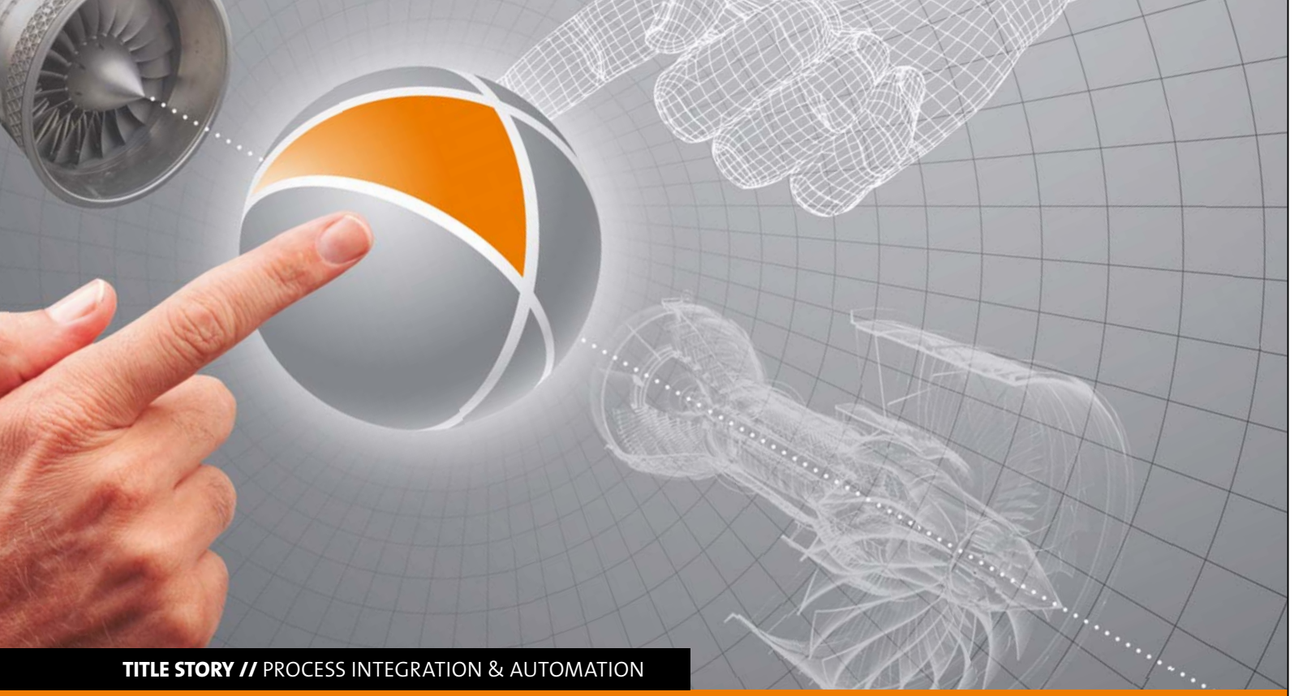

TITLE STORY // PROCESS INTEGRATION & AUTOMATION

OPTISLANG - READY FOR DIGITAL TWIN TO BRIDGE INTO PRODUCTION 4.0 & INTERNET OF THINGS

optiSLang is capable to bridge the gap between modern Product Lifecycle Management (PLM) systems and individual product development hubs.

Motivation

The new generation of process automation within Industry 4.0 has transformed the scope of Business Process Models (BPM) for leading global manufacturers. With tools such as Virtual Manufacturing Execution Systems, Cloud Computing and Big Data Analytics, the Internet of Things (IoT) is becoming a modern and efficient umbrella of planning, processing, feedback and control systems, paving the way for the next generation of smart designs and manufacturing systems.

Within the scope of Industry 4.0, there has been a widespread development of standalone tools, each offering special solutions to underlying problems and requiring software specific know-how. While the number of standalone modules and corresponding software vendors have increased, the advent of IT-HPC and Big Data has led to enormous amount of data generation and necessitated the need for an integrated data evaluation and management system. Integration of modern simulation processes could open up even further opportunities into optimization and control of such systems. It would enable to speed up the decision-making process, enhance traceability and improve existing Quality Management Systems (QMS) in place. It should be noted, however, that simulation technology is not an IoT product itself but is proving to be a pivotal driver of IoT processes in the future.

In the various phases of Product Development Processes (PDPs), optiSLang is capable to play a vital role to shorten production cycles, deliver enhancements and resolve conflicts with respect to quality, product robustness and costs. Apart from optimizing individual process workflows within various stages of PDPs, optiSLang could be used to bridge the gap between modern Product Lifecycle Management (PLM) systems and individual product development hubs. Here we look at optiSLang's potential role at various process stations such as:

- Design of Experiment, Software-in-Loop (SiL) and Hardware-in-Loop (HiL) integrations
- Statistical Analysis
- Databased ROM
- Virtual Product Optimization
- Generation of parametric models and workflows
- Calibration of virtual models to tests
- Robust Design Optimization (RDO)

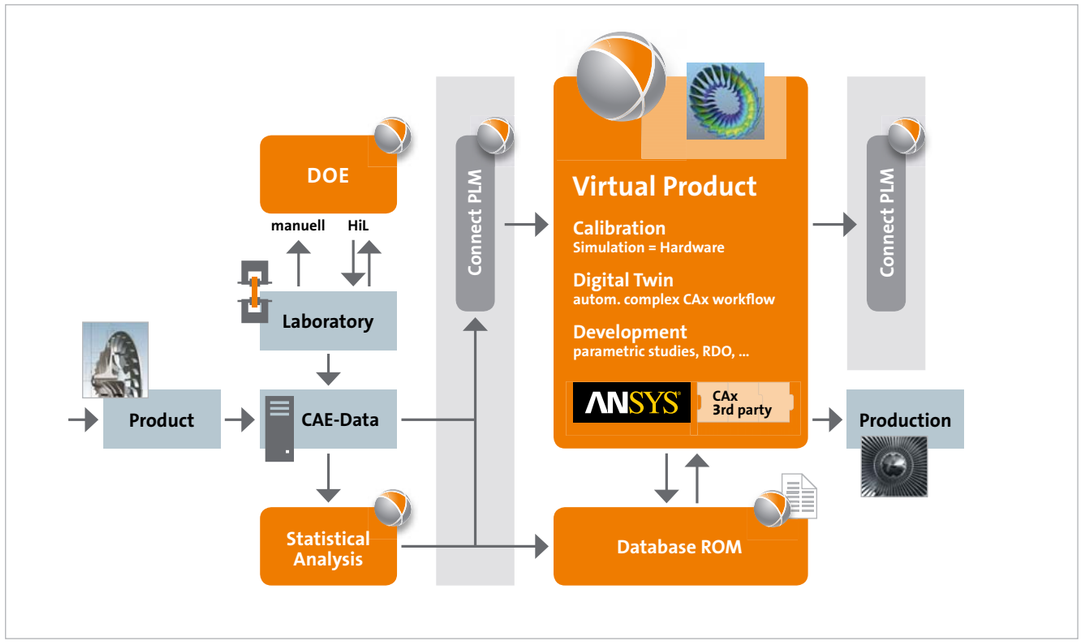

Fig. 1: Integration of optiSLang within and beyond CAx Processes, Product Lifecycle Management and Hardware-in-Loop

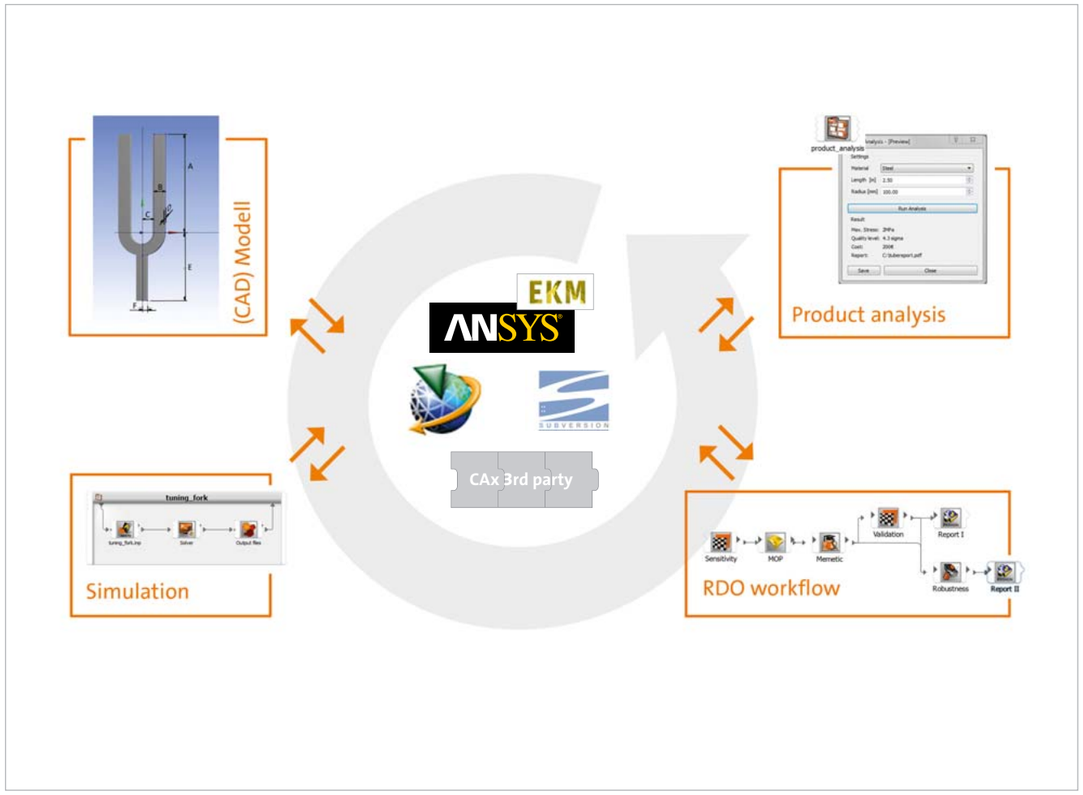

Fig. 2: Sceme of a modern Product Development Process using collaborative work based on a PLM / SPDM data base and optiSLang

Design of Experiments or Hardware Integration

In its truest sense, Design of Experiments (DoE) refers to evaluation of parameter value sweeps over a defined design space. DoE can be regulated manually or as an integrated Hardware-in-Loop (HiL) system. optiSLang could be used here as a data exchange interface tool to perform real-time sensitivity analysis and optimization on working systems. Together with Integrated Development Environment (IDEs) such as LabView, an automated measurement and result evaluation system could be set-up. Such an integrated system would prevent errors, minimize the total number of runs and hence provide immense savings in time and effort.

Such a HiL system was deployed by the Institute of Photonic Technology (IPHT, Jena) focusing on magnetometer characterization based on parameters such as laser frequency, source voltage, laser power and cell temperature and pressure. Manual characterization processes which took months for determining a single cell properties were replaced with an optiSLang + Engineering IDE system. This ensured optimal functionality, repeatability and optimization of the HiL system.

Further info: http://bit.ly/2bs9XEd

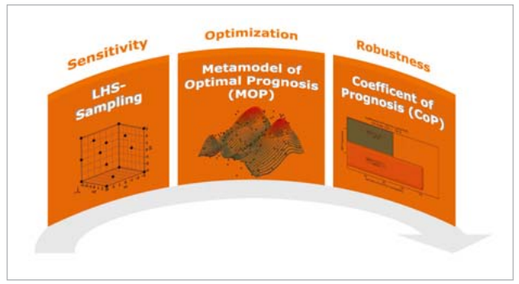

Fig. 3 : The statistical tools in optiSLang provide a good basis for Design understanding and design optimization.

Statistical post processing

Statistical analysis tools in optiSLang follow Dynardo's minimalist philosophy of allowing minimal user input with emphasis on ease-of-use and seamless integration functionality. Algorithms are designed and tested for robustness to cater noise or design zone failure within the paradigms of the design space. optiSLang automatically searches for the best possible correlation model in subdomains of important parameters with a given number of design points using the Metamodel of Optimal Prognosis (MOP®) workflow. That workflow becomes very powerful in large dimensions of input parameter and guarantees the user with the maximum amount of output information from given set of design points or experiments. Regardless of whether the raw data is acquired from Big Data analysis pool, Digital Twin or other resources, optiSLang offers efficient methods for Robust Design Optimization using sensitivity analysis, multi-disciplinary optimization, parameter identification, robustness evaluation, etc. In terms of visualization and post processing, optiSLang provides diverse features such as illustration of nonlinear multidimensional correlation matrix, 2D and 3D anthill plots, meta-model forecast quality in terms of Coefficient of Prognosis (CoP®), Principal Component Analysis and illustration of statistical evaluations.

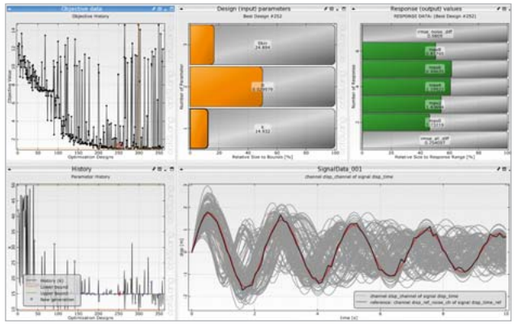

Fig. 4: optiSLang provides an enhanced visualization toolbox with histograms, signal channels and algorithm overview for design evaluation

Over the years, optiSLang's statistical algorithms have been employed across several backgrounds and domains. One such domain is Virtual Prototyping in the automotive industry.

In a joint study carried out at the Bergische Universität Wuppertal, optiSLang was used to generate a design space and carry out a Robust-Design Optimization of the machine element. The defined tolerances of the individual components were used to determine the design space and the normal stress distribution was extracted as a fitting response. It was illustrated that optiSLang could play a key role in Tolerance Management and meet the objectives of suitable, controllable and centered processes for the automotive industry.

Further info: http://bit.ly/2b9dlla

Databased ROM

Dynardo's concept of Databased ROM (DB-ROM), extends beyond the general definition of meta-data for concept evaluation. It is designed to be a critical component of the process

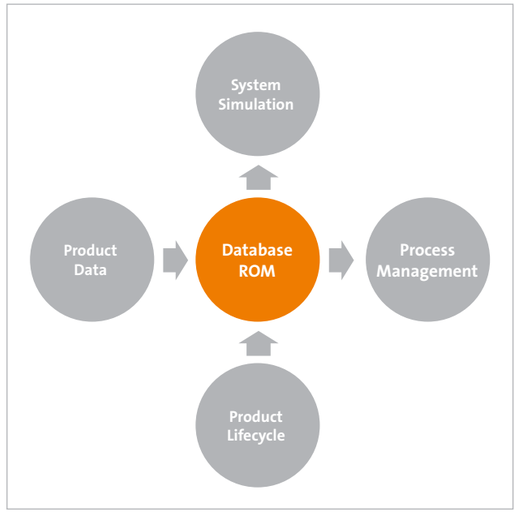

Fig. 5 : Databased ROM provides a crucial link to interfaces such as Digital Twin, System Design, Process Workflows and Product Lifecycle Management.

server, acting as interfaces between several hubs of Product Development cycle. In this regard, Dynardo's DB-ROM can serve as a source of information using defined protocols between PLM systems, Big Data sources and participating CAx processes. It follows Dynardo's 'One-for-All' principle and is designed to be easy, safe, intuitive resource which can be

The vision of optiSLang's meta-model as a Databased-ROM hub is vividly illustrated with the automated optimization study of a machine tool cascade controller by CADFEM GmbH. The study uniquely highlights process abstraction, system simulation capabilities and integration into already created workflows using Simplorer.

Further info: http://bit.ly/2bwoUnp

easily retraced at various junctures of VPDP. Dynardo's DB-ROM is physics and environment independent and can function seamlessly in a co-simulation environment, as a monitor of IoT process. This allows the user to build a simulation-controlled Robust Design Development module where design robustness and optimization could be handled at the entry-point of virtual product development.

Virtual Product Development – CAx workflows, RDO, calibration and PLM

With the introduction of Lean Management in Product Development Processes, the role of CAx processes has become commonplace. Although hardware-based product tests form the core processes in a modern product development envi-

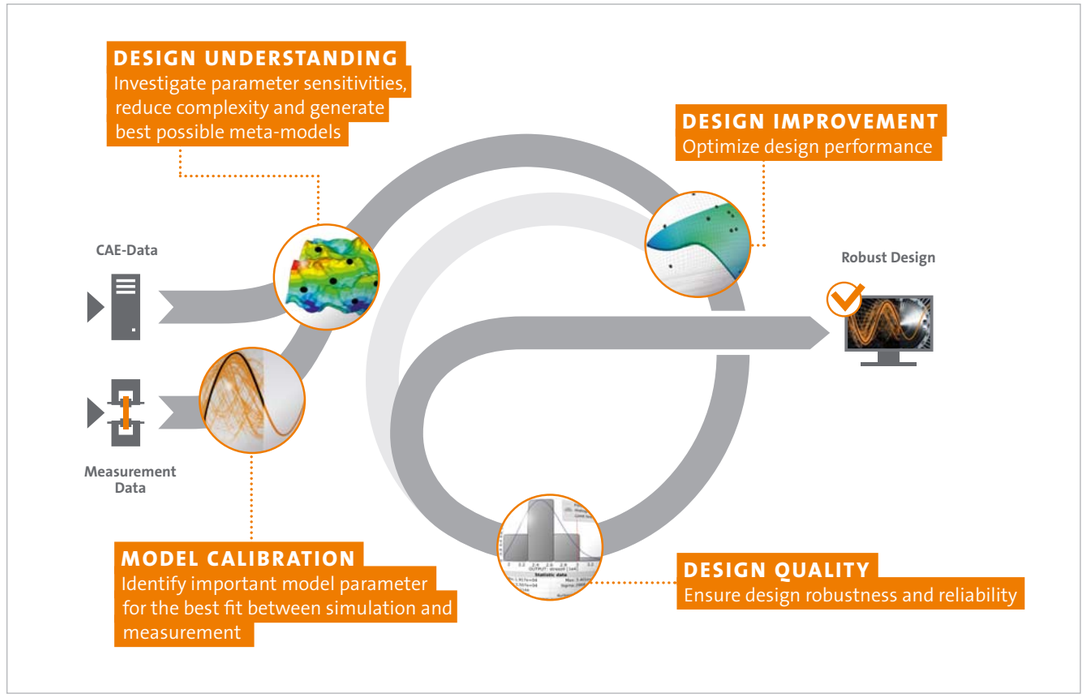

Fig. 6 : Dynardo's products support Virtual Product Development cycle through various gates and milestones in the PDP.

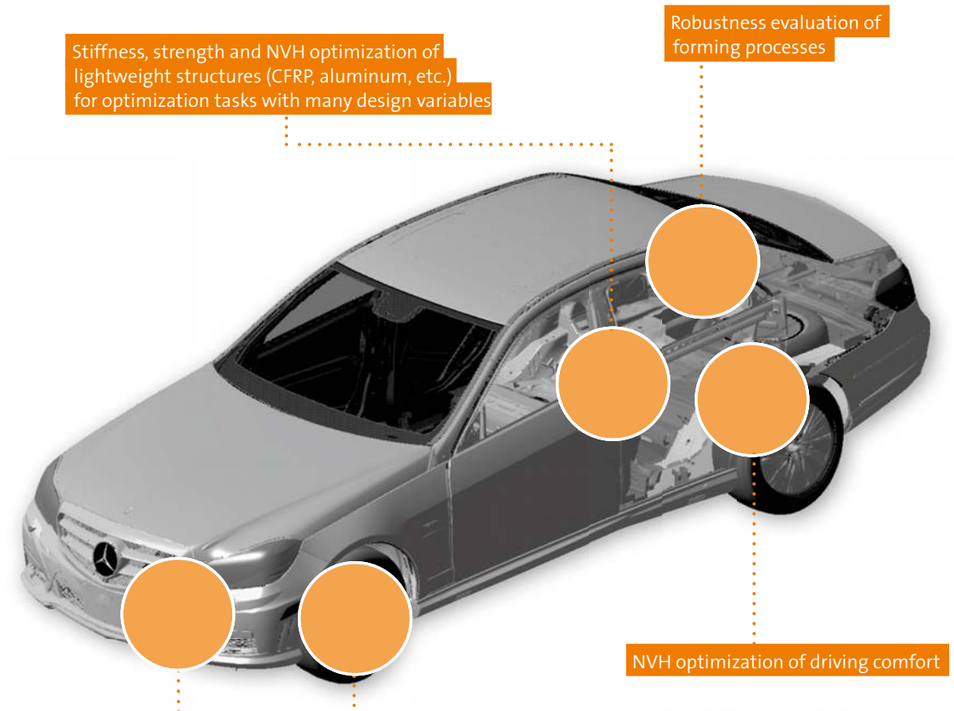

Fig. 7: optiSLang is being used to perform design optimization across the automotive sector (Courtesy Daimler AG)

ronment and simulation – based approaches still require real-world validation, the advent of robust CAE processes with high-end HPC systems has put numerical simulation at the forefront of PDPs. Herewith, Dynardo's 'One-for-All' philosophy extends beyond specific physical phenomena and bridges the gap between real and virtual world environment with integration modules for Hardware, PLM, VPDPs, etc. In this context, optiSLang provides an interface to bring various tools in VDP to a common platform and serve as an explicit parameter management system for process integration solutions.

The next generation of optiSLang provides direct access to the parametric modeling of CAE environments like ANSYS or SimulationX as well as to programming environments like EXCEL, MATLAB or Python. It allows users to combine several tools in sequences and iteration loops. As a control tool, optiSLang circumvents the errors associated with failed designs due to missing licenses, unfeasible geometries and other inconsistencies. optiSLang extends above and beyond a single OS-based platform, i.e. modules compatible with Windows, Linux and HPC as well as Cloud computing are provided. The following section gives an outlook of software application in the various phases of PDP:

1. Model Calibration
When Siemens AG attempted to estimate the pretension loss due to bolt temperature, optiSLang was chosen to perform FE-model calibration and subsequent Robust Design Optimization. Using optiSLang's Extraction Tool Kit (ETK), all post-processing results were gathered and the application of signal processing tools in optiSLang enabled the identification of calibrated FE-model parameters. Based on the calibrated model, a subsequent RDO was carried out to complete the optimized design process-chain. Additionally, optiSLang was identified as an efficient module to investigate robustness and optimization in the daily design process.

Further info here: http://bit.ly/2bzXexY

2. Automated CAx Workflows
Product Engineering at Robert Bosch GmbH and Daimler AG has seen optiSLang at the entry-point of VPD. As a driver of

CAx processes, optiSLang has been used to generate automated workflows to address the various phases of CAE modules and bridge interfaces between CAD-CAE-CAM hubs. Automation of CAE modules along with available HPC technologies has accelerated product development to new levels and with features such as FMU export, Excel add-in, SPDM extensions, optiSLang is leading the race for next generation process integration schemes. Moreover, custom integration options with 3rd party softwares such as Comsol, GT-Suite, NX, Simulation X has widened the scope of application of optiSLang across various domains and sectors.

Further info here: http://bit.ly/2cc7XML

3. Robust Design Development
Robust Design Optimization with optiSLang is based on 'minimum input – effective development' philosophy. The goal of CAE-based optimization in virtual prototyping is often to achieve an optimal product performance with a minimal usage of resources (e.g. material, energy). This pushes designs to the boundaries of tolerable stresses, deformations or other critical responses. Conducting a sensitivity analysis, multidisciplinary optimization, robustness evaluation and reliability analysis with optiSLang enables the user to quantify risks, identify optimization potential, improve product performance, secure resource-efficiency, save time to market, etc. The Robust Design Optimization (RDO) combines CAE-based optimization with robustness evaluation and allows a product optimization with a synchronized assurance of robustness. A classica example involves our customer story from Daimler AG with the analysis of shape accuracy of single and assembled parts. A process-workflow was created to simulate a S-rail forming and joining process-chain to analyze the sensitivity of the model parameters. As a result of the investigation and the use of meta-models for sensitivity analysis, the calculation time for RDO of forming and forming station parameters were reduced and the translation effects of S-rail plates could be better understood.

Further info here: http://bit.ly/2bncGP4

4. PLM Integration
Integration of DB-ROM or CAx database into PLM systems still remains a challenge since interfaces with multiple software support are not yet supported. However, optiSLang provides a feasible solution to create parametric process workflows with automatic integration to PLM systems such as ANSYS EKM, Siemens Teamcenter, etc. At the same time, optiSLang allows for seamless integration into existing process workflows. So whether it is transfer of data between Big Data Analytics and CAx processes or the assimilation of VPDP within the complete manufacturing cycle, optiSLang provides a one-stop solution for access to and from PLM systems.

Further info here: http://bit.ly/2cT31Os

Conclusion

The new generation of optiSLang has moved beyond the conventional general purpose tool for variation analysis. All in all, optiSLang provides solutions to challenges prevalent in each phase of PDP. With its modular nature, the software can be moulded or upgraded based on industry's needs. With newer and other user-customizable features already on the roadmap, optiSLang is showing great promise to become a powerful bridge between next generation CAx (CAD, CAM, CAE) processes.

The key points, in view of a successful Product Development process, can be highlighted under the following:

- Automation and Standardization of VPDP workflows
- Parametric studies and Robust Design Optimization
- Flexibility and Extensibility
- Supporting continuous improvement
- Enabling collaborative work

Authors //
Animesh Ranjan, David Schneider (Dynardo GmbH)