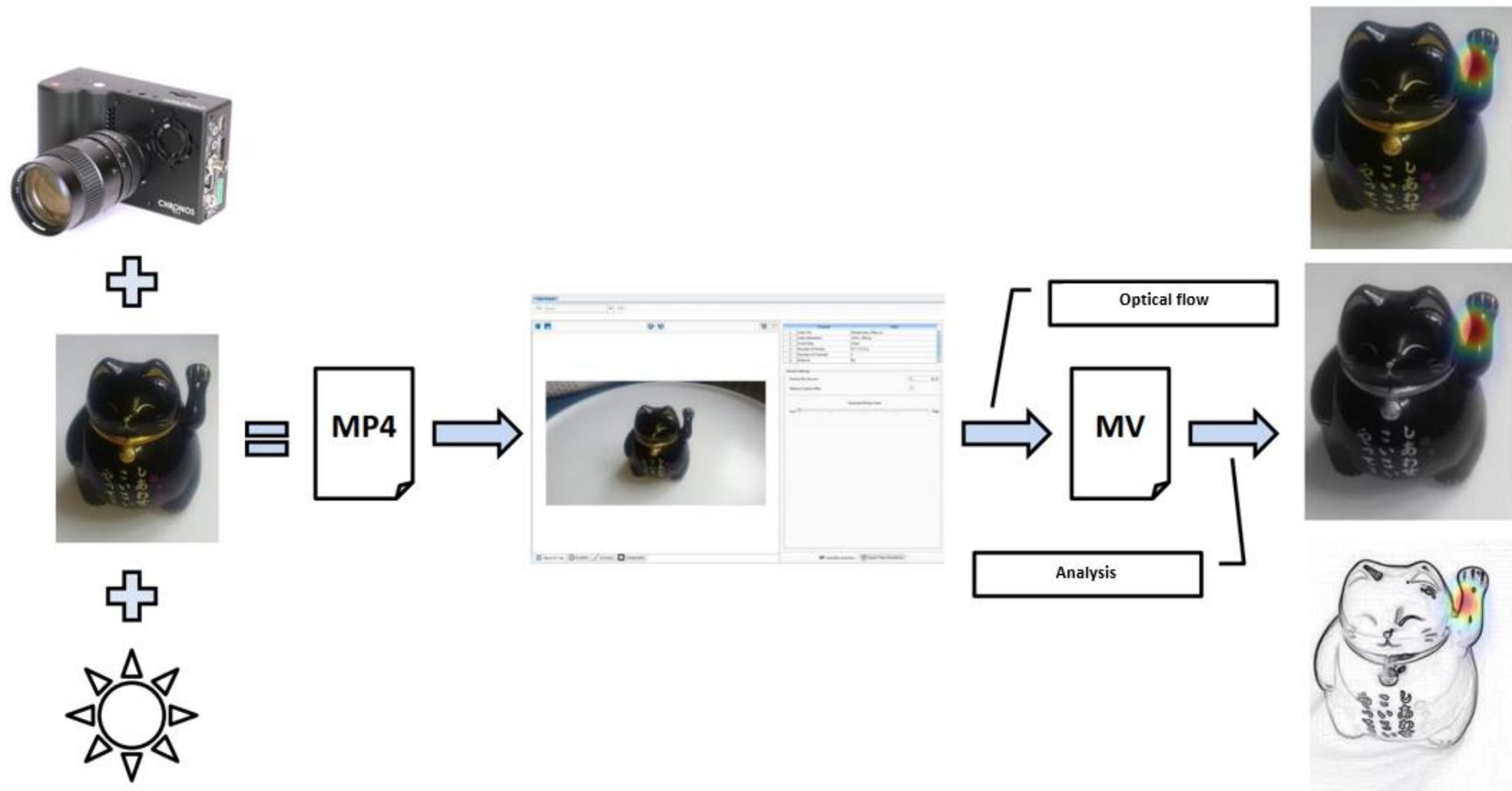
一種革命性的振動測量方法，

A revolutionary approach to measure vibration with a minimum of

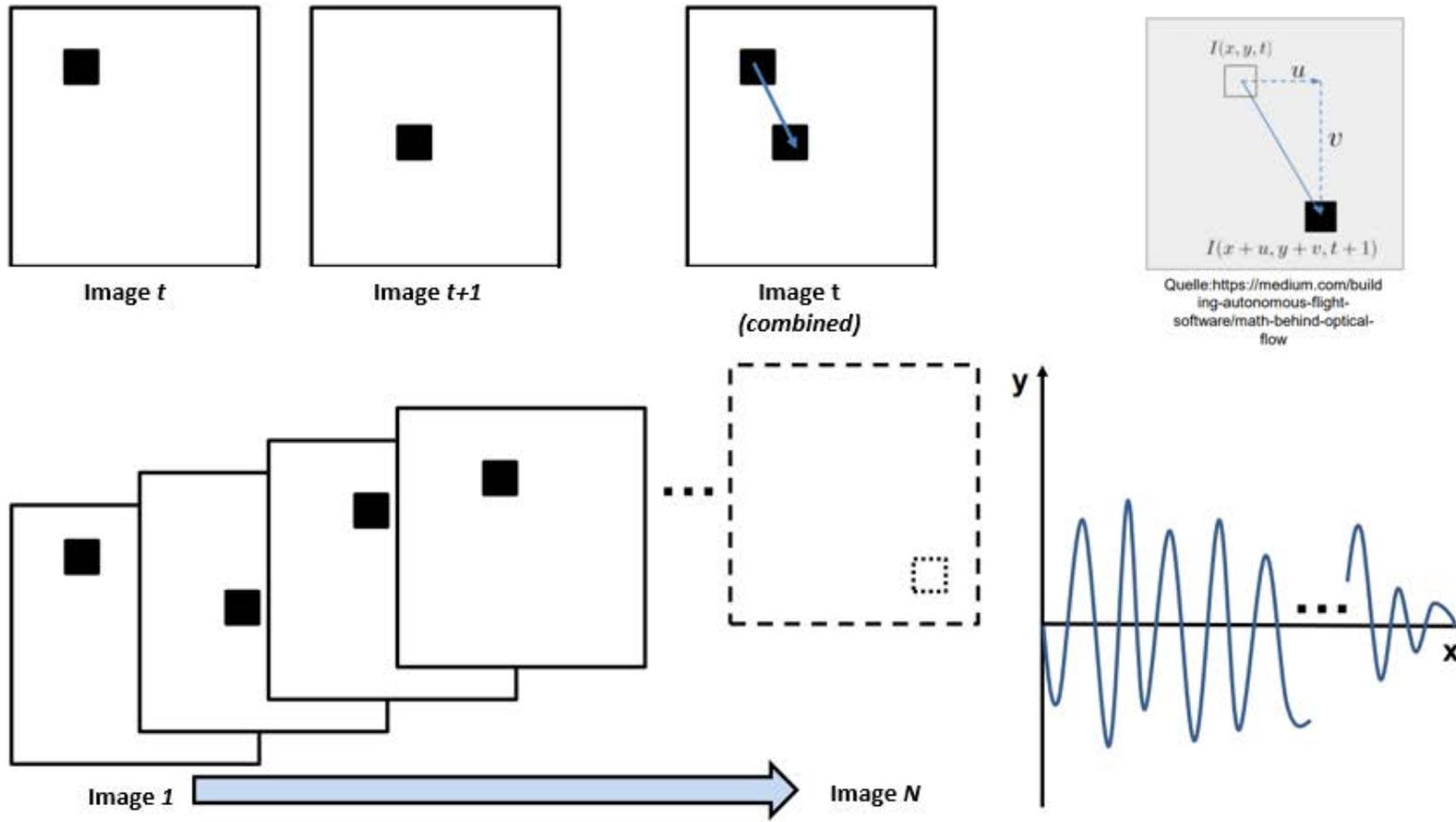
- 硬體 Hardware
- 時間 Time
- 專家的知識 Expert knowledge



基本工作流程和要求 Basic Workflow and Requirements



WaveCam: Optical Flow Tracking



Time waveforms are created for each pixel, improved optical flow and AI algorithms, automated processing

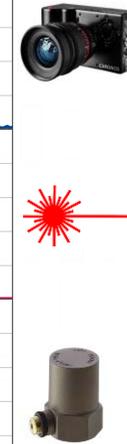
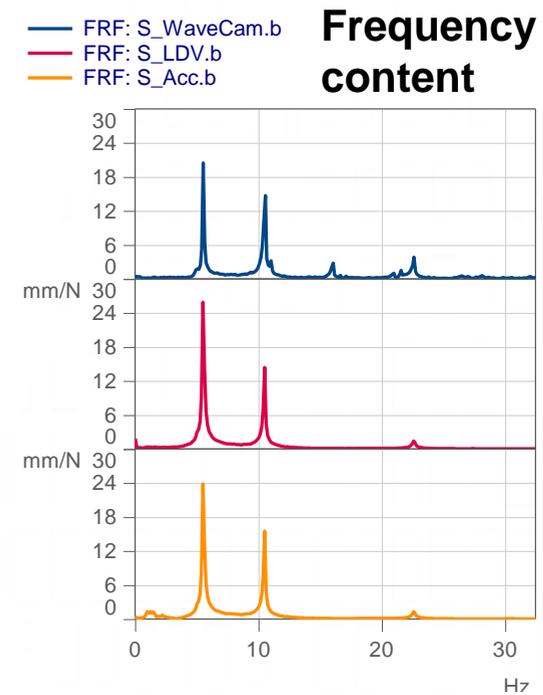
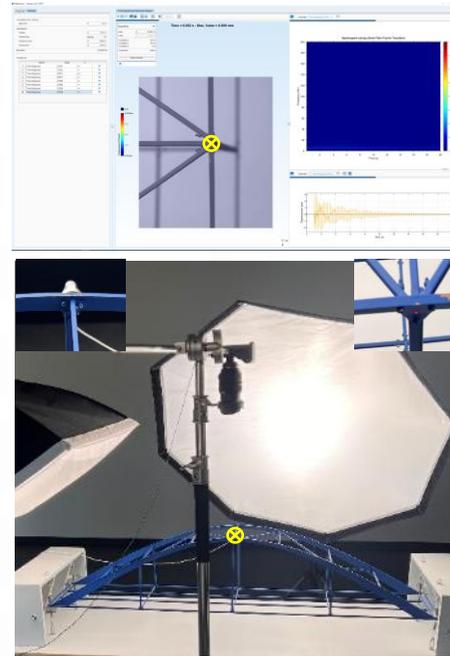
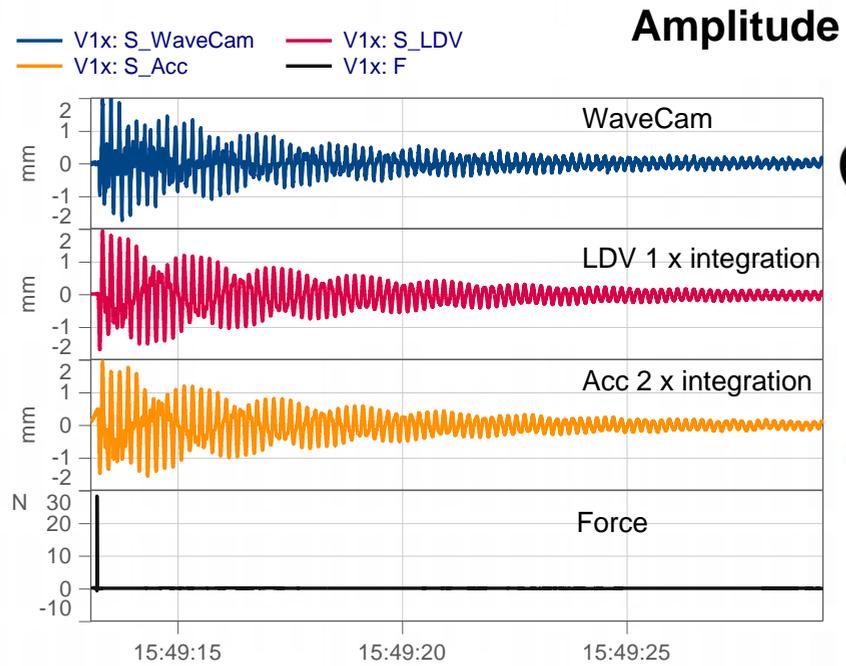
WaveCam vs.傳統方法 WaveCam vs. Traditional approaches

	Accelerometers	Scanning Vibrometer	WaveCam
Frequency range	DC - 6 kHz	DC - 25 MHz	DC - ... ¹
Operating distance	0	1 – 100 m	1 - ... ²
Additional weight	2 – 30 gram /sensor	No	No
Max measurable displacement	490 – 980 m/s ²	30 m/s	0.0005 pixel ³
Max number of measuring points	1	512 x 512	1280 x 1024 ⁴
Expert knowledge	High	High	Low
Setup effort	High	Medium	Low
Hardware costs	Medium	High	Low

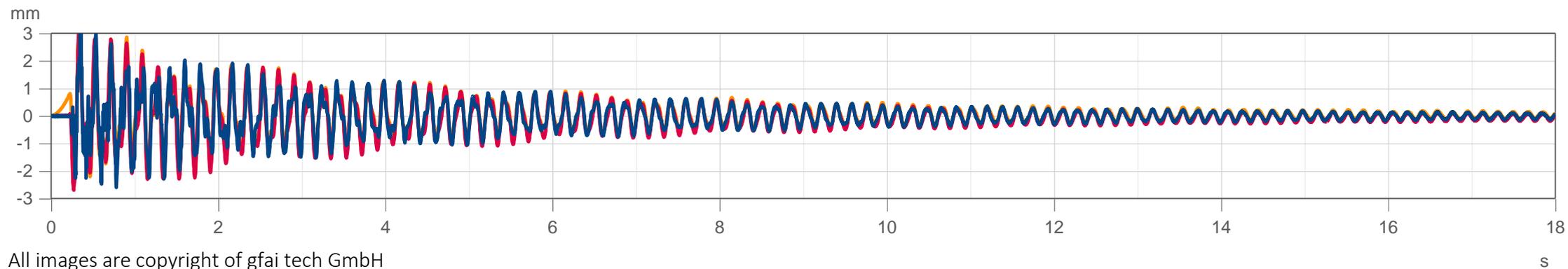
1
2
3
4

Depending on FPS of the camera
 Depending on the focal length of the objective, test object length and the resolution of the camera
 Depending on the texture of the test object
 Depending on the resolution of the camera

交叉驗證—振幅/頻率 Cross Validation – Amplitude / Frequency

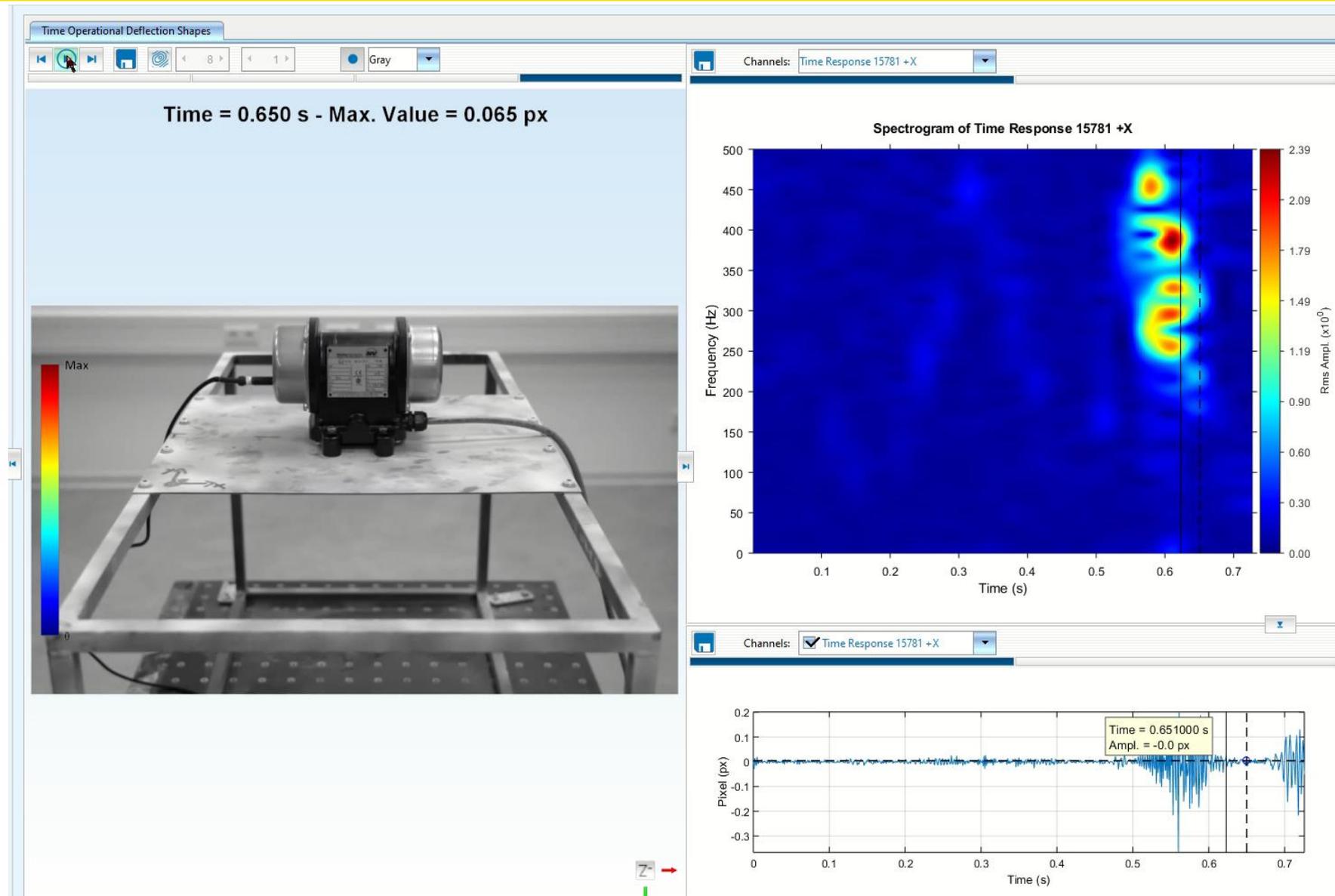


— Valid_400fps: S_WaveCam_ (Blue)
 — Valid_400fps: S_LDV (Red)
 — Valid_400fps: S_Acc (Orange)



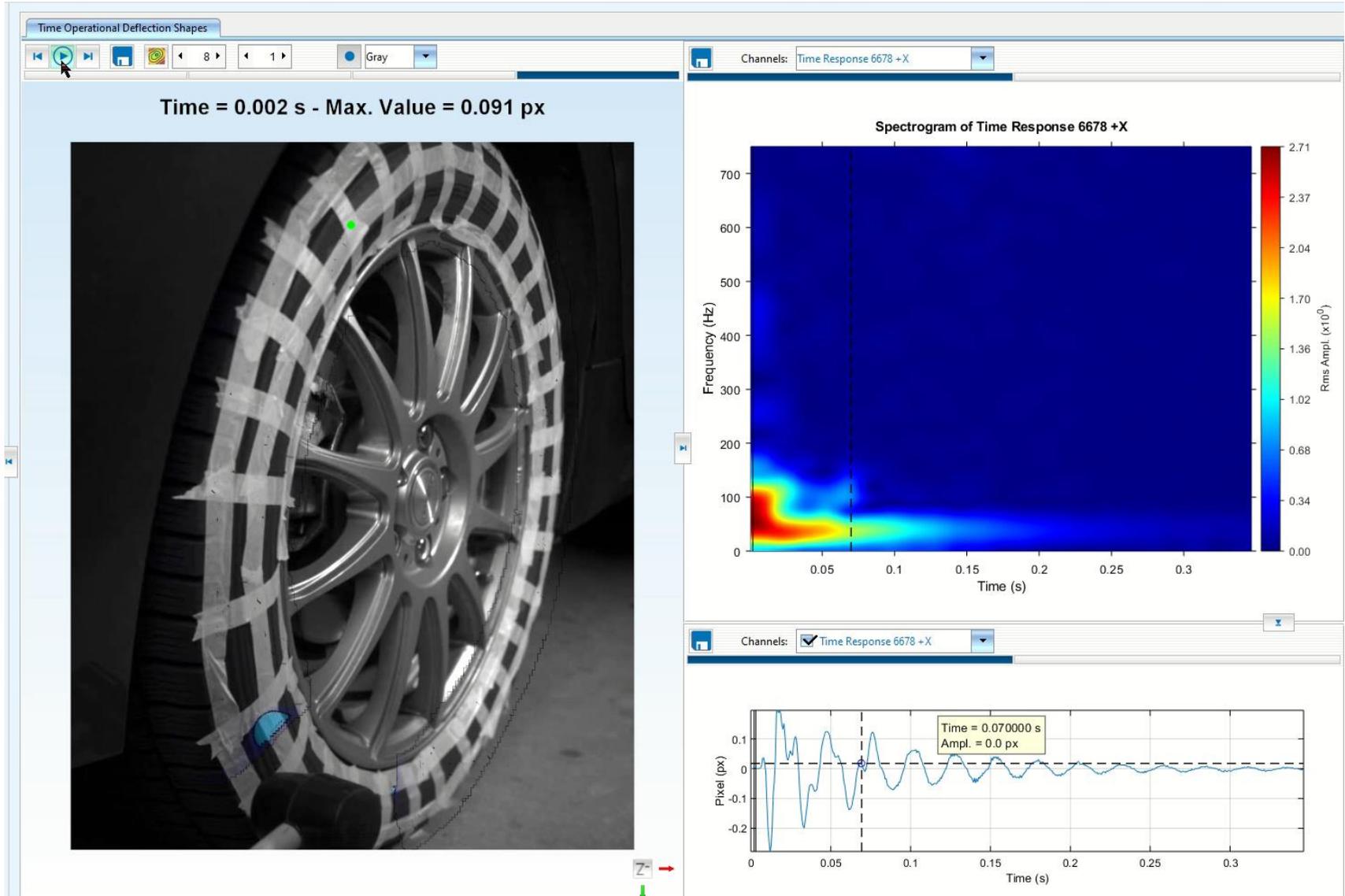
All images are copyright of gfai tech GmbH

Cast down

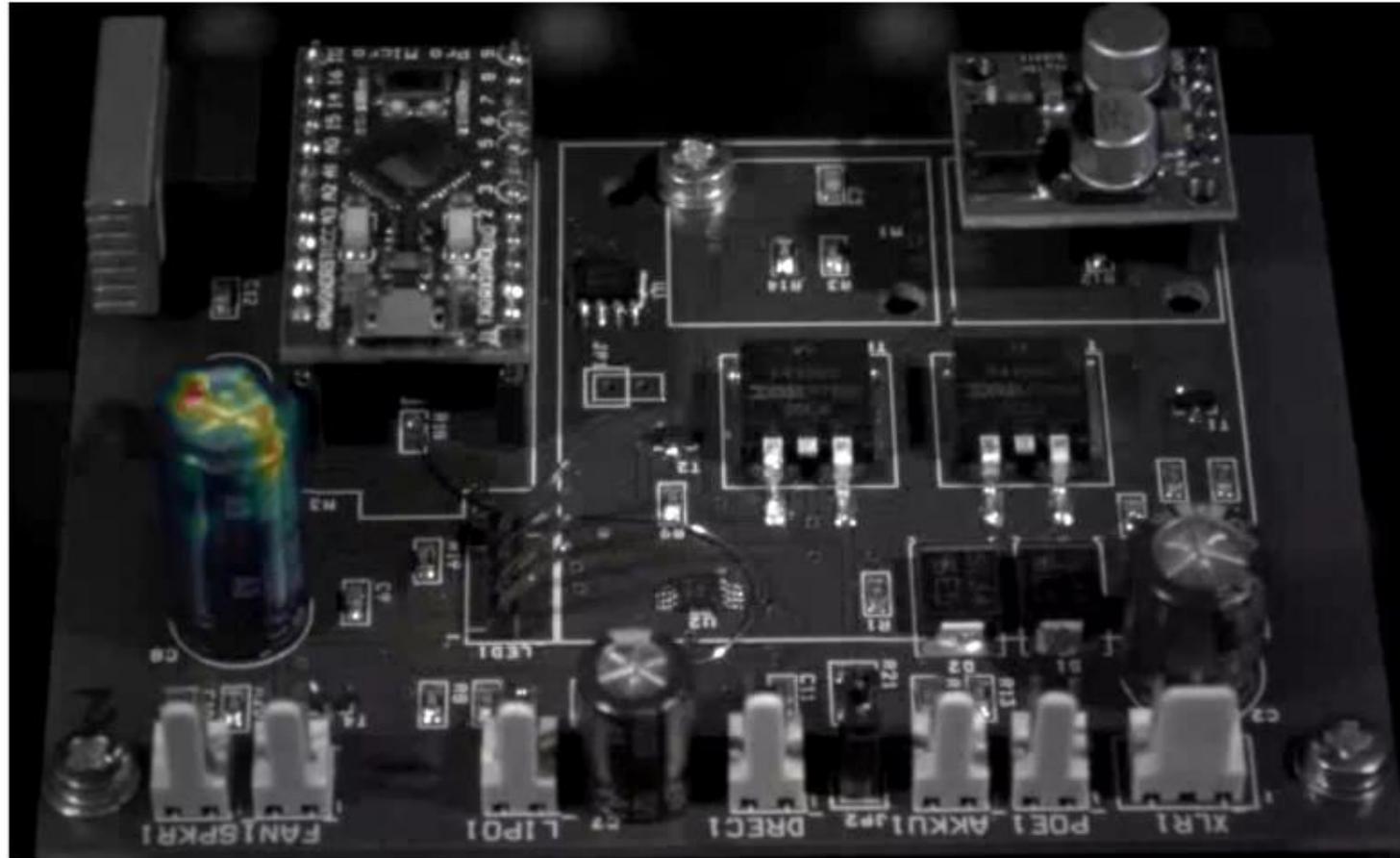


Tire Testing

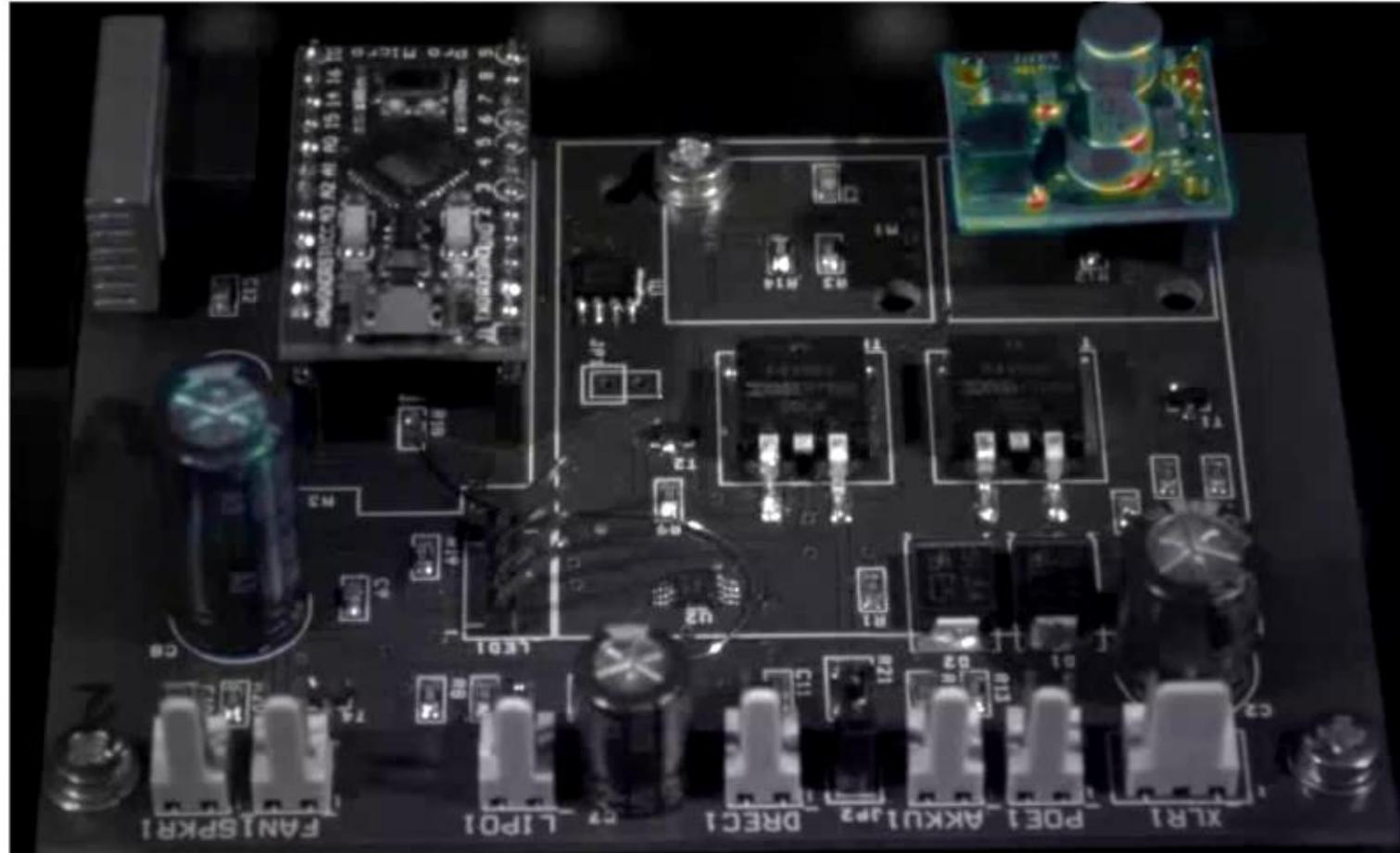
ODS 8 - Frequency = 655.779 Hz



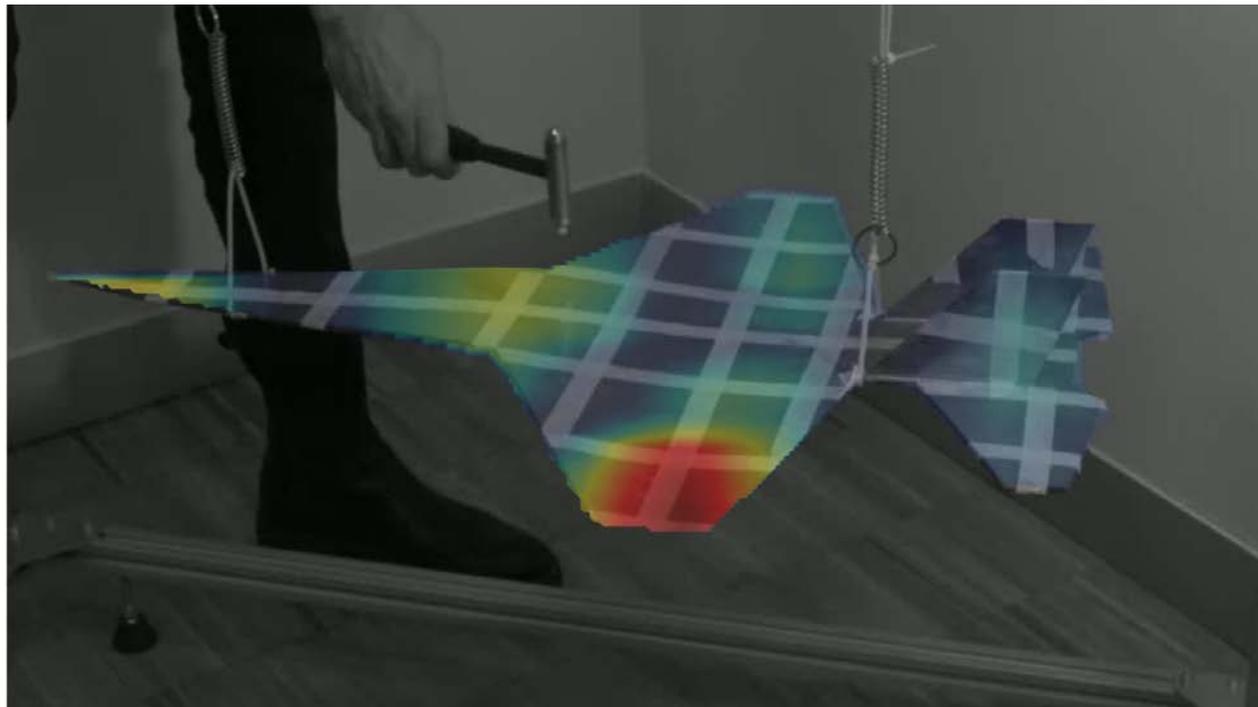
Frequency ODS of a PCB board 293 Hz



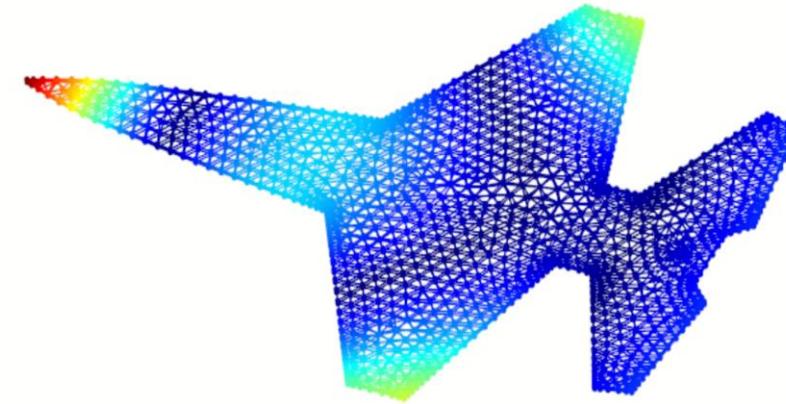
Frequency ODS of a PCB board 358 Hz



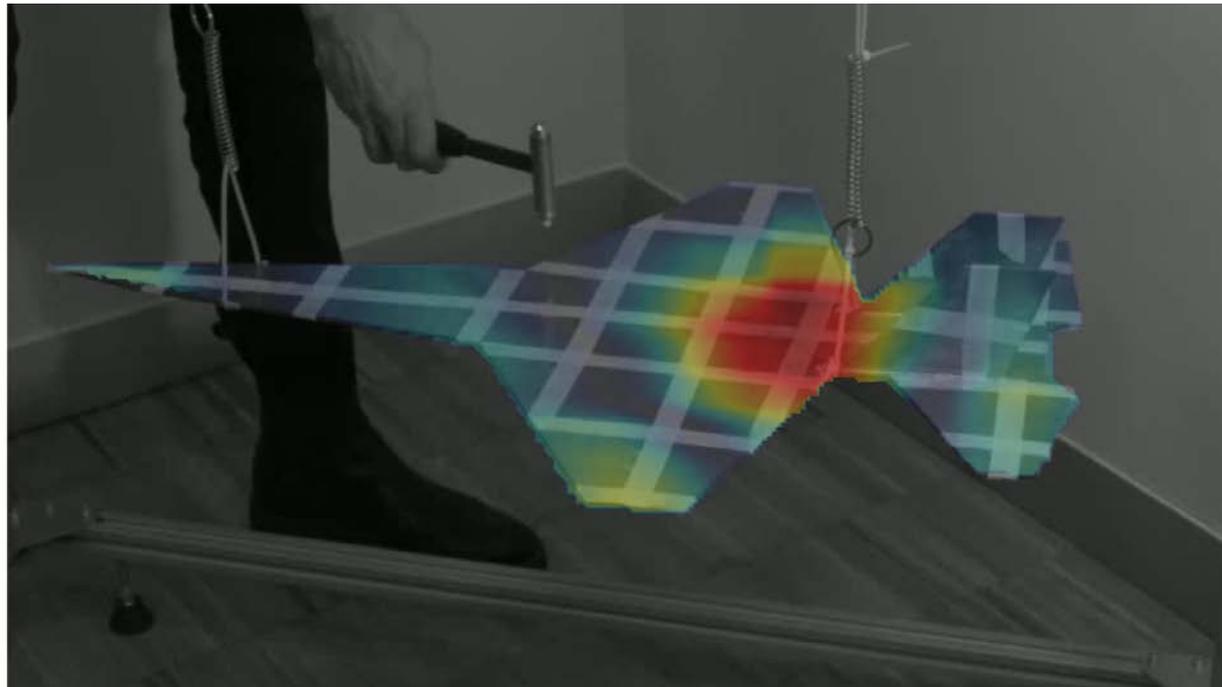
Frequency ODS of a model plane incl. FEA results



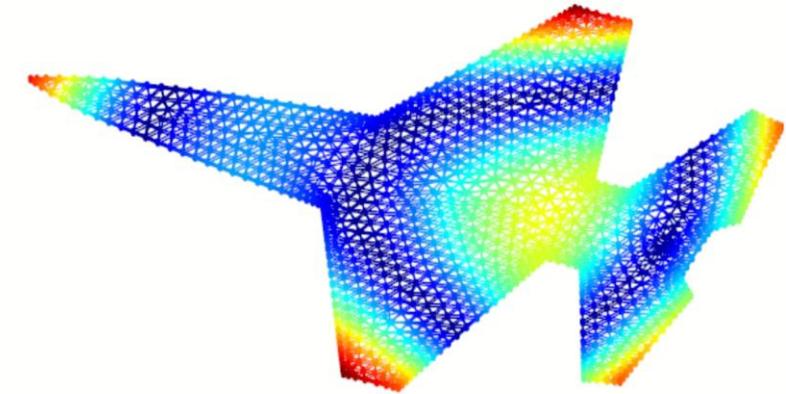
Mode 3 - FEA - Frequency = 68.191 Hz



Frequency ODS of a model plane incl. FEA results



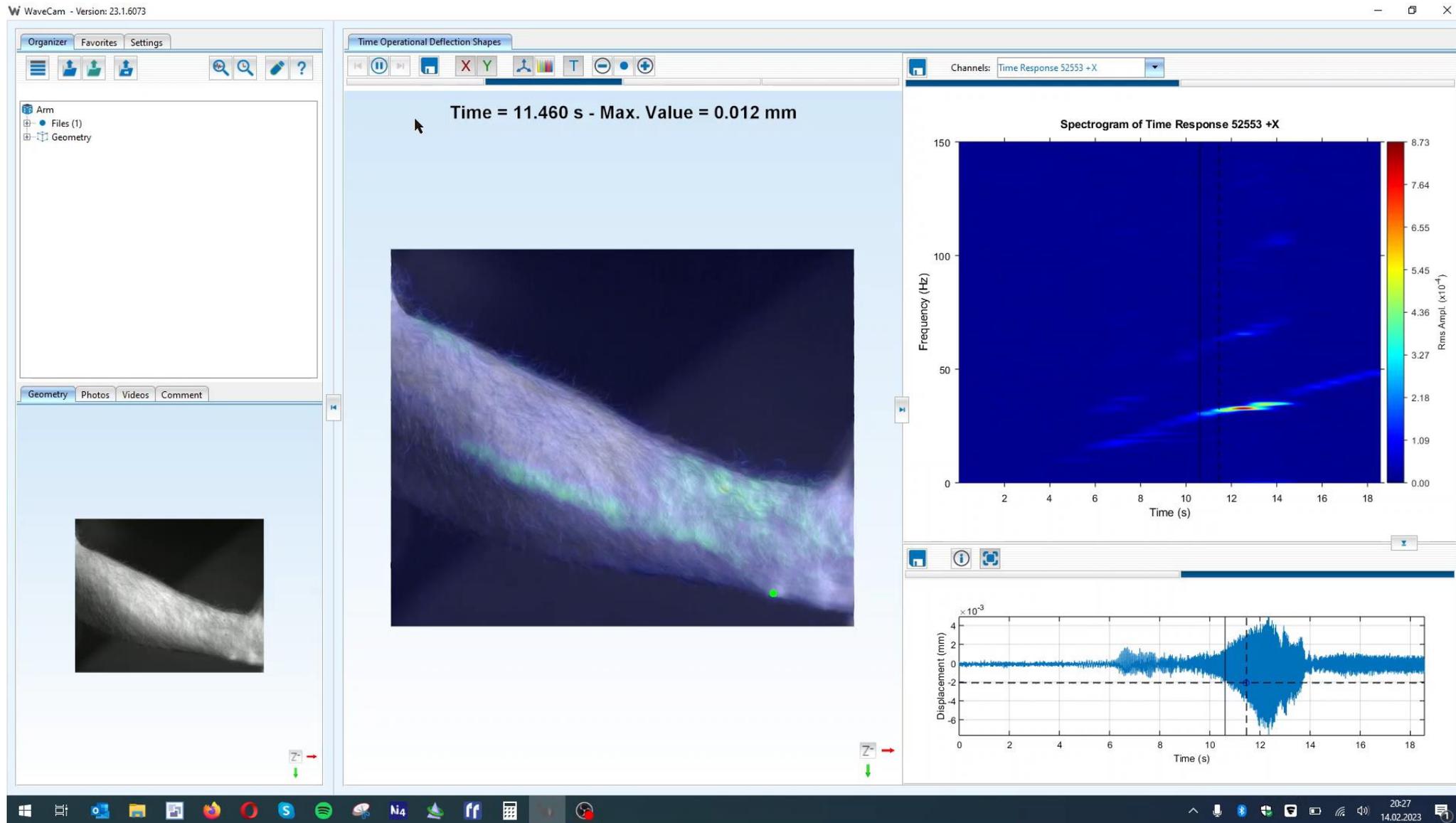
Mode 4 - FEA - Frequency = 98.207 Hz

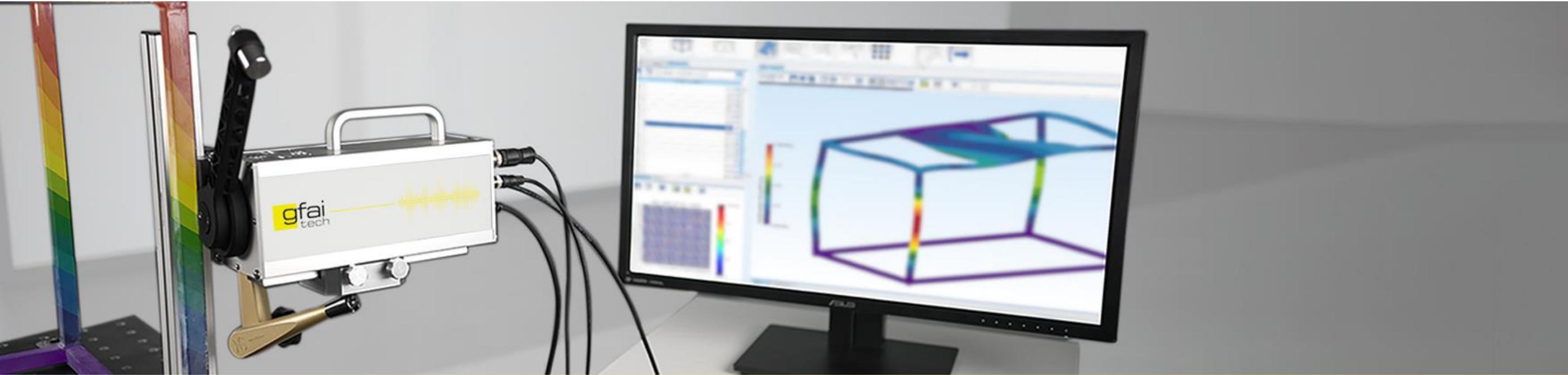


Frequency ODS of the Tokyo Tower



Time ODS of body vibration in an arm





振動測試 Vibration Testing – WaveHitMAX

Impulse Hammer WaveHit^{MAX}

First smart impulse hammer for fully automatic single impact excitation

- 可重複的高精度單次激發

Reproducible, high precision single hit excitation

- 自動零點搜索和自動自校準過程

Automatic zero point search and automatic self calibration process

- 傳感器信號的內部處理

Internal processing of the sensor signal

- 使用的幅度和脈衝寬度的配置

Configuration of magnitude and pulse width using the

- 提供的配件（重量和提示）

supplied accessories (weights and tips)

- 通過觸發器、紅外遙控器啟動熱門系列

Start the hit series via trigger, IR remote control,

- TTL信號或軟體

TTL signal or software

- 設置衝擊力

Set impact forces

- 用於質量保證的 SD 卡

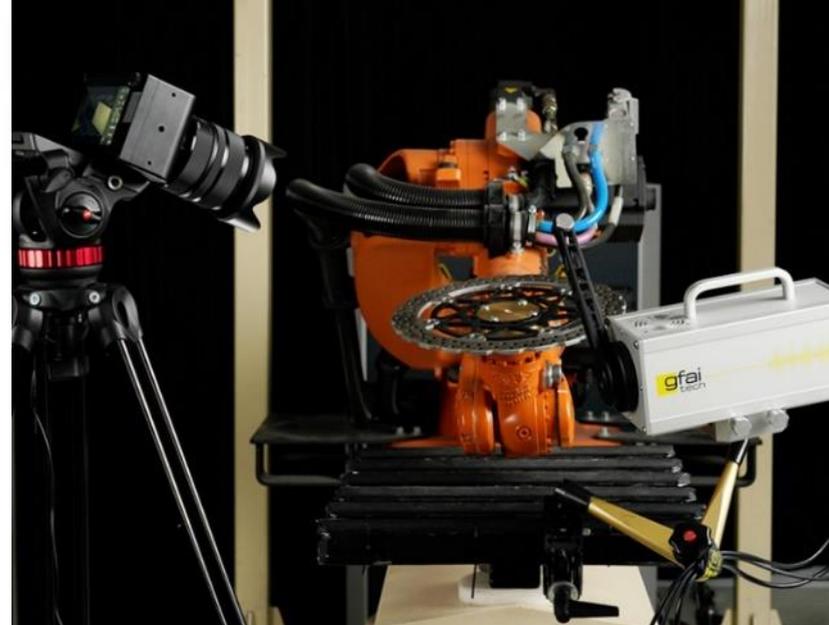
SD card for quality assurance



Impulse Hammer WaveHit^{MAX}

First smart impulse hammer for fully automatic single impact excitation

- 應用 Application
- 實驗模態分析 Experimental modal analysis
- 聲共振測試 Acoustic resonance testing
- 狀態監測 Condition monitoring
- 材料測試 Material testing
- 衝擊錘測試 Impact hammer testing
- 頻率響應功能測試 Frequency response function testing



Impulse Hammer WaveHit^{MAX}

Technical Details



	ICP [®] force sensor – 445 N	ICP [®] force sensor – 2224 N
Impact force	50 – 445 N	80 – 2000 N
Sensitivity (BNC Output)	50 N/V	250 N/V
Impact pulse width	≥ 0.80 ms	≥ 0.80 ms
Kinetic energy	3 – 850 mJ	3 – 850 mJ



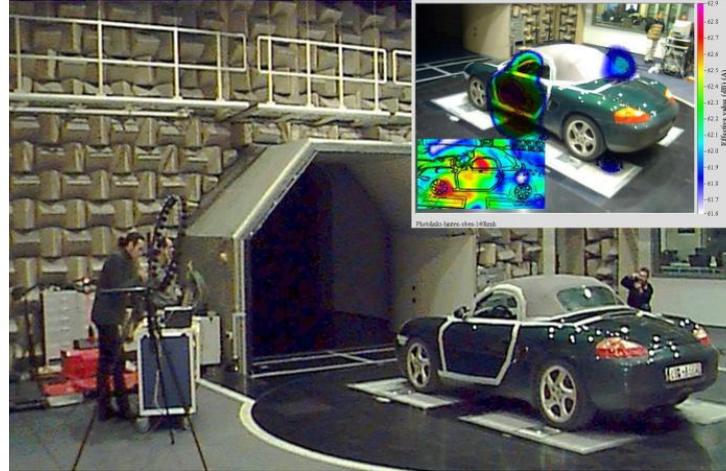
客製化解決方案 Customized solutions by gfai tech

Automotive wind tunnels



15+ Years of Wind Tunnel Experience

- Aston Martin
- Audi
- BMW
- Chrysler
- CAERI
- CATARC
- Daimler
- Ford
- Incas Romania
- Jaguar Land Rover
- Porsche
- Tongji University
- ...



2001

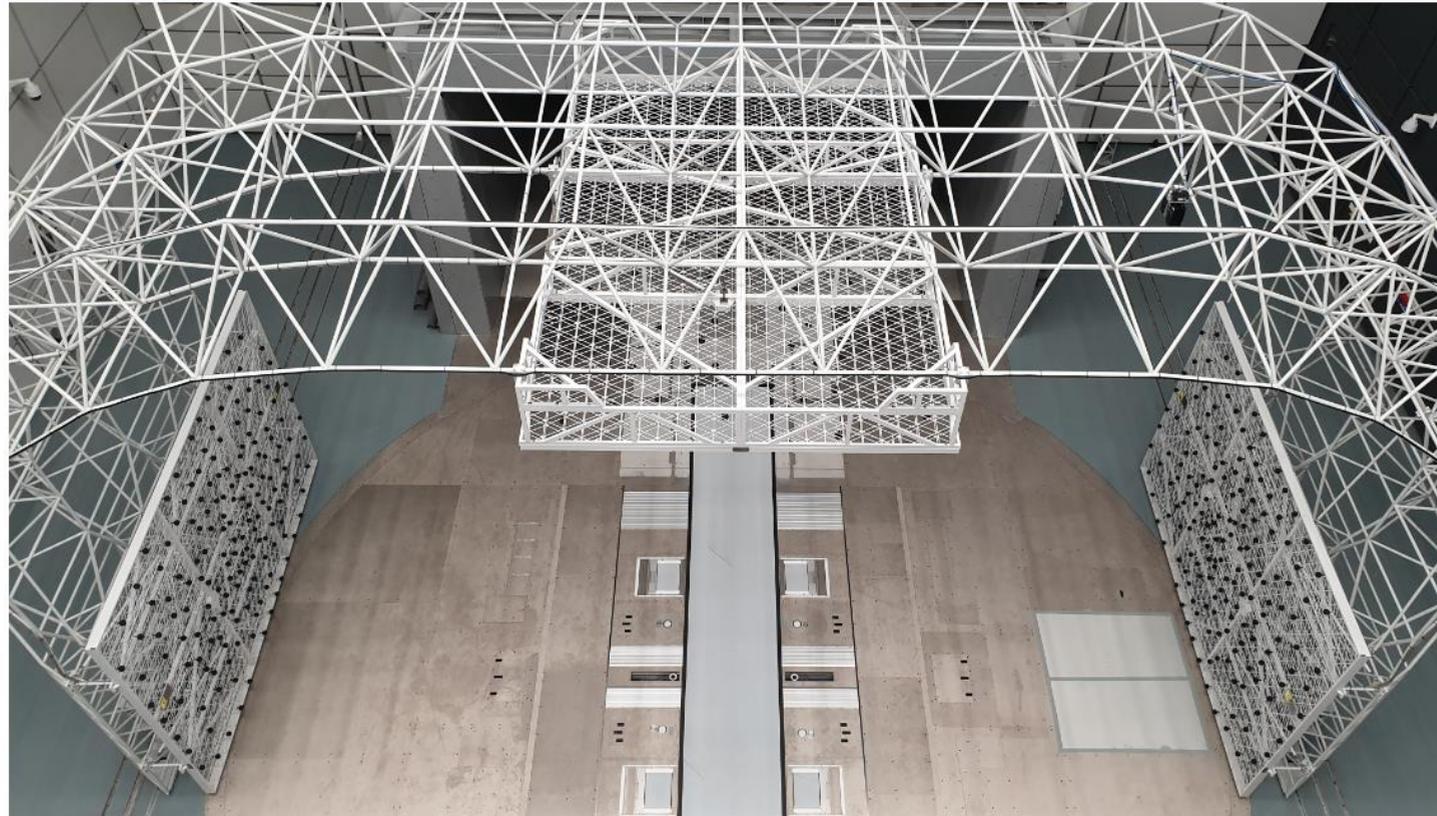


2016 and onwards

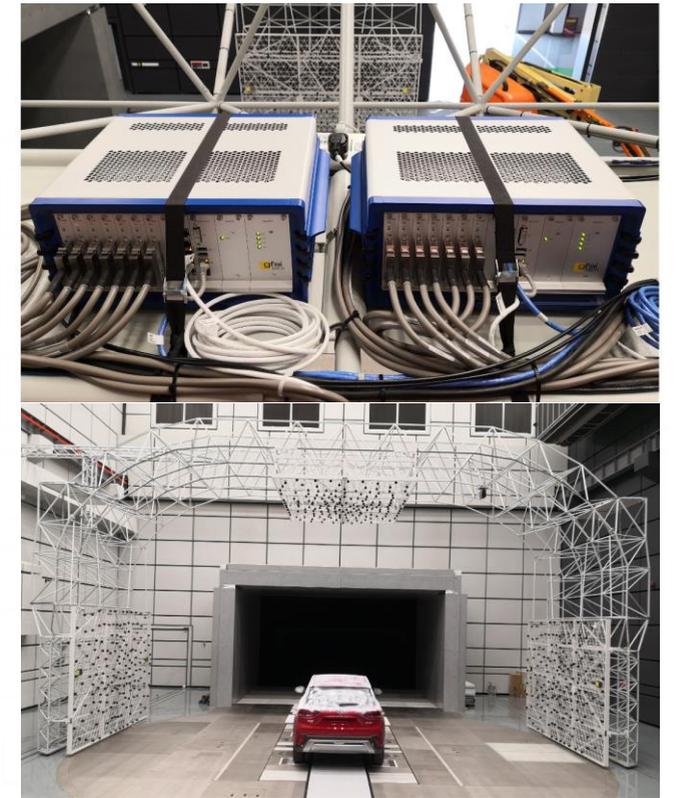
Wind tunnel solutions

Highest Quality in Hardware

Microphone array and structure



Hardware set-up example



3D Beamforming and auto-fitting

gfai tech supports real 3D Beamforming, based on the distance between each mesh and each array. The data from all arrays will be combined and the highest precision can be reached.

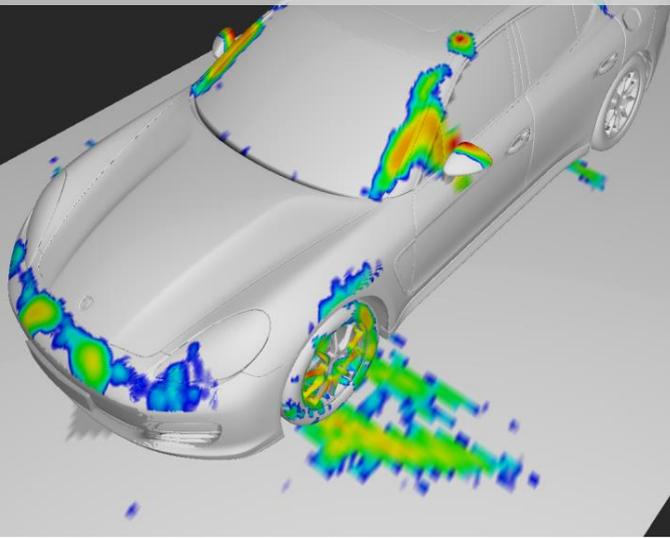
To achieve the highest accuracy in fitting it is based on 3D scanners in the system.

Overlay of
optical image
and fitted 3D
model –
accuracy within
mm-range

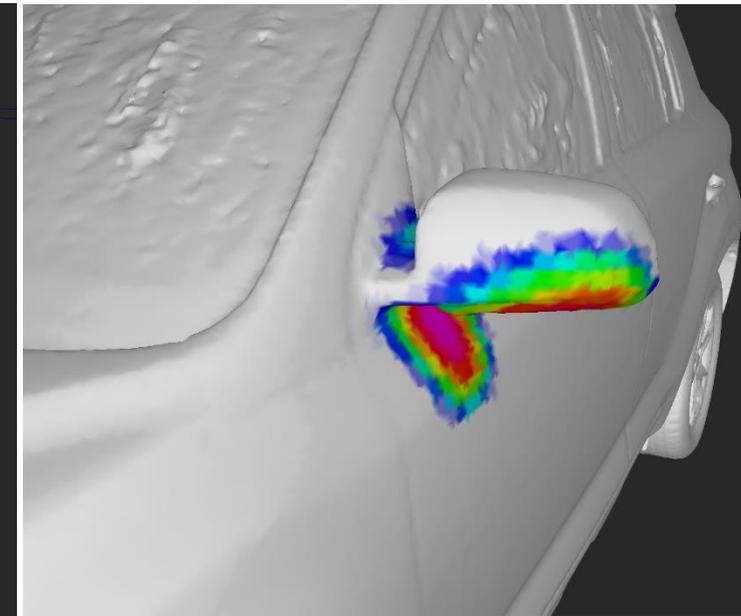
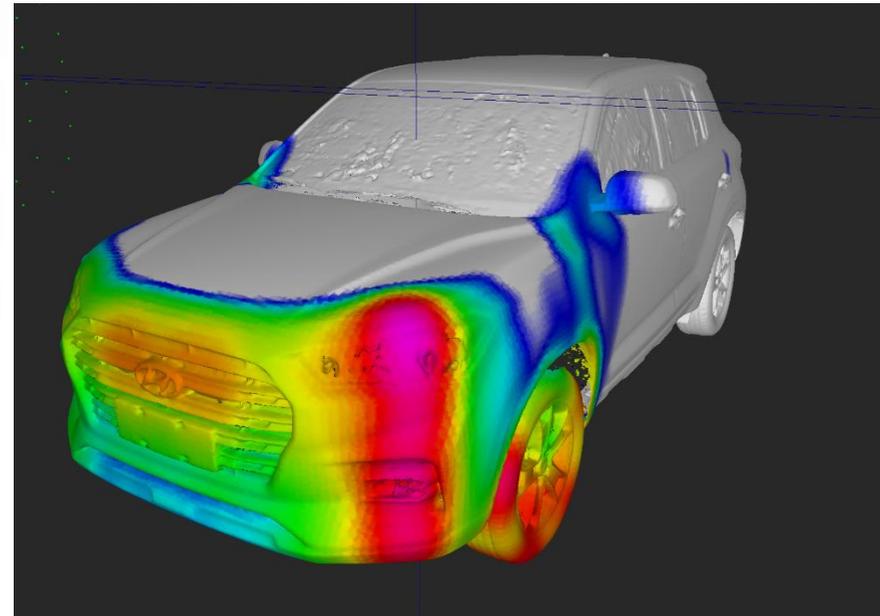


Results of 3D Beamforming in a wind tunnel

Panamera S - 3D Beamforming –
CleanSC - 2 kHz - 38 dB



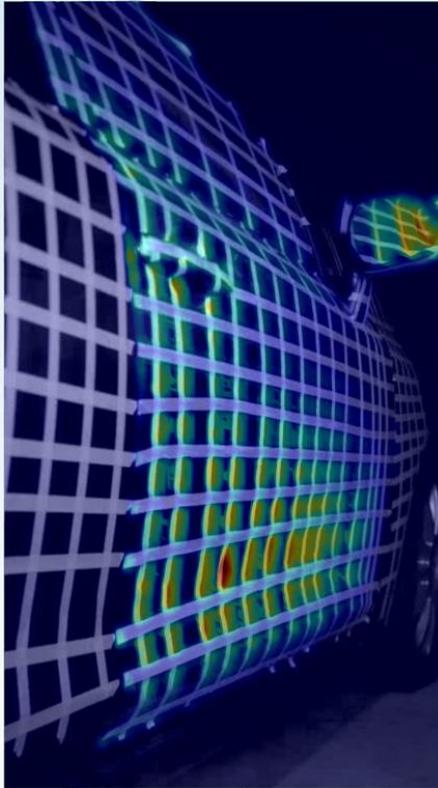
The correct result of a measurement from all three arrays combined with one of the additional algorithms (CleanSC) and the shear layer correction.



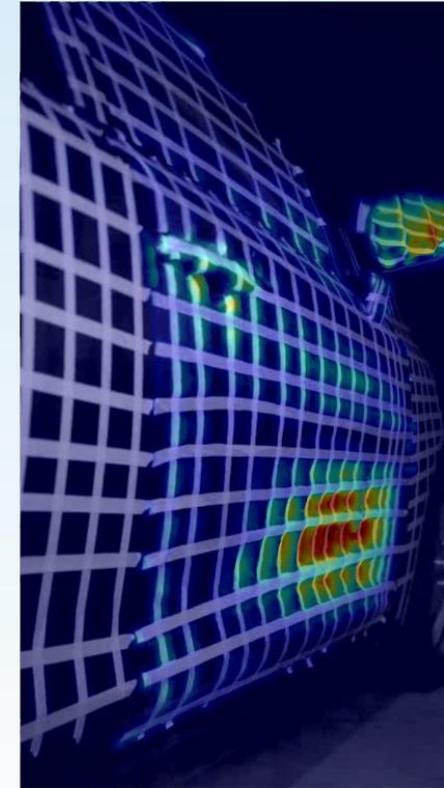
Source: „On 3D-Beamforming in the wind tunnel“ - BeBeC 2016, Dirk Döbler, Dr. Christof Puhle, GFai; Jörg Ocker, Porsche AG

WaveCam Dynamic Vibration analysis

ODS 2 - Frequency = 28.061 Hz



ODS 3 - Frequency = 45.918 Hz



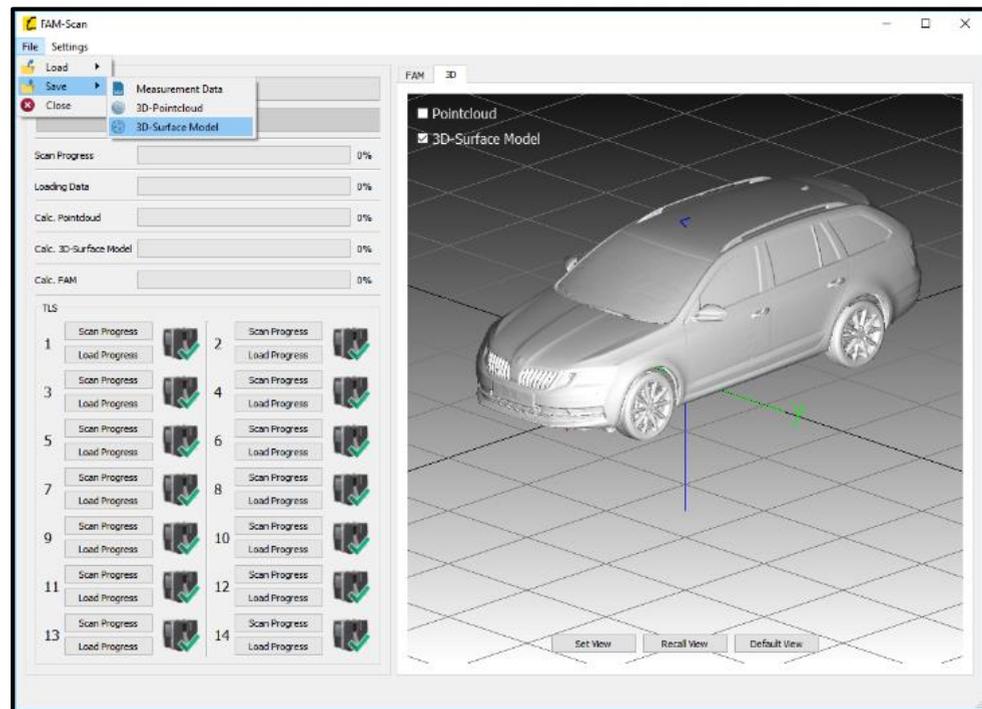


Contour Capture, FAM and Deformation Analysis



FAM-System – 3D Solution (Results)

- Fully automatic system
 - All scanners work automatically and the results will be exported in a document
 - Self-calibrating system for quality assurance

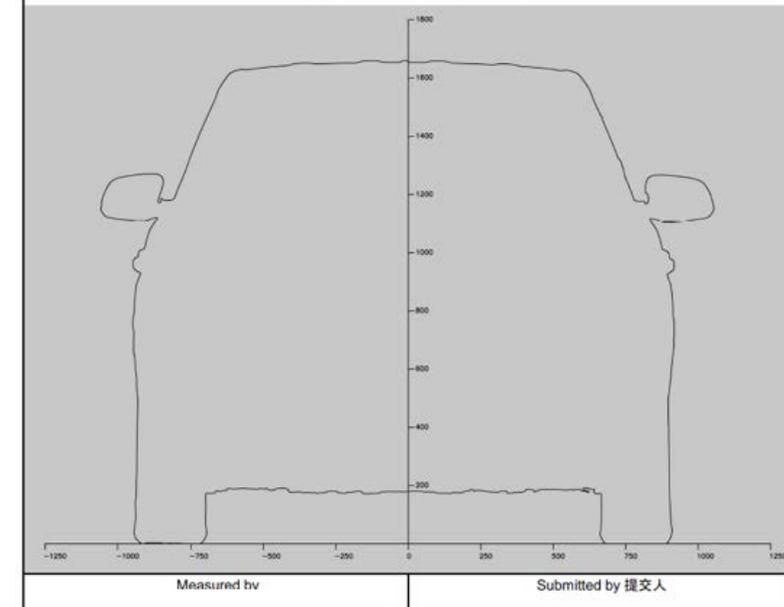


Measurement Report of the Frontal Area

正投影面积测量报告

Client 客户		Number 序号		
Vehicle Model 车型		Date 日期		
Frontal Area 正投影面积	2.6195 m ²	Yaw Angle 侧偏角	-0.3°	
Height 高	1660 mm	Width 宽	2113 mm	
Wheel Arch Height 轮眉高度 (mm)	LF 左前	mm	LR 左后	mm
	RF 右前	mm	RR 右后	mm
Loading 配重	LF 左前		LR 左后	
	RF 右前		RR 右后	
Loading (Option) 配置(可选)	RM 后排中间			
	Trunk 行李箱		Gas Tank 油箱	
Tire Type 轮胎类型		Tire Pressure 胎压		
Configuration 配置				

FA Contour 正投影面积测量轮廓图

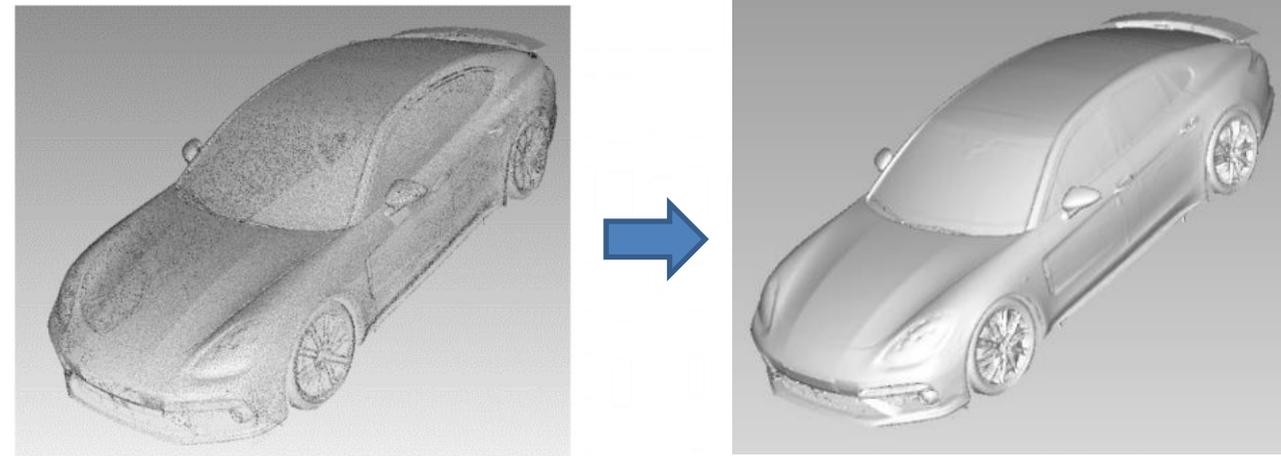


gfai
tech

Contour capture

An automated solution to generate 3D models of any vehicle under test. Based on 3 or more 3D scanners.

- Inside the wind tunnel or in a separate room
 - Set-up in the wind tunnel allows auto fitting of the 3D model
- The software will automatically generate a 3D mesh of the vehicle
 - ✓ No need for external 3D model
 - ✓ Exact vehicle model will be generated
 - ✓ Highest precision for further analysis

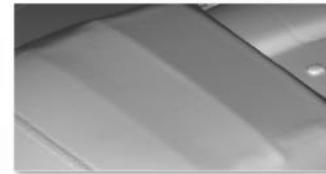


Source: Laser Geometry Detection in the Porsche Wind Tunnel - Laser Geometry Detection in the Porsche Wind Tunnel Base for 3D Beamforming and Deformation measurements, Stuttgarter Symposium 2018, J. Ocker, L. Paul

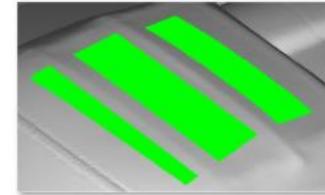
Static Deformation Analysis

Results can be visualised in different views:

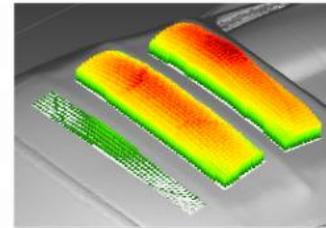
- Overview
- Close-up
- Detail



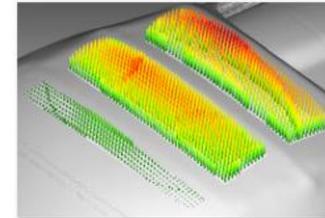
01Modell.png



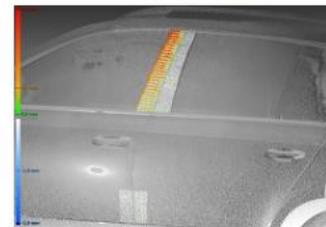
02_Messbereich.png



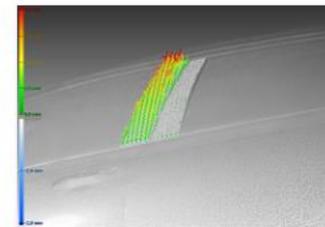
03_Ergebnis_01.png



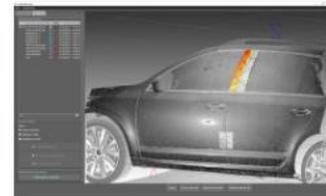
04_Ergebnis_02.png



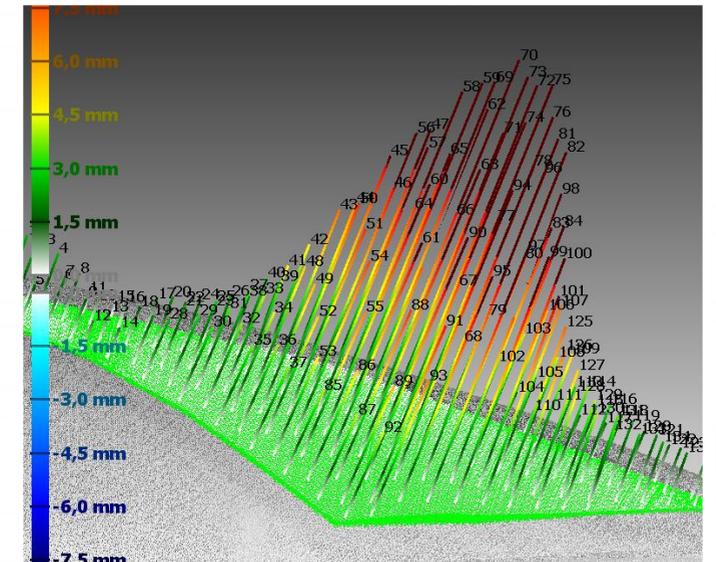
Deformation.png



Deformation2.png

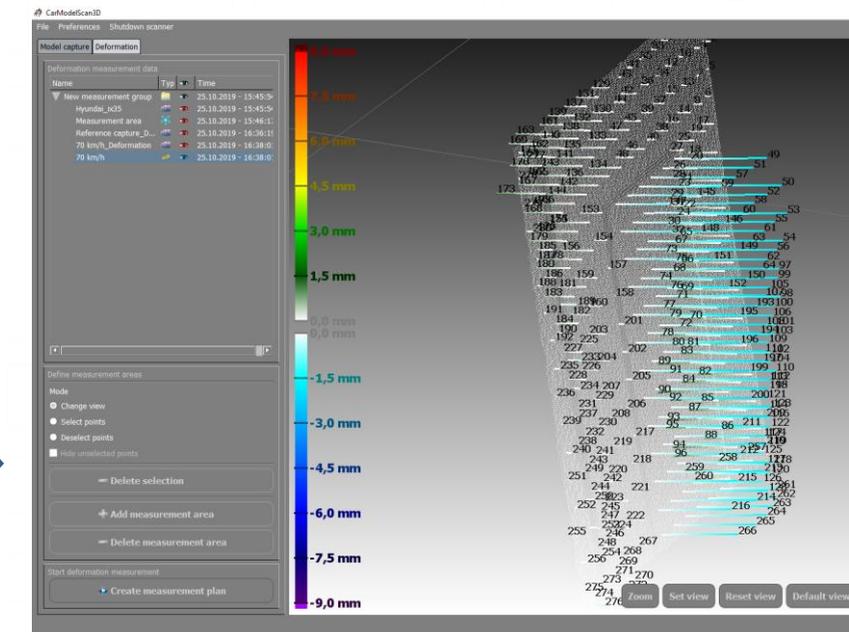
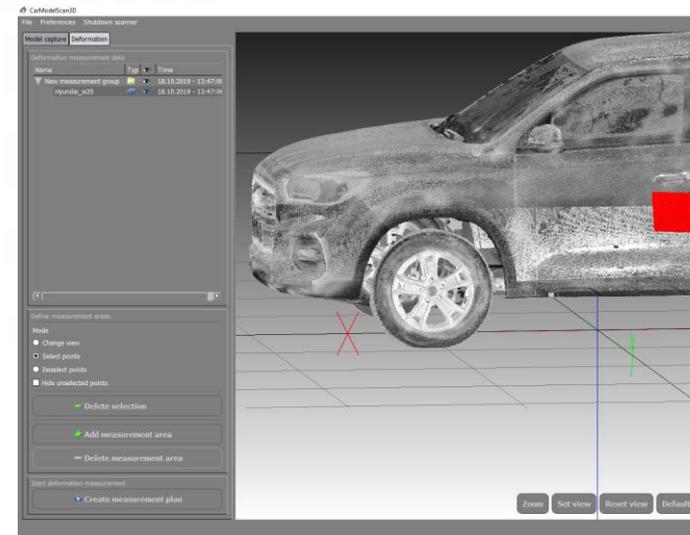
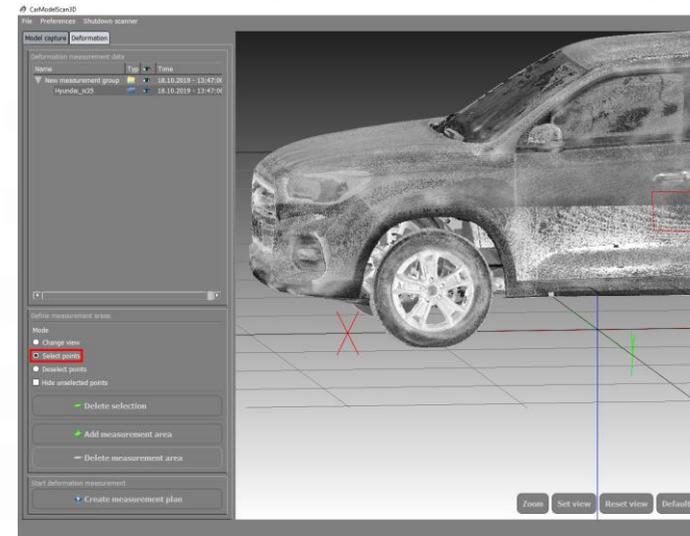


GUI_ScreenShot.png



Static Deformation Analysis

More precision can be obtained by defining areas to be analyzed.



Join the Acoustic Camera Team!

- Airbus
- Aston Martin
- Audi
- BMW
- Bombardier
- Bosch
- CAERI
- Canon
- CATARC
- Chang'an
- DAF
- Dassault
- Delphi
- Denso
- Ford
- Hitachi
- Honda
- Hyundai
- Iveco
- Jaguar Landrover
- John Deere
- MAN
- Mazda
- Mercedes-Benz
- Michigan University
- MIRA
- Penn State University
- Porsche
- Renault
- Rutherford Appleton
- Samsung
- Scania
- SEW Eurodrive
- Sekiso
- Siemens
- Skoda
- Sony
- Suzuki
- Toyota
- Tongji University
- Volkswagen
- Volvo Engineering
- ...

Thank you

Thank you for your attention.

Benjamin Vorrhein



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📠 +49 30/814563-755
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