Integrating the NASA Lewis Method for Mass Loaded Panels Into AutoSEA2

Cliff Kaminsky and Bryce Gardner
Vibro-Acoustic Sciences, Inc.

Spacecraft & Launch Vehicle
Dynamics Environments Workshop
June, 2001

Overview

- Mass-loaded honeycomb panels
- NASA Lewis method
- AutoSEA2 scripting
- NASA Lewis method in AutoSEA2
- Results
- Conclusions

Mass-loaded Honeycomb Panels

- Unreinforced honeycomb panels with a significant amount of attachments
- Total mass can be 5-100 times the mass of the panel
- For example, instrument panels

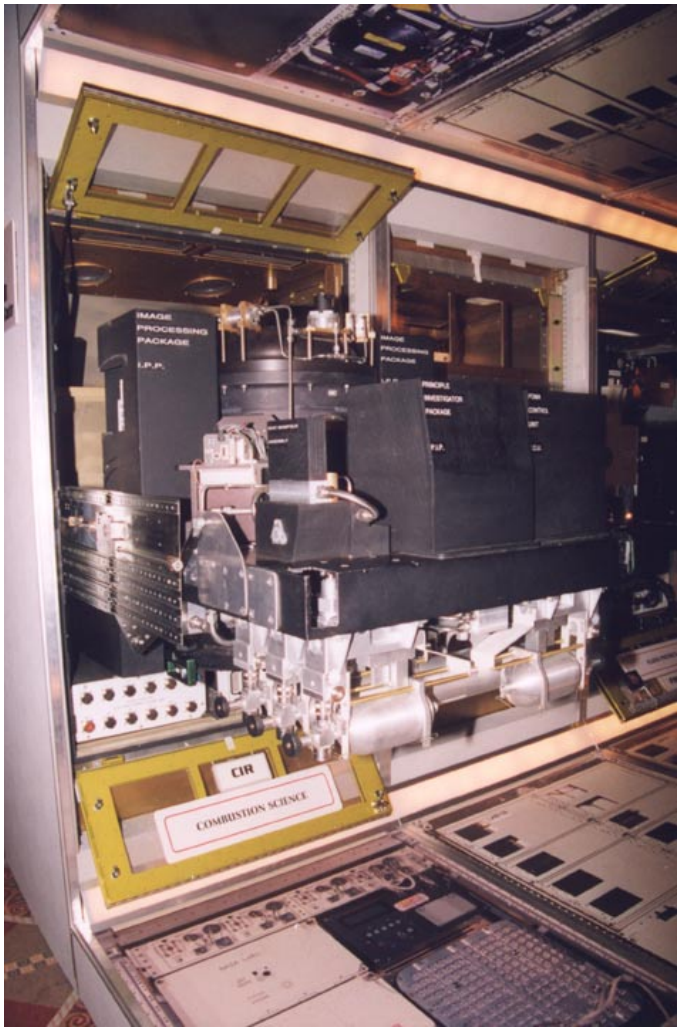


Photo courtesy NASA Image Exchange

Typical Mock-up of a Mass-loaded Panel

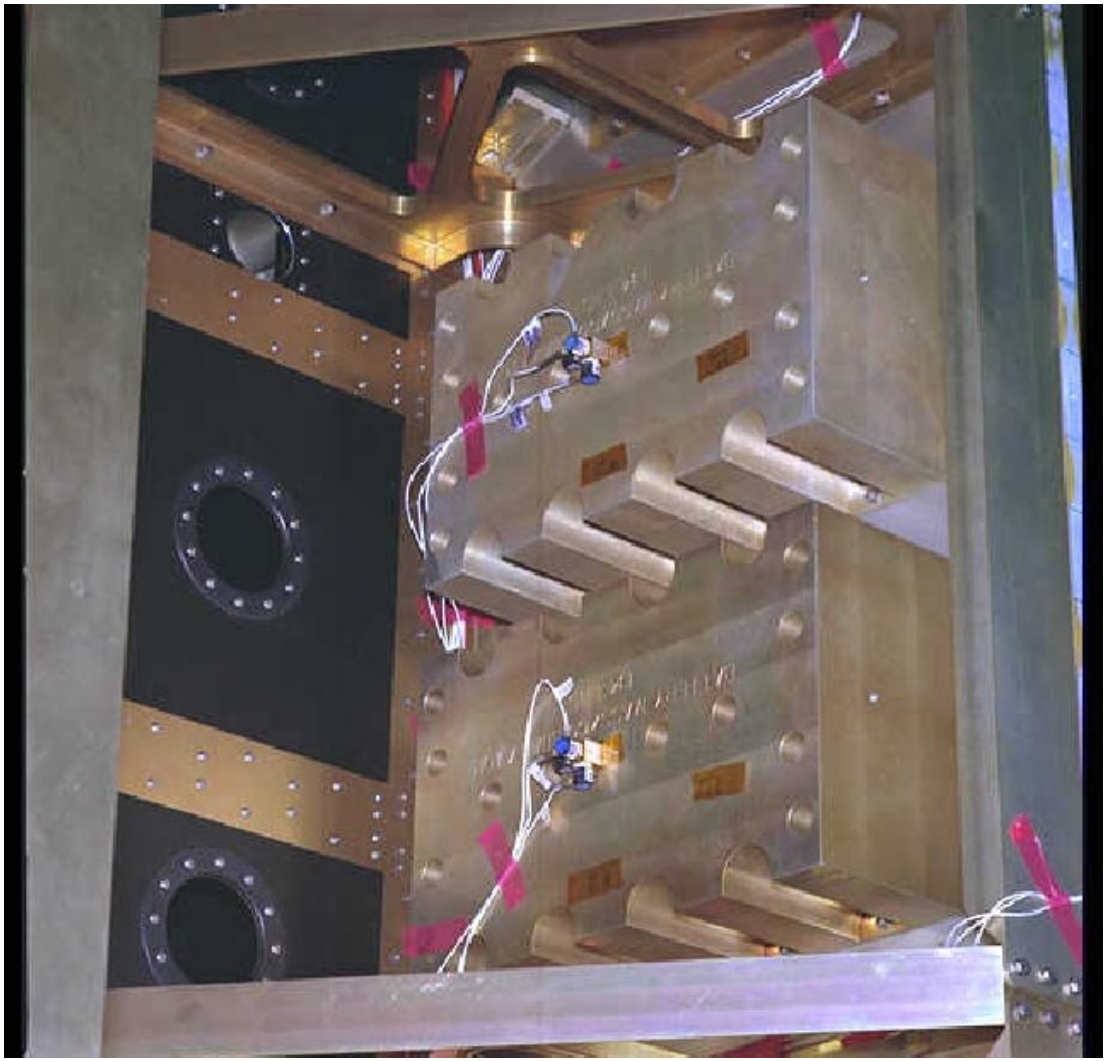


Photo courtesy NASA Image Exchange

Analysis of Mass-loaded Panels

- Analytical panel response and radiation (Maidanik 1962, Leppington 1982)
- Non-structural mass method (??)
- NASA Lewis method (McNelis 1989)
- Detailed investigation of panel response with complex attachments (Conlon 2000)
- Detailed modeling of mass interaction with simplified panels (Atalla 2001)

Non-Structural Mass Method

- Assumes that added mass does not effect the energy distribution throughout the model
- The added mass does effect the relationship between the energy and velocity of a mass loaded panel

$$E = (m_s + m_{ns})v^2$$

- In VAPEPS, the ASMS parameter adds non-structural mass
- In AutoSEA2, the “Energy to Engineering Units Conversion” term is used to add non-structural mass

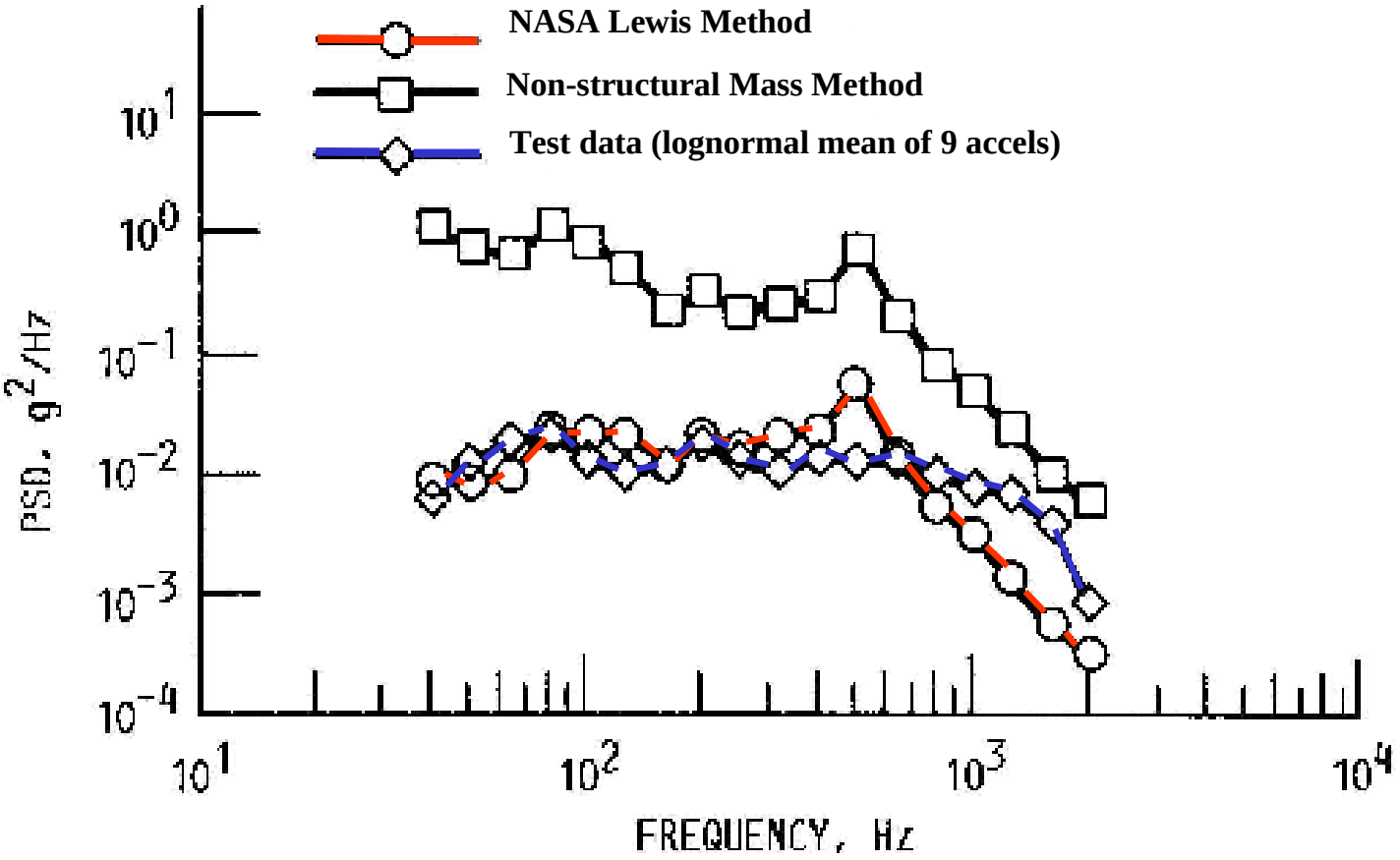
NASA Lewis Method

- Equivalent mass loaded panel – conserve important panel properties:
  - Total mass
  - Longitudinal phase speed
  - Critical frequency
- Empirical radiation efficiency

$$\sigma = \begin{cases} \dfrac{f^2}{f_c^2}; & f < f_c \\ 1; & f \geq f_c \end{cases}$$ for flat panels

Reference: McNelis, NASA Tech Memo #101467

Spacecraft Panel (40”x40”x1”) with added mass to panel mass ratio of 23:1



From McNelis, NASA Technical Memorandum #101467

AutoSEA2 QuickScript

- Basic language syntax
- Full access to the AutoSEA2 computation engine
- Accessible from AutoSEA2 graphical interface
- Ideal method for implementing new mathematical models

NASA Lewis Method in AutoSEA2

1. Equivalent isotropic panel calculation
2. Mechanism for adding mass
3. NASA Lewis CLF model

Step 1: Equivalent Isotropic Panel

- Assume the important structural properties are conserved:
  - Total mass
  - Flexural wave speed
  - Critical frequency
- Uses average bending wavenumber from AutoSEA2
- Creates a new material property in the database and assigns it to the selected panel

Step 2: Add Mass Loading

- Inputs
  - Total added mass
  - Structural/Non-Structural distribution
- Adjusts two parameters
  - Density for structural mass
  - Equivalent mass ("Engineering Units Conversion") for non-structural mass

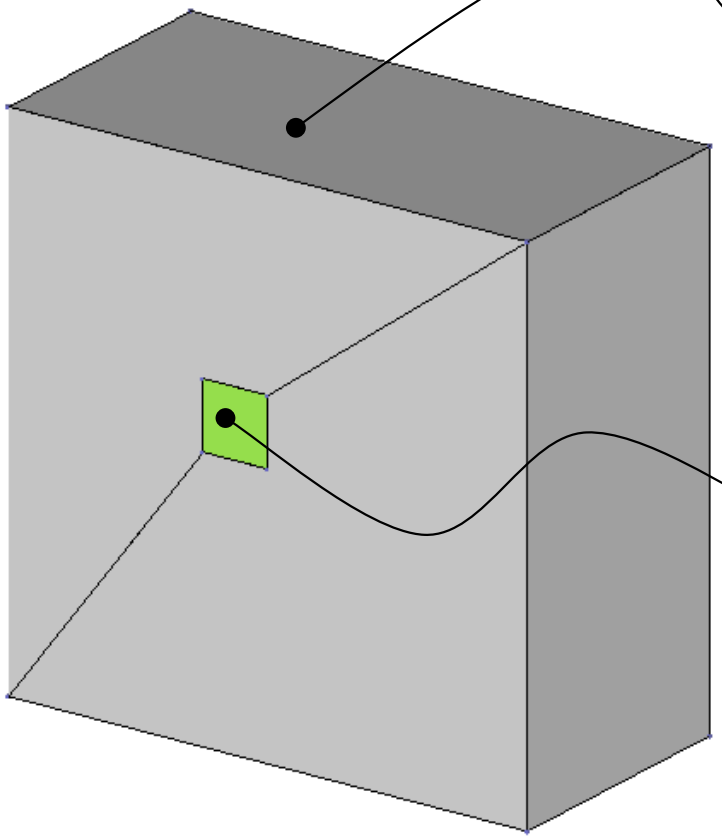
$$E = (m_s + m_{ns})v^2$$

Step 3:
NASA Lewis Radiation Model

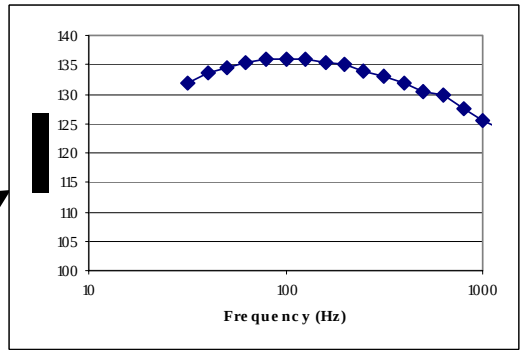
- Finds acoustic junctions associated with selected panel
- Calculates ring and coincidence frequencies
- Calculates radiation efficiency
- Calculates coupling loss factor (CLF)
- Inserts CLF into database and sets CLF of selected junctions

Validation vs. VAPEPS

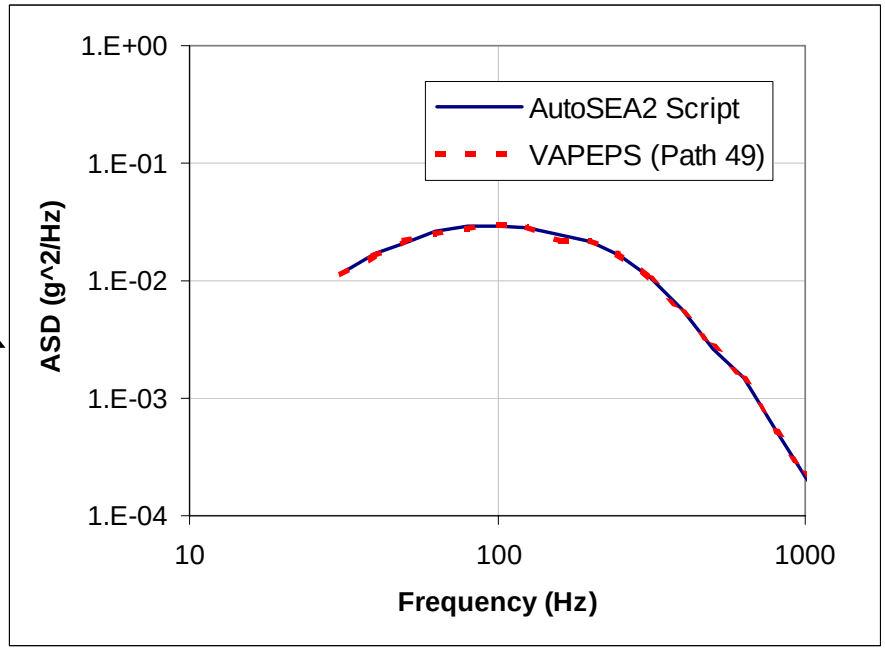
Response of mass loaded (23:1) flat honeycomb panel (1 m x 1m) to acoustic excitation



Acoustic Excitation (144.9 dB)



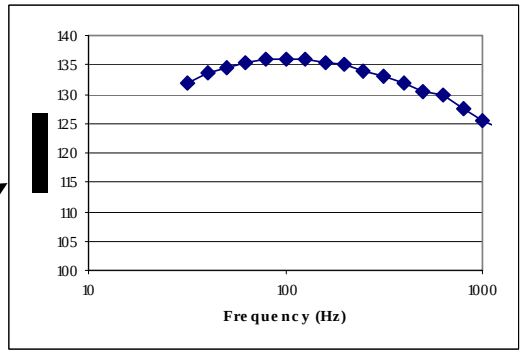
Panel Response (2.8 g rms)

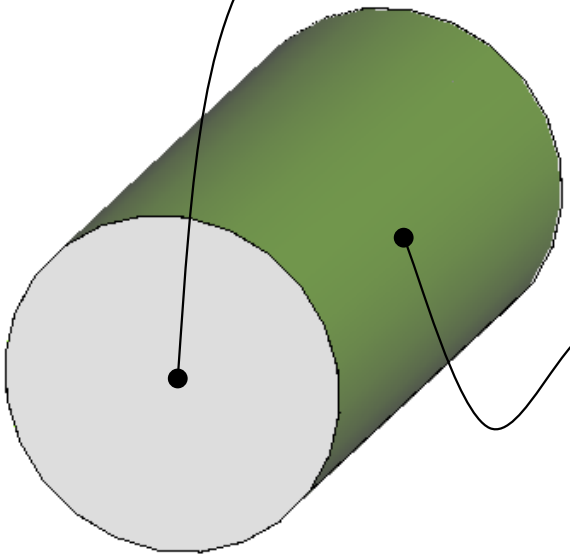


Validation vs. VAPEPS

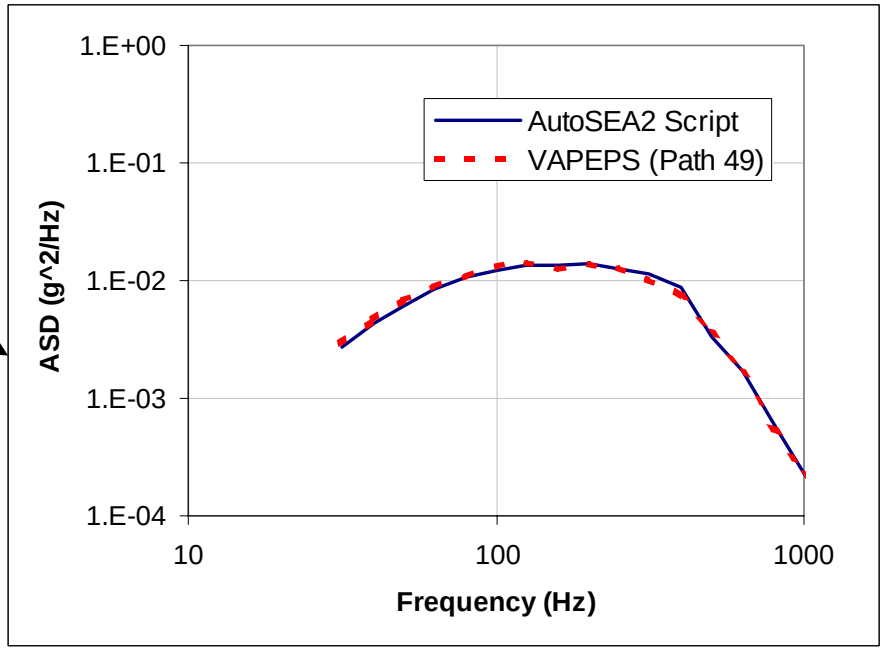
Response of mass loaded (23:1) honeycomb cylinder (9 m x 2 m radius) to acoustic excitation

Acoustic Excitation (144.9 dB)





Cylinder Response (2.3 g rms)



Conclusions

- Implemented NASA Lewis method for unreinforced mass loaded honeycomb panels
- Scripting provides for a tool for automating specialized analysis