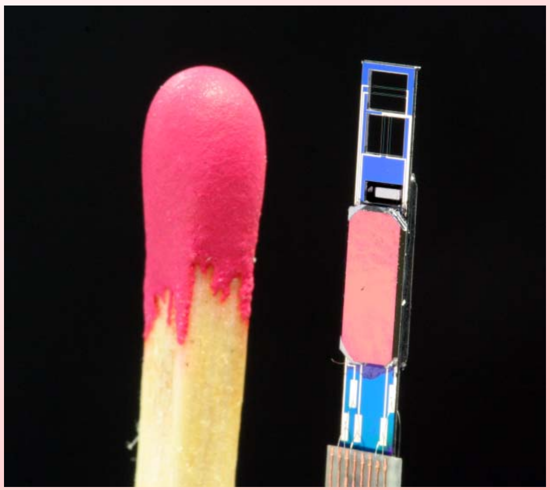
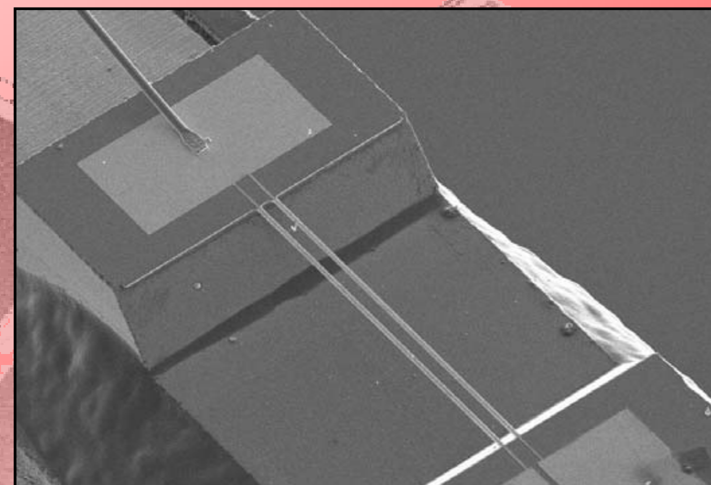
Microflown Technologies
Charting sound fields

Fast and Broadbanded Car Interior Panel Noise Contribution Analysis





Dr. Oliver Wolff, Open Technology Forum
at Testing Expo Europe 2008, Stuttgart, 6th – 8th May 2008

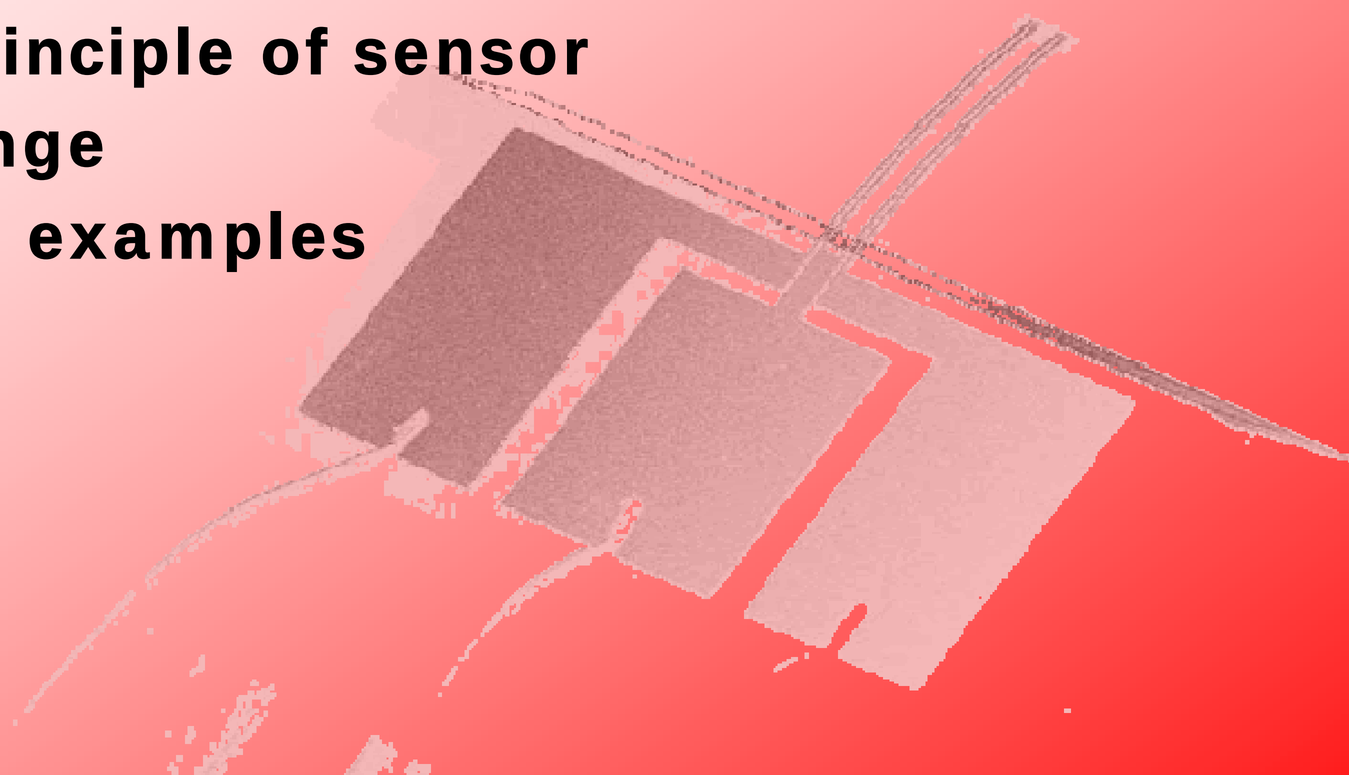
Microflown Technologies

Charting sound fields

Contents

Contents of presentation:

- ✓ Company history
- ✓ Working principle of sensor
- ✓ Product range
- ✓ Application examples
- ✓ References



Microflown Technologies

Charting sound fields

- **Company history**
- Working principle of sensor
- Product range of Microflown
- Application examples
- References

Microflown Technologies
Charting sound fields

Company History

1994: Invention of the Microflown by Hans- Elias de Bree at University Twente

1997: Ph.D. Hans-Elias de Bree

1998: Founding Microflown Technologies B.V. (de Bree, Koers)

2001: Industrializing product

2003: Introduction broad banded Titan sensor element

2004: First application scientifically proven / first arrays sold

2005: Rapid growth in automotive industry

2005: De Bree appointed Professor “Vehicle Acoustics” at HAN University, College of Automotive Engineering (100 testing engineers/year)

2006: Strategic decision to penetrate the aerospace market

2007: 12 FTE company + 4 Ph.D. students, > 1 Million Euro turnover

Participating in two EU FP 7 engine acoustic related projects, Flocon led by DLR Engine Acoustics and Teeni led by Turbomeca

Leading IGOR consortium for JTI Clean Sky Green Rotorcraft

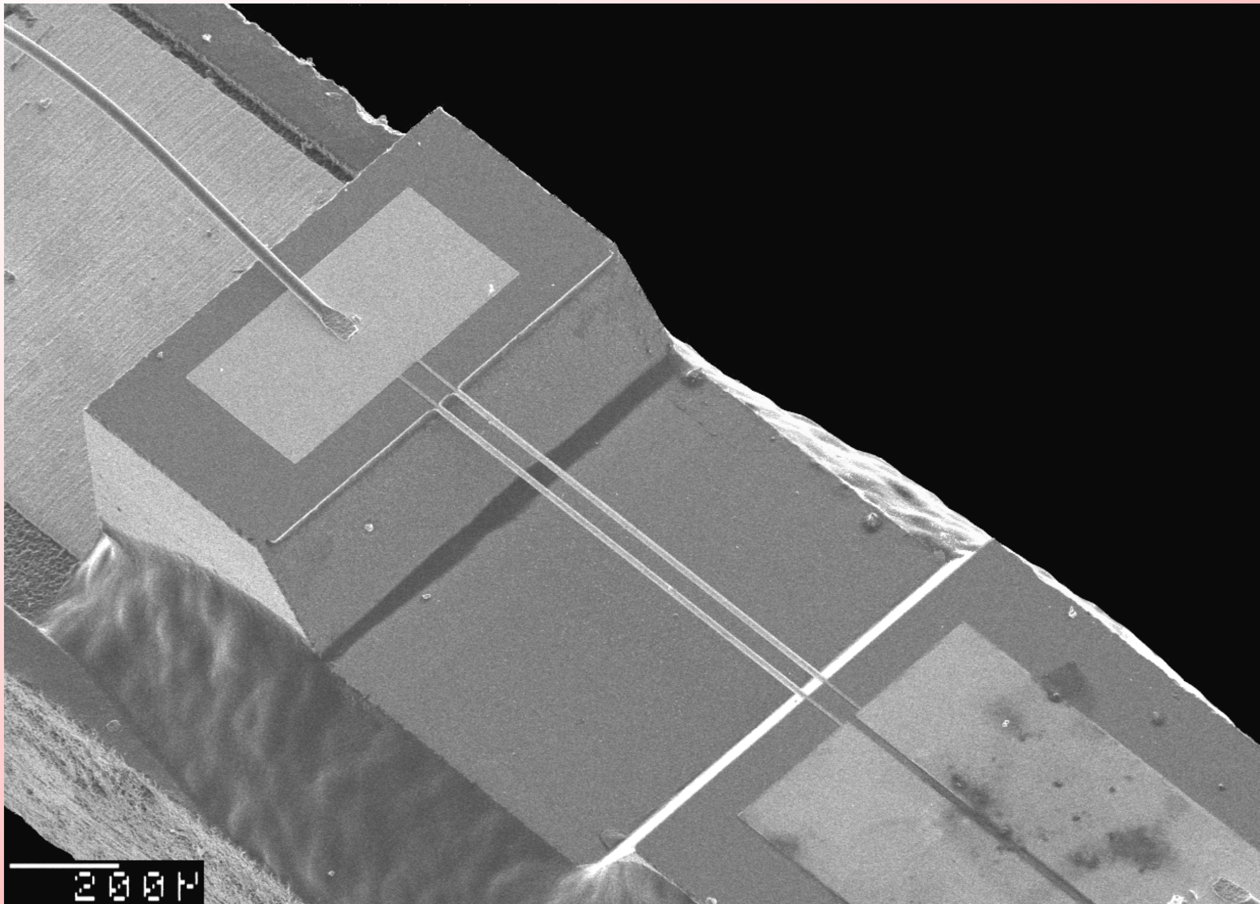
Microflown Technologies
Charting sound fields

- Company history
- **Working principle of sensor**
- Product range of Microflown
- Application examples
- References

Microflown Technologies
Charting sound fields

Working Principle of Sensor

Microflown SEM picture: two heated wires



Microflown Technologies
Charting sound fields

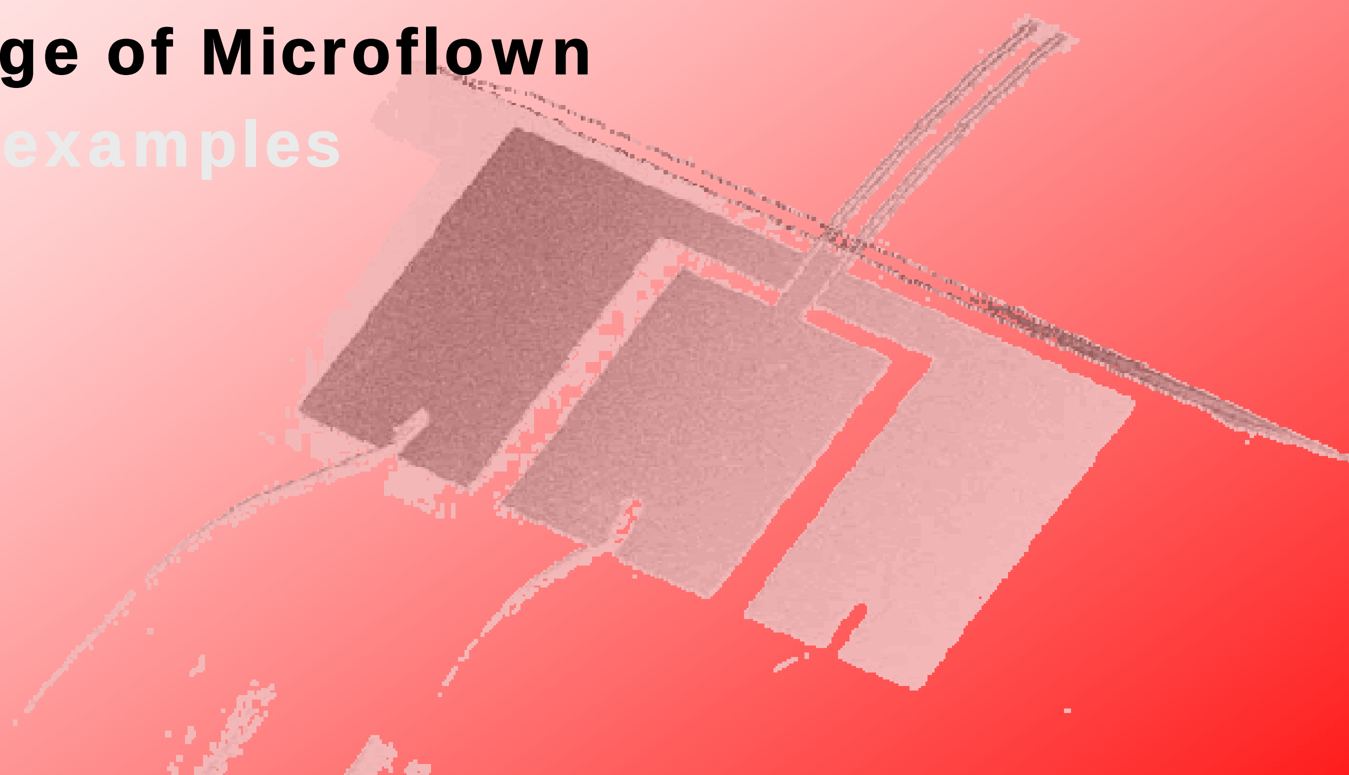
Working Principle of Sensor

The MEMS based Microflown sensor is based upon:

- ✓ **a silicon material resisting 300 degrees Celsius “just” to carry two wires**
- ✓ **two extremely thin platinum wires heated about 200 Celsius above the ambient temperature to get enough sensitivity**
  - ✓ **temperature difference is scientifically proven to measure acoustic particle velocity**

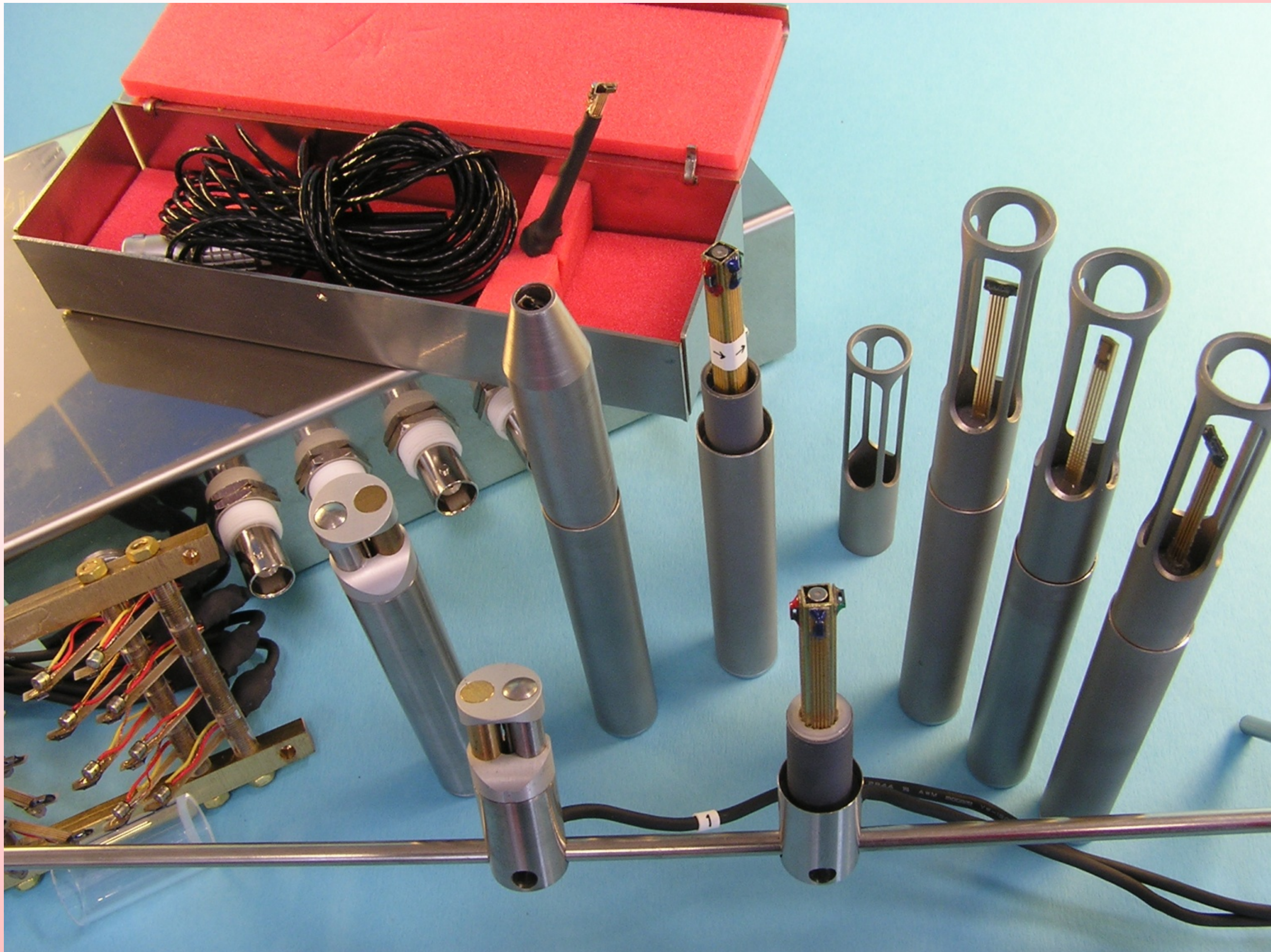
Microflown Technologies
Charting sound fields

- Company history
- Working principle of sensor
- **Product range of Microflown**
- Application examples
- References



Microflown Technologies
Charting sound fields

Product Line



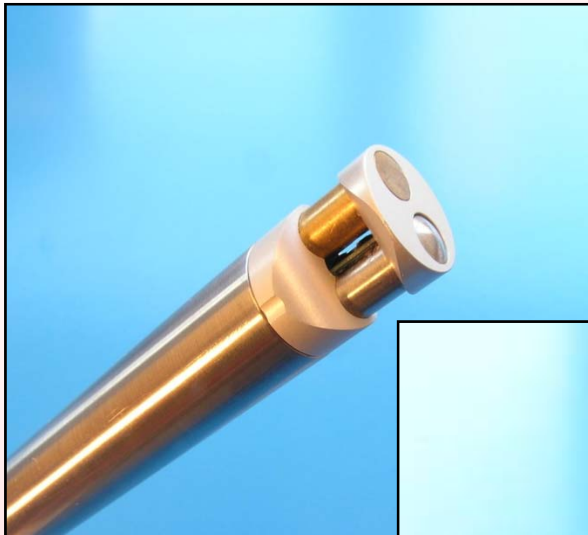
Scanning Probe

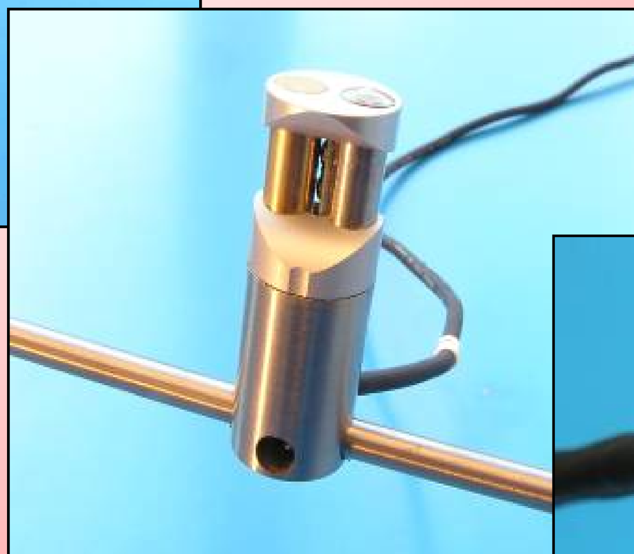
- 1D Velocity
- For small objects

Microflown Technologies
Charting sound fields

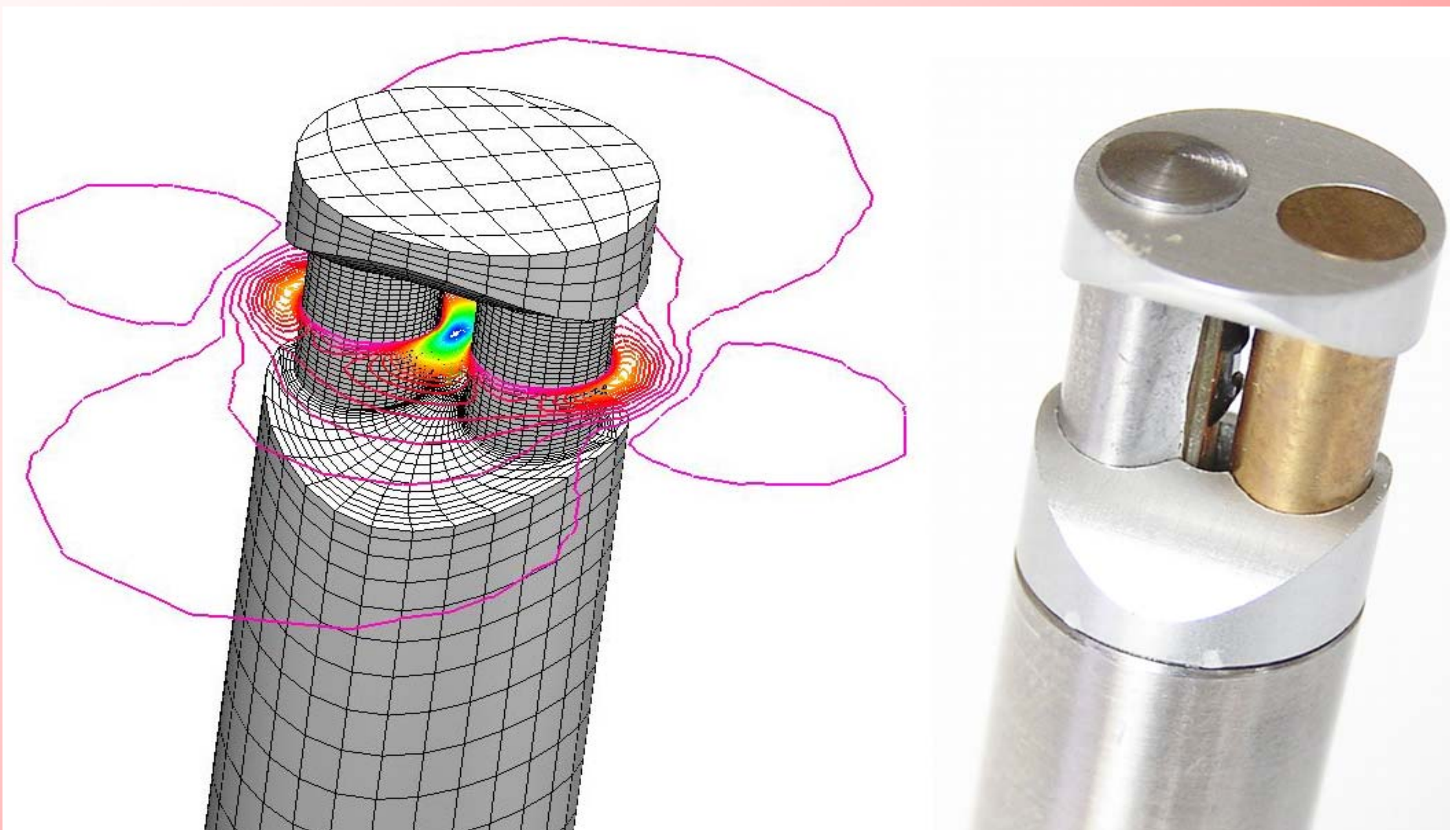
1 dimensional PU probes

- Particle Velocity
- Sound Pressure
- 1D sound intensity
- Impedance
- 1D sound energy

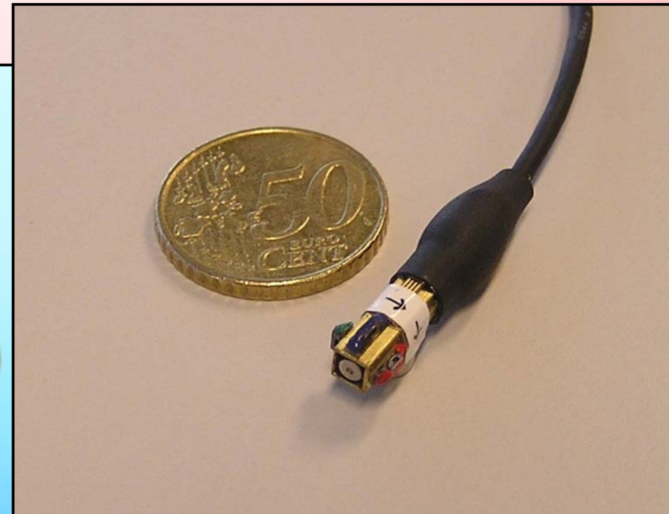


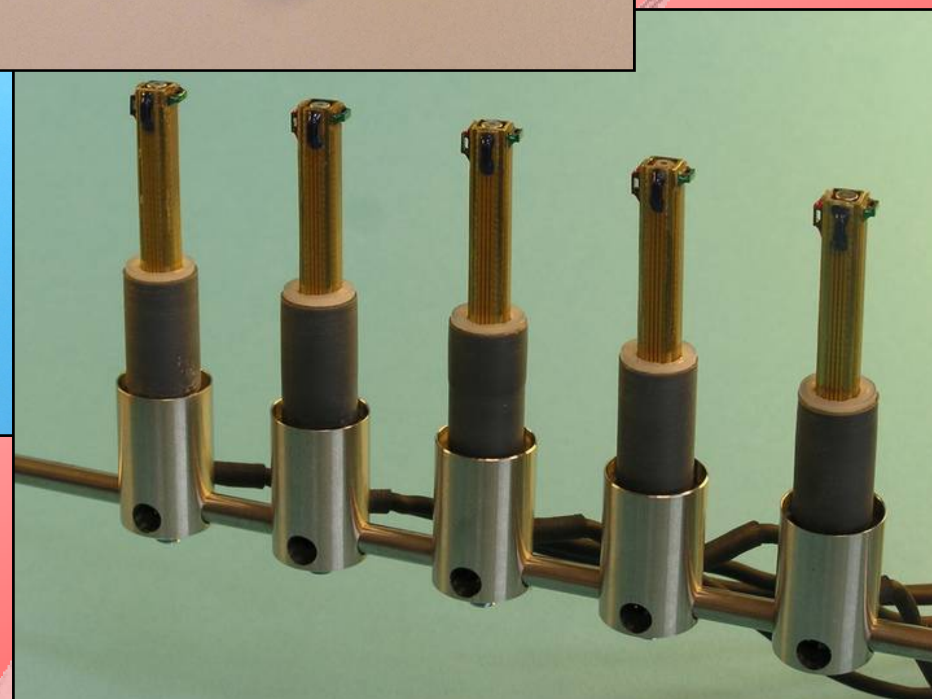


Package gain



3D USP probes

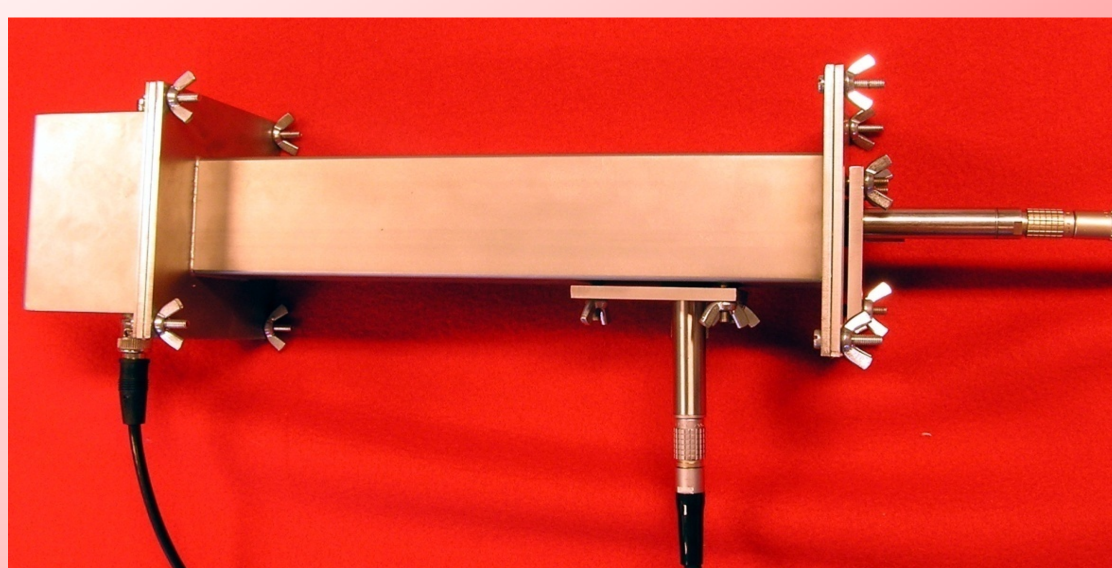




usp, usp match, usp mini

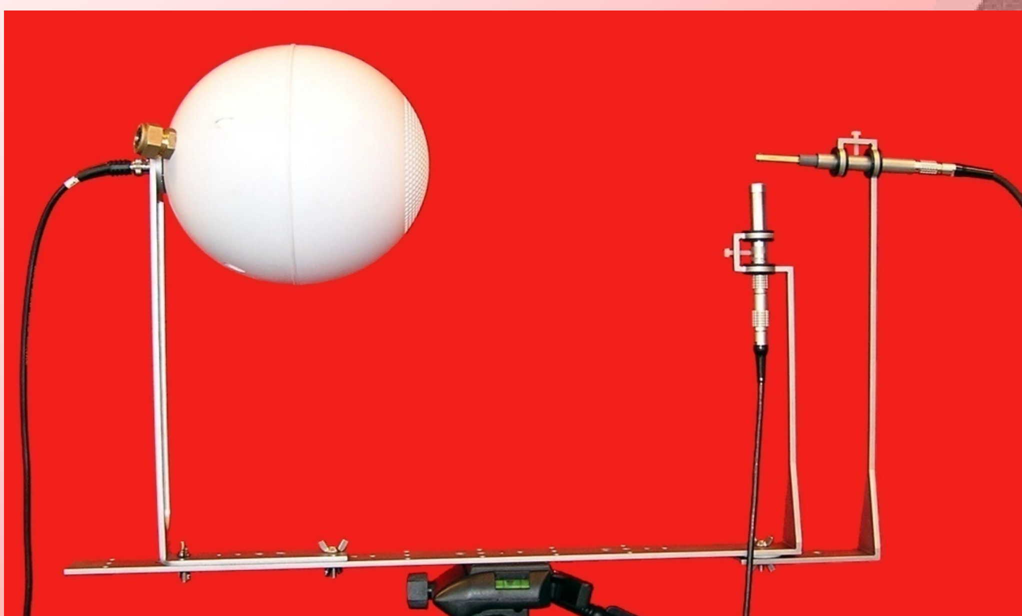
Microflown Technologies
Charting sound fields

Calibrators



Short standing wave tube

Sphere calibrator



- Company history
- Working principle of sensor
- Product range of Microflown
- **Application examples**
- References

Microflown Technologies
Charting sound fields

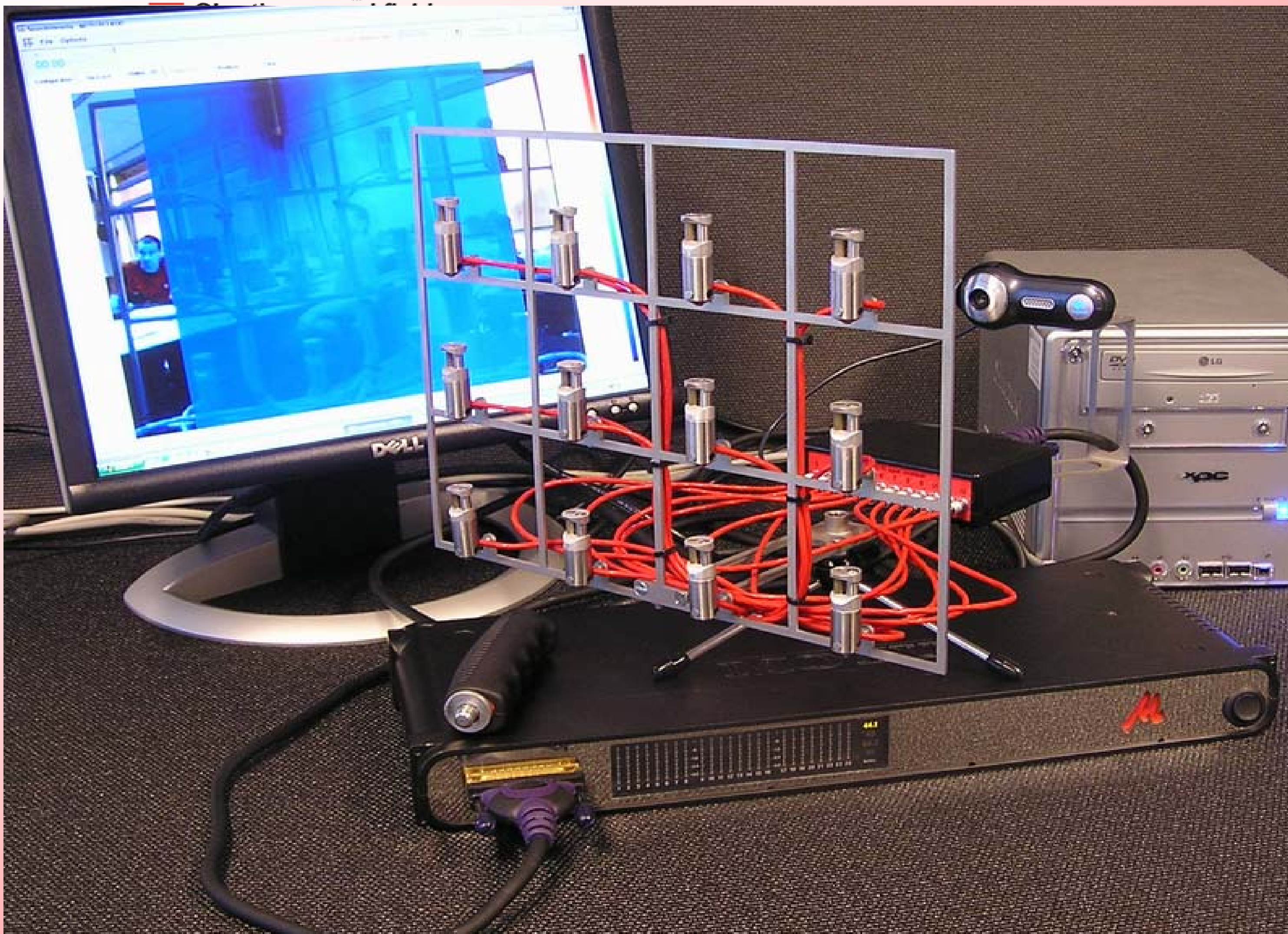
Application Examples

1) PU direct acoustic near field camera
2) 3-D Intensity Measurements
3) Acoustic Eye
4) End of line testing
5) Scan & Listen
6) Mini Acoustic Camera
7) In situ acoustic impedance
8) Car Panel Noise Contribution

Microflown Technologies
Charting sound fields

1) PU direct acoustic near field camera
2) 3-D Intensity Measurements
3) Acoustic Eye
4) End of line testing
5) Scan & Listen
6) Mini Acoustic Camera
7) In situ acoustic impedance
8) Car Panel Noise Contribution

1. Acoustic camera



1. Acoustic camera

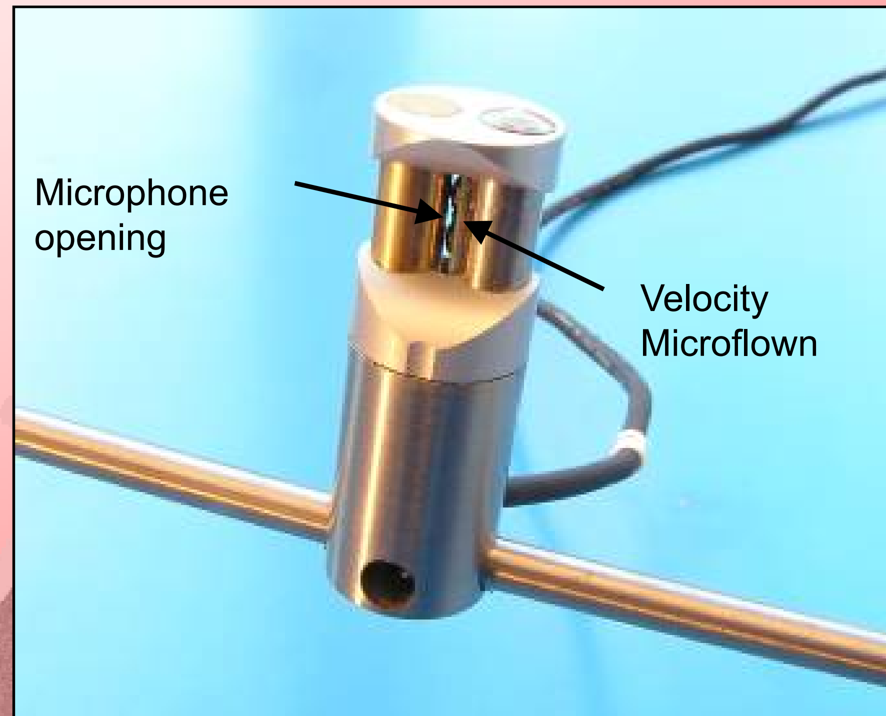
User benefits

- Reliable acoustic particle velocity data
- Real time visualization of all relevant acoustic data
- One point methodology
- Full bandwidth
- Large dynamic range
- Low susceptibility to background noise
- Visualization of transients
- Free configuration of measurement grid
- Multi purpose tool
- Intuitive approach
- Much better than NAH and IBEM (a.o. JASA Paper by Finn Jacobsen)

1. Acoustic camera

Each probe measures Sound Pressure and Particle velocity (and thus Intensity) in one spot

Velocity and Intensity are directly determined, without complex mathematics

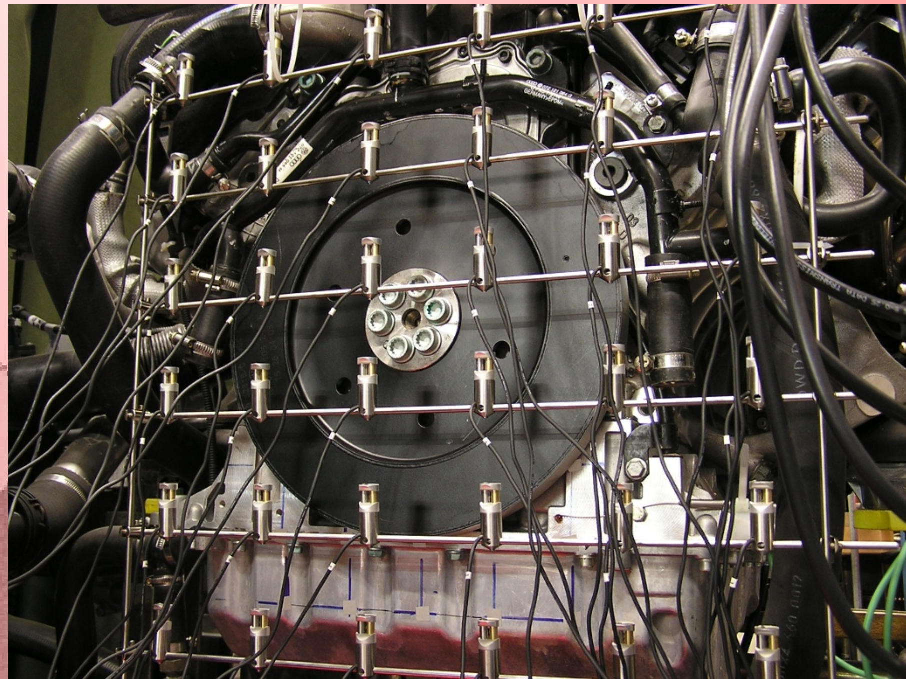


Mini PU probe

1. Acoustic camera

Sound radiation can be measured with just a single probe or with an array of probes

Spacing between probes will not result in frequency limitations. So any probe grid configuration can be defined

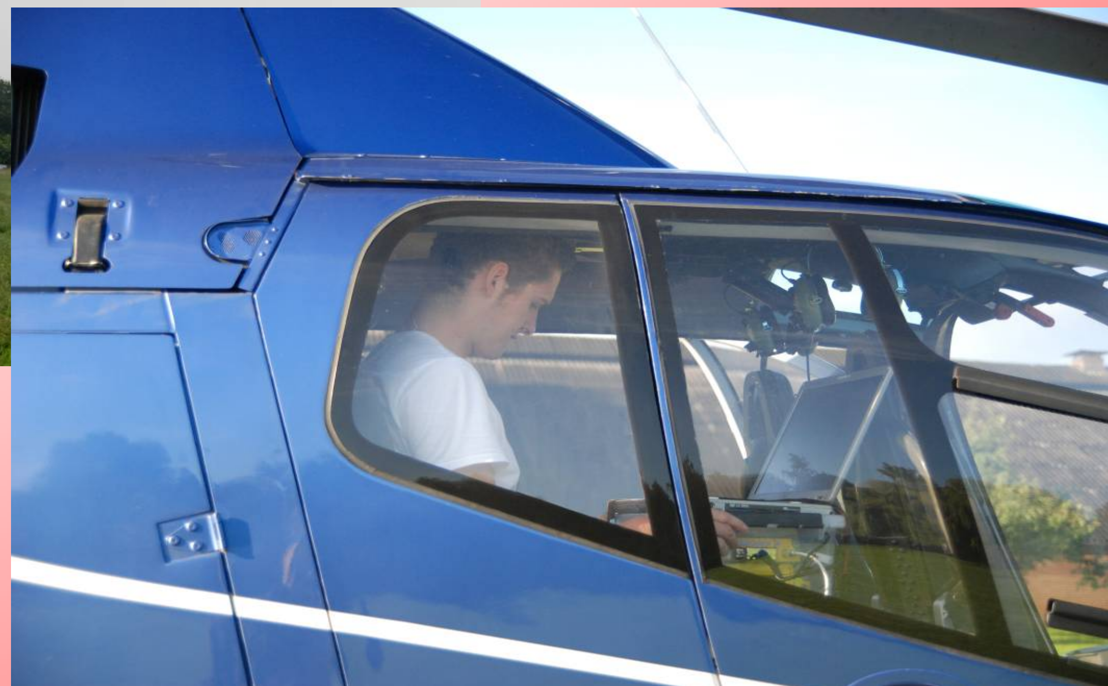


PU array with flexible grid

1. Acoustic camera

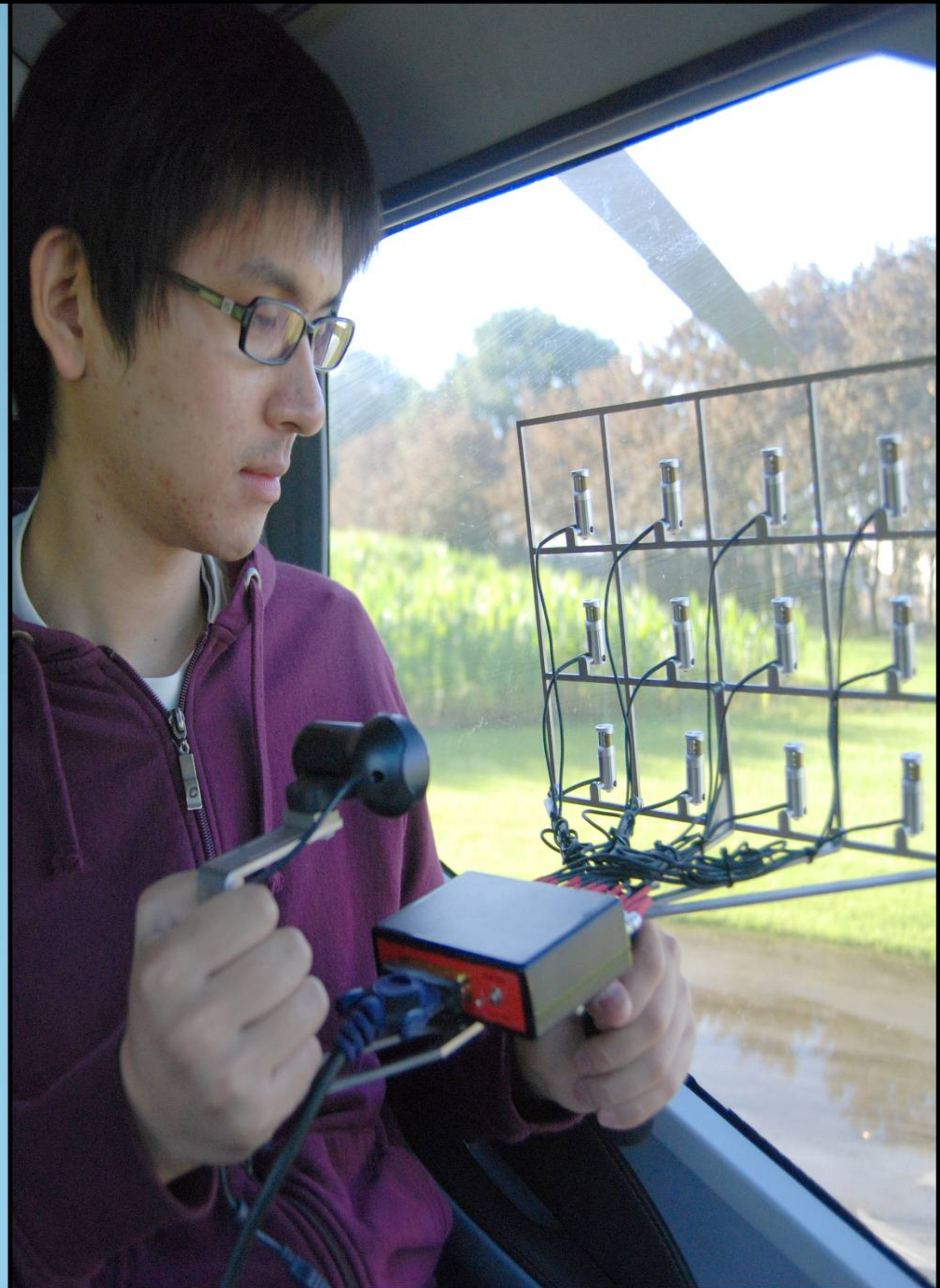
Microflown Technologies

1. Acoustic camera



Measuring with a portable setup inside the Eurocopter EC 120


Data Acquatition
Acoustic Camera
Notebook
Power supply
Portable Solution
for Acoustic Camera

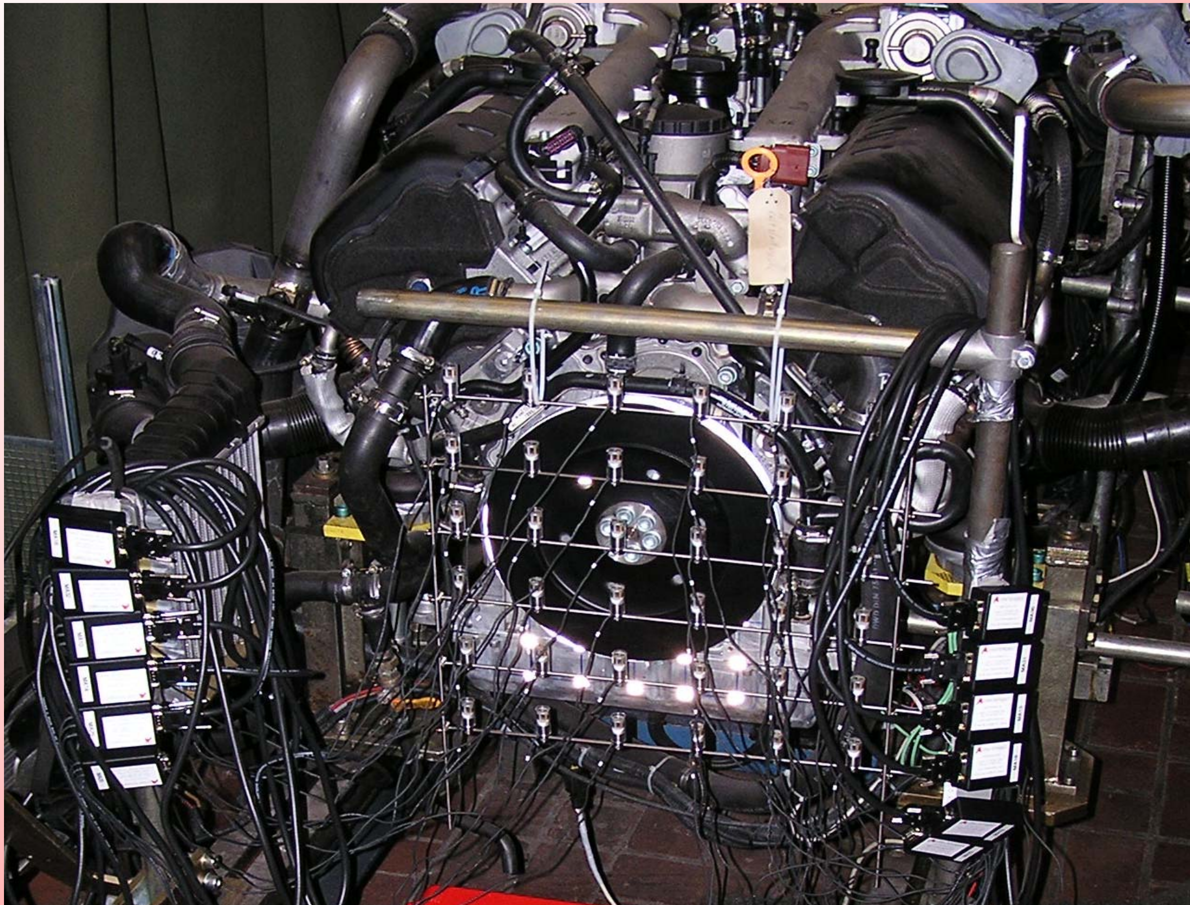


1. Acoustic camera

Microflown Technologies
Charting sound fields

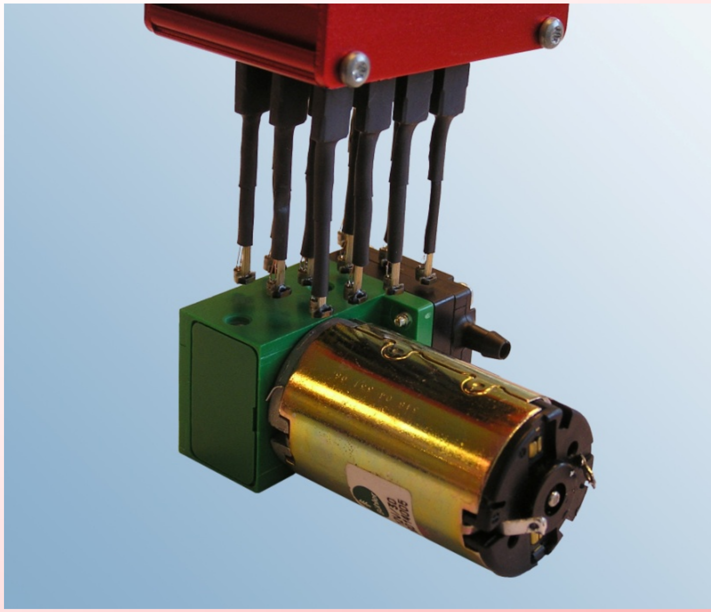
Microflown Technologies
Charting sound fields

1. Acoustic camera

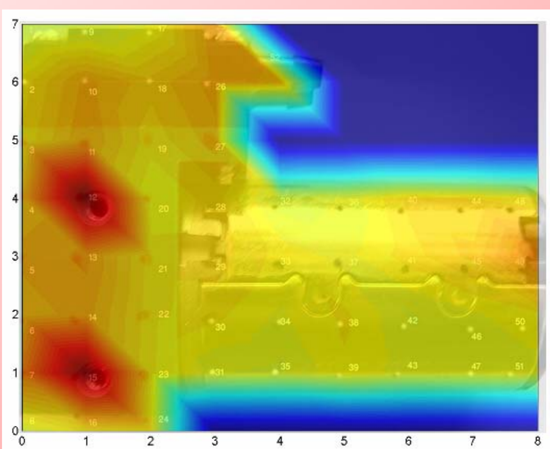


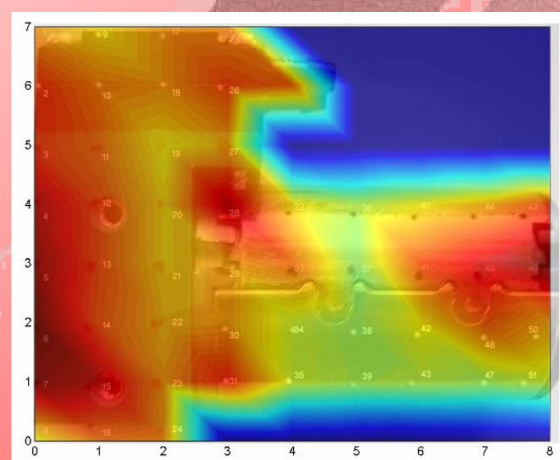
Microflown Technologies
Charting sound fields

1. Acoustic camera



- 1cm x 1cm spacing
- Sound leak finding
- End of line control
- Real time movies





1) PU direct acoustic near field camera

2) 3-D Intensity Measurements

3) Acoustic Eye

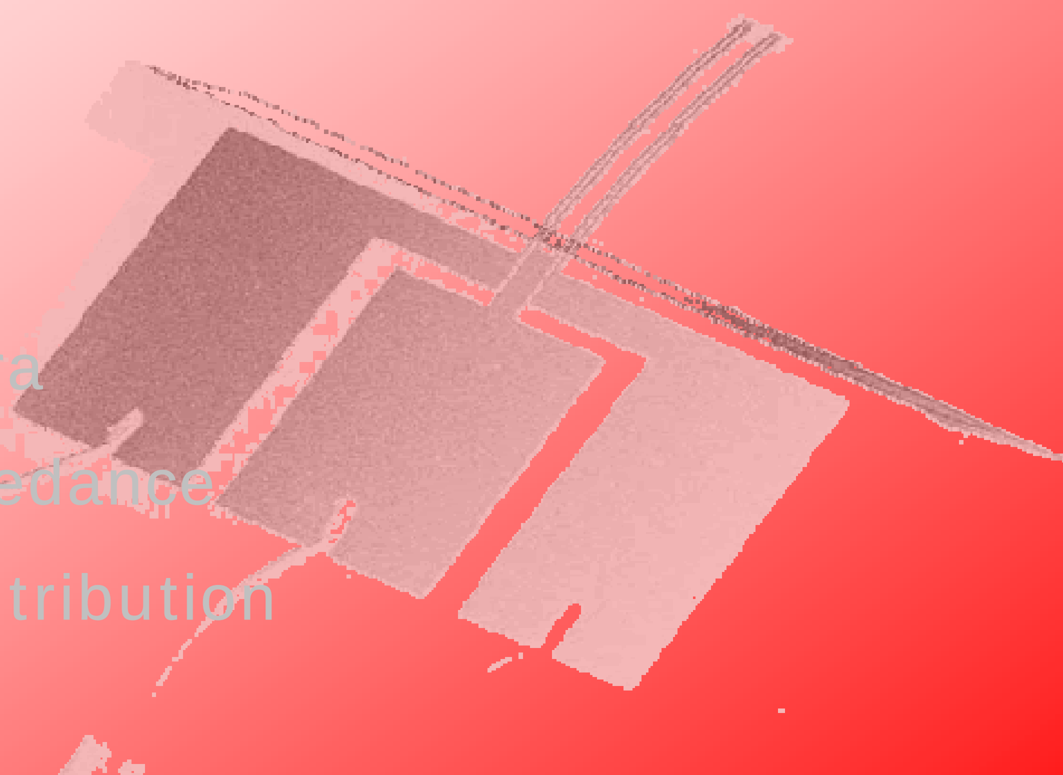
4) End of line testing

5) Scan & Listen

6) Mini Acoustic Camera

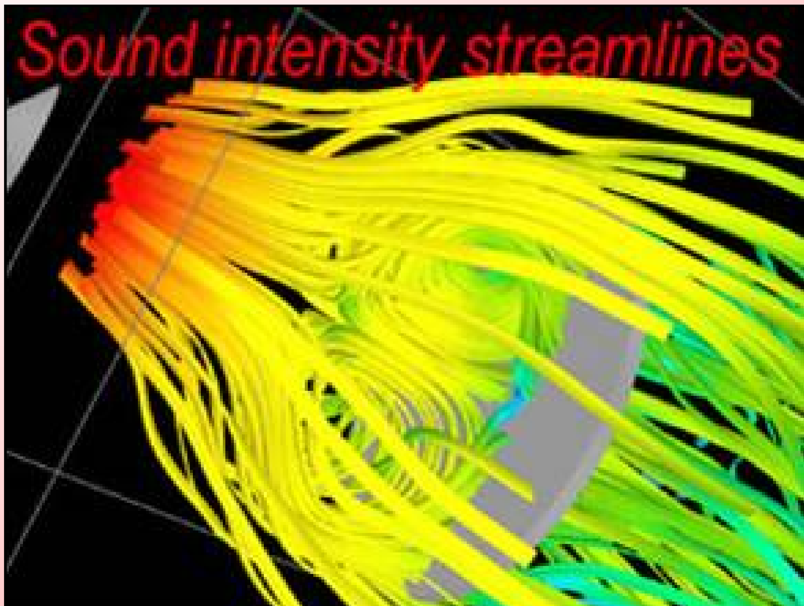
7) In situ acoustic impedance

8) Car Panel Noise Contribution

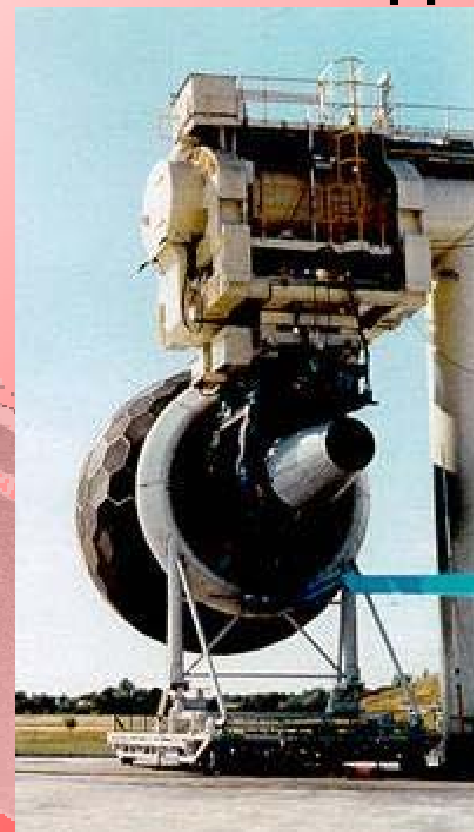


3-D Intensity Measurements

Moving arrays of 3 D USP probes can be used for mapping of 3 D sound intensity streamlines



Courtesy: Univ. Stettin

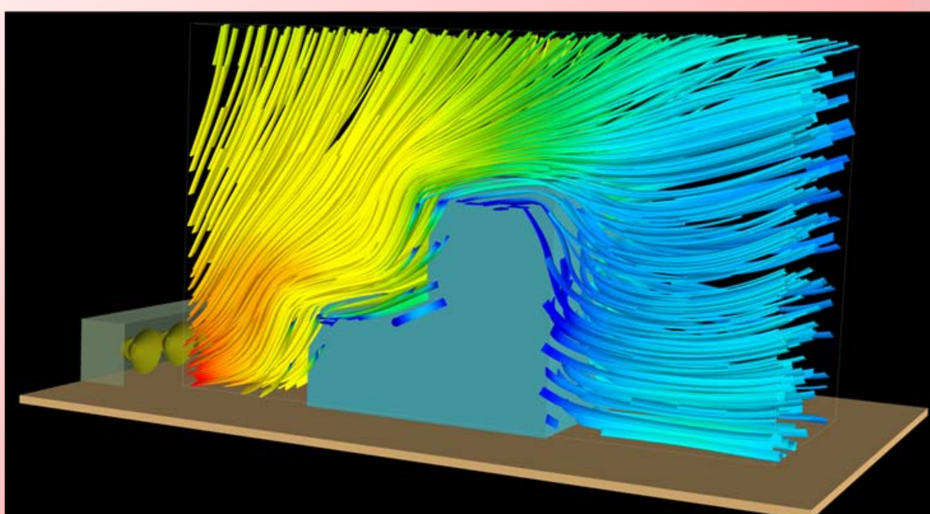


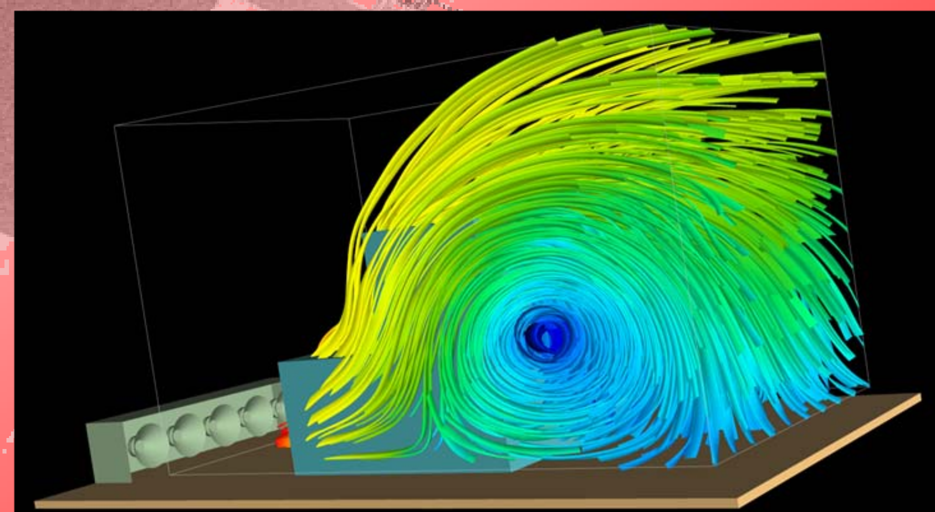
Courtesy: Rolls Royce

Microflown Technologies
Charting sound fields

3-D Intensity Measurements

3D intensity probe





Microflown Technologies

Charting sound fields

1) PU direct acoustic near field camera

2) 3-D Intensity Measurements

3) **Acoustic Eyes**

4) End of line testing

5) Scan & Listen

6) Mini Acoustic Camera

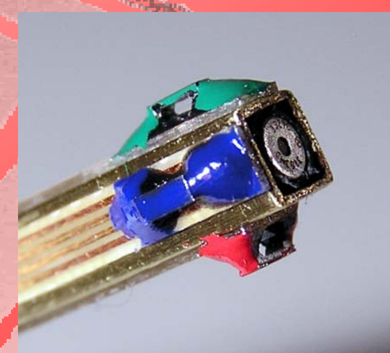
7) In situ acoustic impedance

8) Car Panel Noise Contribution

Microflown Technologies
Charting sound fields

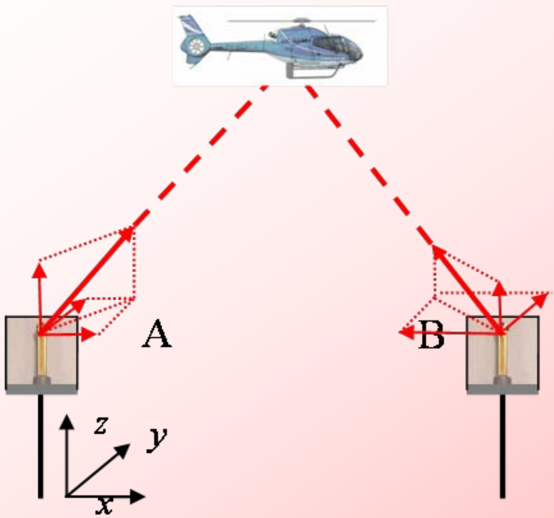
Conventional Test

USP approach replacing large beamforming arrays, capturing simultaneously geometric position and acoustic data



Microflown Technologies
Charting sound fields

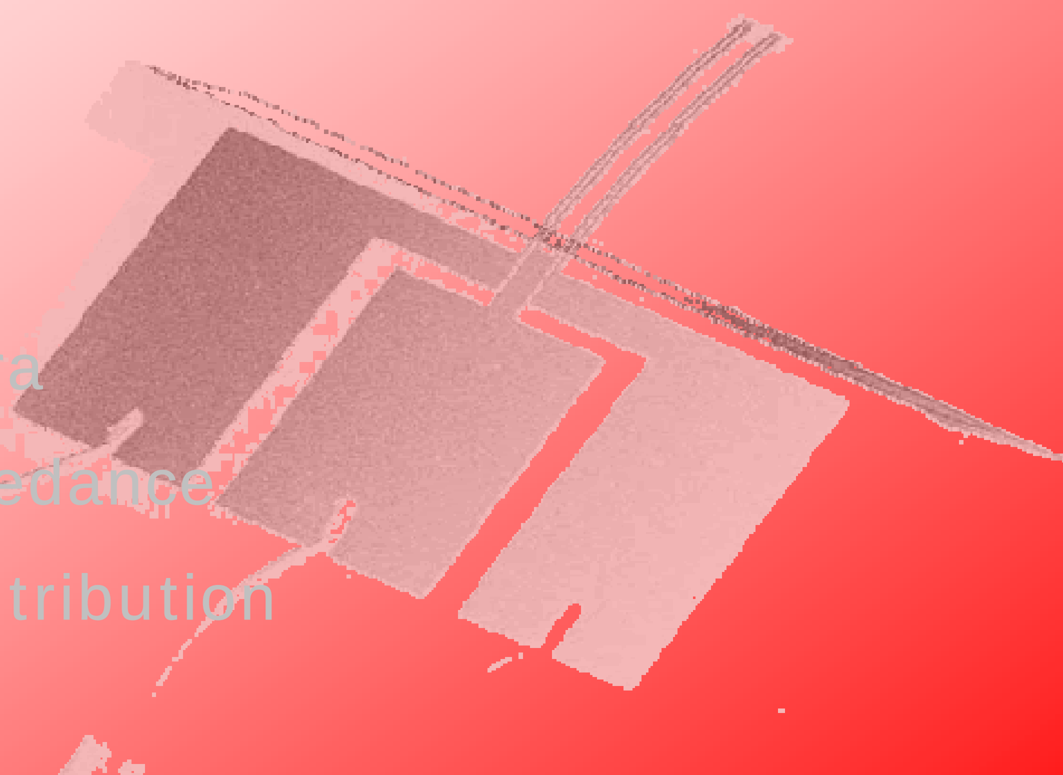
Acoustic Eye



Proven and presented at European Rotorcraft Forum Kazan, September 2007

Microflown Technologies
Charting sound fields

1) PU direct acoustic near field camera
2) 3-D Intensity Measurements
3) Acoustic Eye
4) End of line testing
5) Scan & Listen
6) Mini Acoustic Camera
7) In situ acoustic impedance
8) Car Panel Noise Contribution

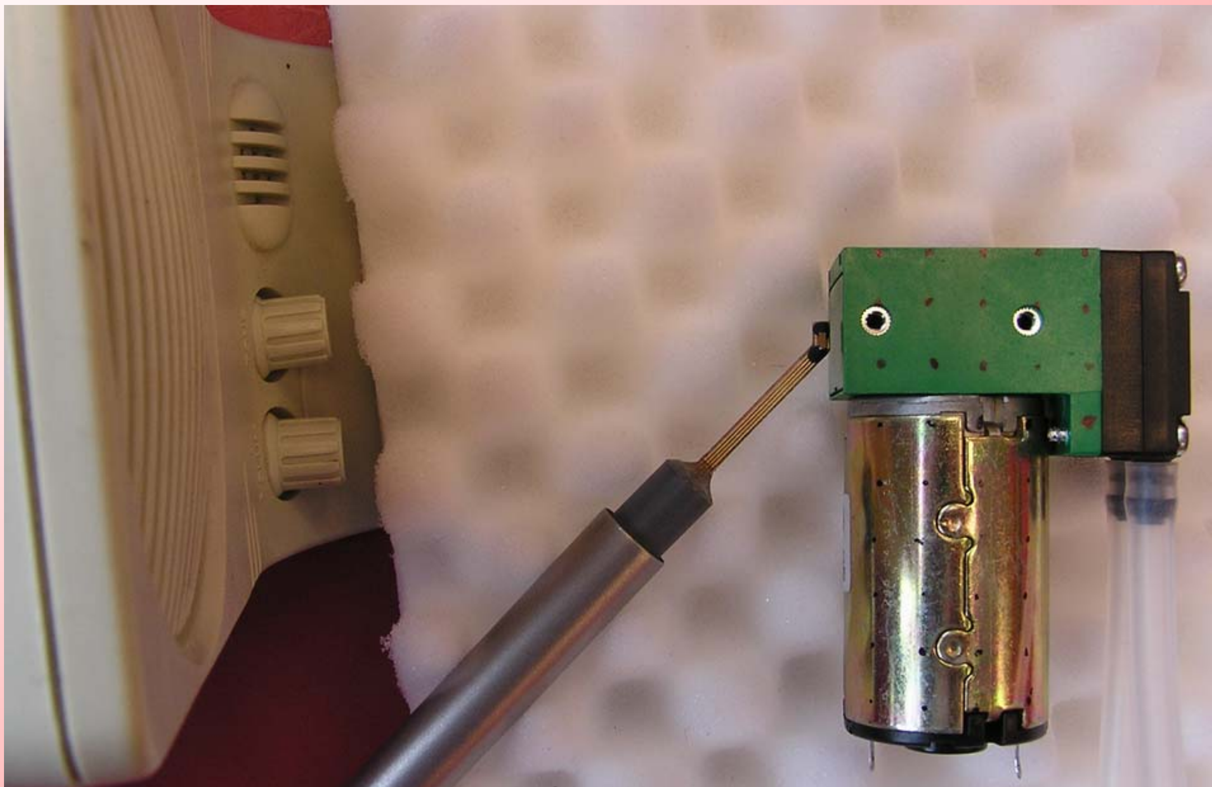


Microflown Technologies
Charting sound fields

End of line testing

Motors & Gears

Acoustic check of products



Microflown Technologies
Charting sound fields

End of line testing

Motors & Gears

Audio example

Background noise reduction

		Good pump	Wrong Pump
No	Pressure		
background noise	Velocity		
	Pressure		
Background noise	Velocity		

Microflown Technologies
Charting sound fields

1) PU direct acoustic near field camera

2) 3-D Intensity Measurements

3) Acoustic Eye

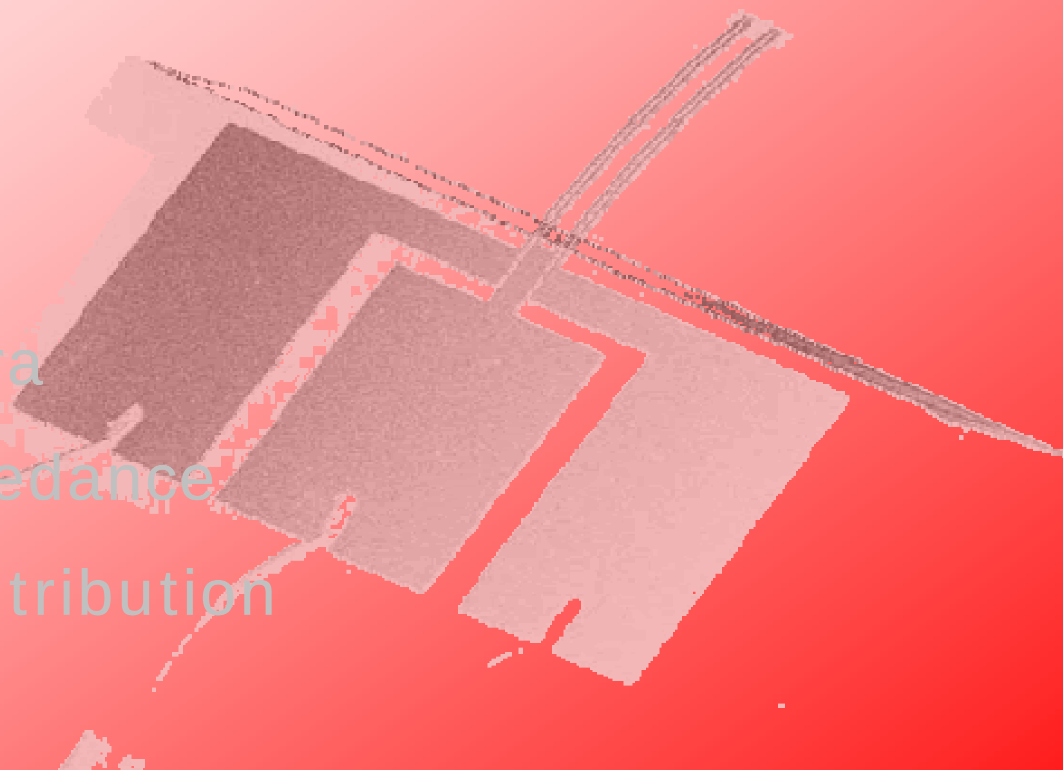
4) End of line testing

5) Scan & Listen

6) Mini Acoustic Camera

7) In situ acoustic impedance

8) Car Panel Noise Contribution



Scan & Listen

Microflown Technologies
Charting sound fields

Scan & Listen

With the Scan and Listen device p and u can be heard directly

- Easy finding of modes
- Easy finding of sources
- Noise source finder
- Squeak & Rattle
- Portable
- Simple to use

1) PU direct acoustic near field camera

2) 3-D Intensity Measurements

3) Acoustic Eye

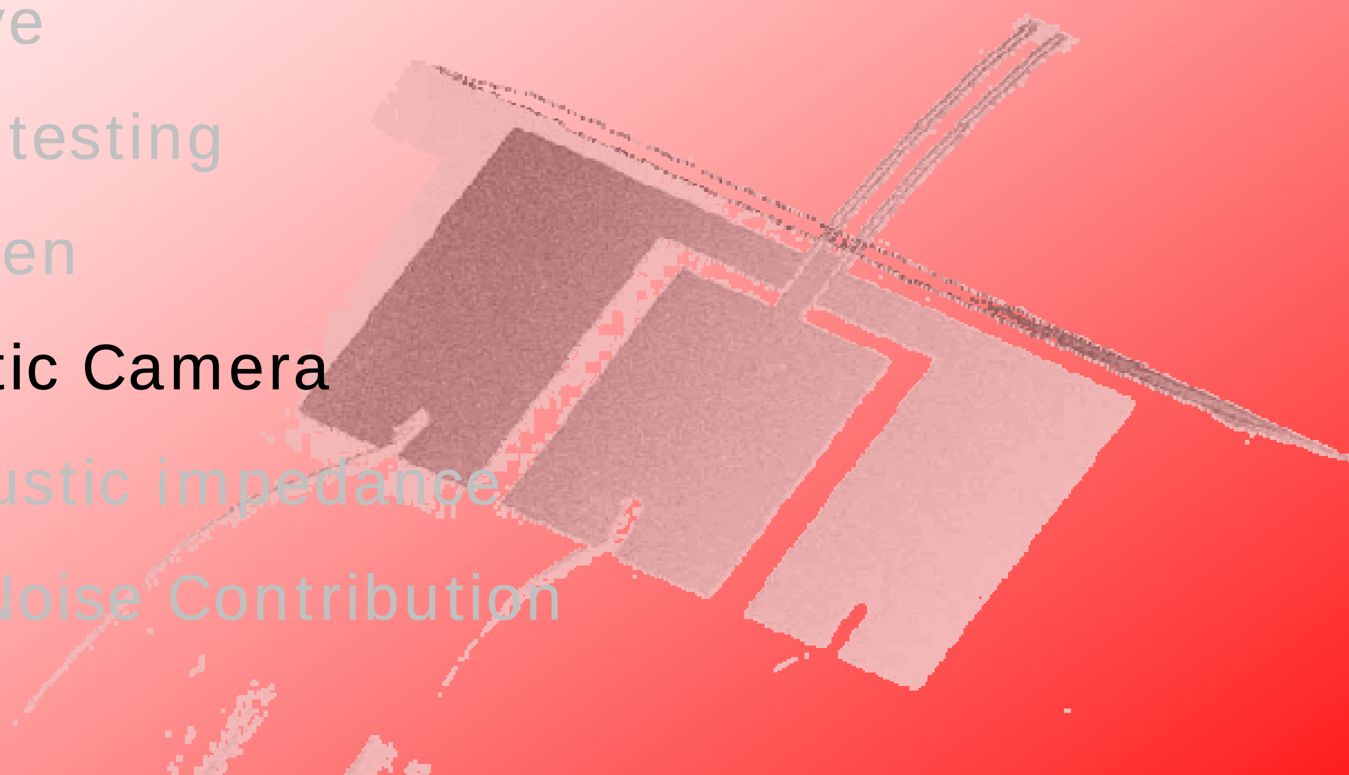
4) End of line testing

5) Scan & Listen

6) Mini Acoustic Camera

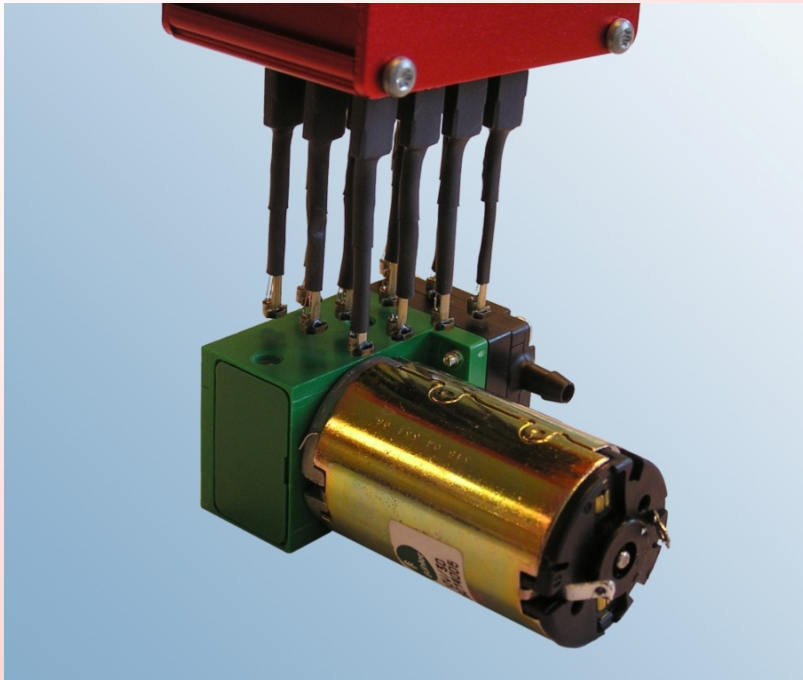
7) In situ acoustic impedance

8) Car Panel Noise Contribution



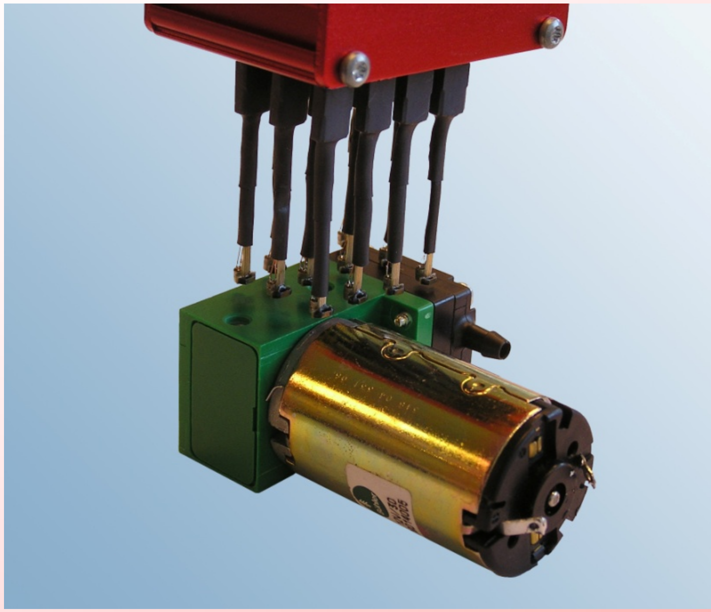
Mini Acoustic camera

Miniature PU match Acoustic Camera

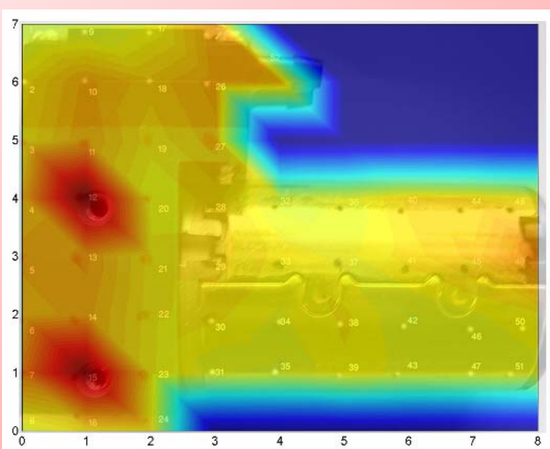


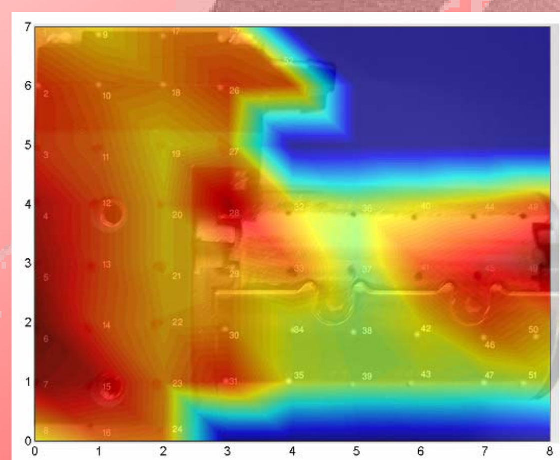
Microflown Technologies
Charting sound fields

Mini Acoustic camera



- 1cm x 1cm spacing
- Sound leak finding
- End of line control
- Real time movies





Microflown Technologies
Charting sound fields

1) PU direct acoustic near field camera

2) 3-D Intensity Measurements

3) Acoustic Eye

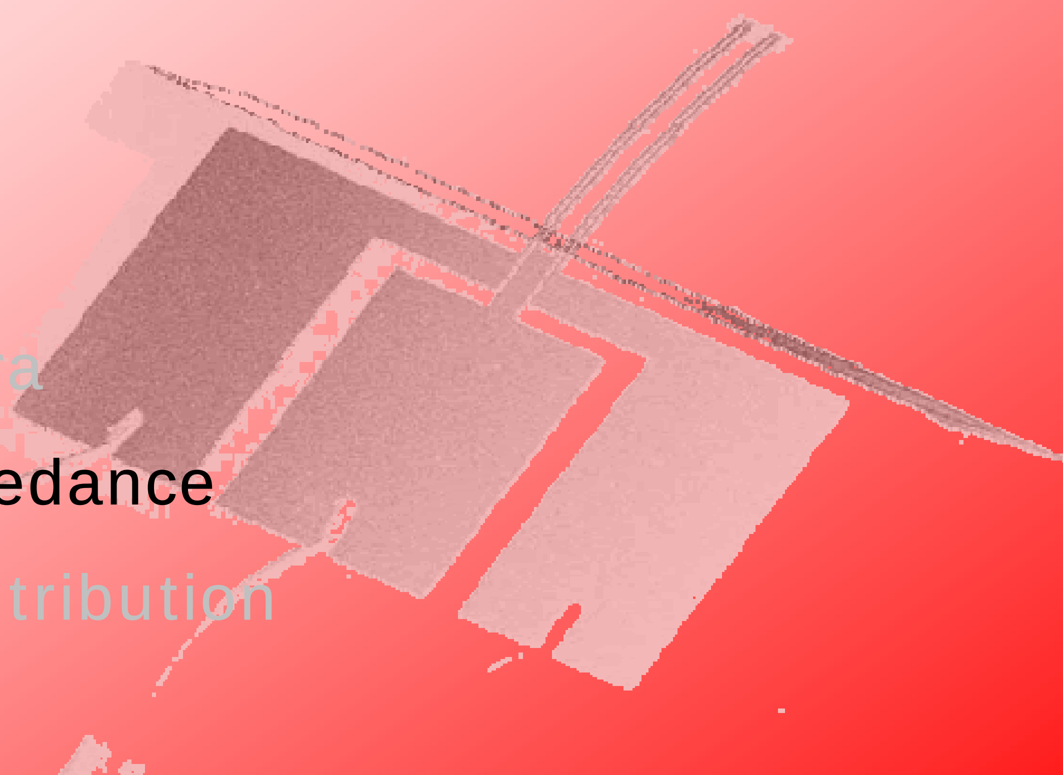
4) End of line testing

5) Scan & Listen

6) Mini Acoustic Camera

7) In situ acoustic impedance

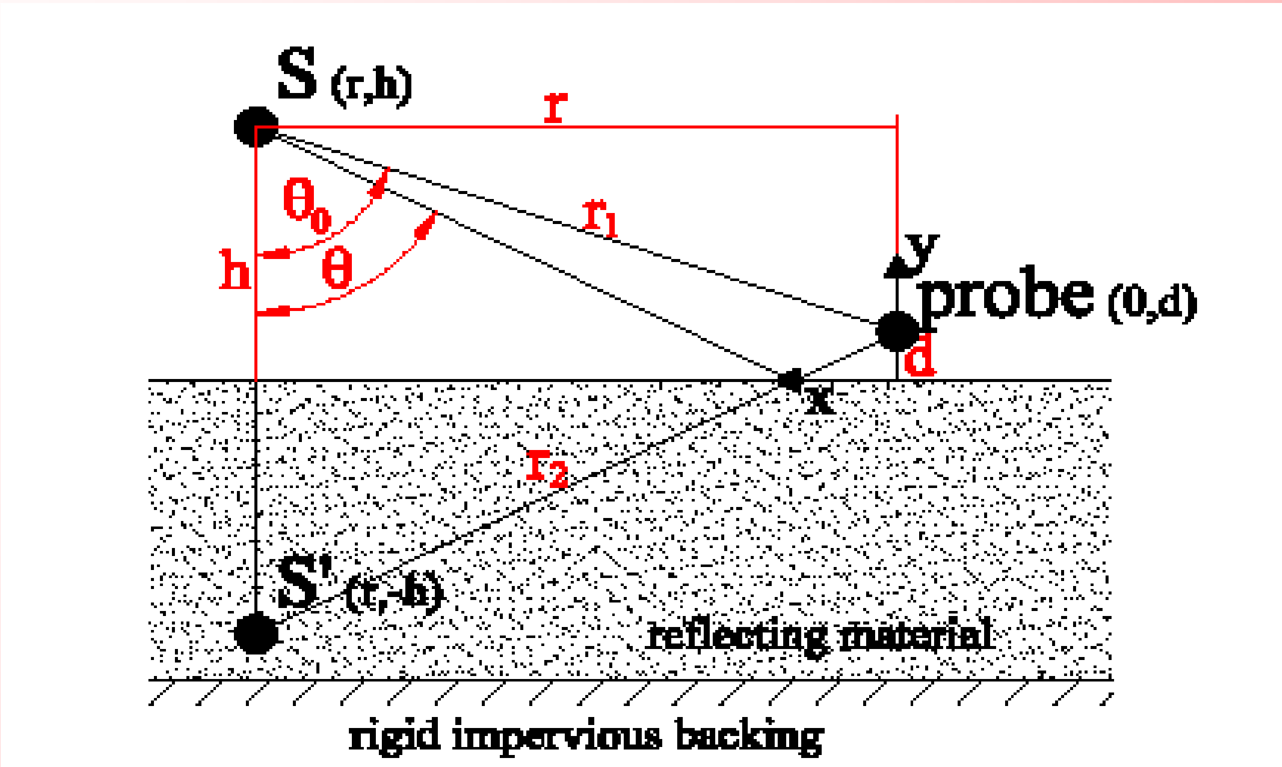
8) Car Panel Noise Contribution



Microflown Technologies
Charting sound fields

In situ acoustic impedance

Principle



Microflown Technologies
Charting sound fields

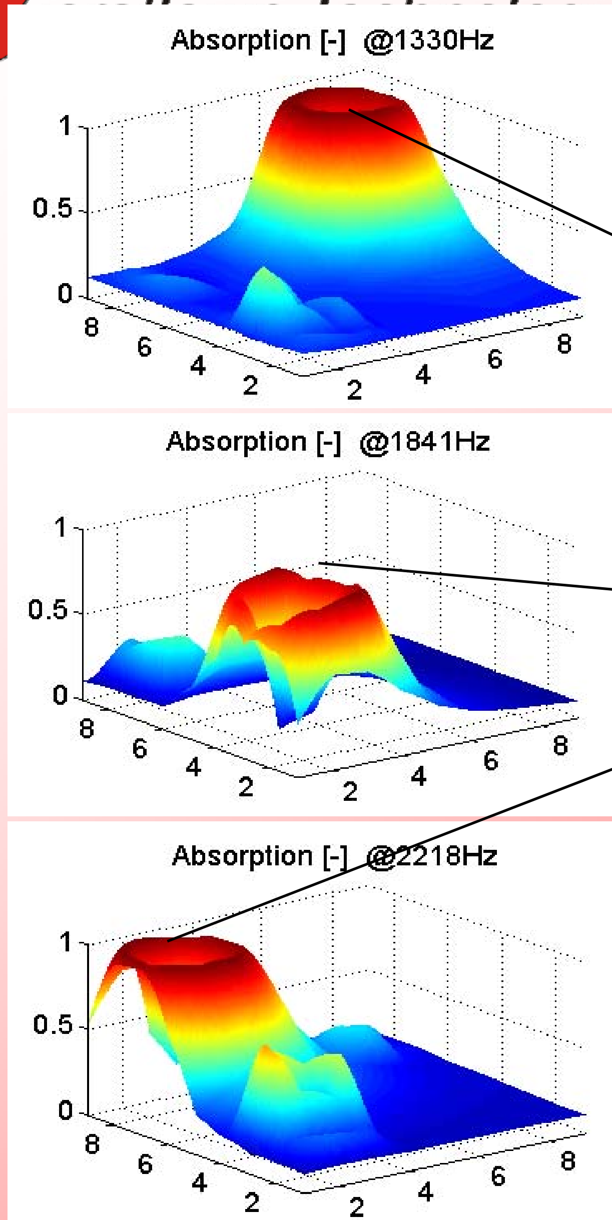
In situ acoustic impedance

Microflown Technologies
Charting sound fields

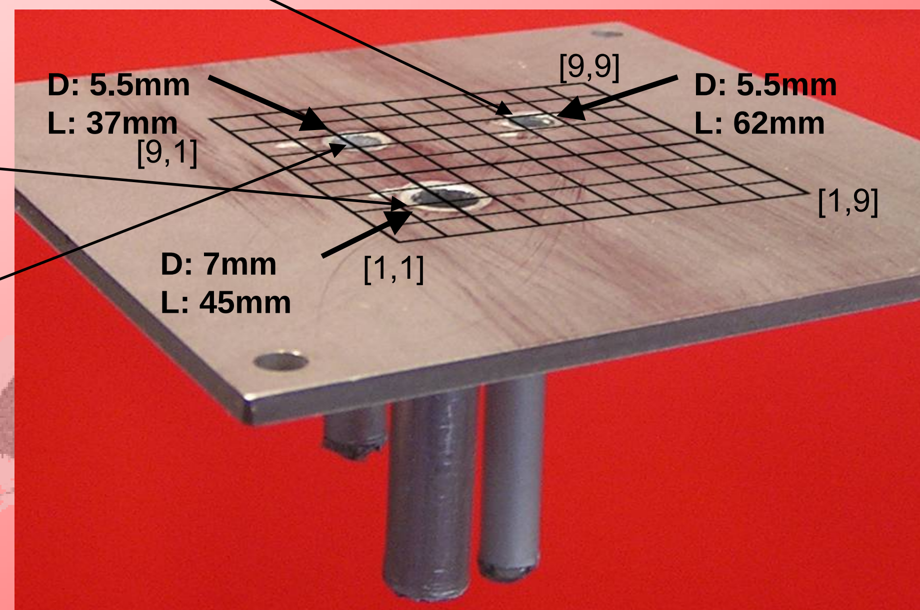
In situ acoustic impedance

In situ acoustic impedance

High spatial resolution



Sample with three quarter lambda resonators



Microflown Technologies
Charting sound fields

1) PU direct acoustic near field camera

2) 3-D Intensity Measurements

3) Acoustic Eye

4) End of line testing

5) Scan & Listen

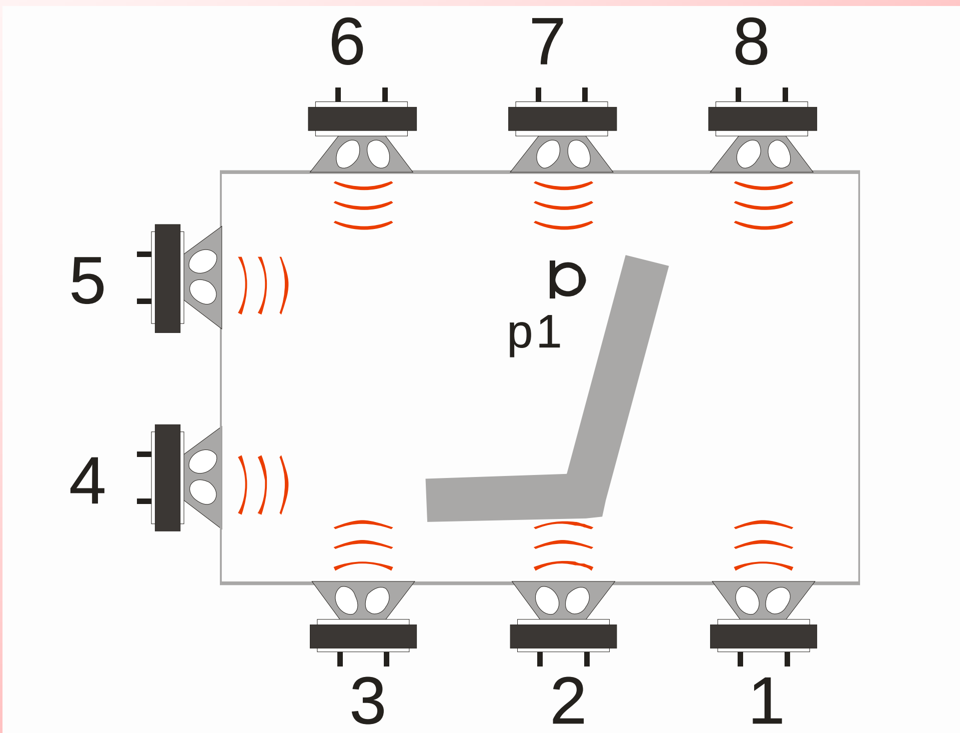
6) Mini Acoustic Camera

7) In situ acoustic impedance

8) Car Panel Noise Contribution

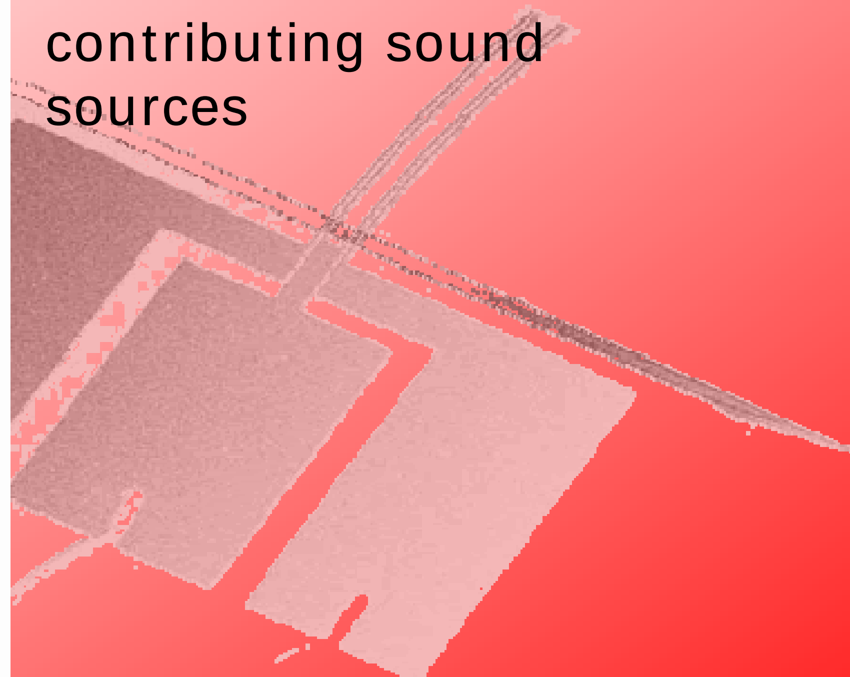
Microflown Technologies
Charting sound fields

Car Panel Noise Contribution



Step one:

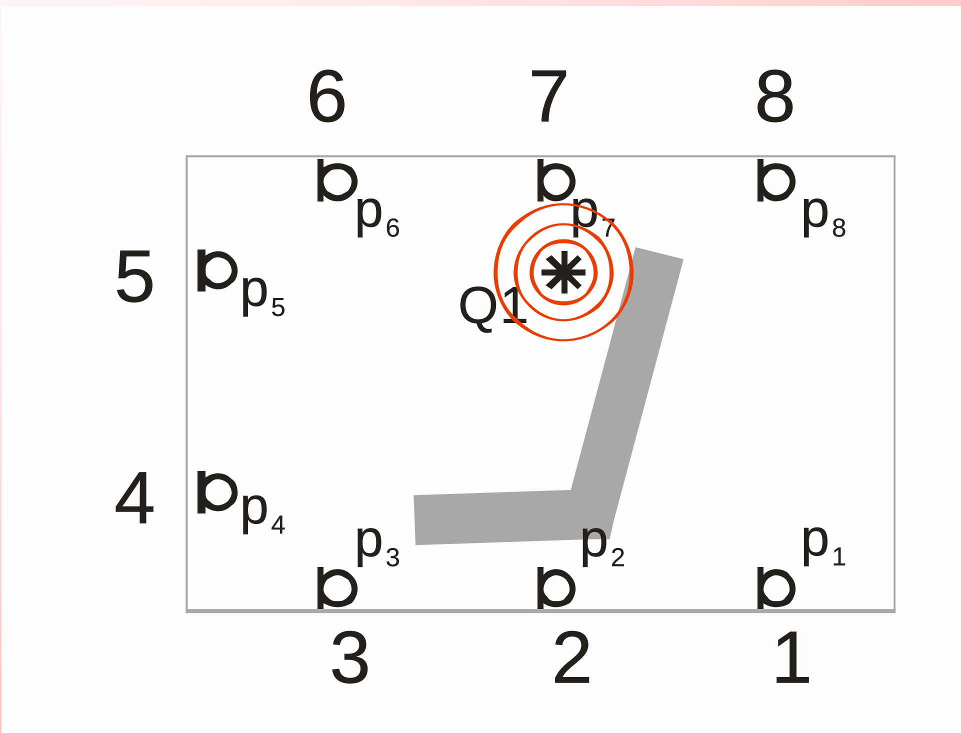
Measurement of all contributing sound sources



Microflown Technologies
Charting sound fields

Car Panel Noise Contribution

Reciprocity principle



Step two:

Using a true volume velocity source to determine the transfer path to the panels, using the reciprocity principle

Omnidirectional sources

Low freq. source
30Hz-300Hz

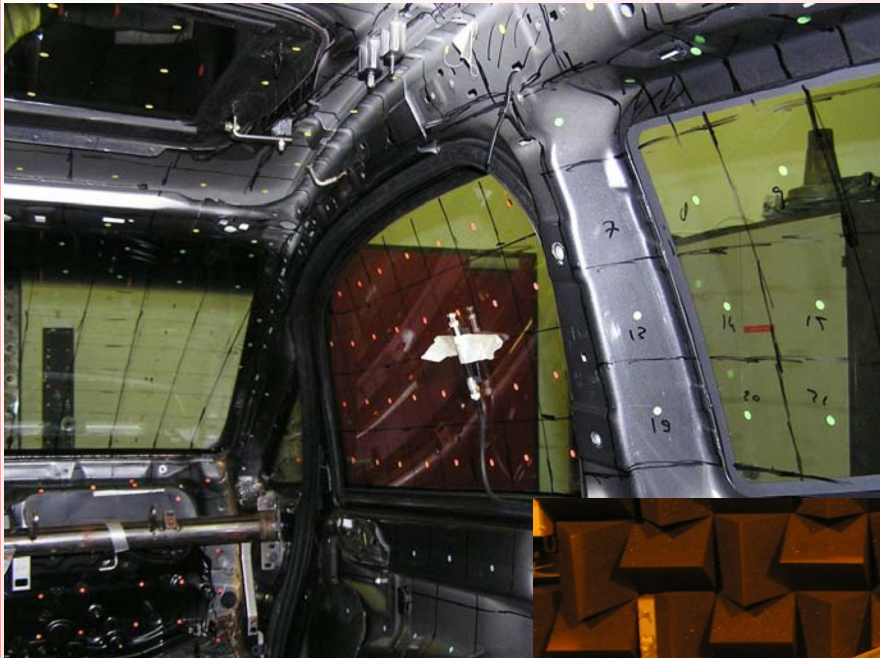
High freq. source
100Hz-6kHz

Car Panel Noise Contribution

Head source: reciprocal counterpart of ‘human hearing’

Microflown Technologies
Charting sound fields

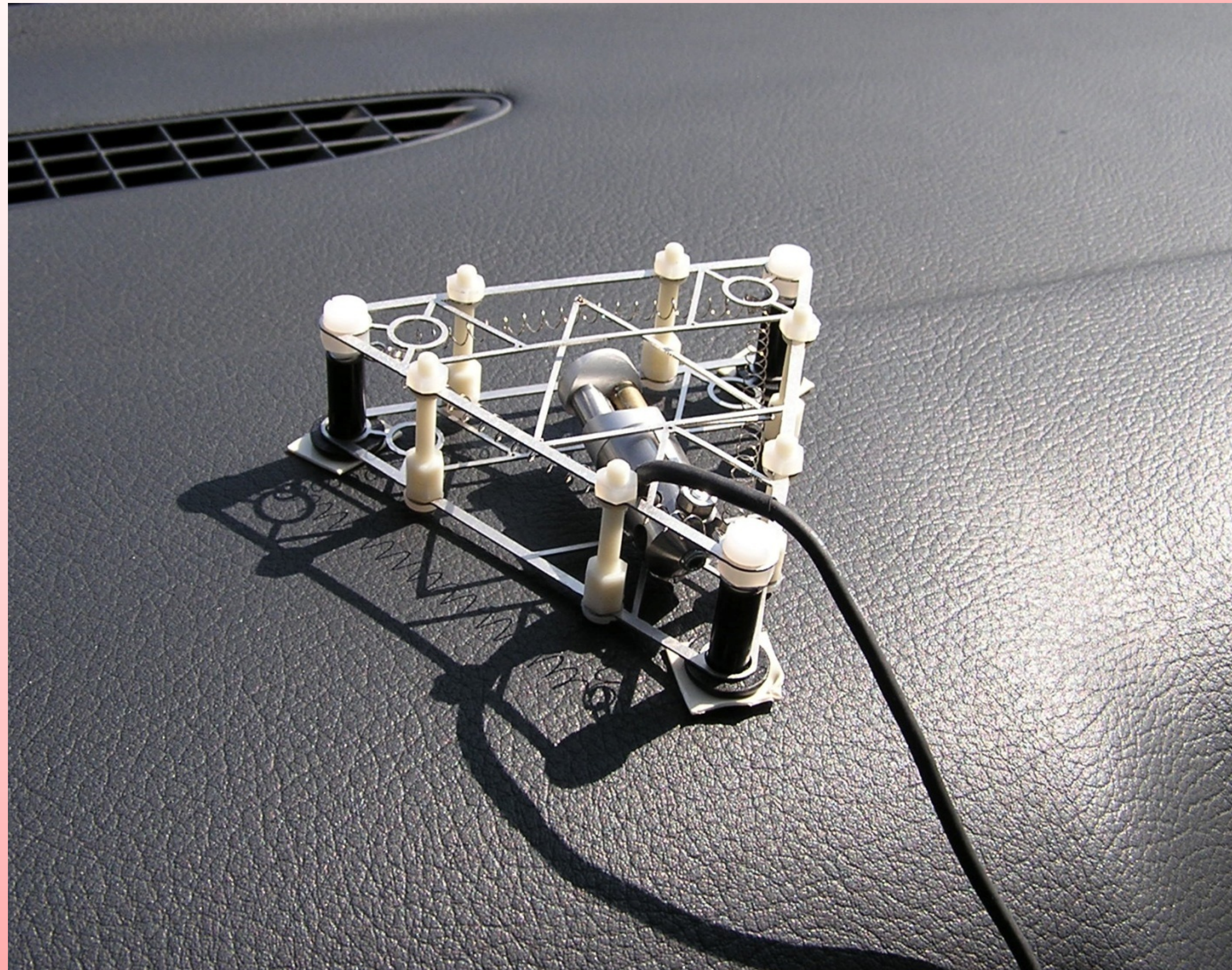
Car Panel Noise Contribution



Measurements at PDE automotive

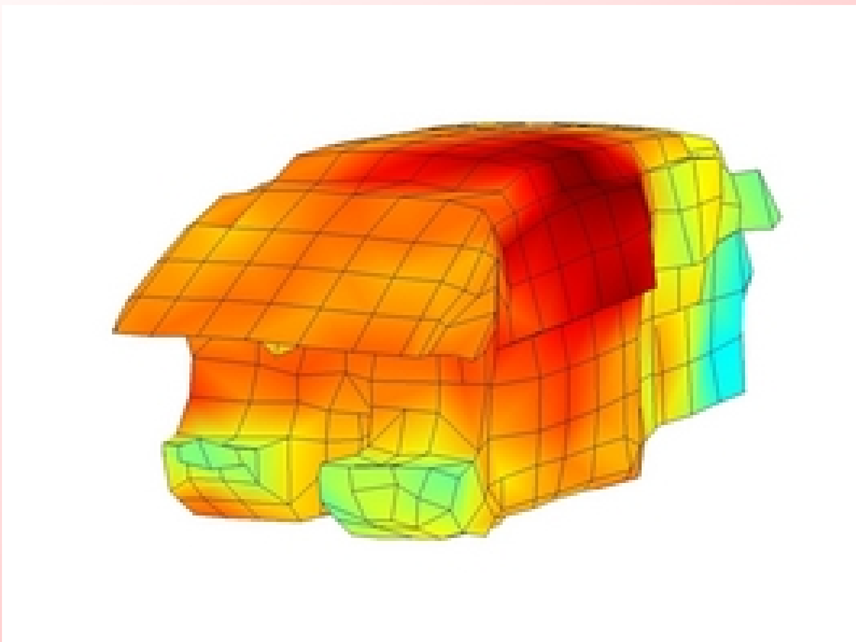
Microflown Technologies
Charting sound fields

Car Panel Noise Contribution

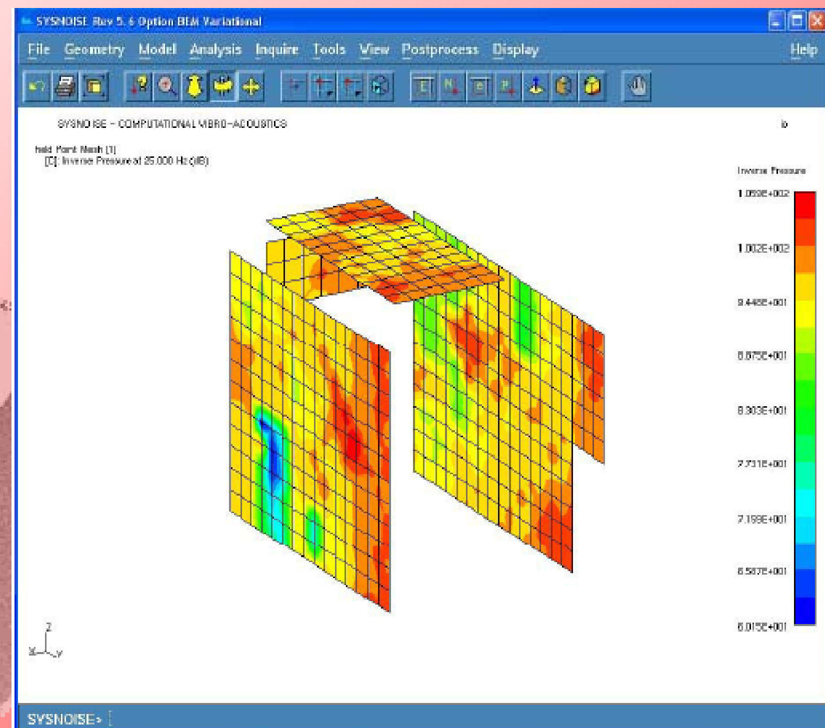


Microflown Technologies
Charting sound fields

Car Panel Noise Contribution



(Peugeot / Faurecia)



(LMS / Eurocopter)

Microflown Technologies
Charting sound fields

- Company history
- Working principle of sensor
- Product range of Microflown
- Application examples
- **References**

References

Automotive references:

Audi, BMW, DaimlerChrysler, Dong Feng, Faurecia, Ford, Honda, Hyundai, Isuzu, Mazda, Muller-BBM, PSA Peugeot Citroen, Samsung Renault, Rieter Automotive, Stankiewiecz, Toyota, Volkswagen.

Aerospace references:

ADE Bangalore, Airbus France & Germany, DLR,

Helmut Schmidt University, Univ. Compiegne,

Univ. LeMans, Univ.Oldenburg, US Airforce

Microflown Technologies

Charting sound fields

Are there any questions ?

We welcome you at our booth 1808.