Advanced Performance Engineering in Aerospace

Didier Granville

29th of June

EUCASS 2022, Lille

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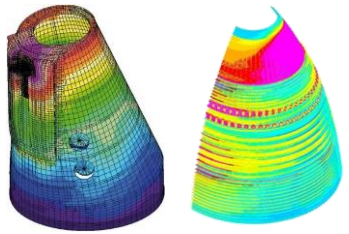
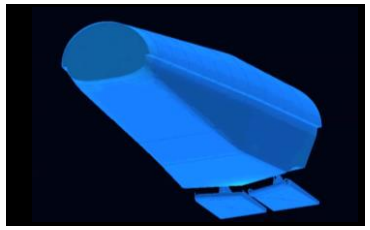
Agenda

- FEA background and some history in Aerospace
- Simcenter for Spacecrafts and Aircrafts
- Simcenter for Turbomachinery performance engineering towards Multi-Physics

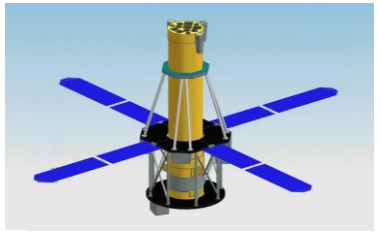
3D Structures FEA background
in Spacecraft & Satellite performance engineering



Structure and thermo-mechanics

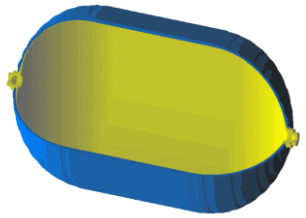


Thermal

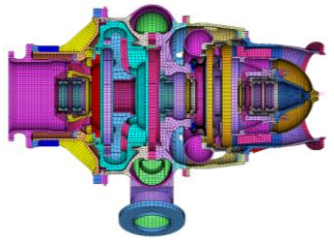


Solar panels

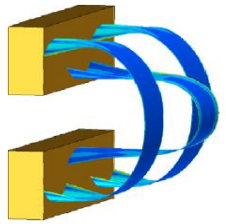
Composites



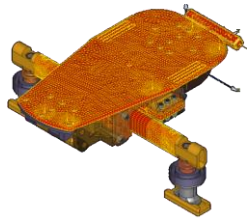
Turbo-pump (Rotor Dynamics and Thermal Analysis)



Compliant mechanism



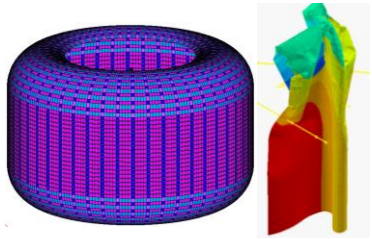
Antenna positioning mechanism



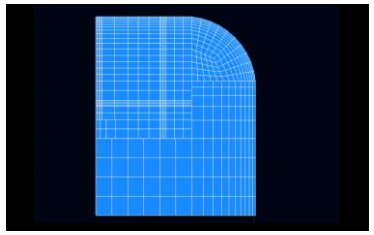
Foot loop mechanism

Large deployable antenna

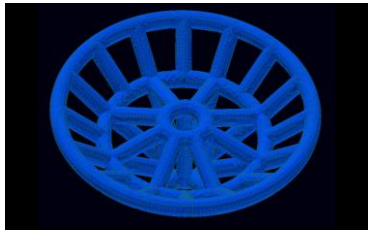
Large inflatable structure



Ablation



Inflatable heat shield



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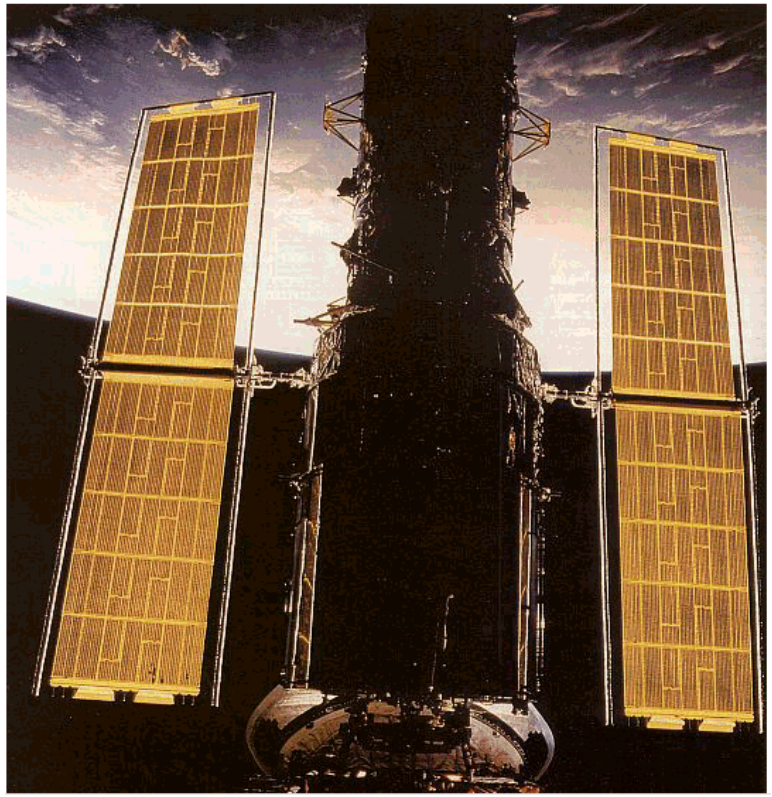
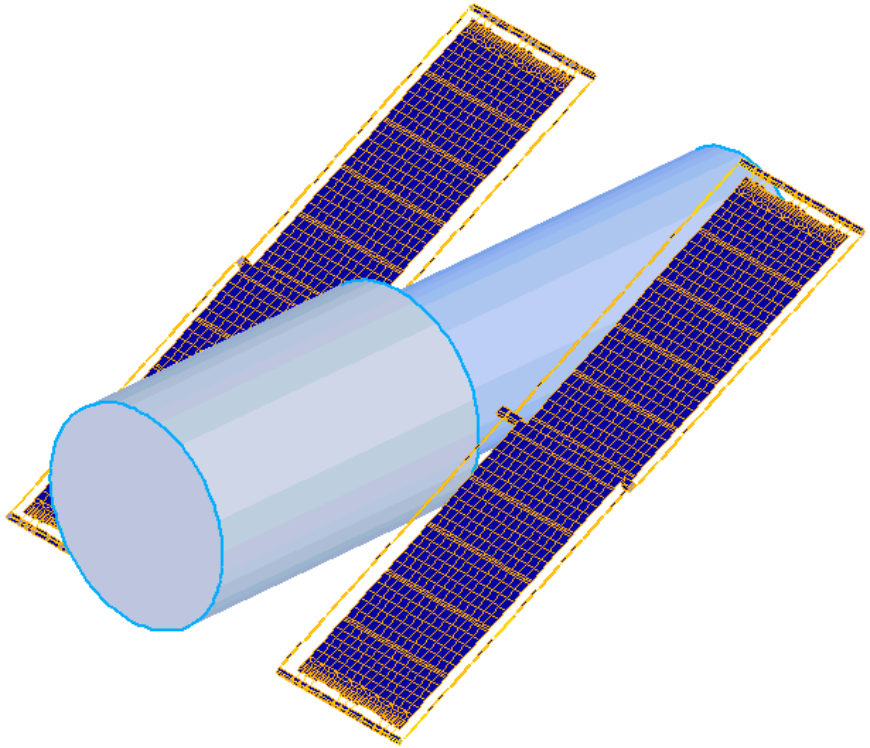
Some history
Hubble Space Telescope Solar Arrays collaboration with ESA-ESTEC (1991-1992)





Samcef Mecano NL FEA thermo-mechanical model of solar arrays to analyze buckling

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Simcenter for spacecraft performance engineering

Launch it before you build it

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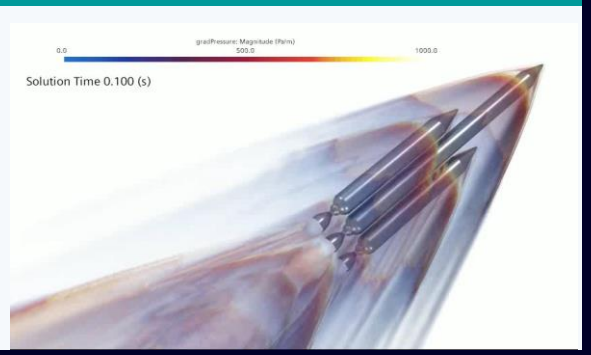
Digital transformation in Simcenter for Spacecrafts

Gain competitive advantage by using performance engineering

Model the complexity

Decision confidence



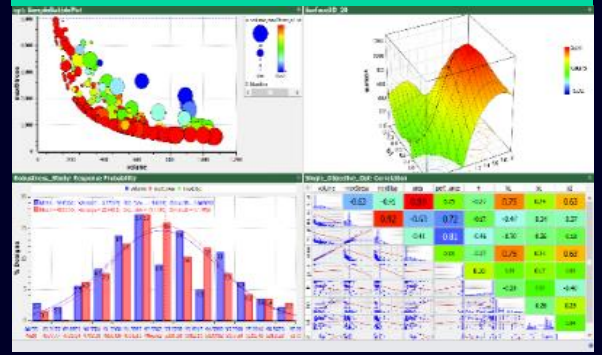
Model engineering physics

Adopt systems approach: from component till integrated product

Grow models with lifecycle

Explore the possibilities

Enabling insights



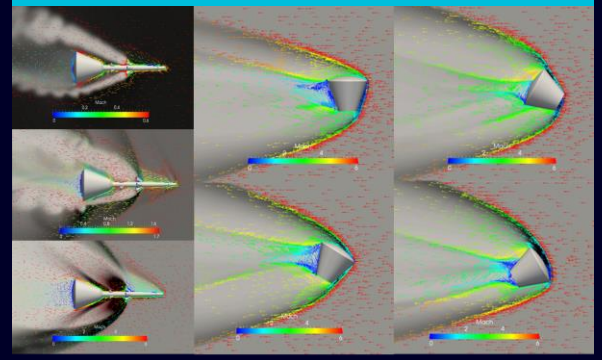
Explore design space using engineering models from start

Understand impact of design trade-offs on performance

Exploit the benefits of end-to-end parameterisation

Go faster

Speed and agility



Benefit of new methods / tools closely associated with DMU

Maximize value-add engineering, minimize coding

Accelerate time to results with scalable cloud collaboration

Stay integrated

Full traceability and alignment

Integrate with engineering processes: MBSE, verification management

Establish handshake between virtual and physical

Digital thread covering the complete ecosystem

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Simcenter for aircraft performance engineering

Fly it before you build it

Source: IATA

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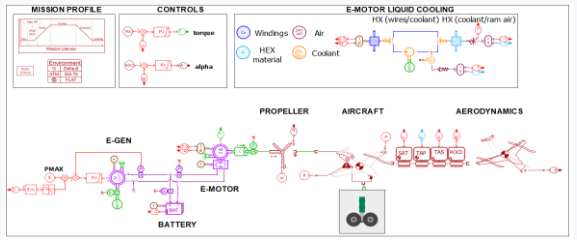
Digital transformation in Simcenter for Aircrafts

Gain competitive advantage by using performance engineering

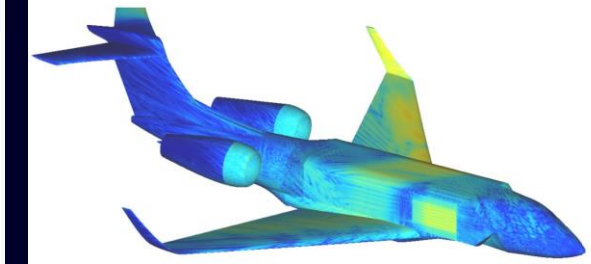
Model the complexity

Decision confidence



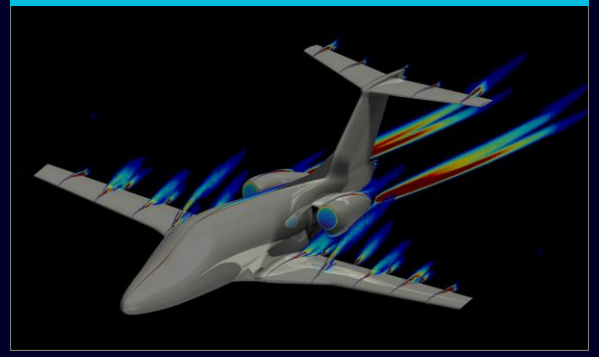
Explore the possibilities

Enabling insights



Go faster

Speed and agility



Stay integrated

Full traceability and alignment

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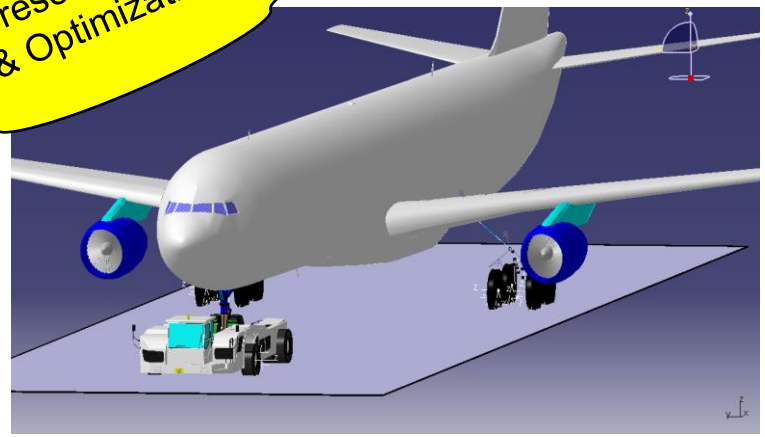
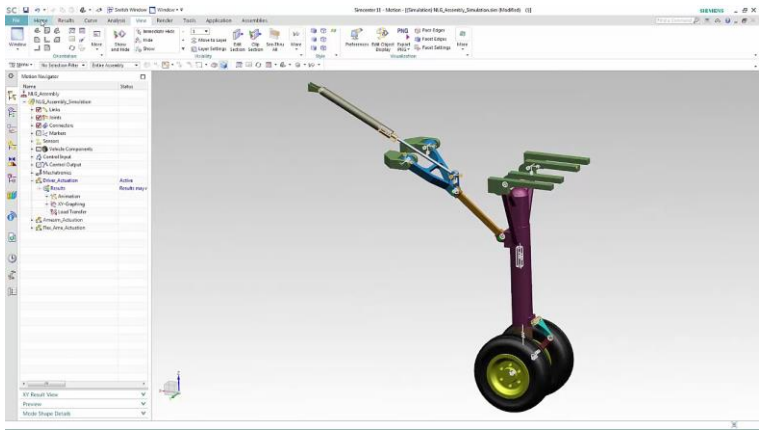
Model the[illegible]y - Loads calculating and cascading
Synthe[illegible]g gear simulation models based on architectures and templates

Presentation of STRMAT Design & Optimization Thursday 10h40





Ground Loads departments and landing gear manufacturers

Challenge

- Accurate load calculation (in service: heavy landing, towing, etc.) and cascading ➔ Requires accurate simulation models

Solution

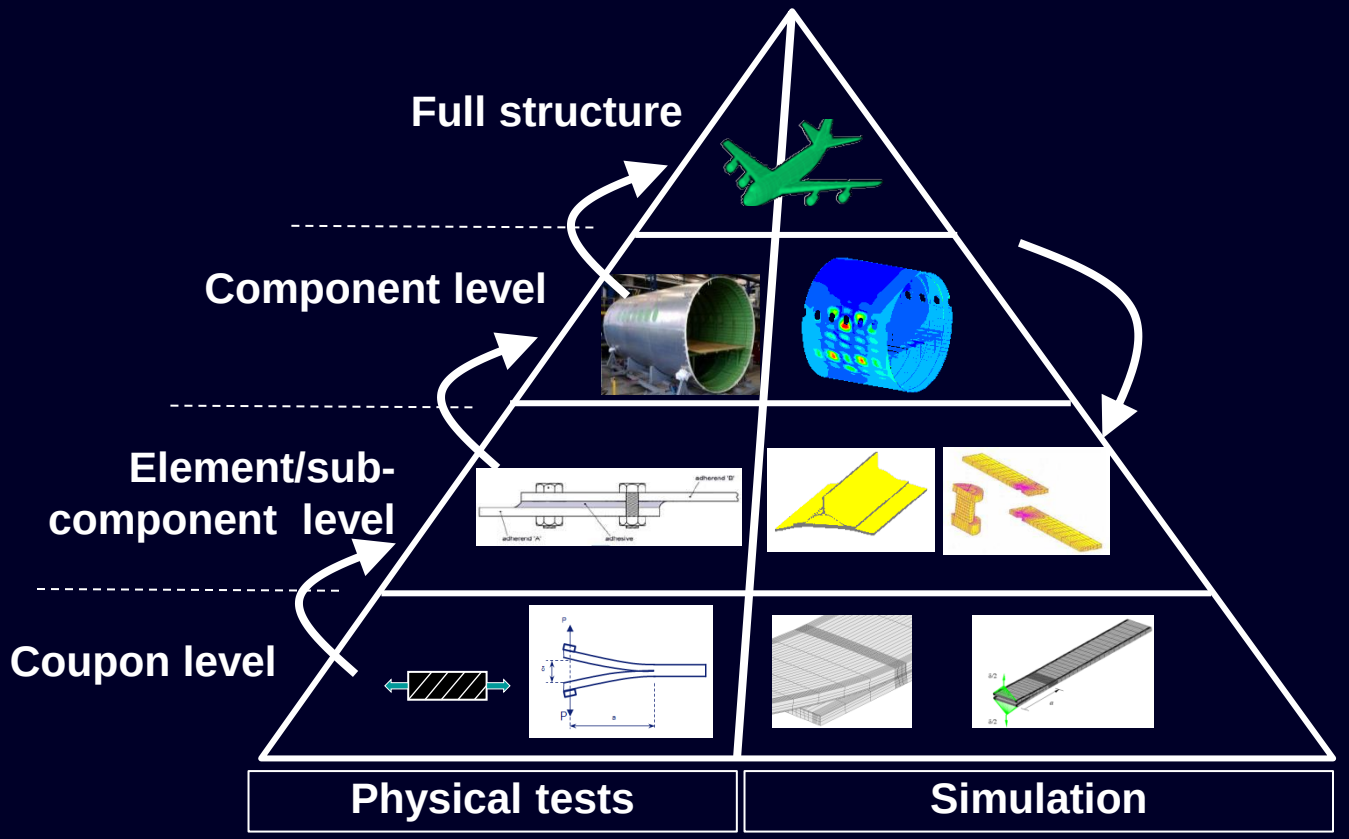
- Multi-disciplinary approach: Simcenter 3D Motion + 1D damper model
- Comparison with Simcenter testing results

Benefits

- Confidence in process through accuracy and automation

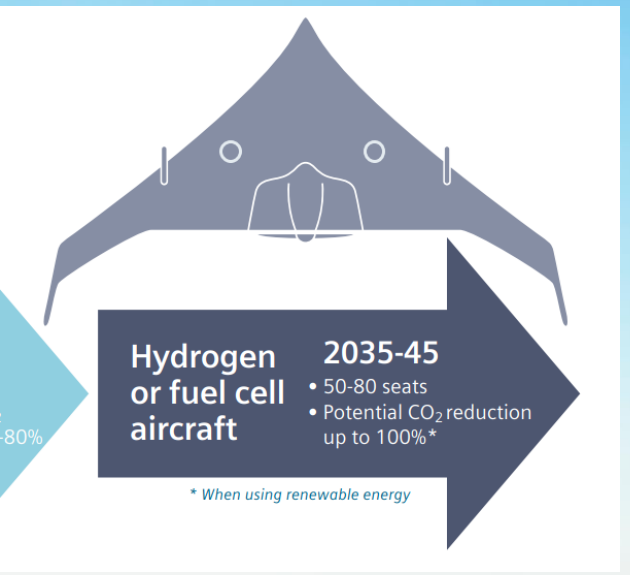
Model the complexity - Aircraft Structure Performance Engineering of course based on classical engineering pyramid (ISAMI with Airbus A350XWB)

- The building block approach
- The pyramid of tests: **real and virtual testing**



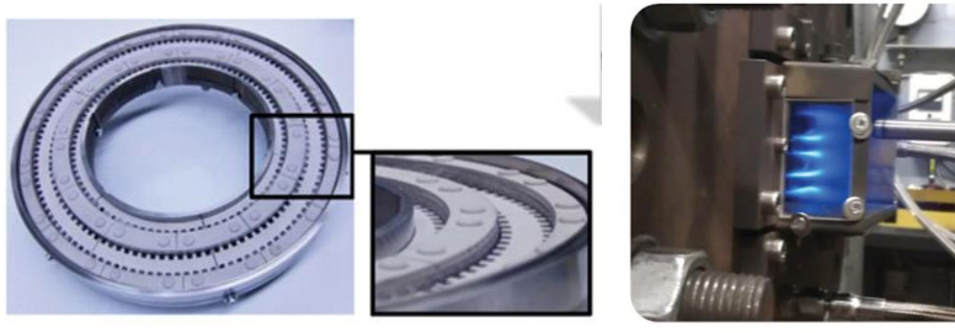
Trends

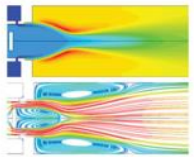
Hydrogen as propulsion energy source

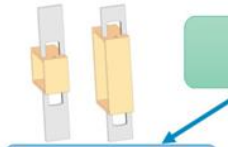


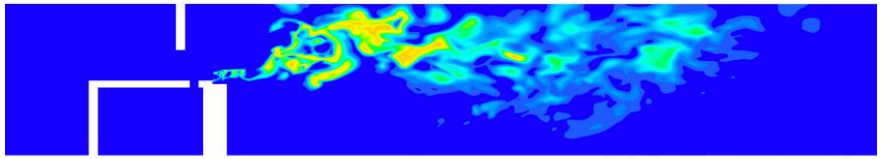
Kawasaki Heavy industries and B&B-AGEMA

The world’s first premixed hydrogen gas turbine in operation during the Tokyo Olympics





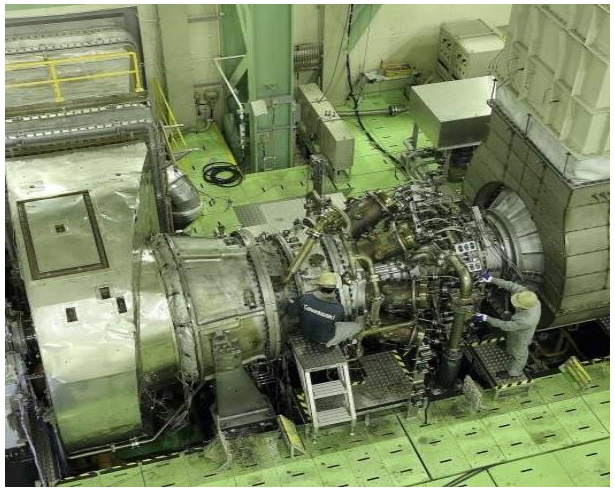




Simulations enabled safe energy source without flashbacks.
With low NOx and
zero CO2 emissions

100%
Hydrogen fuel

0 %
CO2 emissions



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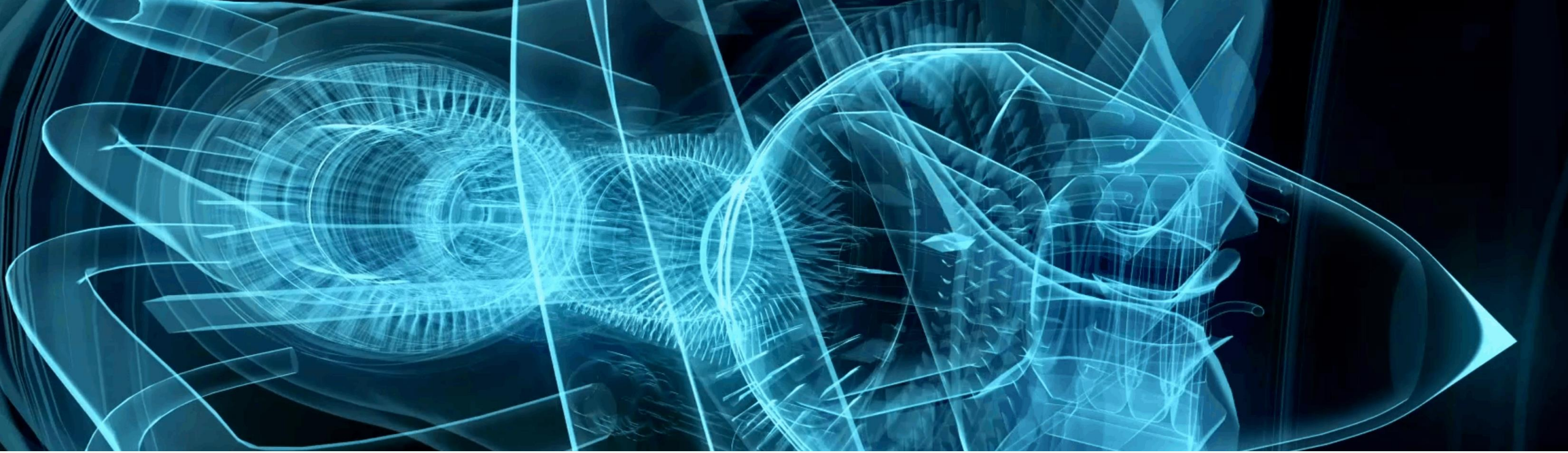

Simcenter for aircraft engine performance engineering towards Multi-Physics

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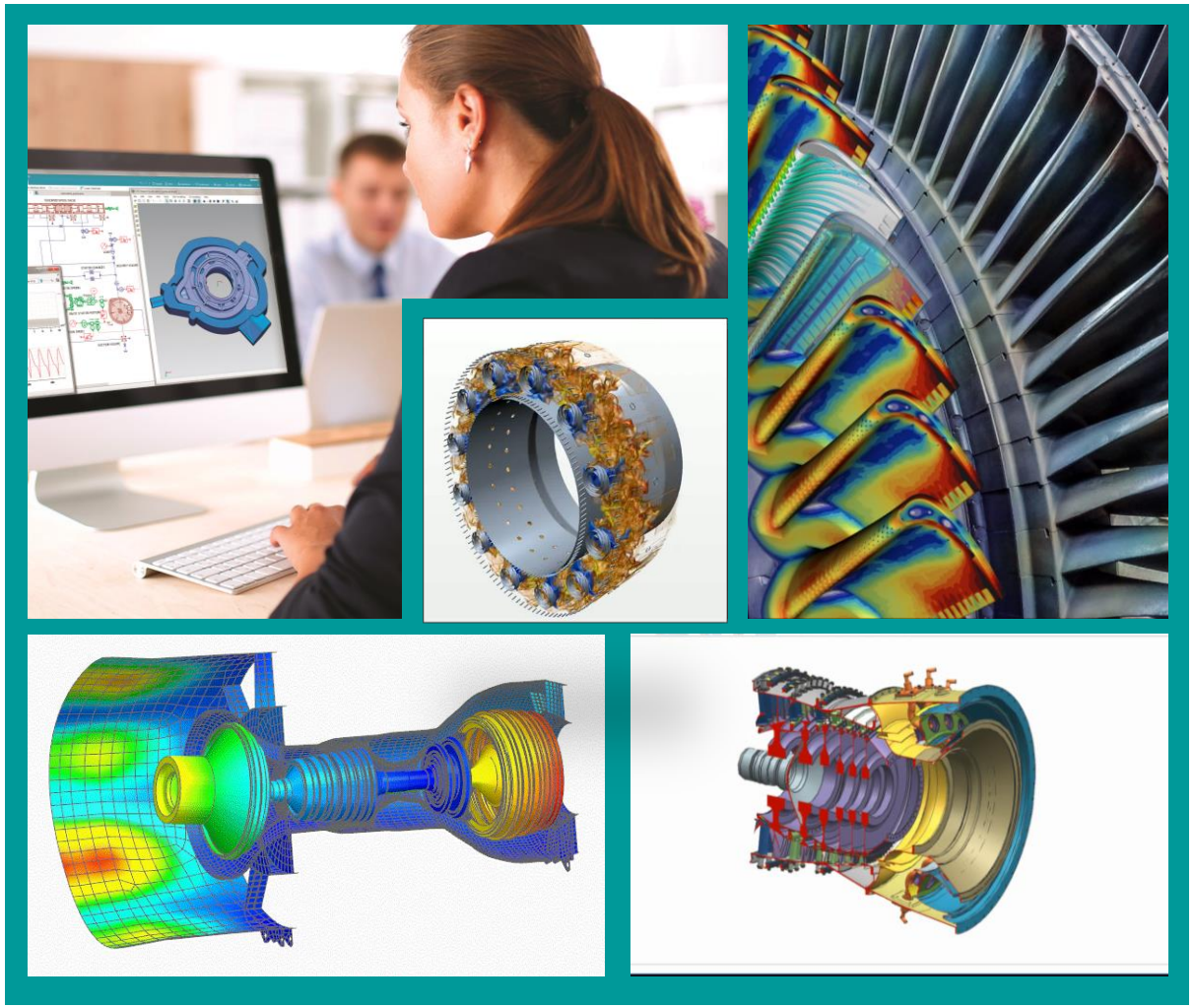
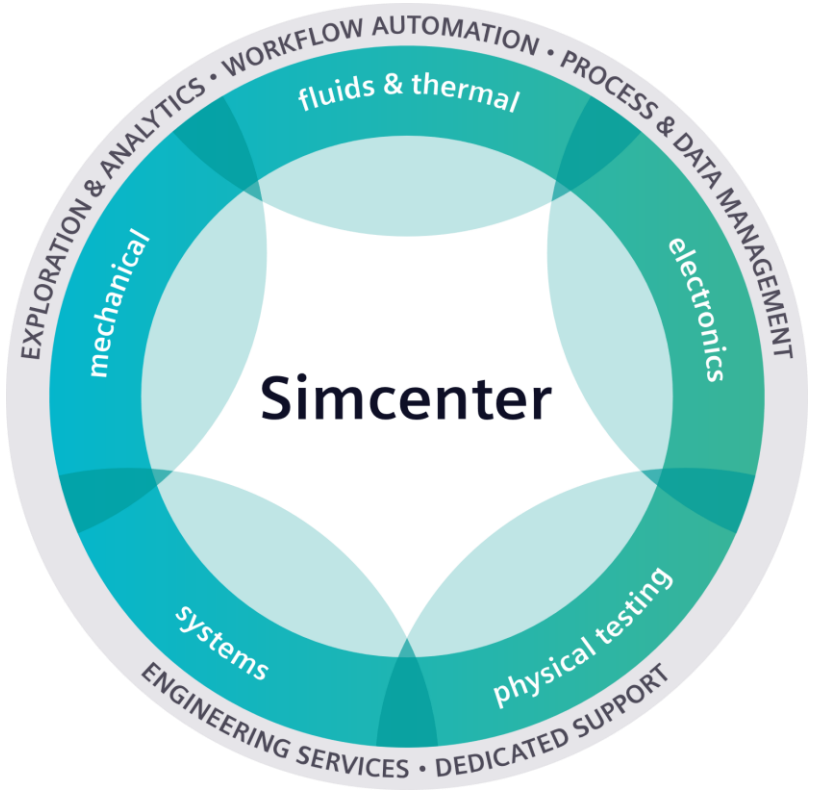
Simcenter: developed by and for gas turbine experts

Enables turbomachinery companies to deliver actual engines faster to market





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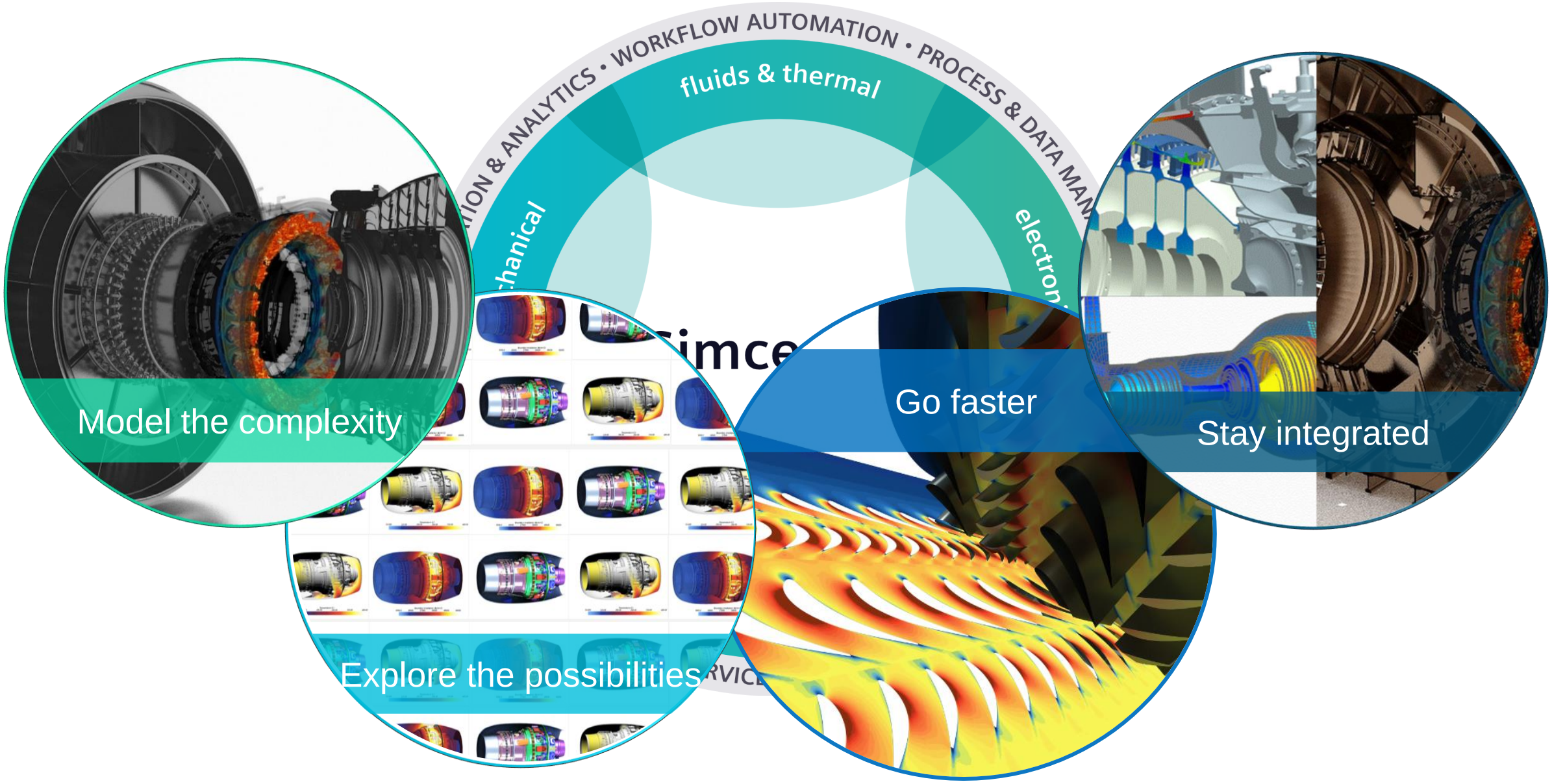

Model the complexity

Ensuring decisions with confidence

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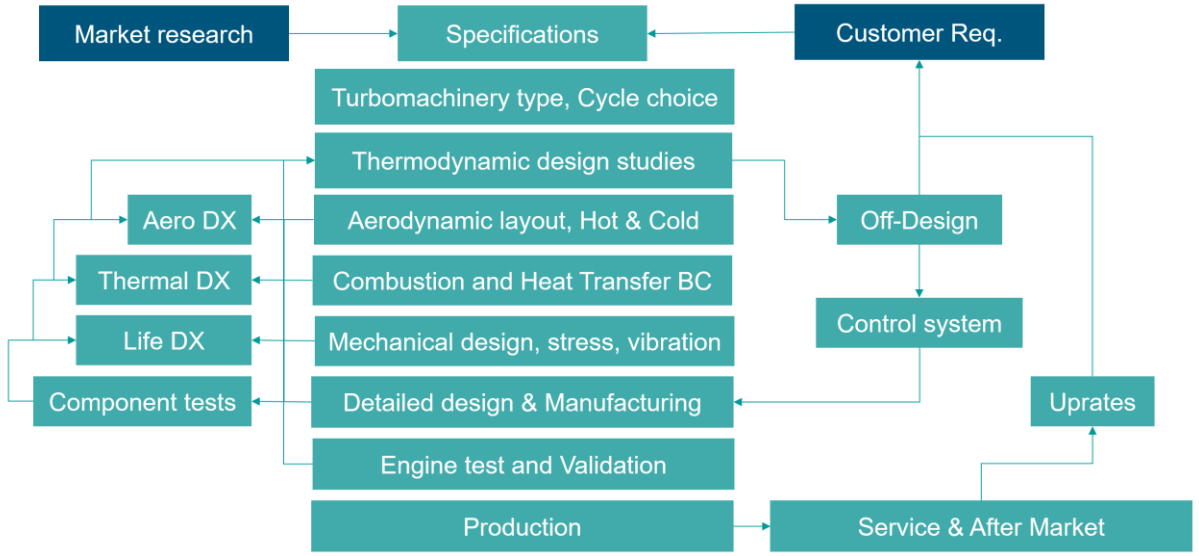
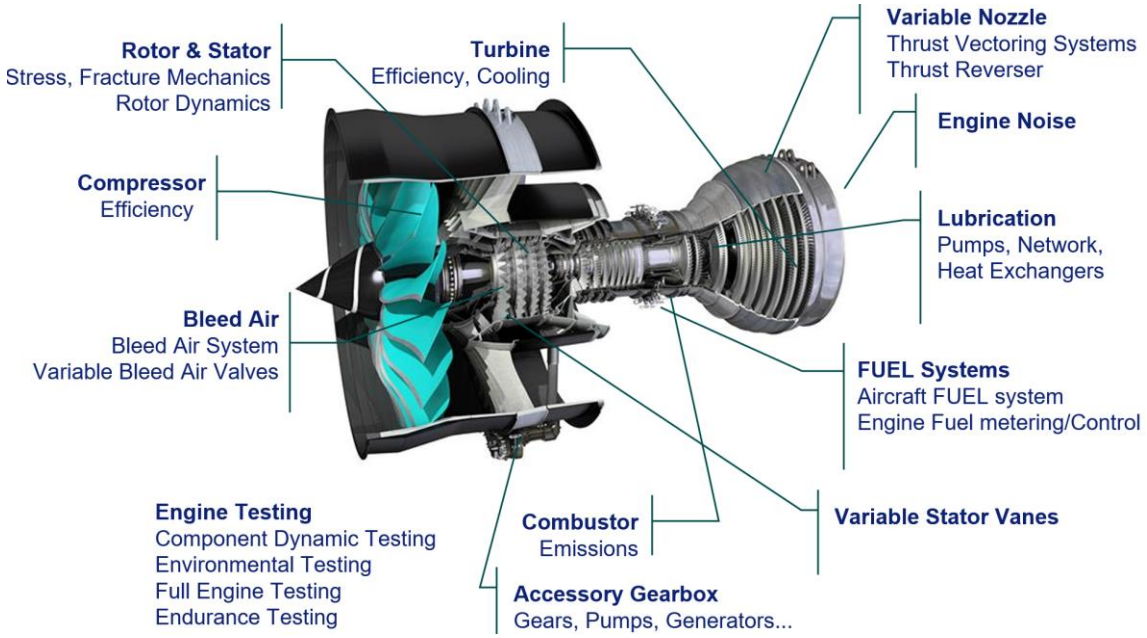
Accelerate the digital transformation for jet engine design

Enables turbomachinery companies to deliver actual engines faster to market

Integrated Product Performance – System-of-Systems – Structure-of-Structures





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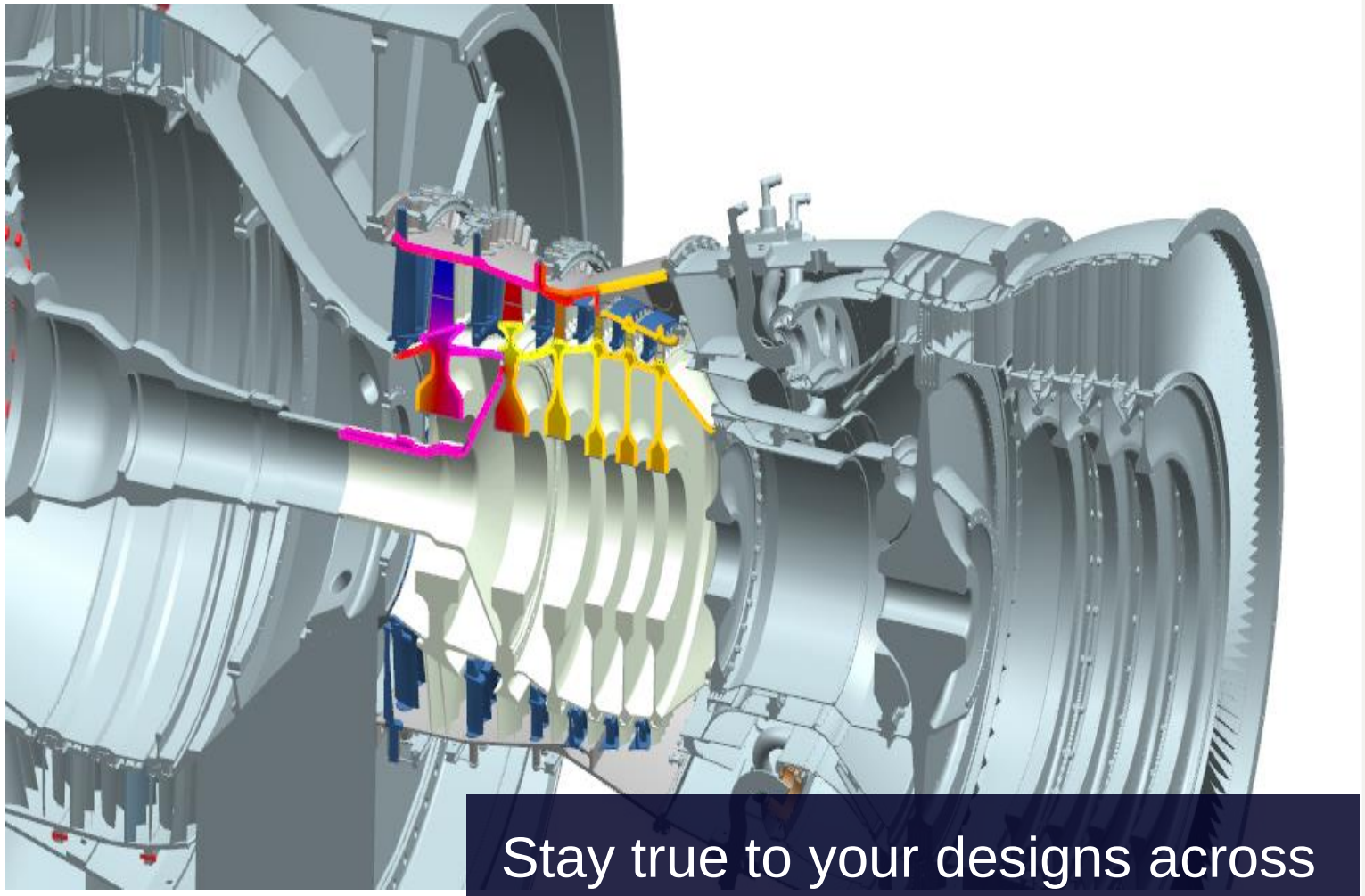
Geometric fidelity with CAD based models



Stay true to your designs across all your simulations

Capture all the necessary details from component to system

Get appropriate precision for every stage of the design cycle

Increase consistency by working directly on CAD geometry

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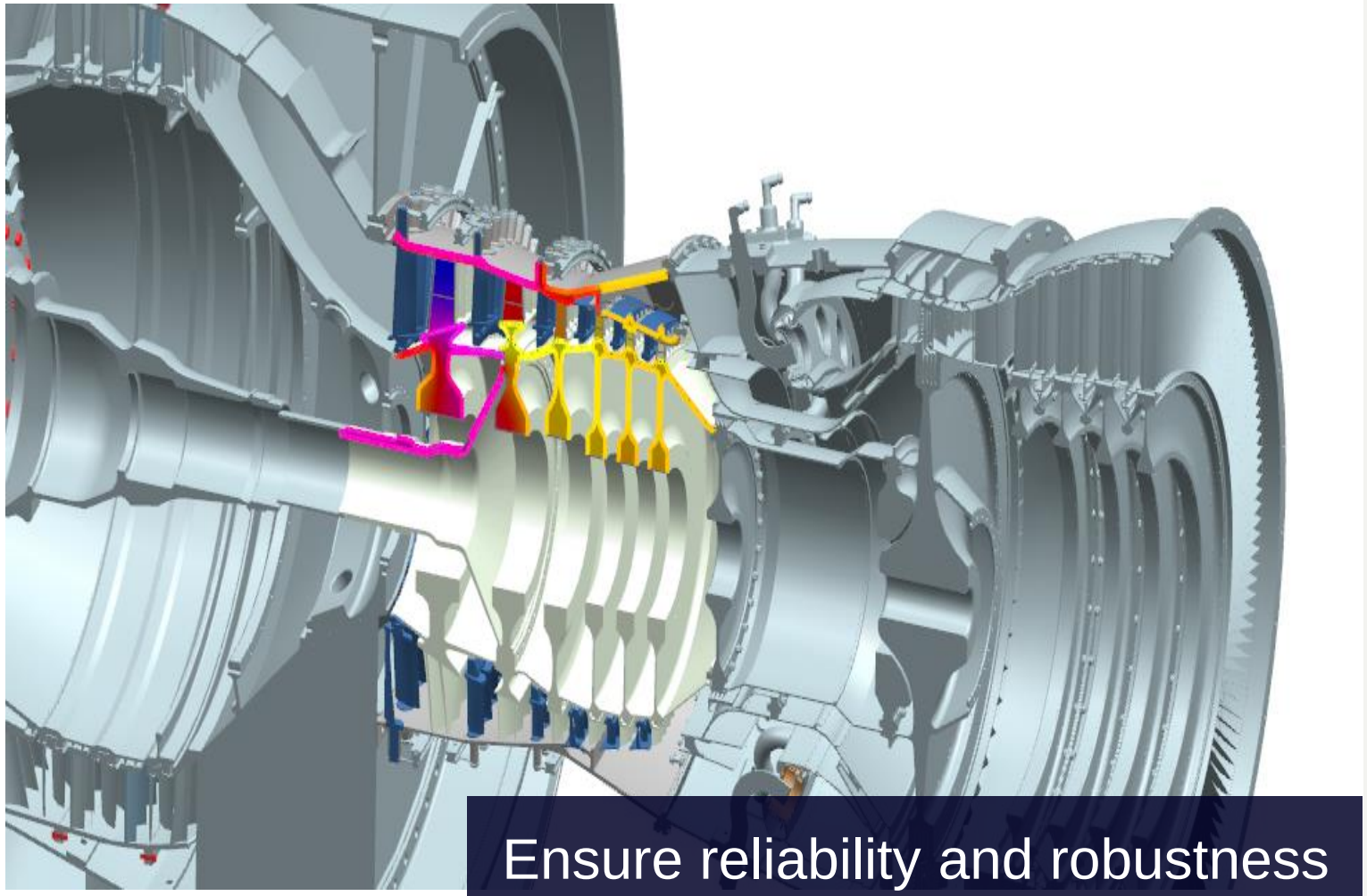
Structural and Multi-Physics Design



Ensure reliability and robustness at all times

Thermo-Mechanical Whole Engine Models, Mechanisms and Structural Assemblies

Hot-to-cold and cold-to-hot transformations in one step

Material engineering on multiple scales

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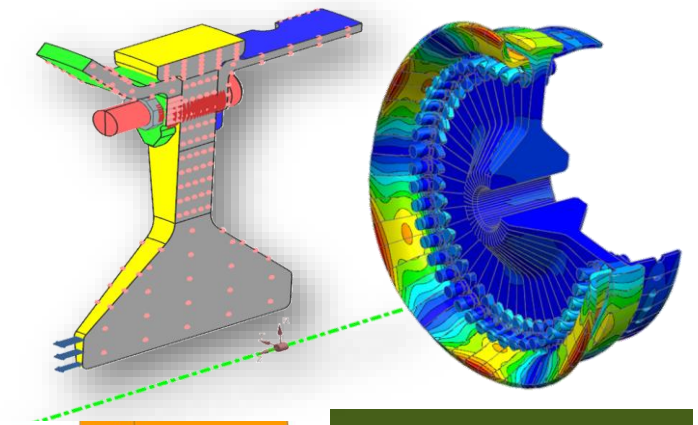
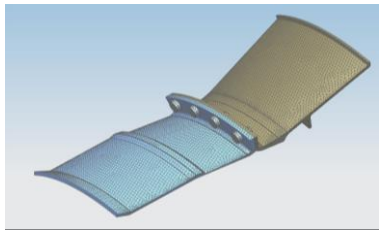
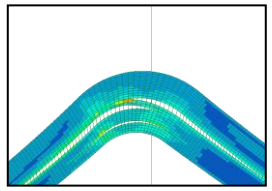
Solutions for Turbine Engines
Simcenter Nastran&Samcef FEA capabilities



Cyclic Symmetry



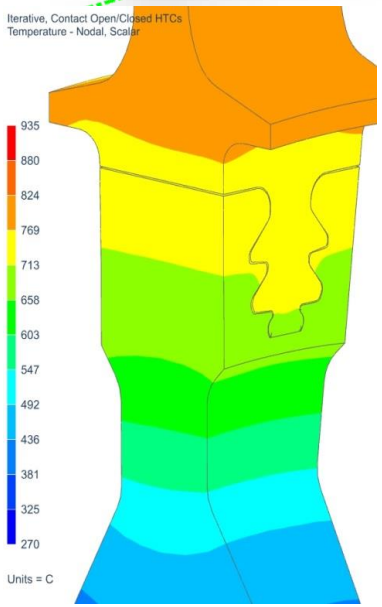
Composite Damage



Bolted Joint Connections

Cold to Hot

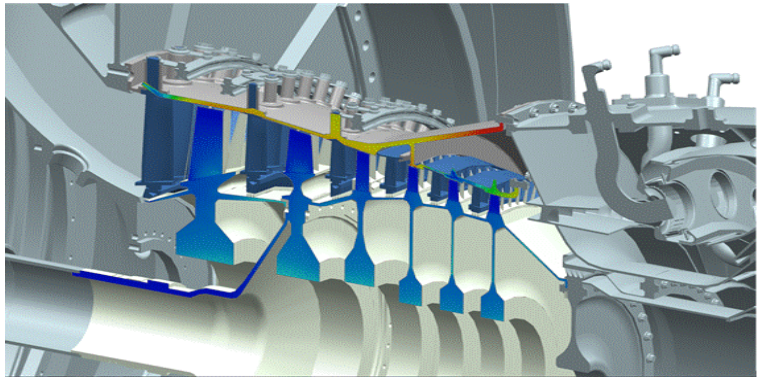
Hot to Cold



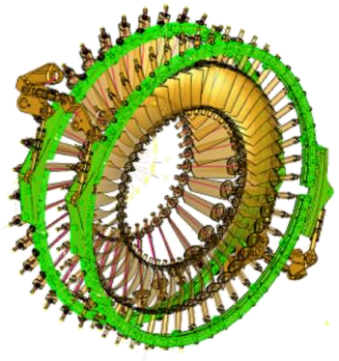
Thermo-Mechanical Analysis

Variable Stator Vanes

2D WEM



Structural Assemblies & Contact



Sealing

Creep and Plasticity for Lifing

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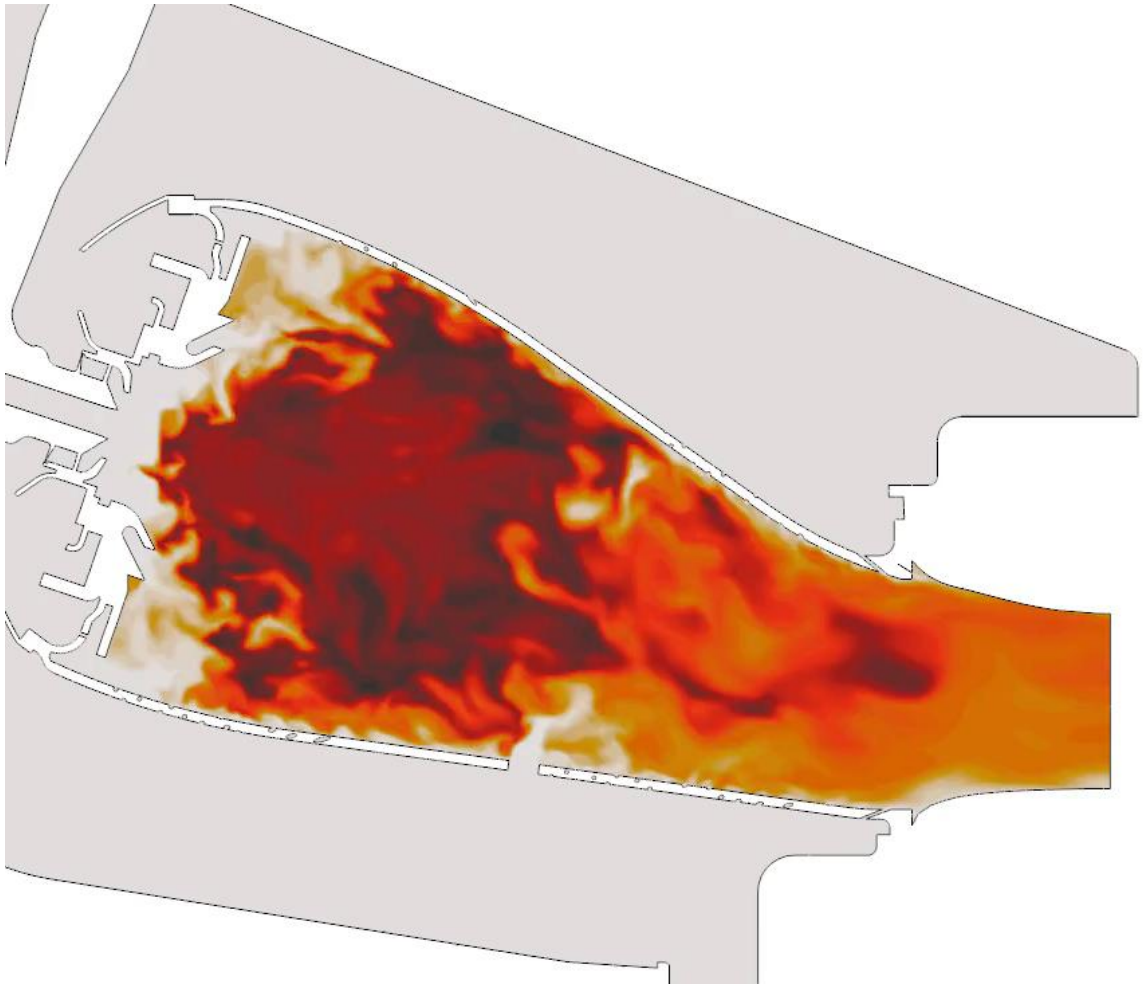
In parallel to Structural Design, High Fidelity Fluid Dynamics Computations (Simcenter Star-CCM+)



Large Eddy Simulation

Chemistry

Multi-Timescale

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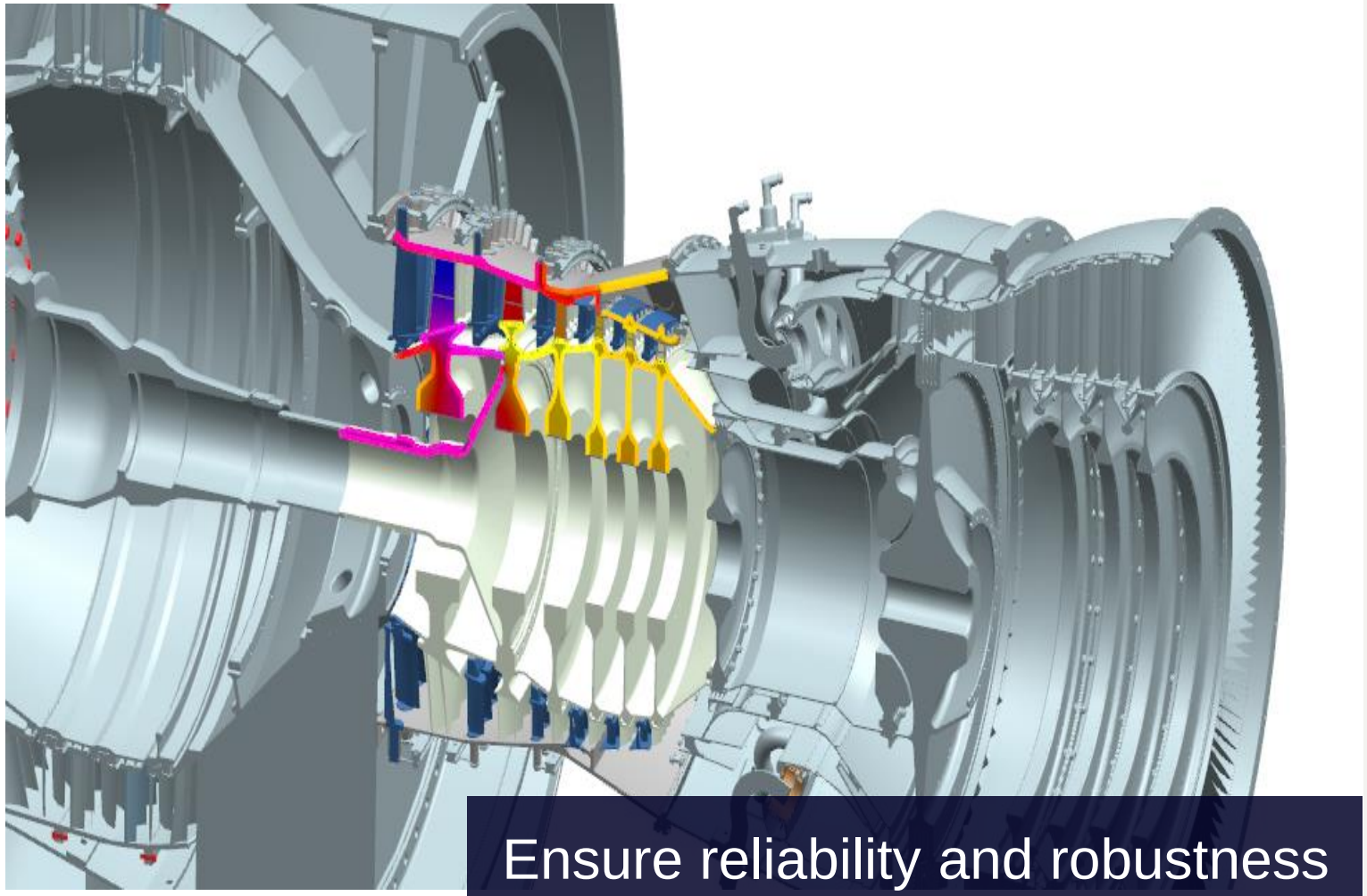
Structural and Multi-Physics Design



Ensure reliability and robustness at all times

Thermo-Mechanical Whole Engine Models, Mechanisms and Structural Assemblies

Hot-to-cold and cold-to-hot transformations in one step

Material engineering on multiple scales

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Accurate cooling performance prediction - Multiphysics Component Simulation

Challenge

Flow Definitions

CFD Solution

Thermal Solution

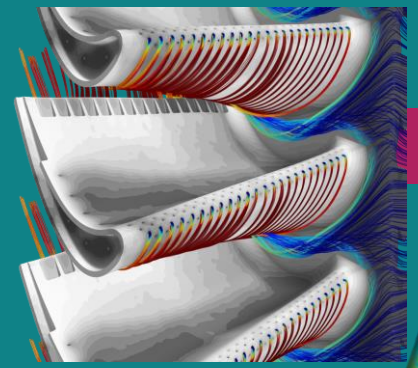
Structural Solution

Stress and Deflections

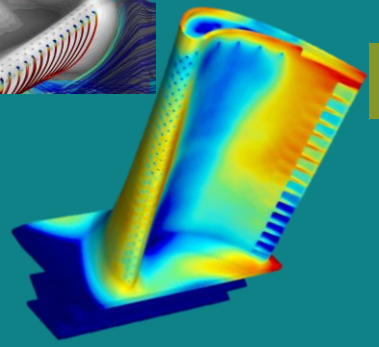
Engines are governed by physics of aerodynamics, thermal, and structural

Need scalability to analyze for single physics or multiple physics.

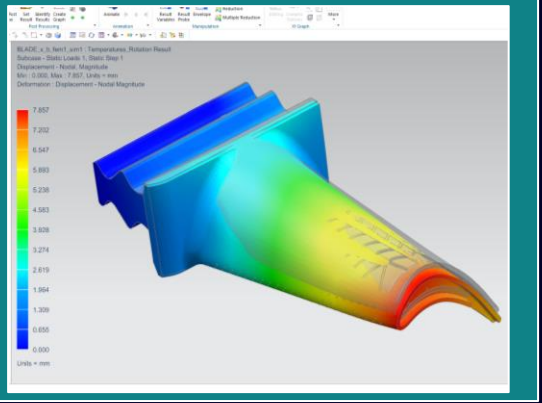
Simcenter solutions



Cooling Flow



Metal Temperature



Structural

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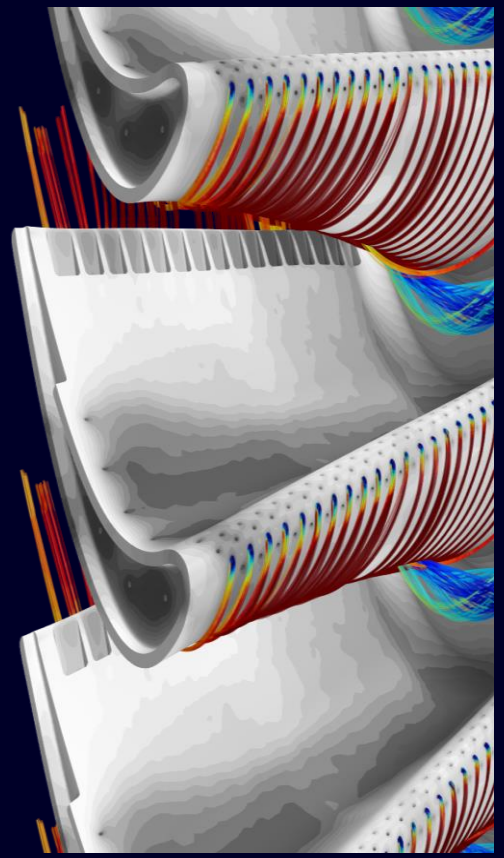
Blade Manufacture
Hot-to-Cold Solution

Challenge

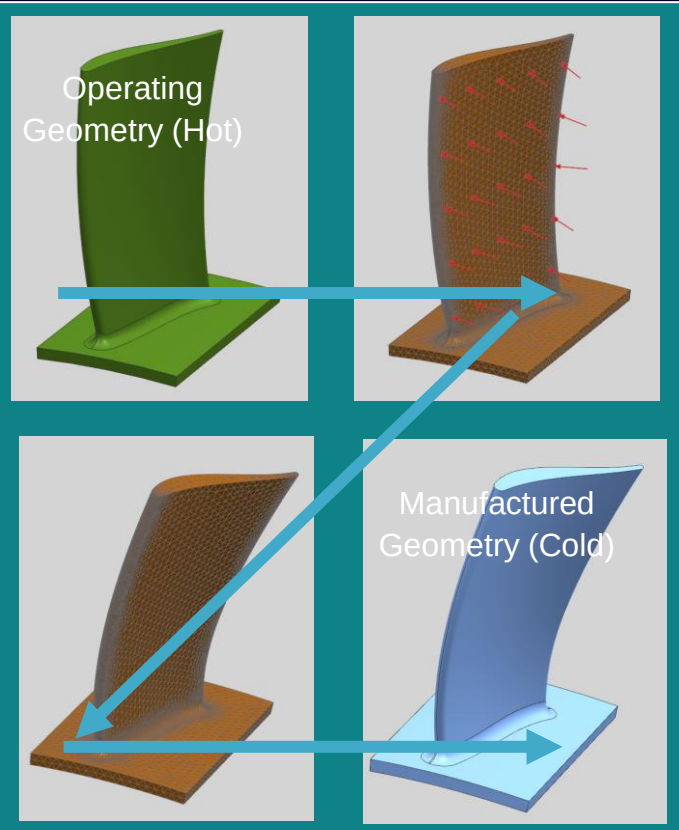


Blade geometry is first defined for operating shape

Operating shape is the manufactured shape + deformation from thermal and pressure loads

How do you reverse engineer to get manufactured shape?

Simcenter solutions



Pressure and thermal loads mapped from CFD to structural

“Unrun” structural solution for hot to cold – start with operating FEM shape and iterate to manufactured FEM shape

Create new deformed geometry

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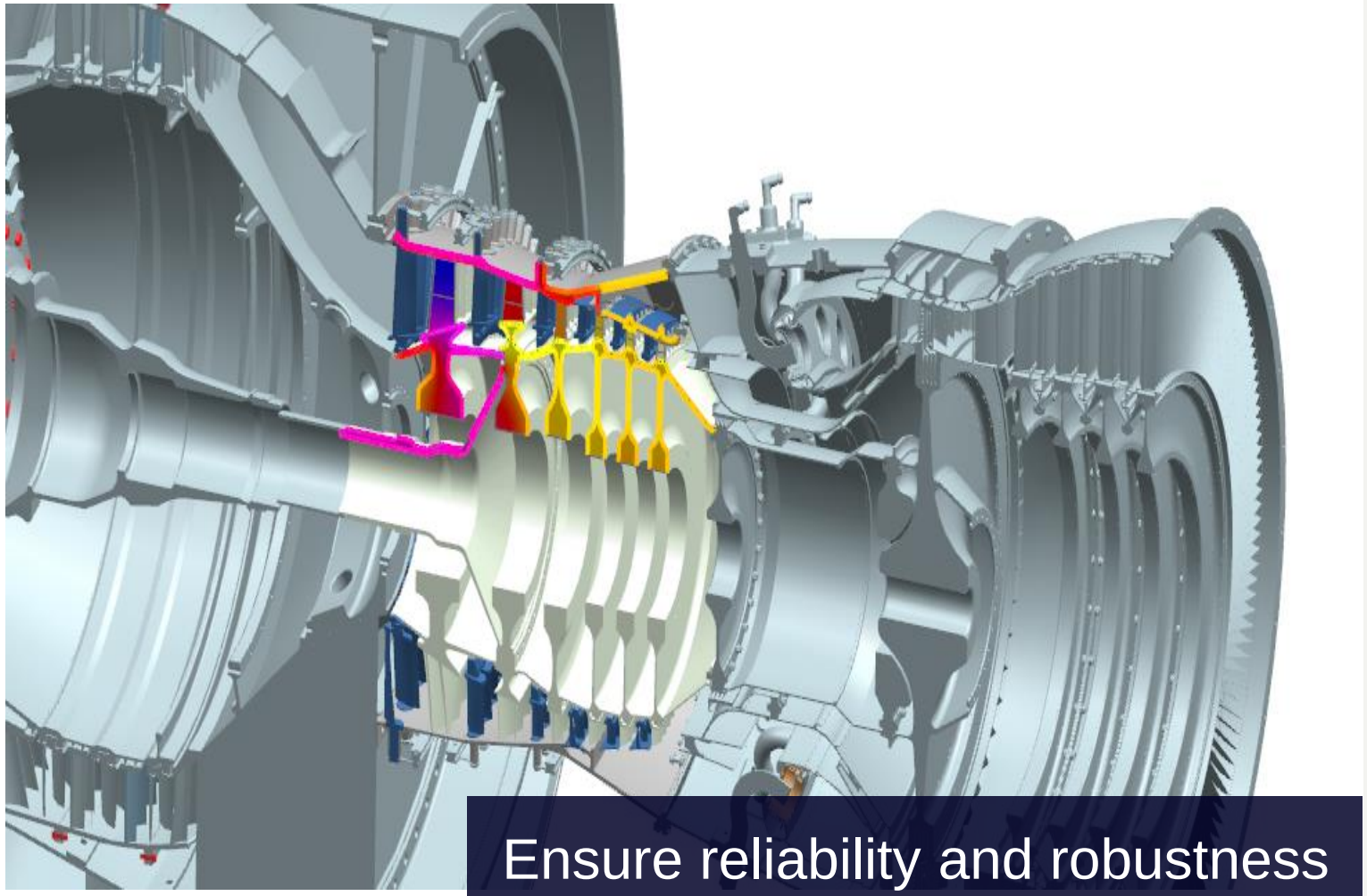
Improve durability



Ensure reliability and robustness at all times

Thermo-Mechanical Whole Engine Models, Mechanisms and Structural Assemblies

Hot-to-cold and cold-to-hot transformations in one step

Material engineering on multiple scales

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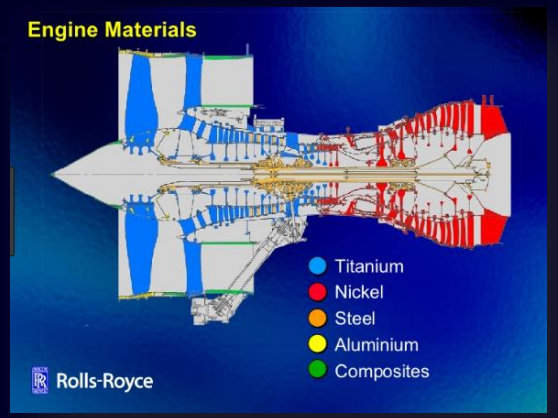
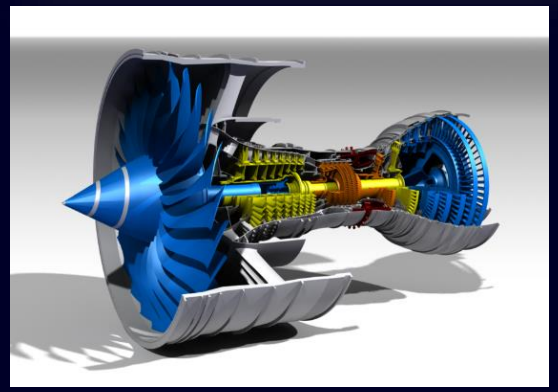
Advanced Material Modeling

Challenge

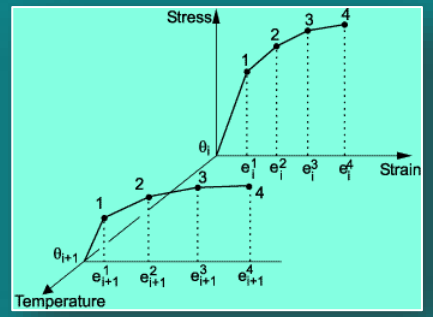


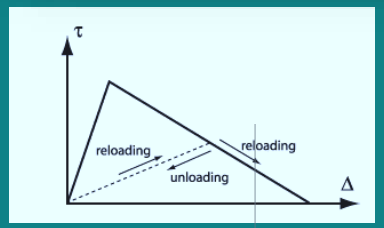


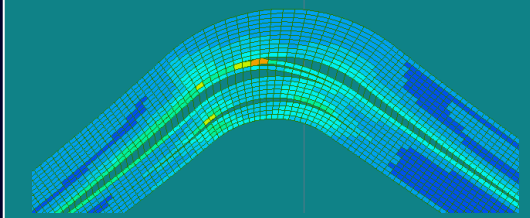
Aero-engines depend on high performance materials that operate in extreme conditions.

Need ability to accurately model nonlinear behavior of materials.

Simcenter solutions







Temperature Dependent Plasticity and Creep Materials
Mulitilinear plasticity models with hardening
High temperature creep materials

User-Defined
Link in proprietary advanced material models

Damage
Play failure and delamination models for composites

Material Databases
Links to commercial or in-house material databases

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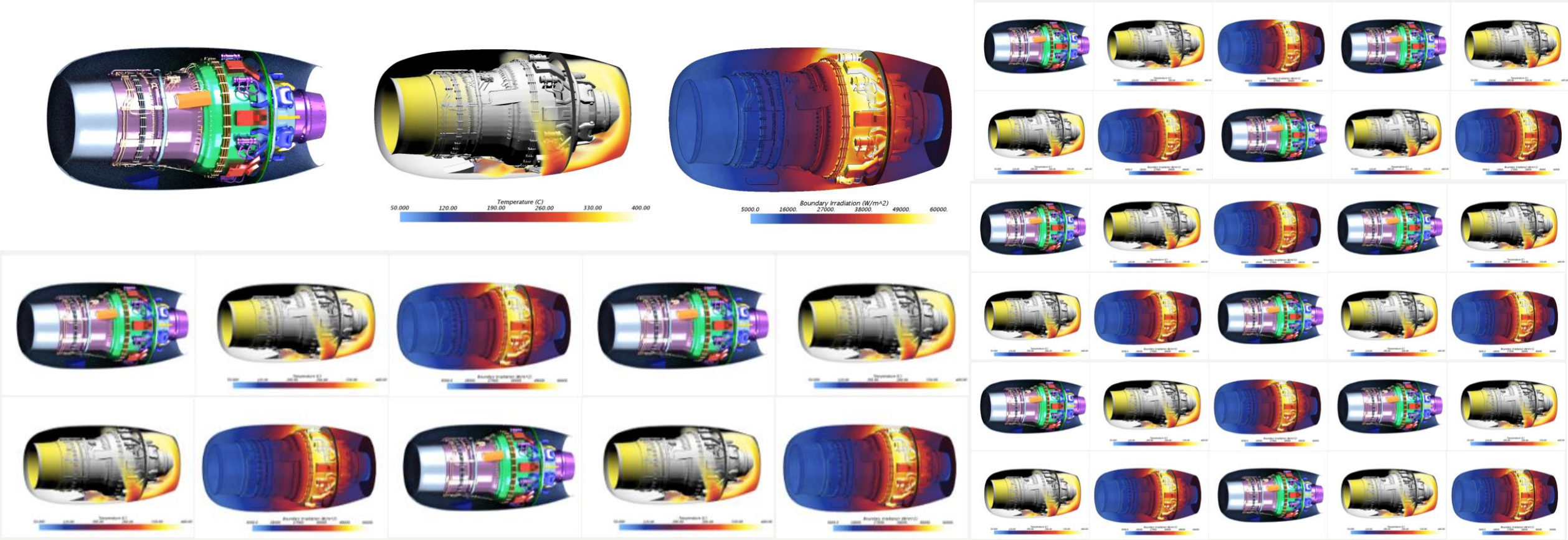

Explore the possibilities

Enabling insights to deliver better products

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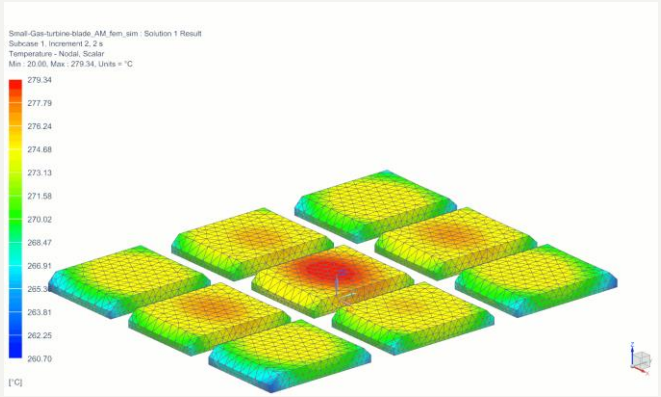
Unimaginable designs with generative engineering and Additive Manufacturing

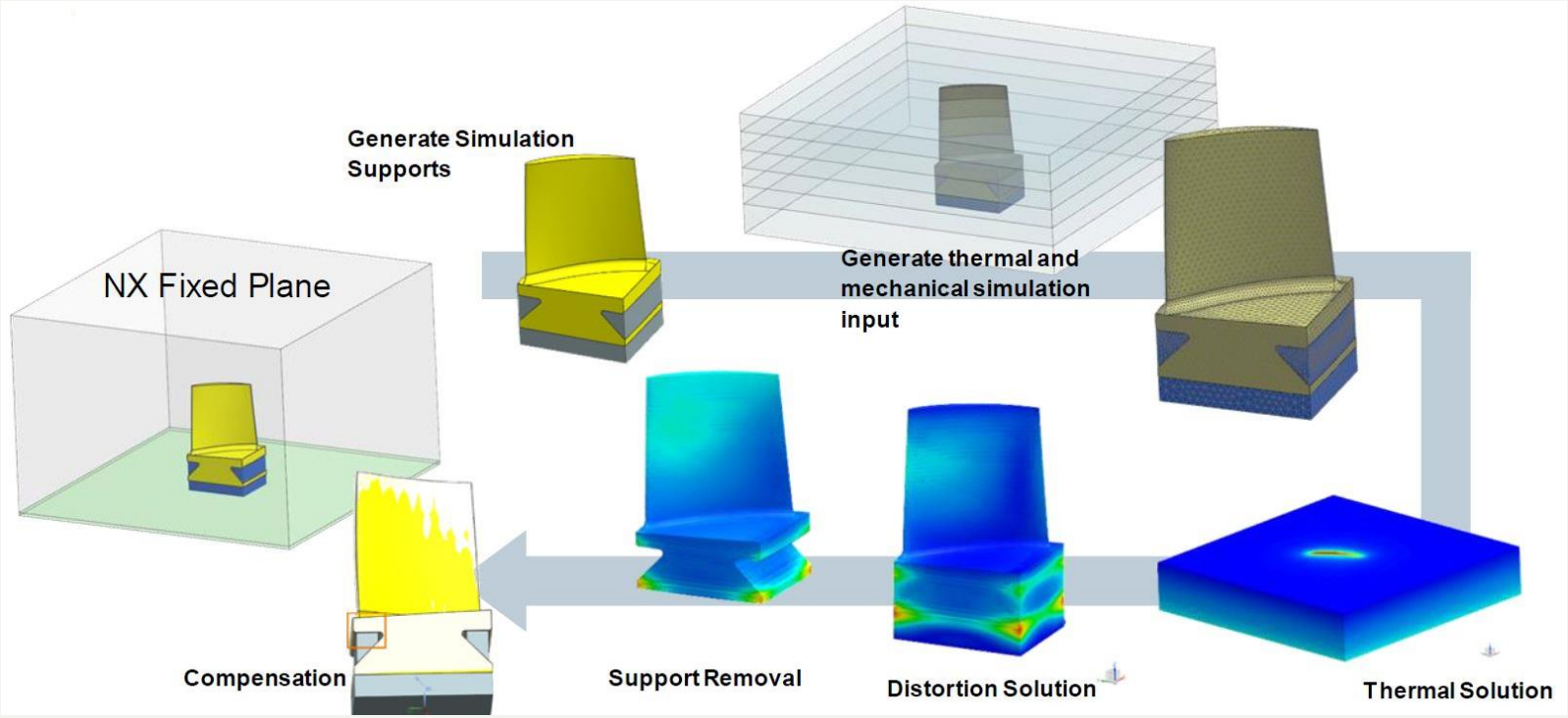


Design innovation

Make the best use of additive manufacturing technology

Reverse engineering in Additive Manufacturing through compensation

Employ topology optimization



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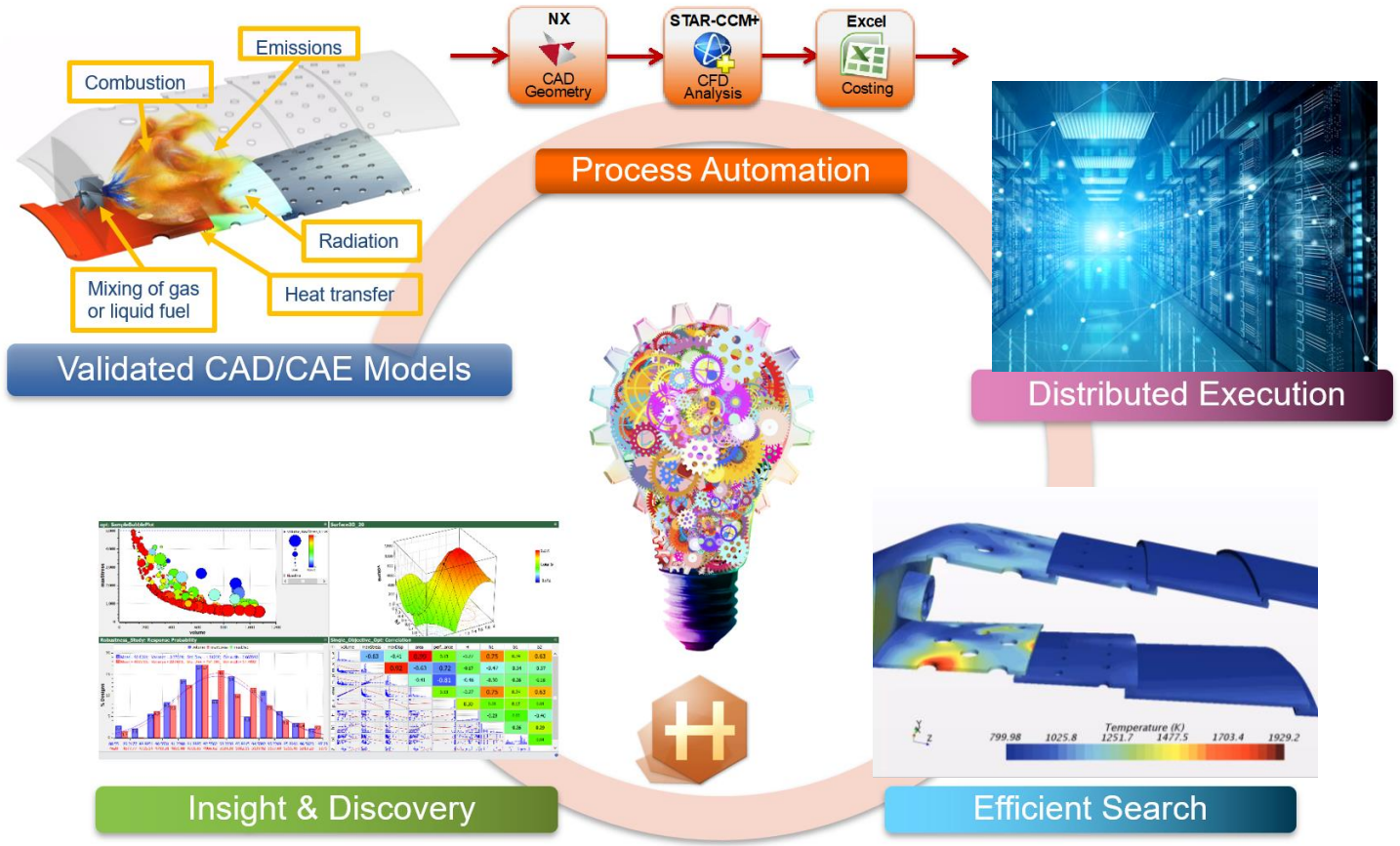

Exploration and automation with MDO

Automates data sharing in desired workflows (Heeds)

Easy to use for everyone to explore 100s of design trade-offs

Efficient search for innovative solutions

Discover better designs, faster

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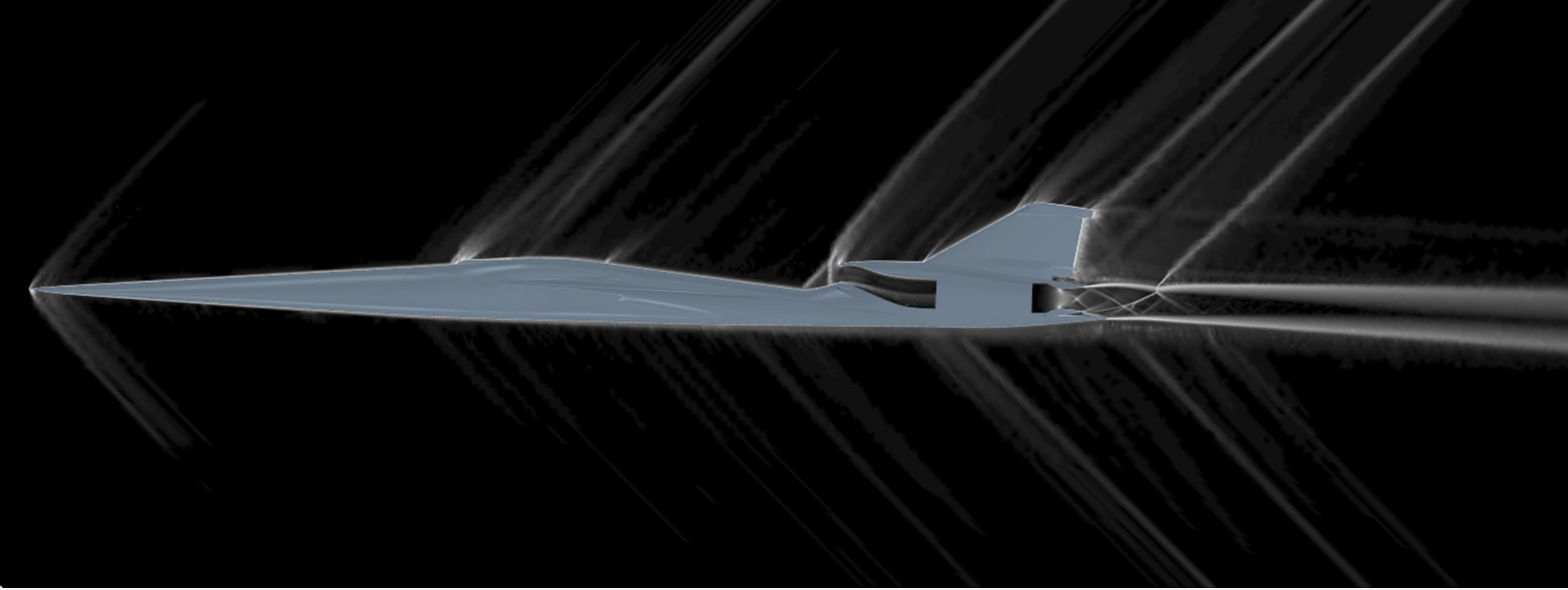

Go faster

Achieving speed and agility

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High Performance Computing

Leverage massive HPC scalability for both meshing and solving

Parallel computing with automatic domain decomposition

Development of cloud solutions

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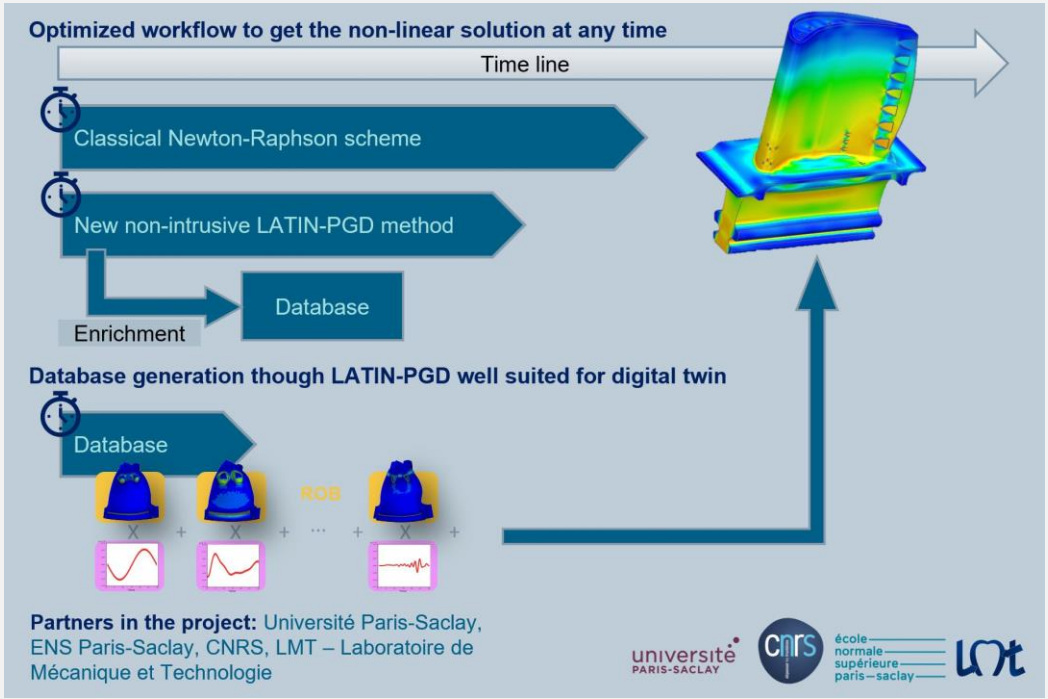
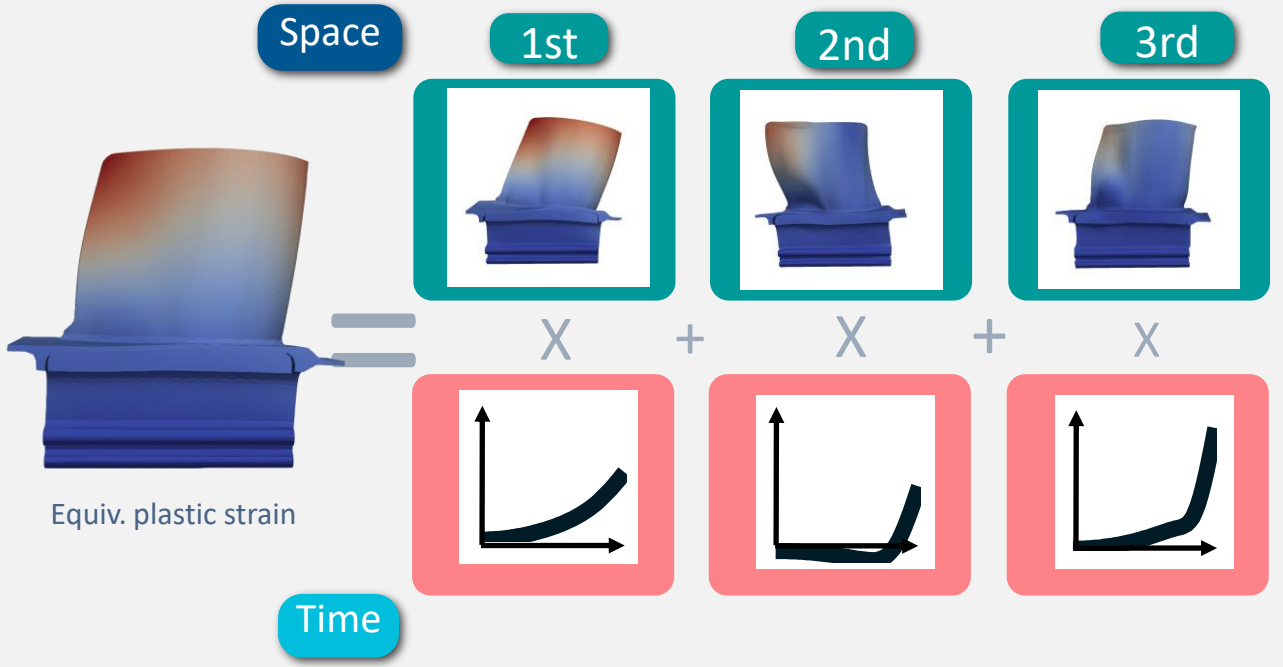
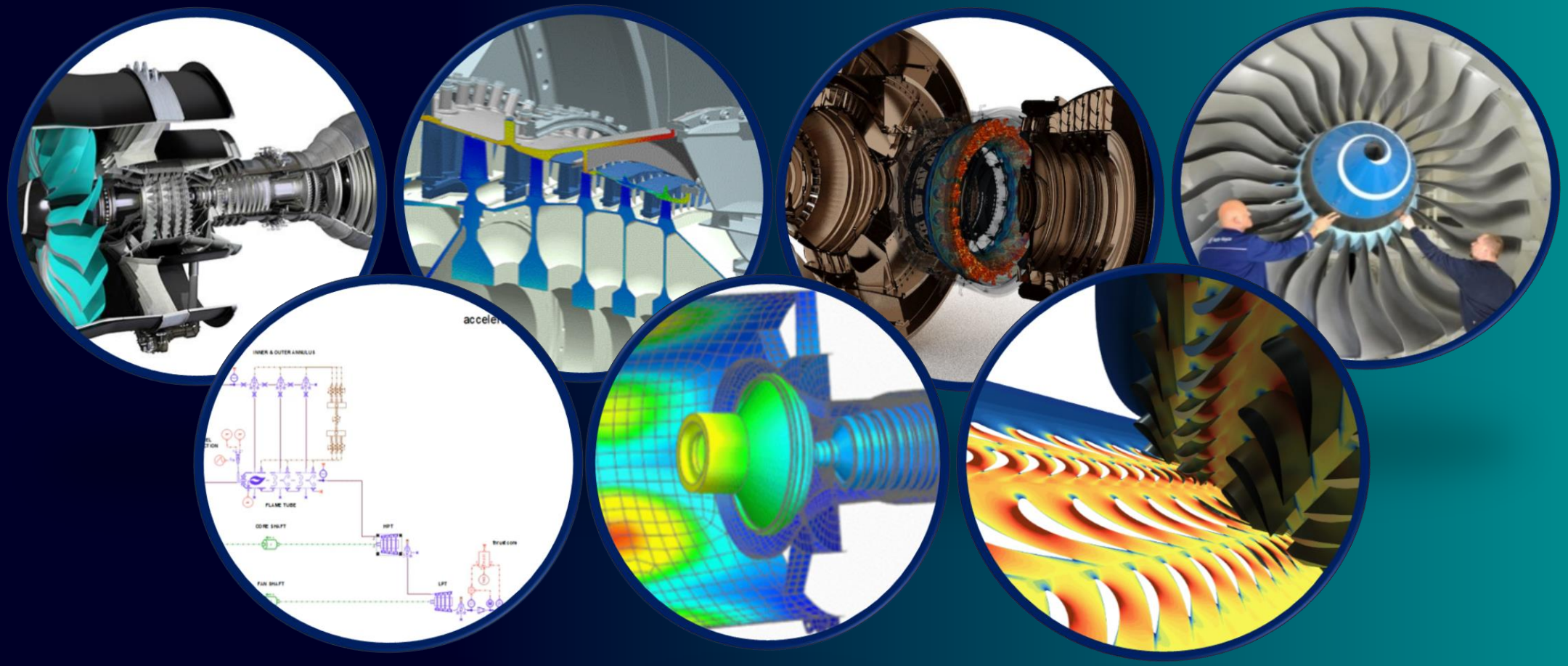
First presentation of SIMPHY 1
Mechanical - Friday 9h00

Reduced- els for aeronautics based on the LATIN-PGD method linear industrial Simcenter Samcef software

- linear computations faster than ever.
- -order modeling methods occupy a prominent place in numerical simulation: strategies such as Proper thogonal Decomposition (POD), Reduced Basis (RB) or Proper Generalized Decomposition (PGD) have largely proven their value in drastically reducing CPU time.
- Product : Simcenter 3D Samcef solver







Stay integrated

Connecting all activities for full traceability and alignment

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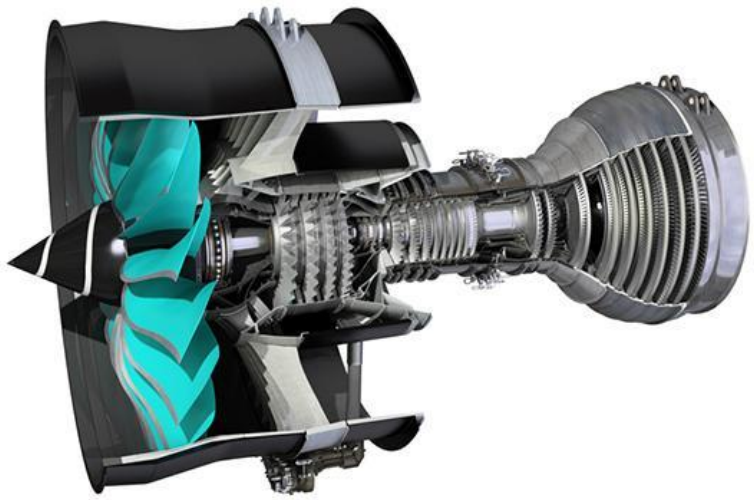
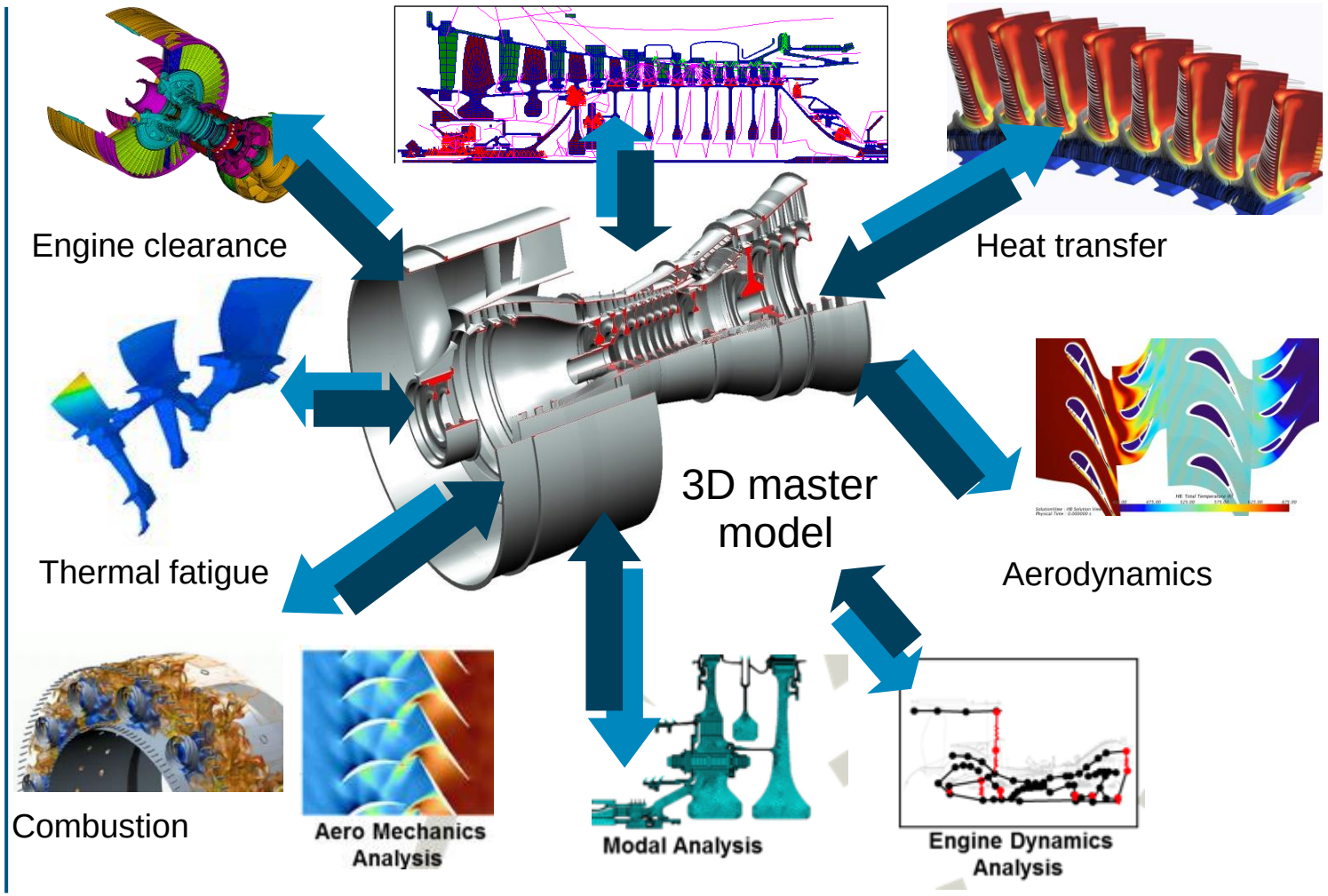
Integrated gas turbine performance engineering
Improve efficiency, fuel flexibility and durability



Towards Multi-Physics Integration



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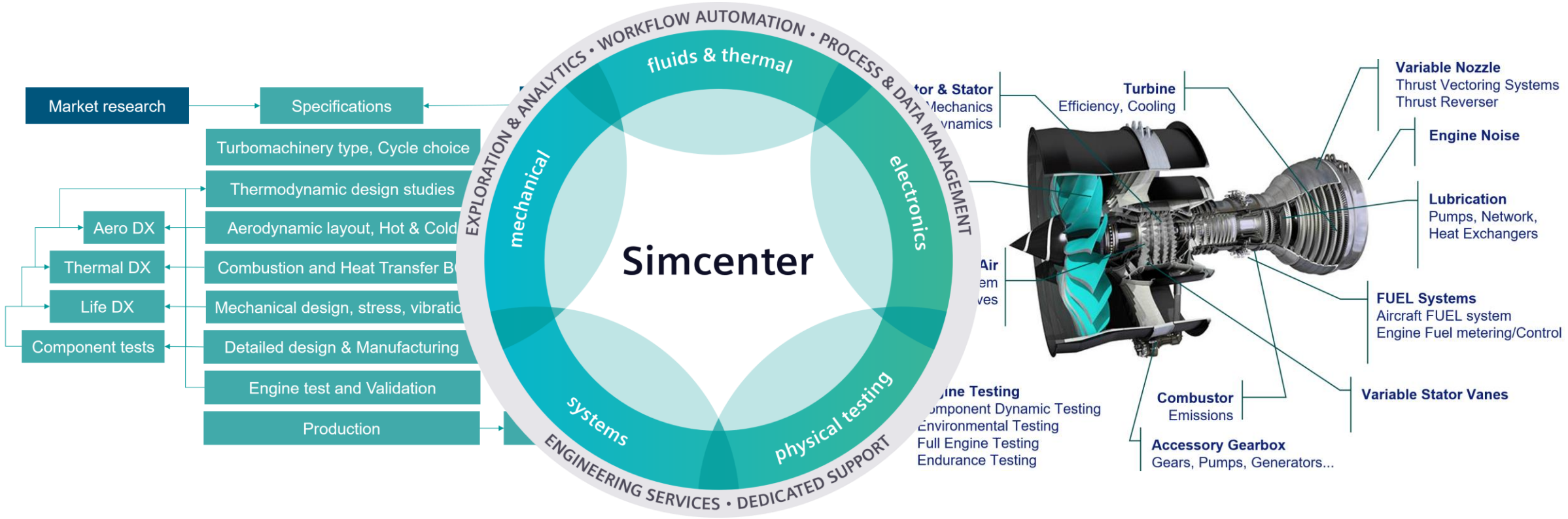
Accelerate the digital transformation for jet engine design

Enables turbomachinery companies to deliver actual engines faster to market

Integrated Product Performance – System-of-Systems – Structure-of-Structures



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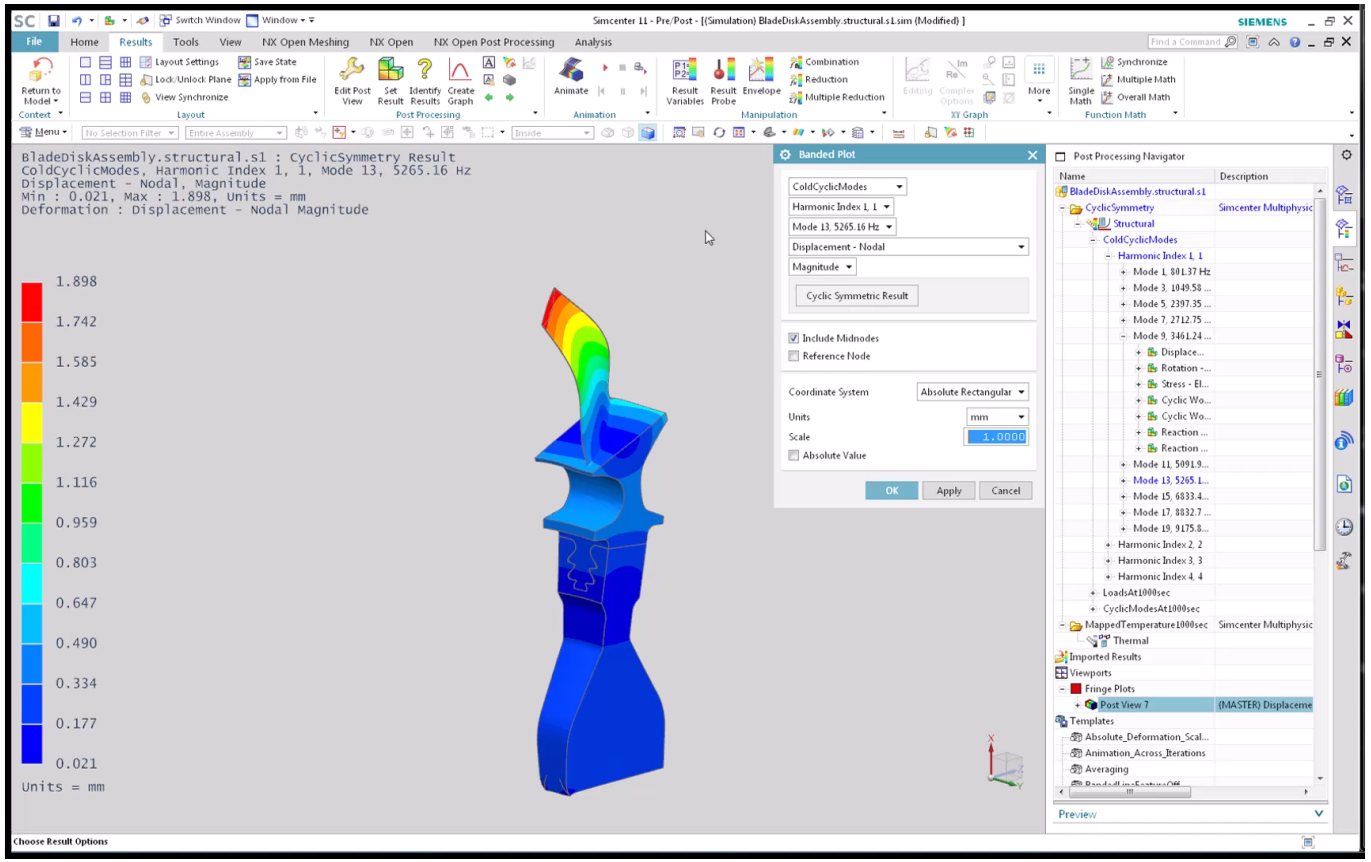

Simcenter transparent CAE environment

Improve the development experience across time and space

Share boundary conditions, materials and design changes

Simulation data and lifecycle management

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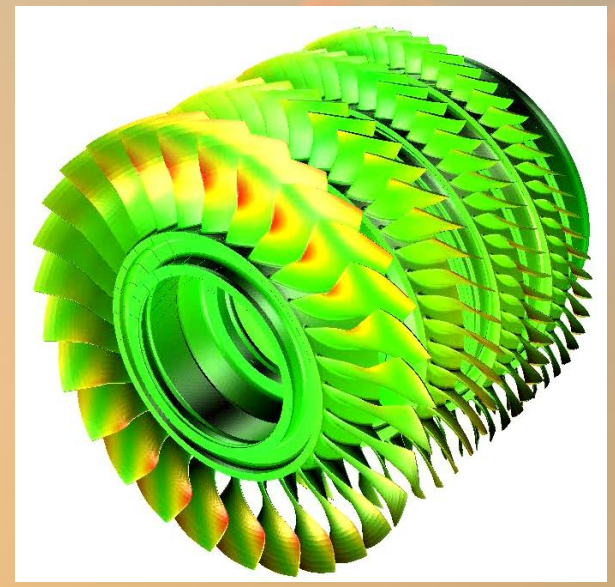
Thank you for your attention



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