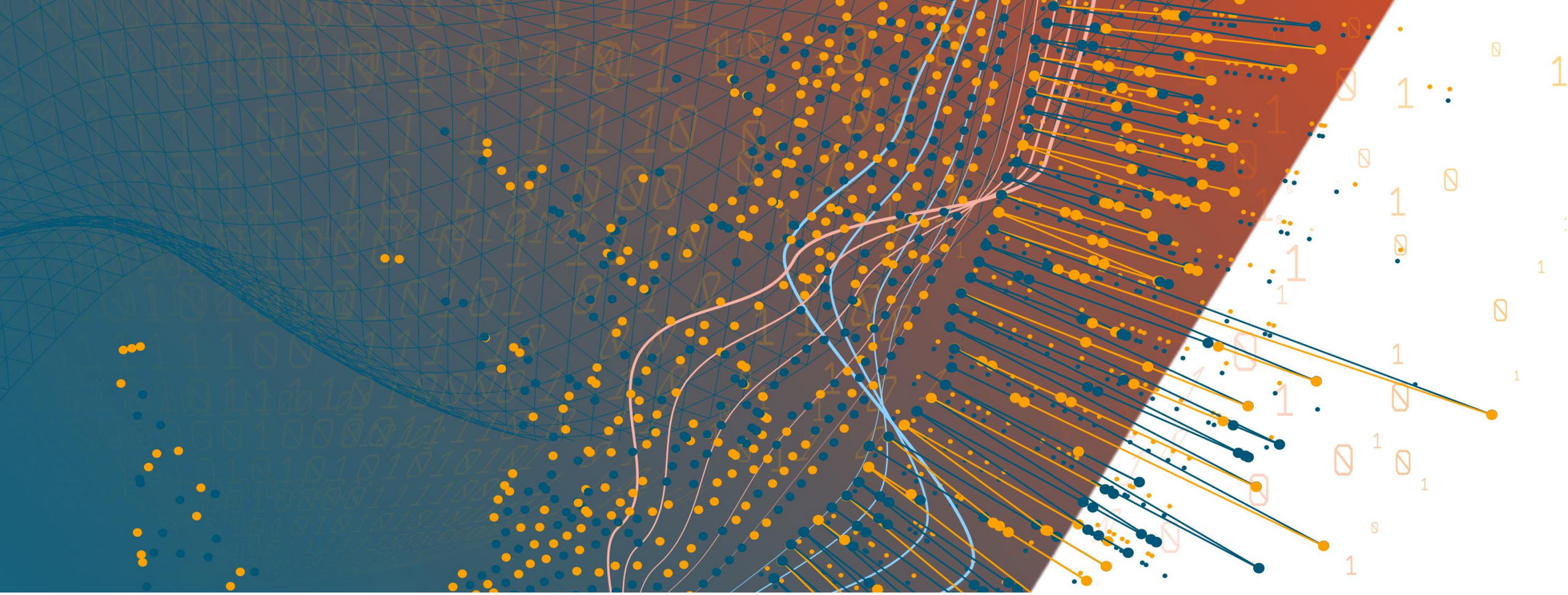


CLOSING REMARKS

Jianmin Guan, Sr. Director, Vibration and Acoustics Solutions

Altair Engineering

Many thanks to the presenters, expert panelists and participants for your contribution to this event

Closing Remarks

Key takeaways

- Adopt a ‘population’ point of view
- Apply the right process and tools
- Training and case studies videos

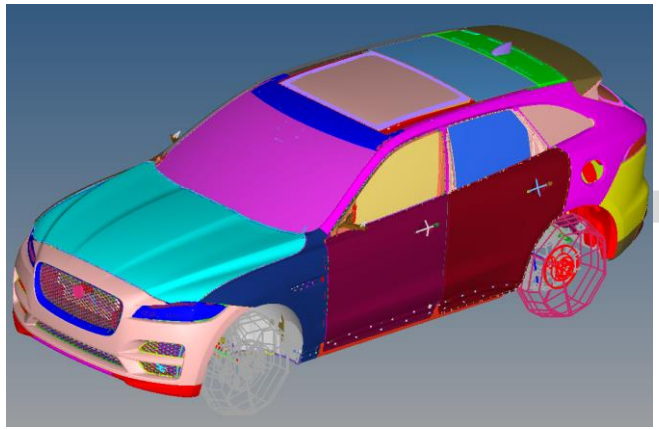
Challenges and opportunities

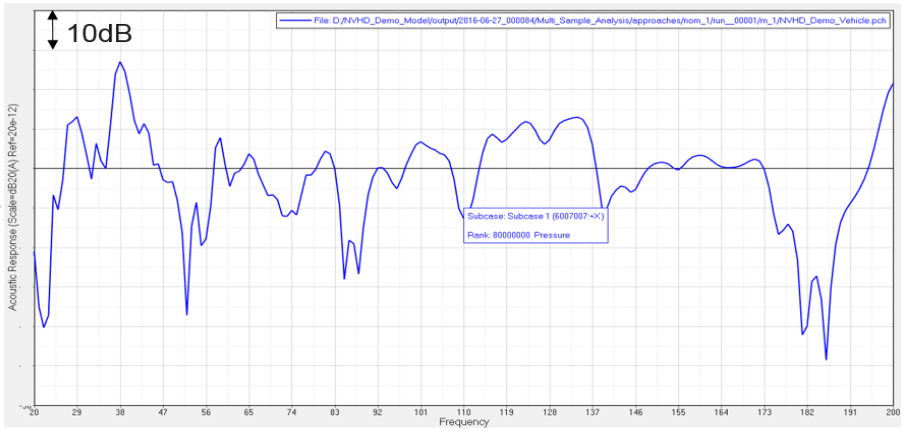
How could you go about solving your own variability problem?

Adopt a ‘population’ point of view

‘Nominal Design’ point of view:

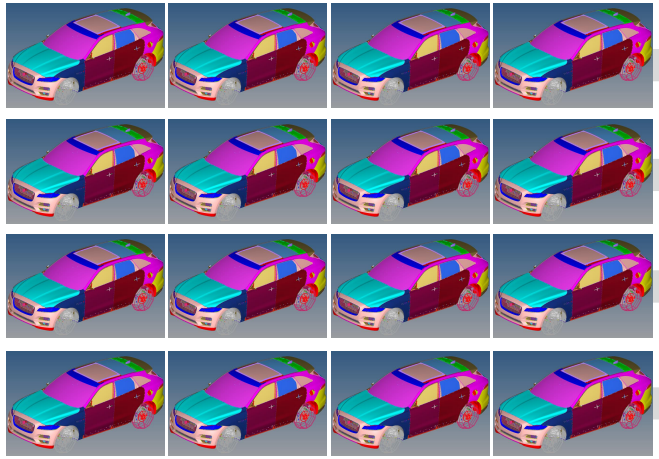
Single Sample based on the nominal design

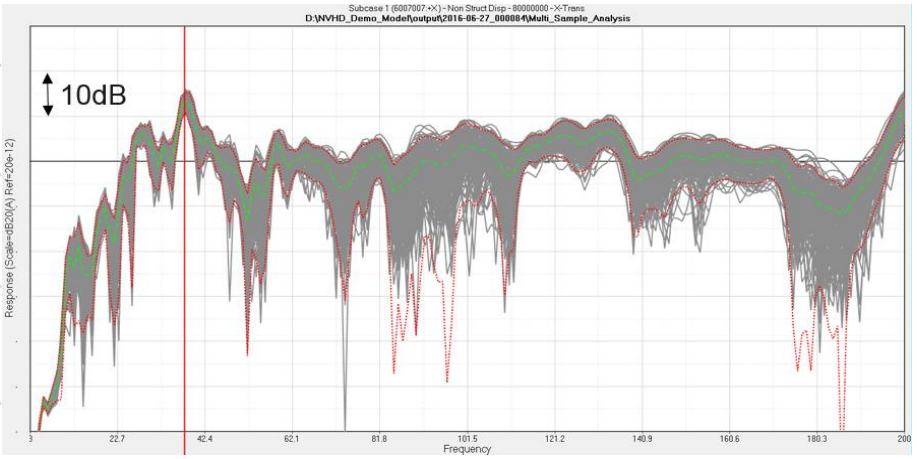




Vehicle ‘Population’ point of view:

Perturb nominal design to create multiple samples that account for variations,

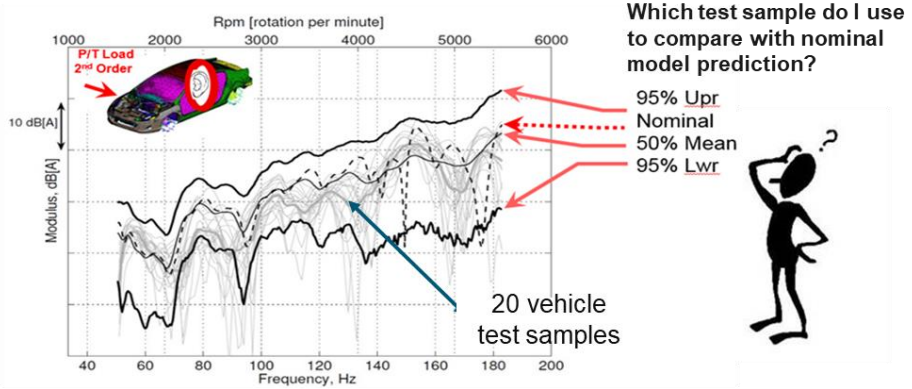




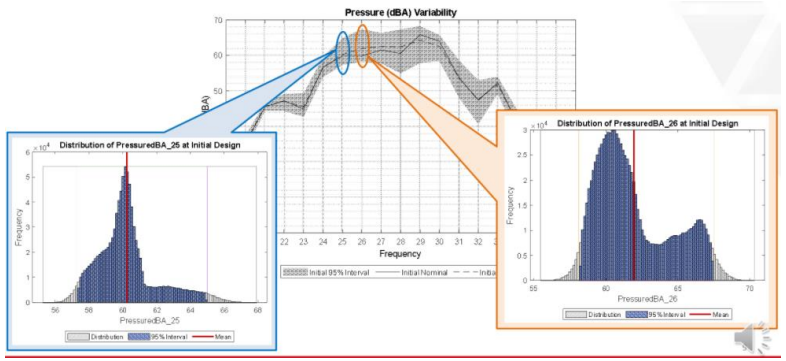
How the ‘population’ point of view can help

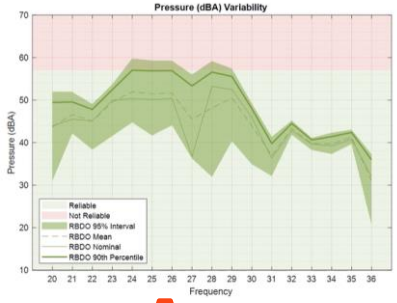
- Provides a good conceptual ‘mental picture’ in understanding the concepts and tools we have discussed in this event
- Explains why NVH problems don’t happen consistently on every prototype and how simulation could capture them all
- Provides a framework for rational comparison of simulation and test results
- Helps us find the right target metric which could be used in RBDO to achieve a despaired level of customer satisfaction

NVH Issues	Proto-1	Proto-2	Proto-3	Proto-4
Road NVH @75Hz	NOK	OK	NOK	NOK
PT Shake @29Hz	OK	NOK	NOK	OK
Idle Boom at 45Hz	NOK	NOK	OK	OK
Suspension Squeak	OK	OK	OK	NOK



Non-Parametric Probabilistic Simulation; Soize, Durand, Gagliardini

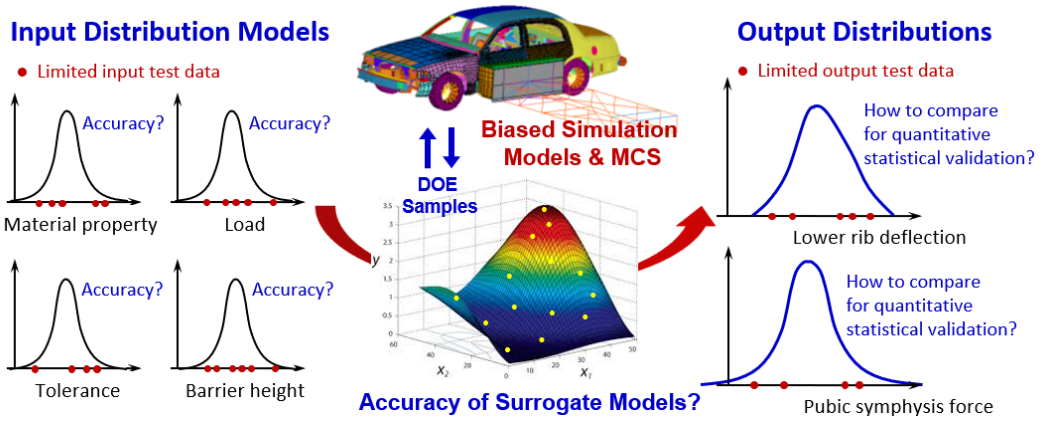


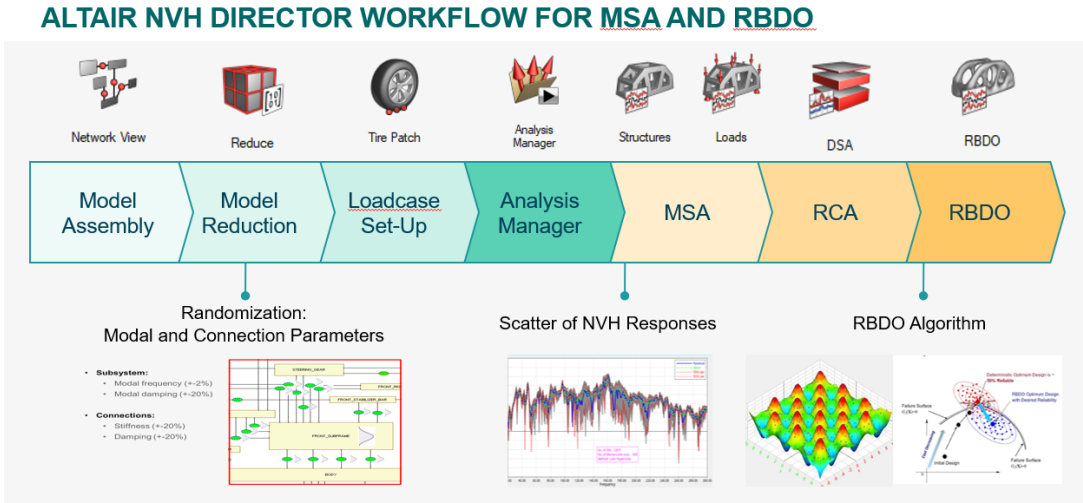


ALTAIR RAMDO SOLUTIONS

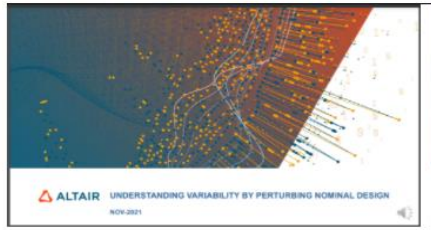
Apply the right process and tools

- I have seen a lot of interested in simulating variability problems among NVH engineers
- It seems every large auto OEM has some effort going on, but many people struggle due to lacking experience and a good process to follow
- As demonstrated by the four proceeding presentations, and examples shown in the training videos, it is possible to successfully consider variability in simulation
- The training videos, created specifically for this workshop, are a good place to start exploring the concepts, process and tools to see how they could be applied in your specific situation





Training Videos and Case Studies



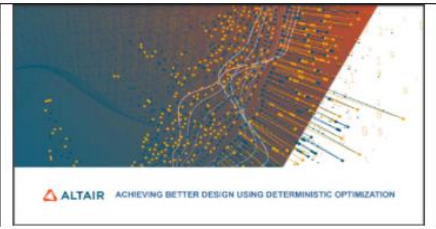
Understanding Variability by Perturbing the Nominal Model

Duration: 10 minutes
Topics covered include:

- Perturbing nominal model to understand variability
- Parametric and non-parametric perturbations
- Example of parametric perturbation
- Example of non-parametric perturbation

View the presentation slides

Watch Now



Achieving a Better Design Using Deterministic Optimization

Duration: 10 minutes
Topics covered include:

- What does a better design for NVH – low amplitude or narrower variation?
- Design sensitivity as a filter to reduce no. of variables
- Deterministic optimization
- Is the optimal design reliable and robust?

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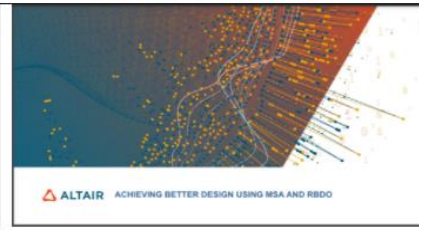

Achieving a Better Design Using MSA and RBDO

Duration: 10 minutes
Topics covered include:

- Multiple sample analysis
- Design sensitivity based on both nominal and extreme samples
- Design variable filtering
- RBDO

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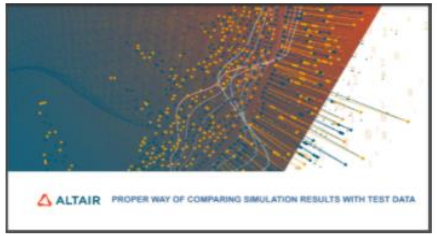

Proper Way of Comparing Simulation Results with Test Data

Duration: 10 minutes
Topics covered include:

- Why is my simulation result so different from test?
- Does the nominal model do a good job in representing the response trend?
- The proper way to compare simulation results to test data
- A better way to set NVH targets by level of customer satisfaction

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Introduction to Uncertainty Quantification

Duration: 47 minutes

This presentation introduces uncertainty quantification (UQ), discussing the differences between variability and uncertainty. The question of where to find input variability information will be answered. Examples will be provided to show how tolerances and percentage variations can be used to calculate standard deviations that can be used to create distributions to characterize the variability.

An advancing machine learning algorithm will be presented that will show to efficiently propagate variability to obtain the output, i.e., response variability. Finally, it will be shown how the response variability, i.e., response distribution can be used in various ways to achieve the end goal.

View the presentation slides

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Reliability-Based Design Optimization

Duration: 38 minutes

It is important for the manufacturing industries obtain reliable optimum designs under a wide range of given environment. However, a deterministically optimized design without inclusion of uncertainty will be most likely only 50% reliable. RAMDO has developed comprehensive capabilities that include input distribution modeling for both independent and correlated variables; a variable screening method for high dimensional RBDO problems; reliability analysis; RBDO; and confidence-based RBDO. For the input distribution model, a two-step maximum likelihood method generates best fit input distribution models from eight marginal PDF and eight copula candidates. RAMDO predicts reliability accurately and efficiently using highly accurate and efficient Dynamic Kriging (DKG) surrogate models over the variance window using efficient sequential sampling strategy. For optimization, score functions derived from copulas are used to compute accurate sensitivities of probabilistic constraints with respect to random design variables. Numerical examples, including a high dimensional multidisciplinary vehicle design (crash & NVH), durability of vehicle suspension components, casting process, 5-MW wind turbine blade, and wind turbine drivetrains, demonstrate that the RAMDO finds highly accurate optimum designs efficiently.

View the presentation slides

Watch Now

Statistical Model Validation, Calibration & RBDO for Virtual Product Design Process

Duration: 42 minutes

To utilize physics-based simulation models in Virtual Product Design in manufacturing industry, they need to be validated for accuracy. There are several challenges in model validation, calibration, & RBDO: (1) limited numbers of input data for modeling input distributions, (2) biased simulation models, (3) inaccurate surrogate models, and (4) limited numbers of output test data for model validation and calibration. This webinar presents RAMDO's solution for model validation and calibration. Dynamic Kriging surrogate (DKG) models, which selects an optimum combination of basis and correlation functions from 54 combinations over the variance window, provide highly accurate and very efficient results. Using simulation output distributions obtained using the DKG surrogate models and limited output test data, target output distributions, which provide good approximations of true output distributions, are obtained. These target output distributions are used to measure biasness of simulation models for model validation. In addition, an optimization-based calibration method is developed, by minimizing convex Hellinger distance measure, for unknown input parameter distributions. Several examples are used to demonstrate effectiveness of validation & calibration methods.

View the presentation slides

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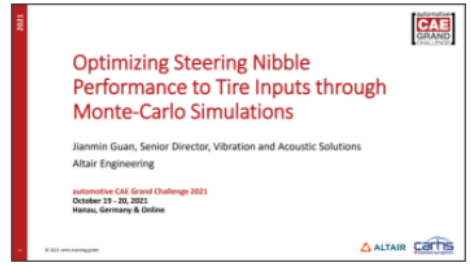
Additional presentations you may be interested in

Presented at 2020 NAFEMS: Accounting for Variability in NVH Design to Achieve Higher Customer Satisfaction

Duration: 22 minutes

Watch Now



Optimizing Steering NibblePerformance to Tire Inputs throughMonte-Carlo Simulations

Duration: 26 minutes

View the presentation slides

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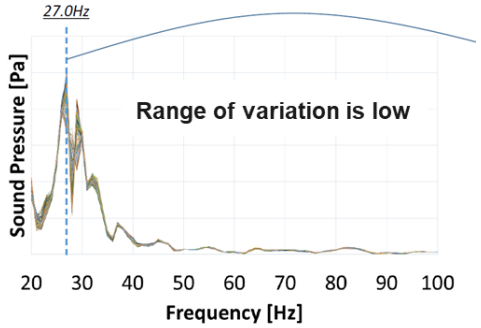
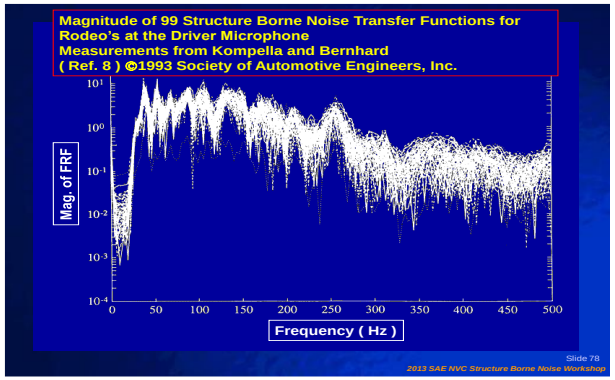
ALTAIR RAMDO SOLUTIONS

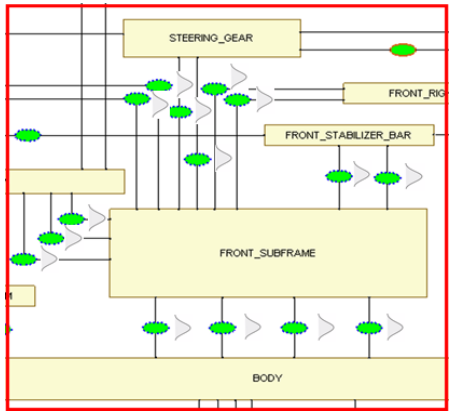
Challenges

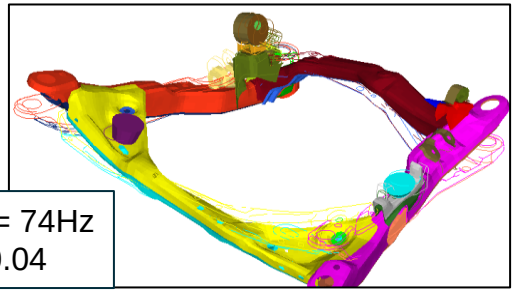
- **Input variability** data can be hard to obtain and may not cover all possible sources of variation present in the final product
- **Output variability** can be very costly to obtain, and is essential for meaningful and successful variability simulation
- **Simulation model content** may bot capture all possible sources of input variability. Consider parametric and non-parametric approaches
- **Simulation model quality** need to be validated and calibrated to ensure the optimized solution from RBDO is meaningful
- **Simulation time** can be long, even though both Altair NVH Director and Ramdo have special functionalities to reduce runtime
- **Learning curve** can be steep as the process requires familiarity with concepts from multiple disciplines – statistics, DOE, Monte-Carlo simulation, advanced optimization etc



Distribution of Sound Pressure @27.0Hz

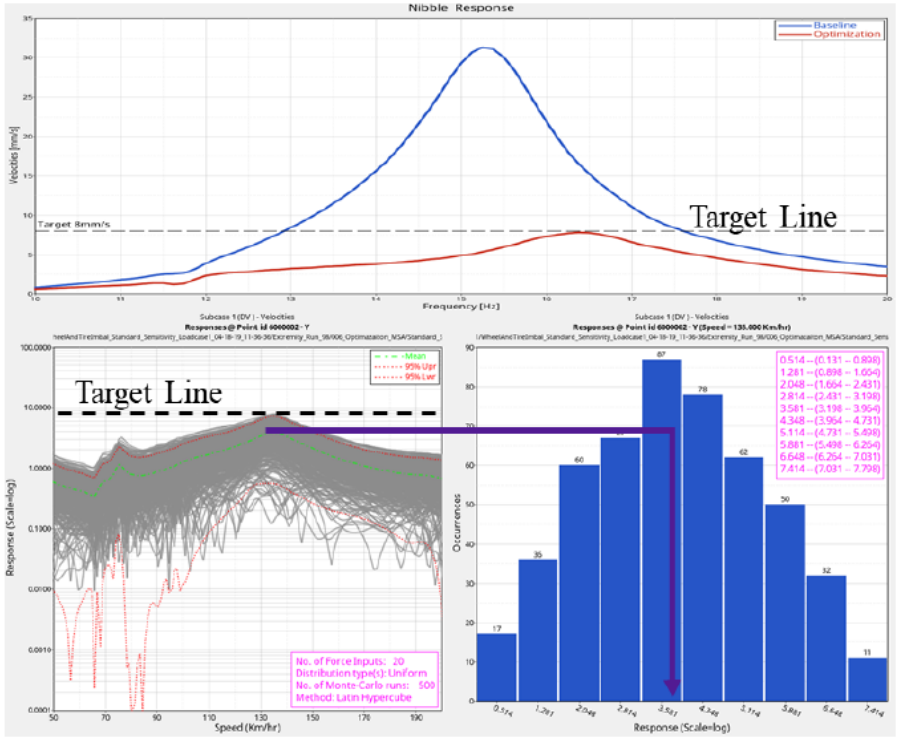





Full Torsion = 74Hz
Damping = 0.04

Opportunities

- Historically, prototype testing has been the primary, if not the only, tool for product design signoffs in almost all industries, with a potential exception of the aerospace industry
- However, there has been cases where prototype testing failed to identify the worst-case scenarios that have resulted in costly late changes and launch delays
- Trying to avoid failures like these has been an important motivation leading people to find ways to simulate variability
- Today, using **simulation as the primary tool for signoffs** is already happening, and we are seeing this trend becoming more prevalent among auto OEMs
- Some OEMs have set internal timeline to move 100% of signoffs from prototypes to simulation
- **Advance in AI/ML** can potentially have significant impacts on our ability to simulate variability, particularly in runtime



How could you go about solving your own variability problem?

- Everyone's problem may require a different way to structure the solution, and the most challenging part of the journey is to formulate the problem in such a way that tools Altair and Ramdo provide could be applied
- It will be very helpful to review the presentation material and training videos in detail to see if you can find any inspirations form them
- **Don't hesitate to contact us or the authors for help**. We can work with you to overcome the initial challenges that will increase your chance of success

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THANK YOU

altair.com

#ONLYFORWARD

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