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

Microflown SEM picture: two heated wires
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
• Company history
• Working principle of sensor
• **Product range of Microflown**
• Application examples
• References
Scanning Probe

- 1D Velocity
- For small objects
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
Calibrators

Sphere calibrator

Short standing wave tube
• Company history
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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
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)
Each probe measures Sound Pressure and Particle velocity (and thus Intensity) in one spot.

Velocity and Intensity are directly determined, without complex mathematics.
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
Measuring with a portable setup inside the Eurocopter EC 120
Portable Solution for Acoustic Camera
1. Acoustic camera
1. Acoustic camera
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
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Moving arrays of 3D USP probes can be used for mapping of 3D sound intensity streamlines

Courtesy: Univ. Stettin

Courtesy: Rolls Royce
3D intensity probe

3-D Intensity Measurements
1) PU direct acoustic near field camera
2) 3-D Intensity Measurements
3) Acoustic Eyes
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Conventional Test

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

Proven and presented at European Rotorcraft Forum Kazan, September 2007
1) PU direct acoustic near field camera
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End of line testing
Motors & Gears

Acoustic check of products
### Audio example

#### Background noise reduction

<table>
<thead>
<tr>
<th></th>
<th>Good pump</th>
<th>Wrong Pump</th>
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<tbody>
<tr>
<td>No</td>
<td>Pressure</td>
<td></td>
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<tr>
<td>background noise</td>
<td>Velocity</td>
<td></td>
</tr>
<tr>
<td>Pressure</td>
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<tr>
<td>Background noise</td>
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8) Car Panel Noise Contribution
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
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Mini Acoustic camera

Miniature PU match Acoustic Camera
Mini Acoustic camera

- 1cm x 1cm spacing
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1) PU direct acoustic near field camera
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In situ acoustic impedance

Principle

- Source $S_{(r,h)}$
- Reflecting material
- Rigid impervious backing
- Probe $y_{(0,d)}$
- Incident angle $\theta$
- Reflection angle $\theta_0$
- Distances $r$, $r_1$, $r_2$
In situ acoustic impedance
In situ acoustic impedance
In situ acoustic impedance

High spatial resolution

Sample with three quarter lambda resonators

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<th>D</th>
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<tbody>
<tr>
<td>5.5mm</td>
<td>37mm</td>
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<tr>
<td>7mm</td>
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<tr>
<td>5.5mm</td>
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</tbody>
</table>

\[ [1,9], [9,9], [9,1], [1,1] \]
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Car Panel Noise Contribution

Step one:
Measurement of all contributing sound sources
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’
Car Panel Noise Contribution

Measurements at PDE automotive
Car Panel Noise Contribution
Car Panel Noise Contribution

( Peugeot / Faurecia )

( LMS / Eurocopter )
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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. Compiégne, Univ. LeMans, Univ.Oldenburg, US Airforce
Are there any questions?

We welcome you at our booth 1808.