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Future Trends in Noise Control Technology

J Stuart Bolton
Purdue University, bolton@purdue.edu

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2aNS1: FUTURE TRENDS IN NOISE CONTROL TECHNOLOGY

J. Stuart Bolton

Ray W. Herrick Laboratories
School of Mechanical Engineering, Purdue University
West Lafayette, IN, USA

Presentation available at Herrick E-Pubs: http://docs.lib.purdue.edu/herrick/
See also: https://www.youtube.com/watch?v=1voc1-2ZUYQ

FUTURE TRENDS

- **Noise Control ≠ Acoustics**
- **Noise Control = “Constrained” Acoustics**
- **Constraints:**
  - Cost
  - Weight
  - Volume
  - Robustness
  - Manufacturability
  - Recyclability

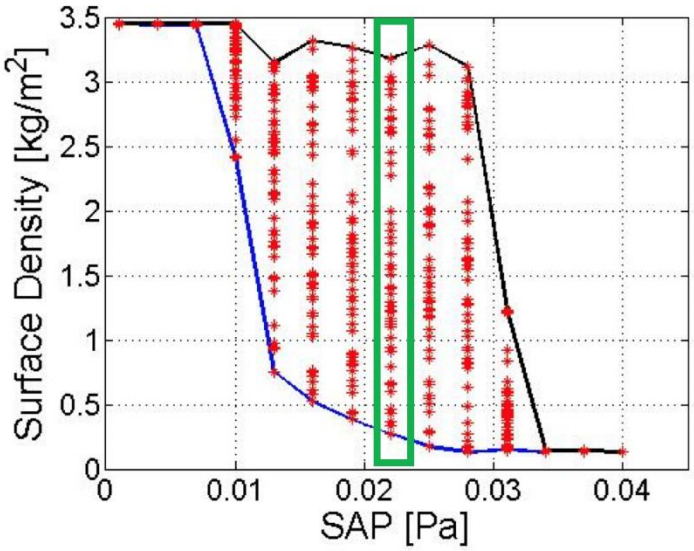
FUTURE TRENDS

1. Targets
2. Measurement Procedures
3. Predictive Tools
4. Noise Control Methods

1. Targets

- **Perception-based Engineering**
  - **Human in the loop**
  - **Auralization based on machine design (e.g., NASA auralization of aircraft flyovers)**
  - **Virtual prototyping**
- **Not just reducing levels, but shaping the acoustic environment →**
- **More sophisticated sound quality models – including impact of non-acoustic parameters (thermal, illumination, etc.)**
- **Soundscapes**
  - **Design of urban sound environments based on characteristics of community and intended outcomes**

Sound Package Lightweighting*



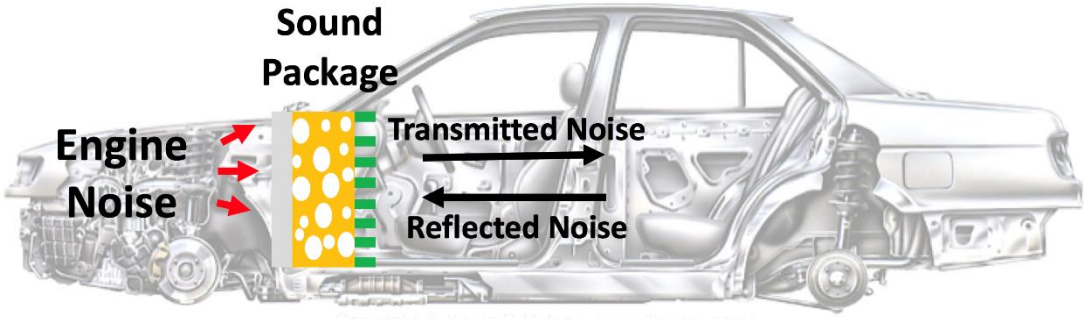
Total surface density for various SAPs (No leakage)

LIGHTEST Combinations

Heaviest Combinations

Possible Combinations

- Vary mass/unit area and flow resistivity of fibrous layer and MPP surface treatment
- Balance barrier and absorption performance



* Hyunjun Shin and J. Stuart Bolton, "Weight minimization of automotive sound packages in the presence of air leaks," Paper 1469 *Proceedings of InterNoise 2018*, Chicago, August 2018.

1. Targets

- **Perception-based Engineering**
  - **Human in the loop**
  - **Auralization based on machine design (e.g., NASA auralization of aircraft flyovers)**
  - **Virtual prototyping**
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2. Measurement Procedures

- Developments of holography
  - Real-time, time-domain
  - Advanced equivalent source methods
  - Radiation mode-based procedures
- Pressure-Sensing – eliminate microphones: fiber optics, laser scattering
- Whole field dynamic vibration measurement to replace single point laser Doppler methods
- Very large-scale data acquisition – hundreds/thousands of channels
- Wireless transducers
- Very large-scale environmental noise measurements using smart-phones and the public

3. Predictive Tools

- **Finite Element Methods**
  - Convenient incorporation of radiation modes
  - Incorporation of more complete acoustical material models
  - Incorporation of uncertainty quantification – to compete with Statistical Energy Analysis
- **Finite Difference Time Domain methods**
  - Incorporation of realistic boundary conditions and poroelastic material models
- **CFD/CAA**
  - Fan noise is ubiquitous
  - Finally design fans that are optimally quiet with realistic inflow conditions
  - Micro-scale modeling of porous materials and thin absorbents

4. Noise Control Methods

- **Active Noise Control (is back)**
  - **Processing power and electronic devices are everywhere**
  - **Incorporation of human perception models to shape sound fields to create pleasant environments**
  - **Enable weight reduction of conventional sound packages**
  - **Enable localized communication and quiet zones**
  - **Electric Vehicles – road noise and aerodynamic noise, plus torque ripple are the major issues**
  - **SAE Forum Shanghai in Sept. 2018: EV focus**
    https://www.sae.org/binaries/content/assets/cm/content/attend/2018/nvh-forum/180717_sae_2018_nvc_brochure_en.pdf

4. Noise Control Methods

- **Advanced Noise Control Materials →**
  - **MPP's – very attractive functional attributes – multilayer barriers & absorbers**
  - **Carbon fiber composites**
  - **Very thin absorbents (internal degrees of freedom)**
  - **Hybrid metamaterials**
  - **3D printing of acoustical materials**
  - **Multi-functional acoustic materials**
    - **– damping plus absorption**
    - **– absorption plus barrier**
  - **Custom manufacturing of noise control materials**

4. Noise Control Methods

- **Advanced Noise Control Materials**
  - **What's important about a noise control material?**
    - **Cost**
    - **Safety**
    - **Weight**
    - **Volume**
    - **Recyclability**
    - **…**
    - **…**
    - **Acoustical Performance**

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Hybrid Metamaterial

PURDUE MECHANICAL ENGINEERING

RAY W. HERRICK LABORATORIES

(12) **United States Patent**
Varanasi et al.

(10) **Patent No.: US 9,163,398 B2**
(45) **Date of Patent: Oct. 20, 2015**

(54) **SOUND BARRIER SYSTEMS**

(71) Applicant: **Purdue Research Foundation**, West Lafayette, IN (US)

(72) Inventors: **Satya Surya Srinivas Varanasi**, West Lafayette, IN (US); **Somesh Khandelwal**, Sunnyvale, CA (US); **Thomas Siegmund**, West Lafayette, IN (US); **John Stuart Bolton**, West Lafayette, IN (US); **Raymond J. Cipra**, West Lafayette, IN (US)

(73) Assignee: **PURDUE RESEARCH FOUNDATION**, West Lafayette, IN (US)

USPC 181/290, 284, 292
See application file for complete search history.

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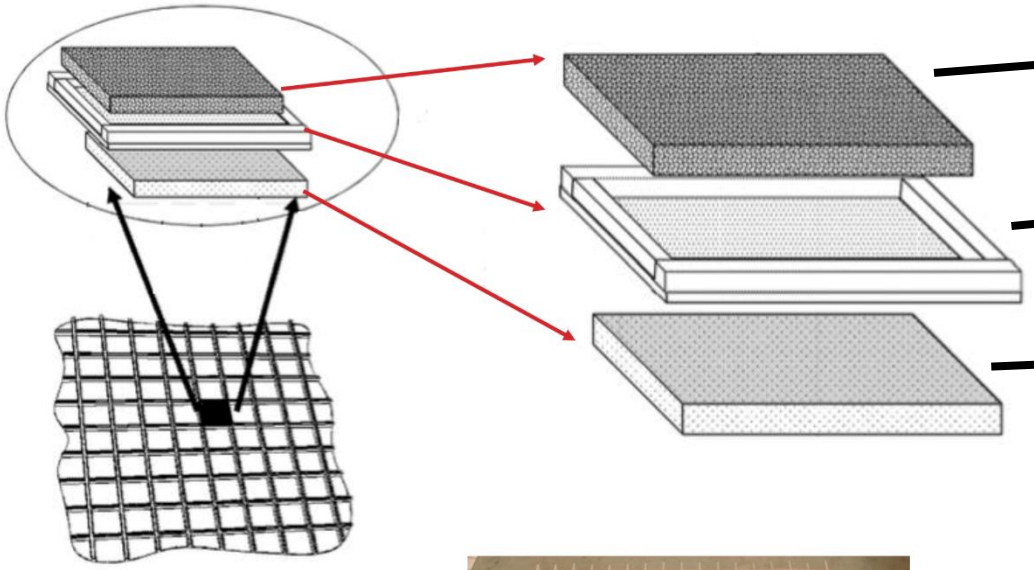
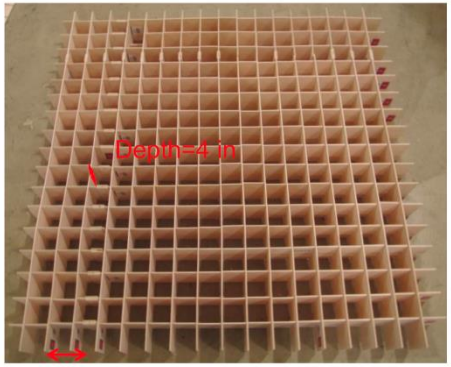
Hybrid Metamaterial

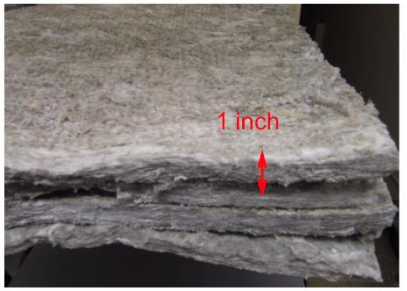


Normalizing layer

Cellular metamaterial

High performance fibrous layer





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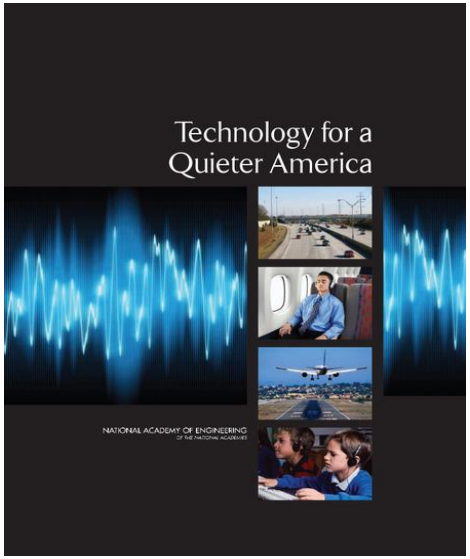
ADDITIONAL READING



Technology for a Quieter America

Available from National Academies

www.nap.edu/catalog/12928/technology-for-a-quieter-america

Thanks to Yutong (Tony) Xue for help with the presentation