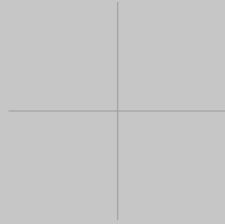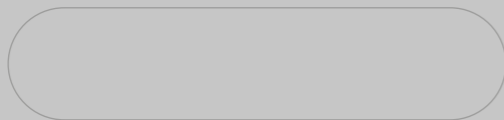**modeFRONTIER**

EXPEDITE DESIGN PROCESS WITH CUTTING-EDGE OPTIMIZATION TECHNOLOGY

Step-by-step guide into modeFRONTIER - the intuitive vendor agnostic software for process automation and design optimization

what's
inside

Design Optimization in the digital engineering age

Today's complex products require you to simultaneously take into account multiple disciplines in order to optimize the design at system, subsystem and component level. Nevertheless, large-scale adoption of process automation and design optimization software seems to be slower. Perhaps, it is challenging to link different CAD/CAE/in-house codes together into a simulation process workflow. Or because of the difficulties in applying trustworthy Artificial Intelligence (AI) methods on the top.

As your company's digital engineering initiative grows, what should you expect from an optimization software to become a de facto tool for simulation-driven product development?

- Lower the barriers to automating simulation workflows, and making them reusable.

- Make it easy to set up multiple design optimization strategies with pre-configured scenarios.

- Democratize the use of automated simulations and design optimization across your organization.

In this eBook, we take a deep-dive into ESTECO modeFRONTIER's open ecosystem for simulation process automation and design optimization. A pioneer in this field for over 20 years, modeFRONTIER provides engineers with a modern, intuitive optimization-driven design approach to help them eliminate endless simulation iterations and unleash product innovation.

Untapped potential of improving product design performance

> **3 out of 5 organizations consider a shortage of talent and a limited understanding of the benefits as a critical impediment towards adoption of AI/ML-based simulation**
>
> Survey: The future of Simulation - **NAFEMS and McKinsey & Company**

Simulation-driven product development presents challenges in managing hundreds of interdependent design parameters, balancing complex trade-offs and making informed design decisions. While process automation and design optimization seems to be the only way to deal with these complexities, simulation engineers hesitate to embrace this paradigm shift:

- **Simulation still heavily relies on trial-and-error**
  Manually modifying geometry, creating new meshes, and running simulations until an optimal design solution is found, requires specific domain knowledge and a lot of time.

- **Manual or partially automated CAE workflows**
  Typically, method developers create coordinated workflows between existing modeling, simulation and analysis tools using custom scripts. These custom-tailored workflows lack reusability and cannot always be extended with AI/ML methods.

- **Design optimization requires expertise or significant investment of time**
  Configuring algorithms and choosing the right strategy to get the best design results can be a complex and time-consuming task. As a result, the expertise of simulation experts is not used to its full potential.

- **The availability of simulation experts is limited**
  This becomes a bottleneck when multiple CAE departments are assigned to improve design performance and shorten product time-to-market.

Get rid of tedious routine design tasks with modeFRONTIER

Process automation and design optimization software's usability is crucial, especially for users with limited experience or time. ESTECO modeFRONTIER is intuitive, enabling experts and newcomers to the field to automatically explore the design space with AI-enabled methods and accelerate product development.

modeFRONTIER provides everything you need to be efficient with parametric design optimization. It allows you to automatically evaluate thousands of designs by directly integrating third-party engineering solvers within a single automated workflow, maximizing efficiency and reducing operational costs. With its complete set of smart algorithms easy to configure through a dedicated interface, you can balance conflicting objectives and identify innovative design solutions that could be missed out with traditional engineering methods.

But there's more to it. Through the integration of modeFRONTIER technology into the ESTECO VOLTA Simulation Process and Data Management (SPDM) platform, you can scale up modeFRONTIER process automation and design optimization capabilities, and make them available to a wider audience of subject matter experts. As a result, Multidisciplinary Design Optimization (MDO) becomes a cross-team effort.

> **modeFRONTIER helped achieve five-star Euro NCAP for head protection.**
>
> **The overall optimization process allowed us to reduce 6% of the crash deformation compared to the conventional aluminum hood and satisfy Head Injury Criterion target values.**
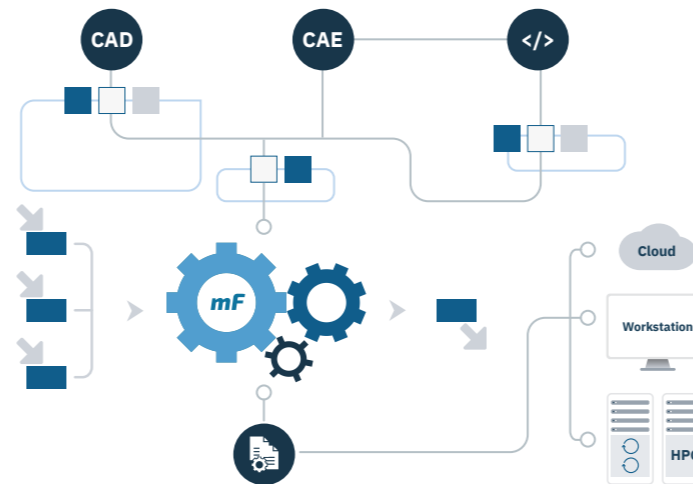
OSAMU ITO
Assistant Chief Engineer,
Technology Research Division
Honda R&D Co. Ltd.

1. Automate any CAD/CAE toolchain with no coding

modeFRONTIER's vendor-neutral simulation process workflow is the foundation for an effective design optimization approach. You can integrate and automate even the most complex CAD/CAE toolchains and in-house solvers without having to script or code anything. With modeFRONTIER, you can eliminate time-consuming tasks while easing the process of introspecting CAD/CAE models. Its guided process also allows non-experts to skip the critical stage of workflow building and move directly to define design exploration or optimization studies.

Due to the multidisciplinary aspects of the engineering design problems and the nature of the solvers used, simulation workflows require a high level of computing power. modeFRONTIER job scheduling technology lets you balance the computational load by concurrent execution of design evaluations and distribution of solver runs on dedicated HPC and Cloud environments.

modeFRONTIER's process integration technology is constantly tested for compatibility with the latest releases of the most popular CAD/CAE tools in engineering simulation.

2. Decouple process workflow from optimization strategy

When configuring simulation workflows in modeFRONTIER, there are two options available to suit different backgrounds in process automation. With the traditional approach, you can graphically define the engineering process and the optimization strategy at the same time. This is beneficial especially for experienced method developers who want to have a single view on both the engineering process and the optimization strategy adopted.

The alternative is the purely process-based workflow. You just need to focus on the logic of your engineering process during the workflow construction phase. Multiple design exploration and optimization strategies can be practically defined in the separated modeFRONTIER Planner environment. With this approach, you are able to explore various parameters, constraints, and goal configurations for the same engineering process and compare the design solutions in a single place.
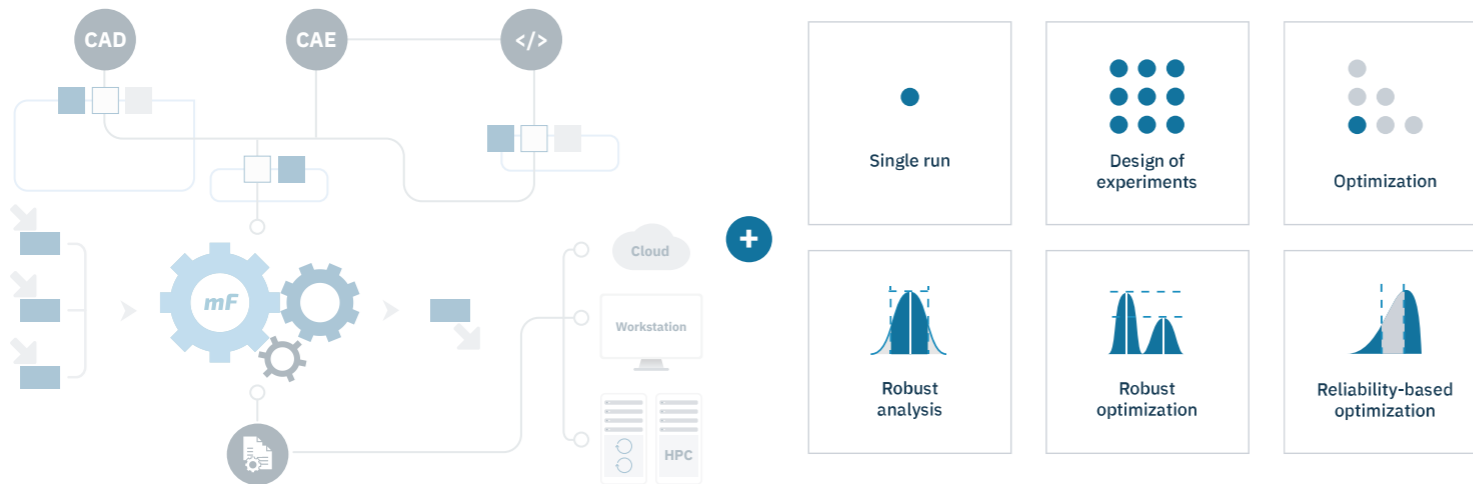
modeFRONTIER's Planner interface enables you to create, reuse, and apply various design space exploration strategies to the same simulation workflow in a single project file.

Single run

Design of experiments

Optimization

Robust analysis

Robust optimization

Reliability-based optimization

"We realized that modeFRONTIER software is the ideal solution for vehicle trade-off-analysis and optimization.

JAMES (KR) YOON
Senior Research Engineer, Virtual MBSE & HPC AI Research
Hyundai Motor Company

"We took advantage of modeFRONTIER software solution to automatically execute a huge number of simulations and evaluate thousands suspension system designs within a few weeks. The optimization process led us to achieve up to 10% reduction in cab vibration compared to the baseline.

ANDREA MORELLO
Performance Engineer and CAE Senior Analyst
IVECO - CNH Industrial

Try modeFRONTIER hands-on
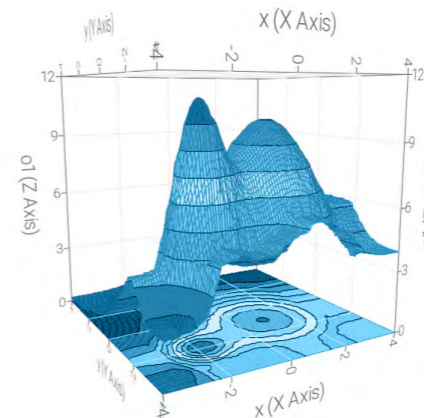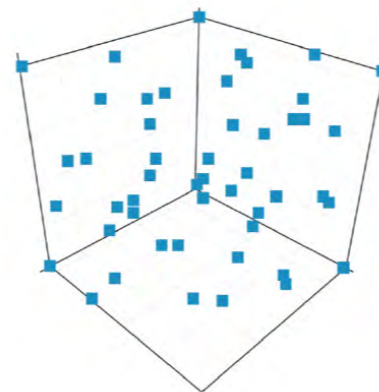
→ esteco.com/modefrontier

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3. **Explore design space and build meta-models**

Extend your CAE toolchain automated in the simulation workflow to Design of Experiments (DOE). It allows you to quickly explore regions of interest of certain designs without checking every possible combination. modeFRONTIER's DOE techniques can be used for different applications:

- **Statistical analysis**
  Extract the most relevant qualitative information from a limited database of experiments.

- **Response Surface Models (RSM) training**
  Get an instant and accurate insight into the relationship between a set of parameters and one or more design objectives.

- **Optimization**
  Generate a suitable starting population for the optimization algorithms.

modeFRONTIER contains a wide range of algorithms for DOE and a powerful set of RSMs, ranging from basic polynomials to advanced deep learning models.

4. Configure optimization algorithms in one-click

modeFRONTIER is equipped with a range of manual optimization strategies that empower the expertise of skilled simulation engineers. Selecting the right approach for your design problem, though, may require a certain level of knowledge and expertise.
With the Self-Initializing or Autonomous algorithms mode, you can expect to balance the time needed to reach an optimal design with the quality of that solution.

By defining just one parameter or none at all for the autonomous approach, modeFRONTIER opens its door to non-expert users or those experts who just want to effectively investigate the design space while minimizing the amount of iterations required.

modeFRONTIER provides deterministic, stochastic and heuristic algorithms for both single and multi-objective problems, exploiting available computational power.

Manual
Set all parameters

Self-initializing
Single parameter

Autonomous
No parameter
just one click

Algorithm set-up
Time & Expertise

GLOBAL SEARCH			LOCAL REFINEMENT
HEURISTIC	**MULTI-STRATEGY**	**DERIVATIVE FREE OPTIMIZATION**	**GRADIENT-BASED**
SIMULATED ANNEALING PARTICLE SWARM	HYBRID		CLASSICAL SQP METHODS
	FAST	POWELL	
GENETIC	pilOPT	SIMPLEX	AFiltersSQP
EVOLUTION STRATEGY	SANGEA		Bounded BFGS
	MEGO		

EVOLUTIONARY

ACCURACY

ROBUSTNESS

> " modeFRONTIER has proven to be an effective tool for the design team, identifying feasible solutions and achieving a 2.5% enhancement of aerodynamic performance and a 4% wing weight reduction. "

ENRICA MARENTINO
CFD Specialist
Leonardo

> " We trust the results we get with modeFRONTIER so much that we don't expect we'll require a prototype. We go straight into production. "

DAVID ERŽEN
Aerodynamics Engineer
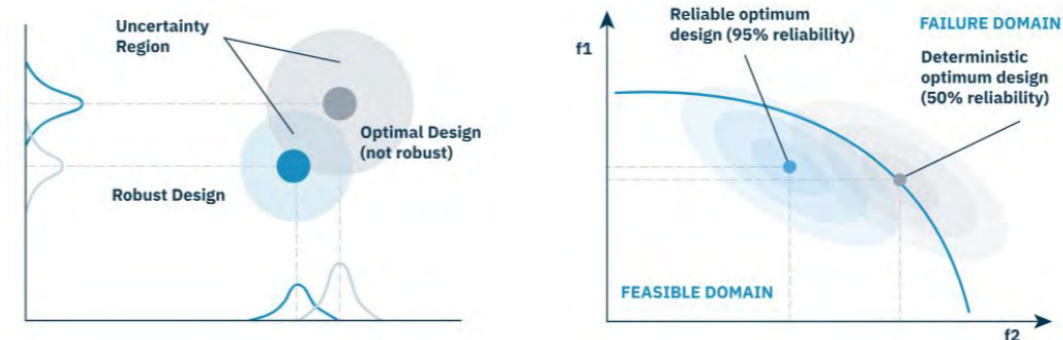**Pipistrel**

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5. Turn uncertainties into well performing products

modeFRONTIER offers robust and reliability-based design optimization strategies to select designs that perform better in real-word and have the lowest failure rate possible.

In many engineering design optimization problems, uncertainties (like manufacturing tolerances, operating conditions, etc.) affect the design parameters, objectives, and constraints. Deterministic optimization methods yield solutions with the best nominal values but do not guarantee that such solutions also have good off-design characteristics or a low probability of violating constraints.

modeFRONTIER's stochastic robust design approach allows you to find so-called "robust" (i.e., less sensitive to input parameters changes due to the uncertainties) optimal solutions. You can, for instance, optimize the mean value and minimize the standard deviation of the objective functions. In this way, you can reduce output variability due to input variations. Moreover, with modeFRONTIER's reliability module, you can estimate percentile values of objectives and constraints. As a result, you can maximize the probability that optimal designs will not fail to meet a pre-defined criterion or performance.

6. Make informed data-driven design decisions

Design space exploration studies usually generate a lot of numbers which are meaningless unless you give them a proper interpretation. modeFRONTIER answers this need with multi-dimensional design charts and advanced data analysis techniques.

Tools like Sensitivity Analysis and Clustering are very powerful to identify the most important parameters or to group similar data to better understand their relationship. With Multi-Criteria Decision Making (MCDM) algorithms, you can rank all reasonable design alternatives on the basis of your own preferences.

modeFRONTIER contains advanced data analysis and visualization tools to perform statistical assessment of complex datasets.

> " Our simulation toolchain combined with modeFRONTIER optimization capabilities led to evaluating 500 catalyst system designs within two weeks. Manufacturing and testing few prototypes would have taken us months and significant resources due to the expensive precious metals incorporated and additional operational costs. "

STEFAN KAH
Application Engineering Modeling
BASF Catalysts Germany GmbH

> " modeFRONTIER proved highly reliable for reducing design cycle time and improving the performance of the valve train system. From the outset, it helped drastically reduce the time taken for calibrating GT models. "

AMBIKAPATHY NAGANATHAN
Structural and Dynamics Analysis Engineer
**Cummins**

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7. **Use Python scripting skills in modeFRONTIER**

By combining Python programming language with modeFRONTIER, it is possible to create custom simulation workflows as well as perform Machine Learning-based data analysis and predictive modeling. Through the Python integration interface, you can automate specific solvers and drive simulation chains in modeFRONTIER workflow by interacting with your Python interpreter. In addition, modeFRONTIER's PyCONSOLE environment lets you post-process optimization results with dedicated Python ML libraries, and train Python-based RSMs. With the pySCHEDULER, you can even import your own Python-based algorithm and use it as native modeFRONTIER optimizer.

modeFRONTIER's Python ecosystem enables users to execute code in the simulation workflow and import Python-based ML libraries.
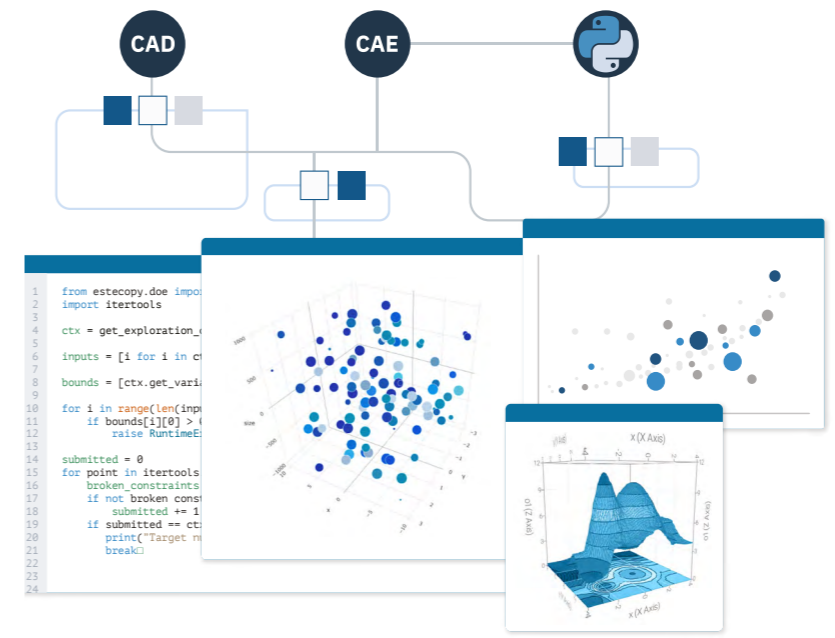
8. Connect to ESTECO VOLTA SPDM platform

In most organizations, few experts have the skills to automate simulation processes and apply design optimization strategies. To break down silos of expertise, the next logical step is to make simulation workflow re-usable by a wider audience of engineers. Through the seamless integration between modeFRONTIER and VOLTA SPDM platform, you can directly execute simulation workflows and perform design space exploration studies from an intuitive web interface.

Furthermore, VOLTA enables you to version and share all your data, CAD/CAE models, modeFRONTIER workflows and optimization studies across your engineering teams. Using this approach, multiple users, from different sites and with different competencies, can more easily participate in the Multidisciplinary Design Optimization (MDO) process.
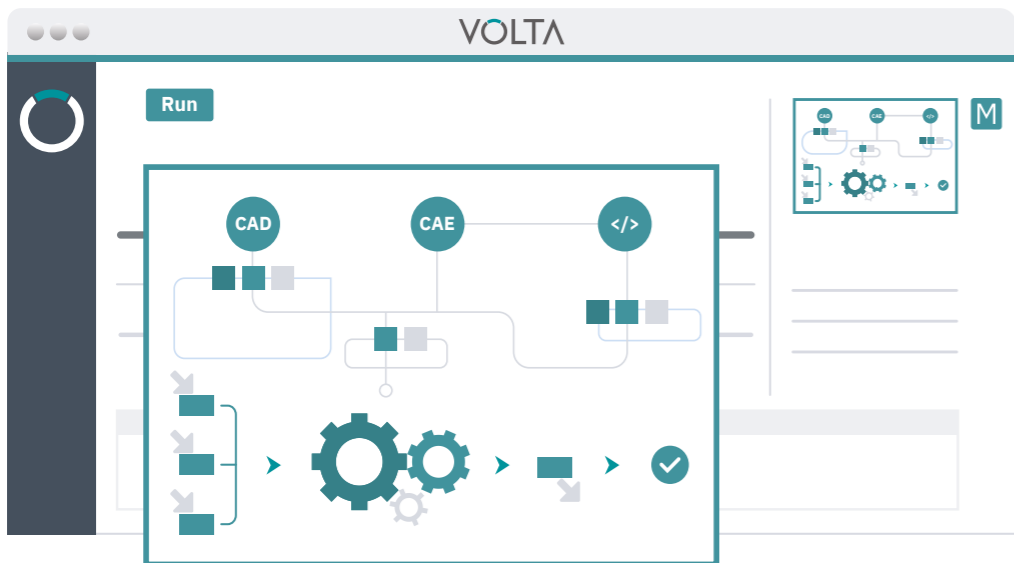
VOLTA provides modeFRONTIER users with features related to collaboration, distributed execution of designs, and traceability of optimization results.

> **Bombardier reduces aerodynamic drag by 20% and saves about the 10% of energy consumption with modeFRONTIER.**
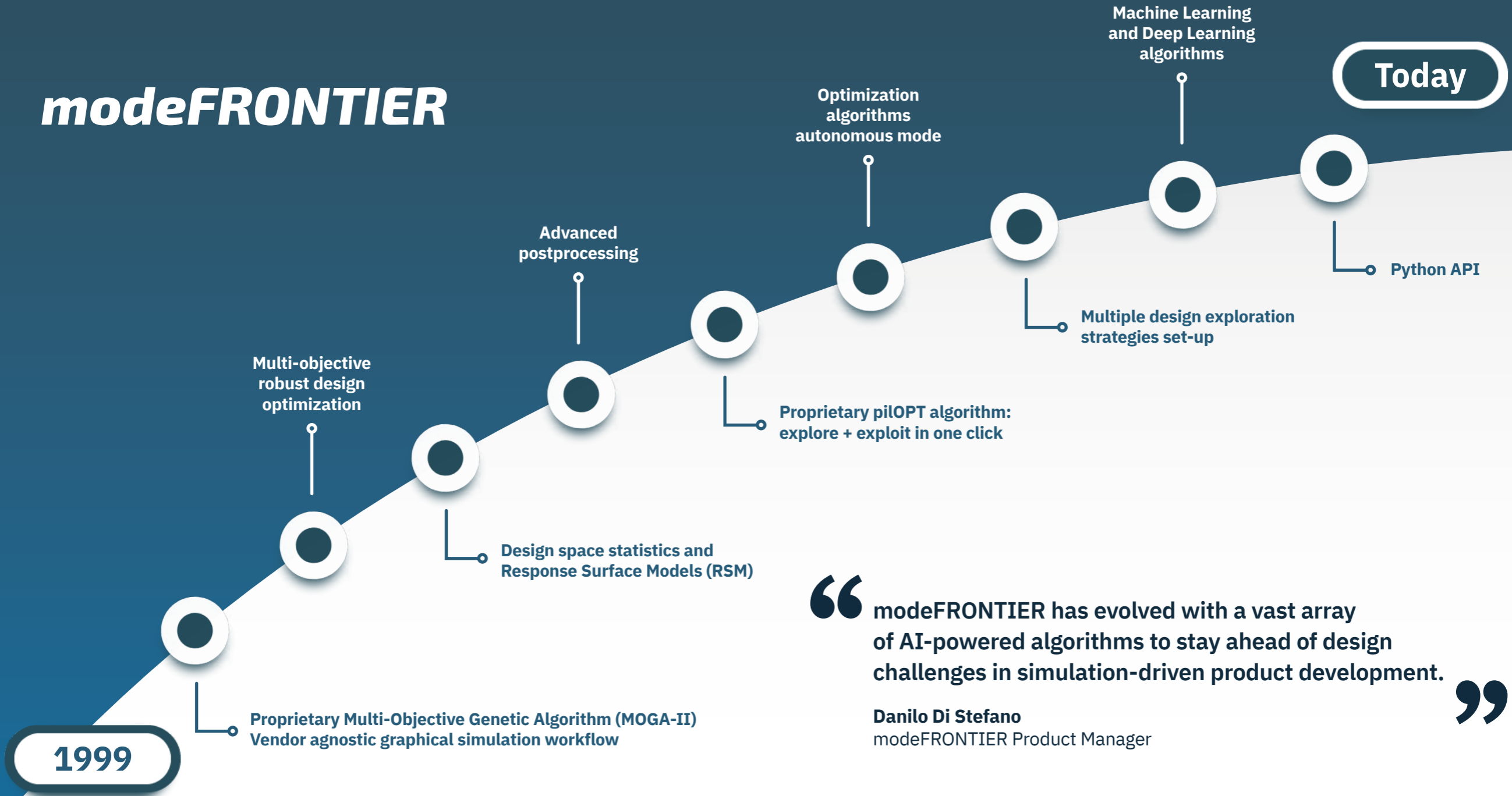>
> **Alexander Orellano**
> Head of Aerodynamics
> Bombardier

Why modeFRONTIER: optimization that works for every simulation engineer

For industrial applications, Process Integration and Design Optimization (PIDO) software available today may not be able to handle the computational workload required by an optimization task. Their simulation workflows often have limitations when it comes to modeling complex design processes for a wide range of engineering challenges. modeFRONTIER is unique in that because it offers:

- **High-quality code base and continuous development**
  Built from the ground up and maintained to solve any computational heavy multidisciplinary and multiobjective optimization problems.

- **The most versatile application of optimization**
  Regardless of the industry or engineering disciplines you work in.

- **Simplified optimization experience**
  Intuitive interface with fast access to set-up simulation workflows and apply design space exploration strategies.

- **Over 20 years of experience in numerical methods**
  All-inclusive set of DOE and optimization algorithms to respond to the most varied customer needs.

- **One-to-One CAE engineering support**
  Work side-by-side with ESTECO engineers to apply the most appropriate design space exploration strategy for your design challenge.

modeFRONTIER

1999

Today

Proprietary Multi-Objective Genetic Algorithm (MOGA-II)
Vendor agnostic graphical simulation workflow

Multi-objective robust design optimization

Design space statistics and Response Surface Models (RSM)

Advanced postprocessing

Proprietary pilOPT algorithm: explore + exploit in one click

Optimization algorithms autonomous mode

Multiple design exploration strategies set-up

Machine Learning and Deep Learning algorithms

Python API

" modeFRONTIER has evolved with a vast array of AI-powered algorithms to stay ahead of design challenges in simulation-driven product development. "

Danilo Di Stefano
modeFRONTIER Product Manager

Future scenario: master engineering complexity and speed up product development

Consider adopting modeFRONTIER like hundreds of leading organizations worldwide (including ABB, Cummins, Ford Motor Company, Honda, Lockheed Martin, Sony, Toyota and Whirlpool) that use it extensively to:

- Reduce operational costs by automating complex simulation chains in a single actionable workflow.

- Maximize the investment in CAD/CAE software with DOE and optimization algorithms.

- Increase product performance by evaluating thousands of design configurations simultaneously.

- Save time across the entire design process by automatically running repetitive simulations.

- Make it easy to set up and run complex Multidisciplinary Design Optimization (MDO) processes.

> " modeFRONTIER has been widely used in the engine modeling phase, in combination with GT-SUITE. There is great potential for further accuracy improvement by using optimization results as continuous feedback between design and testing phase. "
>
> **MR. GOH**
> Project manager,
> TMC Laboratory Automation System
> **Toyota TD**

> **"** Using modeFRONTIER process automation, intelligent algorithms and decision making capabilities enables us to decrease foil optimization time from 3 weeks to 4 days. **"**
>
> **PAOLO MOTTA**
> Performance Prediction Engineer
> **American Magic**

> **"** modeFRONTIER is one of the essential work tools of our Team, because it supports us in optimizing the hydrodynamic profiles that will form the basis for a wider 3D analysis in the wing and rudder design of the AC75. **"**
>
> **ANDREA VERGOMBELLO**
> VPP and CFD optimization
> **Luna Rossa Prada Pirelli Team**

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See modeFRONTIER
in action: BOOK a DEMO

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modeFRONTIER   EXPEDITE DESIGN PROCESS WITH CUTTING-EDGE OPTIMIZATION TECHNOLOGY

About us

ESTECO is an independent software company, specialized in numerical optimization and simulation process and data management.
With a 20-year experience, ESTECO supports over 300 international organizations including: Ford Motor Company, Honda, Lockheed Martin, Toyota and Whirlpool.

esteco.com