# ANALYSIS OF STRUCTURAL ACOUSTIC DESIGN VARIABLES FOR A PERIODICALLY STIFFENED PLATE USING THE FINITE ELEMENT METHOD

Joseph Blochberger
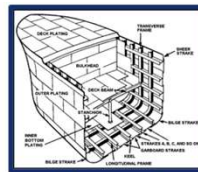Advisor: Dr. Alok Sinha (PSU)

PennState
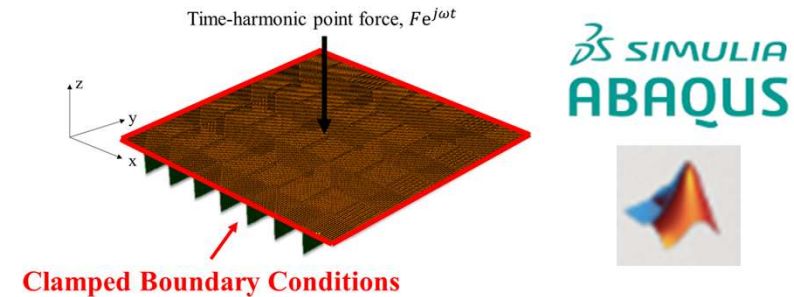College of Engineering

## Motivation



Automobile*

Aerospace*

Marine*

Designing quieter engineering systems requires insight into *how* stiffened structures radiate sound

## Modeling & Simulation



Time-harmonic point force, $Fe^{j\omega t}$

**Clamped Boundary Conditions**

DS SIMULIA ABAQUS

Geometric dimensions of the finite element model.

| Design Variable | Value |
|---|---|
| Plate Thickness | Varied in Case Studies |
| Plate Length/Width | 1.2 m |
| Stiffener Thickness | Varied in Case Studies |
| Stiffener Height | 10 cm |

Material properties of the finite element models.

| Material | Density, $\rho$ | Young's Modulus, $E$ | Poisson's Ratio, $v$ | Loss Factor, $\eta$ |
|---|---|---|---|---|
| Aluminum (Plate) | $2700 \frac{kg}{m^3}$ | $71\ GPa$ | 0.33 | 0.02 |
| Steel (Stiffeners) | $7700 \frac{kg}{m^3}$ | $195\ GPa$ | 0.28 | 0.02 |

## Technical Approach

Forced vibration analysis performed in Abaqus CAE

$$[M]\{a\} + [C]\{v\} + [K]\{u\} = \{F\}$$

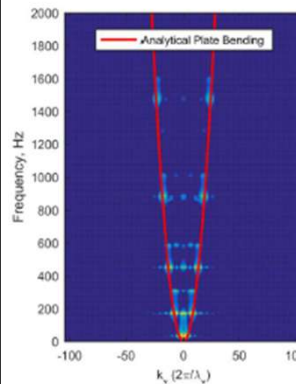Surface averaged mobility

$$Y = 20 \log_{10}\left(\frac{<|v|>}{F}\right)$$

Wavenumber space

$$V = \iint v e^{-jk_x x} e^{-jk_y y} dx dy$$

Radiated sound power
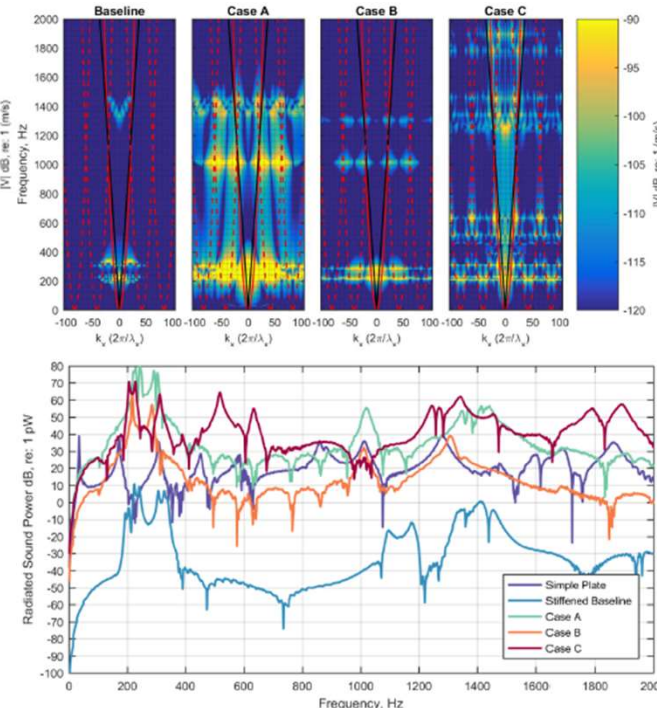
$$P = \frac{1}{2} \iint \text{Real}[pv^*] dx dy$$

*pictures of stiffened structures in industry are taken from google images for "car liner," "aircraft liner," and "ship hull," respectively.

## Results



- FEM was validated
- Periodically stiffened plate exhibits predicted Bloch wave phenomena seen in wavenumber space and radiated sound power
- Performance mainly controlled by stiffener thickness