

## INTRODUCTION

PRIMODAL is an interactive software tool for analyzing, improving and above all, *understanding* the dynamic behavior of your structures.

PRIMODAL offers an open and modular architecture written entirely in MATLAB in order to satisfy constantly evolving needs in a cost-effective manner. PRIMODAL may be run either as a MATLAB application or as a compiled standalone application with no need for a MATLAB license.

PRIMODAL is developed by TOP MODAL - a small but motivated company in Toulouse France dedicated to industrial innovation in the field of structural dynamics whose director, Dr. Nicolas Roy, is a specialist with over 30 years of experience in aerospace, automotive and other advanced technology fields.

## LICENSING OPTIONS

There are two ways of acquiring a PRIMODAL license: by purchase or rental.

In the case of a purchased license the software is licensed on a perpetual basis, providing the right to use the software indefinitely. The software may be installed on any number of machines and may be used by any number of users for the licensed site. Moreover the software includes both MATLAB and standalone (compiled) versions for windows and linux platforms. The purchased license also includes a two-day on-site training course as well as one year of maintenance and updates. At the end of the maintenance period the licensee has the possibility to renew the maintenance services via an annual maintenance contract.

The rental license consists of a monthly-based rental of Primodal. The rental license allows the licensee to use the software only during the period of the rental (controlled by a license key file). The software may be installed on any number of machines and may be used by any number of users. Only the standalone (compiled) versions for windows and linux platforms are available for the rental version. Support and updates are provided during the rental period. At any time, the licensee may opt for the purchase of a license in which case the amounts spent on license rentals will be deducted from the license purchase price.

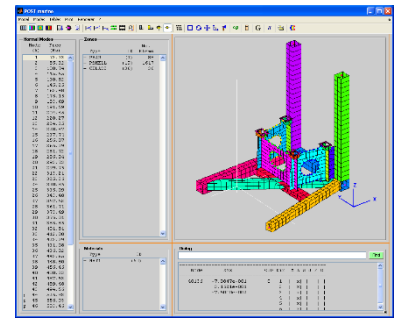
## APPLICATION MODULES

PRIMODAL offers the following application modules:

- **POST** FEM Post-Processing
- **RESP** Frequency Response Computation and Management
- **REDMOD** Reduced Models
- **VIAC** Sound Power Radiation
- **NASTAR** Vibro-acoustic Responses using NASTRAN
- **SENOPT** Optimal Sensor Design
- **SENSOR** Sensor Validation following shaker table tests
- **TAPPA** Sensor Validation following modal survey tests
- **IDEN** Modal Identification using the RTMVI method
- **TOMA** Tool for Operational Modal Analysis
- **COMP** Test - Analysis Correlation
- **MODI** Structural Modification and Reanalysis
- **CRE\_LOC** Model Error Localization using the Constitutive Relation Error (CRE) Method
- **CRE\_UP** Model Updating using the CRE Method
- **UPDATE** Model Updating using Modes
- **ORTHOPT** Optimization of Orthotropic Material Constants
- **NOTCH** Sine Test Vibration Test Prediction and Control
- **SOLO** Sound Transmission Loss in Panel Structures
- **RBMASS** Identification of Rigid-Body Mass Properties

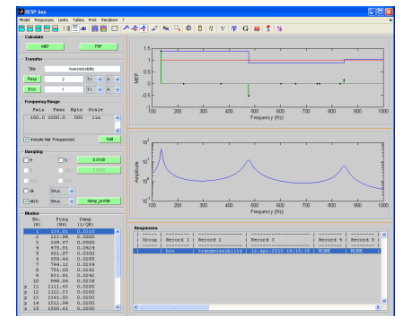
## POST *Post-analysis of FE and Test Data*

- Model import (NASTRAN OP2/OP4, NASTRAN BULK, I-DEAS UFF)
- Display and animation of normal and static mode shapes
- Visualization of elements, property entries (zones), nodes and DOF sets
- Display of Center of Gravity point
- Computation and exporting of Craig-Bampton reduced models
- Definition and management of node groups
- Computation of decomposed modal energies (membrane, bending, shear)
- Frequency and Damping Sensitivities



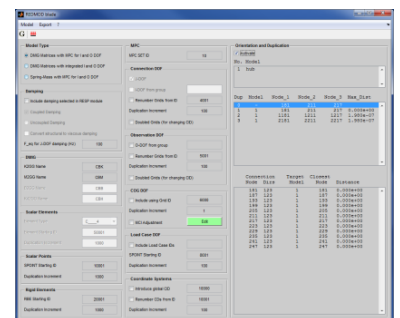
## RESP *Frequency Response Analysis and Management*

- Interactive computation of frequency response functions
- Manual and automatic mode selection using excitability criteria
- Fully coupled damping in the form of viscous, structural and modal damping
- Modal damping from loss factors associated with structural zones
- Viscoelastic materials with frequency-dependent stiffness and damping
- Importing of load cases including distributed loads from NASTRAN
- Responses at the center of gravity (COG) point
- Profile manager for defining excitation levels
- Multi-band excitation frequencies including natural frequencies
- Automated combined responses using node groups
- Visualization of mode contributions to total response to assess modal coupling
- Modal effective parameters for identifying important modes
- Dynamic correction of truncation errors using pseudo-modes
- Direct import of responses from NASTRAN (PCH, OP2) and I-DEAS (UFF)
- Response export to I-DEAS (UFF) files



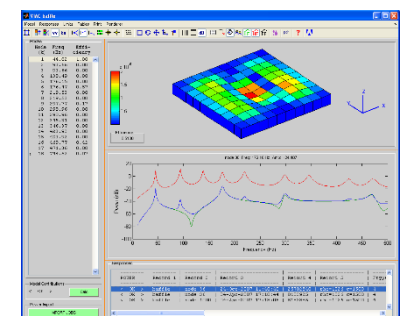
## REDMOD *FE Reduced Models*

- Dynamic model reduction based on modal synthesis techniques
- Fixed-interface (Craig-Bampton) and free-interface (MacNeal) methods
- Export to NASTRAN, MARC, ABAQUS and Arianespace formats
- Matrix (DMIG) and spring-mass (CELAS/CMASS) representations
- Coupled viscous and structural damping
- Parameterization of viscoelastic materials
- Distributed loads incorporated in reduced models
- Physical nodes for excitation, observation and center of gravity points
- Adjustment of rigid body mass properties (MCI)
- Choice of global reference frame position and orientation
- Duplication and repositioning of reduced models using 3-point method



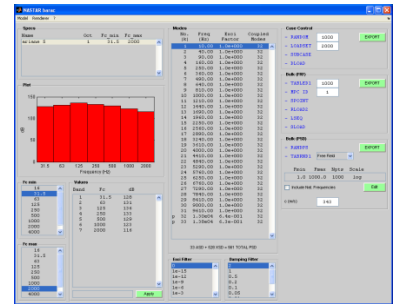
## VIAC *Sound Power Radiation from Vibrating Surfaces*

- Definition of the radiating surface via I-DEAS Universal file
- Nodal (surface) responses from Primodal or NASTRAN via PCH file
- Computation and animated display of volume velocities
- Radiation efficiency of modes and frequency responses
- Low and high frequency approximations of radiated sound power
- Computation and plotting of the radiated sound power
- Computation and display of modal contributions to the sound power



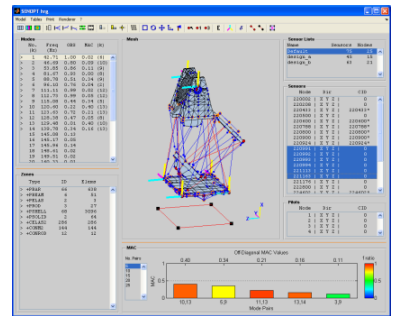
## NASTAR *Vibro-Acoustic Responses in Diffuse Field using NASTRAN*

- Acoustic spectrum editor including ARIANE 5 and VEGA specifications
- Mode filtering by excitability criterion based on generalized forces
- XSD (cross-spectral density) filtering criterion based on modal coupling
- Generation of all NASTRAN entries required for NASTRAN random analysis
- Compatible with random response analysis performed in PATRAN
- Compatible with added mass effects using MFLUID entry



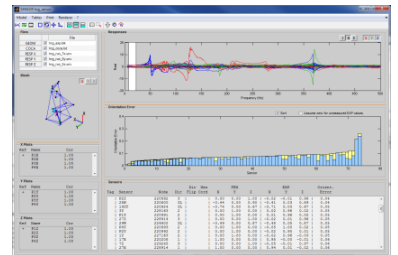
## SENOPT *Model-Based Optimal Test Design*

- Sensor lists to manage and compare sensor designs
- Graphical sensor selection using 3D mesh
- Optimal design for a specified number of sensors using QR decomposition
- Best additional mono-axial or tri-axial sensor to improve current design
- Sensor editing (choice of direction, sign, orientation)
- Graphical creation of wireframe mesh associated with sensor design
- Creation of pilot sensors
- Import/Export of sensor design via TEXT, COCA, BULK and UFF files



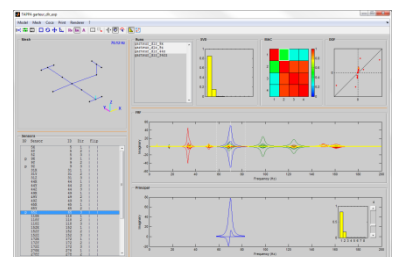
## SENSOR *Analysis and Validation of Shaker Table Test Responses*

- Response import for up to 3 runs via I-DEAS (UFF) file
- Automatic and manual selection of pilot responses
- Response normalization using average or maximum pilot responses
- Automatic extrapolation of rigid-body response using least-squares and SVD
- Automatic computation of sensor orientation error
- Automatic correction of sensor orientation via local coordinate systems
- SDOF modal identification for quick assessment of frequencies and damping
- Exporting of validated responses to universal file (UFF)



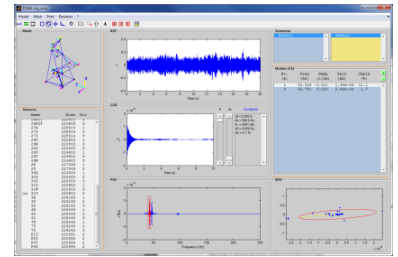
## TAPPA *Analysis and Validation of Modal Survey Test Responses*

- FRF import of multiple runs via I-DEAS (UFF) files
- Experimental mesh import via NASTRAN bulk file
- Response animation (real, imaginary and complex)
- Principal responses for comparison of FRF over frequency band
- SVD and MAC for comparison of runs at a given frequency
- Visualization and comparison of driving point and reciprocal responses
- Sign correction of sensor and excitation directions
- Export of validated FRF to universal files (UFF)



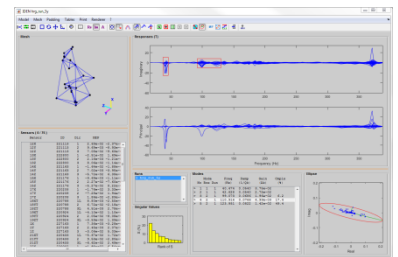
## TOMA *Tool for Output Modal Analysis*

- Direct importing of random responses with resampling options
- Graphical and tabular display of statistic properties
- Use of Welch's method for computation of PSD
- Computation of auto, cross and half PSD
- Spectrogram for analysis of non-stationary responses
- Peak-picking tool to identify natural frequencies and damping from PSD
- Sessions for managing and comparing sets of PSD
- Importing optional geometry from BULK and UNIV files
- Animation of PSD on geometry with padding of unmeasured directions
- Exporting of time histories and PSD to UNIV files



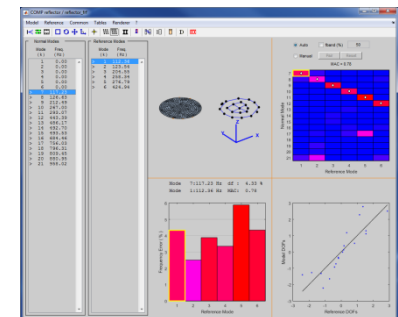
## IDEN *Modal Identification from Test Frequency Responses*

- Improved version of simple, fast and reliable "RTMVI" method
- Compatible with base excitation tests (dynamic transmissibilities and masses)
- Simultaneous use of several runs (excitations) with MIF and reciprocity tools
- Identification of modes via modal effective parameters
- Choice of real or complex modes
- Identification of static response and parasitic motion at interfaces
- Animation of responses and identified static and normal modes
- Verification of sensor orientation via low-frequency response animation
- Compatible with universal file format (UFF)



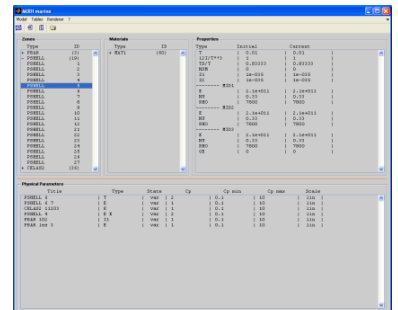
## COMP *FEM-Test Modal Comparison*

- Model comparison of frequencies and mode shapes via the MAC
- Side-by-side or superimposed animation of modes
- Display of FEM modes using test model mesh
- Automatic and manual mode pairing with frequency band criteria
- MAC sensitivity with respect to sensor sign changes and/or removal
- MAC correlation plot for localizing sensor/node discrepancies
- Tables for node/sensor distances, MAC sensitivities and comparison results



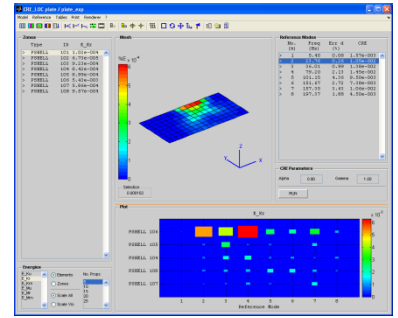
## MODI *Physical Parameter Definition and Structural Modification*

- Physical and material properties imported from NASTRAN
- Physical parameters from individual and combined structural properties
- Honeycomb plates, composites, orthotropic material, etc.
- Automatic generation of modified property and material cards
- Automated open-loop modal reanalysis with NASTRAN



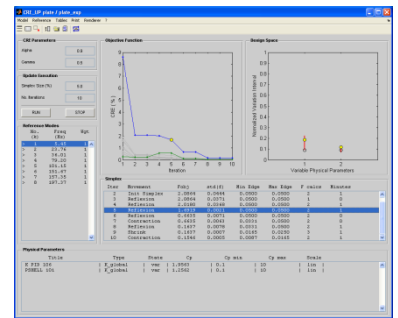
**CRE\_LOC** *Error Localization using Constitutive Relation Error Method*

- Computation of constitutive relation error via automated NASTRAN calculation
- Graphical and tabular display of modal energies of experimental modes
- Graphical and tabular display of residual and normalized residual energies
- Visualization of energies per element or zone with scaling options
- Animation of expanded mode shapes



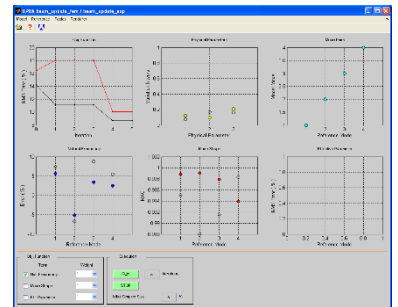
**CRE\_UP** *Model Updating using Constitutive Relation Error Method*

- Computation of constitutive relation error via automated NASTRAN calculation
- Graphical and tabular display of modal energies of experimental modes
- Graphical and tabular display of residual and normalized residual energies
- Visualization of energies per element or zone with scaling options
- Animation of expanded mode shapes



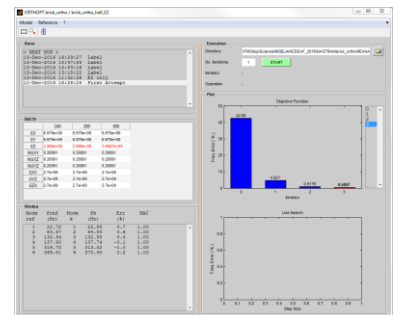
**UPDATE** *FE Model Updating*

- Variable and/or blocked physical parameters with variation limits
- Choice of modal terms including natural frequencies and mode shapes (MAC)
- Normalized design space using linear or logarithmic variations of parameters
- Robust nonlinear optimization using Nelder and Mead Simplex algorithm
- Automated or step-by-step execution coupled with NASTRAN



**ORTHOPT** *Optimization of Orthotropic Material Constants*

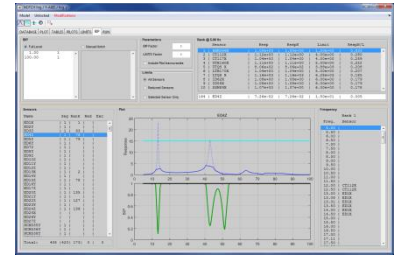
- Conversion of orthotropic material moduli to engineering constants
- Sensitivity analysis with respect to engineering constants
- Optimization and updating using conjugate gradient method
- Automatic mode shape pairing
- Storage and display of optimization runs
- Export of optimal engineering constants to tables and MAT9 entries





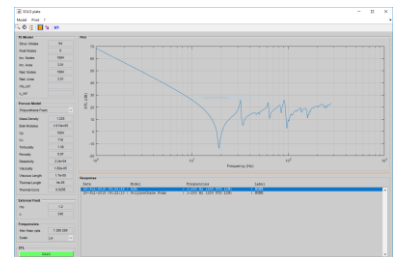
## NOTCH *Sine Sweep Vibration Test Prediction and Control*

- Import of test and analysis responses from UNIV and PCH files
- Response plotting and comparison across multiple datasets and runs
- Sensor-Node correspondence file
- Combined responses (sums, averages, ...)
- Tabular display of values by frequency bands with sorting and thresholds
- Pilot definition and strategy (max, average, amplitude, complex)
- Response limits management (import/edit/select)
- Base input profiles and notching
- Run sheet preparation



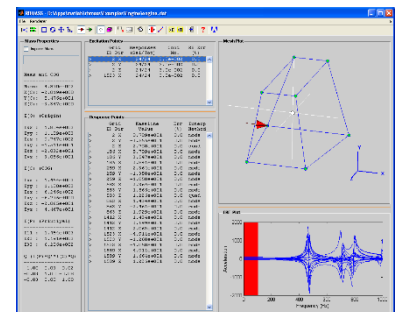
## SOLO *Sound Transmission Loss in Panel Structures*

- Efficient modal approach to computation of STL without boundary elements
- User-defined porous materials via equivalent fluid models
- Reduction of modal truncation errors using residual terms
- Display of modal contributions to total radiated power
- Display of radiated sound power contributions on mesh
- Pilot definition and strategy (max, average, amplitude, complex)
- Display of STL in 1/3 octave bands
- Export of STL to universal files



## RBMASS *Rigid-body mass properties from vibration tests*

- Mass, COG and inertias from acceleration FRF measurements
- Animation of test responses and derived rigid-body responses
- Visualization of COG and inertias using equivalent homogeneous brick
- Interactive selection of frequency interval for mass line identification
- Error estimation parameters for rigid-body responses and mass line values
- Export of identified mass properties to text file



*" ... la dynamique des structures se doit d'être comprise avant toute chose "*