HEXAGON

SEA based methods for high frequency analysis

Nikhil Ghaisas – Acoustic Application Engineer

Introduction

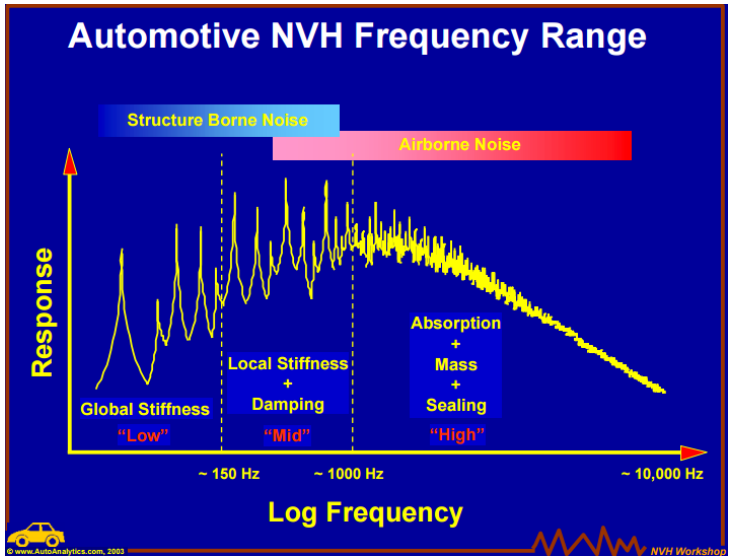
- Nikhil Ghaisas – Hexagon Manufacturing Intelligence
  - Master’s degree in mechanical engineering from Purdue University
  - Now supporting technical activities related to acoustics for Hexagon in the US
  - Based out of Novi, MI

- Hexagon Manufacturing Intelligence – Acoustics Center of Excellence
  - Focused on:
    - Development of the Actran simulation software
    - Support, training and consulting
    - Research in acoustic CAE and related fields

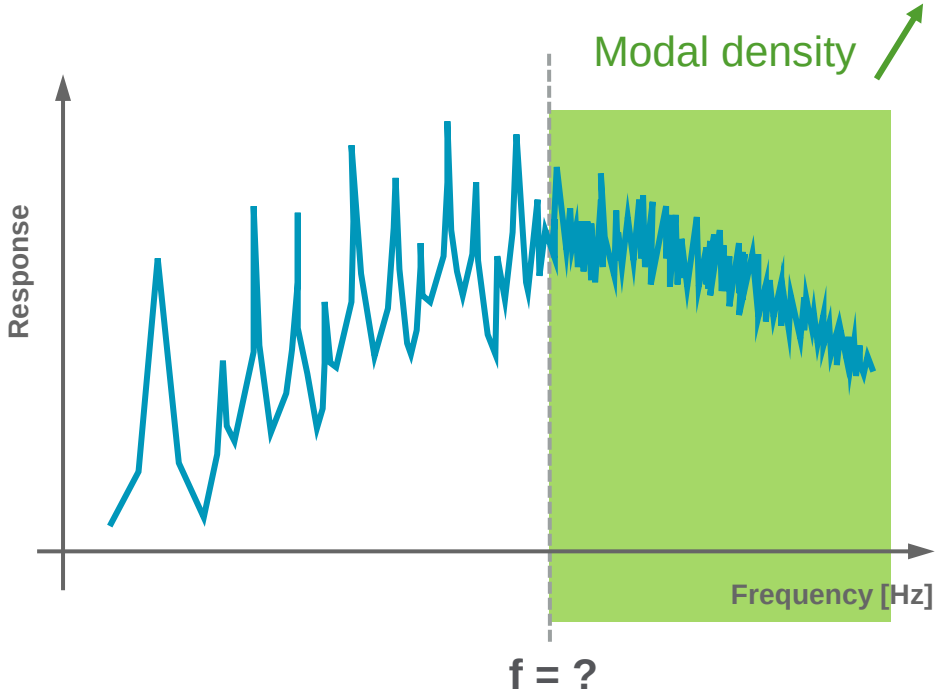
Agenda

1. Context and Challenges
2. Introduction to SEA
3. Case studies

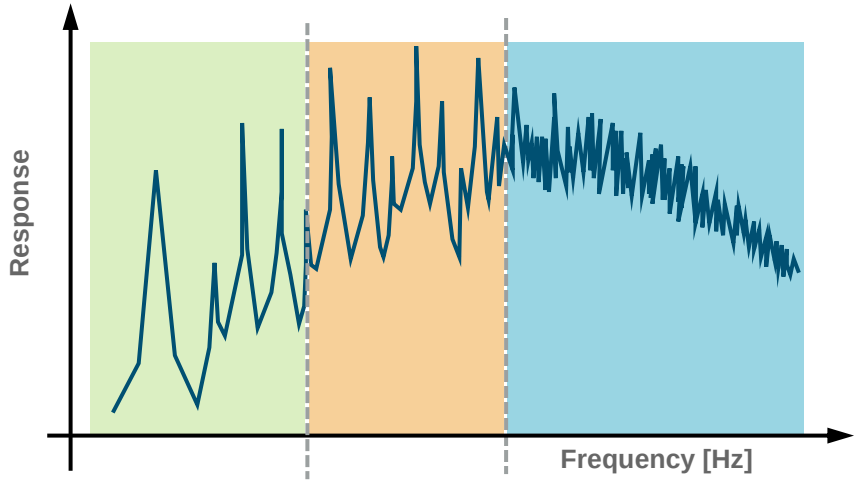
High frequency?



SAE 2003 NVH Conference



Which tool?



Model characteristics

Tools

Low frequency

- Local response
- Local indicator
- Small number of global modes
- …

Mid frequency

Sensitivity + Uncertainty = Variability

High frequency

- System response
- Energetic indicator
- Large number of local modes
- …

FE Solutions

Na **MSC** Nastran

Ac Actran

Na **MSC** Nastran

Ac Actran

SEA

Virtual Statistical Energy Analysis

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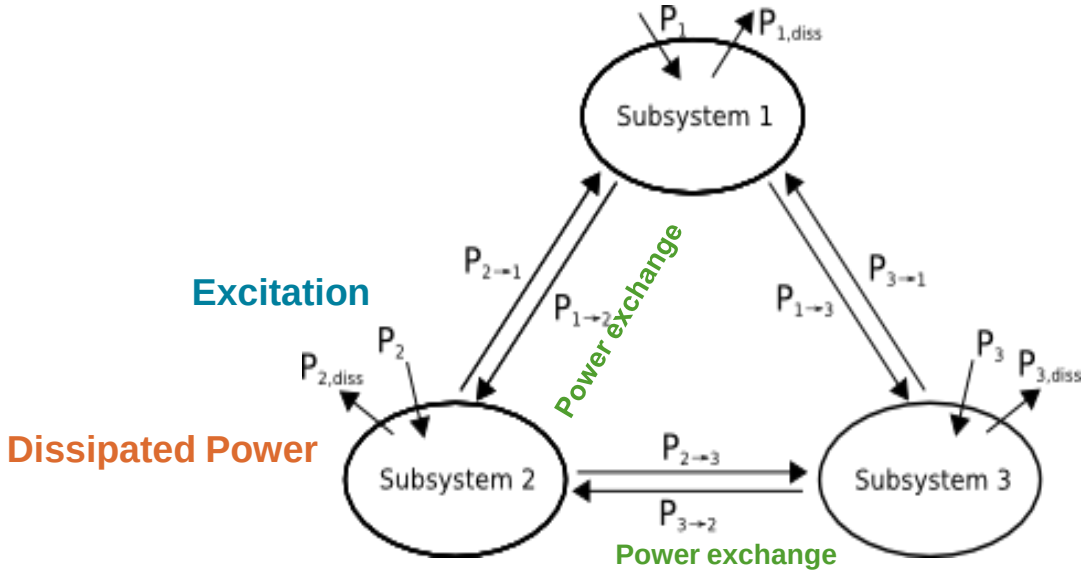
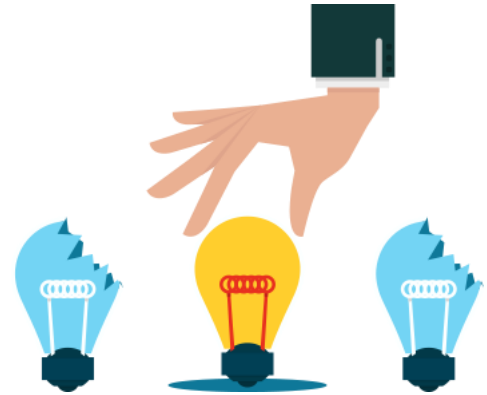
What is Statistical Energy Analysis (SEA)?

- Statistical Energy Analysis is a simulation method targeting **high-frequency** vibration and acoustics
  - The problem is solved for energy and not displacement or pressure
  - The model is divided into a small number of sub-systems
    - Connections between sub-systems are described through coupling loss factors (CLF)
    - Energy dissipated by each sub-system is described through damping loss factors (DLF)
  - Spatial and frequency averaging is performed



Which SEA method?



- Three main approaches are available:

	Analytical SEA	Experimental SEA	Virtual SEA
Concept	Analytical expressions	Measures Power levels with Power Injection Method	Virtual Power Injection Method (based on FE model)
Limitations	**Basic geometrical** objects for complex geometries	Access to a **prototype**	Need to have access to a **FE model**
	Experienced Engineers for Junction Modelling	**In-plane energy cannot be measured**	Actran
	Only Coupling for **Subsystems in Contact**	**Limited size** of subsystem	

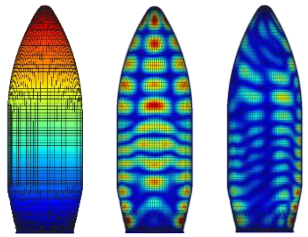
Virtual SEA for mid to high frequency analysis

Process description – Part 1

MSC Nastran

MSC Nastran SOL 103 or Actran modal extraction

- Start from existing Nastran model
- Run SOL103 computing modes up to high frequency **keeping the same mesh**
- Export Mass / Stiffness Matrix (using DMAP) + Structure / Cavity modes

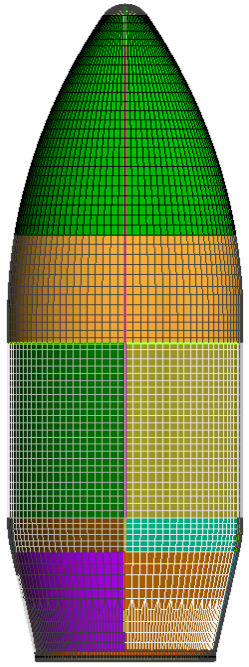


OP2

Actran

Model preparation

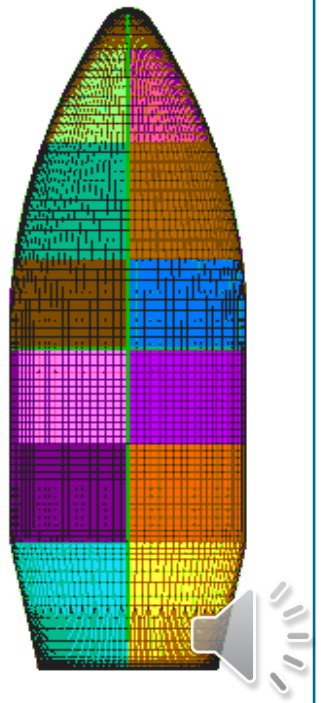
FEM PIDs



Define subsystems in Actran depending on expected excitations / results locations

Alternatively, automatic definition of subsystems to meet weakly coupled assumptions

SEA Subsystems



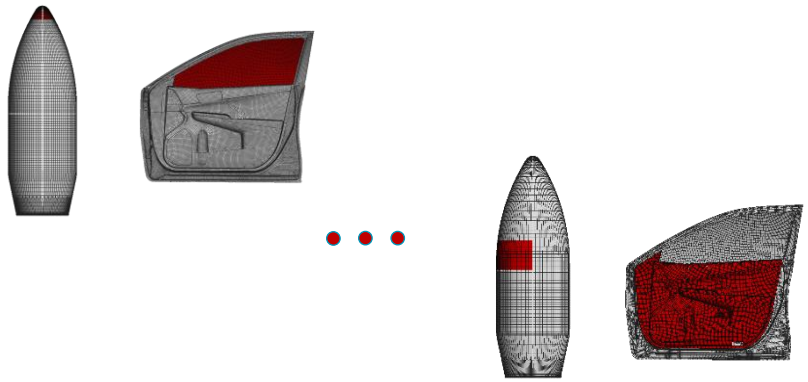
Virtual SEA for mid to high frequency analysis

Process description – Part 2

Actran

SEA Model Generation

- Run the virtual power injection method
- This is a computationally intensive part
- Possibility to extrapolate computed CLF / DLF



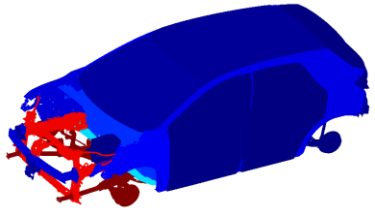
One-by-one loading of each subsystem separately to compute power exchange

SEA Model

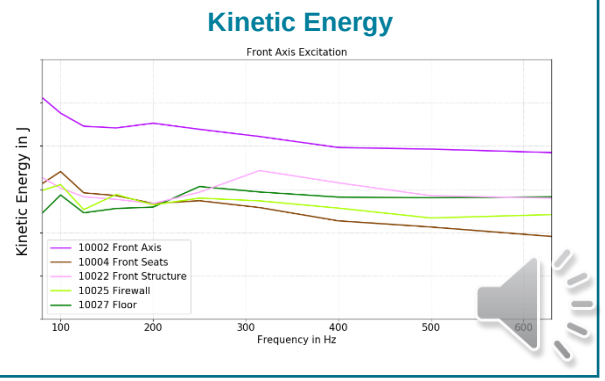
Actran

SEA Model Solving and post-processing

- Define relevant excitation
  - Injected Power
  - Local excitation (e.g. Load)
  - Distributed Excitation (diffuse sound field, turbulent boundary layer…)
- Solve the SEA model for the defined excitation (this is very fast – few seconds/minutes)



Energy levels, energy flux, acceleration, sound pressure level…

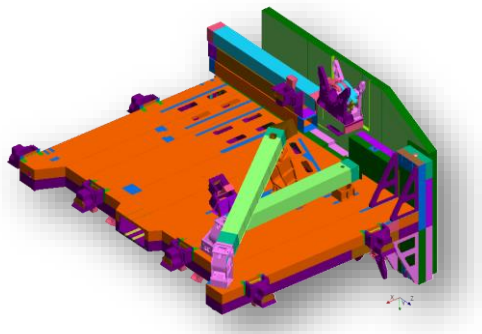


What can be done with Actran Virtual SEA?

AIRBUS DEFENCE & SPACE

Payload hosting platform

AEC – Bordeaux 2020, Vibro-Acoustic Response Prediction of the Bartolomeo Multi-Purpose Payload

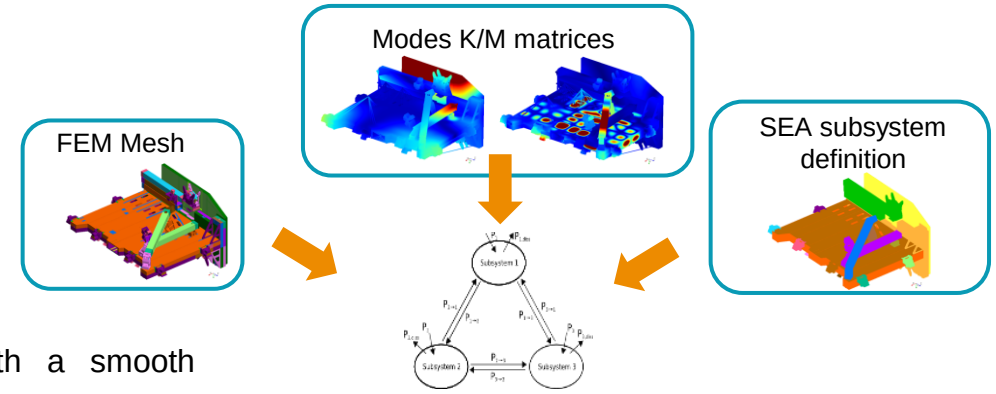


Challenge

- Bartolomeo is a payload hosting platform designed for the ISS (International Space Station) that will be used over 10 years
- At lift-off, high noise levels are capable of damaging payload equipment
- Investigate efficient method for low/mid/high frequency including how to extend the frequency range of the simulation for launch loads

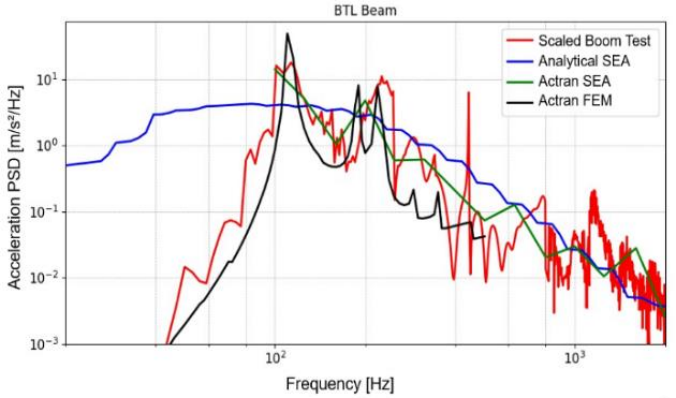
Solution

- Finite Element models for structure integrity:
  - Standard solution
  - Robust and versatile solution
  - Limitation in Low/middle frequency
- **Actran Virtual SEA** → low/mid/high frequency with a smooth transition in middle and high frequency



Benefits

- Actran FEM: standard method for correlation studies and well suited for low and mid frequencies
- Actran Virtual SEA: results are predictive over the whole frequency range, up to 2000 Hz
- Actran is able to predict accurately and efficiently the vibro-acoustic response at low/middle/high frequencies



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Trim modeling in the mid-frequency range

ISNVH 2020, Extended Solution of a Trimmed Vehicle Finite Element Model in the Mid-Frequency Range, David Sipos et al.

Challenge

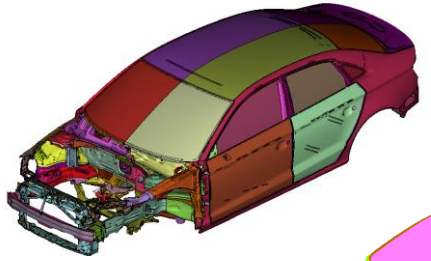
- Finite Element (FE) analysis is an established approach for modeling trimmed NVH models, providing high quality results in early design phases.
- These analyses are typically done in the low range of the frequency spectrum because of the size of the models
- There is increasing interest for tackling the mid-frequency range for trimmed models

Solution

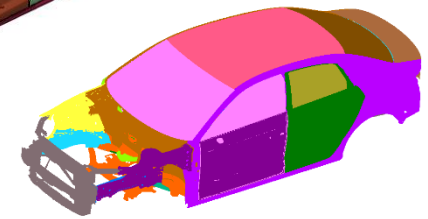
- The Actran SEA approach takes an existing FE model valid of the low frequency range and extend it to the mid-frequency range
- In Virtual SEA, the necessary information required to build the SEA system is extracted from the FE models
- Trim effects can be taken into account through an analytical trim approach based on an equivalent transfer admittance

Benefits

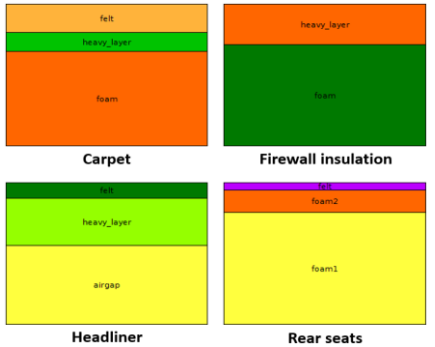
- Good correlation between measurements for both microphones and accelerometers in the mid-frequency range
- Trimmed models can be solved in an industrial timeframe for higher frequencies
- Actran SEA models can be easily set up with an existing finite element model



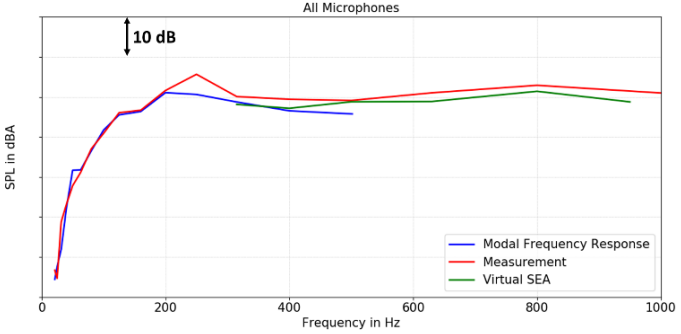
Structure FE model



Virtual SEA model

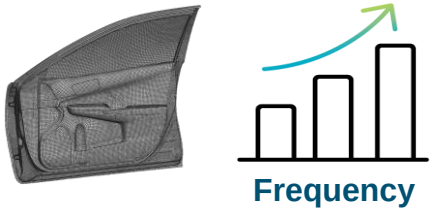


Comparison of mean sound pressure level for the various methods

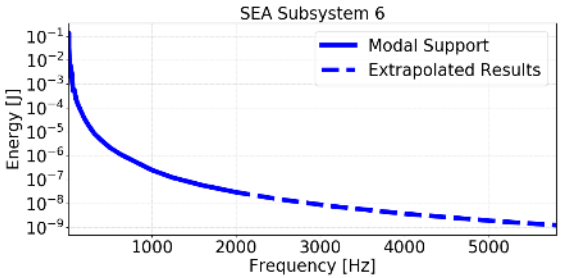


Actran SEA: Overview

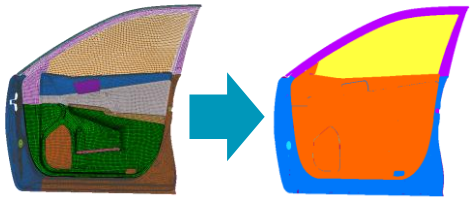
Mesh frequency extension



Results extrapolation

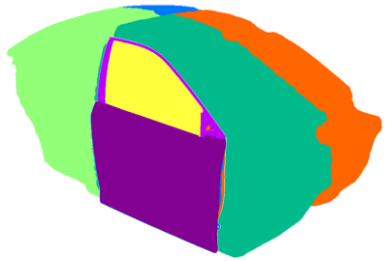


FEM to SEA in one step

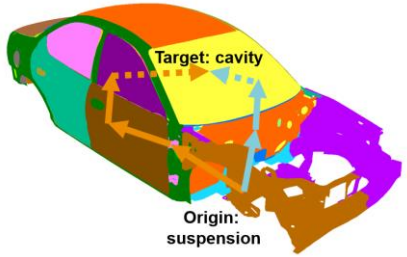


Actran SEA

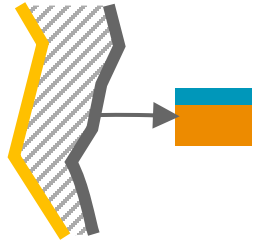
Complete vibro-acoustic solution



Transfer Path Analysis



Acoustic trim modelling



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Conclusion

- Statistical Energy Analysis is a simulation method targeting **high-frequency** vibration and acoustics
- Actran Virtual SEA allows users to build an SEA model from **FEM inputs which allows a seamless transition from mid-frequency to high frequency response**
- Its large array of features **enables users** to perform a **variety of analyses** to get **better insights** on their models
- Actran Virtual SEA has been **validated** against **multiple industrial cases** by several companies

Thank you

Learn more

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Questions?

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