Acoustic Simulation for Spacecraft Launch

Modeling & Simulating Random Excitations

Design Challenge

At lift-off, payload components like satellites or antennas are exposed to intense acoustic excitations that can damage their structures.

Excitations to the Model

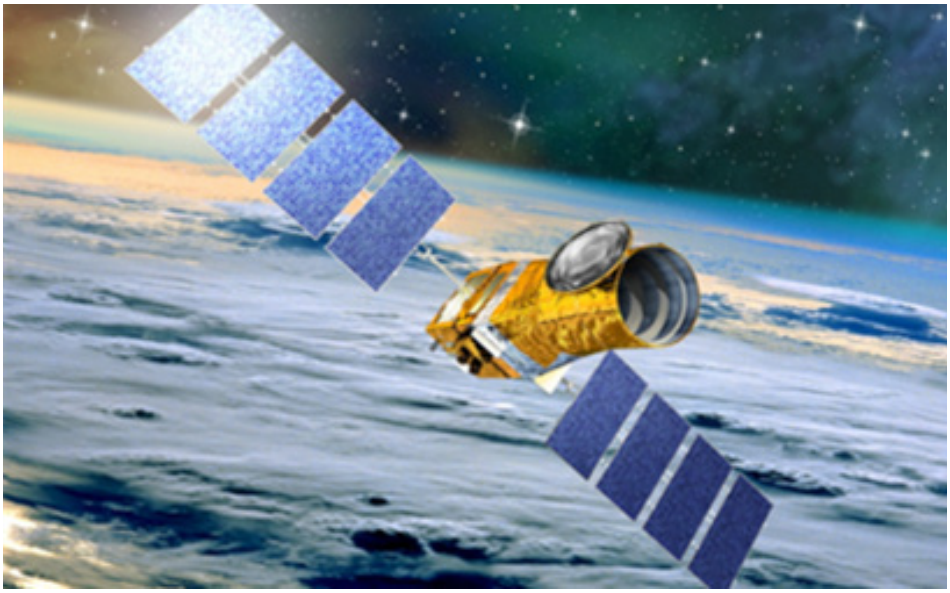
Excitations to the model can include Diffuse Sound Field (DSF) or Turbulent Boundary Layer (TBL) directly on the structure, or randomized plane waves applied to air around the spacecraft or launch vehicle, which in turn applies the DSF to the structure.

Internal air volumes and acoustic blankets can also be modeled for a more accurate simulation. A hybrid frequency response solution is possible where modal frequency response will be solved on the structure and direct frequency response will be solved for the fluid and blanket, or anywhere that damping is frequency dependent.

Results can include acoustic quantities like Sound Power, Sound Pressure, or directivity, as well as quantities calculated on the structure like stress and deflection.

Excitation Types:

- Distributed random excitations:
  - Diffuse Sound Field
  - Turbulent Boundary Layer
- Local Random Excitations (dynamic)
- Global diffuse environment



Key Software Features

- Acoustic Finite Elements for cavity and exterior acoustics modeling
- Acoustic Infinite Elements or Adaptive Perfectly Match Layers (APML) for modeling the far field anechoic condition
- Structure elements library: solids, shells, composites, laminated structures, membranes, beams, springs, rigid connections, etc.
- Poro-elastic element library based on the BIOT theory for modeling bulk reacting materials
- Nastran to Actran translator (NAS2ACT) to convert Nastran structure models into Actran models
- Import of structure modes calculated by Nastran
- Acoustic dissipation mechanisms such as visco-thermal losses, acoustic absorption
- Random excitations on structure including diffuse sound field, turbulent boundary layer and more
- Plane, spherical and cylindrical wave sources
- Acoustic pressure, velocity and admittance boundary conditions
- Mechanical and kinematic excitations
- Full support of non-congruent meshes
- Piezo-electric element libraries for modeling active structures
- Use vibration results from most FEA structural analysis solvers for acoustic radiation modeling
- MUMPS and Krylov solvers for fast frequency response analysis
- Rich post-processing capabilities: frequency response plots, maps, sound directivity, directive microphones, animations and more...

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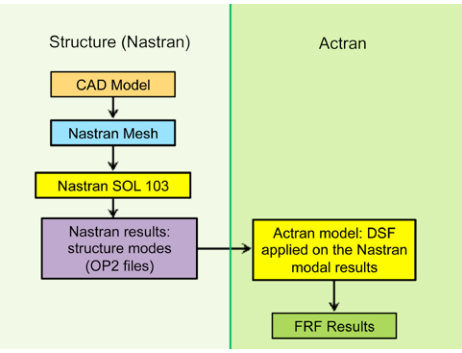
Workflow & FEA Interoperability

Actran can model spacecraft launch acoustics in the low and mid frequency range for typical sized spacecraft.

MSC Nastran structural models can be imported into Actran and converted to Actran models. MSC Nastran, Ansys or Abaqus modal results can be imported into Actran, or they can be calculated inside Actran. Structural and fluid meshes can be imported into Actran in Nastran, Ansys or Abaqus formats.



Studying Acoustic Excitation

Actran offers a unique solution to accurately and quickly study the influence of the acoustic excitation on the component structure.

Solutions include:

- Complete material library:
  - Structural elements including composites
  - Fluid elements
  - Porous materials
  - Visco-thermal fluid elements
- Handling of acoustic treatments

Analyzing System Response - Outputs

Actran can output all the required quantities to perform a complete analysis of the system response:

- **Structural Results**
  - Displacement / Acceleration / Velocity
  - Mean Square Velocity
  - Stress (σ_x, σ_y, σ_z, τ_{xy}, τ_{yz}, τ_{zx}, $\sigma_{Von\ Mises}$)
  - Energy Levels (Kinetic, Potential) / Injected Power
- **Acoustic Results**
  - Fluid Pressure
  - Mean Square Pressure
  - Energy Levels
- **FRFs and Maps**
  - Means, envelopes, standard deviations of any stochastic quantity

Trusted Solution for the Spacecraft Industry

Actran is a commercial finite element code designed specifically for simulating acoustics, vibro acoustics and aero acoustics. It can be used to accurately model structural vibrations, fluid-structure interactions, and turbulence noise propagation. Actran has been relied upon by engineers for 16 years and is used by more than 350 companies and research institutions around the world.

Actran Software Suite

Actran is a complete acoustic, vibro-acoustic and aero-acoustic CAE software suite. Empowered by the technologies of finite/infinite element methods (FE/IFE), as well as the Discontinuous Galerkin Method (DGM), Actran provides a rich library of materials, elements, boundary conditions, solution schemes and solvers. Actran is a high accuracy, high performance and high productivity modeling tool suiting the needs of the most demanding engineers, researchers, teachers and students for solving the most challenging acoustic problems.

Free Field Technologies (FFT)

Free Field Technologies is focused on three main areas:

- Developing Actran software for acoustic, aero-acoustic and vibro-acoustic simulation;
- Providing technical services, support, training and delivering acoustic engineering projects;
- Researching innovative technologies and methods of acoustic analysis in order to remain the leader in acoustic modeling.

Free Field Technologies has more than 250 customers around the world active in the Automotive, Aerospace, Shipbuilding, Electronic and Heavy Equipment industries as well as in the Educational and Research sectors.

FFT is a wholly owned subsidiary of MSC Software Corporation.

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