Process Integration and Design optimization with AIML

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Ansys

Agenda

- Introduction
- What is PIDO – Process Integration and Design Optimization
- Sensitivity Analysis for design understanding and/or Optimization
- Robustness Evaluation and Uncertainty Quantification
- Simulation Automation to Democratization
- AI/ML enabled Intelligent Engineering solution
- Q&A

Ansys Perspective: AI/ML approaches

Bottom-Up Methods

Organic ML Initiatives

- ML-based fast high-fidelity solvers
- ML-enabled enhancements
  - Initial meshing
  - Sub-modeling
  - User-Experience
  - Solution steering / settings
- ML-services across physics
  - C++ based deployment model

Top-Down Methods

Fast, Accurate, Predictive

- Design Optimization
  - Performance & operations scenarios
- Model Calibration
  - Plant & Controls integration
- MIL-SIL-HIL integration
  - Virtualization & acceleration
- Virtual Validation
  - Calibrated Plant and Controllers
- Lifecycle Exploration
  - Plant & Controls integration

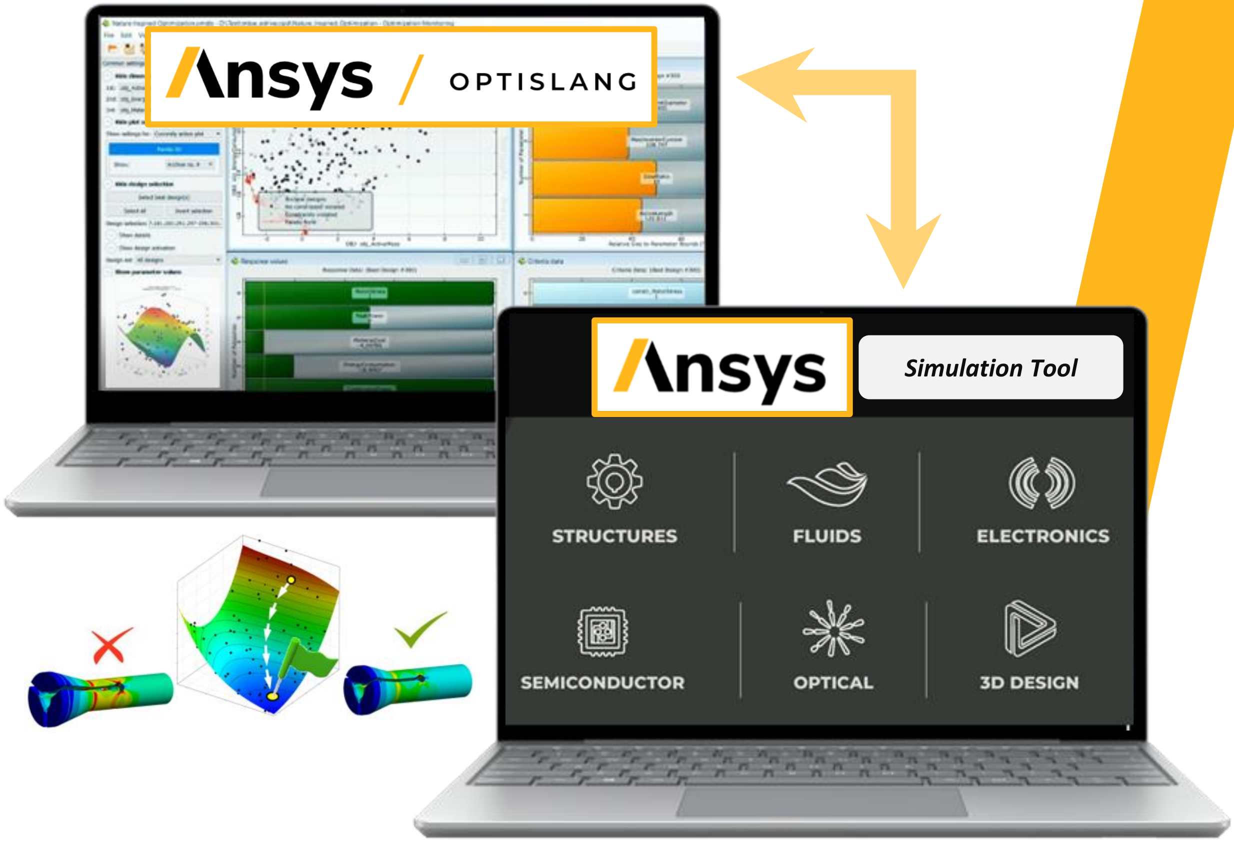
Special Initiatives

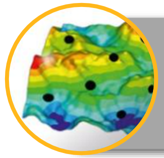
Multi-Fidelity, Hybrids, Twins, Cloud

- 0/1/3-D Reduced Order Models (ROM) from Physics simulation
- Multi-Fidelity models: Physics + Data
- Digital Twins
  - Analytical, Data-driven, Hybrid
- Feature extractions from data for designs, performance and life
- API and UX for ecosystems
  - Partners, customer solutions
  - Cloud services
  - Autonomy and Swarms

Connect to Ansys optiSLang to perform parametric optimization

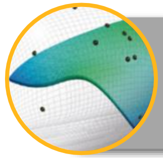
Ansys optiSLang provides a framework for Robust Design Optimization used in conjunction with physics-based simulations to optimize product designs





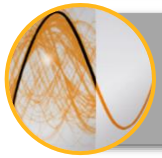
Understand Parameters Importance

Sensitivity Analysis | Parametric Sweep | Metamodels | Design Of Experiment



Use AI/ML-based Optimization Algorithms

Leading Optimization Algorithms | Multi Parameters | Multi Disciplinary



Evaluate Robustness & Quantify Uncertainty

Reliability Analysis | Manufacturing Tolerances | Quality | Design for Six Sigma

Automate & Publish Simulation Workflows

Orchestrate Sequences | Remove Repetitive Tasks | Publish Apps | Extensible API

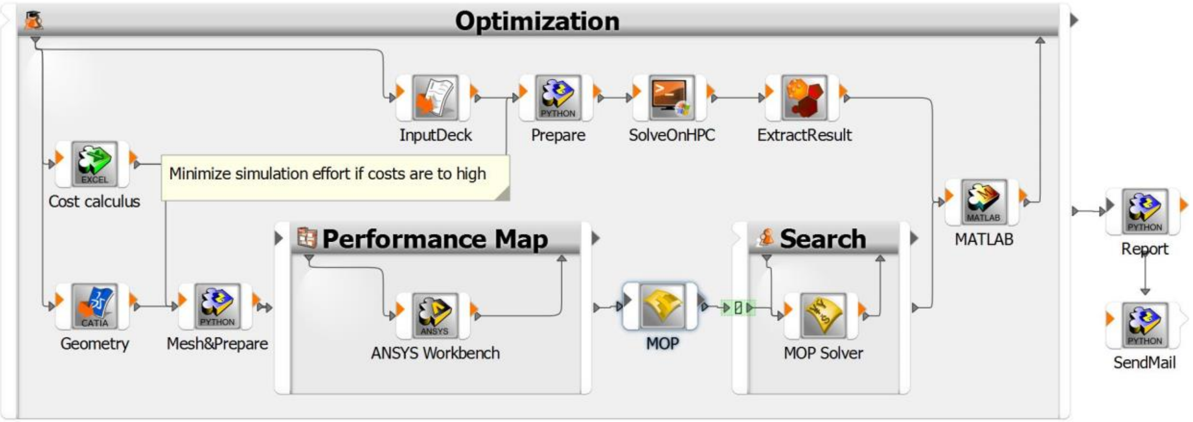
Benefits

- Integrated within Ansys Products: Easy to Learn
- Workflow building: Flexible to Extend
- Integrate toolchains with 3rd party CAE tools
- Applicable to all industries

Improve Product Quality & Get to Market 10X Faster

Process Integration is needed to Automate Simulation Workflows

Ansys Solvers | **External Tools** | **Custom Codes** | **Simultaneous HPC execution**



Ansys / OPTISLANG

Simulation Automation Platform

Connect

Ansys tools, Inhouse Codes, 150+ commercial solutions

Orchestrate

Set sequences, branches, conditions, loops, combination of algorithms

Publish

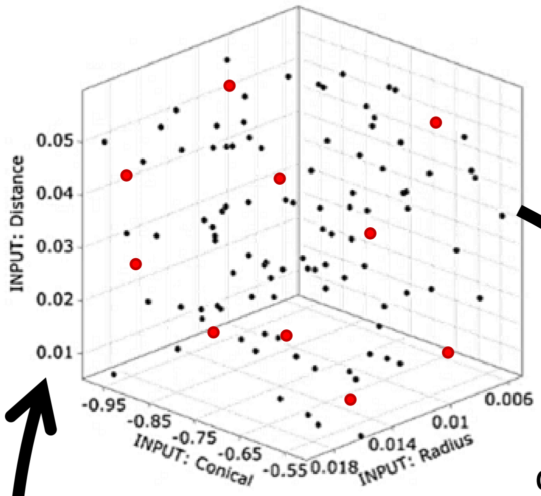
Packaged Apps for Non Simulation experts

Adaptive Metamodel Approach (AMOP)

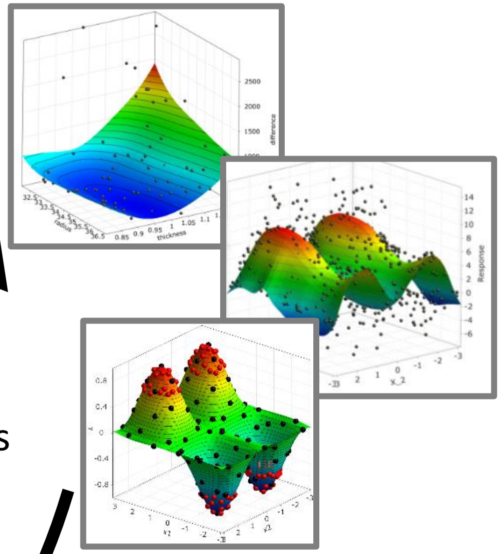
Reduce number of designs by smart design refinement

- Objective measure of prognosis quality = **CoP** (**C**oefficient **o**f **P**rognosis)
- Determination of
  - Relevant parameter subspace
  - Optimal approximation model
- Approximation of solver output by fast surrogate model without over-fitting

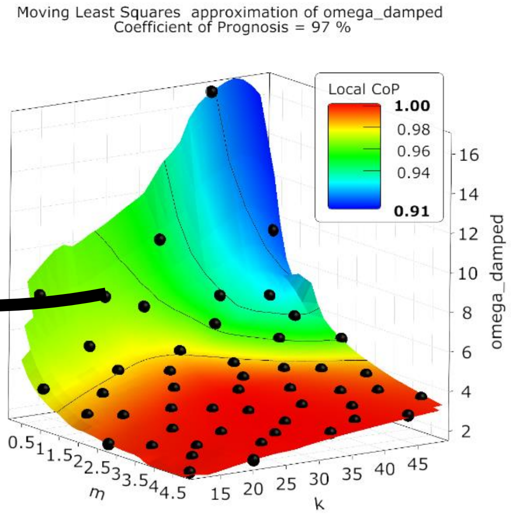
DoE sampling



Generate competing metamodels



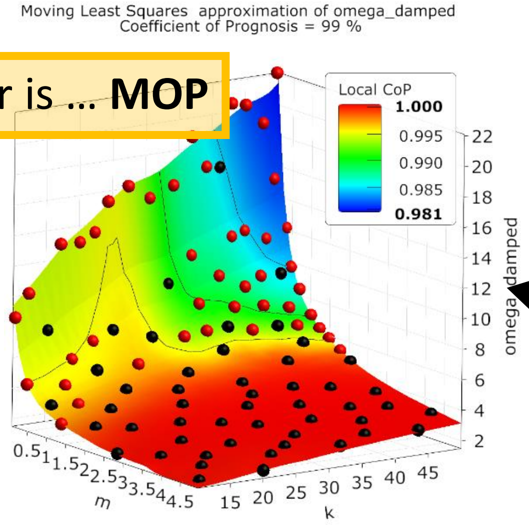
Calculate criteria (e.g. forecast quality)



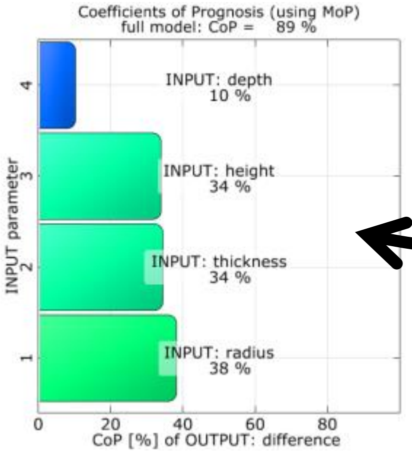
Criteria fulfilled

Add more samples to meet criteria

The winner is … **MOP**



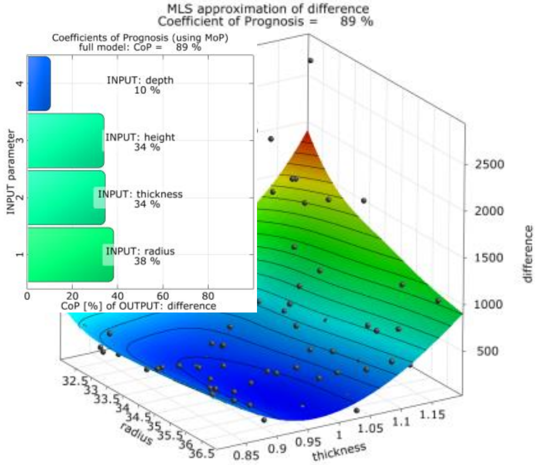
Parameter sensitivities



AI/ML for all available data – 0D/1D/2D/3D/measurements

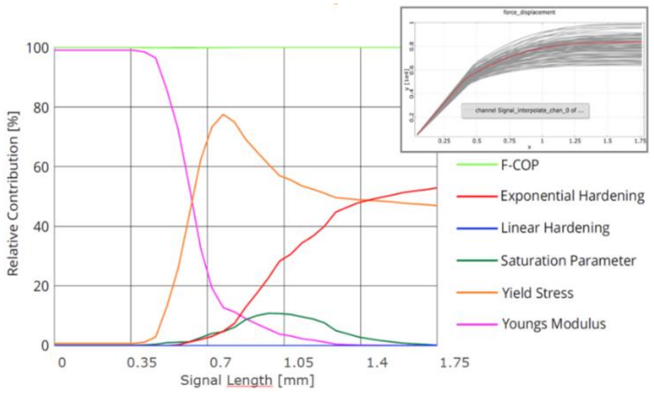
MOP for scalars

See the importance of parameters and how they work together.



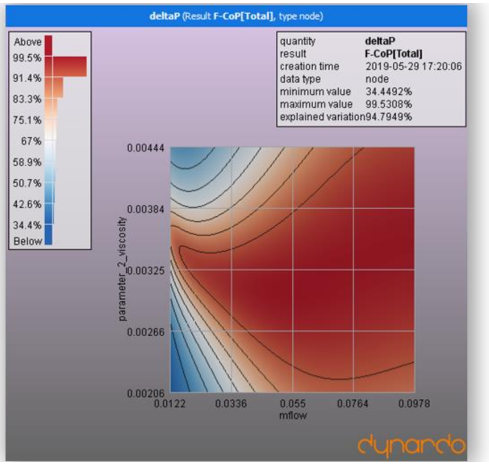
Signal-MOP for signals & curves

Use relevance of parameters at different positions at a curve



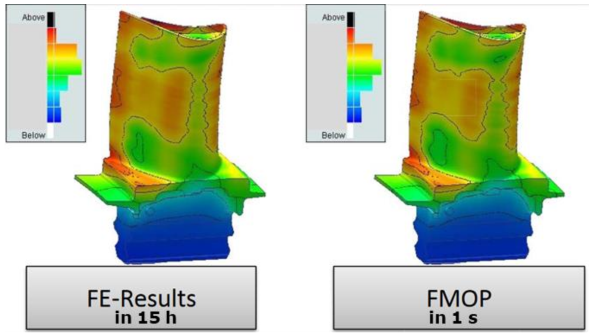
2D Field-MOP for wavefronts, pictures, performance maps …

Which parameter influences which position in the picture?



3D Field-MOP for stress fields, temperatures …

Shows importance of all relevant parameter in 3D Simulation.



Increase design understanding

Increase of model fidelity & value

Ansys

AI/ML Engineering Solutions

1x Simulation

Forward Simulation

n Simulations

Optimization

- Innovative design ideas
- Long simulation times
- Requirements initiate simulation-based optimization runs directly

n Simulations

Machine Learning

ML Model

Intelligent Engineering

- Carry-over designs (Business built on derivatives of past designs – incremental changes of designs)
- Built on ML-models (and/or instantaneous equations) only
- Machine learning is applicable
- Parameter spectrum known and manageable

+ Precision

– Execution time

Trade Off

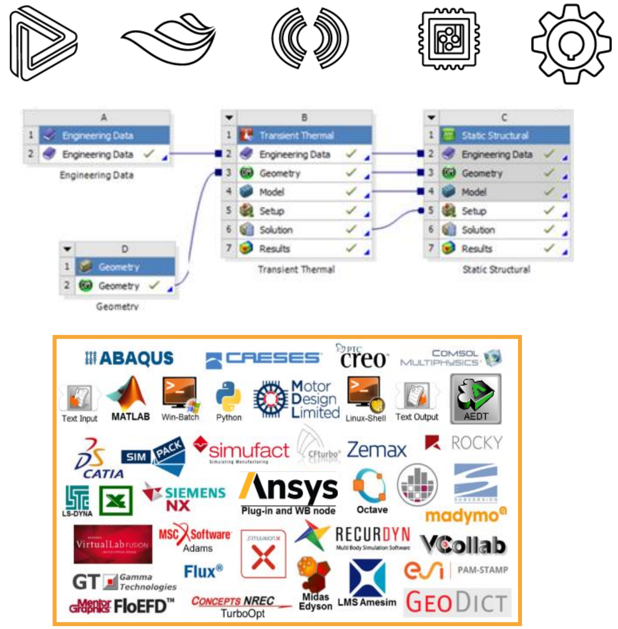
Execution time +

Precision –

Typical customer engagement process for simulation democratization

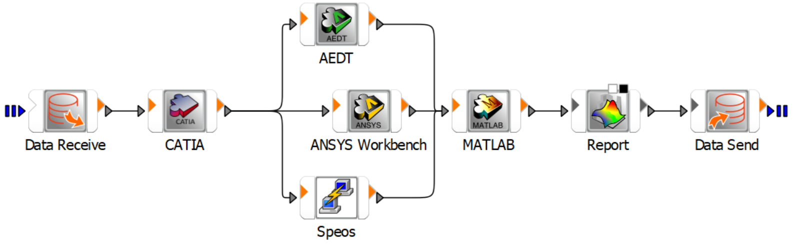
Parametric Simulation

- Industry leading multi-physics & systems offerings
- Vendor neutral, all solvers
- Simulation and Measurement

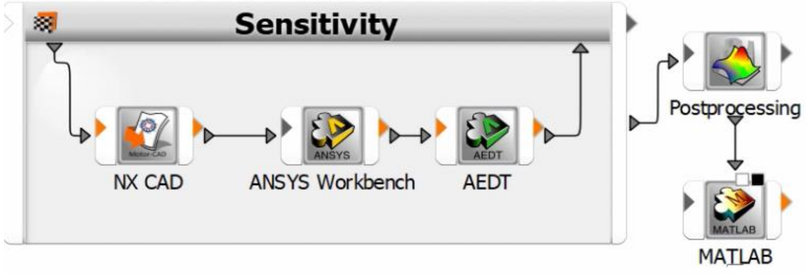


Parametric workflow automation & algorithm

- Parametric Simulation automation
- Design Exploration & Optimization incl. AI/ML algorithms and models
- Robustness / Tolerances Analysis

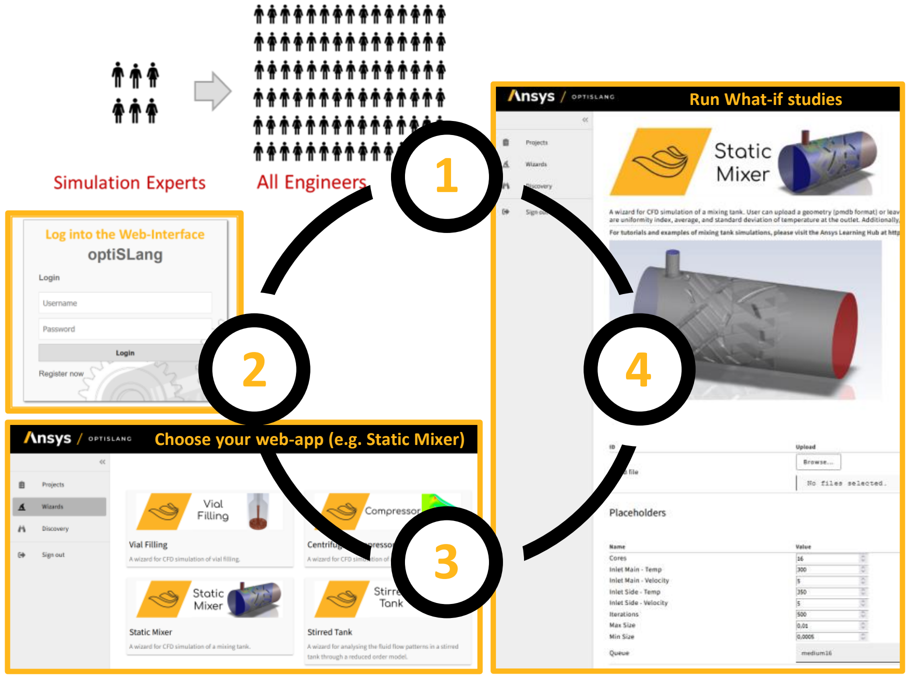


Workflows & Variation Analysis



Browser-based app deployment

- Publish workflows as browser-based apps
- Users are free of licenses, installation, resources → easy to use with custom GUIs
- Incl. Non-Simulation Experts into projects



Multiphysics-Workflow with optiSLang and Mixing applications

Engineering Goals

- Enable more engineers to run standard CFD analysis
- Make it more stable, less manual and even flexible
- Overcome the problem of complex IT configuration for each user

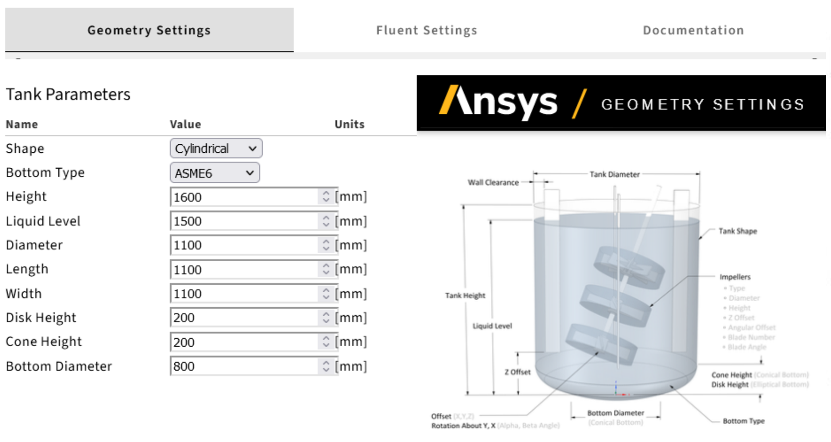
Ansys Solution

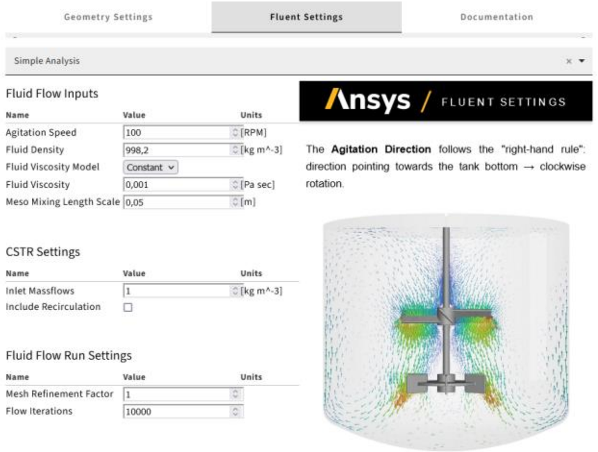
- Parametrized geometry & mesh creation in SpaceClaim & Fluent meshing
- Parameter & Journal driven Fluent runs
- Automated simulation workflow driven by optiSLang
- Easy to use web frontend customized by python
- Auto-generated HTML report with all needed pictures, graphs, video and values

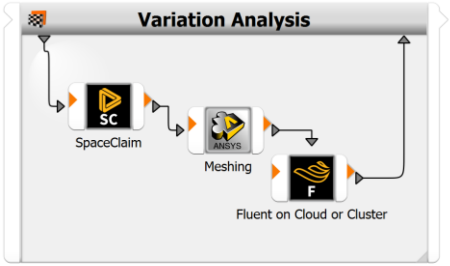
Benefits

- No local installation needed
- Use multiply queues to submit to cloud or company cluster
- User-friendly web frontend
- Faster product development
- Easy to switch from hardware tests to digital/virtual tests

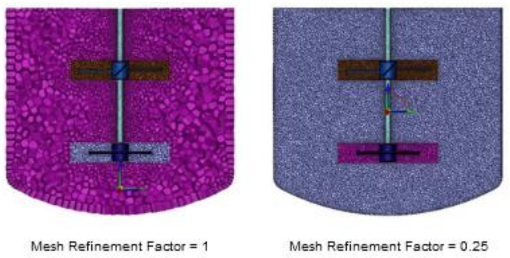
Web frontend (web-app) for democratization of CFD mixing applications in stirring tanks

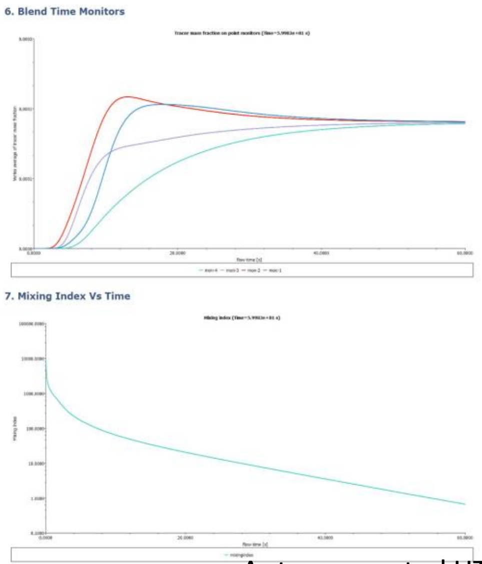


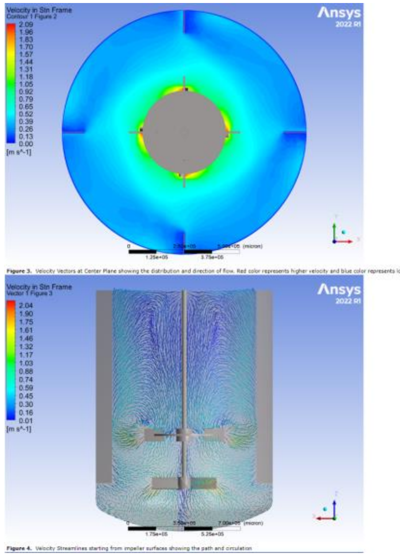




Automated CFD workflow in optiSLang

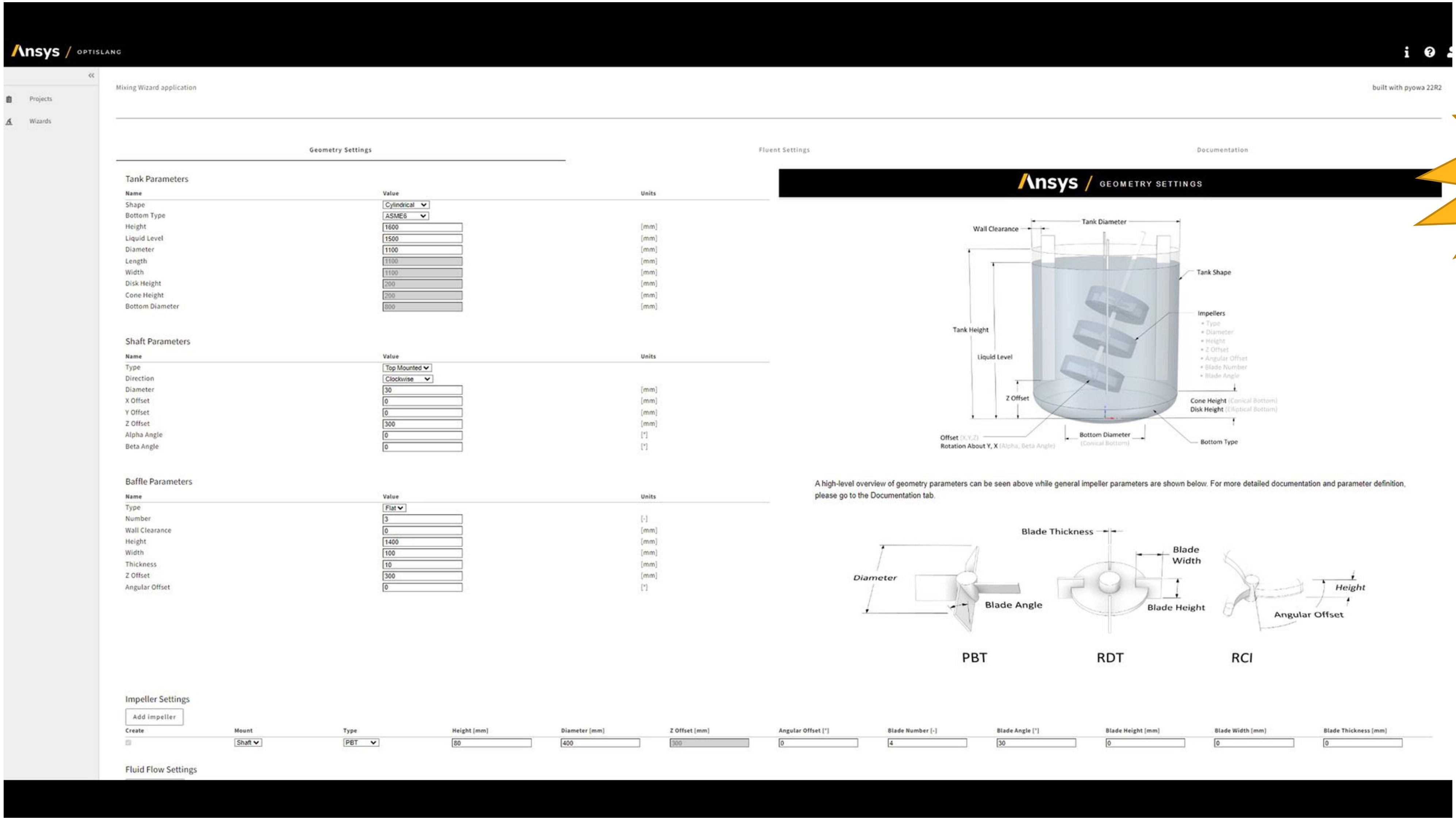






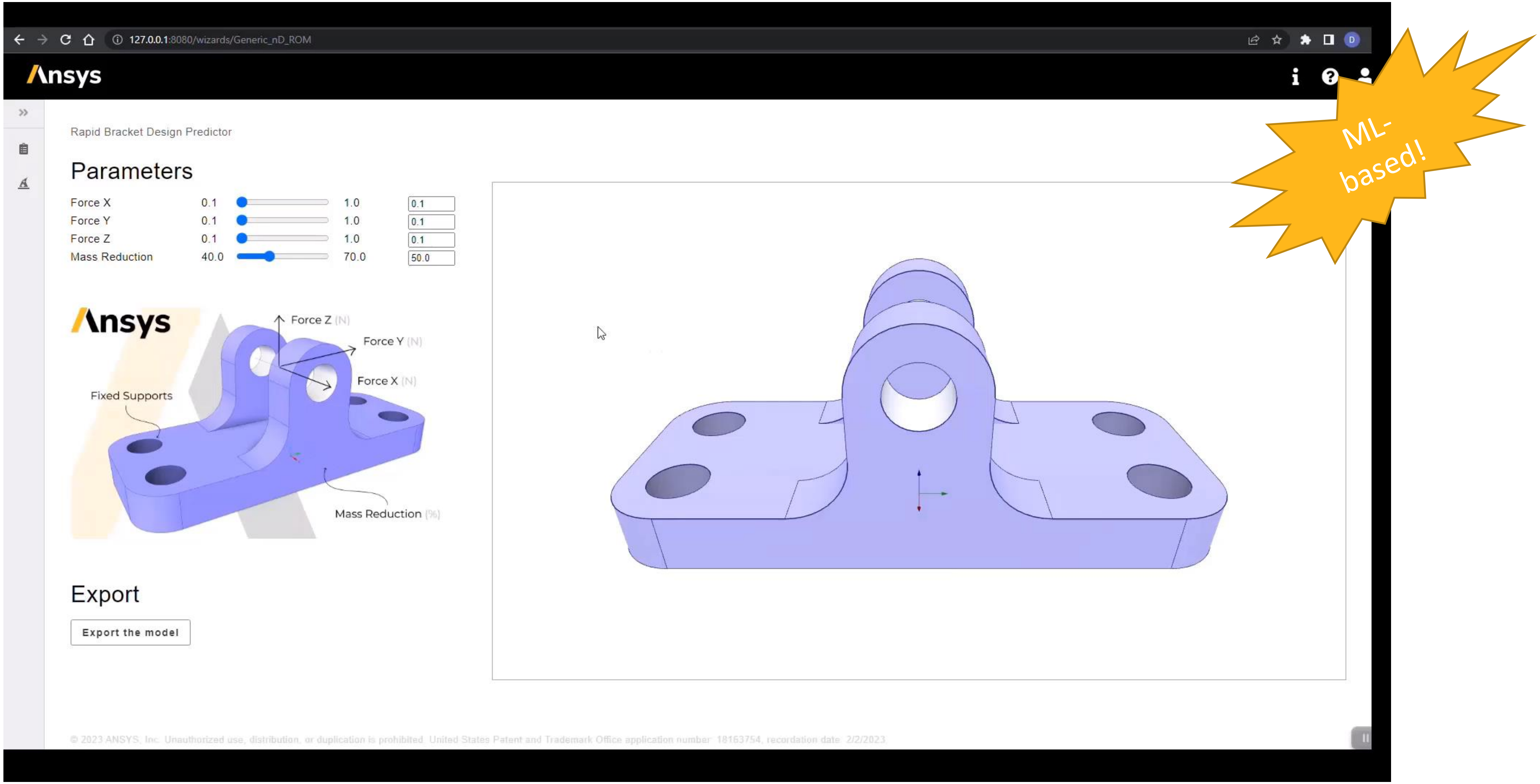
Auto-generated HTML Report

Multiphysics-Workflow with optiSLang and Mixing applications



Forward!

Topology optimization meets Machine Learning



ML based Optimization of Differential Via

optiSLang

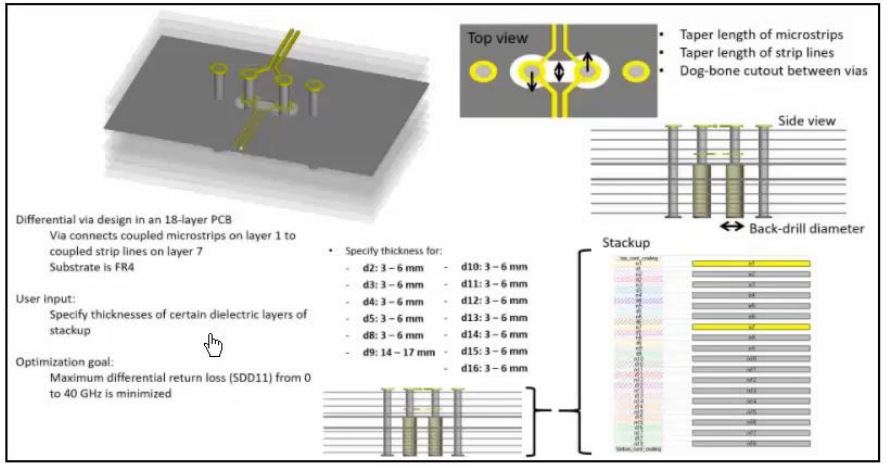
localhost:8080/wizards/webapp_workflow_21R2

Ansys

- Projects
- Wizards
- Administration
- Sign out

Intelligent Engineering

via MOP Optimization



Placeholders

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d13_thickness	4.5	
d14_thickness	4.0	
d15_thickness	4.5	

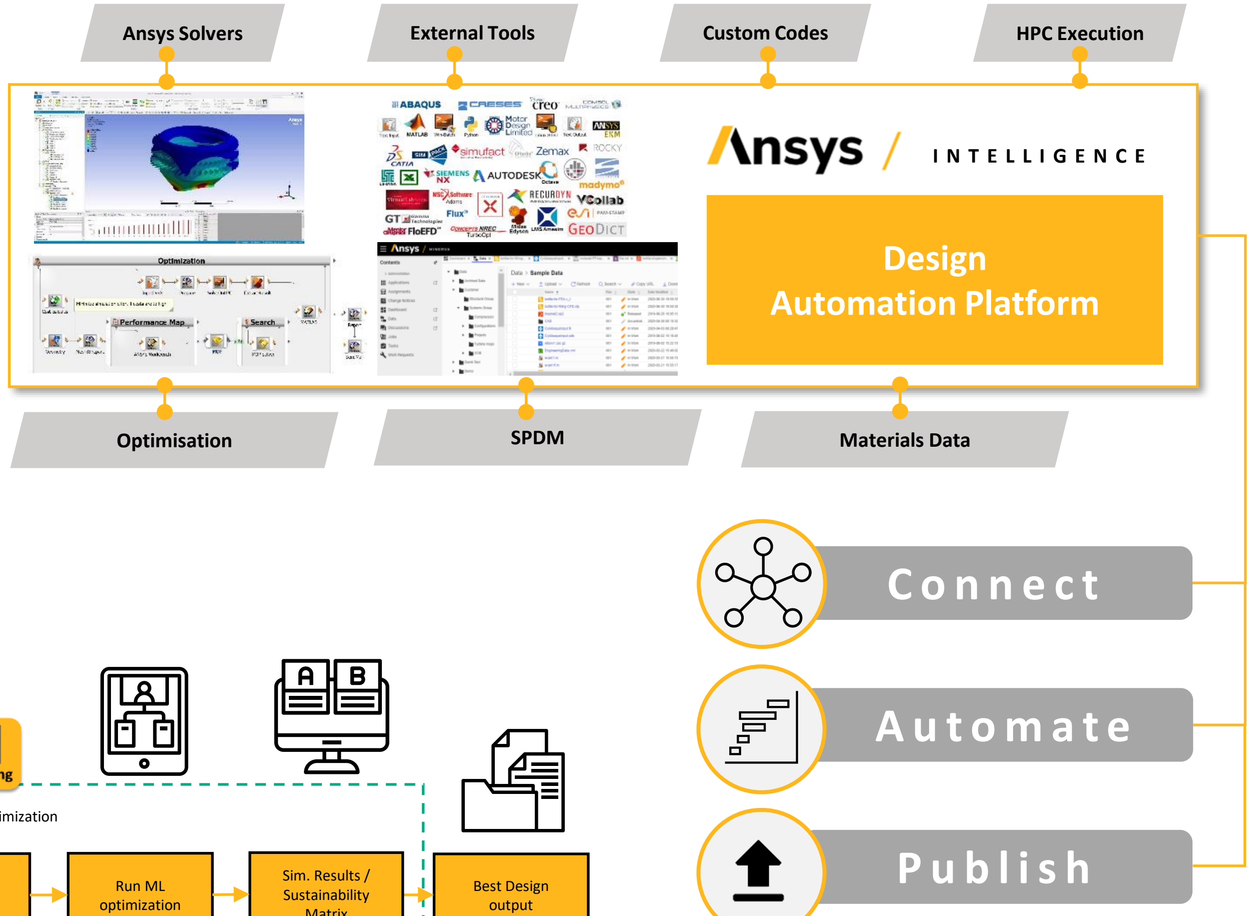
Ansys Intelligent Engineering – Solution Stack

Ansys Intelligence Concept

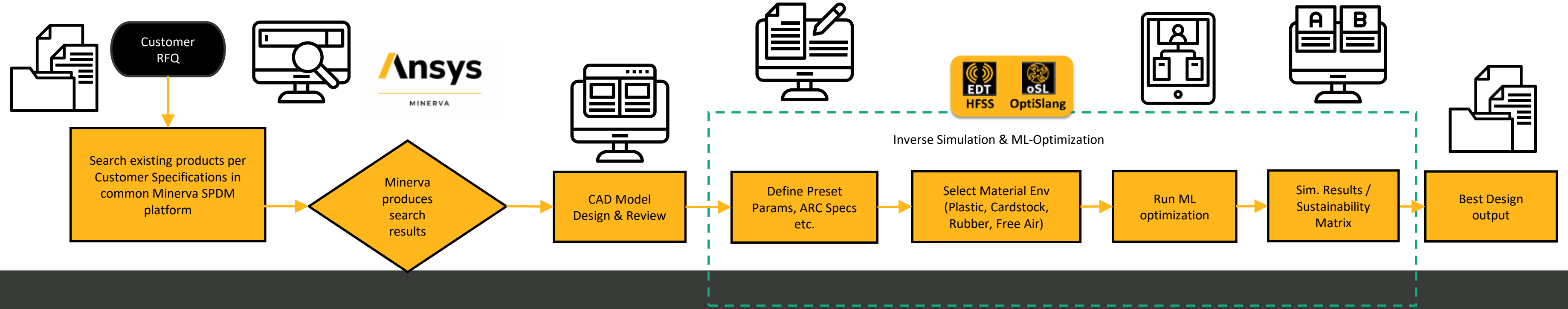
- A solution framework that combines engineering simulation with data science to search, produce, and optimize validated product designs.
- This standardized, scalable solution hyper-automates product design using ML-based parametric optimization to streamline repetitive design and virtual testing efforts.

- Ansys optiSLang
- Ansys Minerva
- Ansys Simulation Solvers
  - **HFSS**, LS-Dyna. Mechanical, etc.
- Ansys Professional Services
- CAD Connectors
- Customer-X AI/ML Solutions

Ansys Intelligence Framework



Ansys Intelligence Workflow



Auto ML used in optiSLang – enabling non-experts to use ML

AI/ML integrated in optiSLang PIDO toolbox and workflows

- **AutoML** Framework combined with automated Simulation Workflow Building
- **MOP** (Metamodel of Optimal Prognosis): Workflow for automatic detection and training of best possible metamodel out of large range of surrogate models including
- AI/ML (Neural Network) integrated into metamodel competition = auto ML
- **AMOP** (Adaptive Metamodel of Optimal Prognosis): Framework for automatic refinement
- **OCO** (One Click Optimizer): AI enhanced optimization algorithm

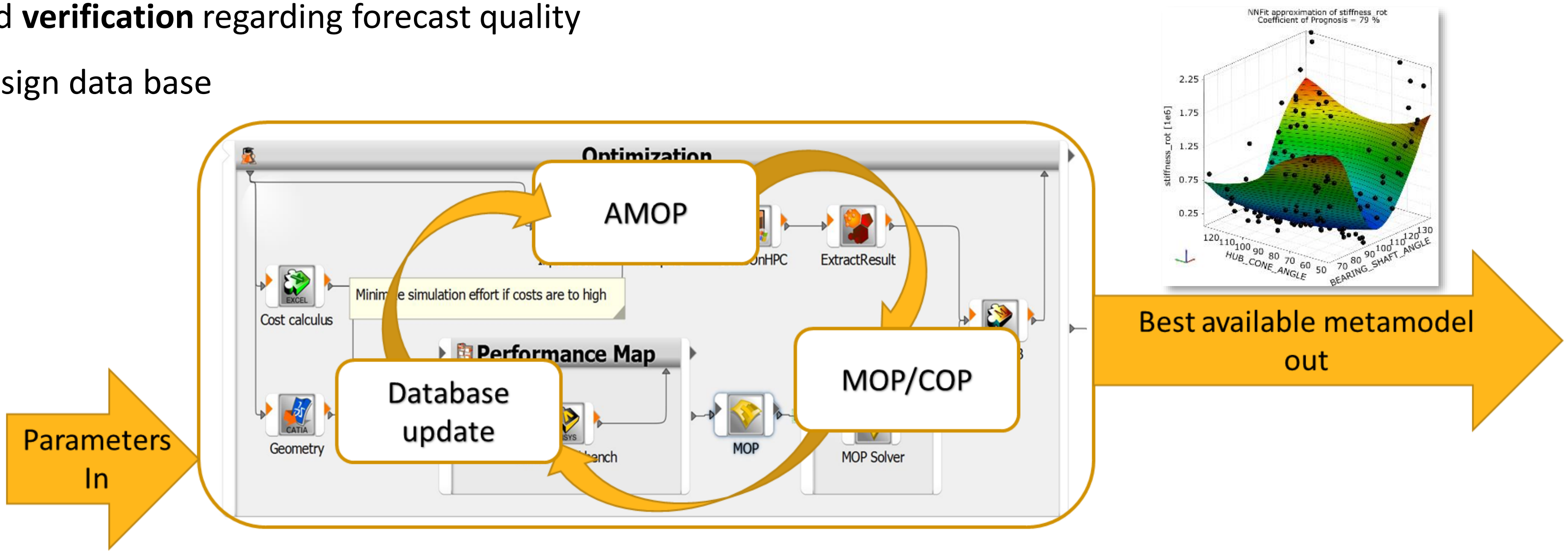
→ **Automatic** generation of best metamodel and **verification** regarding forecast quality

→ Based on the **most efficient** (self learning) design data base

→ Simulation Platform **physics and vendor independent**

→ After Simulation workflow setup democratize as App

→ Enables **everybody** to use it



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