VAO
VibroAcousticOptimization

CDH

Dear engineer,

Today's development process is characterized by high complexity, high diversity of products, shorter design cycles and cost constraints. The designer is therefore challenged to provide an optimal design solution quickly.

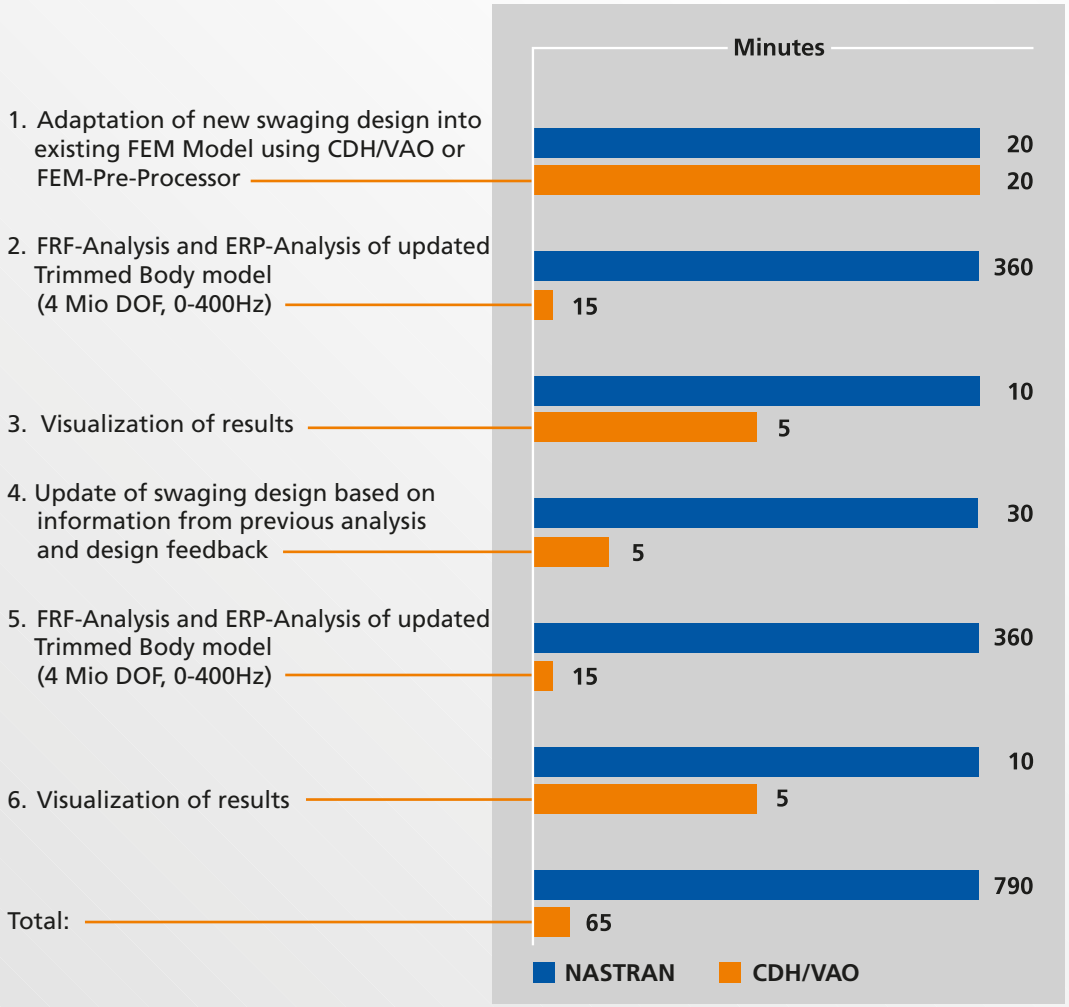
With the CDH/VAO software, design engineers are empowered to

- **interactively modify** structural models based on designer or engineers requests or ideas
- **obtain immediate results** for proposed modifications instead of waiting hours or days
- **understand** the cause-effect behavior of a structure with respect to automotive NVH requirements **much faster** than using conventional analysis
- **respond immediately** to what-if inquiries from design, test and management departments
- create an **optimal solution** for a product development more efficiently

Benchmark VAO vs. Conventional CAE Process

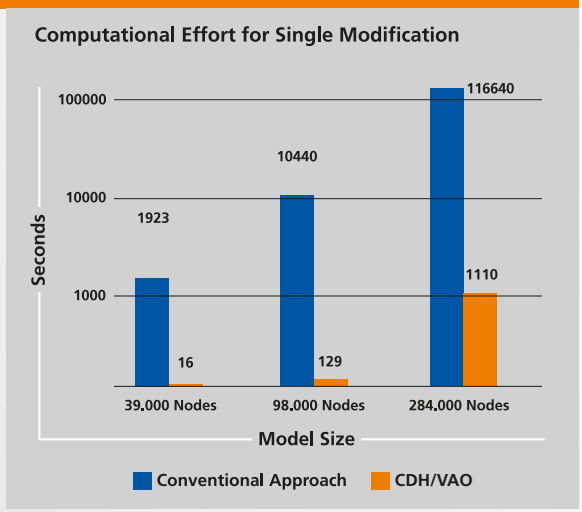
Benchmark example to evaluate effort and efficiency of CAE process:

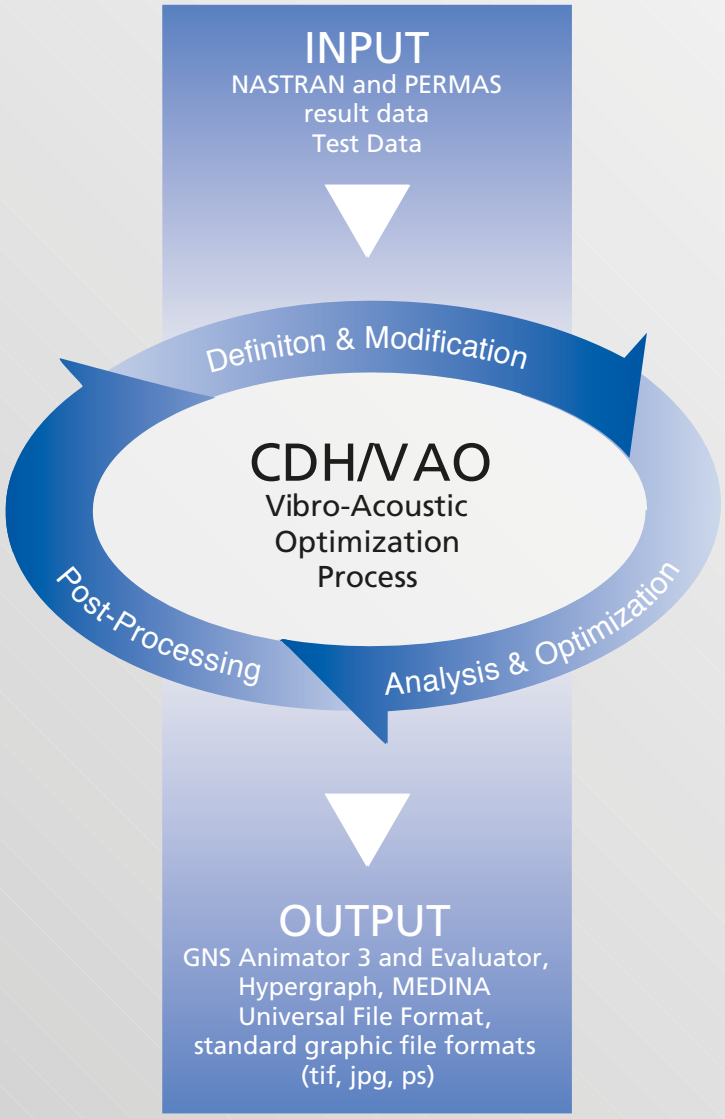
Task: Modification of body floor to adapt new swaging design following reassessment of NVH performance



1. What is CDH/VAO?

CDH/VAO is an intuitive Interactive Computational Engineering Tool for large-problem structural dynamics analysis. CDH/VAO enables engineers working in the virtual product development process to provide fast and reliable solutions to design engineering and test department problems.
Using CDH/VAO users are quickly able to study the structural effects of proposed design changes and to automatically predict a set design modifications to provide optimum dynamic behavior of the structural system. Using the Adaptive Modal Correction Method computational savings of factor 25 to 120 have been demonstrated compared to conventional modal analysis.



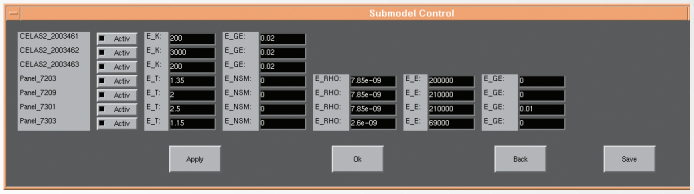


CDH/VAO uses standard NASTRAN or PERMAS finite element models and the eigenvalues and eigenvectors calculated for the baseline structure to perform a wide range of structural dynamics analyses. Where the structure is coupled to a fluid, fluid eigenvectors are used to assemble the appropriate equations of the coupled system. CDH/VAO uses the advanced state of the art numerical solver algorithms available in MATLAB.

2. Definition and Modification

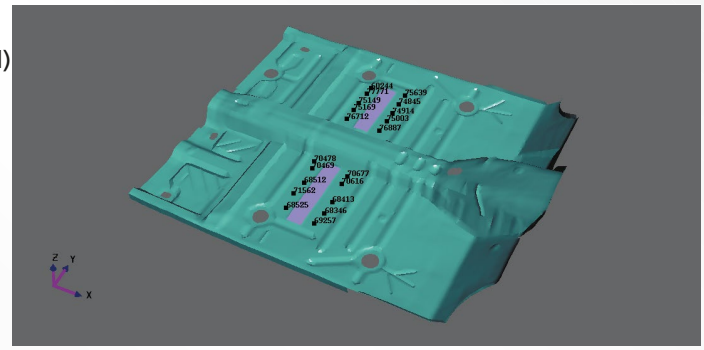
Using the imported FEM model and result data following definitions and interactive modifications can be carried out by users to study effects of material and design changes:

2.1 Model Definition:
- Fluid properties
- Excitation (harmonic or enforced motion)
- Damping (no damping, structure damping, viscous damping)
- Sub-Models



2.2 Definition and Modification of sub-model properties:
- Material properties
- Thickness
- Density, Young's modulus, Non structural mass, Torsional stiffness
- Structural damping
- Absorption

2.3 Geometry modification of sub-models using in-situ technology:
- Interactively create or modify swages, beads and holes, etc. using the VAO-Viewer
- Import new FEM geometry design (sub-model) from FEM Pre-Processor
- Allow the user to quickly determine the approximate effects of local stiffing of a particular plate modification on NVH performance
- Requirement for a completely new modes calculation after a local geometric shape modification may be eliminated



3. Analysis & Optimization

With integrated analysis and optimization features, the CDH/VAO Software is a unique platform for computational engineers to investigate and optimize the sound & vibration performance of vehicle structures. CDH/VAO combines various analysis and optimization capabilities which required in the past the utilization of several commercial FEM software solutions. The combination of rich analysis capabilities and the opportunity to obtain immediate results of re-analysis from user modifications represents a new dimension in interactive computational engineering.

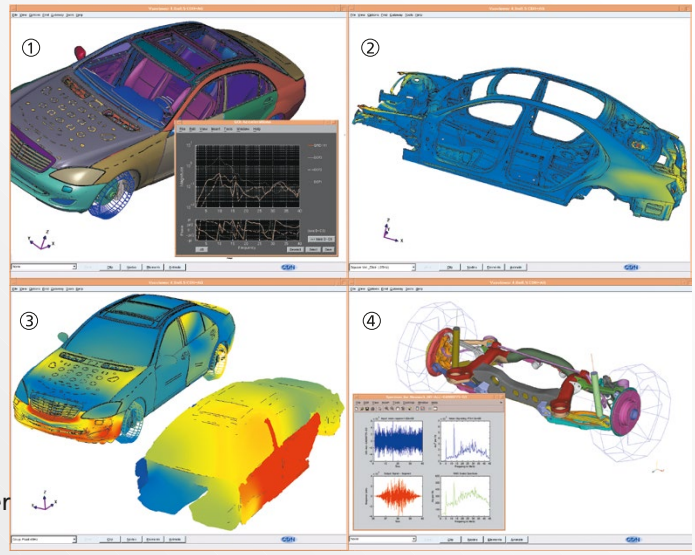
CDH/VAO offers a wide range of analysis capabilities for coupled (fluid and structure) and uncoupled operations to perform:

① **Fast Frequency Response Analysis using Modal Correction Method**

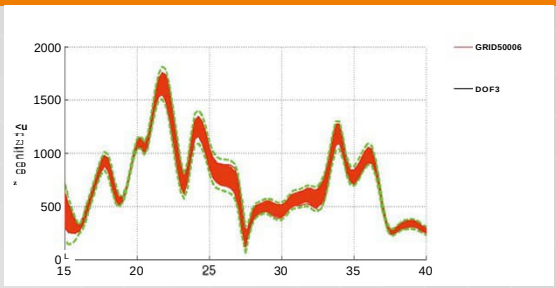
② **Energy Analysis:**
- complex strain and kinetic energy analysis
- equivalent radiated power (ERP)

③ **Acoustic Analysis:**
- acoustic panel contribution analysis
- acoustic and tactile response

④**Transient Analysis:**
- direct FFT analysis
- support of non-linear elements (e.g. shock absorbers)
- import of Nastran TLOAD card data (time domain)
- Combination of transient analysis with all other CDH/VAO analysis features for fast-reanalysis of full system



4. Stochastic and Robustness Analysis

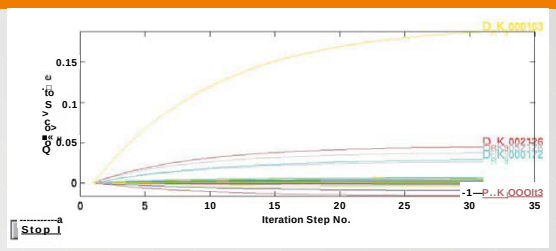


CDH/VAO supports the stochastic paradigm by providing a range of powerful capabilities for the analysis of uncertain structures.
Stochastic simulation is being increasingly applied in the automobile industry in order to obtain robust solutions to design problems in which uncertain design parameters are important. The effects of production tolerances and variation in materials and components can be accounted for in CDH/VAO dynamics analysis leading to an enhanced prediction of actual peformance.

CDH/VAO supports the engineer with state of the art stochastic analysis features:

- probabilistic/possibilistic analysis
- Monte Carlo analysis using uniform, Gaussian or user-supplied distributions
- first order variation method (FOVM)
- first order reliability method (FORM) with robust G function
- stochastic optimization

5. Optimization

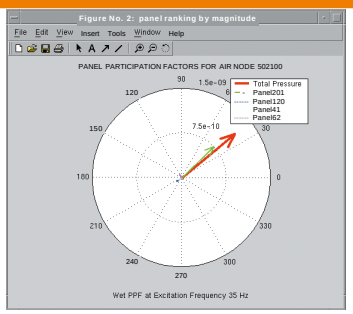


In design optimization numerical algorithms are utilized to achieve optimum structural responses while maintaining constraints on total structural mass etc. Design variables related to structural sub-model parameters can be defined in CDH/VAO, along with targets for performance. The design variables can then be adjusted automatically in the optimization algorithm to achieve desired targets. A unique feature in CDH/VAO allows the user to define special stochastic quantities as variables. These variables can then be used in the formulation of target functions and allow trade off studies between quality cost and performance.

Following numerical optimization algorithms are support in CDH/VAO:

- Design Optimization by the Mean Method
- Stochastic Optimization for Robust Analysis by the Beta Method

6. Post-Processing



Rich interactive post-processor features in CDH/VAO allow the user to generate quality graphical output for analysis result quantities. Additionally, graphics formats are available for reports and presentations. All x-y plot ouput may be manipulated using familiar MATLAB plotting features such as zoom and rescale etc.

Post Processing Features:

- Virtual-SAE Tools
- structural and acoustic modal participation factors
- structural and acoustic mode shapes
- acoustic panel participation factors
- RMS contours
- ASCII – export
- support for universal file exchange
- output to GNS ANIMATOR 3, GNS

7. System Requirements

Software:

- MATHWORKS MATLAB

Operating System:

- Red Hat Enterprise Linux x86_64
- Windows x86_64

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