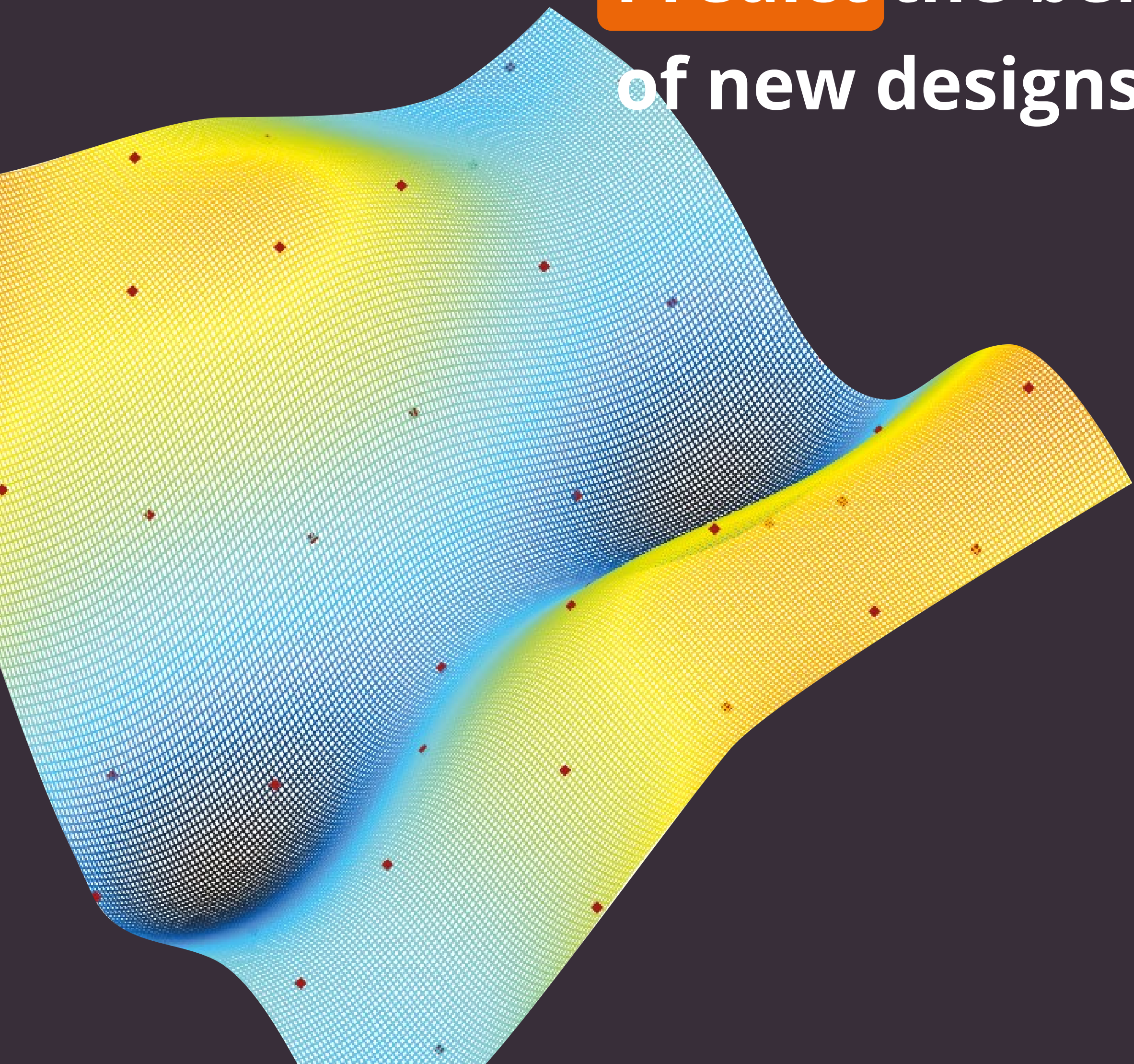
pSeven

Process integration and design optimization software

Integrate all your CAD / CAE software

Explore and optimize your product

Predict the behaviour of new designs



Why choose pSeven?

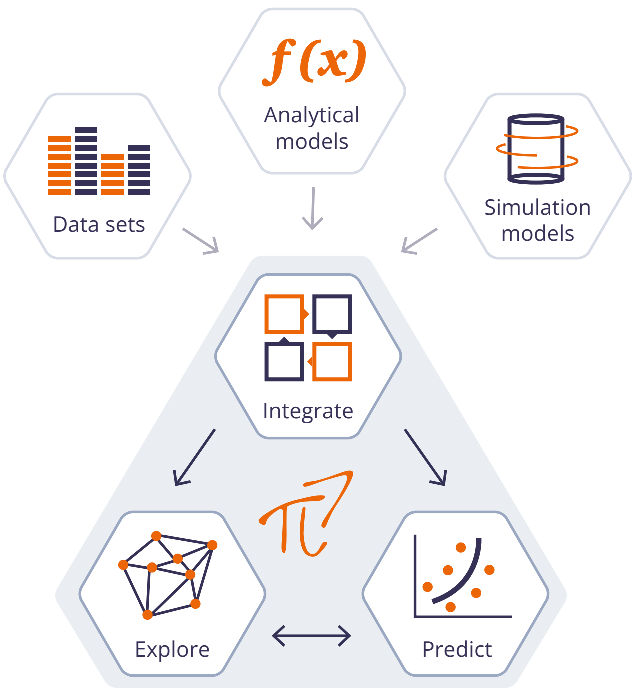
Integrate, Explore, Predict

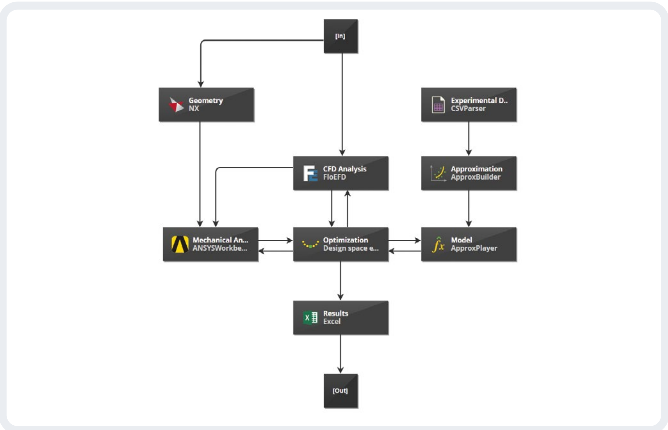
pSeven functionality covers three engineering areas crucial for modern product design:

01. Process Integration
Build a complete and automated model of your product by integrating different data sets, analytical and simulation models into a single workflow.

02. Design Exploration
Explore and optimize your model to find the best design possible.

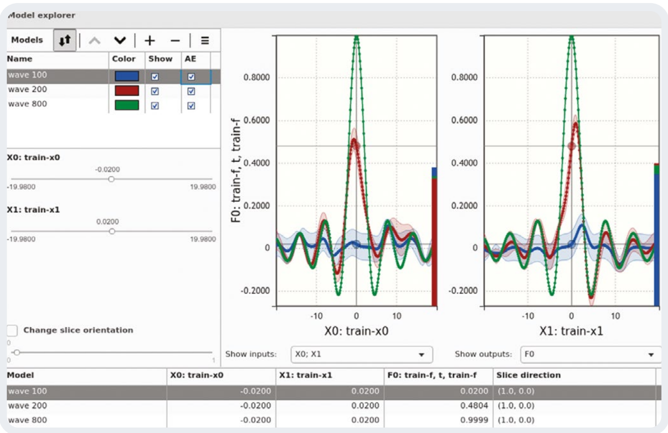
03. Predictive Modeling
Predict responses for new designs or operational regimes of the product.





Sophisticated workflow engine

pSeven workflow engine allows dealing with any level of engineering problem complexity, from a simple integration of third-party software products into a single chain to multi-level and multi-fidelity multidisciplinary optimization tasks, including looping, branching and nested workflows.



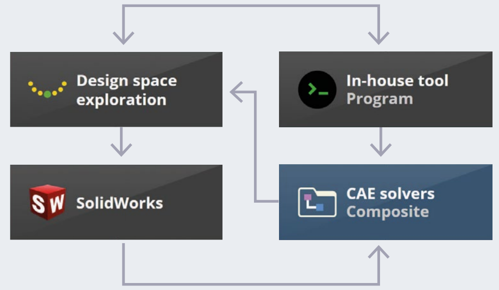
Complete toolset for Design Exploration and Predictive Modeling

Solve complex engineering problems with a complete set of highly integrated and easy-to-use tools for Design Exploration and Predictive Modeling. Automatic selection of state-of-the-art algorithms is handled by SmartSelection.

01 Process Integration

Process automation

The design process in pSeven is represented as a sequence of computations with specific execution order and conditions that are defined by a data driven approach. This is called a workflow. A workflow consists of blocks, links and global parameters and provides an intuitive and visual definition of the computation order.

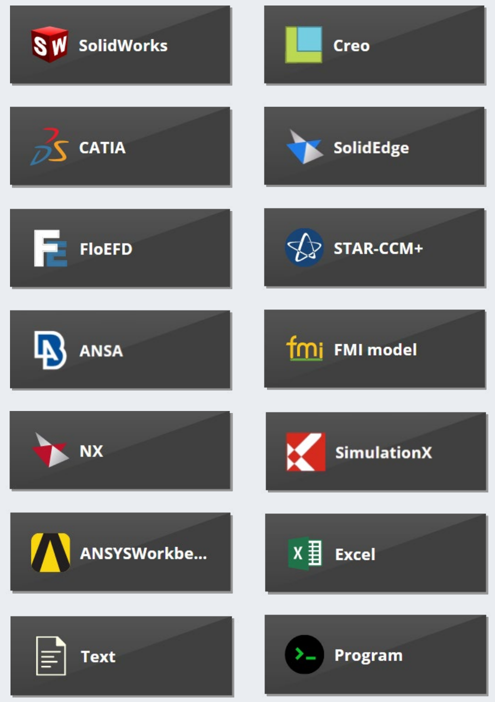


External software integration

pSeven supports convenient direct integration for major CAD/CAE systems and popular tools, like:

- SolidWorks, Creo, NX, CATIA, SolidEdge
- Ansys, FloEFD, Star-CCM+, SimulationX, ANSA
- FMI models, Excel

You can also integrate almost any other software or in-house tool with generic approach via exchange of input/output files and use of command line interface, provided by the majority of modern CAD/CAE software by default. In addition, users can develop custom direct integration blocks that uses API.



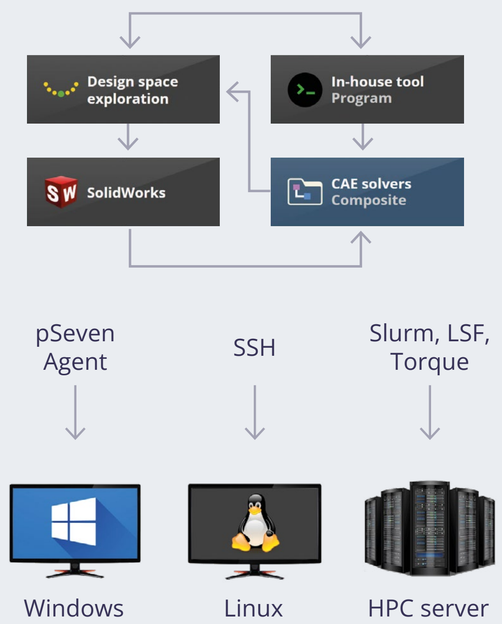
Remote execution and HPC

pSeven allows CAD/CAE remote execution on:

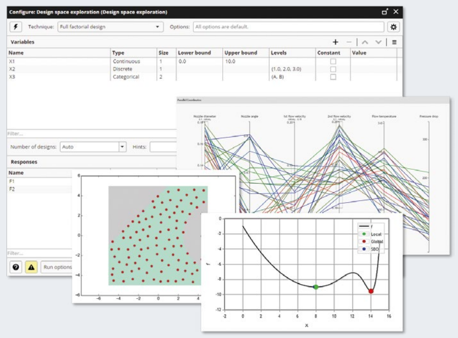
- Remote Windows machines with pSeven Agent (a standalone application).
- Remote Linux machines with SSH connection.
- HPC servers with Slurm / LSF / Torque direct interfaces.

pSeven supports HPC and parallel execution:

- Easy handling of batch input.
- Built-in support for Job Array launch mechanisms.
- Automated handling of file transfer.

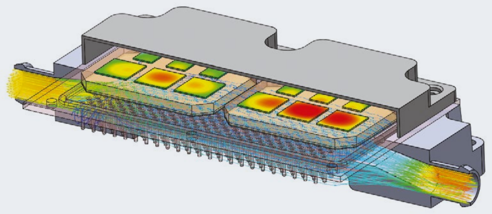


02 Design Exploration



Why do Design Exploration?

Design Exploration allows engineers to:
- Set goals and explore design alternatives.
- Perform trade-off studies and discover bottlenecks.
- Identify models parameters and ensure fit to the reference data.



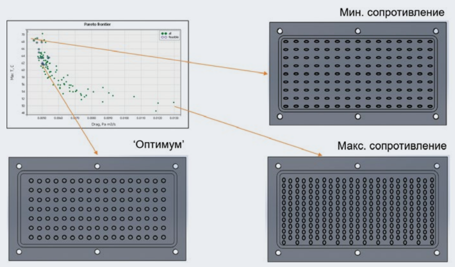
Exploration and Optimization

pSeven allows efficiently exploring model behavior with a wide range of techniques for Design of Experiments (DoE) and solving single- and multi-objective optimization tasks with both fast to evaluate analytical models and computationally expensive simulations.

Design of Experiments (DoE):
- Majority of classic and well-known algorithms.
- Unique in-house adaptive search with linear and non-linear constraints.

Design Optimization:
- Single- and multi-objective optimization.
- Linear, non-linear and implicit constraints.
- Error handling, batch processing and optimization setup during the run.
- Effective surrogate-based optimization (SBO).

Uncertainty Quantification:
- Convenient GUI to set stochastic problem with extensive list of available probability distributions.
- Uncertainty propagation and reliability analysis.

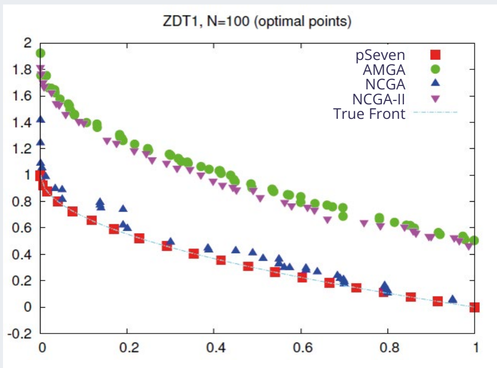


IGBT cold plate optimization using FloEFD and pSeven

SmartSelection for Design Exploration

With pSeven, instead of tedious tuning of exploration technique's internal parameters the user may simply set the basic properties of the model (if known), such as:
- Number of parameters
- Types of variables and responses
- Noisiness of responses
- Model evaluation time

After that, based on the provided information SmartSelection automatically chooses the best fitting algorithm for the task and adapts its parameters during the solution.

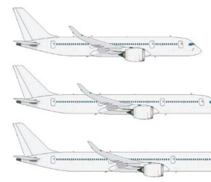


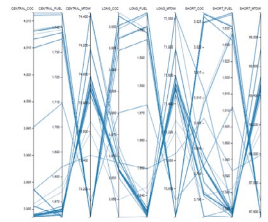
Results of ZDT1 benchmark for Gradient-Based Optimization (GBO) algorithms

Use cases

Multi-objective optimization of aircraft family

AIRBUS





Objective
Optimize a family of 3 aircraft at the conceptual design stage to ensure minimal model modification and related costs at later stages.

Challenges
- High complexity: 9 objective functions, 12 design variables, 33 non-linear constraints.
- The problem is considered unmanageable by human.

Solution
- Integration of several in-house simulation tools into a single automated process.
- Gradient-based multi-objective optimization.

Benefit
- ↑ 5% performance improvement.
- ↓ 20% design time reduction.

Mechanical support optimization with tight simulation budget

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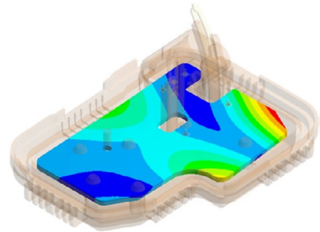
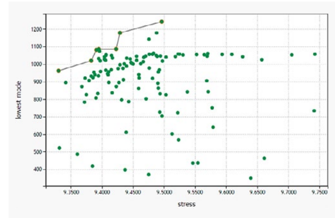




Objective
Define the PCB cover geometry so that the entire assembly is sufficiently resistant to vibration and has an acceptable level of thermo-mechanical stresses.

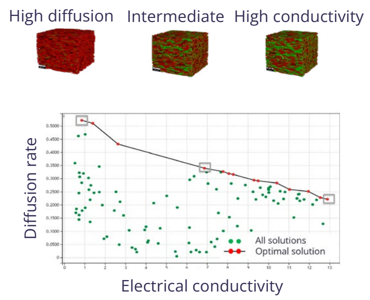
Challenges
- Many forbidden areas with non-trivial shapes where the support pins cannot be located.
- Optimization problem is multi-objective.
- Impossible to find an acceptable solution manually

Solution
- Automation of geometry and mesh generation.
- Two-step multi-objective optimization with limited evaluation budget and constraints. Simple setup thanks to Smartselection.

Results
- Full Pareto-frontier of competitive designs discovered with only 16 evaluation of the model per parameter. Best design identified from the Pareto-frontier.
- Time required to make a design choice is drastically reduced, compared to the manual search.

Lithium-ion secondary batteries microstructure optimization

SCSK



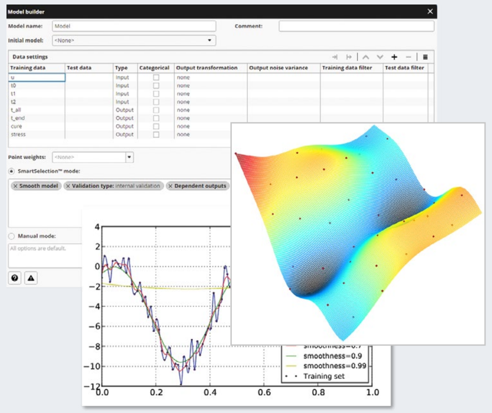
Objective
Maximize electrical conductivity and diffusion rate of battery material.

Challenges
- 6 variables of material structure, 3 constraints on particle sizes and orientations, 2 competitive targets.
- High cost of a single calculation (in GeoDict software).

Solution
Multi-objective surrogate-based optimization (SBO) with explicit budget.

Results
Pareto frontier with 14 optimal solutions for further trade-off analysis achieved with only 118 evaluations.

03 Predictive Modeling



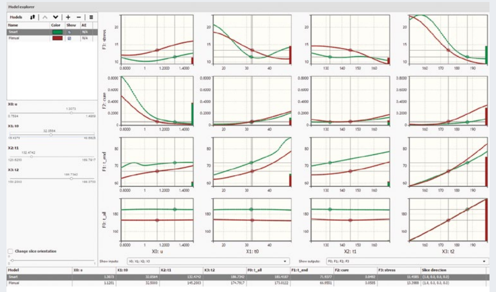
What is Predictive Modeling?

Predictive modeling is an engineering approach that helps engineers answer the following questions:

- How to predict product behavior in various conditions?
- How to process data from experiments and simulations together?

How to get simulation results faster?

At the basis, a predictive model is a function (not always an explicit formula) that allows to evaluate model's responses for given values of inputs or, in other words, a substitution (or a "black box") of existing data or simulation.

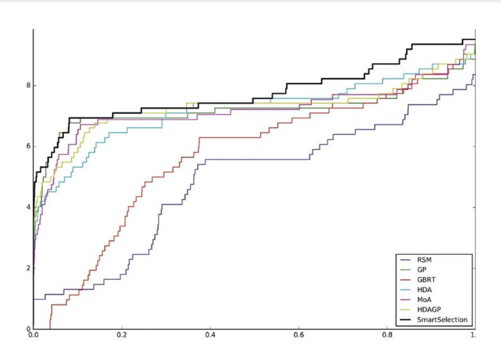


Studying input-output dependencies of a multidimensional predictive model

Building and managing predictive models

pSeven provides a variety of industry-proven techniques for Predictive Modeling that are suitable for any type of problem and given data. pSeven includes a dedicated set of tools for building and managing predictive models that allow to:

- Build fast and reliable predictive models with automatic selection of techniques.
- Validate quality, test against reference data and compare models.
- Explore behavior of multidimensional models by studying input-output dependencies.
- Export models to external files, including C source code, executable, Matlab/Octave, Excel and FMI.



Quality of predictive models built with SmartSelection vs. static techniques

SmartSelection for Predictive Modeling

For users with little experience in Predictive Modeling pSeven offers a special technique called SmartSelection. It is a built-in decision tree for automatic choosing and tuning of the most effective technique(s) for a given type of problem and data.

Set of hints and options in SmartSelection helps the user to describe the problem and desired solution from his point of view, not from the mathematical point of view. It hides techniques' complexity so that the user could concentrate on the engineering problem itself.

Use cases

Predicting combustion model parameters

Objective

Predict combustion model parameters for accurate engine modeling.

Challenges

- Fixed amount of experimental data available
- High accuracy of predictions is required.

Solution

- 1st stage: Fitting combustion parameters to existing experimental in-cylinder pressure vs. crank angle curves using optimization
- 2nd stage: Creating a model to predict combustion parameters at an arbitrary regime using known values.

Results

Fast and accurate predictive model was created that can be used in further 1D engine simulations via export to FMI.

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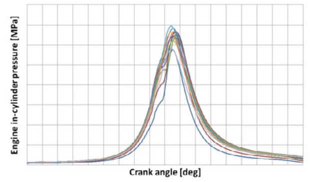


Machine learning for subsea pipeline reeling mechanics

Objective

Replace a "heavy" simulation model with a fast predictive model.

Challenges

- Wide range of variables and several objective functions.
- Expensive simulations: several hours for each single reel-pipeline configuration.

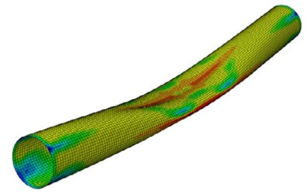
Solution

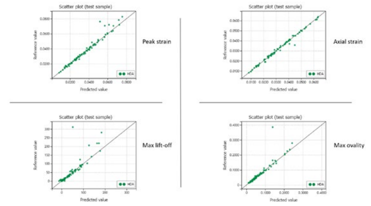
- Automated workflow to perform a DoE and check various configurations of parameters.
- Determination of effective parameters by sensitivity analysis.
- Building and validation of predictive model with SmartSelection.

Results

Accurate predictive model, which demonstrates suitable accuracy for all outputs in almost full range of values.

SAIPEM





Accurate prediction of flight loads for helicopters

Objective

Build accurate models from existing load database for automatic prediction of helicopter static and dynamic loads not initially available in the database.

Challenges

- Huge database of loads.
- Request to enable adding and updating new helicopters, load types, maneuvers and other parameters.

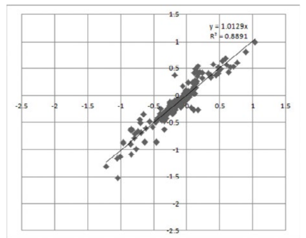
Solution

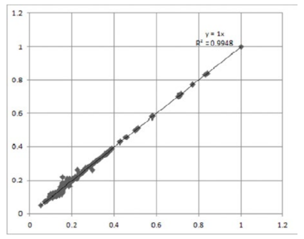
- Models for each flight configuration were built and validated in pSeven to estimate their predictive power.
- Predictions compared to existing measurements to evaluate accuracy.

Benefit

- 50% of missing loads may be calculated using predictive models with sufficient accuracy (< ±20%).
- Reducing time and workforce needed for such calculation.

AIRBUS





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