Prediction and Test Comparison of the NEXTSat Spacecraft Random Vibration Responses Due to Acoustic Testing Joe Hackel

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June 26-28, 2007







Agenda

- Introduction
- Analysis Results of BEM
- Analysis Results of SEA
- SEA & BEM Correlation
- Test & Test Results
- Comparison of Test and Analysis
- Conclusion



ORBITAL EXPRESS Program: To Develop and demonstrate autonomous techniques for on-orbit refueling and reconfiguration of satellites





Introduction

- NEXTSat is a small spacecraft
- SA is 1.5m² of exposed area
 40"x60" in other words
- Bus Panels are 14"x15"
- We will examine certain acoustic surfaces which cover a wide range of acoustic surfaces
 - Solar Array
 - Bus Panels
 - Tank (hidden)





Acoustic Overview & BEM Introduction

- What are the forms of acoustic loads?
 - Direct field
 - specific direction of source
 - initial sound wave from source
 - Diffuse, reverberant field
 - random frequency and direction
 - numerous rebounds off of cavity walls
- BEM is accurate for all frequencies but higher frequency range can be unreasonably computation-intensive (runtime could be measured in days)
- Acoustic mesh size depends on range of acoustic wavelengths in analysis (compute these before meshing)
 - Acoustic BE mesh resolution need not coincide with Structural FE mesh
- Surface associated with acoustic BEM mesh and structural FE mesh must be identical









BEM Analysis Cover 50-400 Hz







SEA Introduction

- Statistical Energy Analysis (SEA) is used to predict high frequency acoustic response of dynamic systems.
- It is a method of analyzing the flow of energy between dynamic systems based on a statistical coupling between the response modes of the systems.
 - Accurate for higher frequencies where structure has high modal density (averaging methods become increasingly valid)
 - No FE Model is used. Elements in the SEA model are structural subsystems (i.e. entire panels, beams, and acoustic cavities)
 - Boundary conditions (i.e., simplysupported, clamped, point supports, etc) are not specifically identified







SEA Analysis Covers 400-10,000 Hz



SEA Acoustic Responses

<u>Alerospace</u>



How Well Does BEM & SEA Line UP?

Predicted Bus Panel



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Ind Launch



Acoustic Test Is Near Field Test









Test vs. Analysis – Solar Array

Solar Array Center (Z-dir) Predicted vs. Actual Protoflight Response







Test vs. Analysis – Bus Panel

Bus Panel Predicted vs. Actual Protoflight Response







Test vs. Analysis – Tank

Tank Predicted vs Actual Response







Conclusions

- BEM predicted fairly well
- SEA predicted the SA well, and slightly over predicted for the Bus panels
- SEA strongly over predicted the response of the Tank
 - Perhaps the modal density of the panels was low at 400 Hz
 - Perhaps the panels were more shaded from acoustic response than predicted
 - Perhaps the acoustic space amplified the calculation response
- Using BEM & SEA provides confidence and conservative results
 - The overall Grms predictions at components exceeded actuals & had more correct correlation for the larger panels



Solar Array

Assembly





Star Tracker Panel





