About us

DATADVANCE is a software vendor specialized in development of design process automation, predictive modeling and multidisciplinary design optimization software.

DATADVANCE has been incorporated in 2010 as a result of a collaborative research program by:

Institute for Information Transmission Problems of the Russian Academy of Sciences – one of the leading mathematical centers in Russia with three Fields prize winners on the staff, and

Airbus Group (formerly EADS) – a global leader in aerospace and defense industry.

DATADVANCE is a resident of Skolkovo Innovation Center in Russia since December, 2010
Our team

- **Moscow: R&D team** of more than 40 highly skilled researchers and engineers
- **Toulouse: Sales and engineers**
- **Munich: Sales**
- **Close collaboration with research labs:**
  - Institute of Information Transmission Problems of Russian Academy of Sciences
  - Institute of Applied Mathematics of RAS
  - Moscow Institute of Physics and Technology
  - Saint Petersburg State Polytechnical University
  - Bauman Moscow State Technical University
Our products and services

- **pSeven** powered by **MACROS** technology is a powerful software platform for automation of engineering simulation and analysis, multidisciplinary optimization and data mining which help to **reduce design time and cost** while **improving quality and performance** of the product being designed.

- **MACROS for Python** – algorithmic core of pSeven.

- Engineering services in solution of complex engineering problems.
Our key customers
CAD/CAE/PLM: Is there a place for improvement?
Typical simulation and design process

- Inefficient “manual” data exchange between tools and departments
- High probability of error during
- Manual selection of “optimal” design parameters

...
Automate and optimize with pSeven!

CAE
Aerodynamics, Mechanics, Dynamics, ...

CAD
Geometry

pSeven – complete solution for Process Integration and Design Optimization!
pSeven powered by MACROS: Main features

Visual process integration

Workflow execution

Visualization and interpretation of results

Data mining and optimization

MACROS – the algorithmic core of pSeven – provides unique proprietary and state-of-the-art data mining and optimization algorithms

Key advantage
Visual process integration

- Capture your design process
  - Automate simulation and analysis
  - Automate trade-off studies
  - Automate optimization
- Integrate various CAD tools
  - SolidWorks, KOMPAS-3D
  - CATIA (beta)
  - Siemens NX and PTC Creo (coming soon)
- Integrate various CAE tools
  - Through ASCII files, e.g. Ansys CFX/Fluent, Simulia Abaqus, etc.
  - In-house and legacy tools
- User-friendly graphical interface and full support of Python scripting
- Rich components library providing access to complete workflow execution control and state-of-the-art proprietary optimization and modeling algorithms
Multidisciplinary Design, Analysis and Optimization

- **Multidisciplinary Design Analysis (MDA):**
  - Parametric studies
  - Sensitivity analysis
  - Design of Experiments
  - Surrogate modeling

- **Multidisciplinary Design Optimization (MDO):**
  - Single level
  - Multi-level (pSeven supports CO, ATC, BLISS and other MDO strategies)

- **Uncertainty Quantification (since pSeven 3.0)**

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![Diagram of Multidisciplinary Design Analysis and Optimization](image)
Advanced optimization algorithms

Supported optimization problems
- Single- and multi-objective nonlinear optimization
- Constraint satisfaction
- Robust and Reliability-based Optimization (RDO and RBDO)
- Engineering optimization (noisy, discontinuous and expensive black-boxes)

Methods
- Automatic selection of optimization method for a given problem (heuristics)
- Primal Sequential Quadratically Constrained Quadratic Programming
- Adaptive Filter Sequential Quadratic Programming
- Multi-objective gradient based Optimal Descent
- Surrogate Based Optimization
- Adaptive Sample Average Approximation Robust and Reliability-based Optimization
- IOSO NM
Engineering optimization: Why is it so difficult?

Engineering optimization features supported in pSeven/MACROS:

- Large dimensionality
  - Number of variables – O(100)
  - Number of generic (linear/nonlinear) constraints – O(100)
  - Several objective functions – O(1)
- Nonlinear and multimodal objective functions and constraints
- Noisy objective functions and constraints
- Presence of Implicit constraints (domains of undefined behavior)
- Large calculation time – O(1h)
- Presence of uncertainties
Sophisticated data analysis methods

- Design of Experiments
  - Factorial, Composite, LHS, X-Optimal, Adaptive DoE, ...

- Important Variable Extraction
  - Feature selection, feature extraction, sensitivity analysis

- Dimension Reduction

- Construction of surrogate models
  - Automatic selection of method for a given problem
  - Classical methods (LR, RSM, ..)
  - Industry proven in-house methods (HDA, GP, SGP, ..)
  - Smoothing
  - Surrogate model export

- Construction of variable fidelity models

- Accuracy assessment of constructed models
Other details

- Local and distributed (coming soon) workflow execution
- HPC support
  - Direct interfaces with Slurm, LSF and Torque
  - Automation of data transfer
- Automatic workflow parallelization
- Cross-platform (Windows and Linux)
- Open and extendable platform
Visualization and interpretation of results

Rich post-processing and data analysis tools
Why choose pSeven powered by MACROS?

- **Improvement** of product performance, quality, reliability, safety.

- Significant design **lead time and cost reduction** thanks to state-of-the-art data analysis and optimization algorithms.

- **Formalization** and preservation of knowledge and experience, practices and design techniques through automation.

- Predictive modeling and optimization problems can be solved **directly in design office**, without involvement of experts in data analysis and optimization.

- Improved **collaboration** between departments and engineers – one more step towards multidisciplinary design optimization.
Solutions & Applications
Airbus: lead time reduction by up to 10%*

*Airbus press release*
Multiobjective aircraft family optimization

Objective
Optimize a family of three aircrafts at the conceptual design stage

Challenge
- 9 objective functions (CoC, MTOW, fuel consumption)
- 12 design variables
- 33 non-linear constraints (6 equality constraints)

Results
- All objective functions are improved by 10-20% compared to initial configurations
- All optimal configurations are feasible, i.e. all constraints are satisfied, compared to initial configurations
- Nontrivial Pareto frontier

Not achievable using state of the art methods based on genetic algorithms!
Aerodynamic wing shape optimization

Objective

Optimize wing shape in order to maximize aerodynamic efficiency, minimize wing mass and minimize production cost:

- Aerodynamics – 3D CFD
- Mass and cost – statistical models

Challenge

- Huge dimensionality (wing shape) – hundreds of variables.
- Time of one CFD simulation – hours.

Solution

- Dimensionality reduction thanks to efficient parameterization of airfoil (60 → 6).
- Multiobjective Surrogate Based Optimization.

Result

Improvement of objective functions by 5-10%. Minimal number of CFD calls.
Surrogate Modeling of Buckling Analysis in Support of Composite Structure Optimization

Objective
Speed up structural optimization of composite wing panels within COMBOX.
Minimize mass of composite structure subject to strength constraints (RF_{buc} > 1, RF_{str} > 1, etc.).

Problem
Analysis of the strength properties of the composite structures is typically very slow.
Computed reserve factors are noisy and discontinuous which causes problems for any optimizer.

Solution
Replace original analysis code (PS3) with accurate and smooth surrogate model.

Result
Constructed surrogate model has less than 1% relative error compared to the original analysis code.
Reduction of structure optimization computational time from several days to a few hours.
Formula-1 car side panel design

Objective
Minimize mass of a side panel exposed to impact loads

Problem
- Impact data coming both from tests and simulations
- Layered panel material makes the problem discontinuous

Solution
Create surrogate model using all available experimental and numerical data (data fusion) and optimize it.

Result
**10% mass reduction** with less number of simulations and full scale experiments.
Low Pressure Steam Turbine Blade Shape Optimization

Objective
Optimize efficiency of the last stage of low pressure steam turbine

Problem
High dimensional problem
Expensive CFD model

Solution
- Low-dimensional parametric 3D blade model (24 in total)
- Multi-level optimization strategy
- Surrogate Based Optimization

Result
Turbine stage efficiency boosted by 1.8%
Flutter analysis of compressor blades

Objective
Flutter analysis of compressor blades

Problem
■ Coupled durability and gas dynamics problem
■ Transient flow system
■ Requires a lot of computational resources

Solution
■ In-house methodology based on energy method
  Calculation of blade natural modes and frequencies
■ Automation using pSeven

Result
Accurate prediction of unstalled flutter of blades.
The methodology is validated by full-scale flutter tests and is recommended for industrial use.

21.08.2014
Optimization of compensation of shear forces to prevent axes misalignment between pump and electric motor

Problem
Oil transporting pumps have large shear force because of large and different input and output pressures. This force leads to short life cycle of dumping system and to increase of misalignment angle between axes of pump and electric motor. The goal was to compensate the shear force with a minimal axes misalignment.

Solution
■ Several patterns of compensation forces were analyzed numerically.
■ Parametric optimization has been performed

Result
Life cycle of a dumping system was increased by 3-4 times, the axes misalignment was reduced by >100 times.
Oil pump volute optimization

Problem
Find optimal geometry of pump volute with respect to hydraulic losses and a rotor radial hydraulic force. Many geometric parameters and high cost of real experiment lead to intensive usage of a numerical simulation with optimization procedures.

Solution
- 6 main parameters were selected which have the largest influence on objective functions
- The CAD designs, solutions and postprocessings were automated
- Pareto optimal design were found

Results
The solutions with reduced (by 10.1%) hydraulic losses or less radial forces (by 10 times) were found with minimum number of calculations.

**Objective**
Minimize mass of locomotive diesel-generator frame subject to strength and stiffness constraints.

**Challenge**
- High dimensionality – 37 geometric parameters
- 3 load cases

**Solution**
- SolidWorks parametric model integrated with pSeven
- Manually automated meshing procedure in Ansys
- Surrogate based optimization (only 143 FEM calls!)

**Result**
Frame mass reduced by 12% (170 kg)
Accelerated fitting of tire dynamics in Formula 1

Objective
Dynamics of tires in Formula 1 cars is described by Pacejka’s “Magic Formula”, which contains 80 free parameters. The parameters depend on specific driving conditions and can be fitted using track data.

Challenge
Customer fitted the model with 80 parameters in ~20 hours. The challenge was to reduce the fitting time to ~1 hour.

Approach
Optimization of the fitting process and fitting with pSeven powered by MACROS.

Result
Fitting time reduced to ~10 minutes: more than 100 times faster!