FOCUS6

Integrated Modular Design Tool

Knowledge Centre WMC
Wind turbine Materials and Constructions

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Topics

- Introduction
- Main features
- Aero-elasticity I: rotor pre-design
- Aero-elasticity II: turbine design
- Offshore
- Structural blade design
- Tidal

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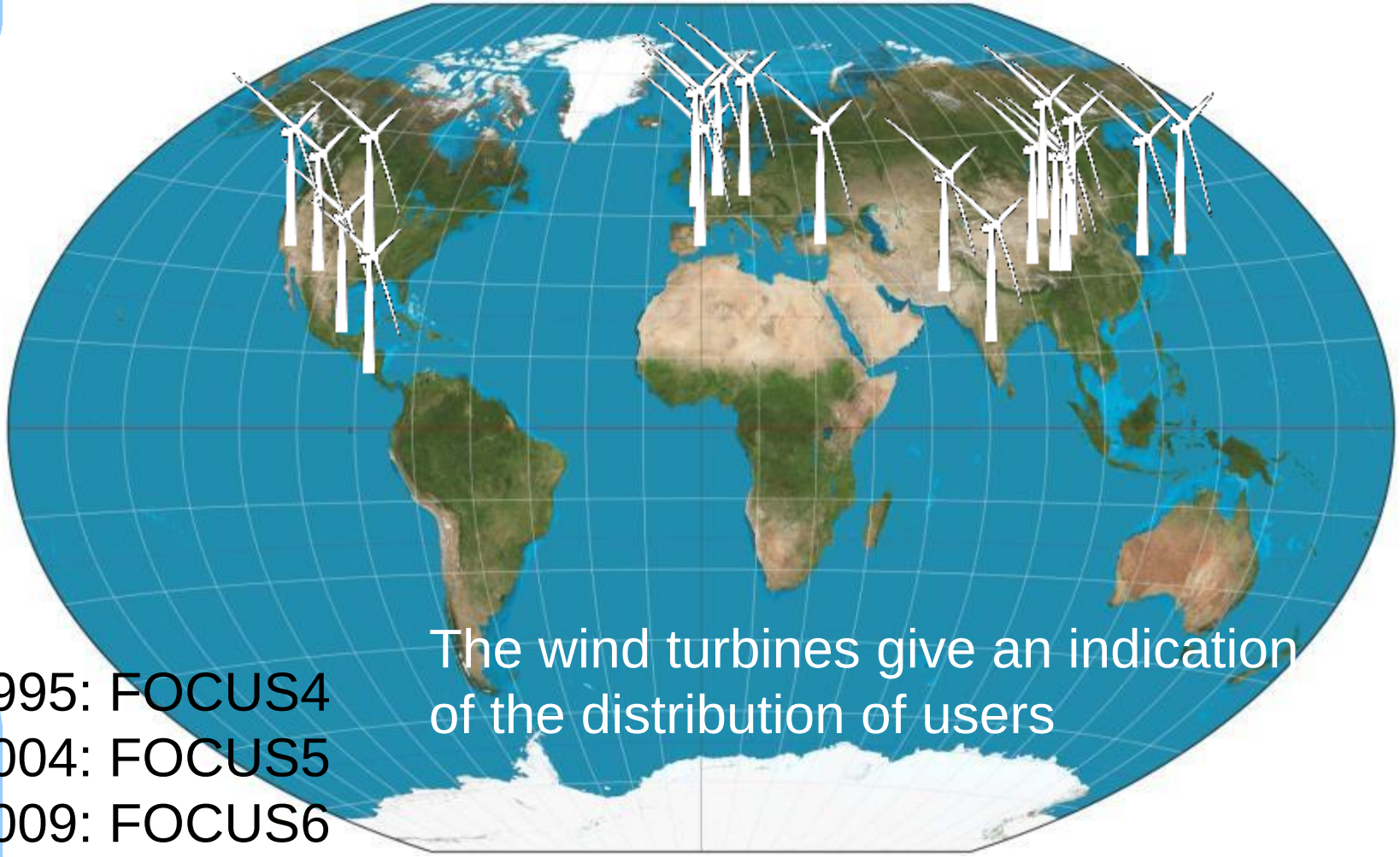
FOCUS across the globe



The wind turbines give an indication of the distribution of users

1995: FOCUS4
2004: FOCUS5
2009: FOCUS6
2016: FOCUS6 version 6.3

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Main Features

- Integrated design environment (GUI)
- Project based
- Multi-user concurrent design and calculations
- Parameterisation of models
- Context sensitive parameter wizards
- Visual / graphical inspection of results

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Integrated Design Environment

- **FOCUS6 provides a Graphical User Interface (GUI) and integrates program modules**
- **The GUI provides capabilities to**
  - Create and manage projects and project data
  - Create and manage data-sets with (parametric) data per project and/or per calculation
  - Create, manage, execute and review calculation jobs

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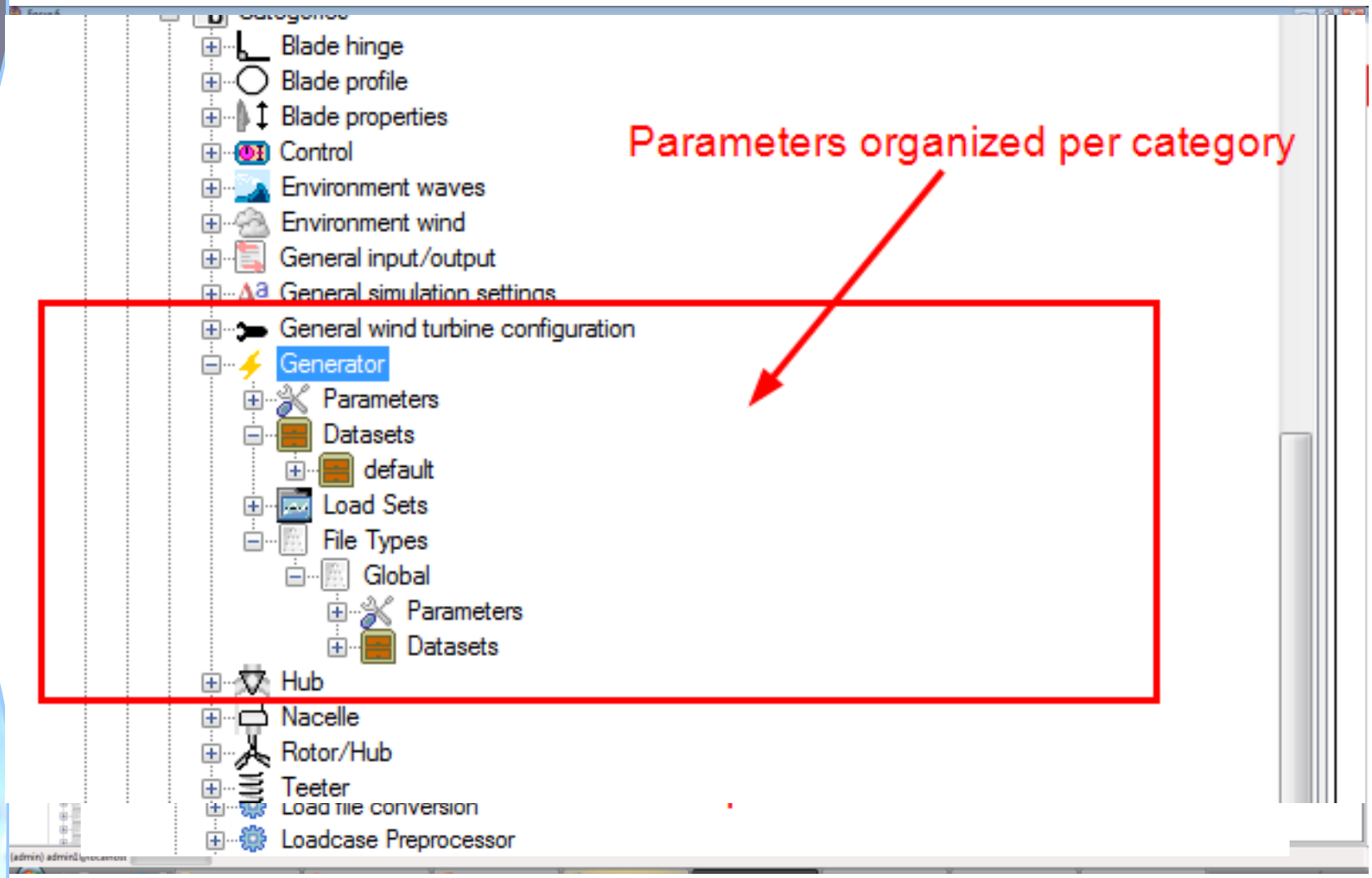
FOCUS6 User Interface



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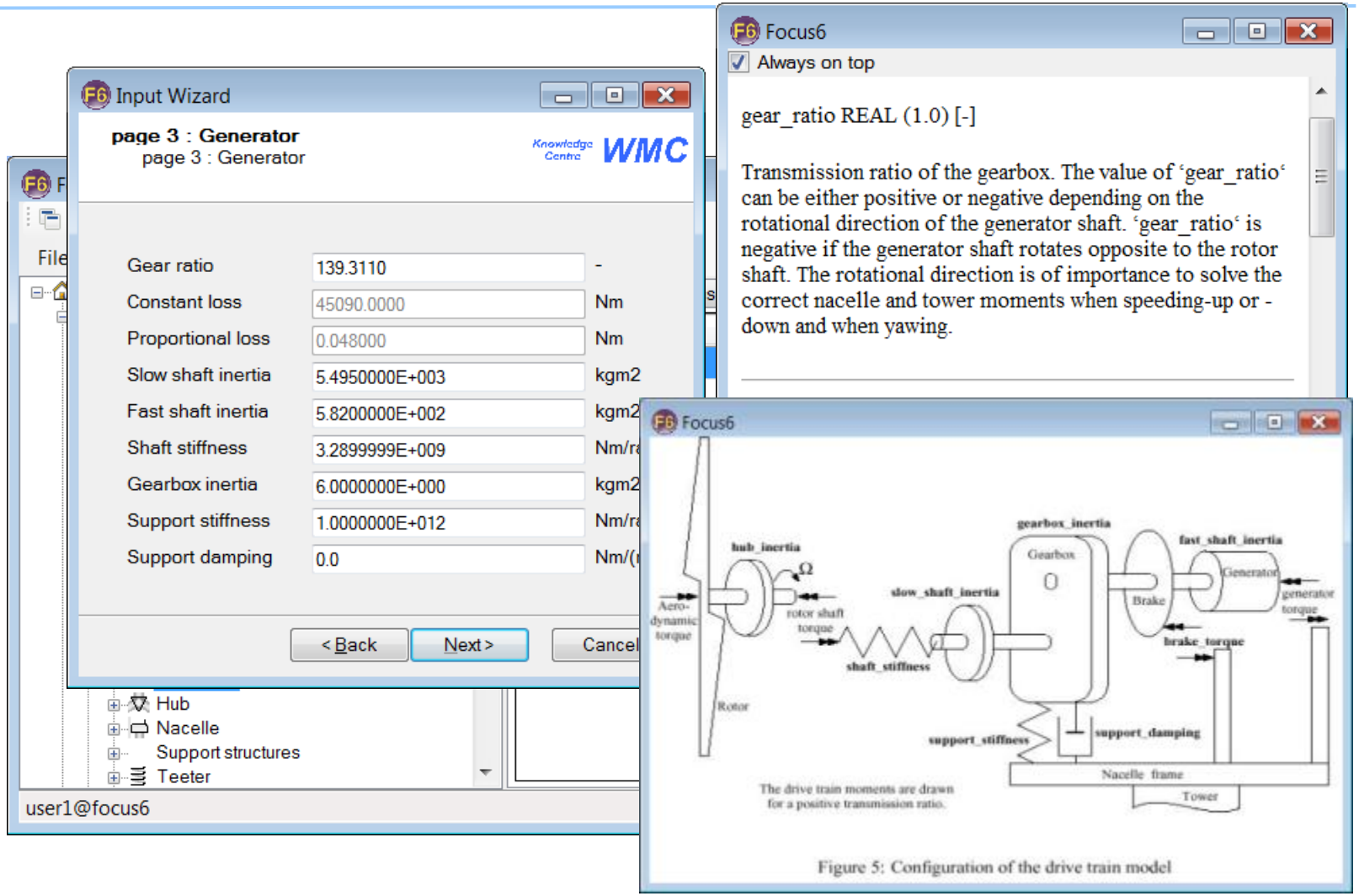
Input Wizards



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Project Based

- **The turbine design consists of several 'parts':**
  - Tower, Support Structure
  - Nacelle, Drive-train Rotor and Hub
  - Rotor Blades
- **FOCUS6 organizes the parametric data for these items inside a FOCUS6 project**
- **FOCUS6 supports quickly copying data between projects**

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Multi-User Design Projects

- **FOCUS6 organizes projects and data into a central database**
- **Multiple users work on the same project simultaneously**
- **All changes by users are tracked**
  - *("Who? – When? – What?")*
- **Calculations can run in parallel on PCs with multi-core processors**
  - Other computers in the network can join in for even shorter turnaround times e.g. for load set calculations

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FOCUS6 Queue Server

- Load set calculations and parameter variation analyses can be off-loaded to a dedicated Queue server
- On the Queue server, a service checks the job queue and runs these jobs
- By default, the Queue server runs jobs in parallel up to number of cores available
- Multiple Queue servers can be used

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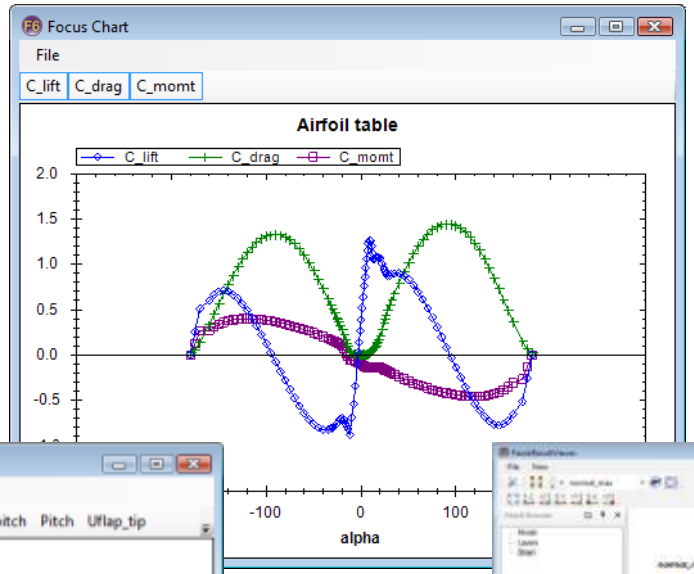
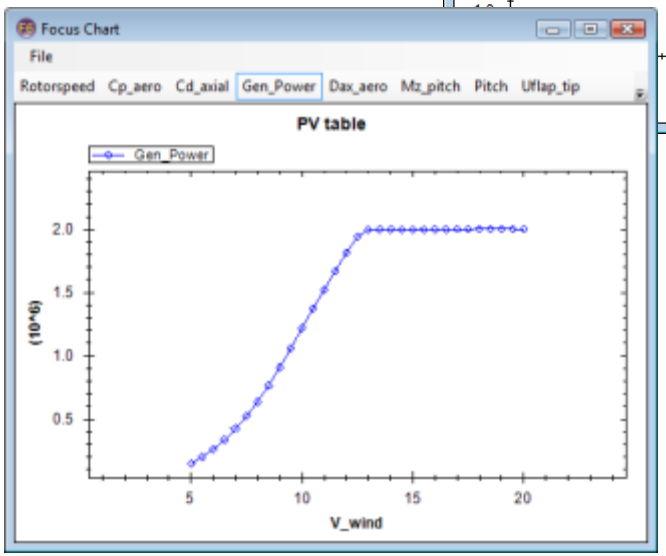
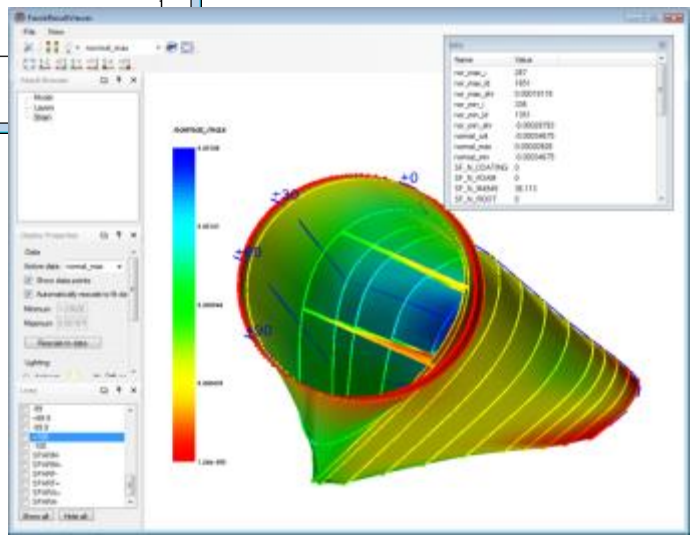
Visualization of data and results



Airfoil data



PV curve



Max normal strain

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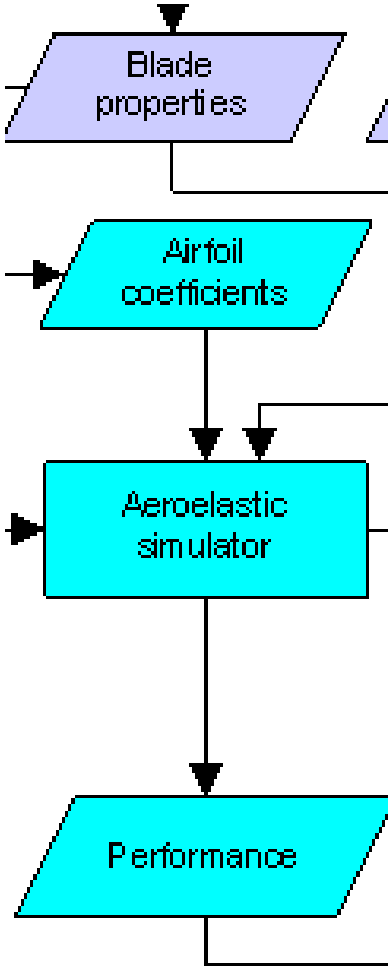
Aero-Elastic I, Rotor Pre-Design



- **Optimize aero-elastic performance of the rotor (PV)**
- **Pre-design optimization of** aerodynamic **blade damping of the rotor blades**
- **Pre-design optimization of eigen frequency, eigenmodes of the rotor**
- **Based on Blade Element Momentum (BEM) theory**

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Aero-elasticity I, rotor pre-design

- **Input (estimated) *blade* properties:**
  - Aerodynamic coefficients (Cl, Cd, Cm)
  - Bending and torsional stiffnesses
  - Transverse shear flexibility
  - Coupling terms for bending and torsion
  - Mass distribution
- **Results:**
  - Eigenmodes and frequencies (Campbell diagram)
  - Damping of the rotor blades
  - Aerodynamic performance
- **Extra option: Noise Emission prediction**

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Aero-Elasticity II: Turbine Design

- Calculates the aerodynamic and structural dynamic behaviour of a wind turbine in the time domain
- Power curve and aero-elastic performance
- Tower model included (monopile, simple tripod)
- Alternatively use advanced tower models via the Craig-Bampton method
- A built-in PD pitch controller
- Built-in supervisory controller
- External dedicated pitch controllers can be used
- Various generator models (e.g. direct-drive)

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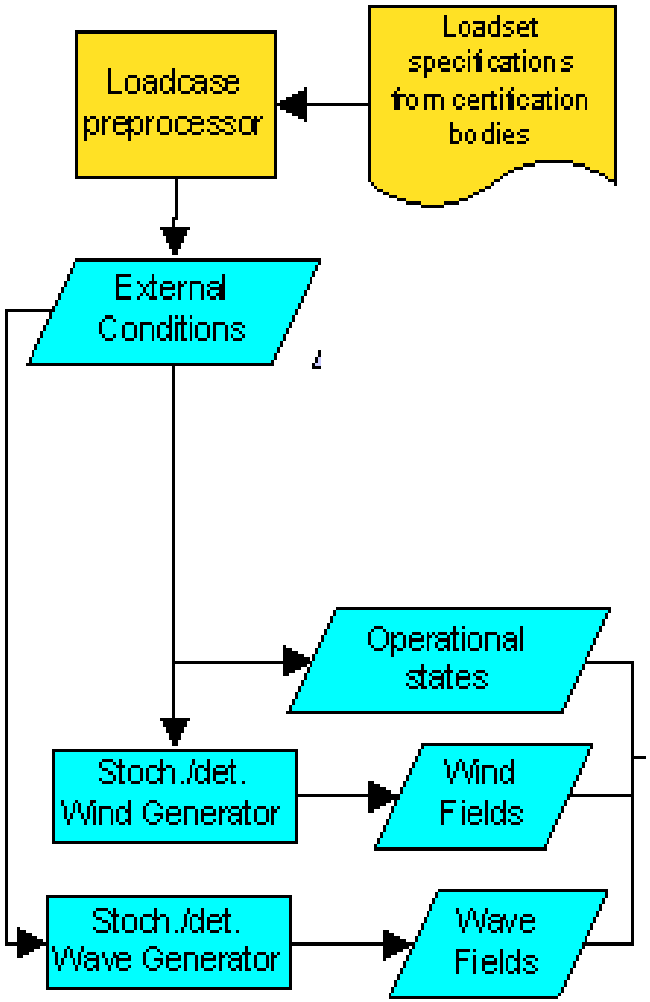
Load Set Calculations



- Automatic load case generation for IEC (2 and 3) or GL load set calculations
- Simulate fault conditions and emergency situations
- The results are accepted by certification bodies (like GL and DNV)

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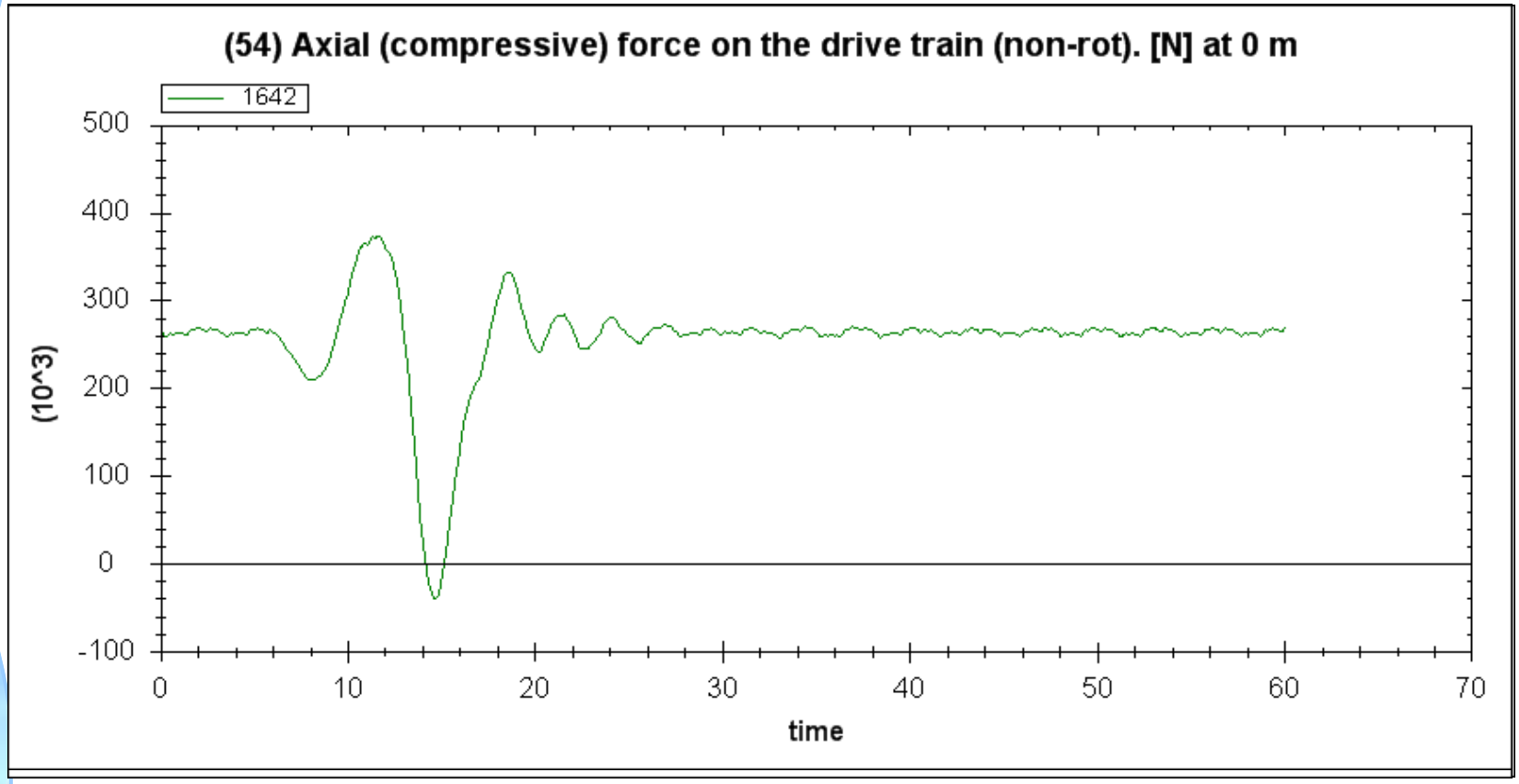
Aero-Elasticity II, Plotting

Extreme operating gust (50 years at rated wind)



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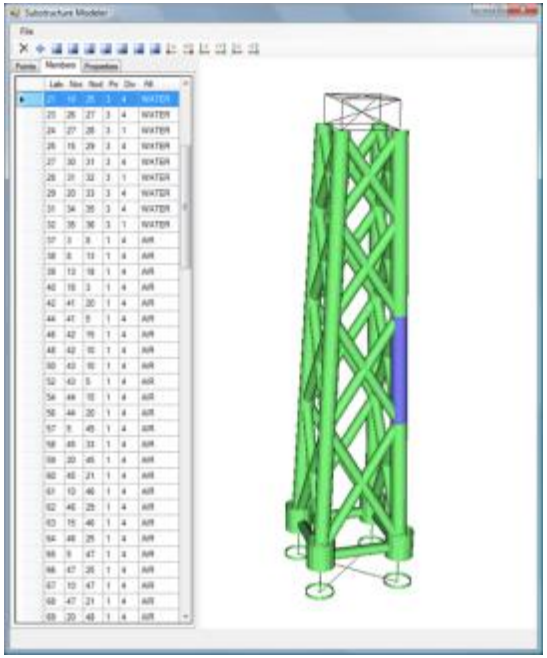
FOCUS6 Offshore



- Interactive support structure modeler
- Beam elements
- Export of Craig-Bampton matrices (“super elements”)
- Generation of waves
- Load case pre-processor according to IEC and GL standards
- Post-processing: time series of member forces

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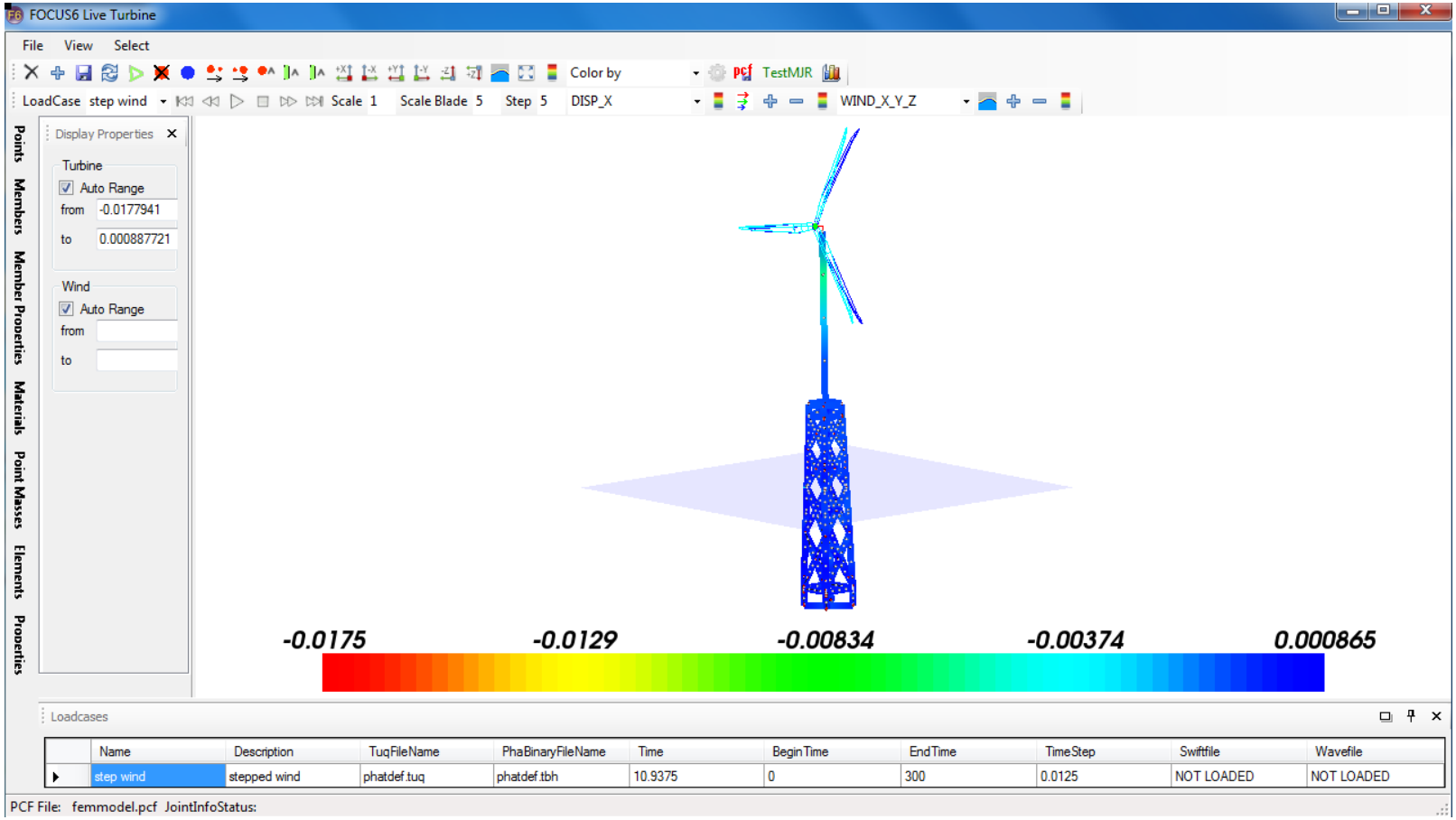
FOCUS6 Offshore



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Postprocessing Load Sets

- Extreme load reports (GL 2005 Annex 4B)
- Load roses
- Fatigue equivalent loads
- Time-at-level counting for bearings etc.
- Load spectra
- Load set summary (e.g. minimum tip clearance)
- Extra option: Extreme Extrapolation

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Structural Blade Design

- **3D interactive blade modeller**
- **Structural analyses**
  - Ultimate Strength, Fatigue and Buckling Strength
  - Modal analysis, Tip deflections
  - Composite failure analysis (IFF, Puck)
- **Visualization of analyses results**
- **External links:**
  - Flex5 and Bladed load set import
  - Export cross-section properties to Bladed
  - FEM export to MSC.Marc, MSC.Nastran, Ansys, Abaqus
  - Blade model export to MSC AdWiMo
  - CAD export in IGES/STEP format

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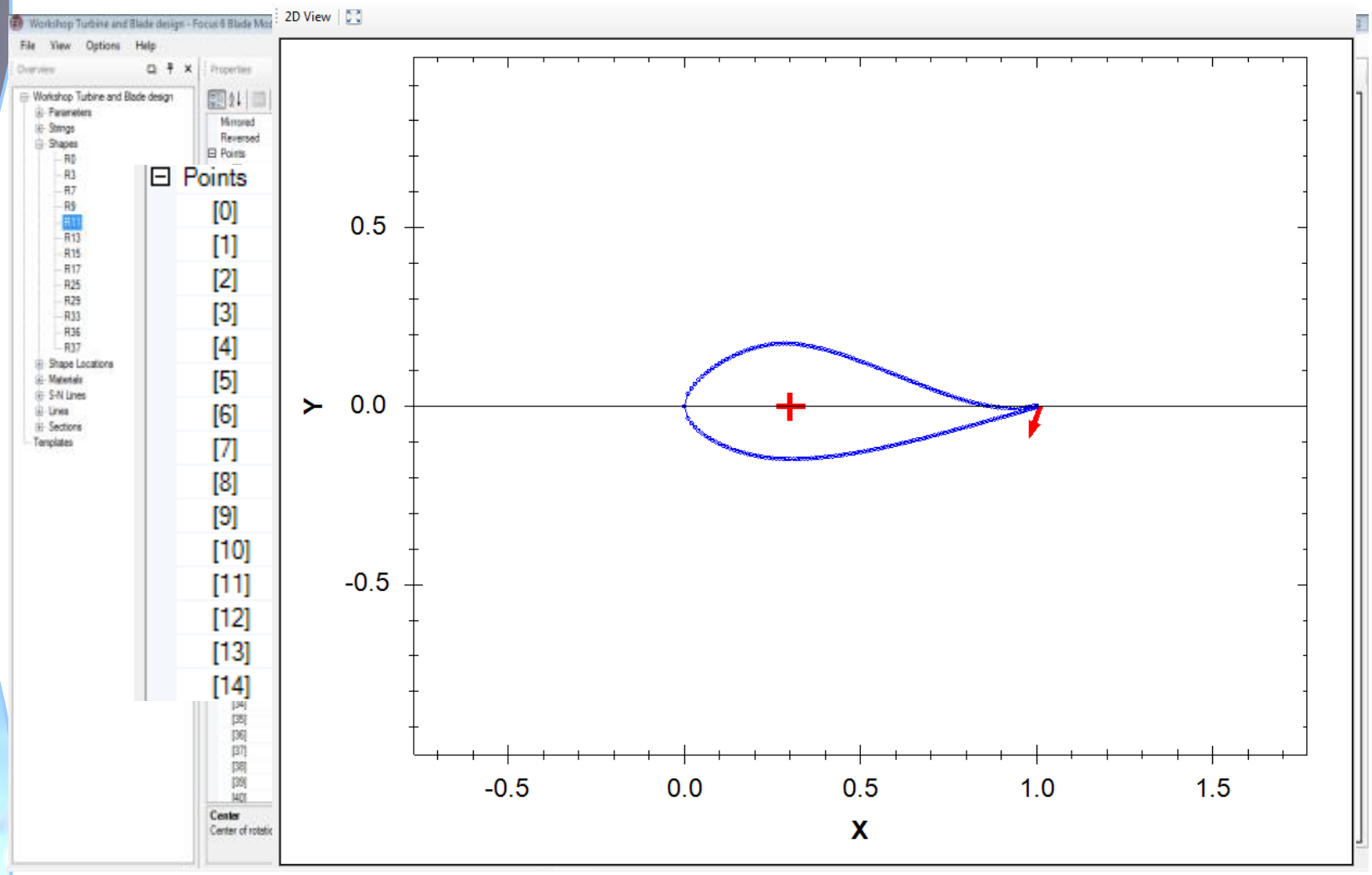
Define Shapes



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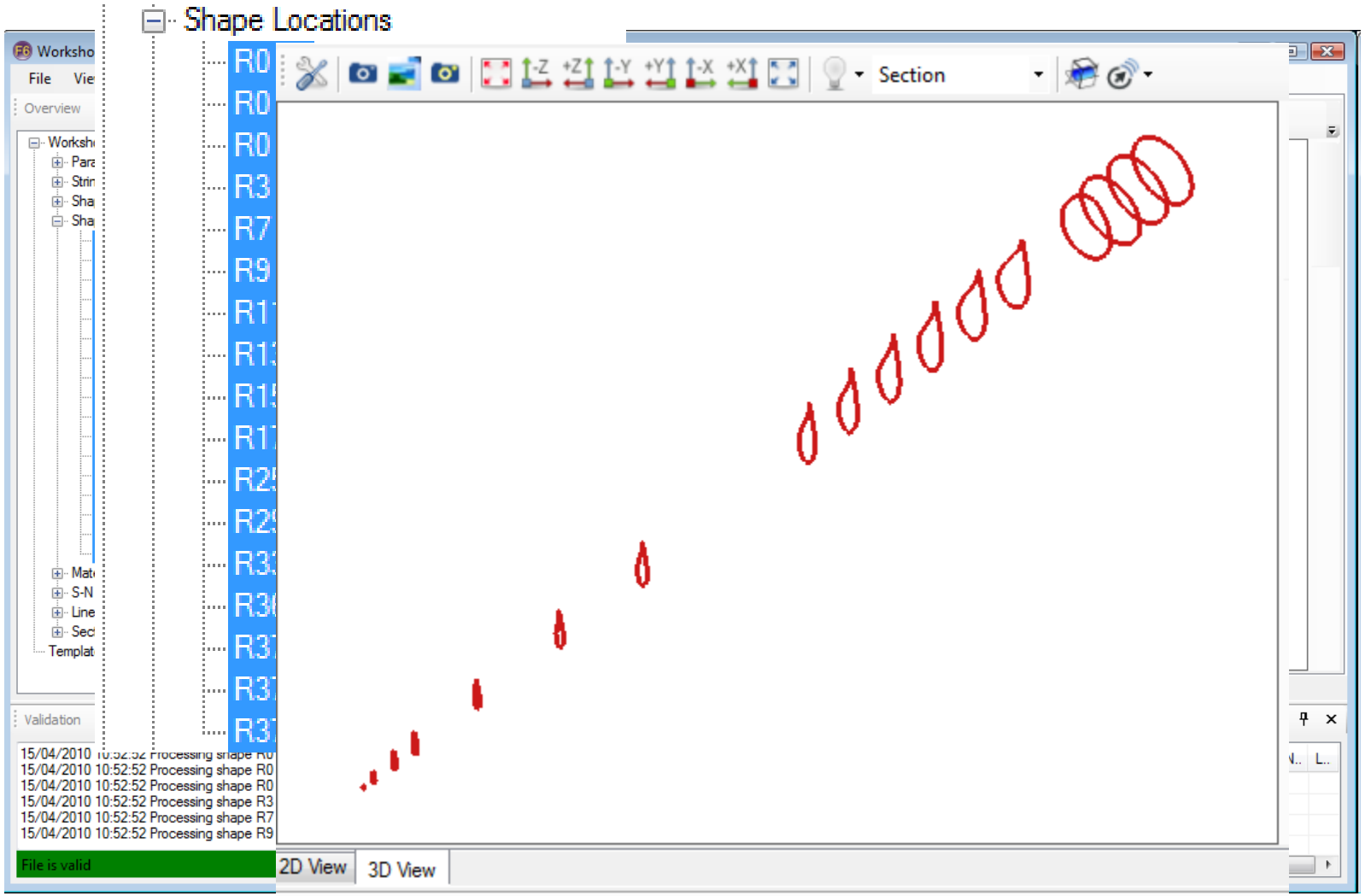
Define Blade: Place Shapes



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Define Material Properties

- Isotropic
- Orthotropic
- Core

- Extra parameters for fatigue formulation

Name	TRIAX
Description	
Material properties	
Type	orthotropic
Density	1.83e-6
E_11	24000
E_22	11000
E_33	
G_12	7200
G_23	
G_31	
nu_12	0.41
nu_23	
nu_31	
FiberAngle	0
E-Modulus (obsolete)	
G-Modulus (obsolete)	
Poisson ratio (obsolete)	
Fatigue analysis	
Constants	...
K	
S-N line name	GL2003
Appearance	
Color	0, 255, 255
Failure data	
Fail_type	none
EPS_T	0.018333
EPS_C	0.014667
TAU	
UTS1_Rk	
UCS1_Rk	

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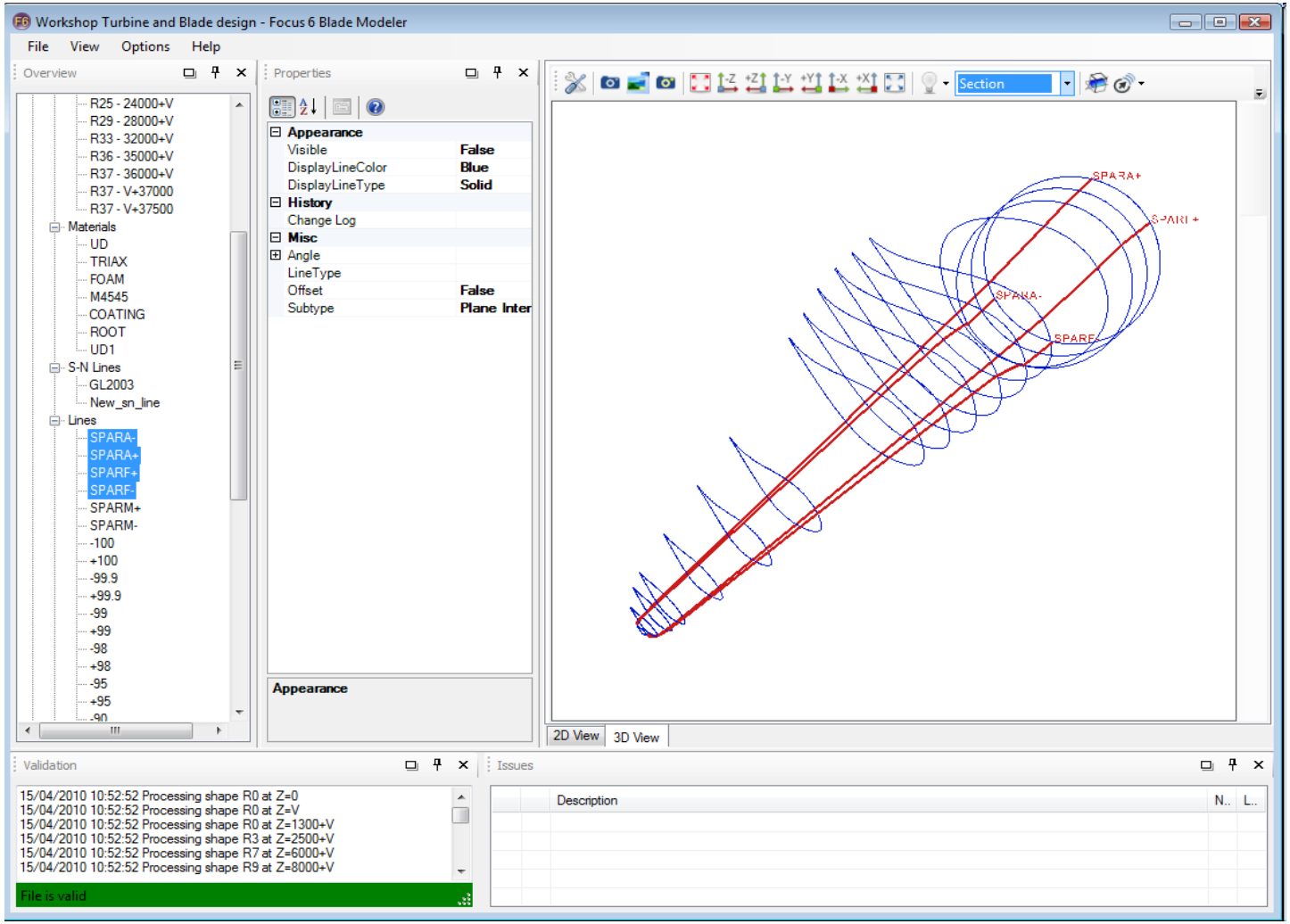
Define Line Elements



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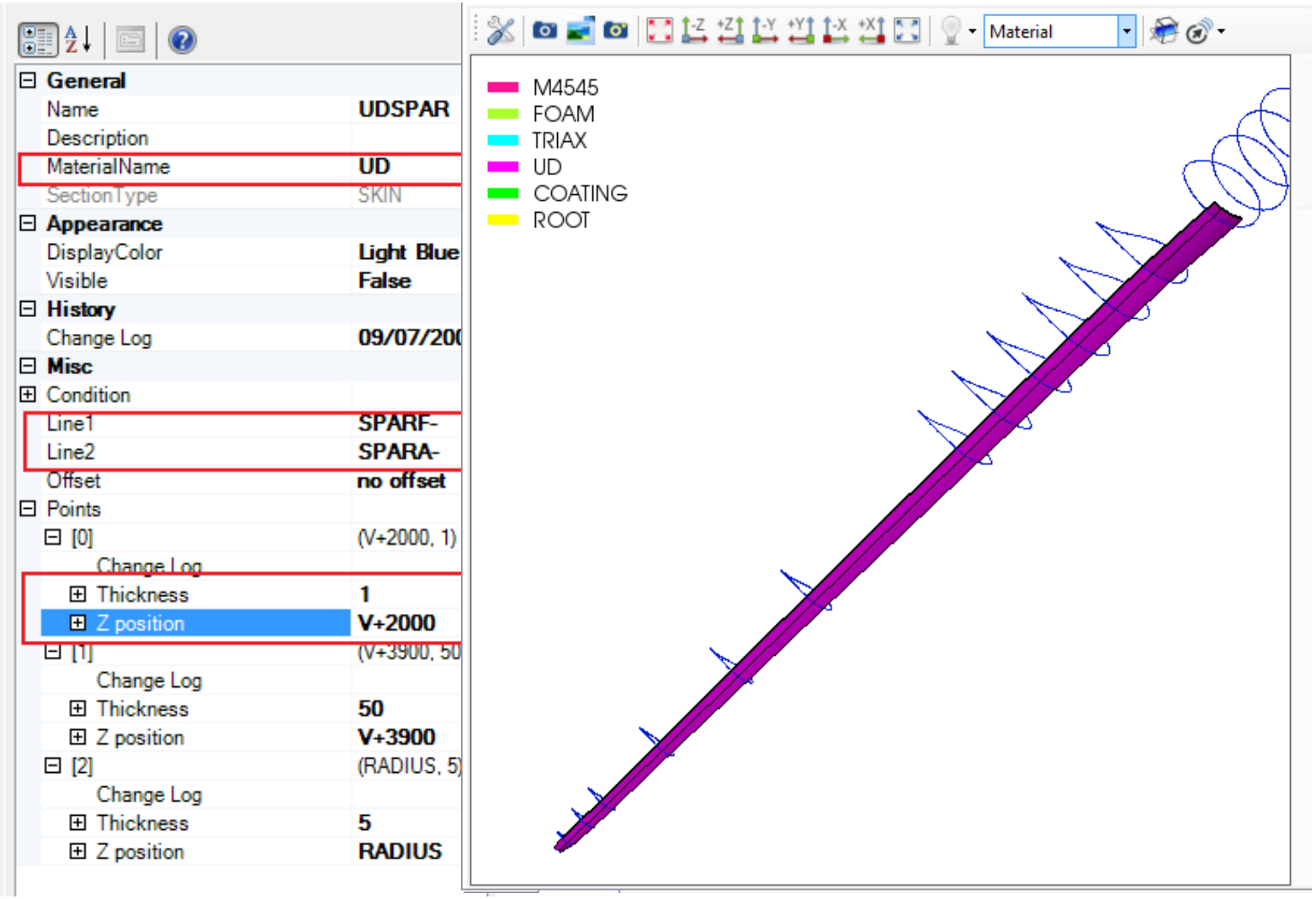
Define Sections



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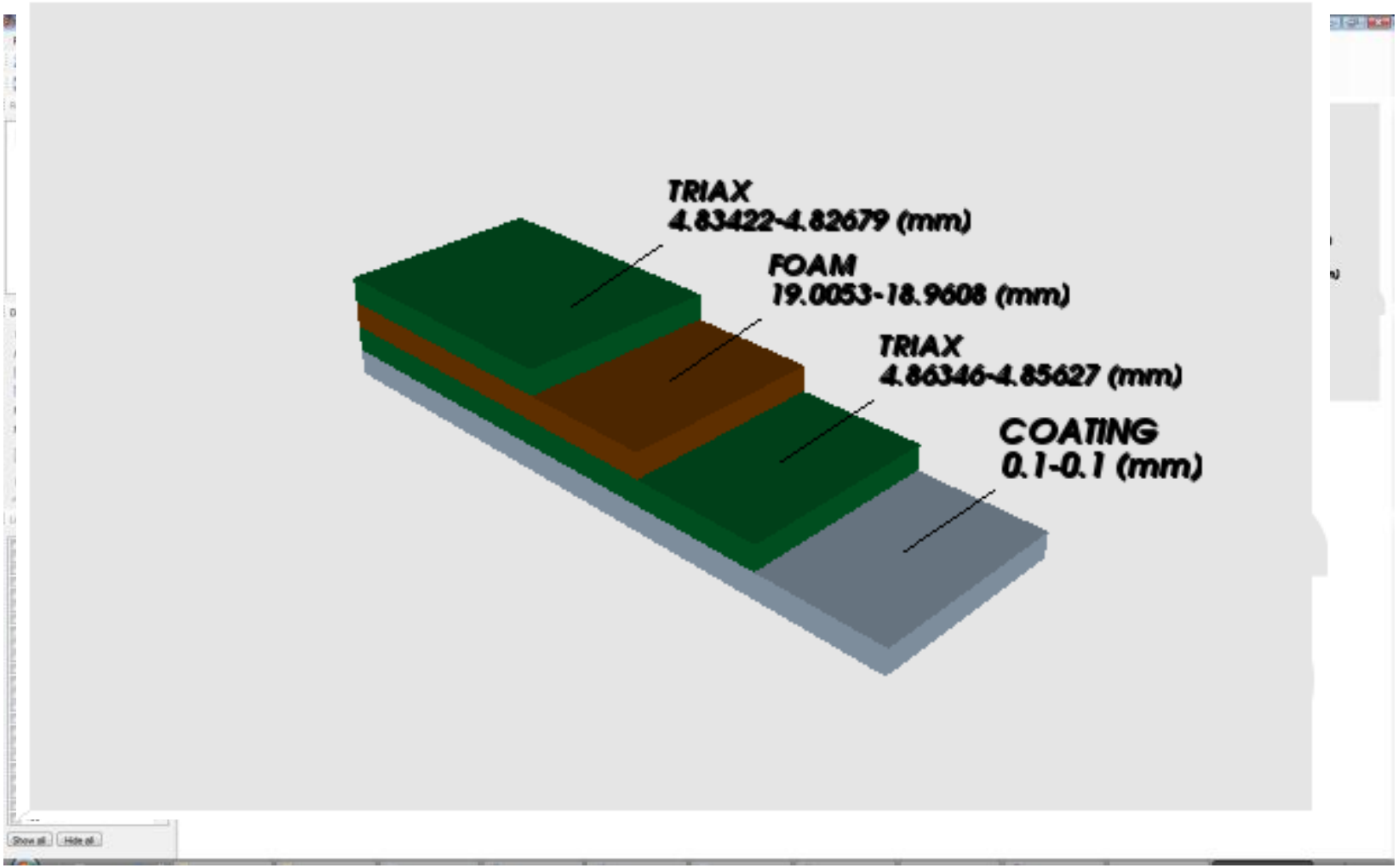
Verify Blade Model



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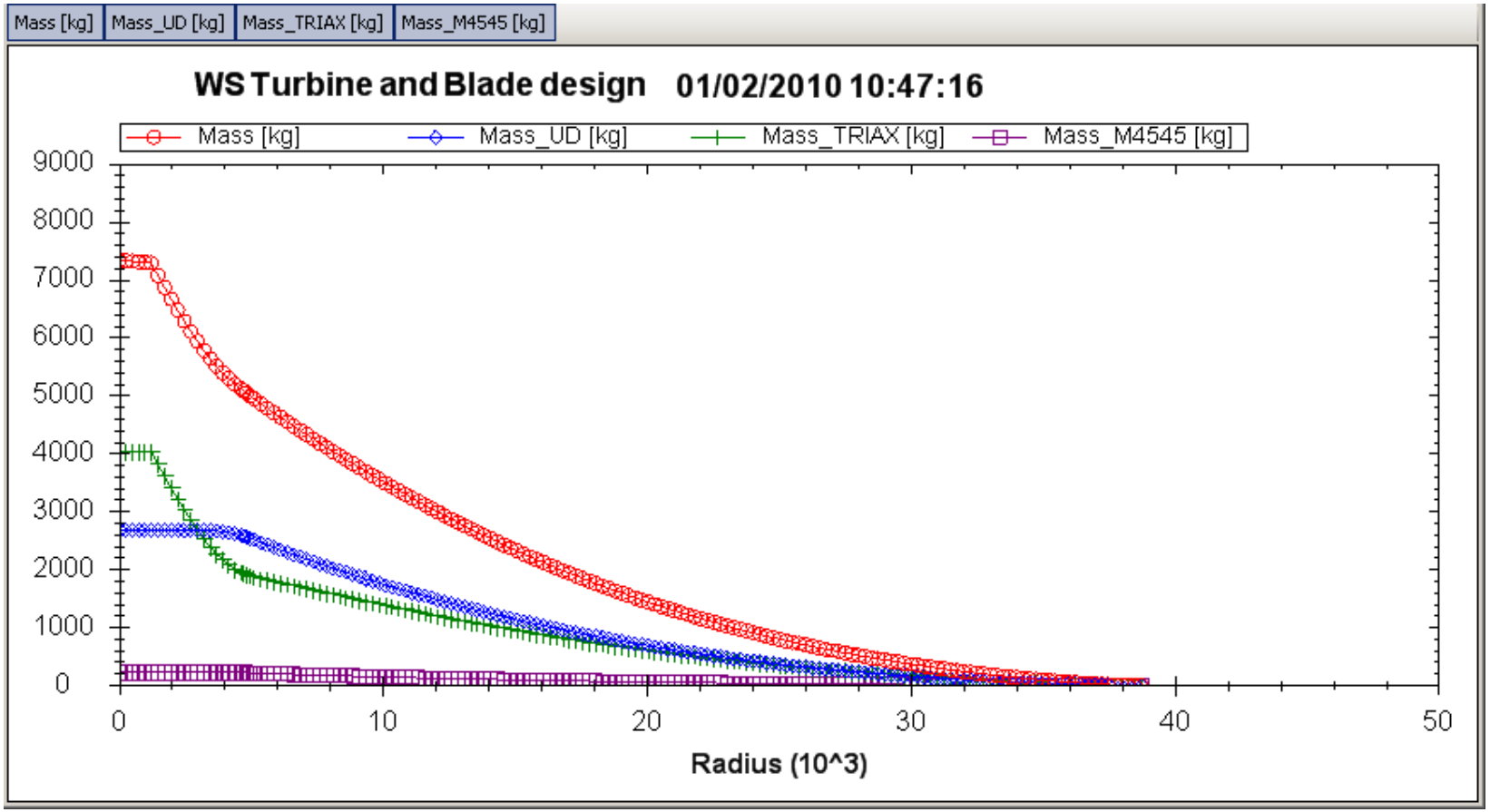
Verify Blade Model



Blade mass distribution per material

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Blade structural analyses features

Structural analyses based in load time series:

- Stress or strain based static analyses
- Stress or strain based fatigue analyses
- Panel and cross section based buckling analyses
- Tip deflections

Modal analysis

- Coupled and uncoupled eigen modes
- Visualization of mode shapes

FEM (composite thick shell) analyses:

- Ultimate strength analyses
- Composite failure (IFF/Puck)

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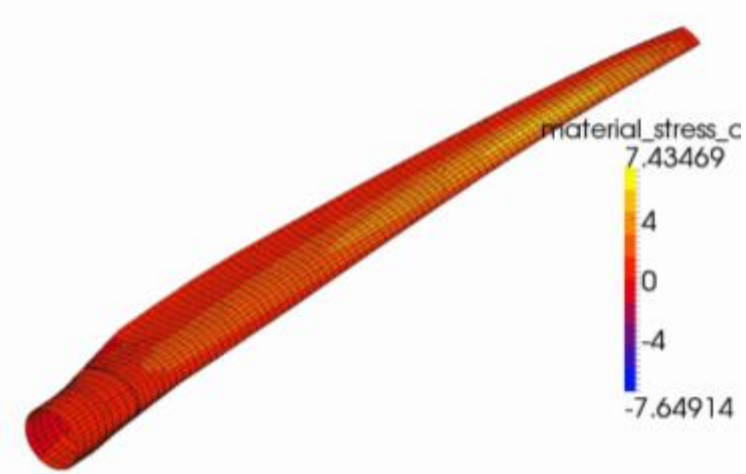
FEM for structural blade design



- Thick shell elements
- Full layup (individual plies)
- Static analyses
- Includes Puck criterion
- RBE3 elements for load introduction

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3D visualization of analysis results

- **Strain based analysis results**
  - Overall minimum / maximum normal and shear strains for a full load set
  - Ultimate strength reserve factors per material
    - Compression
    - Tension
    - Shear
- **Fatigue analysis results (fatigue reserve factors)**

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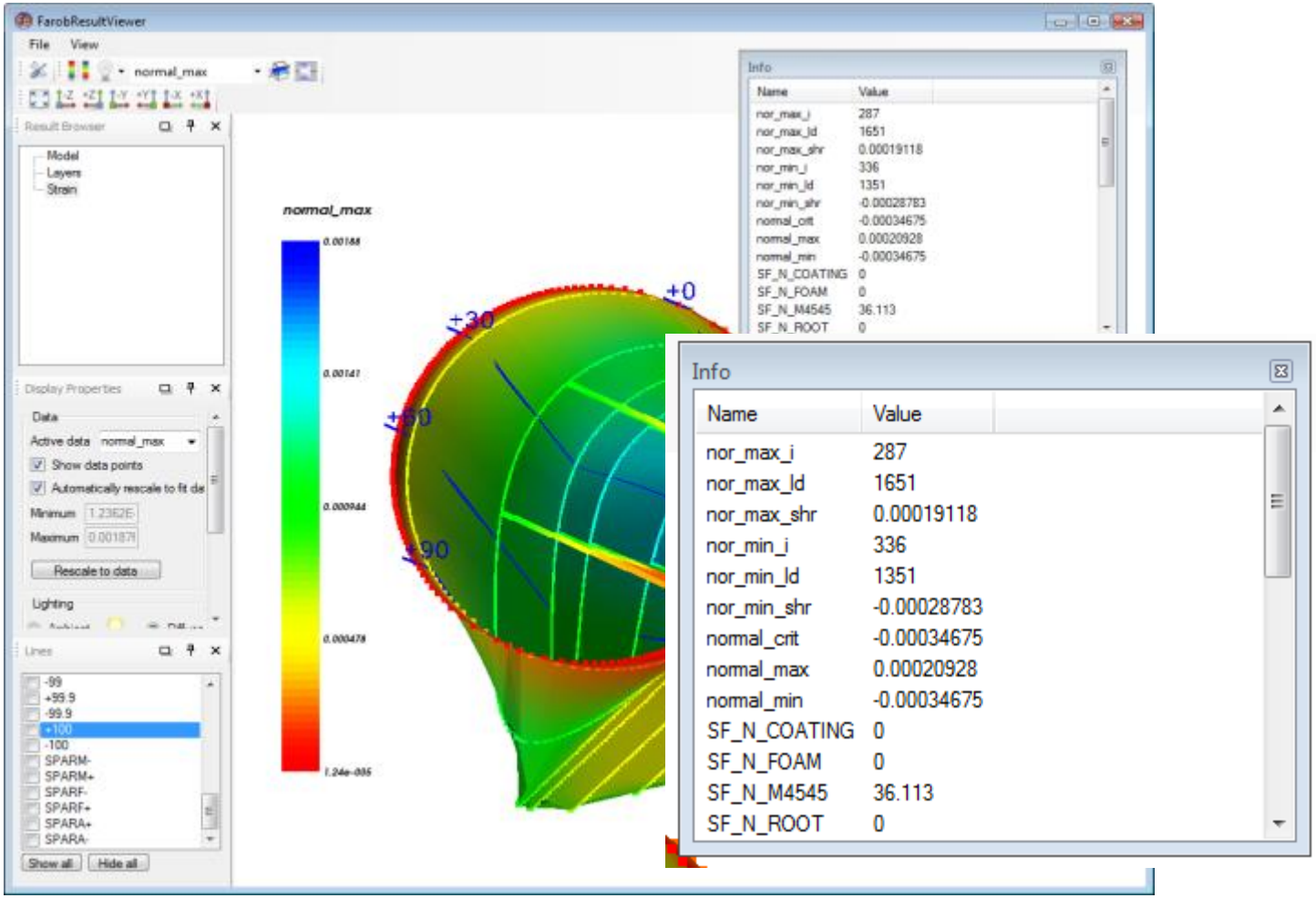
3D interactive view



Maximum normal strain plot

Similar plot to show fatigue reserve factors

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Blade Design Output

- **Export cross-section properties at selected radial positions for BEM based turbine simulation programs**
- **The usage per material can be exported, e.g. for cost calculations**
- **Export *composite thick shell element mesh* to:**
  - FOCUS for Blade Design
  - ANSYS
  - MSC Marc
  - MSC Nastran
  - Abaqus (2014)
- **Ultimate/Fatigue reserve factors**
- **Deflections**
- **Eigen modes / frequencies**

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Parametric Models

- A set of global parameters defines the turbine model
- For "What-If" studies sets of parameters can be defined to override the global parameters without changing the actual model
- Built-in optimization features

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Tidal

- **Tidal stream turbine simulator**
- **Generator combines**
  - Wave models
    - Frequency spectrum
      - Jonswap
      - Pierson-Moskowitz
    - Non-linear regular waves
  - Current
    - Shear: log, power law, user-defined
    - Wind-induced
  - Turbulence

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Demo / training

- FOCUS6 SaaS (Software as a Service) available to test the software
- Detailed workshop manuals
- FOCUS6 training course included in license fee

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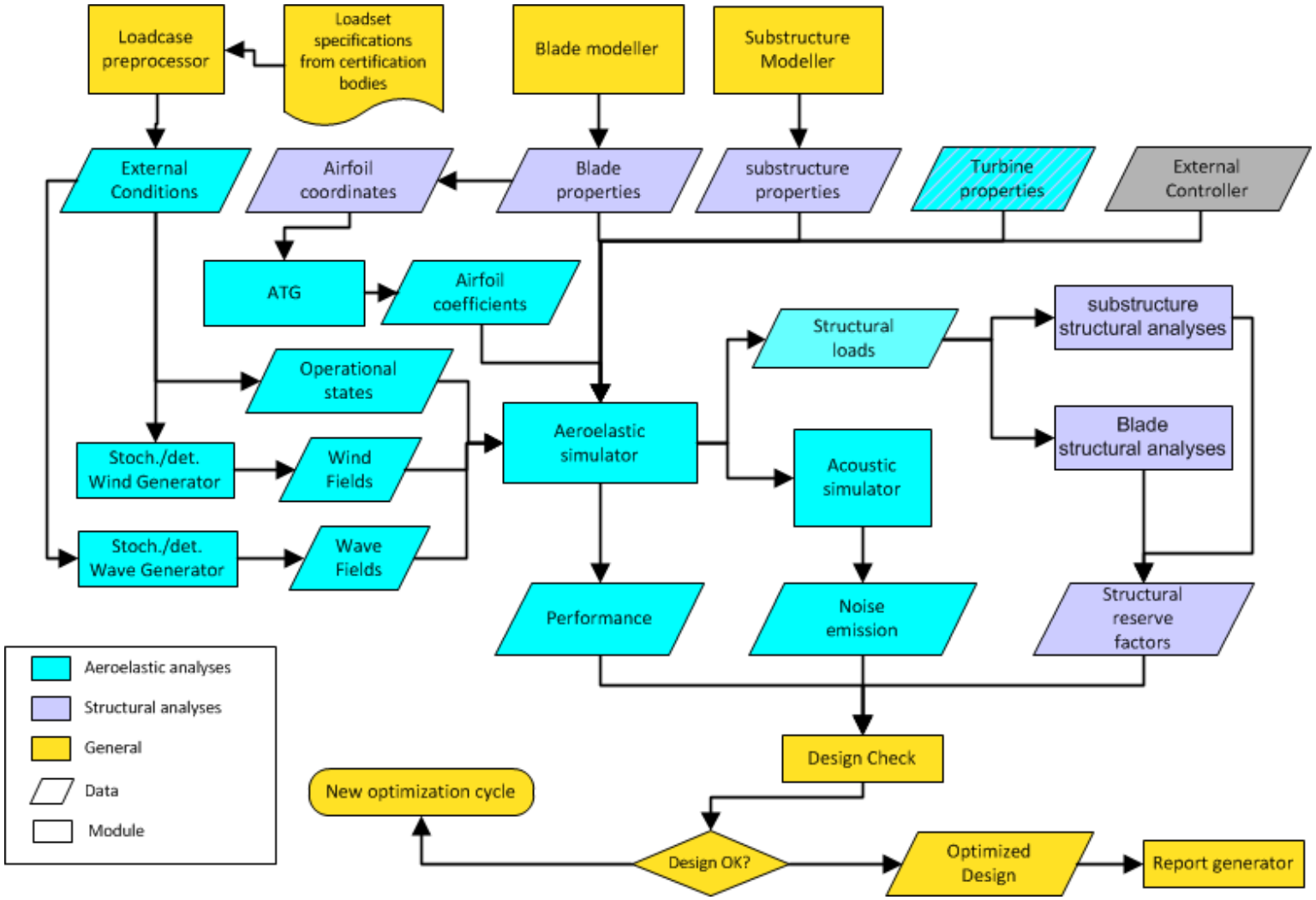
FOCUS 6



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