# 'Engineer by Objective' Transforms Acceptable Designs into Benchmark Products

Why PIDO is needed
to develop better products faster

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Empower your experience

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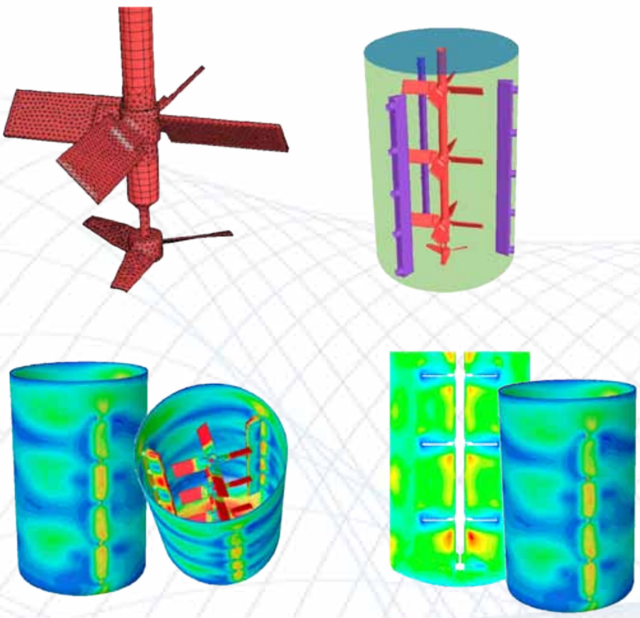
# ‘Engineer by Objective’ Transforms Acceptable Designs into Benchmark Products

It not only takes high quality and clear differentiation to ensure new products excel in today’s competitive market. Manufacturing companies should also ‘get it right first time’ to maximize product profitability. They must do this in a lean environment with intense, continuous pressure to develop better products faster.

Manufacturers can no longer afford not to use virtual prototyping in their product development process, if they want to stay in the running altogether. Leading the market and picking up the habit of timely developing benchmark products, requires them to go one step further and adopt an ‘Engineer by Objective’ approach. A key enabler of this approach is the use of process integration and design optimization (PIDO) technologies that better leverage virtual prototyping investments.

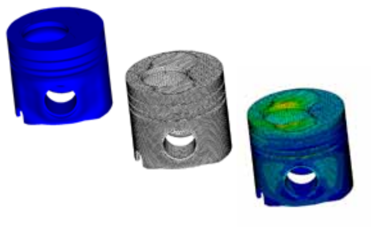
Using PIDO technologies, design engineers gain up-front insight into the product performance that is within reach. In addition, PIDO automatically directs virtual prototyping toward feasible design candidates that deliver benchmark performance, while taking into account all relevant design constraints. Industry-leading users of PIDO solutions report design time savings averaging over 30%, while achieving 10% or more design performance improvements.

*Using Optimus, Snecma (Safran Group) realized a 2% efficiency increase of its HPC rotor blade aero-mechanical design process. Keywords are process integration and multi-objective design optimization.*



*Design engineers searched for the impeller locations that would minimize liquid precipitation in a 600,000 liter mixing tank. Optimus allowed them to reduce the critical precipitation area by 71%, and minimize maintenance downtime.*

# Virtual prototyping changed the development process

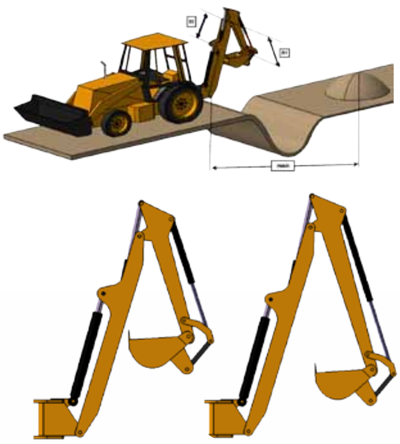


*Virtual prototyping allows engineers to evaluate the functional behavior of a new product design, before building the first physical prototype.*

## Gaining a deeper understanding of product behavior

Over the past decades, leading manufacturing companies integrated virtual prototyping into their product development process. Virtual prototyping allows these companies to front-load simulation in the development process and acquire deeper insight into product behavior, enabling them to deliver higher-quality products and drive innovation.

Engineering departments are using simulation technologies to evaluate the functional performance of new product designs on a virtual prototype – from concept to validation. They set up simulation models and adapt them incrementally in search of the target design objectives, largely relying on their engineering expertise and experience.



*A significant amount of time is spent on implementing the model changes required to evaluate multiple design variants, as well as on handling and manipulating the data for each simulation run.*

## Simulation increasingly accessible to the engineering community

Advances in computer hardware enable simulation software to deliver more accurate results faster, in turn raising the complexity level simulation software can deal with. As a result, the trustworthy evaluation of the functional performance on a virtual prototype (in terms of stress, flow, noise, vibrations, durability, crash, emissions, etc.) became increasingly accessible to the engineering community.

## Requiring fewer, better-targeted physical testing campaigns

Virtual prototyping also repositioned the role of physical testing. It helped establish a development process requiring fewer physical prototypes at a later stage in the development process. The information provided through virtual prototype simulation leads to better-targeted test campaigns, increasing the overall efficiency of physical prototyping. Instead of serving solely as a troubleshooting tool, carefully planned testing is performed on a limited number of physical prototypes to validate and refine the designs and to calibrate simulation models with real-world test data.

# Yet, virtual prototyping not entirely lives up to expectations

## Hurdles slowing down virtual prototyping

In spite of all advances, virtual prototyping remains a time-consuming process involving a considerable amount of trial and error. In practice, design engineers mostly perform manual design iterations in search of the target design objectives. A significant amount of time is spent on implementing the related model changes, as well as on handling and processing the data for each simulation run.

Engineering departments typically use a variety of commercial, legacy and in-house developed software tools. Even if virtual prototyping simulations are executed automatically, the processing and interpretation of the vast amount of data generated by various software tools remains time consuming. This implies that only a limited number of design iterations can be evaluated in the available development time frame – considerably reducing virtual prototyping's window of opportunity to deliver benchmark performance.

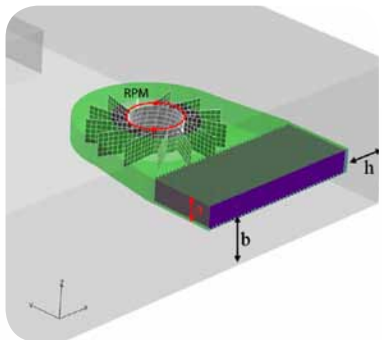
*When detecting unsatisfactory design performance, engineers modify the virtual design by changing the relevant design parameters and re-run the related simulation(s). Temperature peaks observed in a laptop can for instance be reduced by changing the location and characteristics of the laptop's active heat sink in the virtual prototyping model.*

## Struggling with trade-offs and constraints

In the process of engineering new products, development engineers always face conflicting design objectives for which they need to find an acceptable trade-off. They also need to take into account the design constraints imposed by manufacturing realities and more stringent regulatory and standardization requirements.

Virtual prototyping is essentially an iterative process in which simulation models are incrementally adapted. This implies it can only be verified afterwards whether model changes really deliver improved design performance and respect all design constraints. Indeed, specific design constraints and performance objectives cannot be included up-front as an integral part of the process.

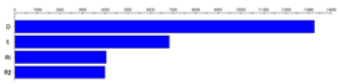
The actual development progress therefore strongly depends on the engineering judgment and experience of the design engineers. Virtual prototyping helps them come up with improved and acceptable product designs, but its limitations typically prevent engineers to timely achieve design performance targets and fulfill all design constraints. Such development uncertainties make it difficult to commit to a product capabilities roadmap, and may cause lengthy and costly product fixes relatively late in the process.




*The challenge is to find a trade-off between flow speed and flow uniformity (cooling performance) on the one hand, and fan torque (power consumption) on the other hand, taking into account contraints with respect to fan position and dimensions.*

# ‘Engineer by Objective’ makes the necessary turnaround

*In a CFD related ‘Engineer by Objective’ project, a leading German vehicle OEM optimized a diesel engine using Optimus, delivering 8% higher engine power.*



*Optimus design exploration capabilities helped supplement tablet manufacturer Asahi balance ease of swallowing and production machine durability. Tablet diameter was identified as the most influential design parameter with regard to the pressure resistance of the tablet punches. Key insight acquired through Optimus post-processing capabilities enabled Asahi engineers to design more durable and consumer-friendly supplement tablets.*

## Directing and automating virtual prototyping

What is needed to transfer acceptable product designs into benchmark products, is an ‘Engineer by Objective’ approach. This approach – based on process integration and design optimization (PIDO) technologies – changes the way virtual prototyping simulation is applied throughout the product development process, and provides the agility that is needed to flexibly adapt product designs in response to new market trends.

‘Engineer by Objective’ starts from the functional performance targets identified as critical factors for a successful product. Following this approach, engineers identify the design parameters that have the highest impact on the most critical performance objectives. Then they trace the design parameter values that define the product design which best matches the critical performance targets and takes into account all relevant design constraints.

PIDO’s automation and design exploration technologies are at the core of a nimble and responsive development process. Users of PIDO solutions report design time savings averaging over 30%, while simultaneously improving design performance by 10% or more. The ‘Engineer by Objective’ approach provides them with the capability to create superior products in time. This not just drives increased sales and profits, but also significantly improves product branding. Customers reward companies that timely and appropriately respond (or even pre-empt) to their changing needs and expectations.

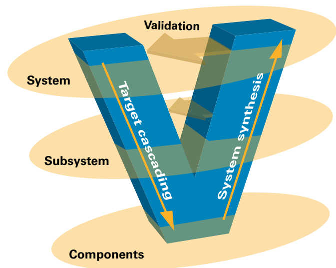
## Supporting a more transparent development process

More and more products have evolved into complex systems that are a combination of an increasing number of mechanical, electronic and software components – very often to be offered in multiple variants.

To deal with this increasing complexity and to define a uniform product development procedure, the 'V'-model concept is widely used in industry to enable a model-based systems engineering approach that emphasizes the importance of objective-driven engineering. The left side of the 'V' represents the cascading of product performance objectives down to design objectives and constraints on the level of the individual subsystems and components. The right side of the 'V' represents the integration of subsystems and components into a system model, and the validation of those integrated models.

The V-model concept improves the transparency of the product development process, and delivers the flexibility and agility that is needed to flexibly manage variant designs. It provides design engineers with a detailed understanding of the complex interactions between components and subsystems, and allows them to identify the design parameters that have the highest impact on product performance.

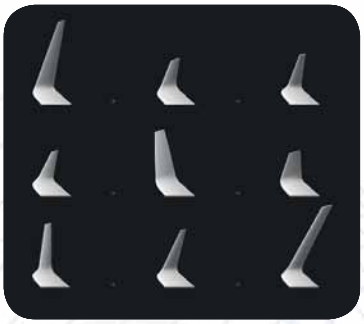
The 'Engineer by Objective' approach, powered by PIDO technologies, fits extremely well with the V-model concept. The use of PIDO technologies provides a framework for managing the development tasks associated with both the left and the right side of the "V", and validating the virtual prototyping models with the available test data.




*To deal with increasing product complexity and to define a uniform development process, the V-model concept is widely used in industry. This approach enables a model-based systems engineering strategy that emphasizes the importance of objective-driven engineering.*

*TNO design engineers sketched the workflow in the Optimus' graphic process integration editor - connecting the available simulation tools and data models into a formal simulation workflow.*

*For a high-end manufacturer of in-car electronics, Optimus reduced simulation preparation, execution and reporting from 8 to 3 days, resulting in a 166% time gain.*



*Using Optimus' DOE and RSM capabilities, Fuji Heavy Industries development engineers grasped the impact of winglet shape variations on aircraft performance up-front.*

# PIDO technologies empowering objective-driven engineering

## Simulation robot eliminates repetitive manual work

PIDO technologies offer the unique capability to automate the design process by formalizing the simulation workflow. Typically, design engineers sketch the workflow in a graphic process integration editor - connecting the commercial, legacy and in-house simulation tools and data models. This is also where design engineers define the design parameter ranges as well as the design objectives and constraints.

A formalized simulation workflow allows PIDO solutions to act as a 'simulation robot' that automates and orchestrates simulations in a transparent way without user intervention. Internally, PIDO takes the necessary steps to parameterize the workflow and automate the required design variable substitutions within the defined design parameter ranges.

When executing a simulation campaign, the simulation robot frees users from repetitive manual model changes, data processing and performance evaluation tasks. This allows similar procedures to be repeated automatically hundreds or thousands of times.

## Simulation process capturing consolidates engineering knowledge

Many benefits of PIDO deployment stem from the capability to systematically capture simulation know-how. In doing so, manufacturing companies build up an information base of best practices, and eliminate the need for design engineers to re-create simulation processes on their own each time from scratch.

A structured PIDO approach enables those companies to standardize on superior development processes across the entire enterprise and consolidate the intellectual assets representing their most valuable resources.

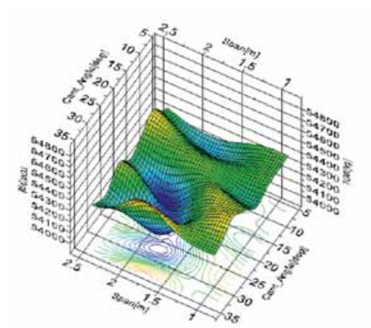
## Up-front exploration of the entire design space

Design space exploration techniques provide up-front insight into the unexplored design potential.

Dedicated Design of Experiments (DOE) methods define a minimum set of well-chosen virtual experiments to sample the design space most effectively, while the simulation robot automates the execution of this experiment set. By post-processing the DOE results, design engineers discover the relative importance of the design parameters and constraints.

Response surface modeling (RSM) condenses complex simulations into so-called surrogate models, using the results of virtual experiments defined by DOE. Surrogate models are very effective in evaluating new designs without requiring a full detailed analysis, or to provide valuable information on the relationship between design parameters and functional performance metrics.

DOE and RSM techniques help design engineers fully and rapidly grasp the unexplored design space potential early in the development process. As a result, they gain up-front insight into the design performance that is actually within reach, providing knowledge on how to trade off multiple, often conflicting design objectives.



*For Fuji Heavy Industries, the hills and valleys on an Optimus RSM provided valuable insights into non-linear winglet physics.*

## Automated search for designs matching the target objectives

Subsequently, an automated and coordinated search identifies the optimum design parameter values. This approach of tracing design candidates that best match performance objectives and respect design constraints, is significantly faster than any iterative process delivering an acceptable design.

Advanced optimization algorithms resolve the toughest multi-disciplinary optimization challenges. Throughout the optimization process, PIDO solutions inform design engineers on the ongoing optimization progress and allow them to steer the process based on their extensive experience.

Regardless of product complexity, design optimization searches and finds those design candidates that deliver benchmark performance. After a further evaluation of the proposed design candidates, design engineers can pick the most optimal design option and move on to the next stage of the development process.

*Skoda Power used Optimus to achieve 16% reduction in stress peak values in steam turbine blades. The average stress in sensitive blade regions and the contact pressure between rotating parts also decreased.*

## Improving return on software and hardware investments

Simulation campaigns powered by PIDO solutions take maximum advantage of the available computing resources by distributing simulation jobs in parallel. Thanks to the integration with resource management systems, PIDO technologies allow virtual prototyping simulations to be submitted to and balanced over the available computation resources in a heterogeneous ICT infrastructure - without any user intervention. Simulation campaigns are fully parallelized, resulting in a significant reduction of the total elapsed time.

Making more effective use of the available software and hardware infrastructure, increases the number of virtual prototyping simulations that can be completed in the available development time window.

*To speed up the execution of a simulation workflow consisting of time consuming virtual experiments, Optimus manages parallel execution on an array of CPUs.*

# Making the right PIDO choices

*Sogeti High Tech engineers streamlined the production process of a center wing box (CWB) factory. They ran Optimus to trace the optimal DELMIA® factory configurations for the required monthly production rate, and exchanged data directly through MS Excel®.*

*TNO used Optimus to automate and direct SIMCAT exhaust after treatment simulations with the MATLAB® based SIMCAT software toward an optimal emissions controller design for heavy duty trucks - meeting Euro VI emissions standards faster and at reduced cost.*

*Asahi engineers used Optimus to reveal the best possible design trade-off between ease of swallowing and durability while developing new supplement tablets – using ANSYS to perform tablet hardness and punching strength simulations.*

More and more manufacturing companies are implementing an 'Engineer by Objective' development strategy to improve product quality, save time and reduce cost. When selecting a powerful and user-friendly PIDO software solution to support this development strategy, companies are advised to benchmark these solutions against a checklist of critical capabilities to ensure a successful implementation:

## *Industry-proven technology*

**State-of-the-art methods**

The availability of industry-proven, state-of-the-art design exploration and optimization methods is a critical enabler of a successful PIDO solution deployment. It is important that the available methods have clearly demonstrated the capability to successfully deal with many diverse real-world applications.

**Robust deployment**

The robustness of the supported methods is equally important. Highly robust algorithms should not require excessive manual parameter specification to start the process and perform the job successfully. Design engineers working with robust algorithms are therefore more efficient, and benefit from a shorter learning curve.

## *Effective decision support tools*

Intuitive and flexible post-processing functions are needed to turn large simulation data sets into information that supports design decisions. Effective tools will not only make it easier to eliminate non-influential design parameters and identify best design tradeoffs, but will also facilitate communication between engineering teams and management.

## *Openness*

**Flexible integration capabilities**

Open PIDO solutions enable easy integration of in-house developed models and methods for design exploration and optimization, capturing an organization's specialized engineering expertise. Such a solution flexibly integrates any combination of commercial and in-house developed technologies as part of a structured development approach.

**Easy customization, when needed**

Tailoring capabilities to match specific design processes allows design engineers to communicate with the PIDO solution using the application language they are familiar with. Embedding powerful PIDO technologies in dedicated applications keeps the focus on their engineering discipline rather than on built-in optimization technologies. This gives design engineers a further productivity boost.

### *Vendor independence*

A vendor-independent PIDO solution tends to provide an open architecture to communicate with any simulation software, including the capability to deal with any file syntax. Besides protecting the investments companies made in legacy codes and models (safeguarding their future use within the organization), such PIDO solution enables companies to deploy an ‘Engineer by Objective’ strategy irrespective of the simulation software actually used.

Benchmarking PIDO software solutions against this checklist of capabilities, helps manufacturing companies make well-informed decisions to successfully implement the ‘Engineer by Objective’ development strategy. Companies implementing this strategy benefit from the ability to perfect product designs and bring better products to market faster. By using PIDO technologies, they are able to standardize on superior development processes that are uniform across the enterprise.

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*Using MapleSim for hybrid electric vehicle modeling and Optimus to control simulation workflow execution, engineers improved fuel efficiency by 21% and legal emissions compliance by 15% in just 2 weeks.*

*Fuji Heavy Industries used Optimus to automate and couple FEM and CFD simulations to identify optimized aircraft winglet design configurations. Optimus realized a 1.2% reduction in aircraft takeoff weight for a typical mission profile at 1G cruise speed.*

**About Noesis Solutions**

Noesis Solutions, a subsidiary of Cybernet Systems Co. Ltd. in Japan, is an engineering innovation partner to manufacturers in automotive, aerospace and other advanced engineering industries. Specialized in simulation process integration and numerical design optimization, its flagship product Optimus focuses on resolving customers' toughest multi-disciplinary engineering challenges. Noesis Solutions operates through a network of subsidiaries and representatives in key locations around the world. The company also takes part in key research projects sponsored by various official organizations, including the European Commission.

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