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Hull resistance prediction with nDAI

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Agenda

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About Fincantieri

Optimization Purpose

Workflow Insight

nDAI and Reduce Order Model

Conclusions

About Fincantieri

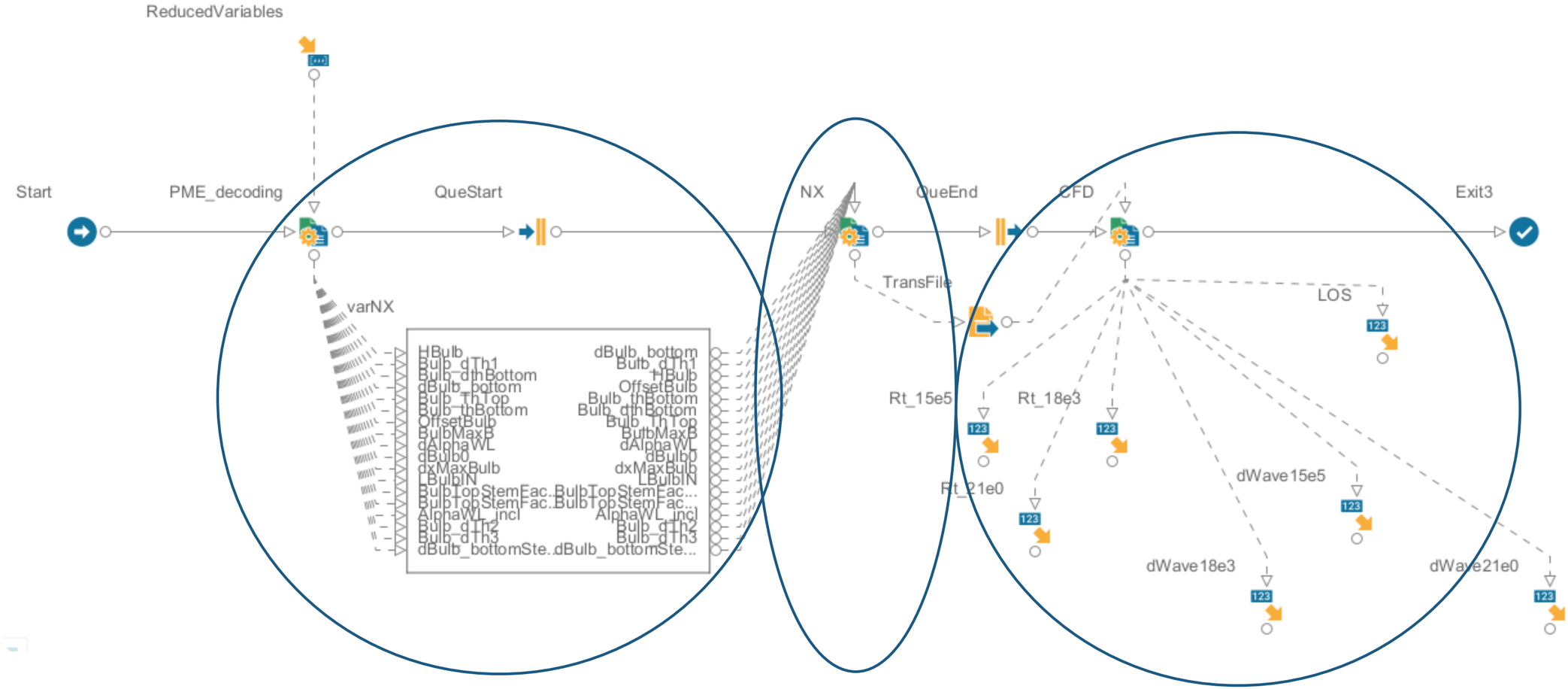
Optimization Purpose

Optimization purpose

- The shipyard has contractual obligation on the speed achievable at a certain power.
- Often this contractual obligations comprehend multiple speeds and powers.
- To reduce the absorbed power is mandatory to reduce the hull resistance.
- The hull resistance can be minimized just for one speed, so it is important to find the best trade off for the project.

Workflow Insight

Workflow Insight



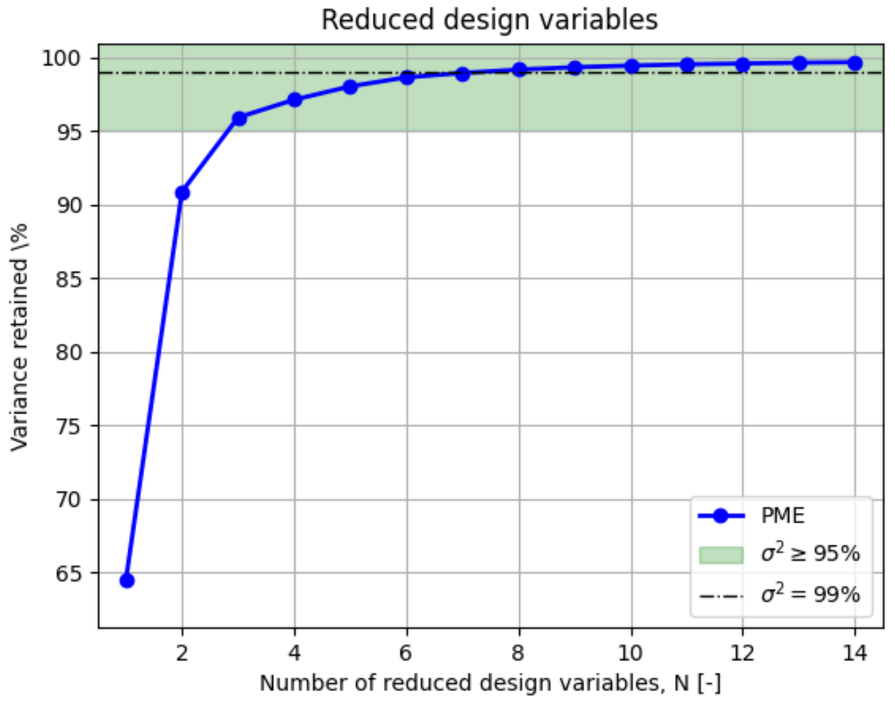
Decoding dimensionality reduction

CAD model

CFD analysis

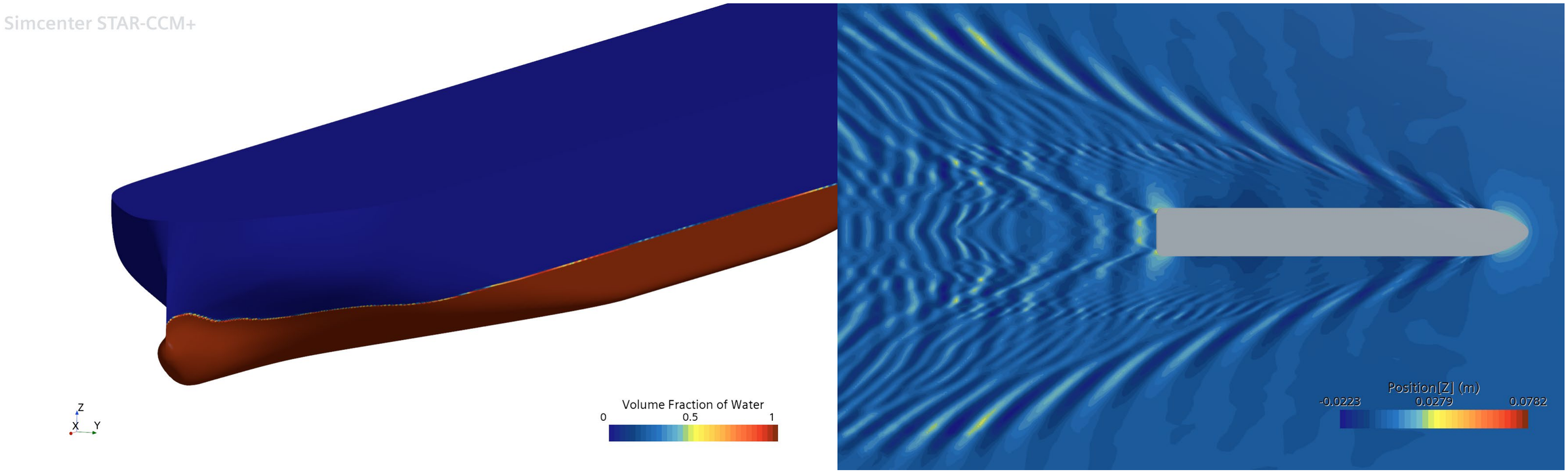
Workflow Insight – Model reduction

- In this phase the Parametric Model Embedding (Serani, Diez 2023) is used in order to reduce the the design-space dimensionality.
- The method is based on the analysis of the geometric variance of the design modifications.
- It allow to rebuild the design in a latent space, using a reduce number of parameters.

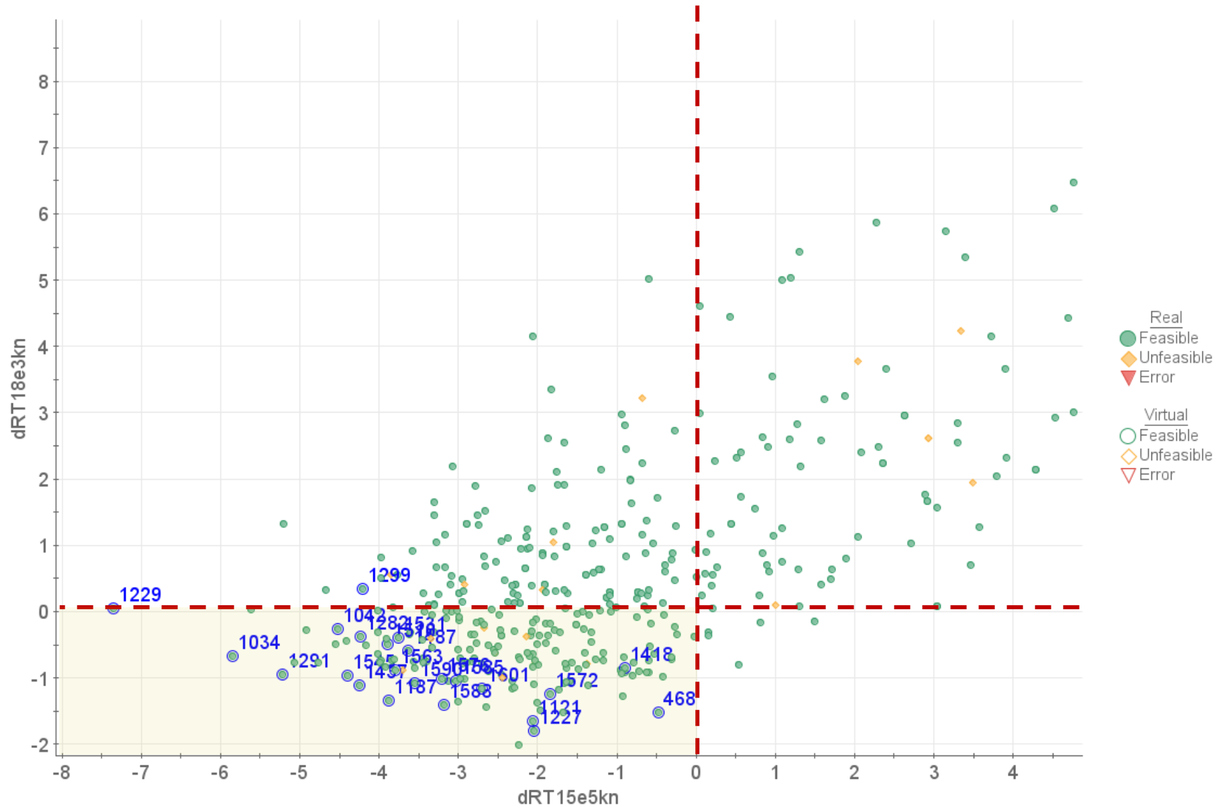


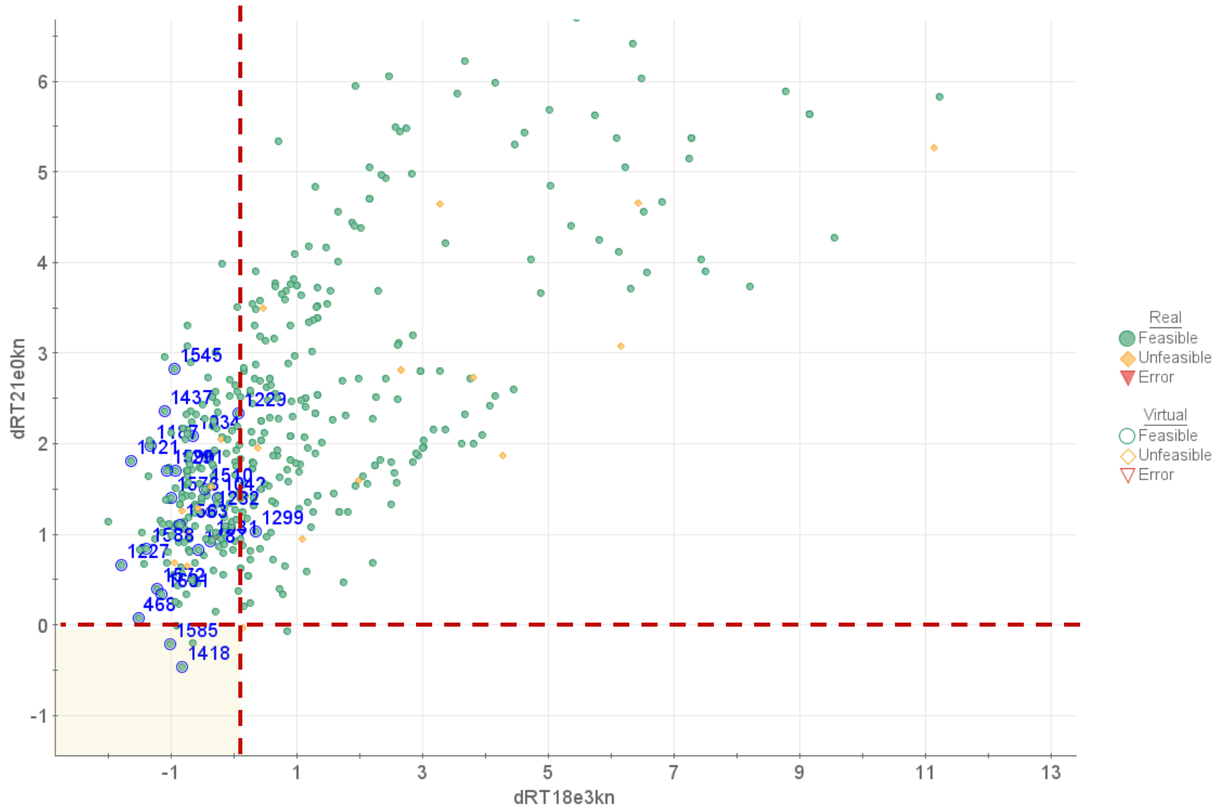
Workflow Insight – CAD modeling and CFD simulations

- The 3D cad model is then bult with Siemens NX
- The CFD analysis is based on an unsteady, VOF, k-omega SST simulations in model scale.



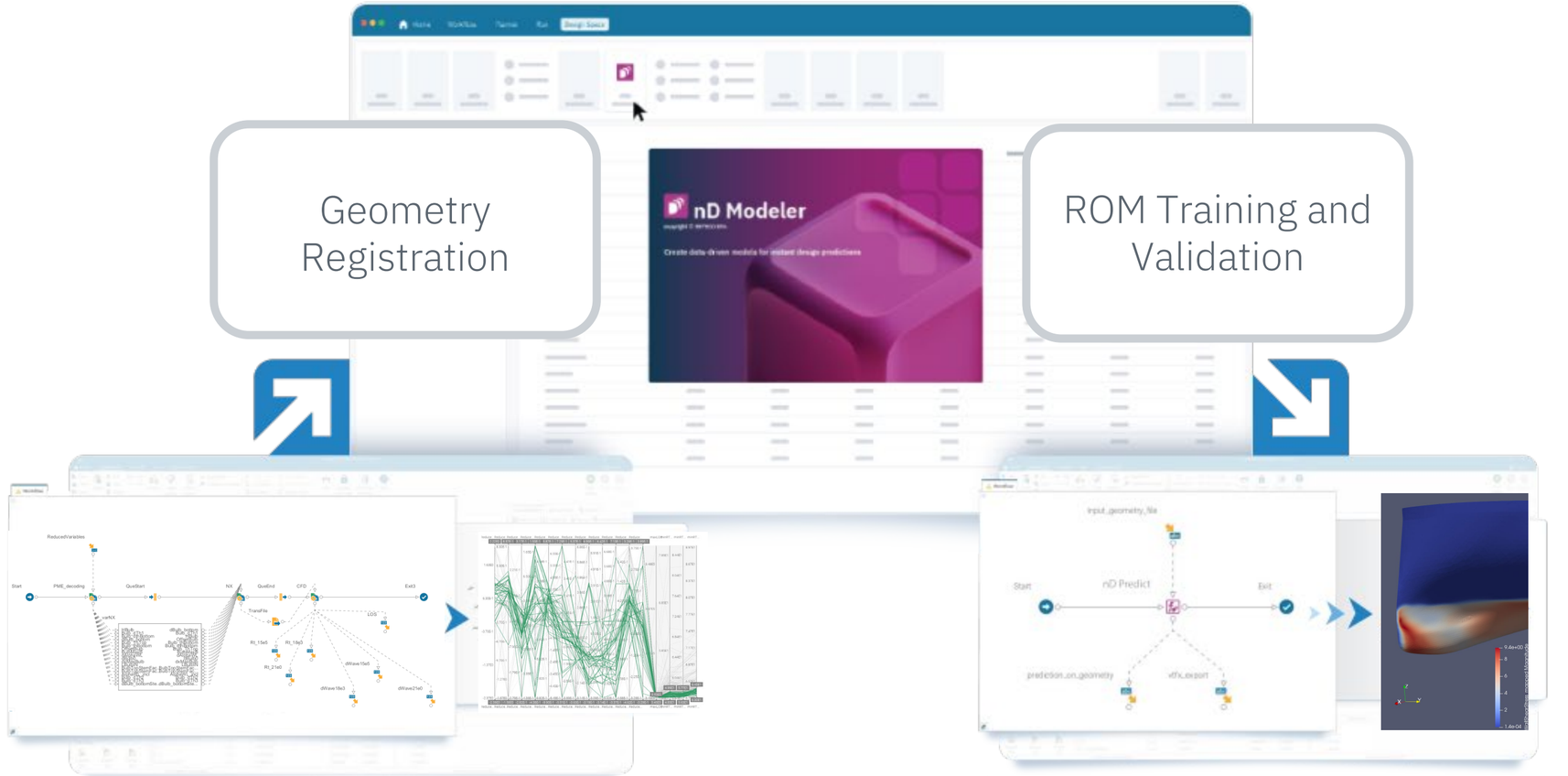
Workflow Insight – Results of the pilOPT optimization





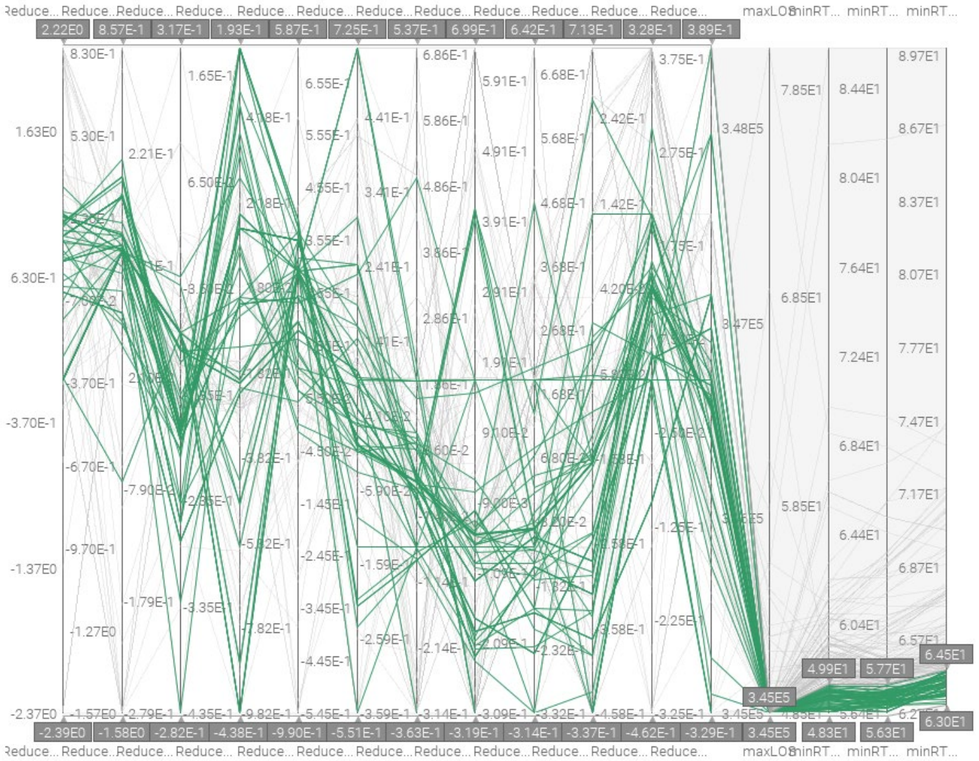
Reduced Order Model training

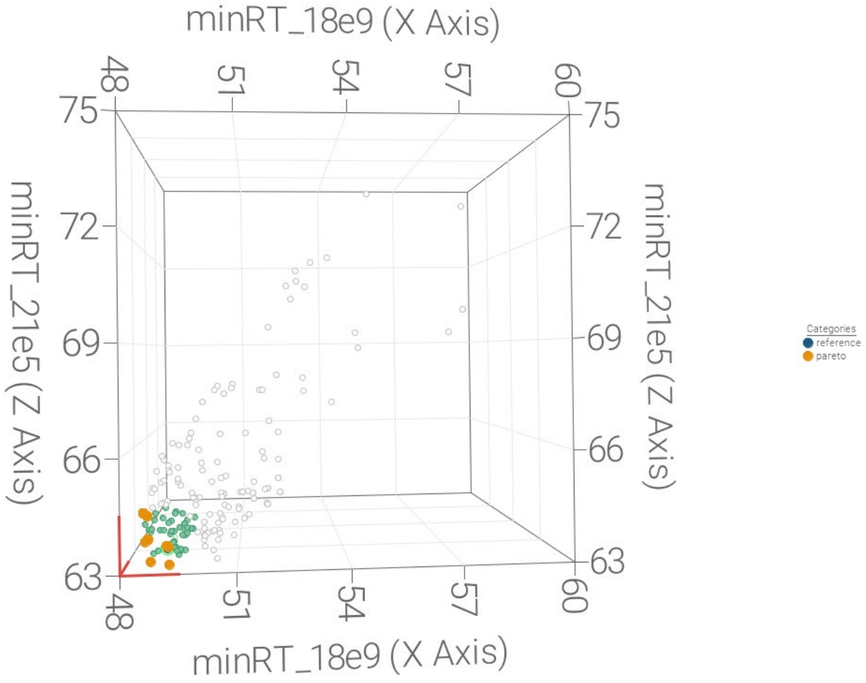
ROM training process



Training set preparation

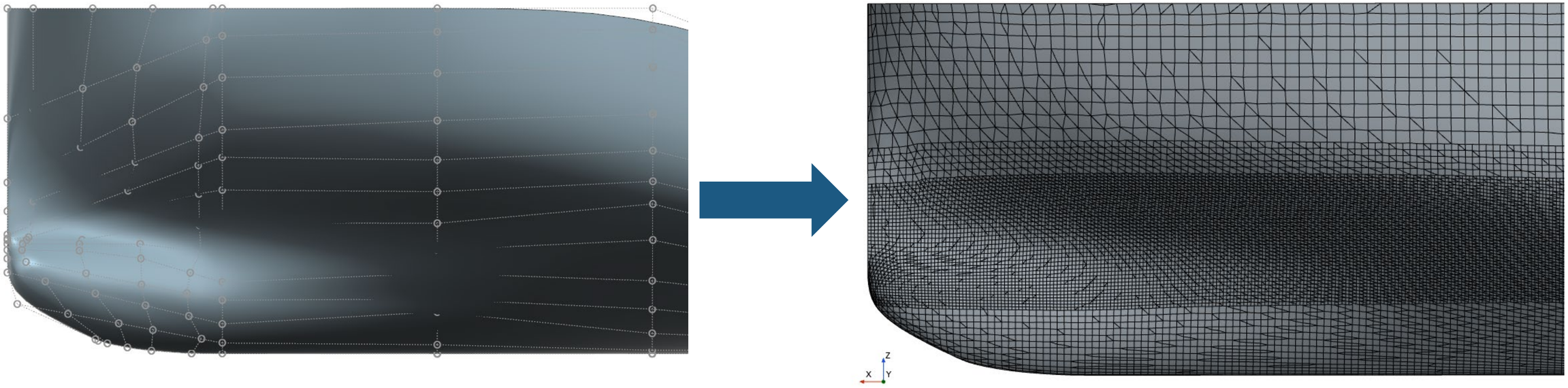
Identify the feasible region within the available design space where performance metrics fit into a defined threshold. The training set is then built exclusively from this filtered subset, ensuring the ROM learns only from high-quality, constraint-satisfying samples.





Geometry registration

In CFD workflow, geometry is parameterised in a CAD Siemens-NX with nurbs surfaces and the mesh is regenerated for each design variant. As a result, every hull mesh has a different topology and a different number of cells — yet ROM training requires a fixed, consistent mesh structure across all samples. Geometry registration is the technique adopted to bridge this gap.



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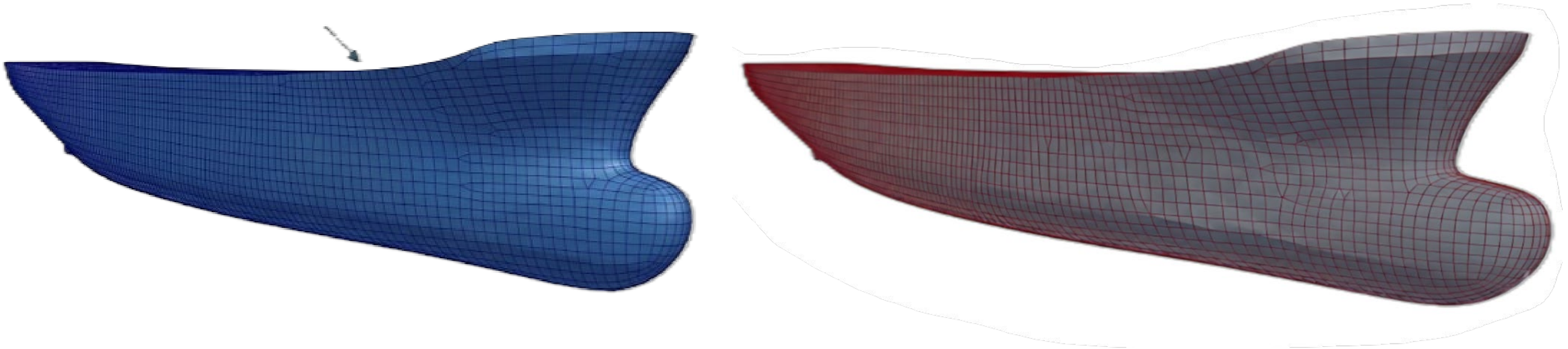
Geometry registration

The baseline (target) mesh is shown on the left, while a design variant mesh is shown on the right. A morphing displacement field is computed to deform the design mesh onto the baseline geometry. Once the two shapes overlap, CFD field quantities are interpolated from the design mesh onto the baseline.



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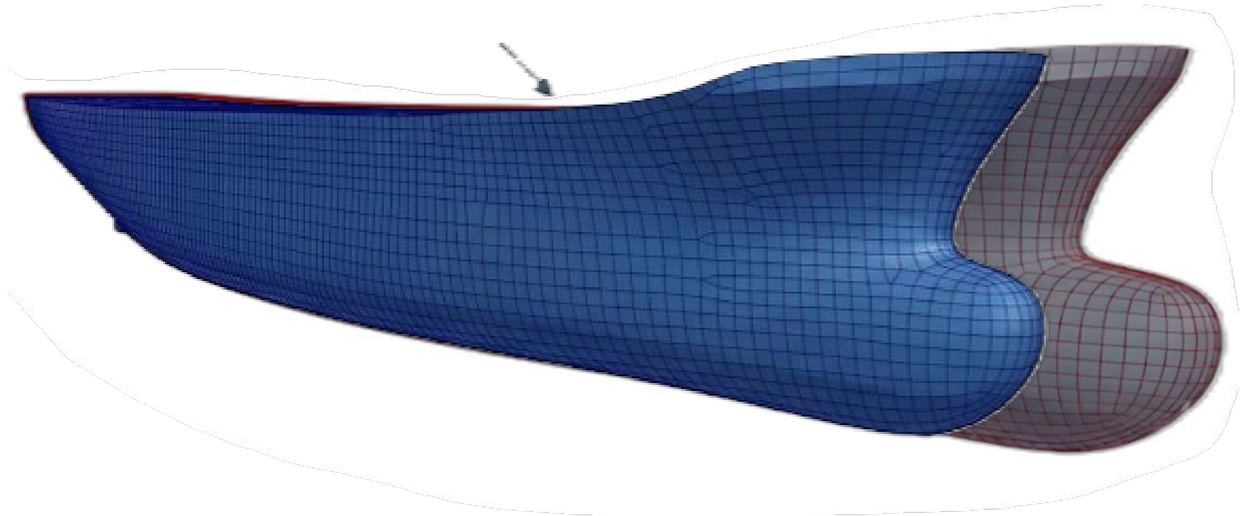

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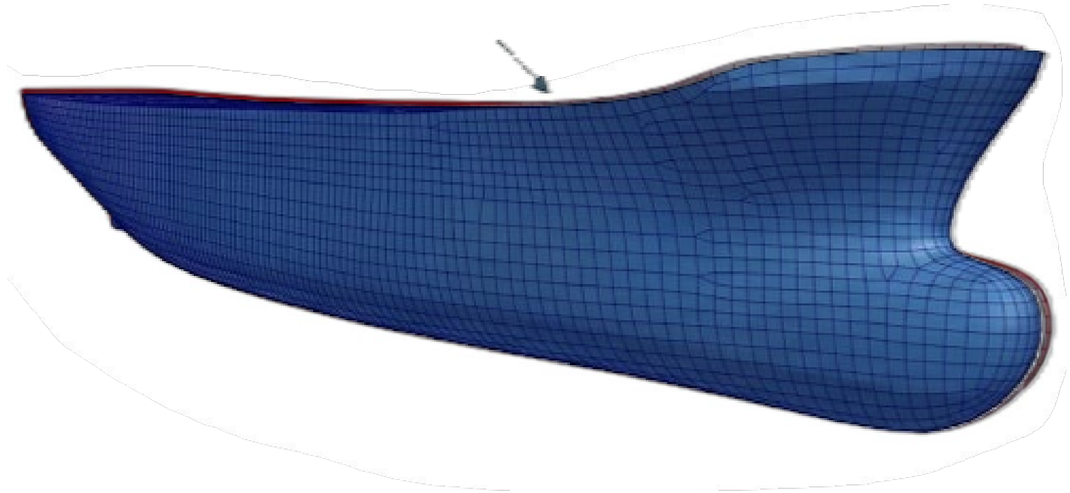

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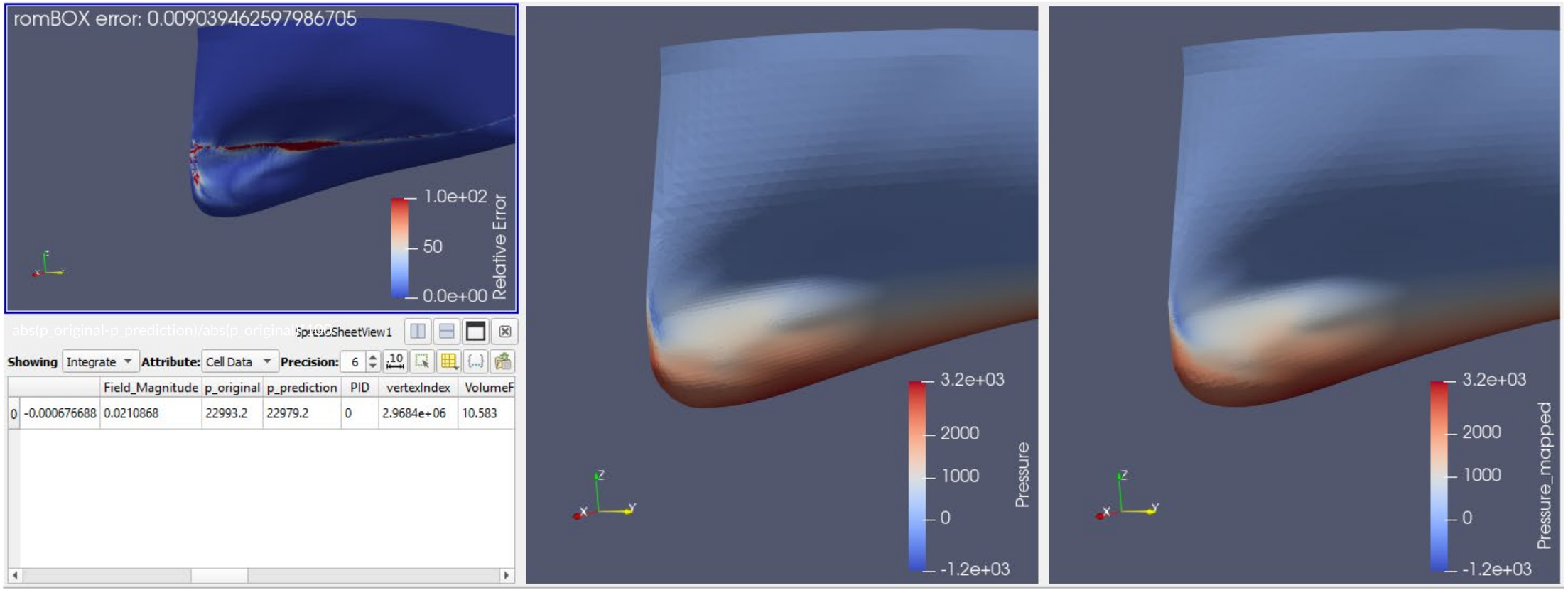
ROM Training and Validation

Once the ROM is trained with nD Modeler, its prediction quality is validated against a set of designs deliberately excluded from the training dataset. For each hold-out design, the ROM-predicted fields of interest are compared against the reference CFD results, providing a quantitative measure of accuracy and generalisation before the model is used for exploration or optimisation.

Design IDs	Pressure Errors	Volume frac Errors	Wall shear Errors
136	0,9038%	1,920%	4,486%
246	1,07E-4%	3.8E-4%	2.99E-3%
297	7,08E-5%	1.17E-4%	5.41E-4%

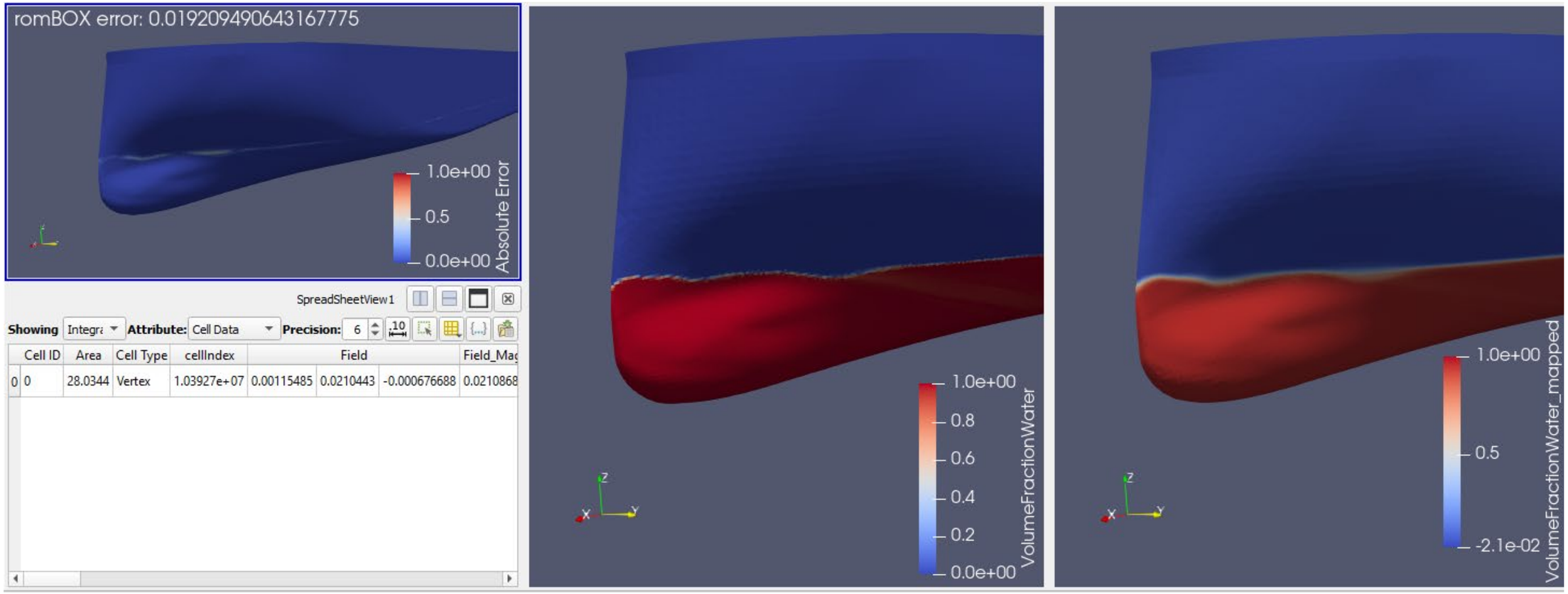
ROM Training and Validation

ID136 Pressure



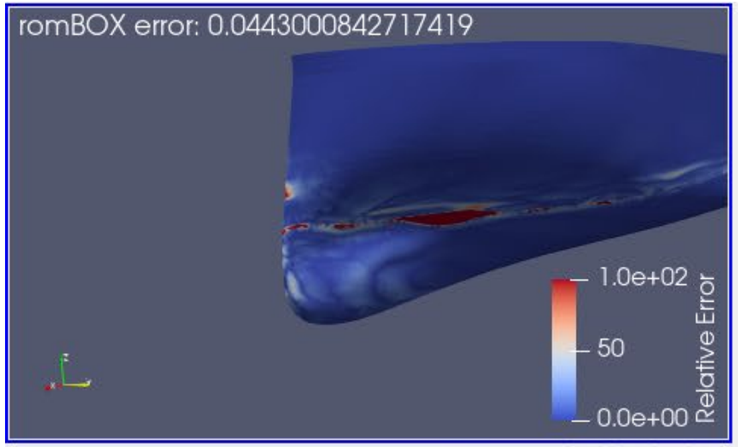
ROM Training and Validation

ID136 Volume fraction



ROM Training and Validation

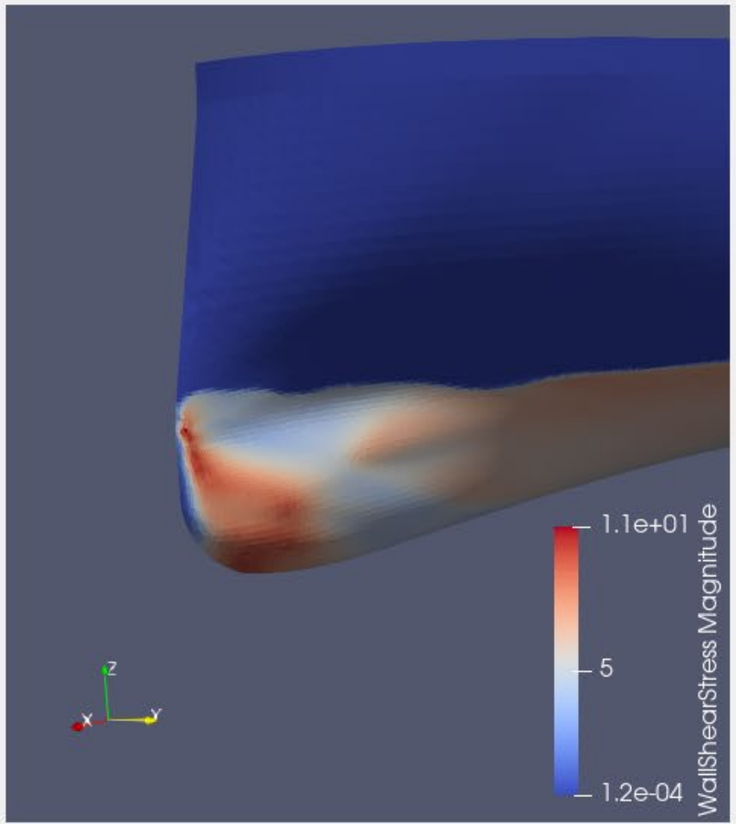
ID136 Wall shear stress

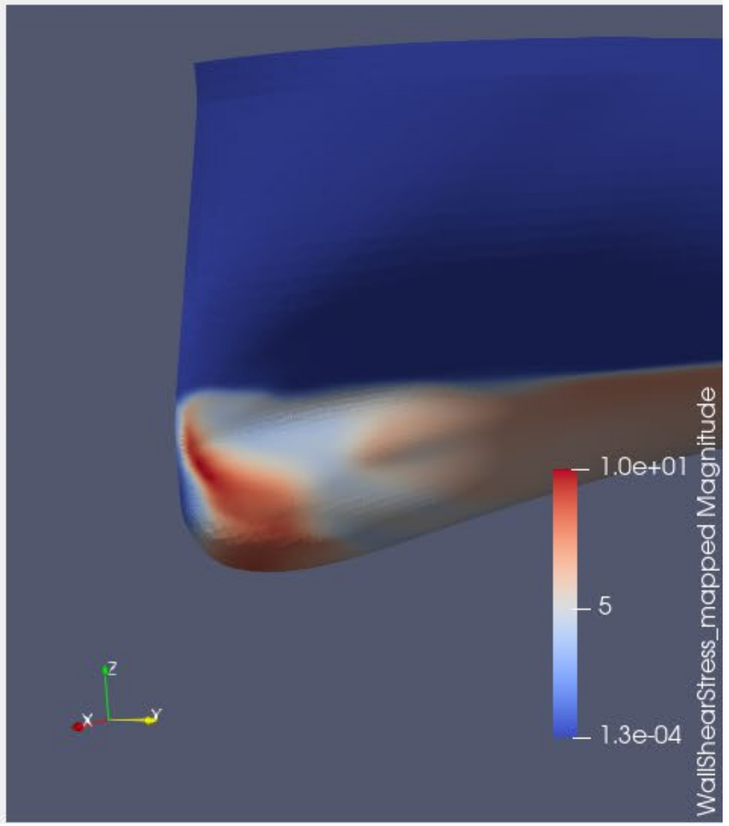


SpreadSheetView1

Showing Integra Attribute: Cell Data Precision: 6

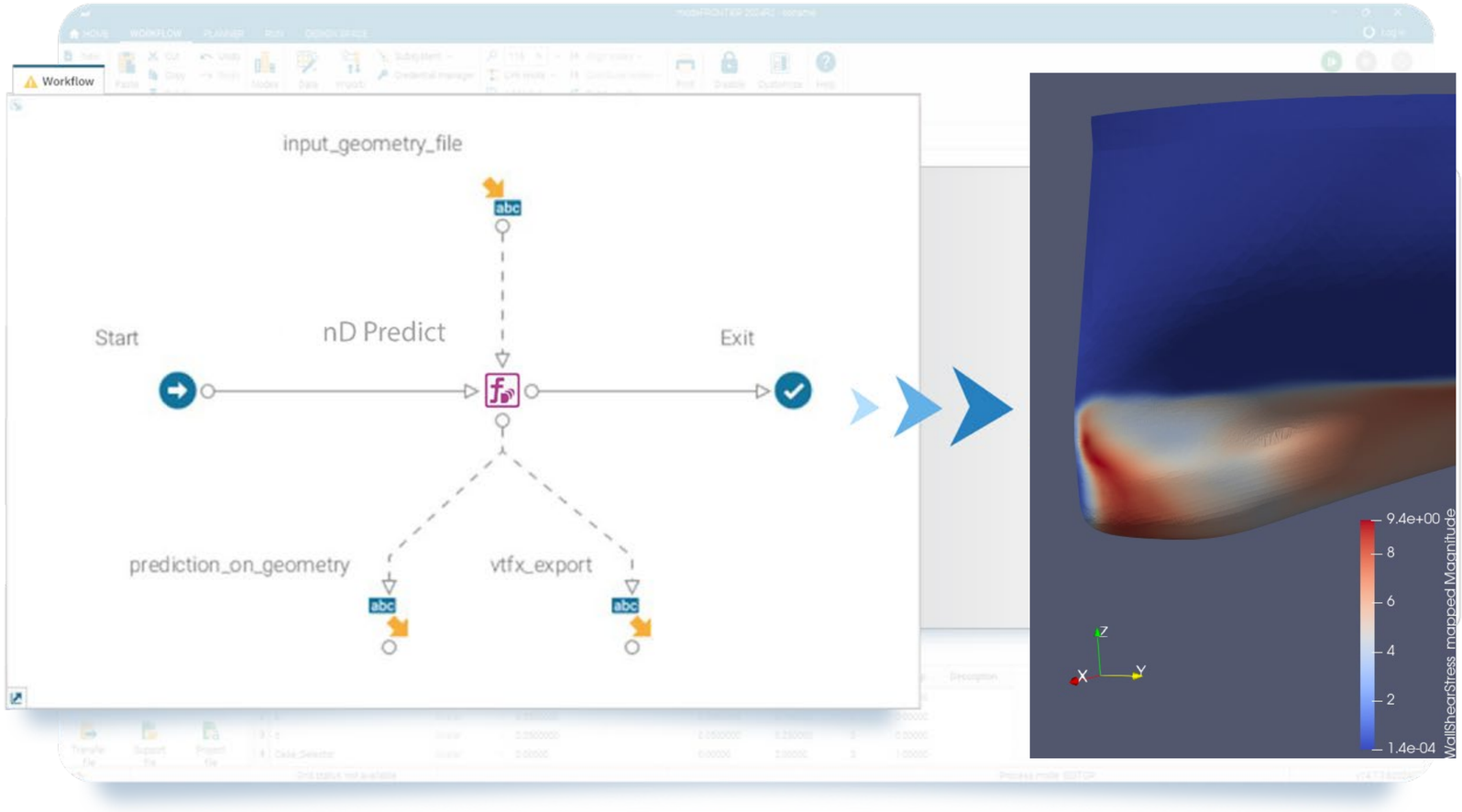
	Cell ID	Area	Cell Type	cellIndex	Field			Field_Mag
0	0	28.0344	Vertex	1.03927e+07	0.00115485	0.0210443	-0.000676688	0.0210868





ROM Prediction

Rapidly evaluate hundreds of new designs against KPIs/constraints using ROM model.



Conclusions

Conclusions

- Accelerate concept-phase decisions or new optimization workflow.

- nDAI allow to overcome the constrain of cad parametrization, enabling exploration beyond predefined design variables.

- The nDAI training dataset can be expanded with new and older hulls to leverage the Fincantieri know how.

- The result is a self-improving model that progressively captures the company experience, turning data into a strategic asset.

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Thank you

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