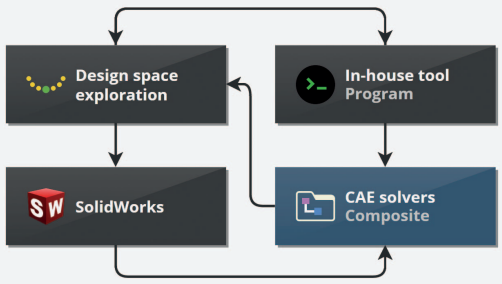
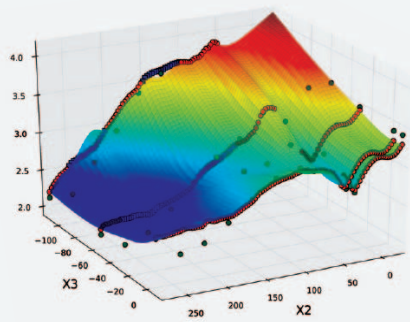
EXPLORE AND OPTIMIZE YOUR DESIGNS

pSeven

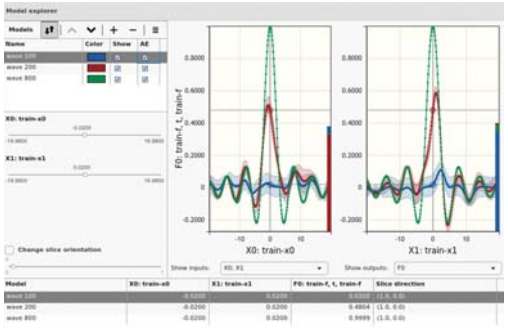
BY

DATADVANCE



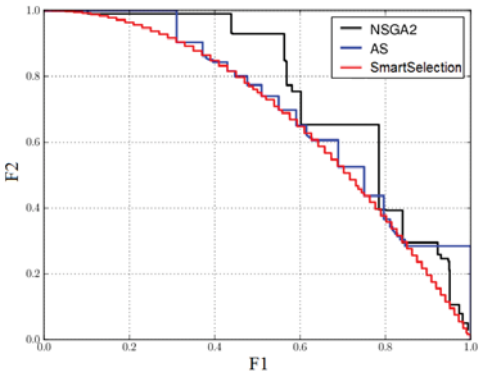


WHY CHOOSE PSEVEN?



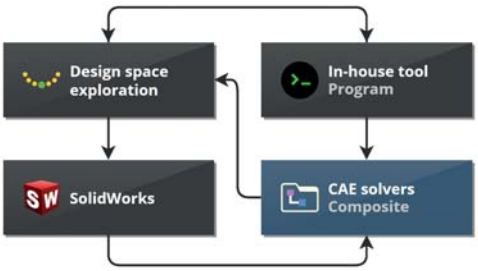
Complete Toolset for Design Exploration & Predictive Modeling

Solve complex engineering problems with a full set of highly interconnected tools for Design Exploration and Predictive Modeling in an easy-to-use graphical user interface.



State-of-the-Art Algorithms

Significantly reduce design lead time and improve your product characteristics with automatic selection of advanced algorithms and techniques for Design Exploration and Predictive Modeling.



Powerful Workflow Engine

Formalize your product development processes and improve collaboration between different departments with a powerful workflow engine and deep integration capabilities.

From a technical point of view

- Unique, fast and efficient optimization algorithms
- Innovative techniques for predictive modeling
- Automatic selection of the most efficient technique for a given problem and data
- Powerful workflow engine for process integration and automation

From a business point of view

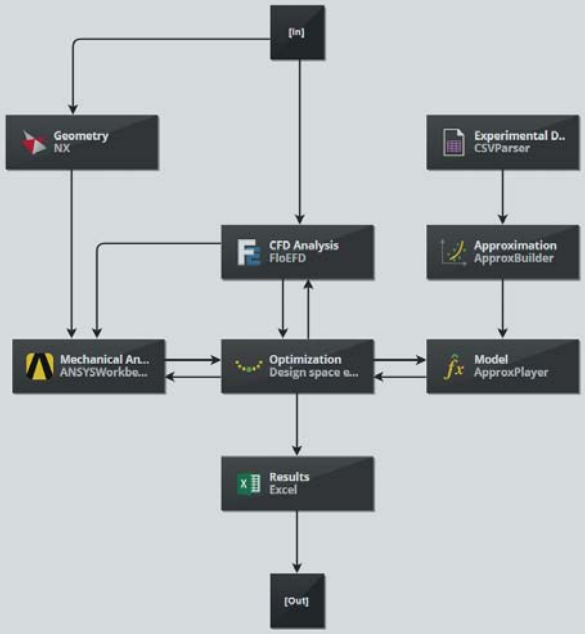
- Reduction of cost-intensive physical and computational experiments
- Reuse of available in-house engineering data
- Improved collaboration between different engineering departments

AUTOMATION & 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 computation order.

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



External Software Integration

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

- ANSYS Workbench, FloEFD, Star-CCM+
- SolidWorks, NX, Creo, CATIA, Kompas-3D
- FMI models, Excel
- and others

You can also integrate almost any other software or in-house tools via input/output files exchange and use of command line interface, provided by the majority of modern CAD/CAE software by default.

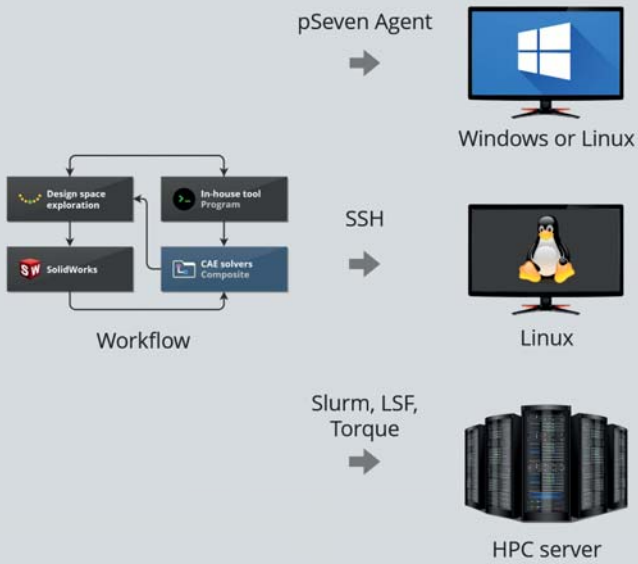
Remote Execution & HPC

pSeven allows CAD/CAE remote execution with:

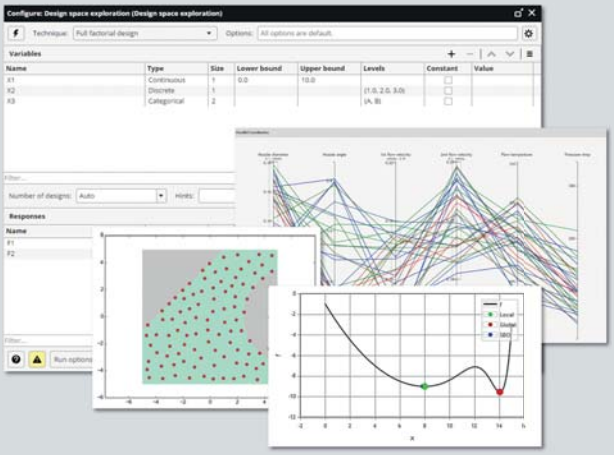
- pSeven Agent (a standalone application) on remote Windows and Linux machines
- SSH connection on remote Linux machines
- Direct interfaces with Slurm, LSF and Torque on HPC servers

pSeven supports HPC and parallel execution:

- Easy handling of batch input
- Built-in support for Job Array launch mechanisms
- Automation of data synchronization



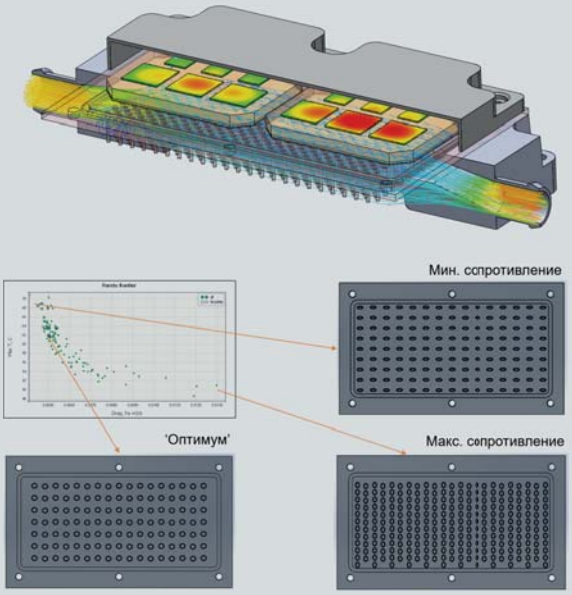
DESIGN EXPLORATION



Why Do Design Exploration?

Design Exploration allows engineers to:

- Develop trust in their models
- Explore design alternatives
- Perform trade-off studies
- Discover bottlenecks
- Identify models
- Set goals



IGBT cold plate optimization using FloEFD and pSeven

Exploration & 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 problems with both fast to evaluate analytical models and computationally expensive simulations.

Design of Experiments (DoE):

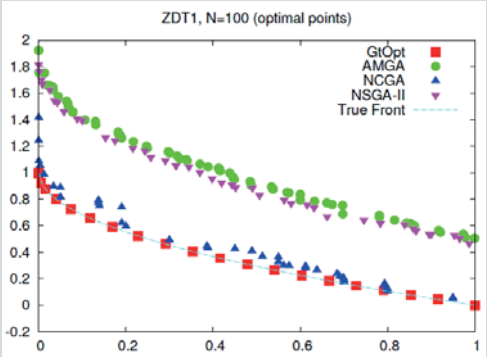
- Majority of classic and well-known algorithms
- Unique in-house adaptive search with linear and non-linear constraints

Design Optimization:

- Single- and multi-objective
- Linear and non-linear constraints
- Error and noise handling
- Effective Surrogate-Based Optimization (SBO)
- All possible Robust Design Optimization (RDO) formulations

Uncertainty Quantification:

- Convenient GUI for OpenTURNS
- Uncertainty propagation & reliability analysis



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

SmartSelection for Design Exploration

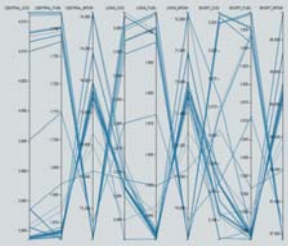
With pSeven, instead of tedious tuning of exploration technique internal parameters the user has to simply set the basic properties of the model (if known), such as:

- Model dimensionality
- Types of variables and responses
- Noisiness of responses
- Model evaluation time

After that type of technique is suggested based on the provided information. During the solution all specific algorithms are chosen automatically and adaptively by SmartSelection.

Multi-Objective Optimization of Aircraft Family

AIRBUS



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

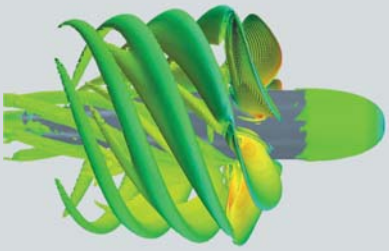
Challenges
- High dimensionality: 9 objective functions, 12 design variables, 33 non-linear constraints
- The problem is considered unmanageable by human.

Solution
- Gradient-based multi-objective optimization
- Integration of in-house simulation tools.

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

Optimization of Marine Propeller Shape

1894



Objective
- Increase propeller's efficiency at a fixed mode with strictly specified constraints.

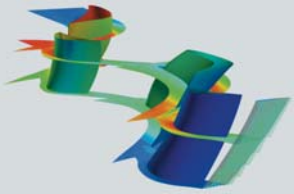
Challenges
- >100 parameters describing propeller blade
- Time-consuming simulation in STAR-CCM+
- Various auxiliary software involved.

Solution
- The number of parameters of propeller shape reduced to 23 with Flypoint Parametrica
- pSeven allowed to integrate all the software into a single workflow and solve an optimization problem with constraints.

Benefit
- Propeller's efficiency increased by ↑ 1.5%.

Multistage Steam Turbine Gas Path Optimization

THE URAL TURBINE WORKS



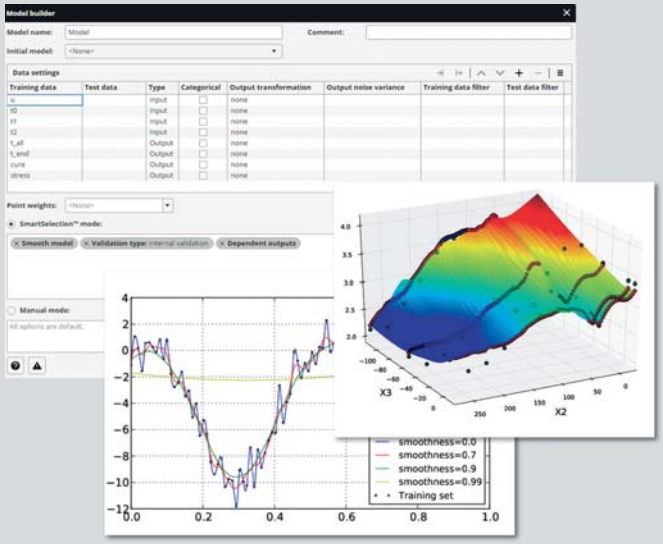
Objective
- Maximize the efficiency of High-Pressure Cylinder (HPC) and Intermediate-Pressure Cylinder – 1 & 2 (IPC1, IPC2) with geometry and stress constraints satisfaction.

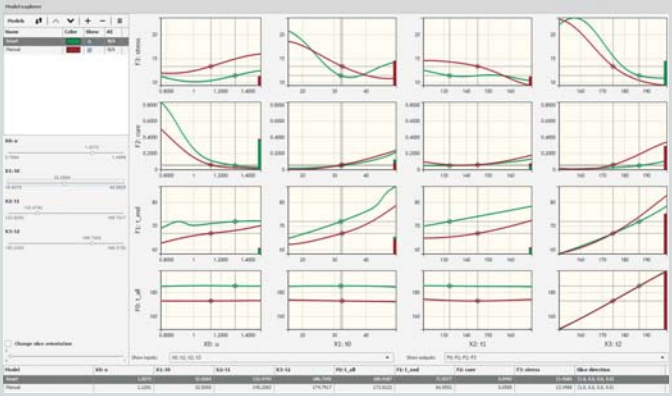
Challenges
- High dimensionality: HPC (69 parameters), IPC-1 (90 parameters), IPC-2 (72 parameters)
- Heavy CFD simulations in ANSYS CFX on HPC cluster.

Solution
- Local Gradient-Based Optimization is used.

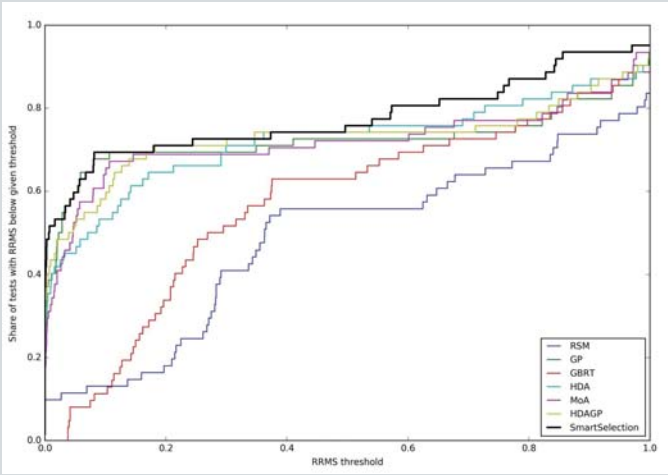
Benefit
- Cylinders efficiency boosted by↑ 2%-4%.
- Capacity increased by ↑ 3%-6%.

PREDICTIVE MODELING





Studying input-output dependencies of a multidimensional predictive model



Quality of predictive models built with SmartSelection vs. static techniques

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 use huge data samples and simulations faster?

At the basis, a predictive model is a complex polynomial that describes model's response surface or, in other words, a substitution (or a "black box") of existing data or simulation.

Building & Managing Predictive Models

pSeven provides a variety of industry-proven predictive modeling techniques 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 robust predictive models with an automatic selection of techniques
- Validate quality, test against reference data and compare models
- Explore behavior of multidimensional models with studying input-output dependencies
- Export models to external files, including C source code, executable, Matlab/Octave, Excel and FMI.

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.

Predicting Combustion Model Parameters

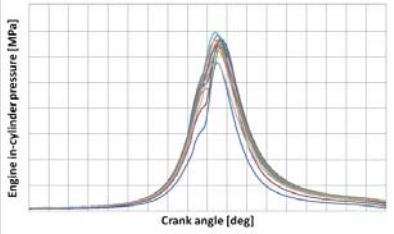
Objective
- Predict combustion model parameters for accurate engine modeling.

Challenges
- Fixed number 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.

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

MITSUBISHI MOTORS



Accelerated Fitting of Tire Dynamics in Formula One

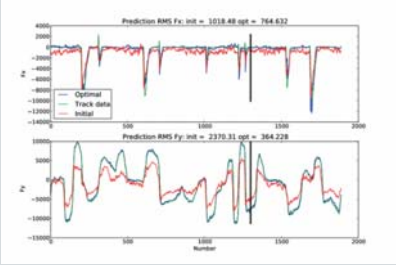
Objective
- Reduce fitting time of tire dynamics model from 20 hours to ≤ 1 hour.

Challenges
- Dynamics of tires is described by Pacejka's "Magic Formula" that contains 80 parameters
- Parameters depend on specific driving conditions and are fitted using track data

Solution
- Original Excel implementation of "Magic Formula" is replaced with a fast and accurate predictive model

Benefit
- Fitting time reduced to ~10 minutes: more than ↑ 100 times faster!

SAHARA force india formula one team



Accurate Prediction of Flight Loads for Helicopters

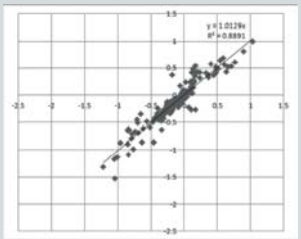
Objective
- Build accurate models from existing load database for automatic prediction of missing helicopter static and dynamic loads.

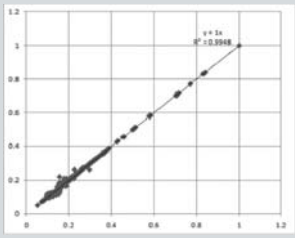
Challenges
- Huge database of loads
- Possibility to add or update new helicopters, load types, maneuvers and other parameters is to be provided.

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 HELICOPTERS





DATADVANCE

About Us

DATADVANCE is an independent software developer that offers its customers software solutions and consulting services for intelligent design exploration and predictive modeling. We collaborate with leading global software vendors, research centers and universities to continuously innovate and improve our products.

Our Origins

DATADVANCE originates from joint projects between Airbus Group, a global leader in the aerospace industry, and Institute for Information Transmission Problems, one of the leading mathematical centers worldwide.

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