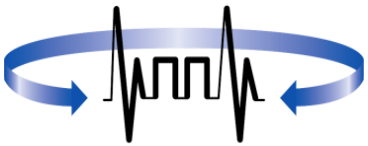
Process Integration. Data Analysis. Design Optimization.

DATADVANCE
AN EADS COMPANY

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

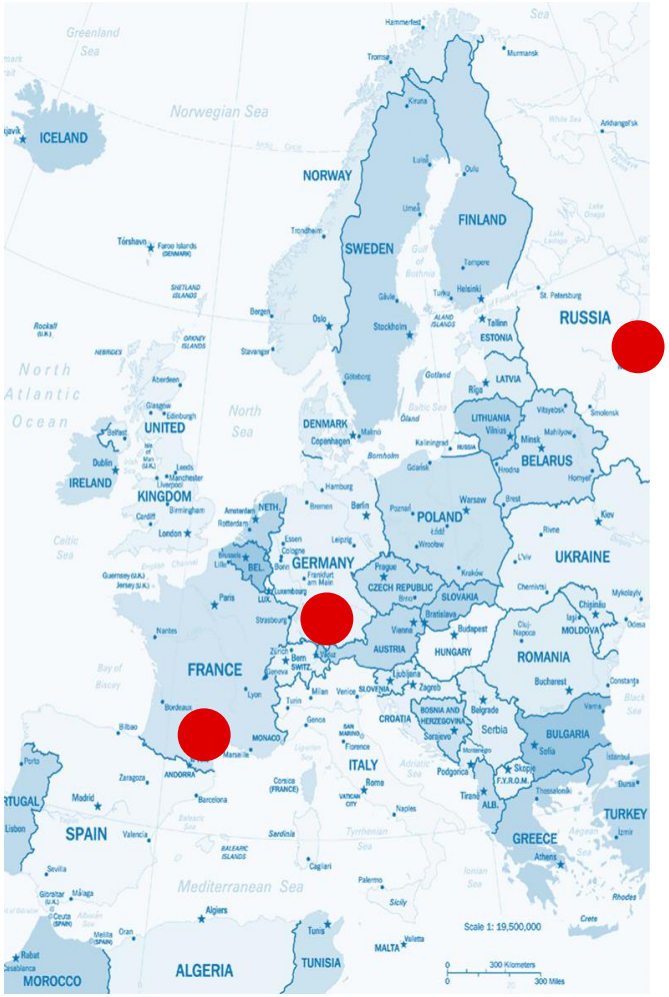
Airbus Group (formerly EADS) – a global leader in aerospace and defense industry.

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

Sk Skolkovo

Our team

- **Moscow: R&D team** of more than 40 highly skilled researchers and engineers
- **Toulouse: Sales and application engineers**
- **Munich: Sales**
- **Close collaboration with research labs:**
  - Institute of Information Transmission Problem 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



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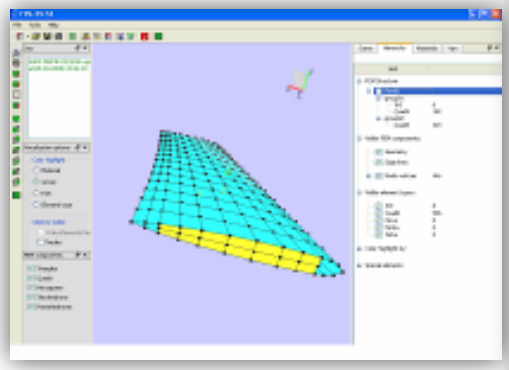
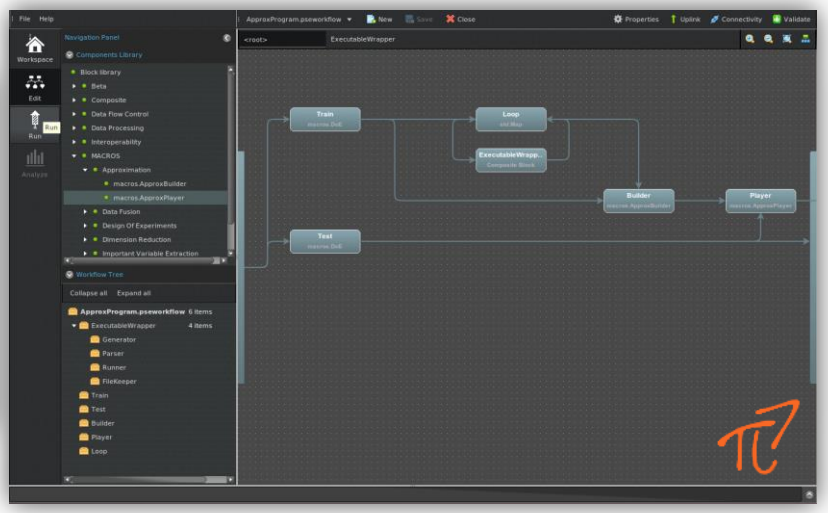
Our products and services

- **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.
- Engineering services in solution of complex engineering problems.
- Research and development on specific customers' topics.





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Major design challenges

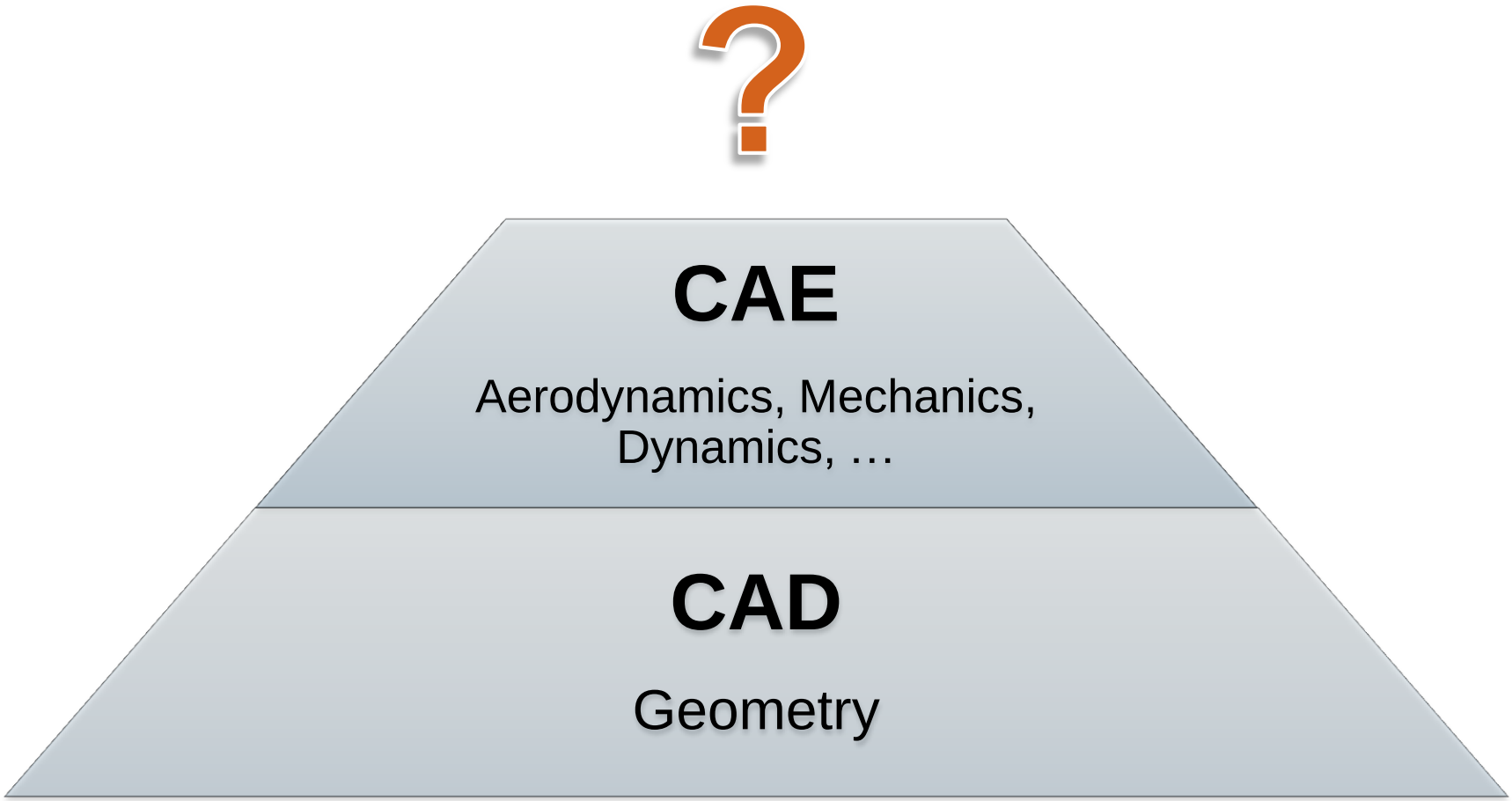
Make better products to meet increasing market requirements!

2013

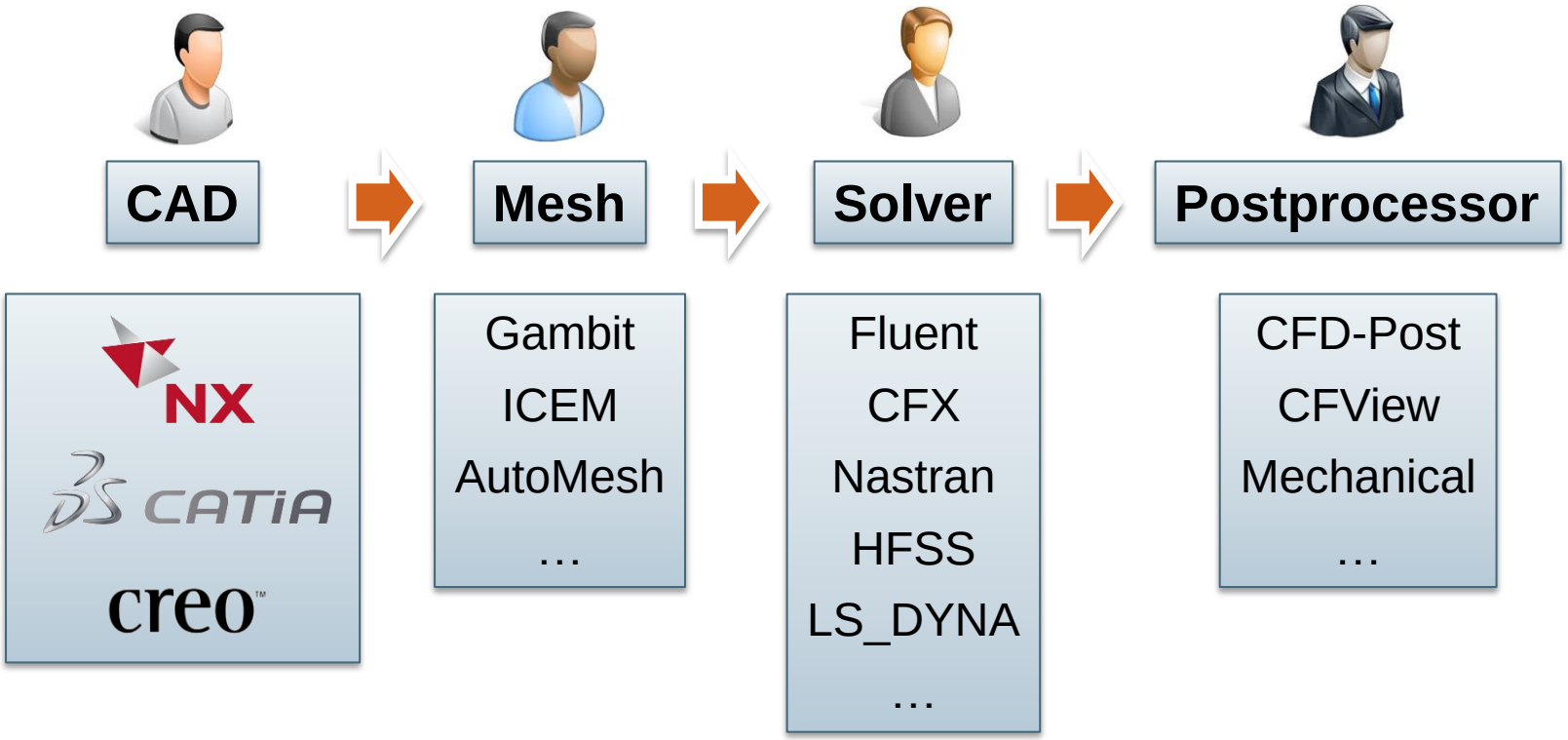
2050

Design lead time and cost reduction

CAD/CAE/PLM: Is there a place for improvement?

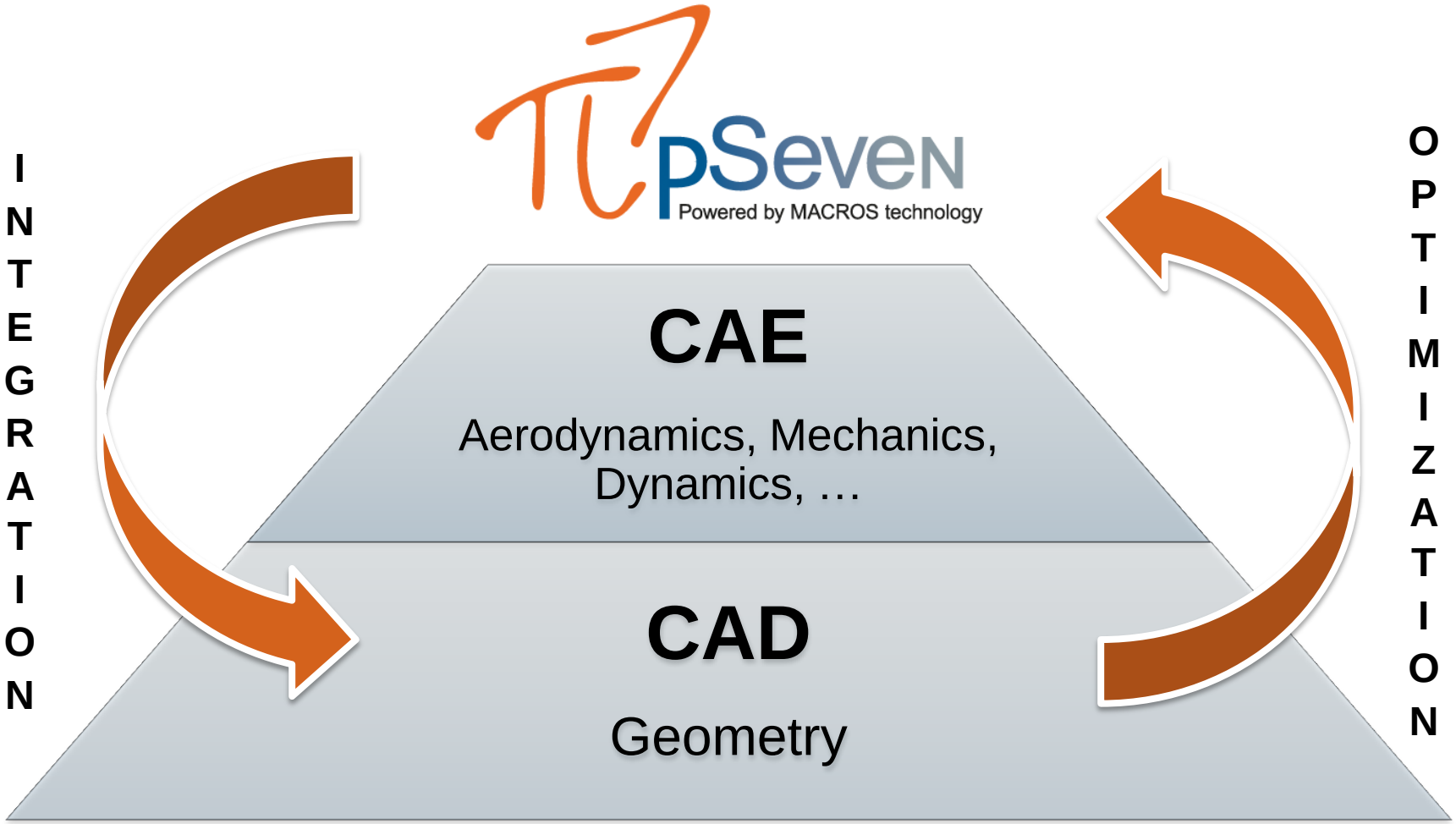


Typical design process



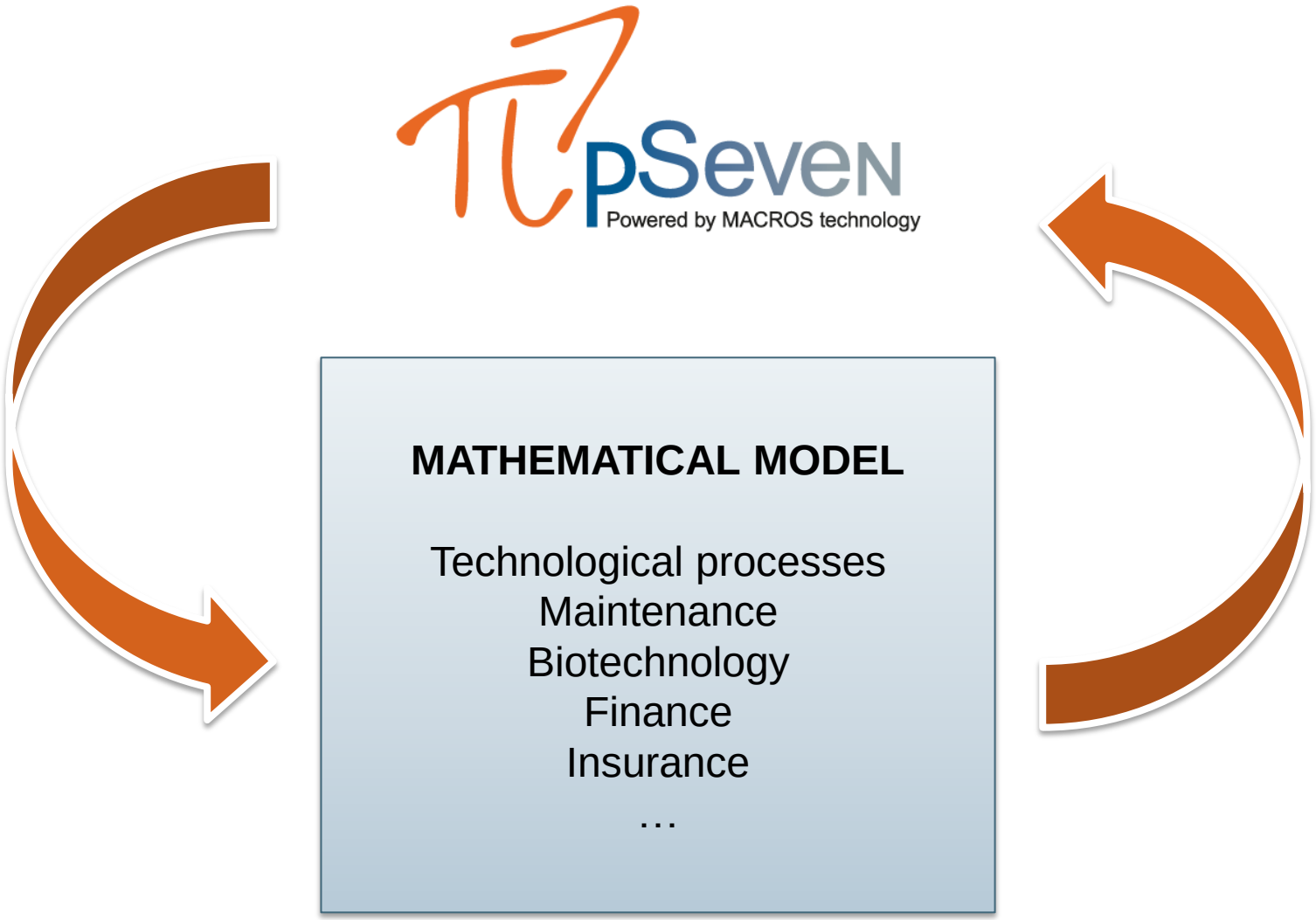
- Inefficient “manual” data exchange between tools and departments
- High probability of error during
- Manual selection of “optimal” design parameters
- …

Automate and optimize with pSeven!

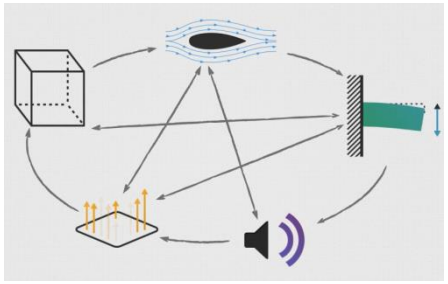


pSeven – complete solution for Process Integration and Design Optimization!

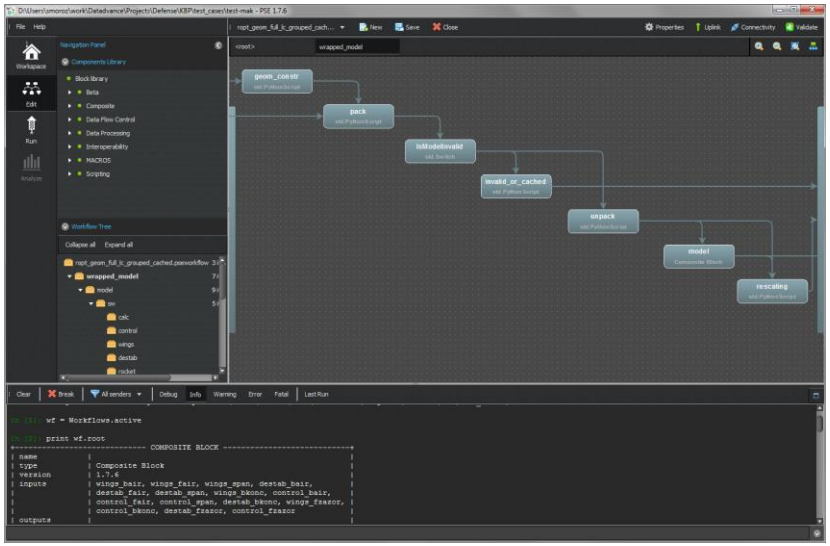
Expanding pSeven horizons

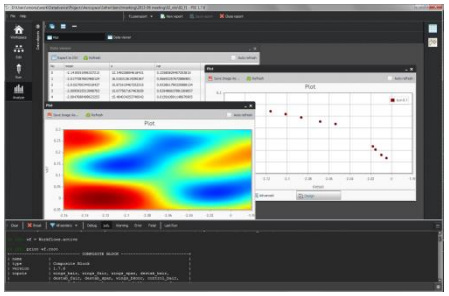


pSeven powered by MACROS: Main features

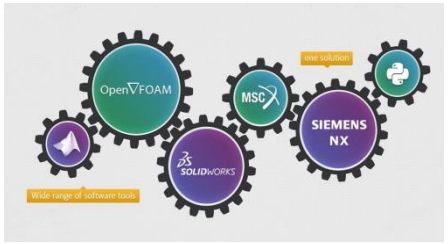


Visual process integration

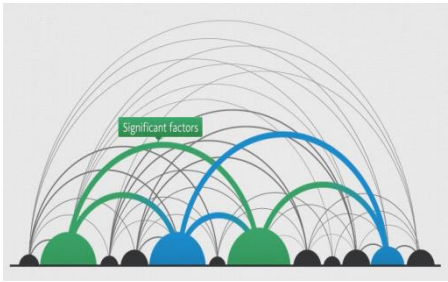




Visualization and interpretation of results



Workflow execution

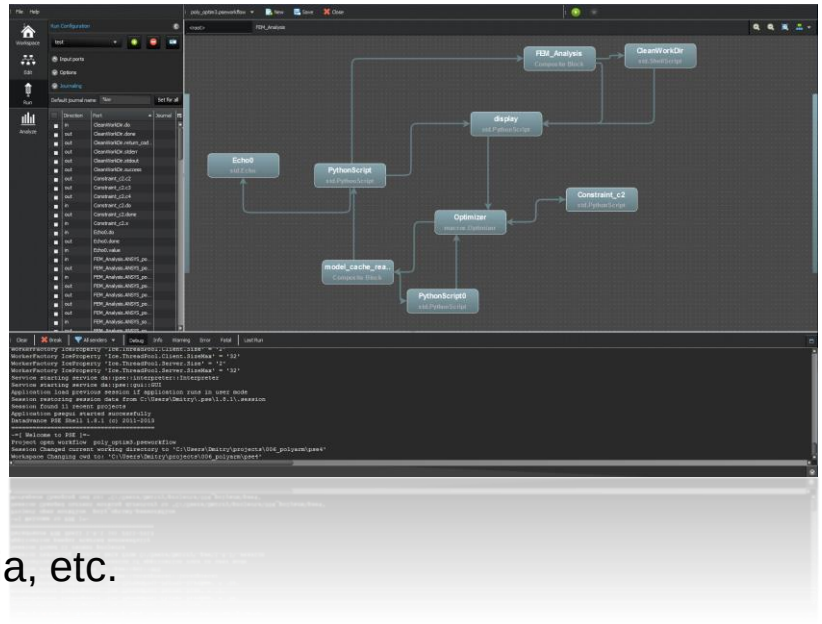


Data mining and optimization

Key advantage

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

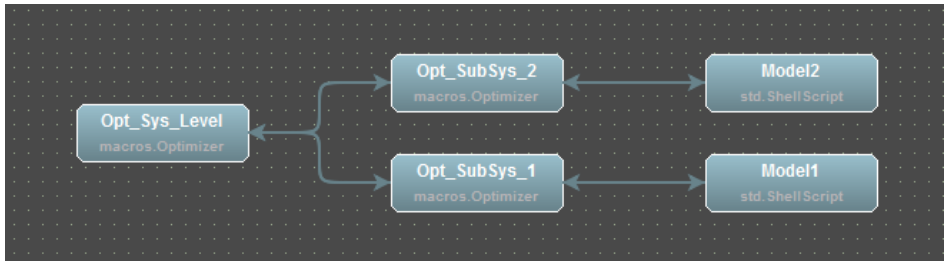
Visual process integration

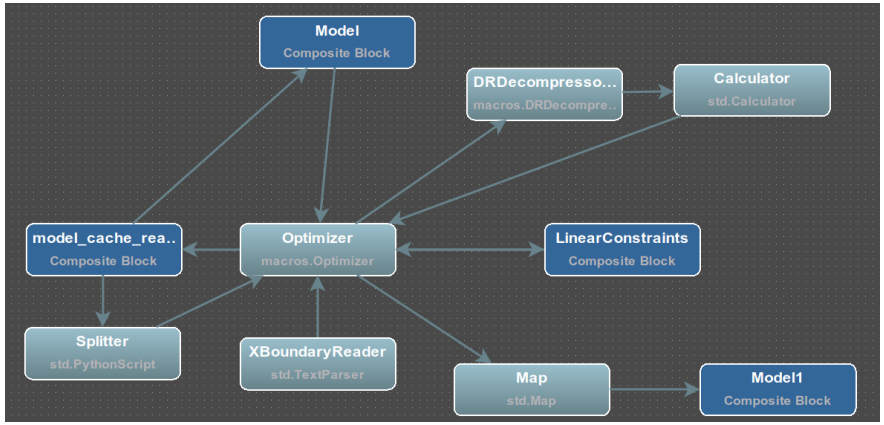


- Capture your design process
  - Automate simulation and analysis
  - Automate trade-off studies
  - Automate optimization
- Integrate various CAD tools
  - SolidWorks, KOMPAS-3D, CATIA
  - Siemens NX (coming soon)
- Integrate various CAE tools
  - Through ASCII files, e.g. CFX, Fluent, Simulia, etc.
  - 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

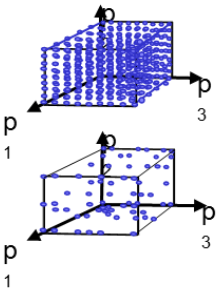
- Multidisciplinary Design Analysis (MDA):
  - Parametric studies
  - Sensitivity analysis
  - Design of Experiments
  - Surrogate modeling
- Multidisciplinary Design Optimization (MDO):
  - Single level
  - Multi-level (pSeven supports CO, ATC, BLISS and other MDO strategies)
- Uncertainty Quantification (coming soon)

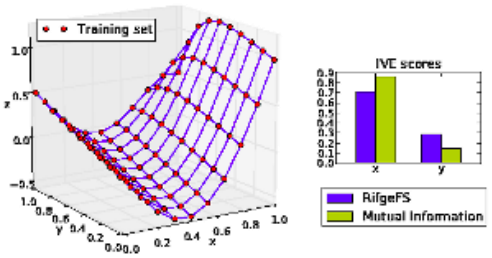


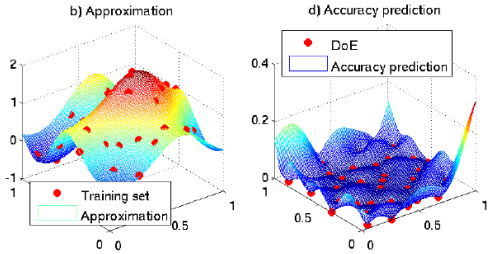


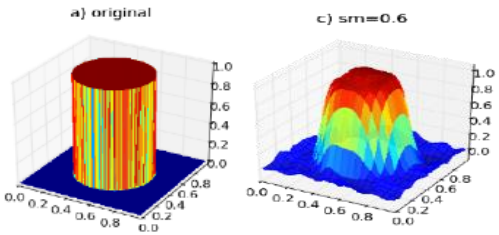
Sophisticated data analysis methods

- 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









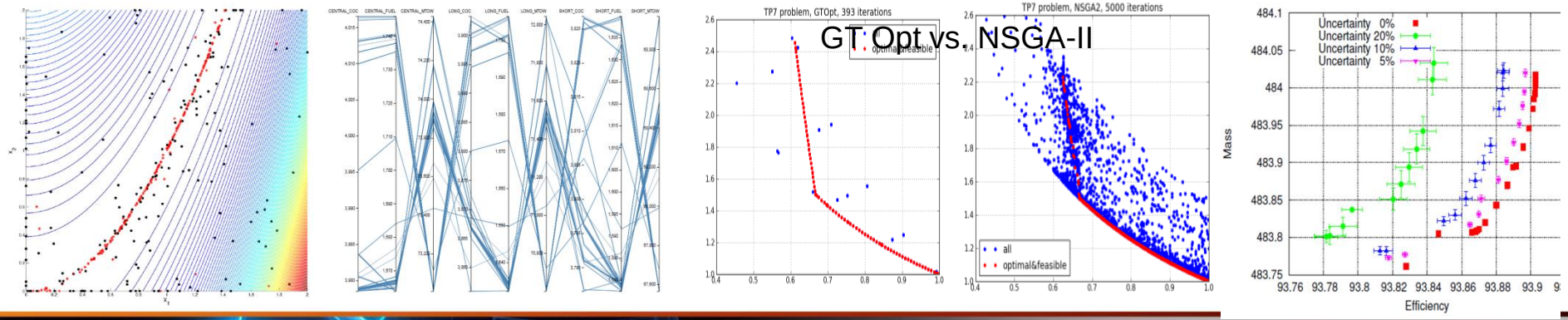
Advanced optimization algorithms

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)

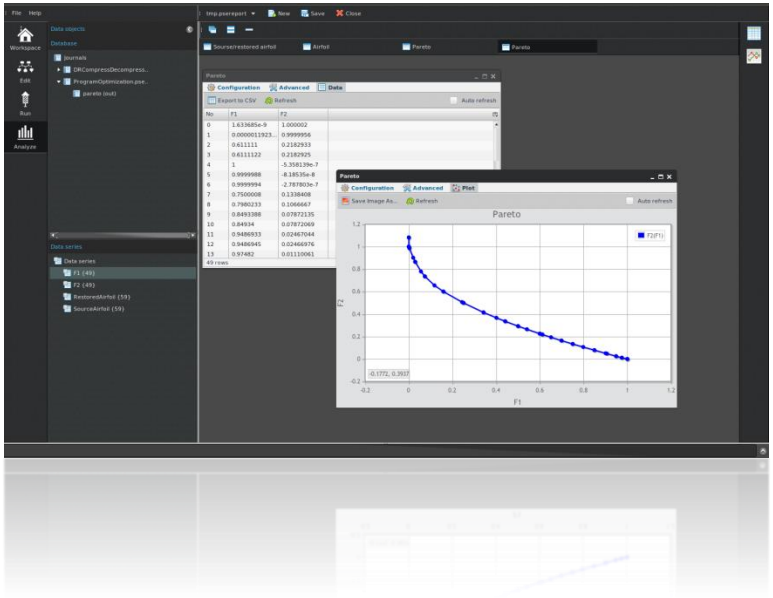
Methods

- 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

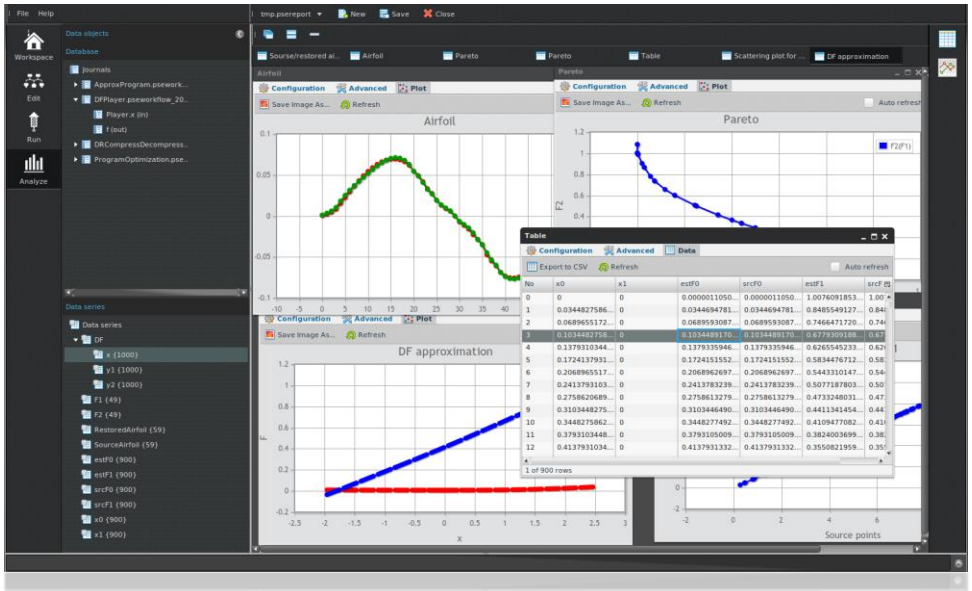


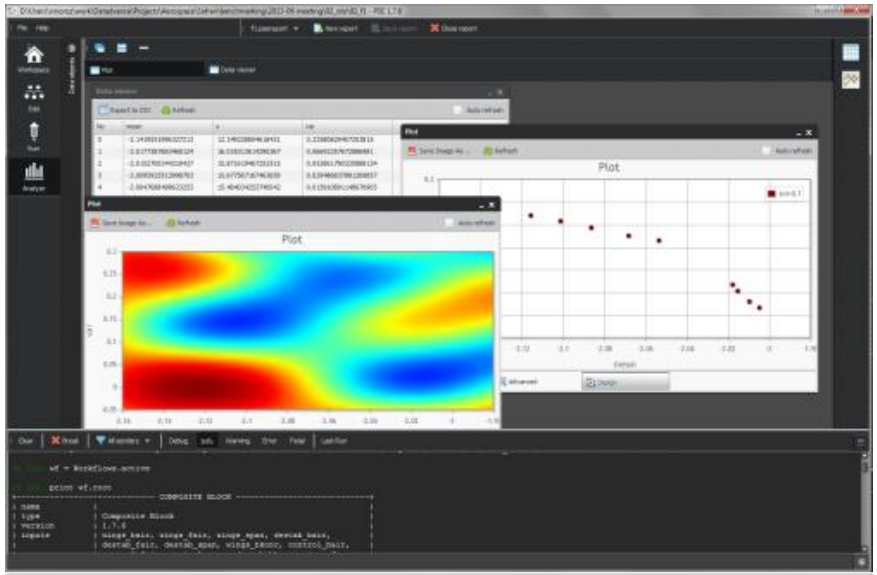
Other details

- 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



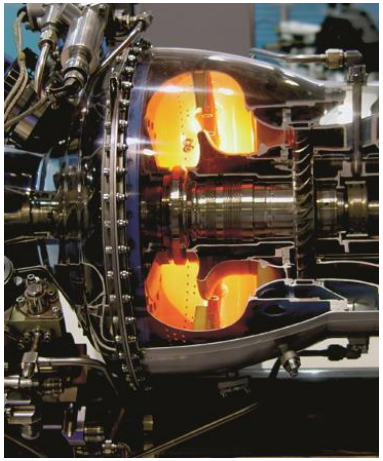


Rich post-processing and data analysis tools

Why choose pSeven powered by MACROS?

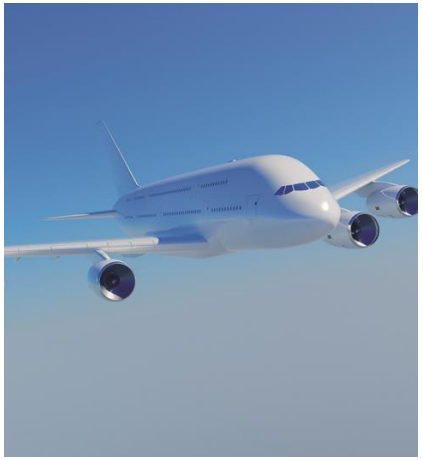
- **Improvement** of product performance, quality, reliability, safety.
- Significant design lead time and cost **reduction** thanks to state-of-the-art data analysis and optimization algorithms
- **Formalization** and preservation of knowledge and experience, practices and design techniques through **automation**.
- Predictive modeling and optimization problems can be solved directly in **design office**, without involvement of experts in data analysis and optimization.
- Improved **quality of interaction** between departments and engineers – one more step towards multidisciplinary design optimization.

Solutions & Applications



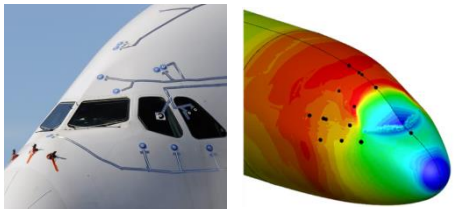




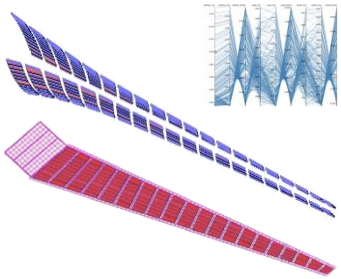



AIRBUS: lead time reduction by up to 10%*

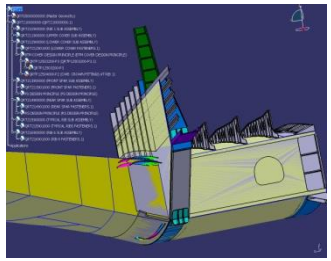
Conceptual Design



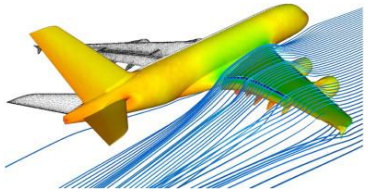
Acoustics



Composites

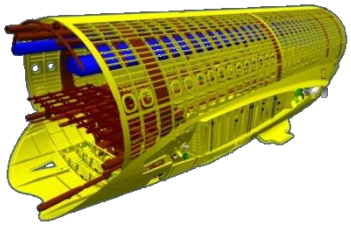


Assembly

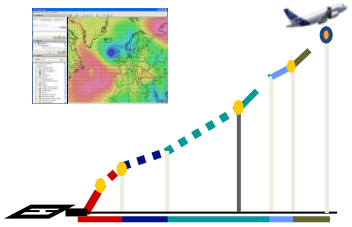


Aerodynamics

Fuel Systems



Airframe



Mission planning

* Airbus press release

Multiobjective aircraft family optimization

Objective

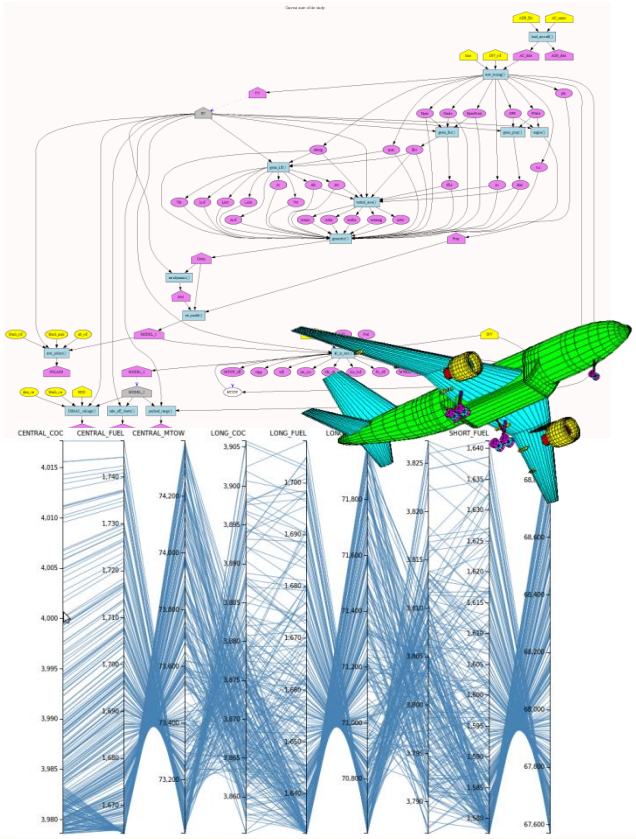
Optimize a family of three aircrafts at the conceptual design stage

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**!**

Aircraft ECS model reduction

Objective

Aircraft ECS model, implemented in DYMOLA, is too slow for real-time usage. Replace DYMOLA models by a real-time capable surrogate model.

Why difficult?

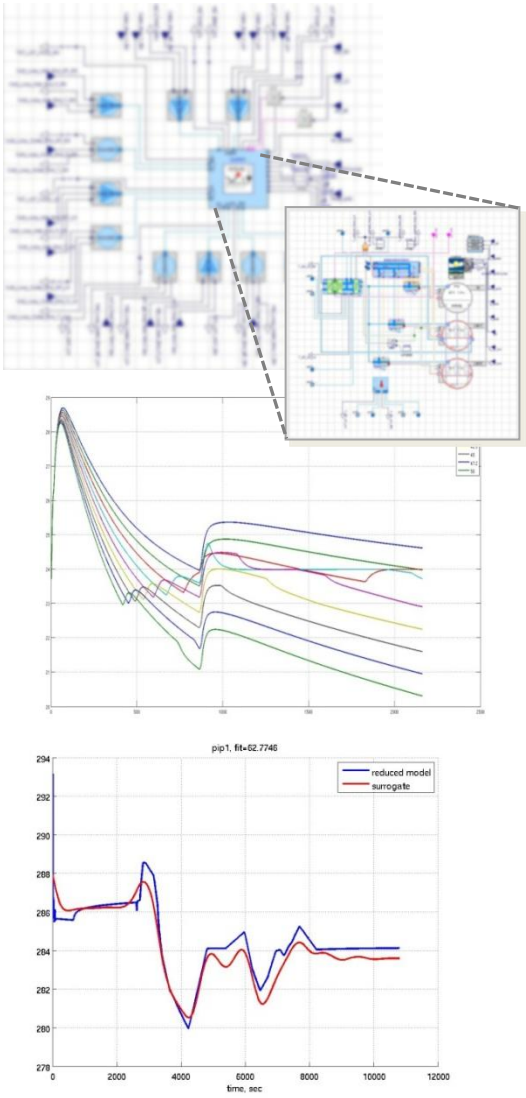
- Dynamic problem
- Highly-nonlinear responses
- Need to ensure reasonable accuracy of the surrogate model.

Approach

System identification methods being implemented in **pSeven**.

Result

Approaches implemented in **pSeven** have allowed to construct fas real-time capable surrogate model.



F1 car side panel design

Objective

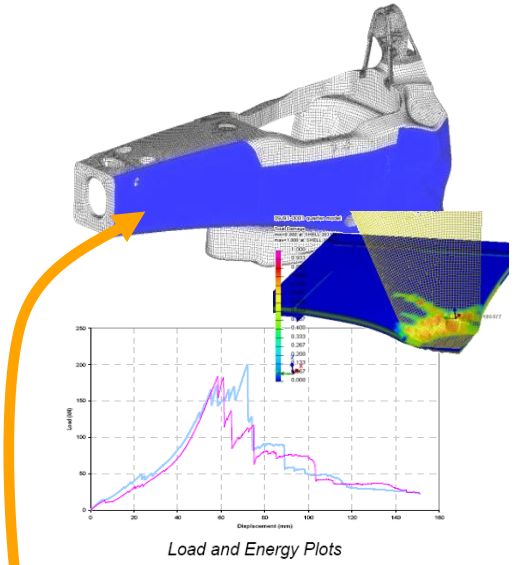
Minimize mass of a side panel exposed to impact loads

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

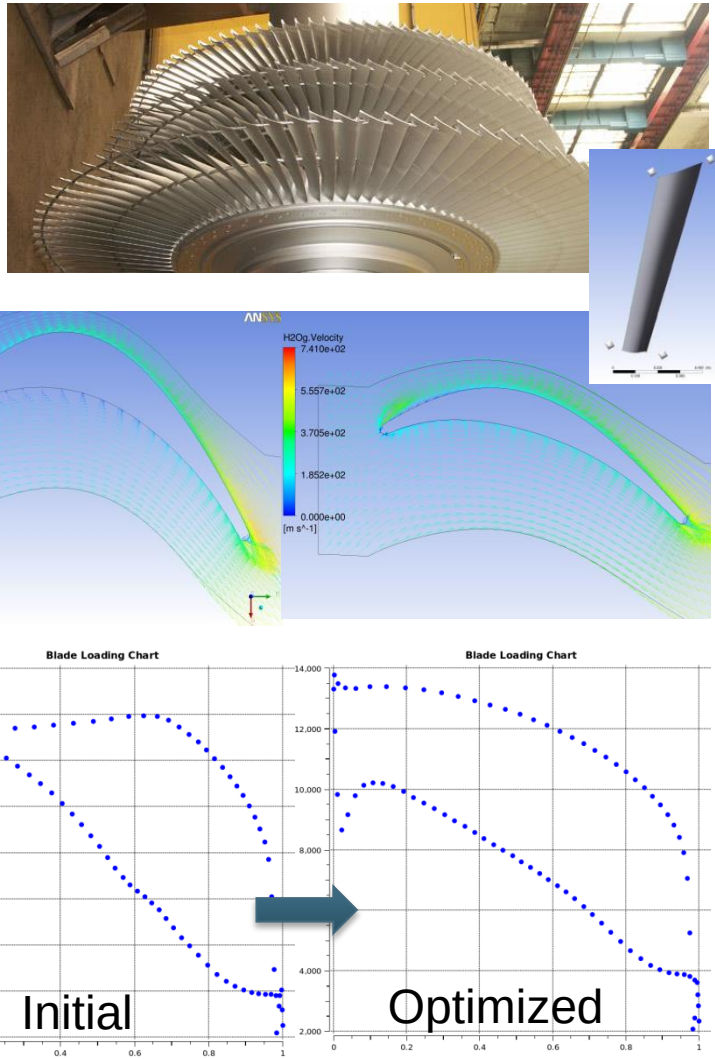
- High dimensional problem
- Expensive CFD model

Solution

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

Result

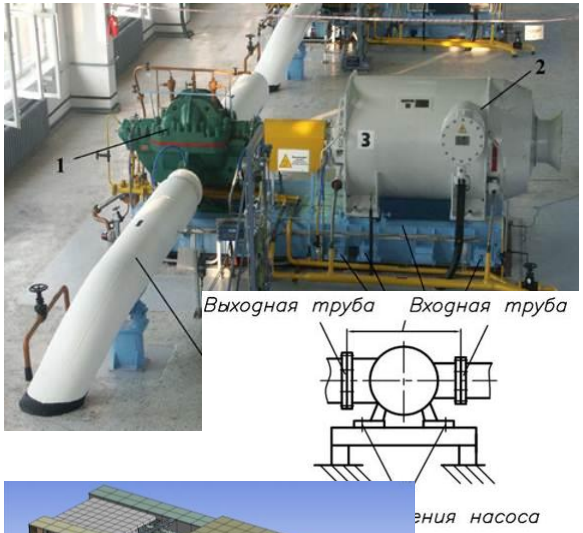
Turbine stage efficiency boosted by **6%**



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

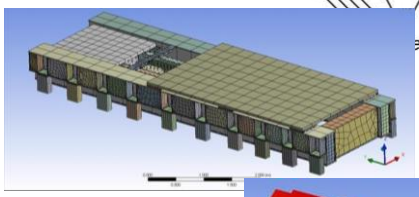
Problem

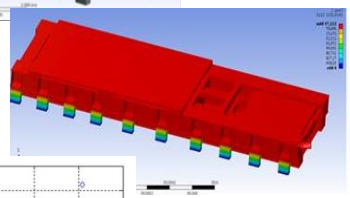
Oil transporting pumps have large shear force because of large and different input and output pressures. This force leads to short life cycle of dumping system and to increase of misalignment angle between axes of a pump and an electric motor. The goal was to compensate the shear force with a minimal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

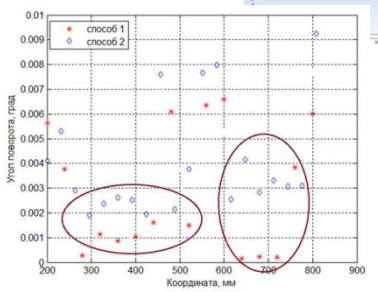


Solution

- 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

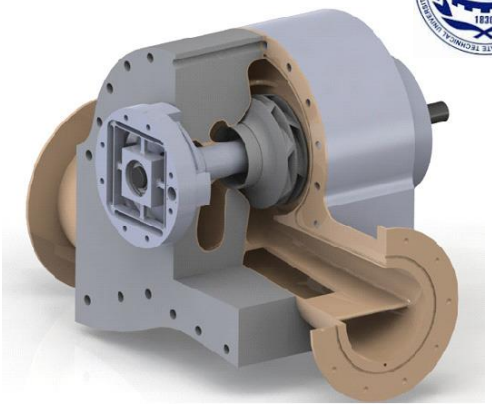
Find optimal geometry of pump volute with respect to hydraulic losses and a rotor radial hydraulic force. Many geometric parameters and high cost of real experiment lead to intensive usage of a numerical simulation with optimization procedures.

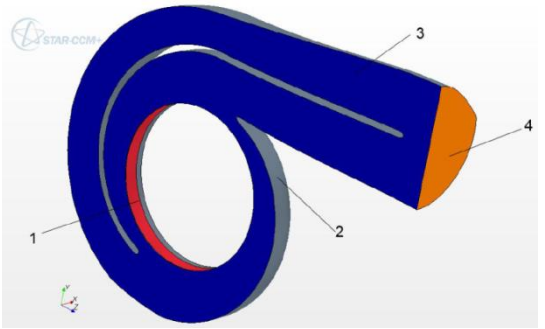
Solution

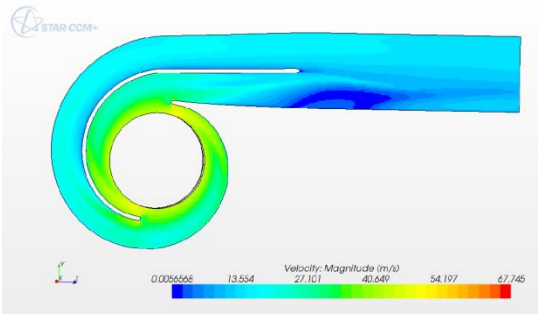
- 6 main parameters were selected which have the largest influence on objective functions
- The CAD designs, solutions and postprocessings were automated
- Pareto optimal design were found

Results

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







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

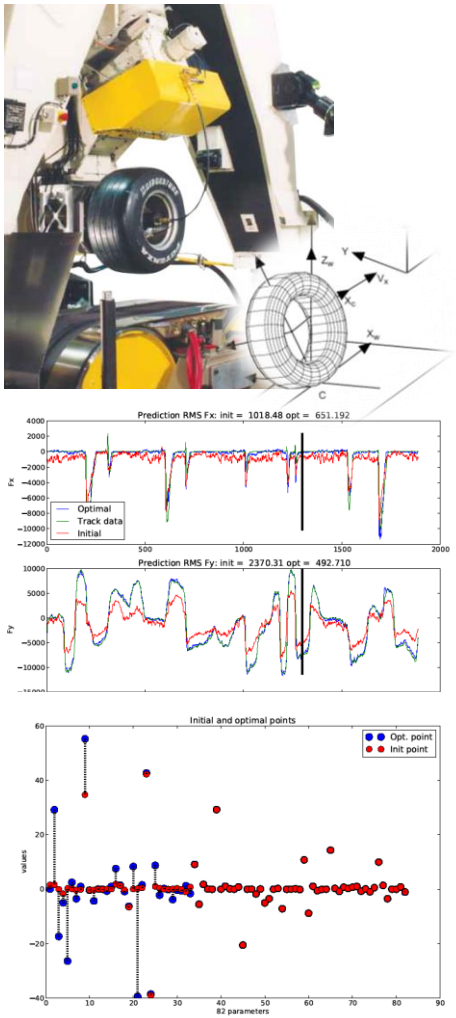
Customer fitted the model with 80 parameters in ~**20 hours**. The challenge was to reduce the fitting time to ~**1 hour**.

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**!**



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Approximation of the engine temperature profile

EUROCOPTER
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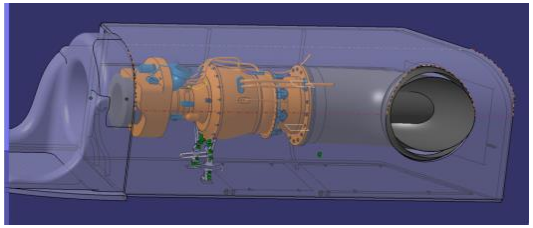
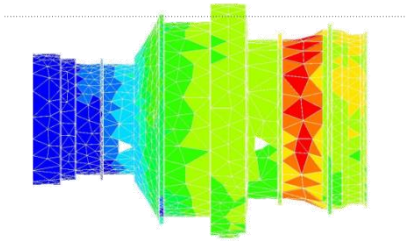
Setup & Challenge



Fast and accurate surrogate model for prediction of engine skin temperature, constructed using available simulation database, is required to perform aerothermal simulations of the whole engine compartment and improve their accuracies.

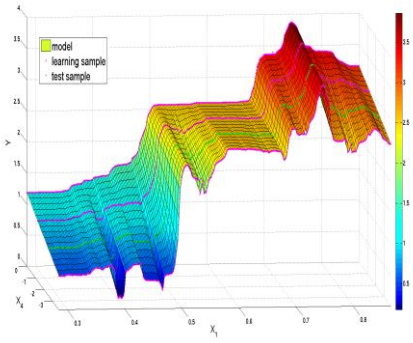
Why difficult?



Standard surrogate modeling methods are inefficient:

- Large size of the database (~18 000 entries)
- A highly anisotropic structure of data: (750 samples of 1st factor) X (4 samples of 2nd) X (6 samples of 3rd combined with 4th)

Approach



Use the unique Tensor product of Approximations feature of **pSeven** powered by **MACROS**.

Result

- Fast and accurate surrogate model has been automatically constructed.
- Aerothermal simulation of the whole engine has been performed.

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