Simcenter 3D – Ansaldo Energia Whole Engine Modelling (WEM)
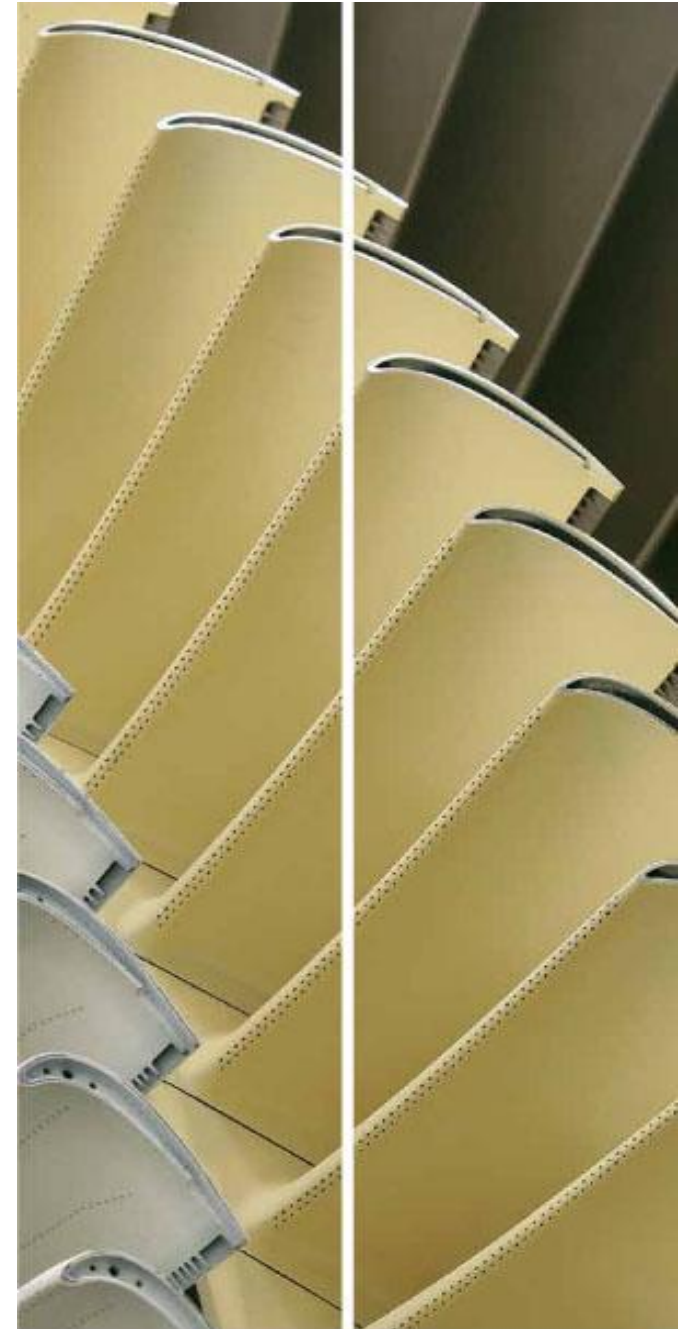
Simcenter™ Nordic Conference
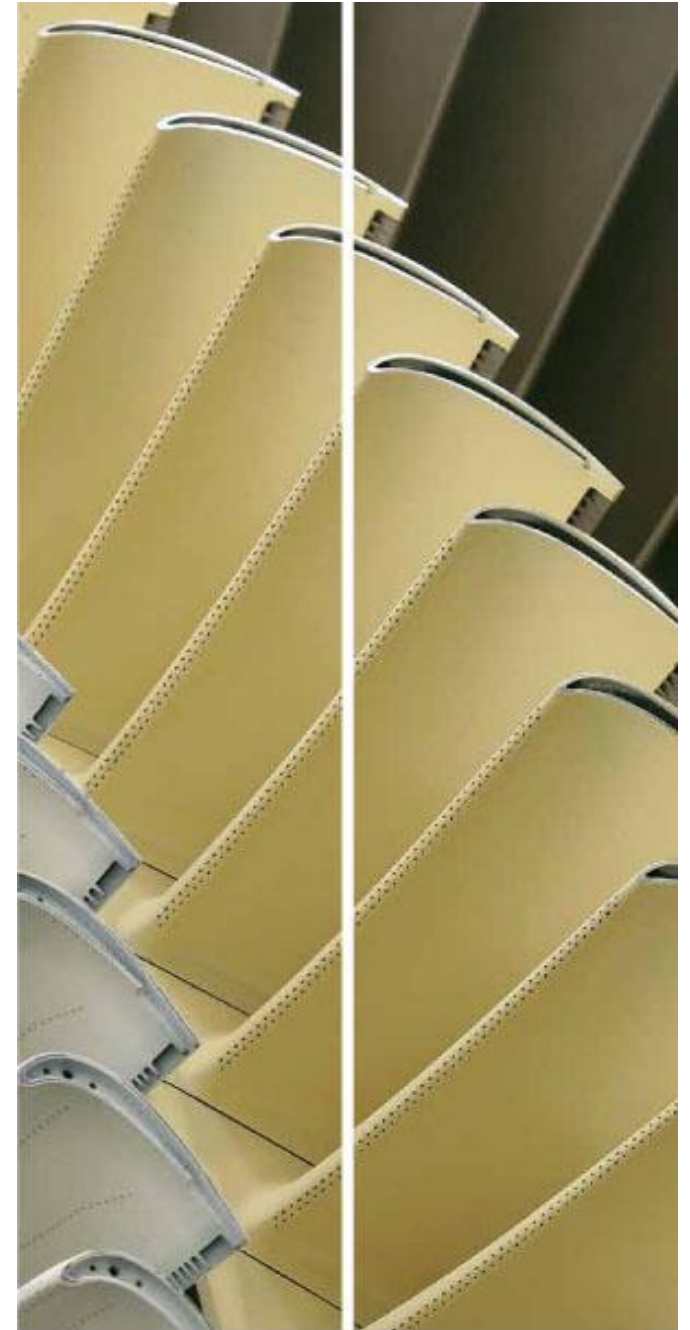
Sven Olmes

03. - 04. May 2018

Agenda

- Introduction

- Whole Engine Modelling

- Use of Simcenter for WEM

- Conclusion

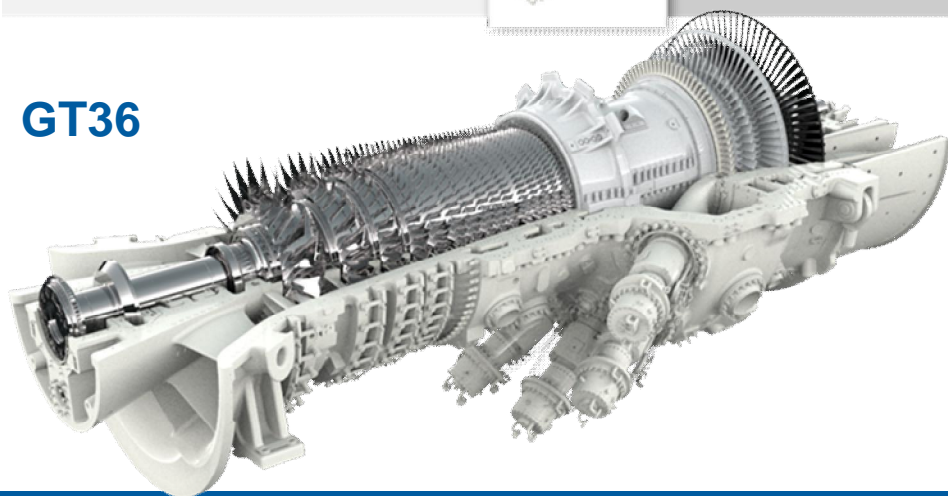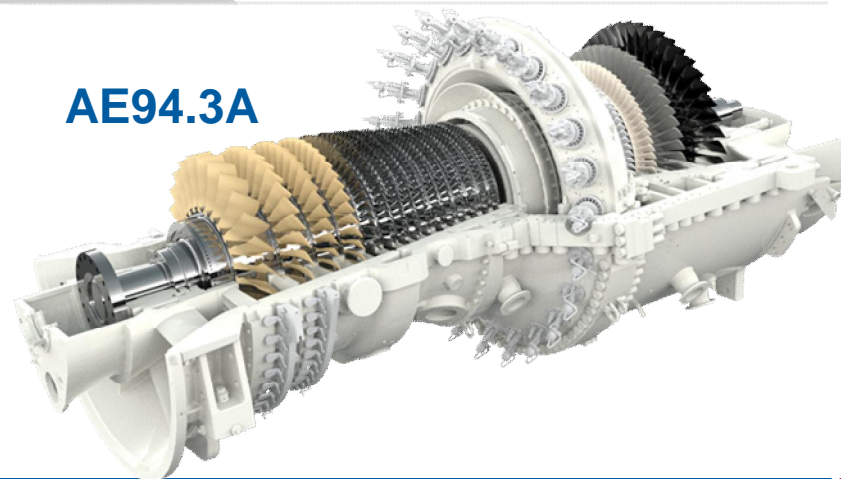# Simcenter 3D – Ansaldo Energia Whole Engine Modelling (WEM)

Introduction

Ansaldo Energia Gas Turbine Portfolio

MODEL		ISO POWER [MW]	FREQUENCY [Hz]
GT36-S5		538	50
GT36-S6		369	60
GT26		370	50
AE94.3A		340	50
AE94.2		190	50
AE64.3A		80	50/60

GT36

AE94.3A

Simcenter 3D – Ansaldo Energia Whole Engine Modelling (WEM)

Whole Engine Modelling

Ansaldo Energia Whole Engine Modelling (WEM)

Analysis Targets – General Requirements
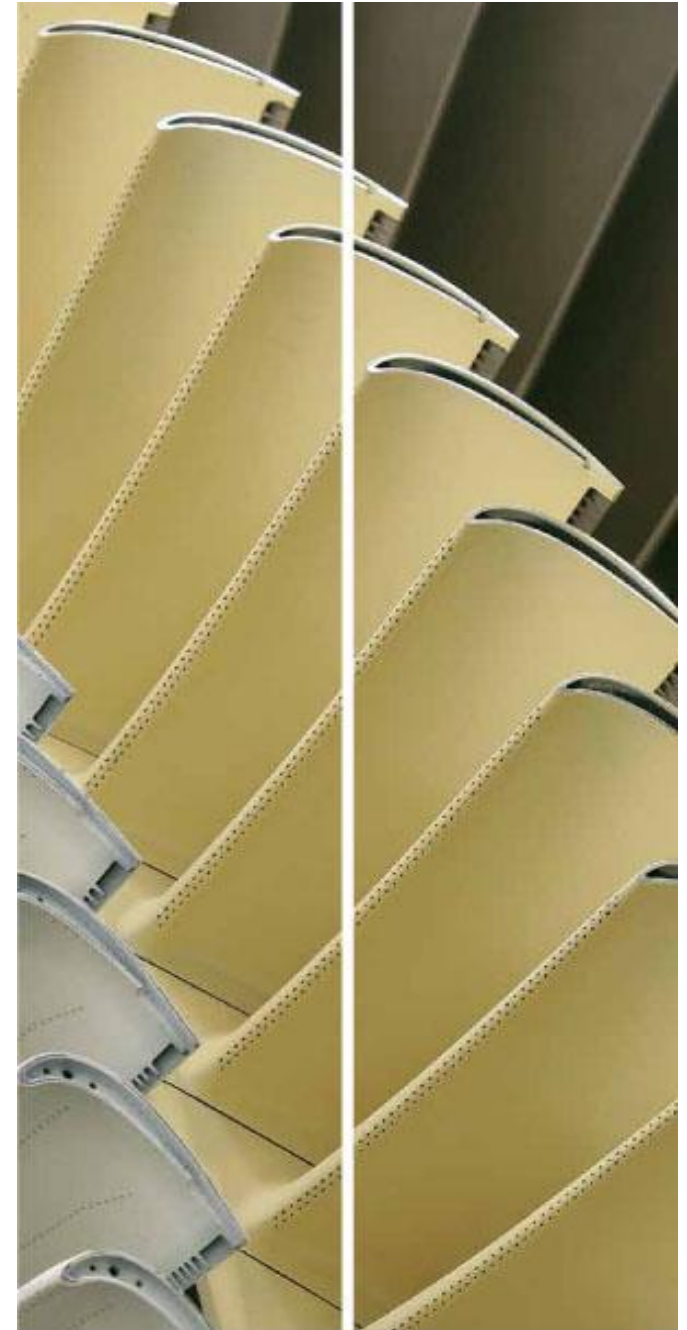
- **Thermo-Mechanical modelling:**
  - § Prediction of metal temperatures and displacements at each point in time for the entire gas turbine (Whole Engine Modelling – WEM)
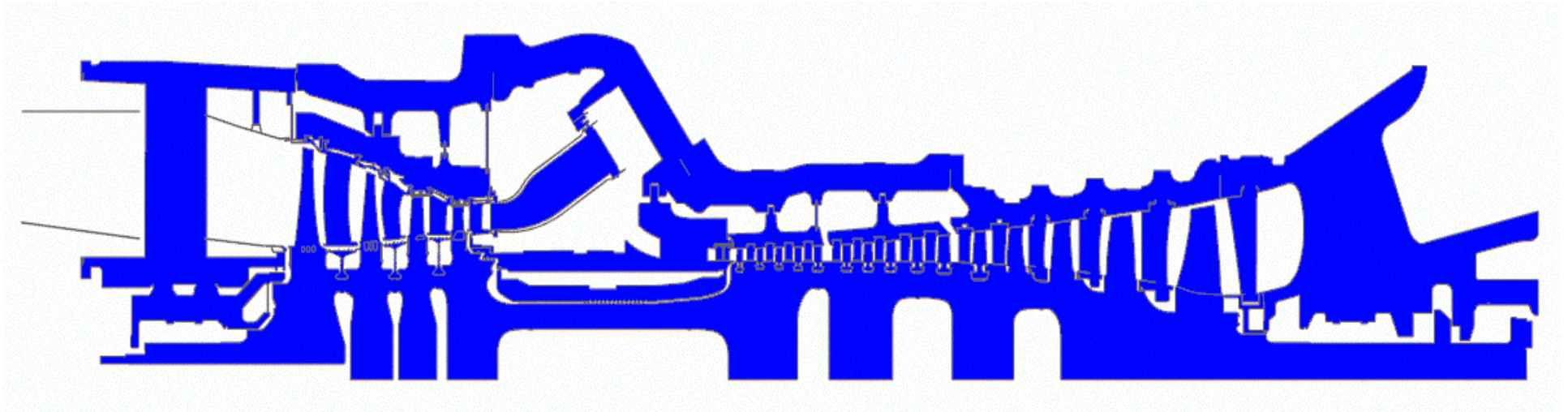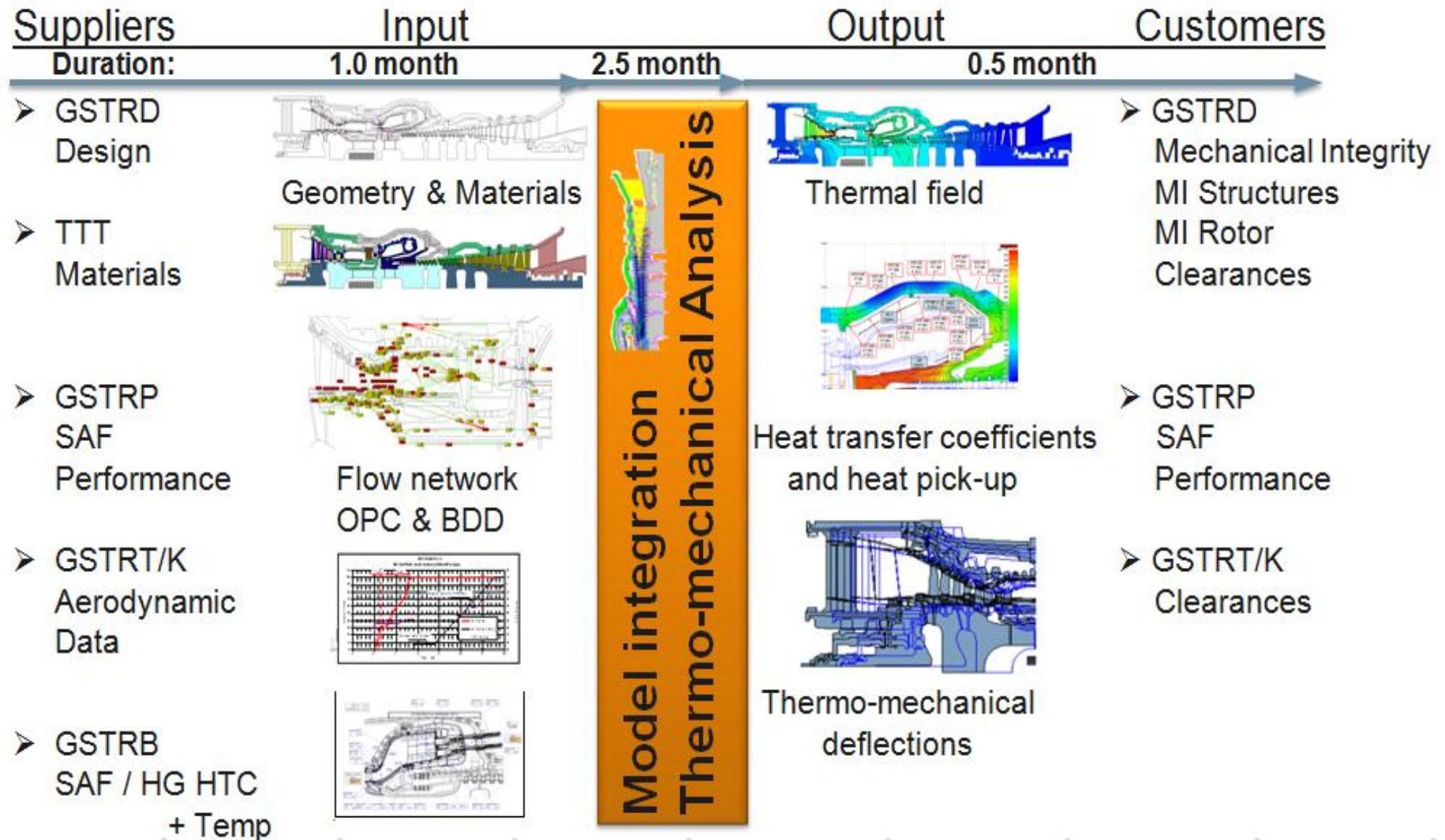

- **Main customers:**
  - § Mechanical Integrity for lifetime of components & clearance prediction as well as for optimization purposes
  - § Performance & Secondary Air Flow for internal cooling air heat pick up
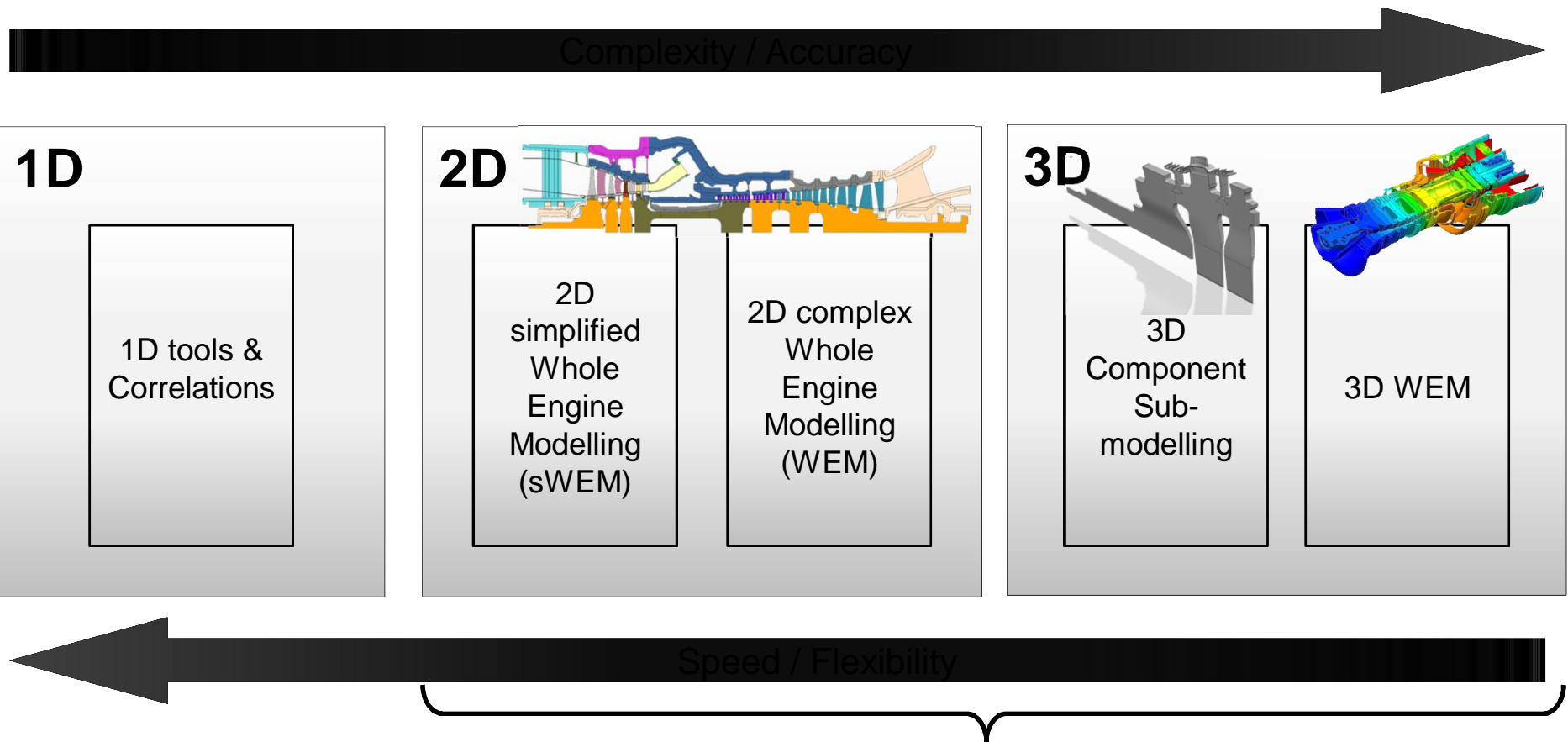
- **Requirements:**
  - § Real geometry representation of engine
  - § Transient thermodynamic key parameters (engine operation)
  - § Heat transfer mechanisms / mass flow distribution

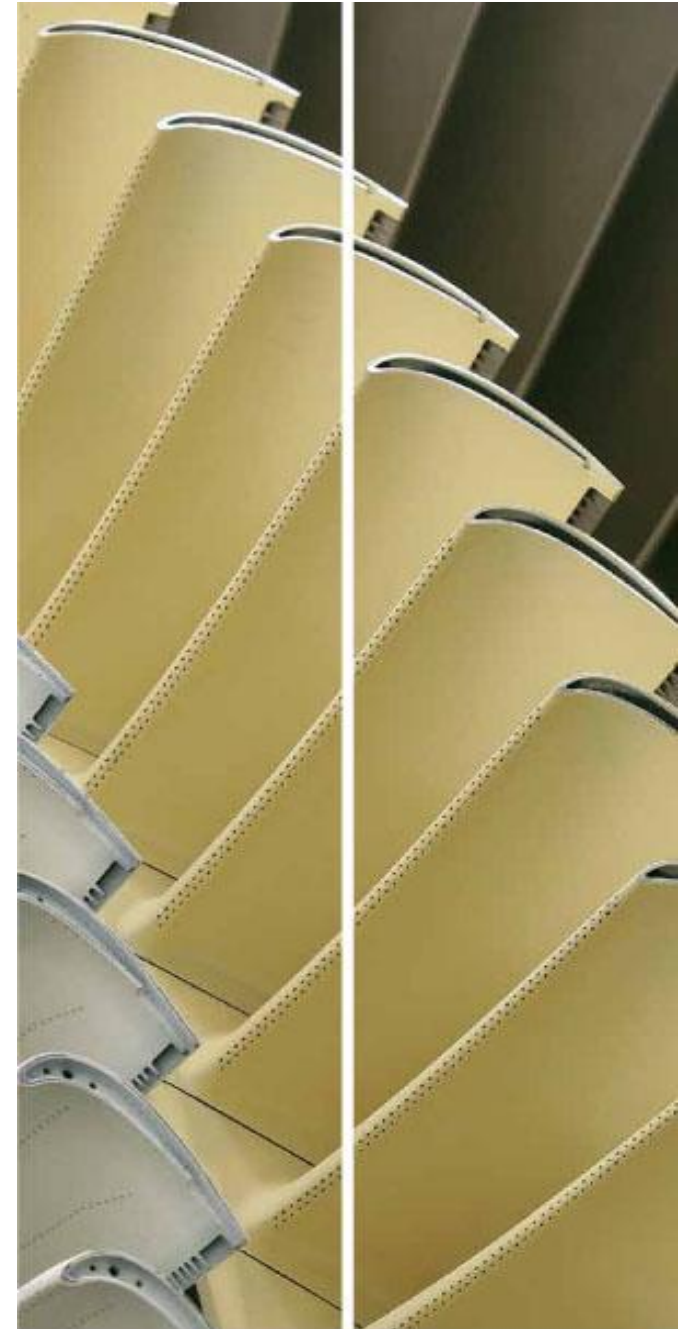# Ansaldo Energia Whole Engine Modelling (WEM)
Model Generation Cycle

Suppliers	Input		Output	Customers
Duration:	**1.0 month**	**2.5 month**	**0.5 month**	

Suppliers:
- GSTRD Design
- TTT Materials
- GSTRP SAF Performance
- GSTRT/K Aerodynamic Data
- GSTRB SAF / HG HTC + Temp

Input:
- Geometry & Materials
- Flow network OPC & BDD

Model integration Thermo-mechanical Analysis

Output:
- Thermal field
- Heat transfer coefficients and heat pick-up
- Thermo-mechanical deflections

Customers:
- GSTRD Mechanical Integrity MI Structures MI Rotor Clearances
- GSTRP SAF Performance
- GSTRT/K Clearances

Ansaldo Energia Whole Engine Modelling (WEM)
Landscape of Thermo-Mechanical Modelling

Thermo-mechanical modelling

Complexity / Accuracy →

1D

1D tools & Correlations

2D

2D simplified Whole Engine Modelling (sWEM)

2D complex Whole Engine Modelling (WEM)

3D

3D Component Sub-modelling

3D WEM

← Speed / Flexibility

Siemens PLM Software

Simcenter 3D

- Legacy tool not available any more (Primary driver)
- Multiphysics environment required (Thermo-Mechanical)
  - Transient - FE – Heat transfer – Flow network / Fluid Flow
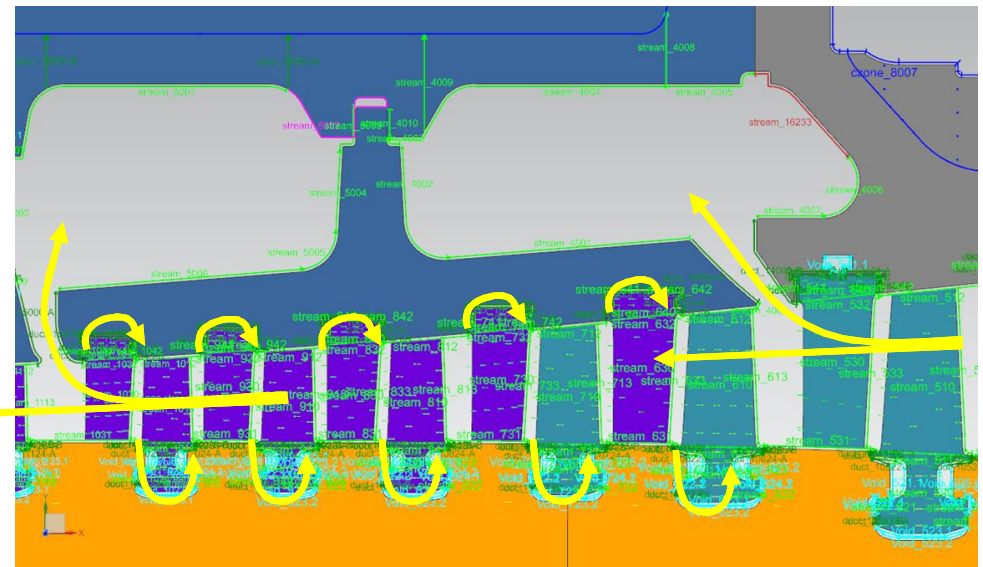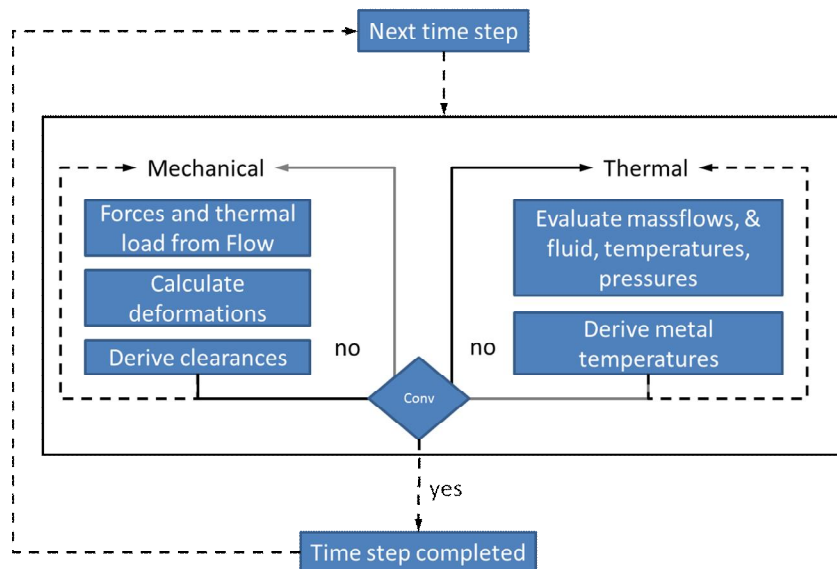
- Heat storage & release in the FE part is essential for the engine heat up and cool down of the simulation
- Flow networks (simple & fully hydraulic ones) are required to distribute the heat accordingly
  - § Clearances determine in reverse the massflow acting
- Powerful GUI to support boundary condition management (~3500 BC's)
- Flexibility with respect to include own codes / subroutines as well as parametrization of inputs

![Ansaldo Energia logo]

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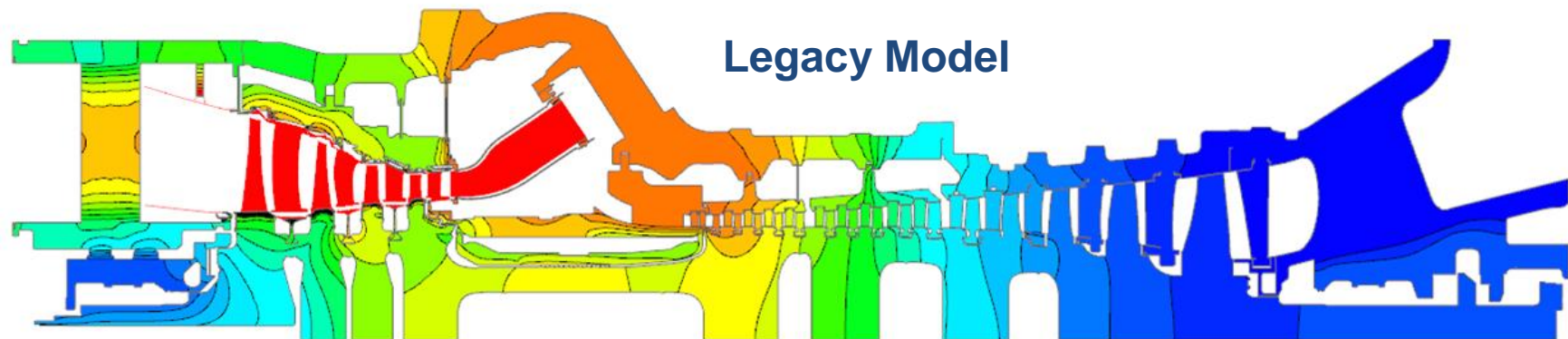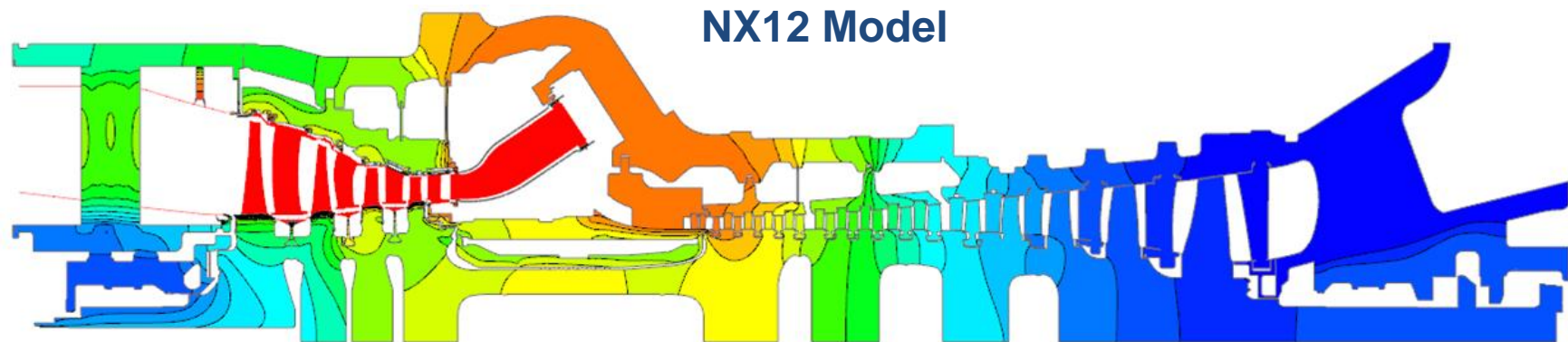
Use of Simcenter 12 for Thermo-mechanical WEM

Ansaldo Energia Whole Engine Modelling (WEM)
Tool Change Boundaries

NO direct comparison

Legacy tool

New tool set

Siemens PLM Software
Simcenter 3D

Existing Model Database
~500 models

Implementation of Ansaldo
know how

NX Productive Environment

ANSALDO ENERGIA

Missing Features
in target tool

Direct Support
Thermal Solver & Scripting

MAYA
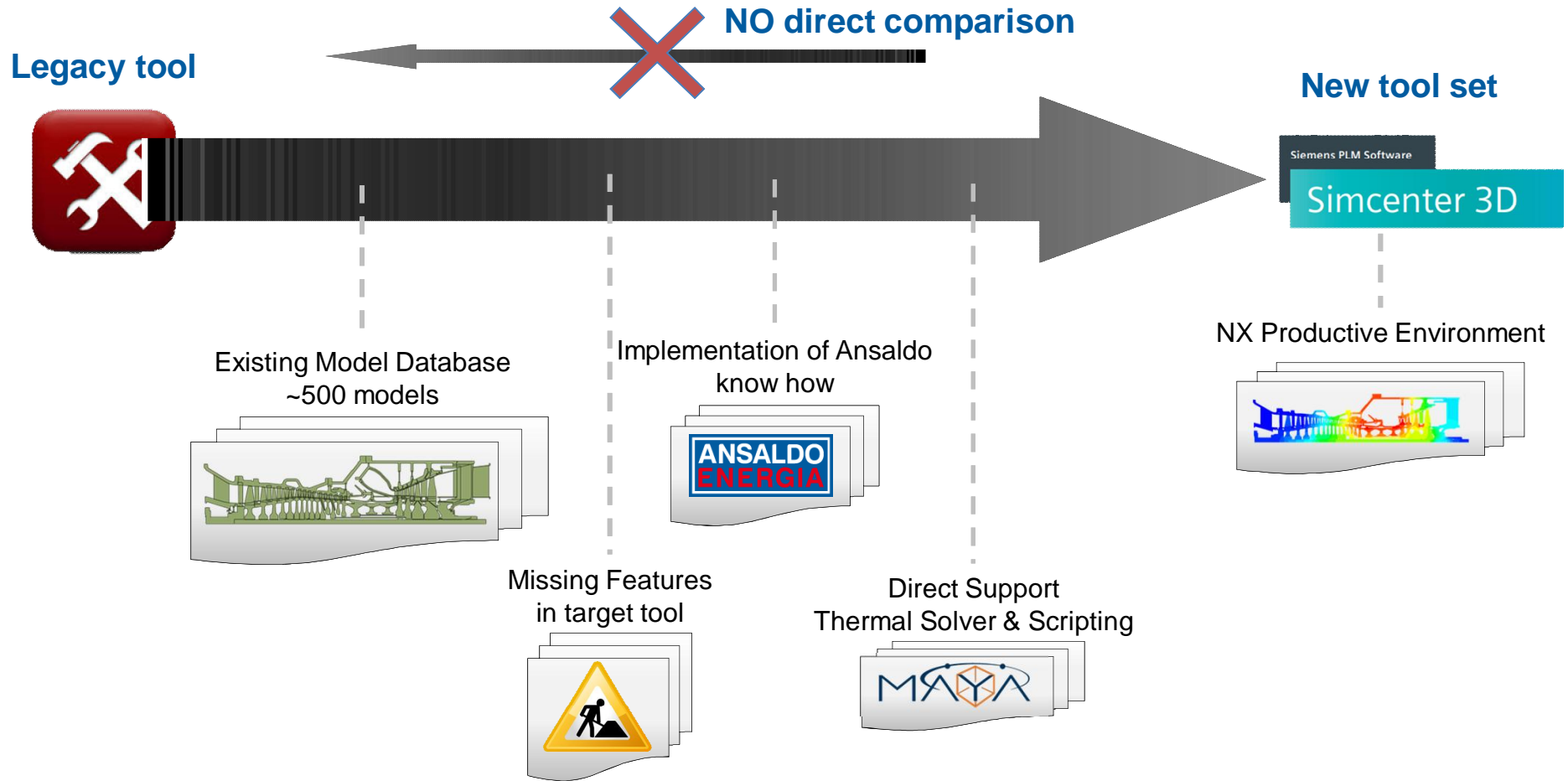
Rebuilding detailed functionality within a new tool without the option of cross-checking the individual features against the legacy tool

2D WEM Thermo-Mechanical Analysis

Simcenter Implementation - Legacy model import

o Python scripting to translate legacy models into Simcenter functionality

o Semi-Automatic process established for model recreation (not just an import)

o Expression Extension via C++ Plug-Ins / Fully parametrized boundary conditions

o Geometry – Materials – User Parameters – Loads – Transient Mission Cycle

Fully functional model utilizing NX capabilities (Link Geometry ↔ Boundary Conditions)
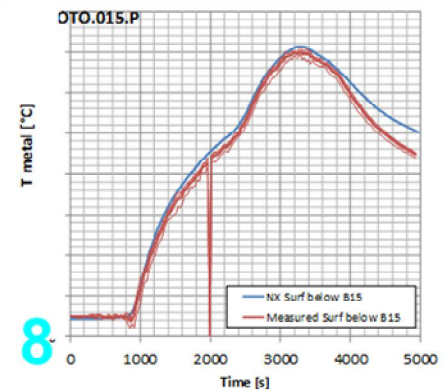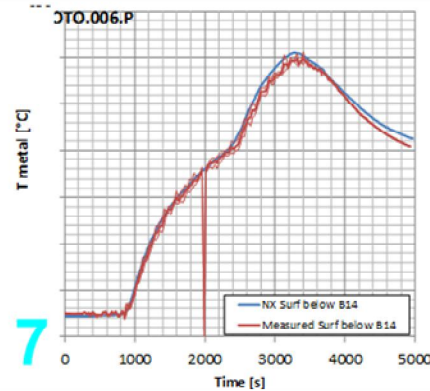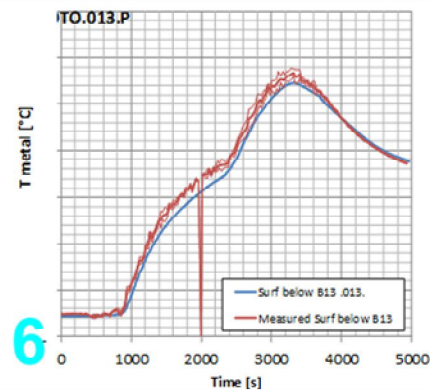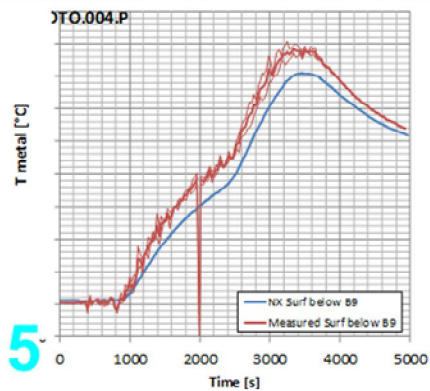
Thermo-Mechanical Analysis

Implementation Status

- Baselining to legacy models completed: demonstrating overall a very good match to legacy tool
- Steady – State and transient matching criteria were fulfilled

NX12 Model

Legacy Model

2D WEM Thermo-Mechanical Analysis
Direct Temperature Validation – GT36 Test Plant Birr (Switzerland)

- Real engine testing confirms local quality of modelling approach
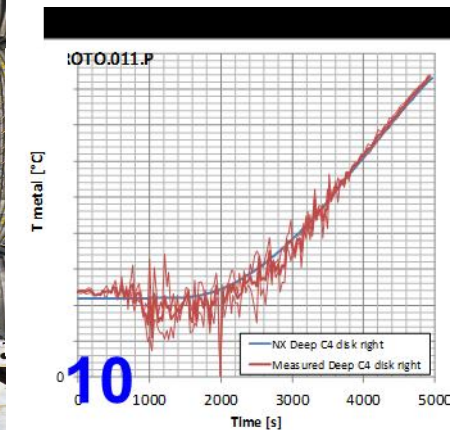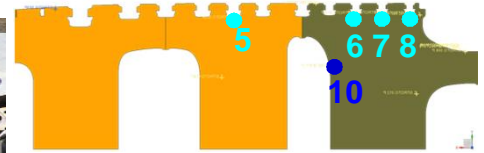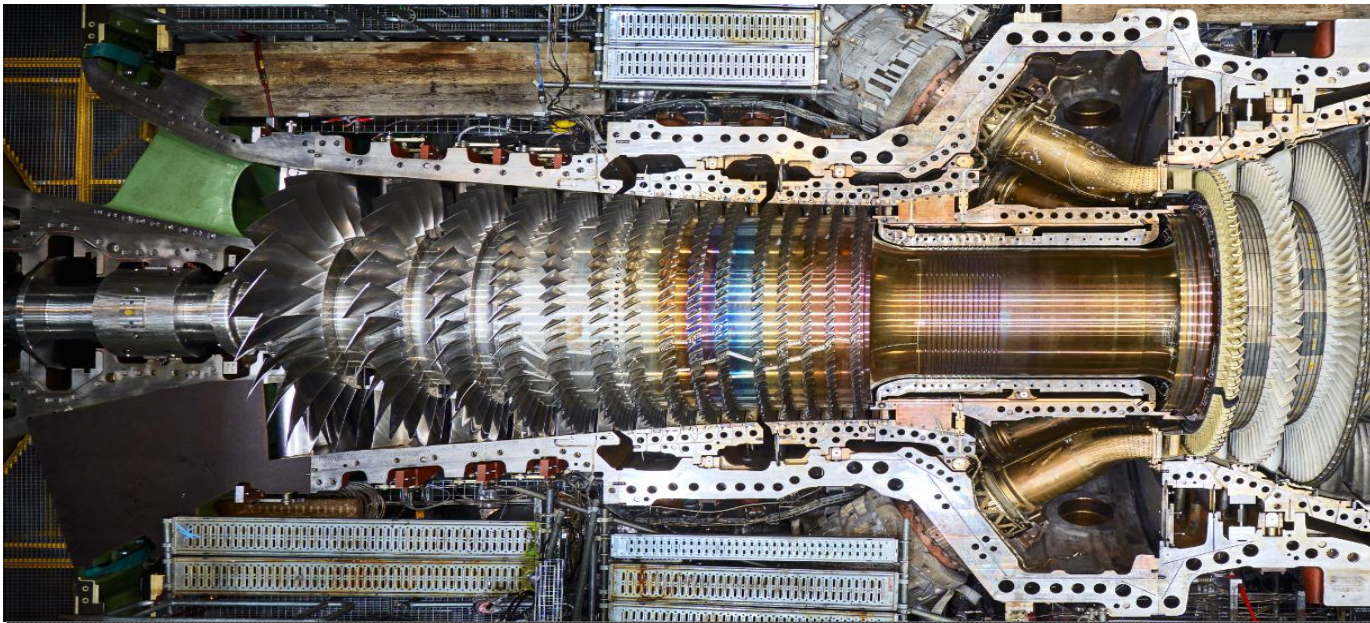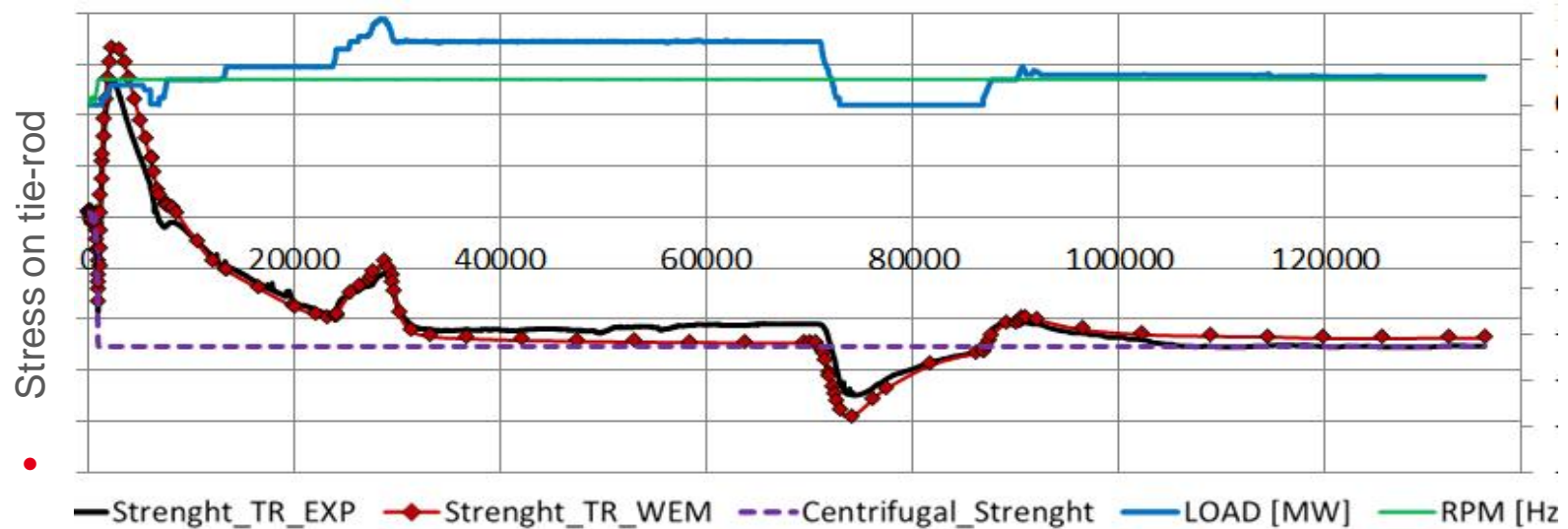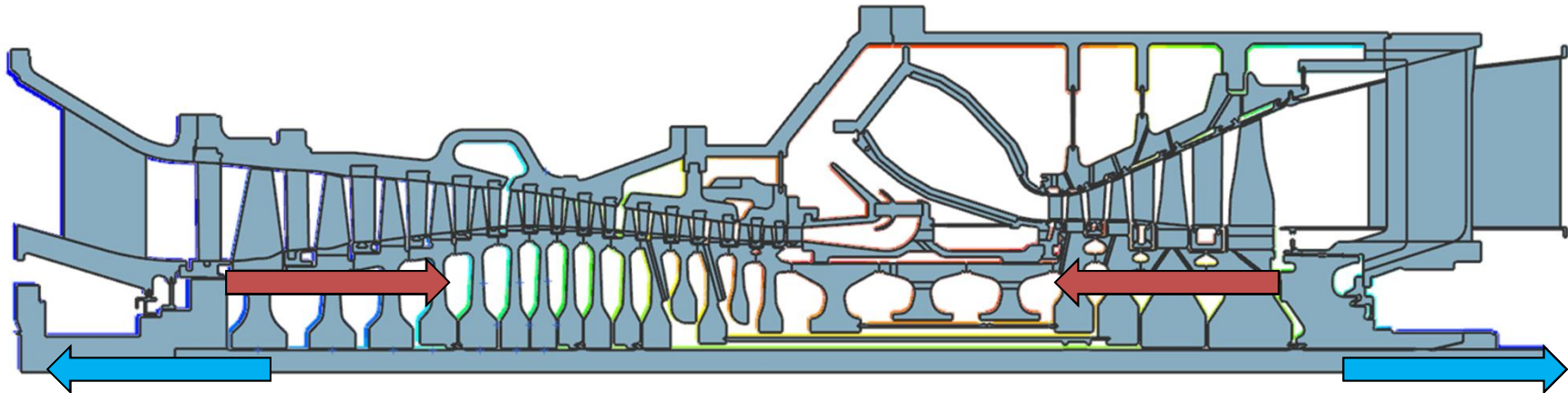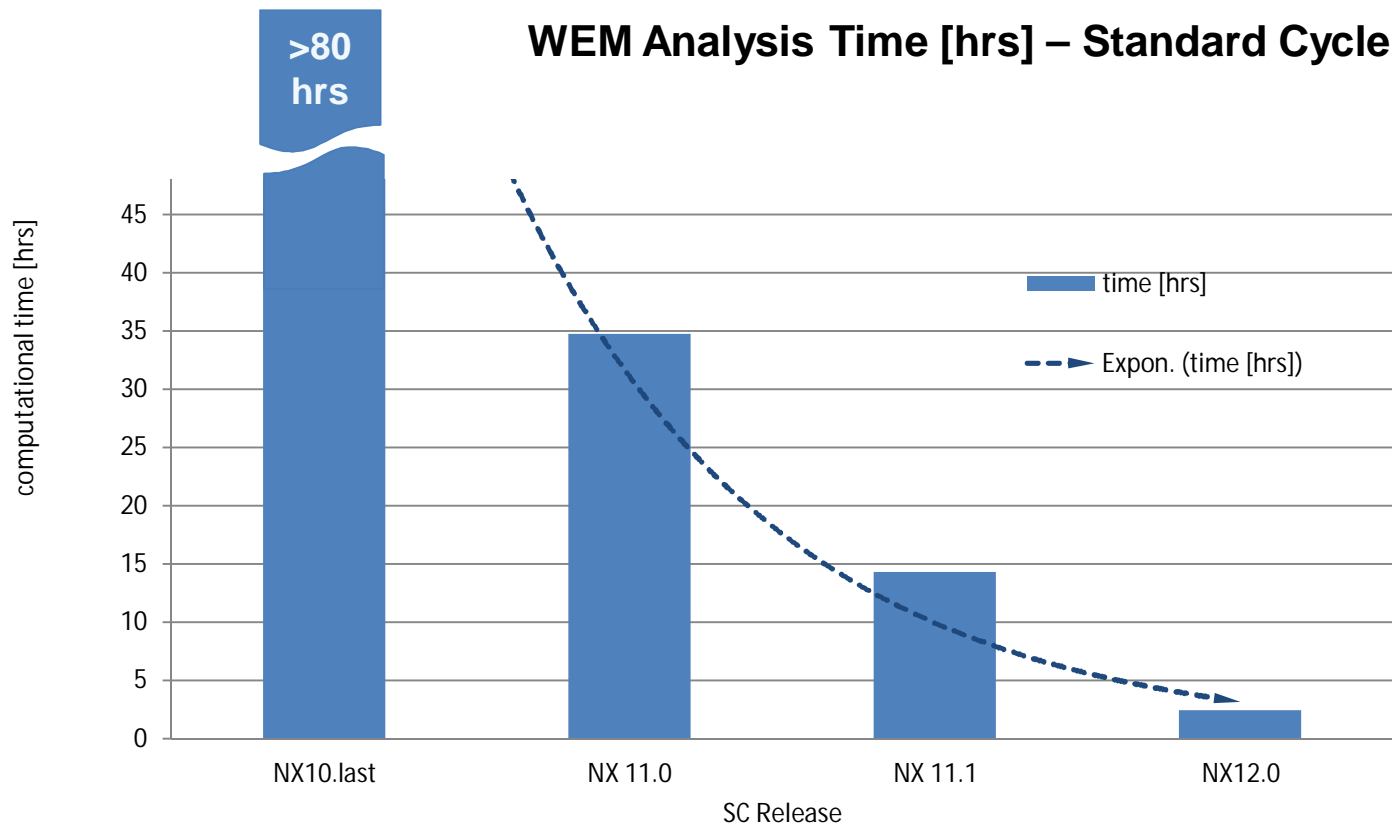
2D WEM Thermo-Mechanical Analysis

Indirect Validation – AE94.3 Field Measurements

- Indirect validation of overall mechanical behaviour via stress level of centre tie-rod
- Confirmation of accumulated accuracy of modelling approach

Stress on tie-rod

Legend: Strenght_TR_EXP — Strenght_TR_WEM — Centrifugal_Strenght — LOAD [MW] — RPM [Hz]

Simcenter Evolution
Computational Efficiency

- Computational time is crucial to succeed within the productive environment as well as for proceeding towards the digital twin
- Starting release (NX10) with too high computational times (>80hrs!)
- During the application Simcenter improved significantly
  - *Remarkable* speed up of the thermal solver from over 80hrs down to 2.5hrs (same model)

WEM Analysis Time [hrs] – Standard Cycle

2D WEM Thermo-Mechanical Analysis
Improvement Proposal: Conditions Sequence / Mission Cycles

- Transient Mission Cycle to prescribe the engine operation
- Within design process about **50** non-standard mission cycles per engine design are evaluated
  - Clearance behaviour (pinch points, critical engine operation)
  - Lifetime prediction – utilization of part lifetime with respect to freedom of engine operation
  - *Unfortunately*: Simcenter only manages ONE condition sequence per model up to now
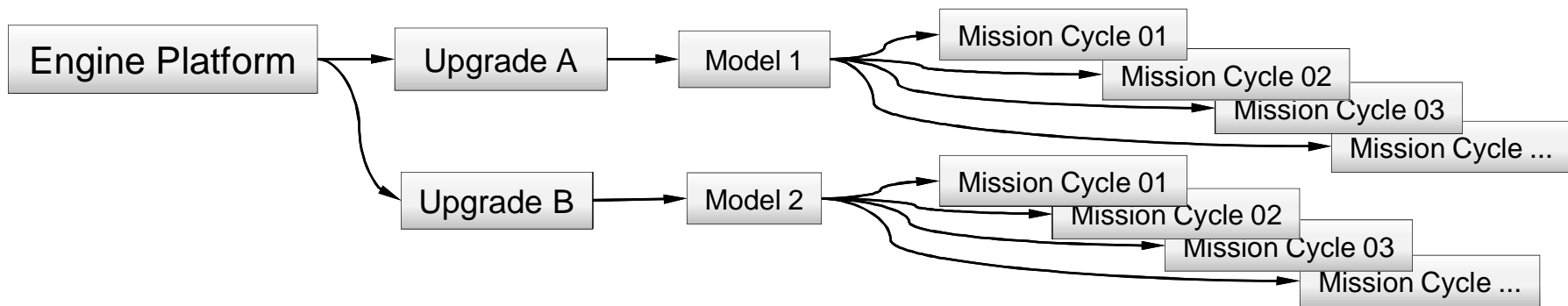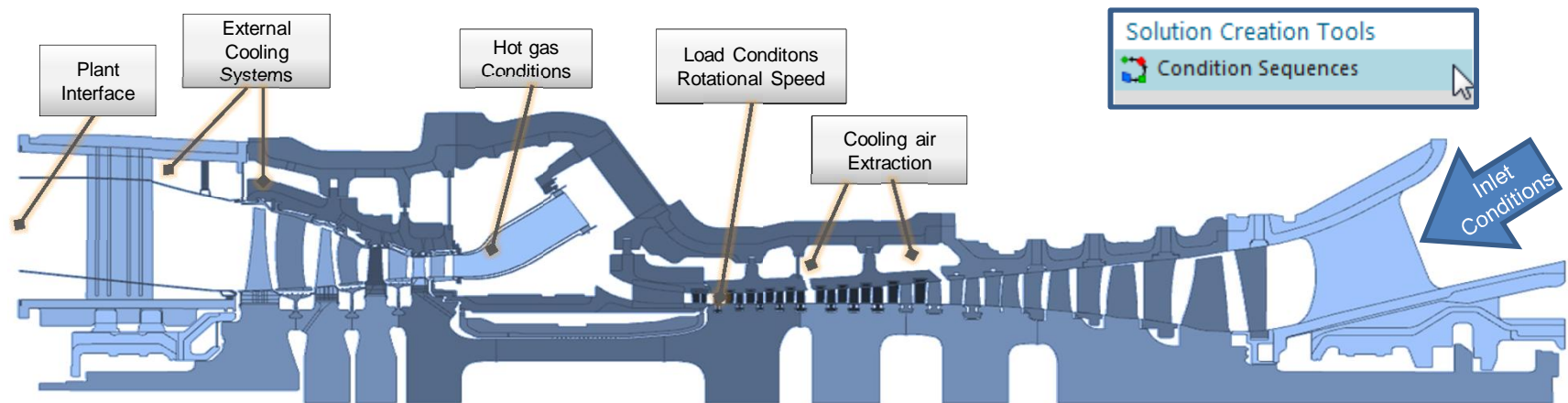
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Conclusions

Ansaldo Whole Engine Modelling
Conclusions
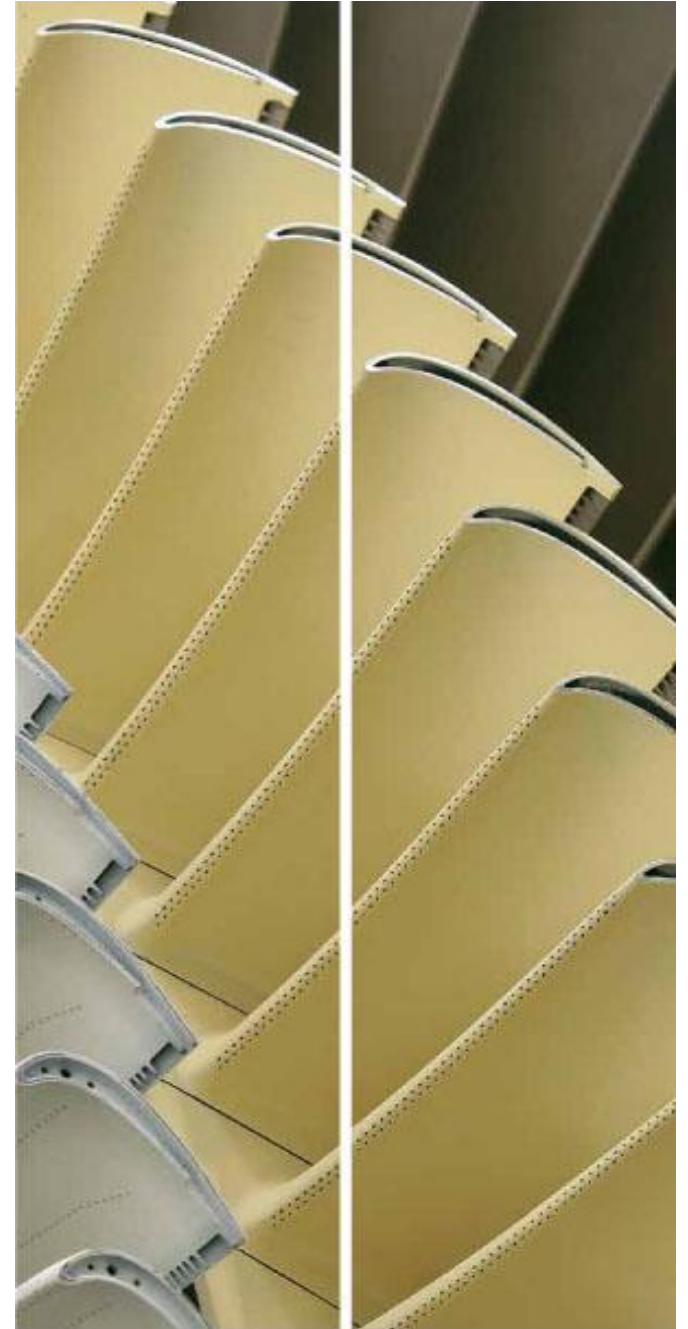
- Full productive tool set for 2D & 3D thermo-mechanical modelling available within NX12
- Thanks to dedicated support from Siemens and Maya HTT WEM within NX was successful
- Simcenter fulfils the requirements and is enabling all required functionality for the next steps

**Moving towards
the digital twin**