Model Calibration  
Sensitivity Analysis  
Optimization  
Robustness Evaluation  
Robust Design Optimization  
Metamodelling

optiSLang
optiSLang supports the engineer with:
• Calibration of virtual models to physical tests
• Analysis of parameter sensitivity and importance
• Metamodelling
• Optimization of product performance
• Quantification of product robustness and reliability also referred to as Uncertainty Quantification (UQ)
• Robust Design Optimization (RDO) also referred to as Design for Six Sigma (DFSS)

In the past, one of the largest bottlenecks for a successful simulation driven product development was to create a workflow including all necessary components for parametric design and system evaluation in one standardized process. Therefore, since version 4, optiSLang has been expanding to a powerful simulation workflow environment. This makes the software the perfect tool for simulation driven workflow generation using parametric models for sensitivity analysis, optimization and robustness evaluation.

Simulation based product optimization in virtual prototyping

The predominant aim of CAE-based optimization in virtual prototyping is often to achieve an optimal product performance with a minimal usage of resources. This pushes designs to the boundaries of tolerable stresses, deformations or other critical responses. As a result, the product behavior may become sensitive to scatter with regard to material, geometric or environmental conditions. Subsequently, a robustness evaluation has to be implemented as a Robust Design Optimization (RDO) strategy consisting of:
• Sensitivity analyses to identify the most affecting optimization parameters regarding the optimization task
• Multi-disciplinary and multi-objective optimizations to determine the optimal design
• Robustness evaluations to verify design robustness and reliability

optiSLang’s Best-Practice-Management supports this strategy by an automatic selection of the appropriate sensitivity, optimization and robustness algorithms and their settings. The procedures are guided by intuitive drag & drop workflows and powerful postprocessing tools. Within optiSLang’s workflow building environment, any parametric CAD or CAE model can be easily integrated. Thus, the engineer extensively benefits from the capabilities of parametric modeling and design studies in order to innovate and accelerate virtual product development.

Metamodelling with optiSLang

optiSLang expands parametric design studies to metamodelling based on a set of virtual design points, experimental design responses or field observations. The software automatically identifies the corresponding input parameters for every response variation. Furthermore, the best possible functional meta-model is identified to adequately describe the impact of input variability to the responses. For the identification process, optiSLang’s Coefficient of Prognosis (CoP) quantifies the prognosis accuracy of the meta-model regarding the response variation of a data set. The result is the Metamodel of Optimal Prognosis (MOP). This procedure fulfills the most important tasks in metamodelling:
• Avoidance of overfitting
• Identification of the most corresponding meta-model
• Reduction of complexity in large dimensions of variability

By automatic reduction to important parameter spaces, the procedure ensures the creation of meta-models with a minimum of virtual design points. Consequently, even tasks involving a large number of optimization variables, scattering parameter as well as non-linear system behavior can be efficiently solved.

Robustness Evaluation and Reliability Analysis

optiSLang provides powerful sets of stochastic analysis algorithms. It enables the user to conduct a reliable determination of failure probabilities by evaluating the result value variation, which includes the identification and consideration of relevant scatter input parameters.

PRODUCT OVERVIEW

Since its market launch in 2002, optiSLang has developed into one of the leading universal software platforms for CAE-based optimization in virtual prototyping. Based on design variations or measurement and observation points, efficient variation analyses can be performed with minimal user input and few solver calls.
OPTISLANG – GENERAL PURPOSE TOOL FOR VARIATION ANALYSIS

Sensitivity analysis, optimization and robustness evaluation based on multiple designs, measurement or observation points with a minimum of user input and solver runs for an effective virtual product development.

**SENSITIVITY ANALYSIS**
- Stochastic sampling (LHS) for optimized scanning of multi-dimensional parameter spaces
- Quantification of prognosis quality (CoP) of meta-models
- Generation of the Metamodel of Optimal Prognosis (MOP)

**MODEL CALIBRATION**
- Find the best fit for simulation and measurement

**COEFFICIENT OF PROGNOSIS (CoP)**
The CoP quantifies the forecast quality of a meta-model (regression model) for the prognosis of a result value.

**METAMODEL OF OPTIMAL PROGNOSIS (MOP)**
The MOP represents the meta-model with the best prognosis quality of the result value variation. For the determination of the MOP, different subspaces of important input variables are evaluated with different meta-models. Thus, a No Run Too Much-strategy is implemented with a maximum of prognosis quality regarding the given number of design evaluations.

**OPTIMIZATION**
- Identification of the relevant input parameters and response values based on sensitivity analysis
- Pre-optimization of the parameter sets with MOP without additional solver runs
- Further optimization of the parameter sets with the most appropriate algorithms (Best-Practice-Management)

**ROBUSTNESS EVALUATION**
- Efficient methods of stochastic analysis for the determination of failure probabilities
- Evaluation of result value variation
- Identification of the relevant scatter input parameter

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Process integration

optiSLang supports the interfacing to any software tool used in virtual product development which can be externally called. Interfacing is either offered by text file based or pre-defined tool integrations. Nowadays, more than 100 different CAx/PLM software solutions are coupled with optiSLang. The new generation of optiSLang gives access to:

- CAD (Catia, Nx, Creo, Solidworks …)
- CAE (ANSYS, Abaqus, AMESim …)
- MS Excel, Matlab, Python …
- PLM (KIM, Teamcenter, Subversion …)
- In-house solver

Different parametric environments can be collected and combined to one automated parametric workflow for simulation driven product development.

Definition of CAx Workflows

The graphical user interface supports the workflow approach visually by single building blocks and algorithms which are graphically coupled in order to show dependencies and scheduling. The relationships can be determined and controlled in one context. Easily understandable charts as well as control panels are displayed at the same time. This enables full access and traceability of the complete workflow. The user can connect any complex simulation process of CAE solvers, pre- and postprocessors in heterogeneous networks or clusters. They are automated either in a single solver process chain or in very complex multidisciplinary / multidomain flows. Even performance maps and their appraisal can be part of standard projects.

Integration of optiSLang into parametric modeling environments

The modular structure of optiSLang supports the direct integration of its modules into standard parametric modeling environments. This framework allows the seamless integration of optiSLang into, e.g., ANSYS Workbench/AIM, Excel or SimulationX. Here, users do not have to leave their parametric modeling environment and can access optiSLang modules through a minimum of user input.

Interfaces and automation

optiSLang provides Python, C++ and command line interfaces to allow the automatic creation, modification, execution and remote control of projects within optiSLang or from external tool integrations. As a consequence, the usage within custom applications is secured and optiSLang projects can be integrated into customized platforms. Repetitive and pervasive tasks can be standardized and automatized.

Extensibility

The openness of optiSLang also enables users to plug:

- Algorithms for DOE, Optimization, Robustness etc.
- Meta-models
- Tool integrations
- Database connections

Current requirements for flexibility and upcoming requests for extensibility are satisfied by those interfaces. Therefore, optiSLang is the platform to address future needs of parametric and simulation driven virtual product development.
ANSYS optiSLang combines leading simulation technology of ANSYS with optiSLang’s powerful capabilities in variation analysis and process automation. By building CAx-workflows for automatic design variation studies (sensitivity analysis, optimization and robustness evaluation), virtual product development becomes more efficient. Thus, better products can be developed in shorter time.

Modes of interoperability with ANSYS
The process integration and workflow building capabilities of optiSLang offer a distinguished support of ANSYS simulation tools. There exist 3 major ways to integrate ANSYS tools into optiSLang workflows and/or to use ANSYS’ powerful parametric modeling with optiSLang’s algorithms:

- In ANSYS Workbench, the optiSLang Workbench plugin makes optiSLang technology available inside the powerful simulation platform.
- Text-based integration (ANSYS APDL) for combining ANSYS with other CAE/CAD tools for process automation and workflow generation.
- ANSYS Workbench node: The direct integration node enables the use of ANSYS Workbench projects in optiSLang workflows.

ANSYS Workbench plugin
optiSLang’s ANSYS Workbench Plugin toolbox includes all modules for Robust Design Optimization namely sensitivity analysis, optimization and robustness evaluation. A wizard guides the user through the definition of the different modules and gives an optimal solution strategy while minimal user input is required. Therefore, the optiSLang integration can be easily started with drag and drop functionality. The user only needs to set up the variability space, the constraints and the objectives. optiSLang automatically identifies the most important parameter and generates the MOP. A Best-Practice-Management selects the appropriate methods for optimization.

The options for parallel computing at several cores with ANSYS Remote Solve Manager and the use of ANSYS HPC Pack Parametric licenses for simultaneous computing of different designs are supported. The plugin also includes robust handling of design failures and any source of noise, like solver accuracy. All successful designs are stored in optiSLang’s database and can be used and postprocessed independently from the ANSYS Workbench design table.

General features of the Workbench Plugin are, e.g.:• Reduction of the number of CAE solver runs by optiSLang’s minimalist philosophy• Automatic identification of important parameters during sensitivity analysis• Automatic buildup of best possible regression functions (MOP)• Multidisciplinary and multiobjective optimization• Robustness evaluation• Insightful and efficient result post-processing module• Support of non-scalar responses (vectors, curves, signals, matrices)
SENSITIVITY ANALYSIS

By means of a global sensitivity analysis and the automatic generation of the Metamodel of Optimal Prognosis (MOP), optimization potential and the corresponding important variables are identified. This previous knowledge enables the formulation of task-related objective functions and constraints as well as the selection of suitable optimization algorithms.

Practical Application
Design variables are defined by their lower and upper bounds or by several possible discrete values. In industrial optimization tasks, the number of design variables can often be very large. With the help of a sensitivity analysis, engineers can accurately identify those variables which effectively contribute to a possible improvement of the optimization goal. Based on this identification, the number of design variables will be decisively reduced and an efficient optimization can be conducted. Additionally, a sensitivity analysis helps to formulate the optimization task appropriately concerning the choice and number of objectives, their weighting or possible constraints. Furthermore, it is used to estimate the numerical noise of the CAE solver as well as the proper physical formulation of the design problem.

Best Practice
- Coverage of the entire design space and minimization of correlation errors among input variables by optimized Latin Hypercube Sampling (LHS)
- Automated identification of the meta-model with the best prognosis quality of the response value in the sub space of important variables
- Quantification of the forecast quality of each meta-model for the prognosis of response values by the CoP
- Identification of the most important input variables related to each response value, constraint and objective
- Minimization of solver runs by MOP workflow

Methods
- Definition of optimization variables with upper and lower bounds or discrete values
- Definition and creation of the Design of Experiments (full factorial, central composite, D-optimal, customized DoE), Latin Hypercube Sampling for optimal scanning of multi-dimensional parameter spaces
- Automated generation of the MOP by testing a library of approximation methods
- Quantification of the prognosis quality by the model independent CoP

Postprocessing & Visualization
- Histograms
- Correlation matrix / parallel coordinate plots
- 2/3D Anthill plots and 2/3D surface plots of the MOP
- CoP matrix with all responses
- Prognosis of residual plots and local error estimates
- Integration of images and processes
- Customized plots
Practical Application
Structures and sub-systems often need to be designed to withstand multidisciplinary load cases. For example, vehicle body structures are exposed to crash (nonlinear transient), Noise Vibration Harshness (frequency domain), stiffness (linear static), durability (linear static) and aerodynamics (CFD). The structural requirements to meet loads in one discipline are very often different to requirements for loads in the other. Unless loads from all disciplines are considered simultaneously during the optimization process, the resulting design will not be well balanced for structural performance. Multidisciplinary optimization considering single and multiple goals is essential to achieve this objective.

Best Practice
• Identification of the most relevant input parameters and response values with the help of sensitivity analysis and MOP
• Pre-optimization of parameter sets and studying possible objective conflicts using the MOP approximation
• Optimization wizard for automatic selection of suitable algorithms for optimization
• Easy definition of parameter ranges, single and multiple objectives and constraints

Methods
• Gradient-based methods (NLPQL)
• Nature-inspired Optimization Algorithms (NOA) for single and multiobjective optimization
• Adaptive Response Surface Method (ARSM) in case of less than 20 important optimization variables
• Customized optimization algorithms

Postprocessing & Visualization
• Interactive postprocessing adapted to the optimization algorithm
• Fast investigation of optimization performance using different visualization options
• Parallel coordinate plots and cluster analysis for selection of best design candidates
• Selection of individual designs and easy visualization of nonscalar results as time-series, 3D-field data, automated animation
• Objective history plot for single objectives, 2D and 3D Pareto plots for multiple objectives

MULTIDISCIPLINARY OPTIMIZATION
optiSLang provides powerful optimization algorithms and automated workflows for an efficient determination of optimal design parameters regarding various multidisciplinary, nonlinear and multicriteria optimization tasks.
MODEL CALIBRATION

Model calibration identifies unknown parameters of CAE models to obtain the best possible agreement with available test results. By combining sensitivity analysis and optimization, model parameters which are not directly measurable can be consistently identified.

Practical Application
Measurement data represents characteristic system responses that are critical to validate and to improve the physical model of the system. In the context of parameter identification, model calibration means using experimental observations and simulation runs to estimate unknown simulation model parameters. By means of sensitivity analyses, first, parameters will be detected which actually have an influence on the simulation results and the calibration procedure. Second, the analysis helps to define suitable measures to quantify the difference between measurement and simulation. Finally, it can be analyzed whether the inverse problem will be solved non-ambiguously, which means a unique parameter combination exists that allows optimal matching between measurement and simulation.

Best Practice
- Sensitivity analysis to check unknown parameters for significant influence on the model response
- CoP supports the identification of the best possible response extraction by comparing model and measured values
- CoP verifies the uniqueness of the best possible correlation model between parameter and response variation
- Identification of non-unique (multiple) parameter sets by coupling of parameters

Methods
- Consideration of scalar response values
- Definition of multi-channel signals, e.g. time-displacement curves
- Extensive library of functions, e.g. local values as maximum and minimum amplitudes, global values as integrals of certain properties and more complex signal calculations
- Definition of individual objective functions
- MOP based sensitivity analysis of different signal properties and pre-evaluation
- Several optimization algorithms (e.g. gradient-based or nature-inspired)

Postprocessing & Visualization
- Illustration of statistical evaluations
- Visualization of signal functions and the corresponding reference value for each design
- Sensitivities and approximation of signal function values/parameter sensitivities
- Interactive evaluation of curve fitting and corresponding design images
- Parallel coordinates plot for uniqueness evaluation

Parameter identification of a spring steel model based on a tension bar experiment: The load displacement curves of experiment and corresponding simulation are compared in the signal processing and the minimum deviation is found in the least squares minimization.

Model Calibration

Match experimental data with simulation to increase simulation quality
Robustness Evaluation

optiSLang quantifies the robustness of designs by generating a set of suitable design variations on the basis of scattering input variables. Optimized Latin Hypercube Sampling and the quantification of every input variability on the result variation by the Coefficient of Prognosis (CoP) ensures the reliability of the variation and correlation measures with a minimum of required design variants.

Practical Application
Optimized designs are often pushed to their performance boundaries, e.g., regarding material strength. It is therefore necessary to investigate the impact of scattering input variables on these designs, e.g., geometry, material parameters, boundary conditions or loads. In order to cope with the unavoidable uncertainties in operating conditions as well as in manufacturing processes, it is essential to introduce an appropriate robustness evaluation and measurement based on stochastic analysis. Our consulting expertise yields that, besides standard variation or Sigma Levels, the variance coefficient is also a suitable robustness measure comparing the relative variations of the critical model responses to the relative variation of the input variables.

Best Practice
• Definition of all possibly influencing uncertainties as the crucial input of a robustness analysis
• Predefined distribution function types and an input correlation matrix to support best possible definition of scattering input variables
• Automated generation of optimized Latin Hypercube Samples (LHS) to scan the robustness space with minimal input correlation error
• Identification of the most affecting input scatter for every response and quantification of input variable influence using the Coefficient of Prognosis (CoP)
• Quantification of robustness by the histogram of result values including fitting of distribution function, approximation of sigma level and violation probability

Methods
• Stochastic input variables with distribution types and input correlation
• Optimized Latin Hypercube Sampling
• Fitting of distribution function in the histogram of result values
• Approximation of Sigma margins
• Approximation of violation probability

Postprocessing & Visualization
• Histograms to illustrate scatter of result values
• Linear correlations matrix, nonlinear CoP based correlation matrix, MOP and CoP plots
• Distribution fitting, Sigma values, violation probabilities
• Traffic light plot to check the violation of limit values of critical responses

Analysis of the scatter of the response values within a variance-based robustness analysis. The traffic light plot indicates the response scatter in comparison to given failure limits. With the help of estimated mean value and variance the safety margin can be observed. Furthermore, the MOP gives more information on the sources of the scatter.
Practical Application
If designs need to meet high safety or quality requirements with low event probabilities of less than 1 out of 1000, a reliability analysis is necessary to investigate how these designs are affected by scattering input variables, e.g., geometry, material parameters, boundary conditions or loads. As an alternative to the estimation of safety distances by using standard deviations in robustness evaluations, a reliability analysis calculates the probability of exceeding a certain limit by using stochastic algorithms. Thus, rare event violations can be quantified and proven to be less than the accepted values.

Best Practice
• Robustness evaluation for the approximation of violation probabilities and for the identification of important random variables as the basis for an appropriate selection of methods regarding a reliability analysis
• Definition of one or various failure mechanisms using limit state functions
• Recommendation of verifying low probabilities of failure with two alternative algorithms of reliability analysis

Methods
• First Order Reliability Method (FORM) and Adaptive Importance Sampling for continuously differentiable limit state functions
• Directional Sampling and Adaptive Sampling (AS) for a moderate number of random variables, multiple failure mechanisms and small probabilities of failure
• Adaptive Response Surface Method (ARSM) as the most efficient method for up to 15 important random variables

Postprocessing & Visualization
• Histograms
• 2D/3D anthill plots
• History plots
• Violation probabilities

The reliability analysis as final proof of the results of a variance-based robustness evaluation: The identification and more accurate integration of the failure domain by directional sampling enables a qualified reliability assessment that is independent of the distribution type of inputs and outputs.
ROBUST DESIGN OPTIMIZATION (RDO)

RDO combines methods of design optimization with robustness evaluation. It allows a product improvement with a corresponding quantification and assurance of quality. optiSLang provides techniques for variance-based and reliability-based RDO in compliance to the Taguchi method or Design For Six Sigma (DFSS).

Practical Application
Quality is one of the most important product properties. Providing it in an optimal dose means to reduce costs for rework, scrap, recall or even legal actions while satisfying customers demand for reliability. During the product development, the common approach to achieve this goal is to apply RDO. The method uses results of stochastic analysis as constraints or objectives to accomplish the optimization.

Best Practice
From our consulting expertise, it is recommended to start with an iterative RDO. In this procedure, the optimization has to consider safety factors to assure a certain safety margin of critical responses. In iteration with optimization and succeeding robustness or reliability analysis these safety factors are adapted until the final proof of reliability:

- Definition of the design space of optimization variables as well as of the robustness space of all scattering variables
- Initial sensitivity analysis within the design space as well as initial robustness evaluation within the space of scattering variables in order to identify important parameters, optimization potential, initial violation probabilities and safety margins
- Recommendation of final reliability proof for tasks with a sigma level higher than three

If safety distances strongly vary in the design space, simultaneous RDO might become the method of choice. Here the workflow building capabilities allow nesting a robustness or reliability analysis into an optimization algorithm.

Methods
Iterative and simultaneous approach for:
- Variance-based RDO - tasks with low sigma level (≤ 2-3sigma)
- Reliability-based RDO - tasks with high sigma level (≥ 3sigma)

Postprocessing & Visualization
- Interactive postprocessing adapted to the optimization algorithm
- Fast investigation of optimization performance using different visualization options
- Histograms to illustrate scatter of result values
- Distribution fitting, Sigma values, probability of failure
- Traffic light plot to check the violation of limit values of critical responses
**EXTENDED METAMODELING – FROM SCALAR VALUES TO FIELDS IN TIME AND SPACE**

optiSLang’s MOP reveals how scalar input variation affects scalar output variation. To analyze how field inputs affect field responses, Dynardo has developed Statistics on Structures (SoS).

Using metamodeling for robust design optimization, in system simulation or on customer’s hardware to operate and maintain products in an optimal way, customer ask for approximating responses in time or space. Using multiple scalar metamodels for discrete time and space support points, however, is often not successful, because existing correlations between individual points in time and space are missing. To extend correlation analysis to field variables Dynardo developed the software Statistics on Structure (SoS). SoS provides models to automatically identify relations in time or space.

SoS is specifically designed for the automatic identification and analysis of data relations between individual points in time and space. Thus, the coupling of optiSLang and SoS will extend correlation analysis and metamodeling from scalar values to input and output variables in time and space.

**SoS decomposition and analysis of variation patterns**

SoS analyzes variations from a given DOE or from measurements and it automatically identifies the dominant variation patterns including their “scatter shapes” and amplitudes. Thus, the variations in time or space are decomposed. This helps to explain their correlation to any other scalar or field variable. Successful applications include a response data decomposition distributed in time or frequency (1D signals, e.g. load-displacement curves), response on 2D grids (e.g. surface stress) or in 3D space (e.g. 3D temperature distribution). Similar to modal shapes, the variation patterns are sorted by their importance.

In addition to the application for correlation analyses, the automatically identified variation patterns are parameterizations of nearly arbitrary input data and can be used to generate scattering design realizations. For example, based on a few real-life measurements, a statistical model can be automatically created, which is capable of generating hundreds of new virtual random samples representing the statistics of the measured data. This is particularly helpful when dealing with geometric imperfections from laser scans. With SoS, these laser scans can be statistically analyzed directly on the FEM mesh. The parameterization how geometry deviates is also given. By generating and simulating a set of possible geometries, the user can quantify the effect of the variations on the structural performance.

**Data-based Reduced Order Model (ROM)**

ROMs are very important in system simulation and are expected to become a key technology for digital twins. In typical applications a detailed product simulation needs to be linked to sensor data in order to predict product parameters (e.g. life of turbine blades) accurately enough to be capable of optimizing the maintenance and operation. To fulfill the reaction time requirements from digital twin, the detailed simulation models need to be reduced. The classical approach of ROMs uses a matrix condensation which is called “physics-based” ROMs, because the formula still contains the physics of how input variation affects response. However, these reductions are often restricted to linear systems. The alternative for non-linear systems are data-based ROMs. They use functional models to approximate response surfaces considering the effect of input variations on the response variation based on the given sample set. For field data as input or response, SoS provides the Field Metamodel of Optimal Prognosis (FMOP) which can be used to approximate signals, FEM solutions or geometric deviations.

**Statistics on Structures**

Complex CAE models are replaced by highly accurate and resource-efficient FMOPs for real-time approximation of signals, FEM solutions or geometric deviations.

**Workflow for the generation of a Field Metamodel of Optimal Prognosis (FMOP) connecting input and response field variation to be integrated in digital twins**
As a general purpose tool for variation analysis based on multiple designs, measurement or observation points, optiSLang serves an extensive range of application fields across various industries.

**Robust Design Optimization**
Initially introduced in the automotive industry in 2002, optiSLang has been extensively used for design optimization, robustness evaluation based on CAE models, reliability analysis as well as parametric CAD-modeling or system simulation in various industries.

**Parameter and System Identification**
optiSLang provides key functionality in the automatic identification of sensitive parameters and the quantification of the forecast quality of response variable variation.

**Data Mining**
optiSLang’s leading technology of processing large numbers of parameter and generating the best possible metamodels has become key technology for data mining or machine learning. The methods can be applied to sets of virtual design points as well as available experimental data or observation points. That opens up new fields of application like generating metamodels based on field data for optimizations in the oil and gas production.

**Product Lifecycle Management (PLM)**
Due to a powerful graphical environment for CAE process integration and automation as well as for workflow building, optiSLang is widely used for the integration and standardization of RDO workflows regarding PLM-Systems.

**Metamodeling**
The metamodeling functionality of optiSLang enables the user not only to identify the optimal design configuration, but also implements the optimal design within a metamodel. This includes the pre-investigation of the expected variation window of the product to understand how the design will operate under this condition. Thus, customized optimizations of product performance, configuration or maintenance can be conducted.

For detailed information please visit the library section of our website www.dynardo.de. There you will find customer stories chronologically ordered by methodology and industry application.

In the uncomplicated and flexible cooperation with Dynardo, it is a great advantage that the company is not only a software developer but also an engineering service provider. Direct communication with the programmers and individual license agreements ensure a rapid adaptation and extension of the software optiSLang to specific technical requirements of Robert Bosch GmbH.

Roland Schirrmacher | Robert Bosch GmbH
Corporate Sector Research and Advance Engineering
Future Mechanical and Fluid Components (CR/ARF1)

Since 2010, Shell has been cooperating with Dynardo to develop and to implement successfully a simulation based workflow for the optimization of oil and gas production at unconventional reservoirs. Key factor for success is the excellent and reliable consulting service of Dynardo as well as the company’s powerful software tool. The FEM based hydraulic stimulation simulator as well as the software optiSLang are sophisticated workflow environments to calibrate simulation models and to generate metamodels for connecting hydraulic fracturing simulations with related production costs and risk management. The workflow has been effectively applied worldwide at major unconventional oil and gas assets of Shell.

Taixu Bai | Shell Exploration & Production Company USA
Completion & Technology Effectiveness Team

Since 2002, Daimler started implementing optiSLang for NVH analysis of driving comfort. Since then, applications have been extended to many functions such as crashworthiness, brake squeal, forming or joining simulation.

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CONSULTING & TRAINING

Dynardo provides simulation services and customized solutions for your FE analyses and CAE optimization in virtual product development. Due to the combination of being a CAE consulting company and software developer, Dynardo is your competent and flexible partner for complex tasks in the CAE field.

Technology Implementation Projects
Especially for the introduction of CAE-based Robust Design Optimization in product development processes, a pilot project based on the customer’s product knowledge and Dynardo’s consulting experience would be an adequate initial cooperation. Dynardo offers expertise in various industrial fields helping you to conduct a realistic safety and reliability analysis. We will further support you in proper assessments of material behavior, the prediction of failure evolution, design optimization or simulation of FEM based limit load analysis.

RDO Consulting Service
If customers have not yet implemented a CAE-based development process but would like to benefit from the potentials for their product lines, we offer the generation and verification of virtual product models as well as the conduction of a CAE-based optimization as a consulting service. The metamodeling methodology will show you possible optimized product configurations and will explain how input variation affects the design responses.

Customization
You want to economize your virtual product development? Dynardo provides you with customized solutions based on our software optiSLang and Statistics on Structures (SoS). We integrate your in-house software into optiSLang or implement optiSLang as part of your company SPDM (Simulation Process & Data Management) solution. Even fully automatized workflows to optimize your products regarding specific customer requirements can be generated. We help you to establish a company-wide standard workflow and make your products benefit from consistent and efficient CAE processes.

Getting Started and Advanced Training
For a competent and customized introduction to our software products, visit our basic or expert training clearly explaining theory and application of a sensitivity analysis, multidisciplinary optimization and robustness evaluation. The training addresses all engineers and decision makers involved in the development process and product life cycle. Furthermore, our internet library is the perfect source for your research on CAE-topics and applications of CAE-based RDO. There you will find practical references and state-of-the-art case studies matched to the different fields of methods and industrial applications.

For detailed information please visit our website: www.dynardo.de.

ANNUAL WEIMAR OPTIMIZATION AND STOCHASTIC DAYS

Your conference for CAE-based parametric optimization, stochastic analysis and Robust Design Optimization in virtual product development.

The annual conference aims at promoting successful applications of parametric optimization and CAE-based stochastic analysis in virtual product design. The conference offers focused information and training in practical seminars and interdisciplinary lectures. Users can talk about their experiences in parametric optimization, service providers present their new developments and scientific research institutions inform about state-of-the-art RDO methodology.

Take the opportunity to obtain and exchange knowledge with recognized experts from science and industry.

You will find more information and current dates at: www.dynardo.de

We are looking forward to welcoming you to the next Weimar Optimization and Stochastic Days.