OneWind

Concepts and Products

Urs Wihlfahrt

2015 Wind Energy Systems Engineering Workshop

Fraunhofer IWES

Agenda

Fraunhofer IWES

OneWind Concept

OneWind Modelica Library

OneWind Software Products

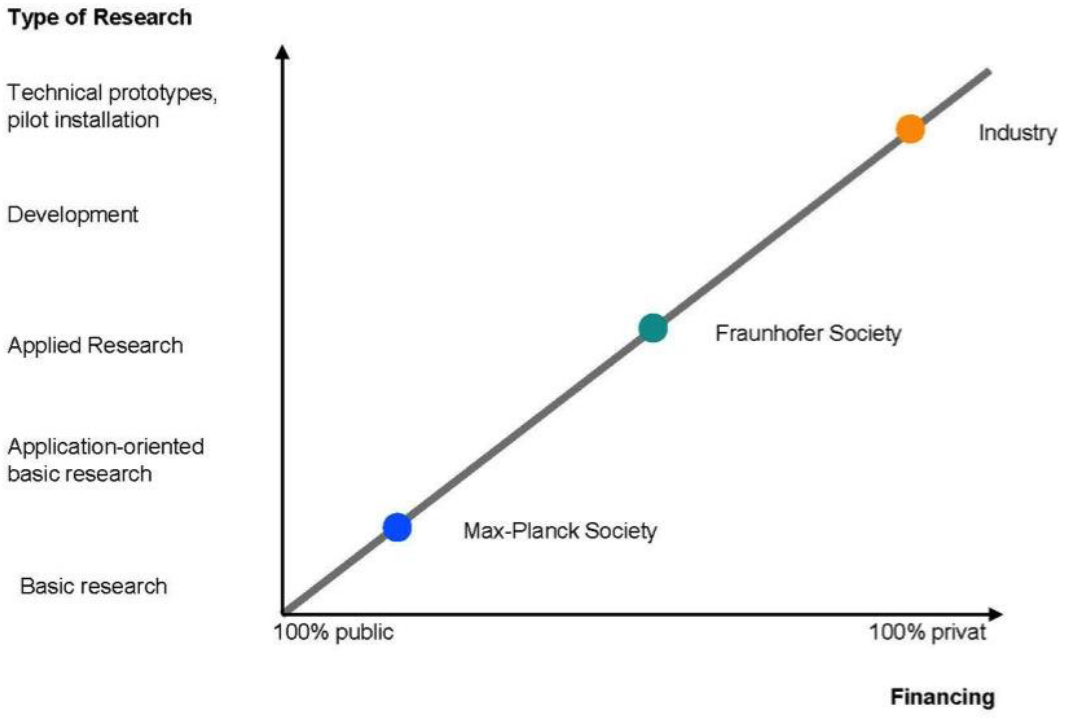
Extensions

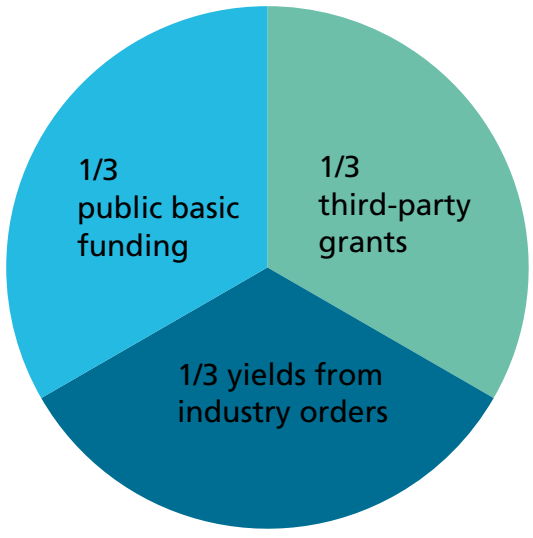
Conclusion

Agenda

Fraunhofer-Gesellschaft: Industry focus as success factor

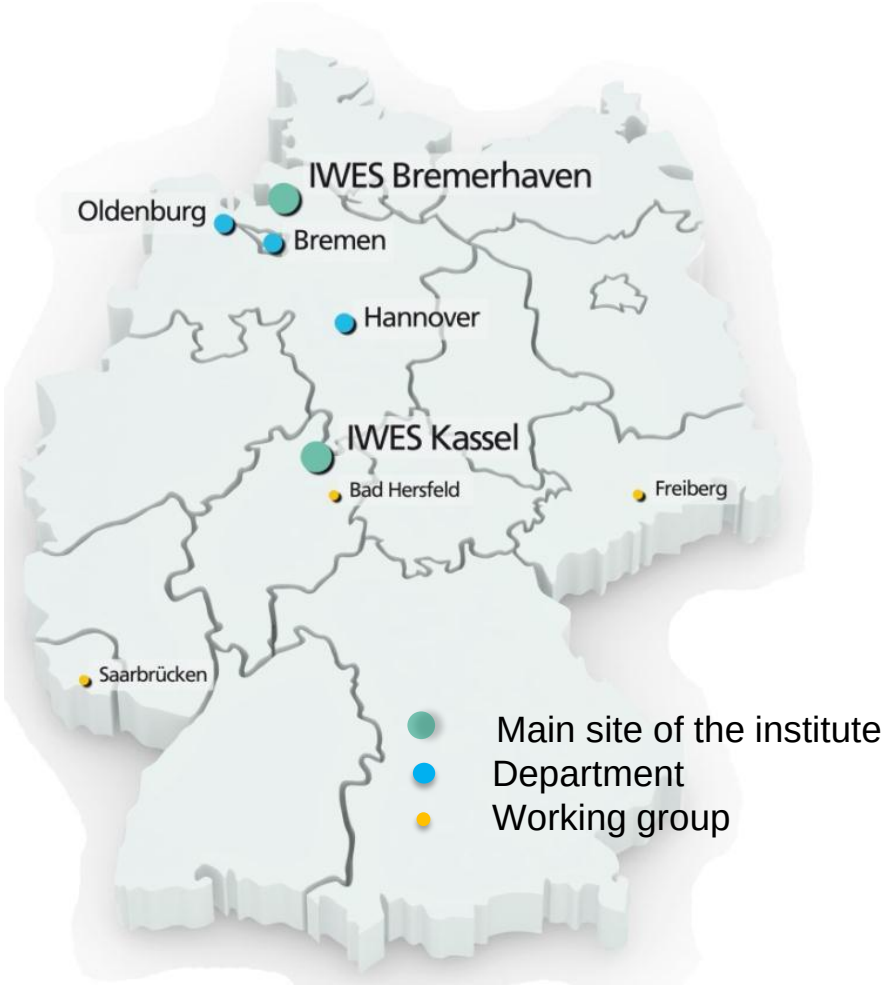
- Largest organization for applied research in Europe
- More than 80 research institutions, including 67 Fraunhofer institutes in Germany
- More than 24,000 employees, mainly with natural or engineering science education
- € 2.0 billion annual research budget totaling





Fraunhofer IWES

Fraunhofer Institute for Wind Energy and Energy System Technology (IWES North-West)



- **Managing Director:**:
  Prof. Dr.-Ing. Andreas Reuter
- **Research Spectrum:**
  Wind energy from wind physics up to energy network feeding
- **Budget 2014:**
  around €14 million
- **Staff:**
  150 employees
- **Previous investments in the establishment of the institute:**
  €50 million
- Strategic Association with ForWind and the German Aerospace Center (DLR)

Research Alliance
Wind Energy

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Accelerated time-to-market by realistic testing

Rotor Blade Test Hall up to 90 meter

- Testing of design prior to series production
- Simulation of 20 year life-spans in a few months
- max. static bending moment 115,000 kNm; max. dynamic bending moment: +/- 30,000 kNm

DyNaLab with 10 MW Drive Performance / Peak 15 MW

- Norminal torque: > 8,6 MNm
- Rotor load application unit for dynamic bending moments, thurst and radial forces
- Artificial network: 44 MVA installed inverter power

Support Structure Test Center

- Testing support structure fatigue behaviour
- Solving production problems through design changes
- Scale of 1:10 - 1:3,5

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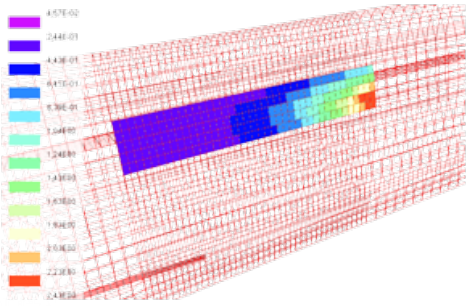
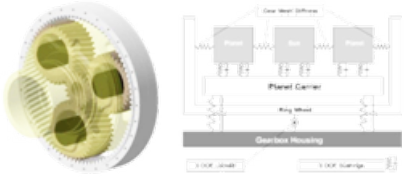
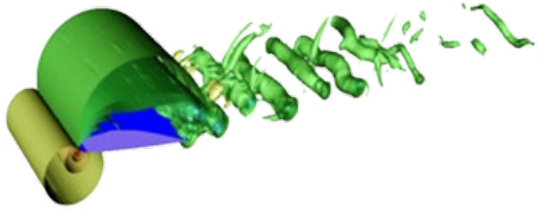
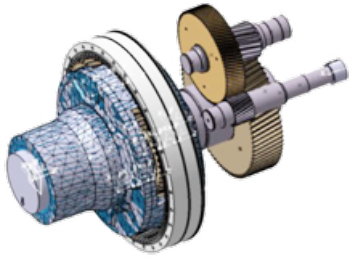
Agenda

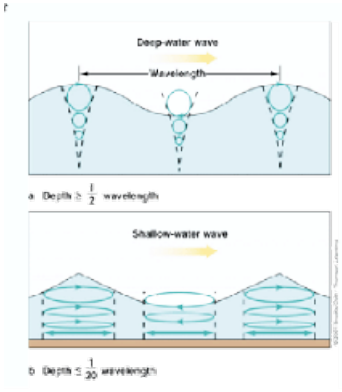
Multiple domains

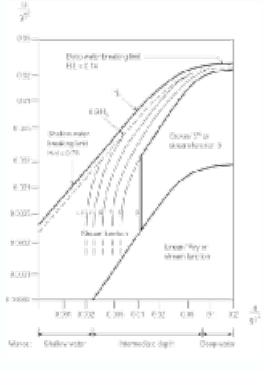


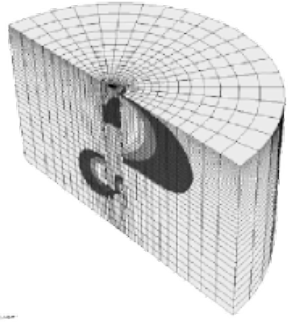


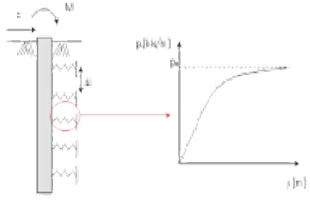












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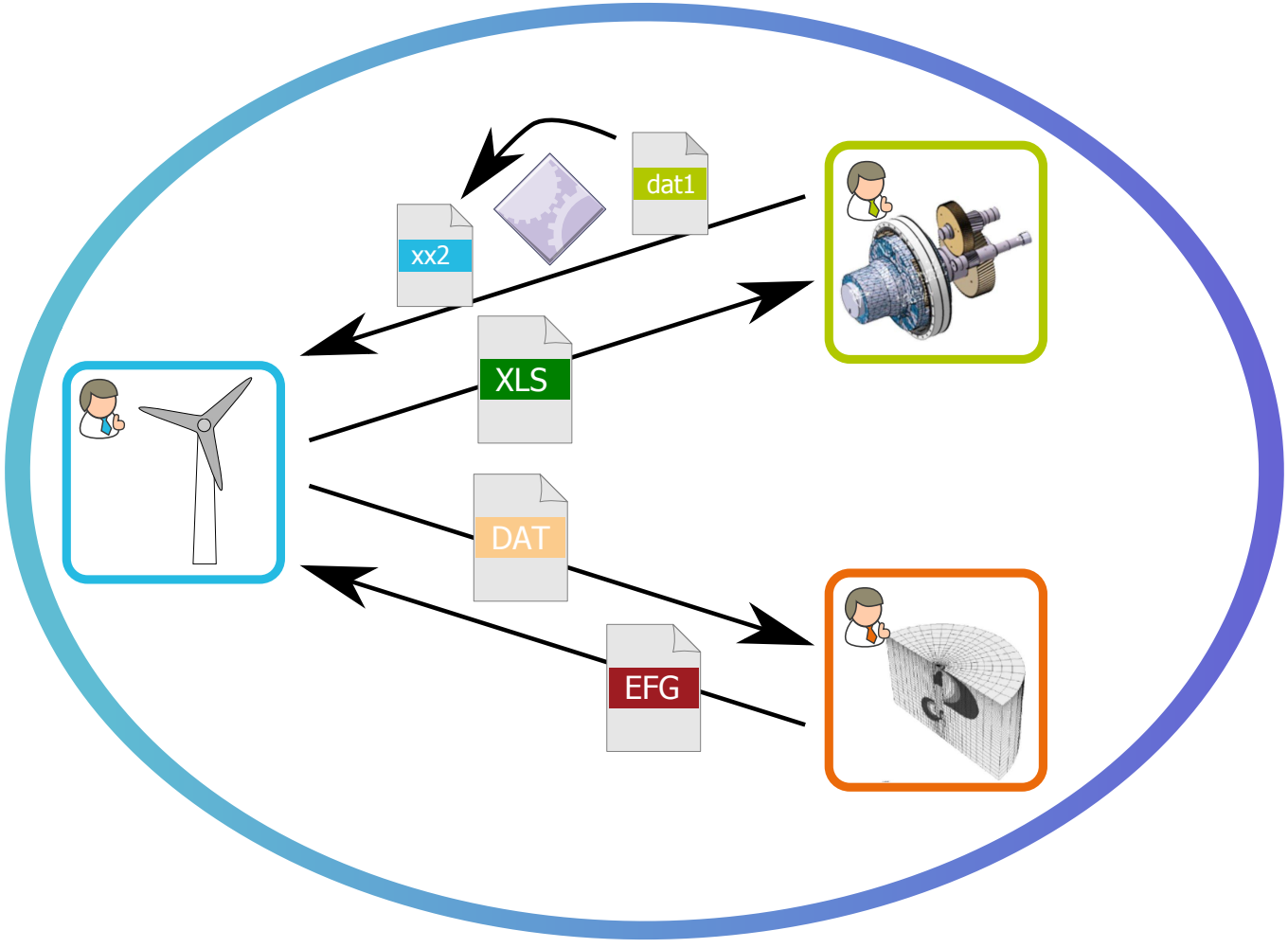
Cooperation in the design process



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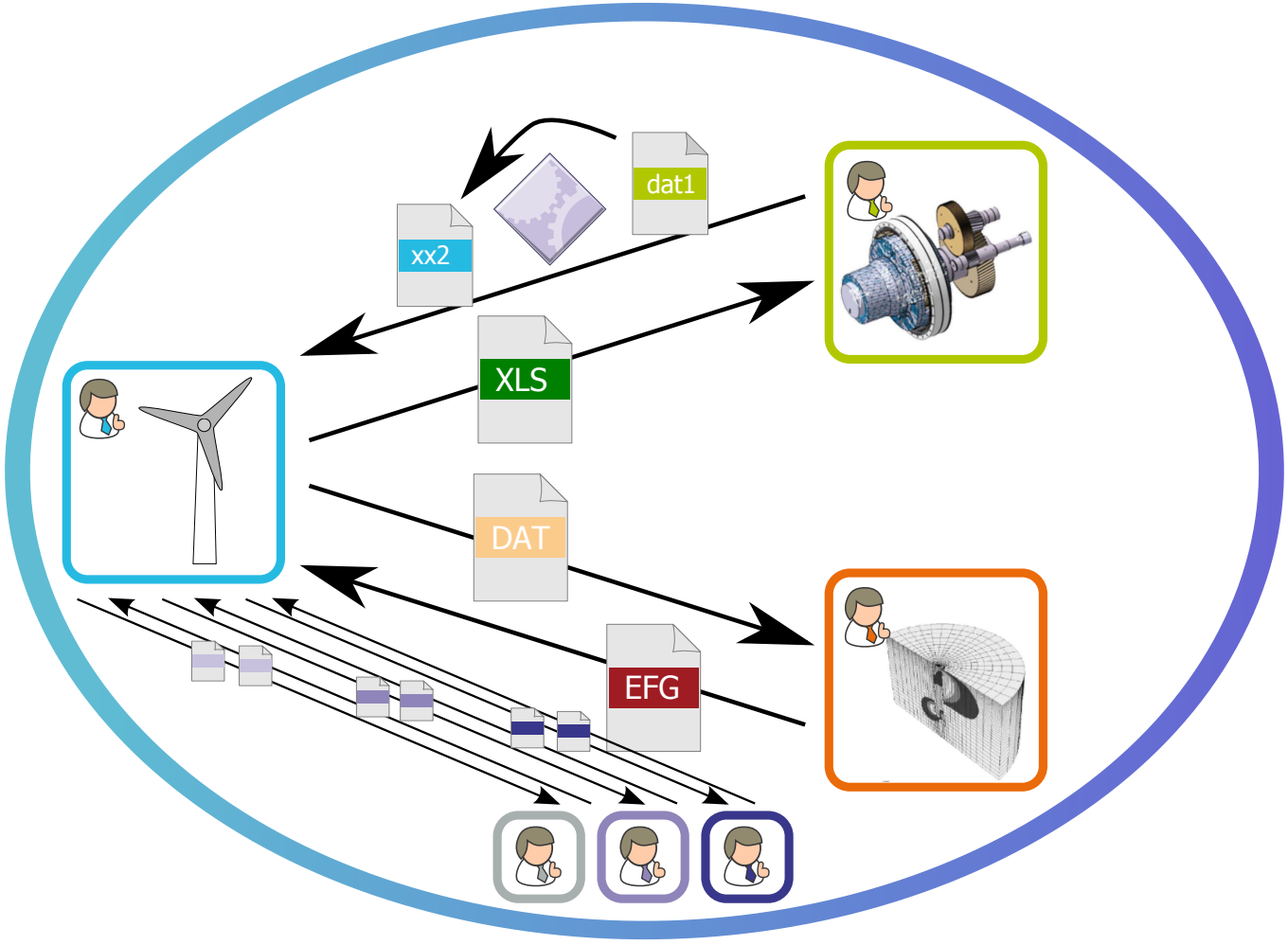

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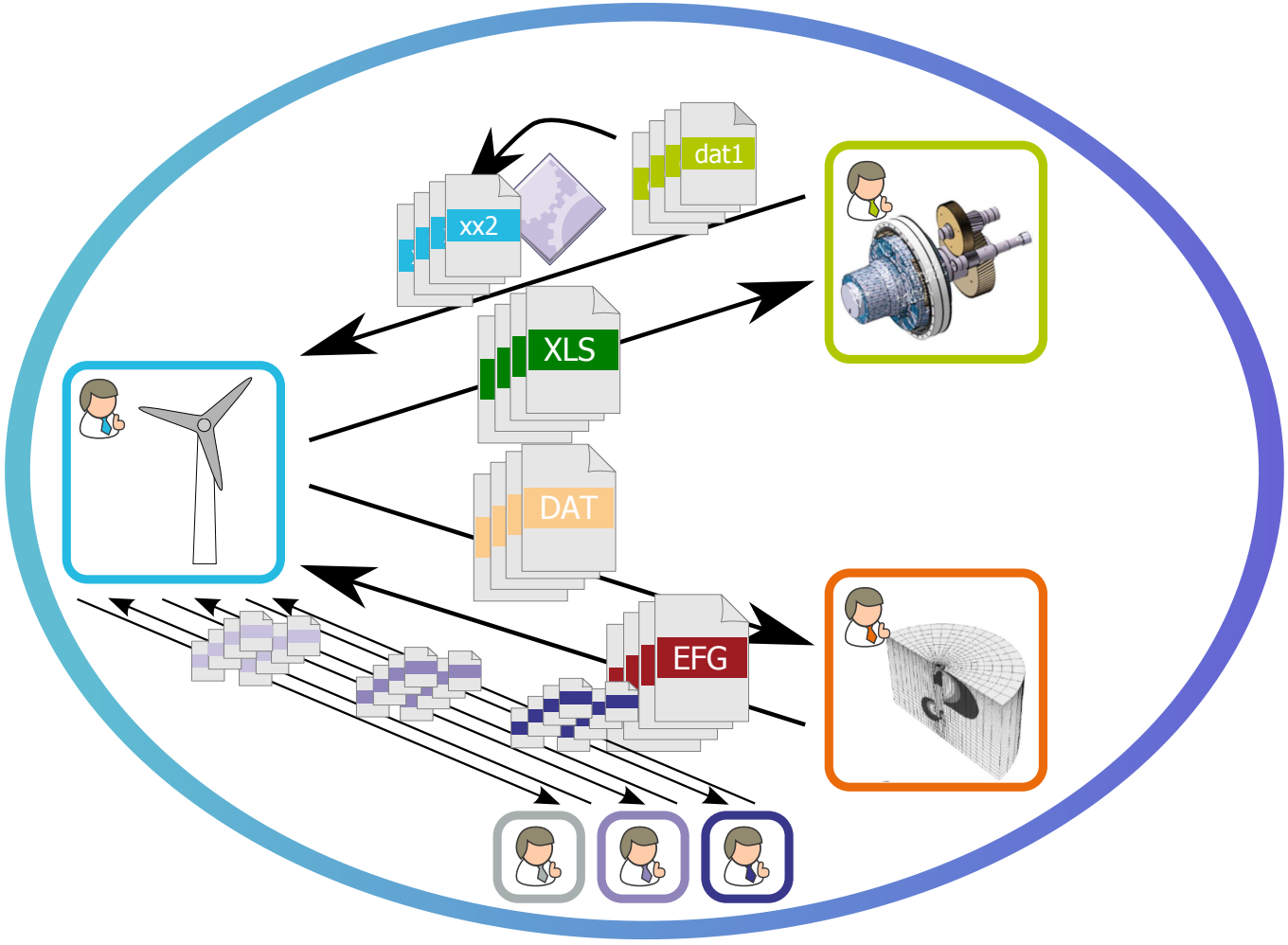

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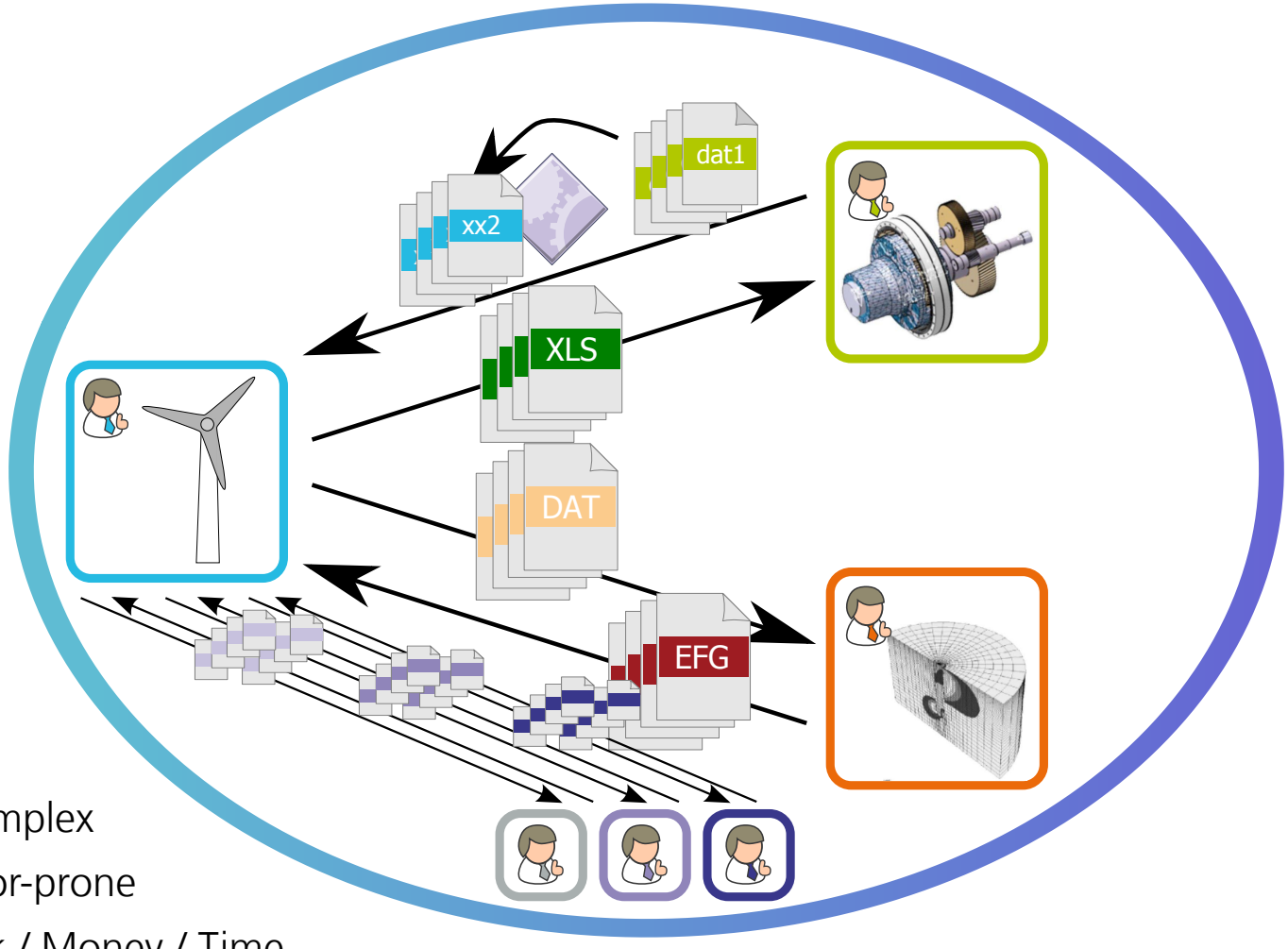
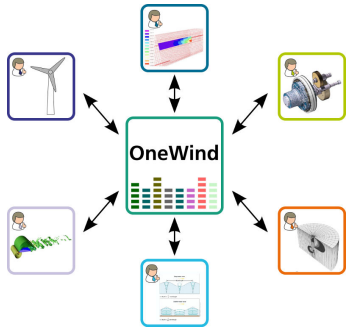


- Complex
- Error-prone
- Risk / Money / Time

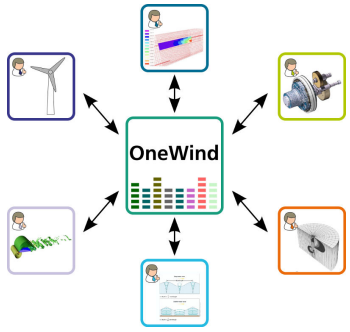
Consistent modeling



All components of a wind turbine

- in **one** numerical model
- with **different** levels of detail
- and automatic **transformation** of models

Consistent modeling



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- in **one** numerical model
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- and automatic **transformation** of models

Project OneWind

duration:	2009 – 2014
budget:	5.7 Mio. €
personnel:	≤ 10 employees

Supported by:

Federal Ministry
for Economic Affairs
and Energy

on the basis of a decision
by the German Bundestag

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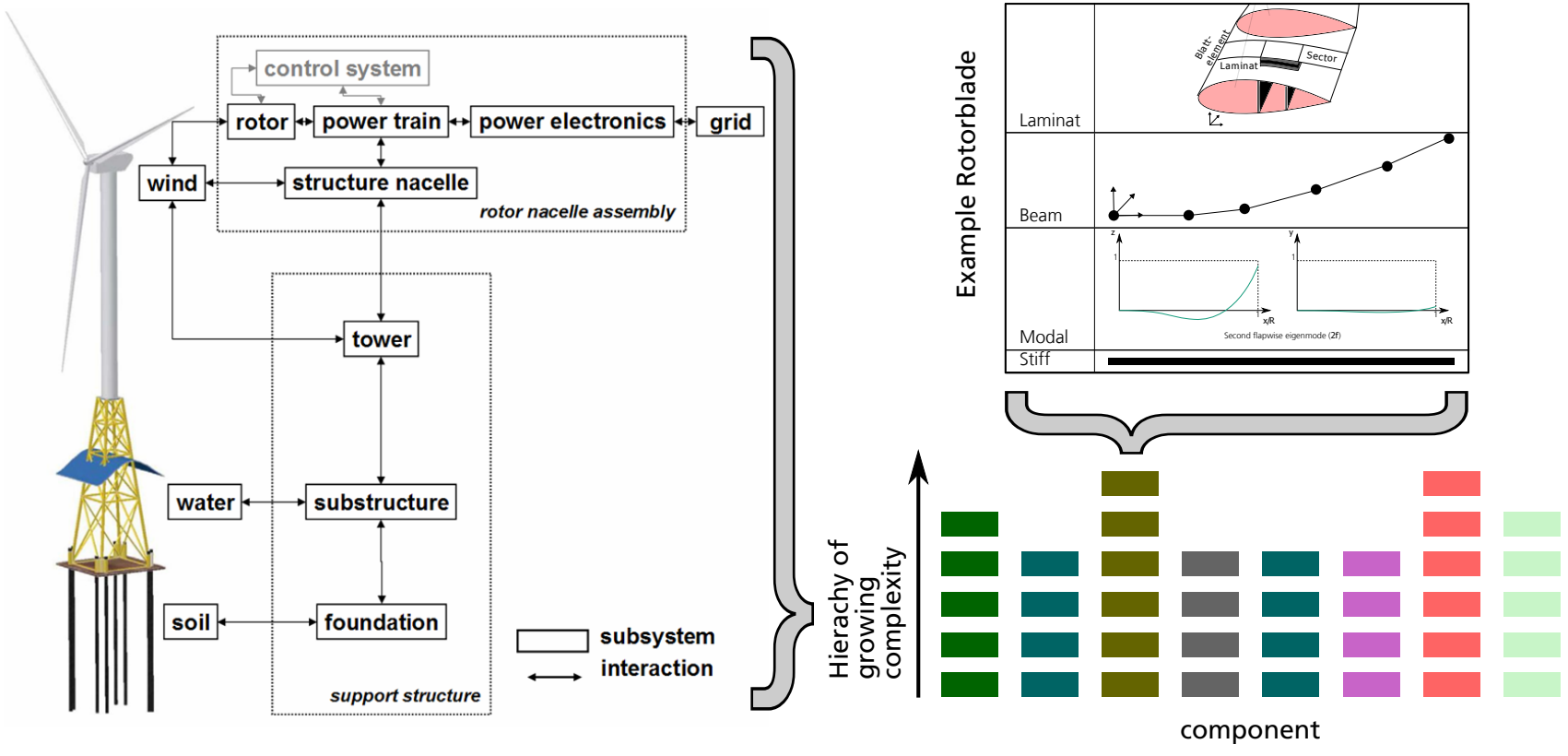
Concept

- **Purely parametric** component models (Engineer Design Data)



Fraunhofer IWES

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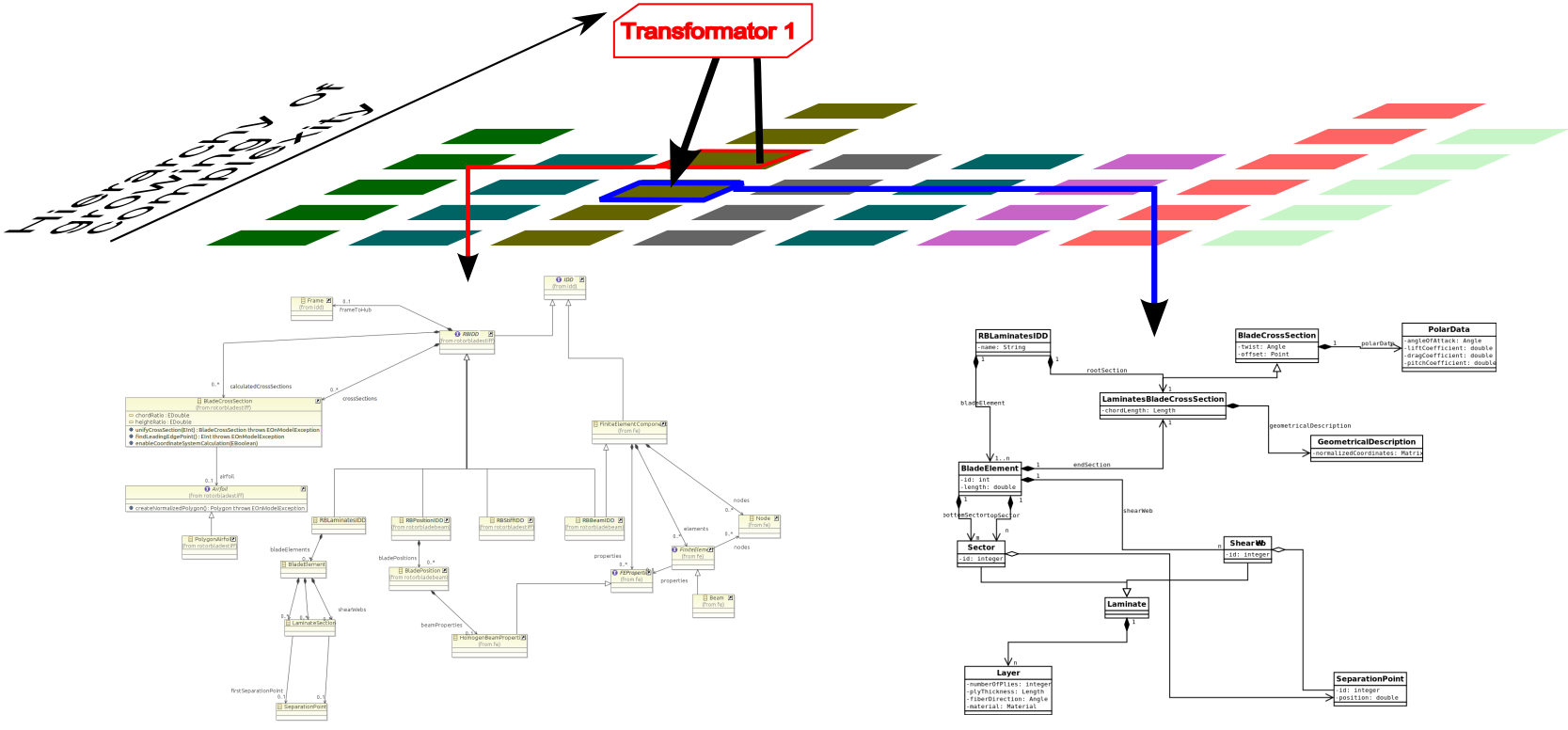

Fraunhofer IWES

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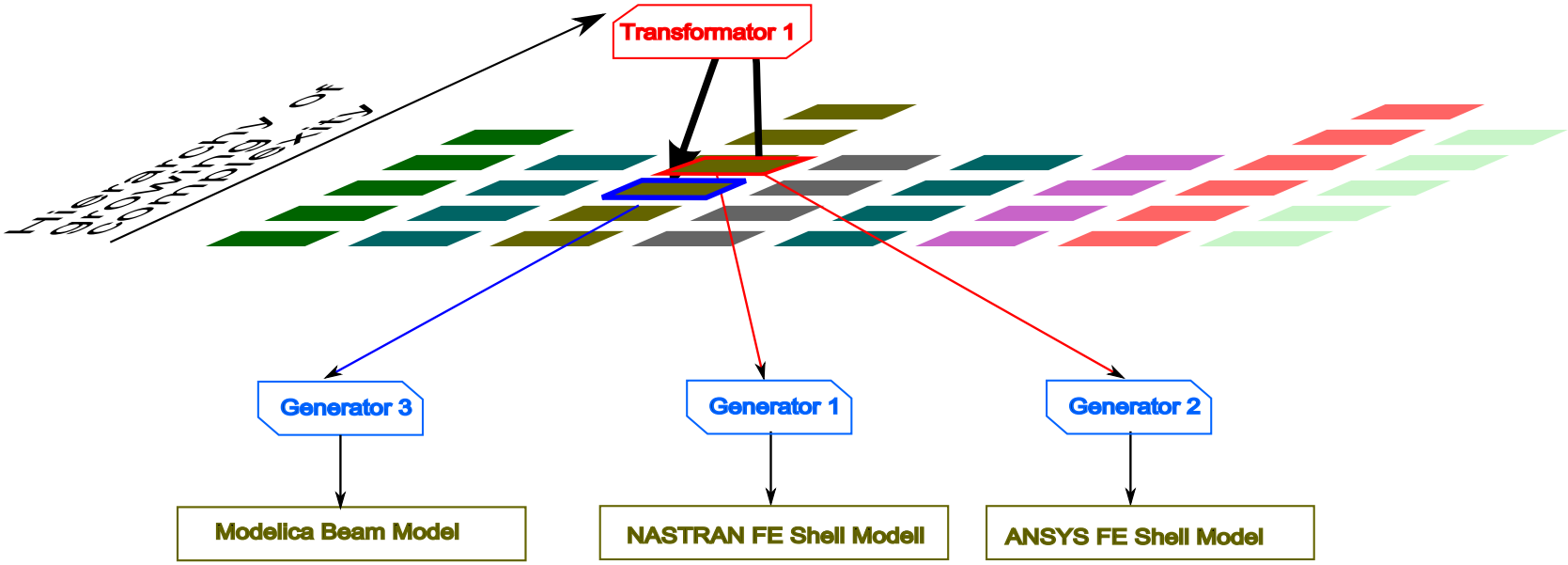
- **Generation** of models for calculation



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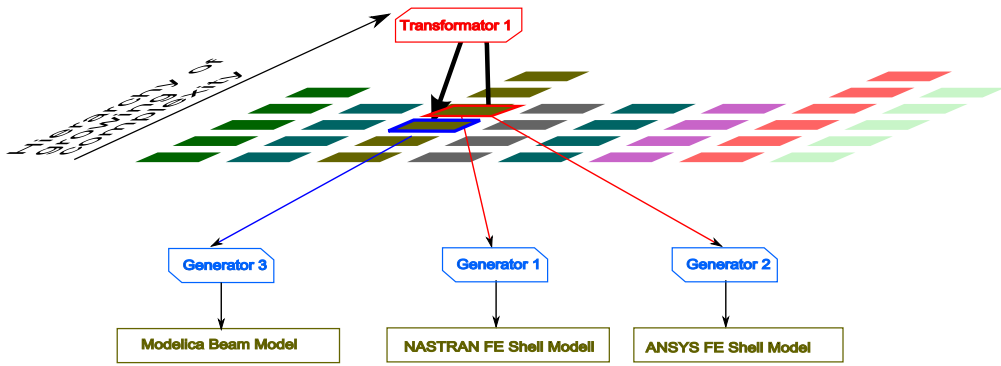

Advantages:

- Consistency of the models with different levels of detail
- Decoupling of model and tool knowledge

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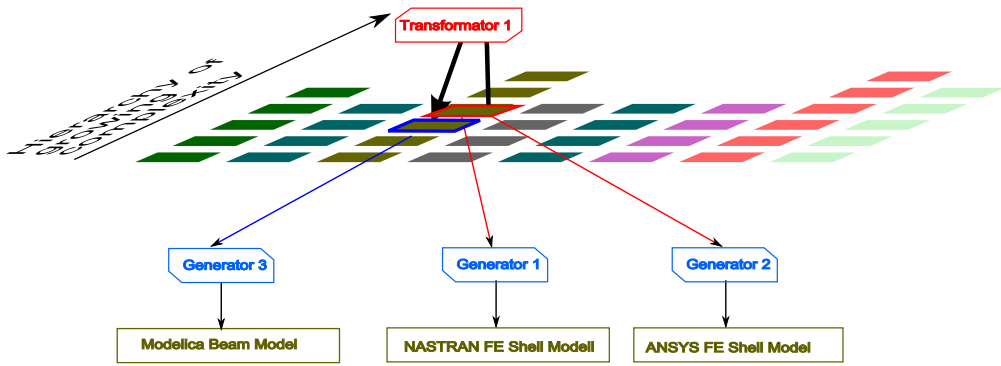

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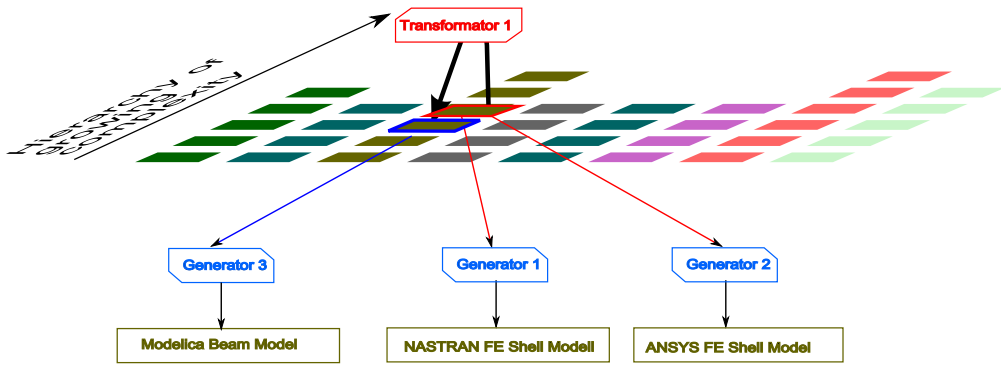

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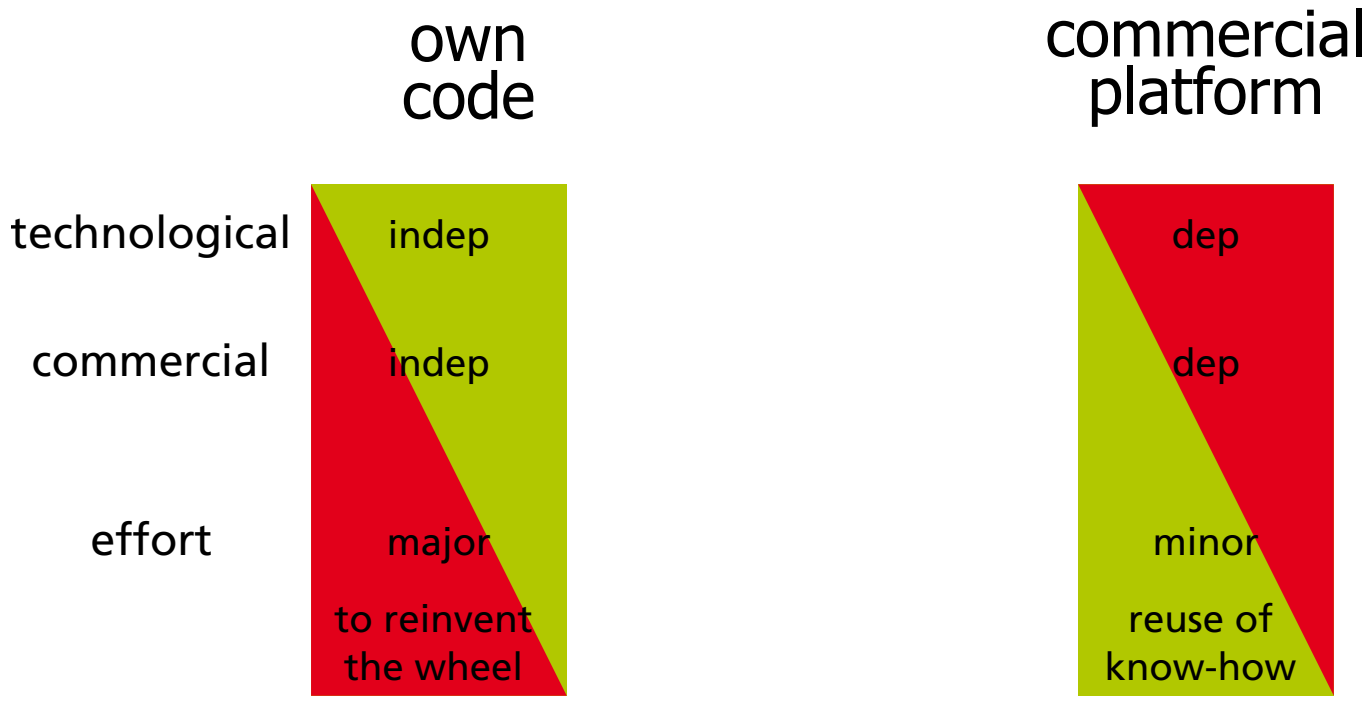
OneWind base technologies: Modelica and Eclipse



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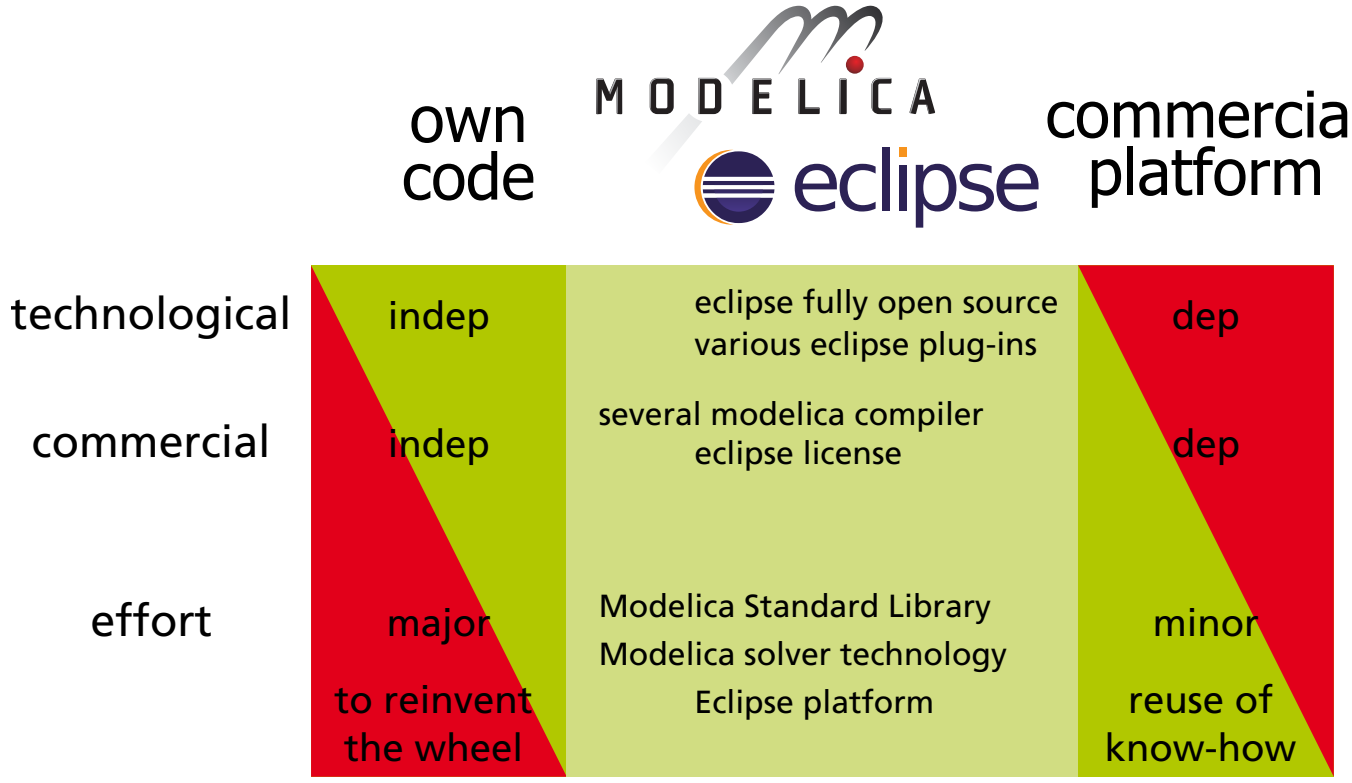

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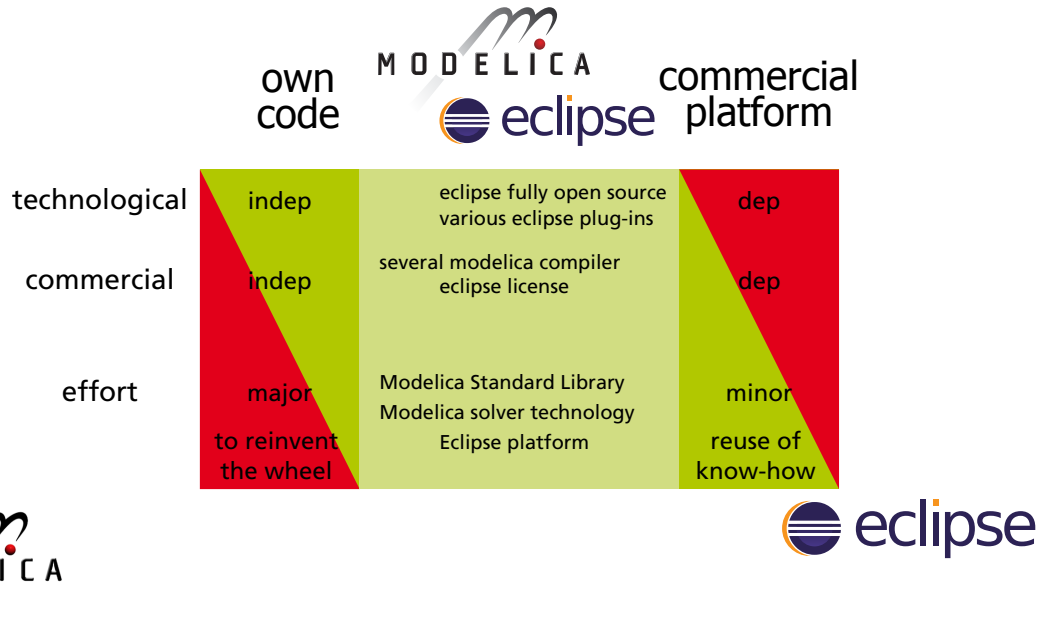
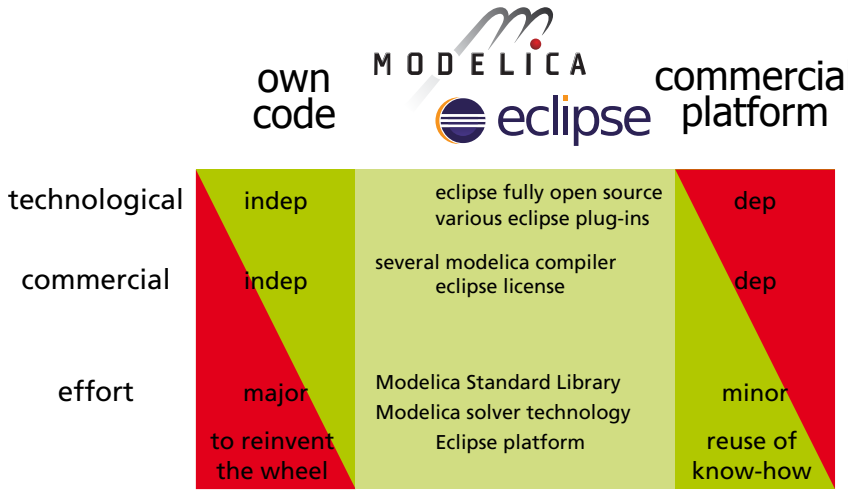


- Open source language for physical modeling (ODE)
- Separation of physics and numerics and → intuitiv to engineers
- Extensive Modelica Standard Library (MSL)
- Vendor independent, component based, extensible

OneWind base technologies: Modelica and Eclipse



MODELICA

- Open source language for physical modeling (ODE)
- Separation of physics and numerics and → intuitiv to engineers
- Extensive Modelica Standard Library (MSL)
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eclipse

- Open source community
- Reuse of techniques from software development: plug-in framework, support for collaboration (subversion, tickets)
- Domain specific models → EMF
- Example: Eclipse Automotive Industry Working Group

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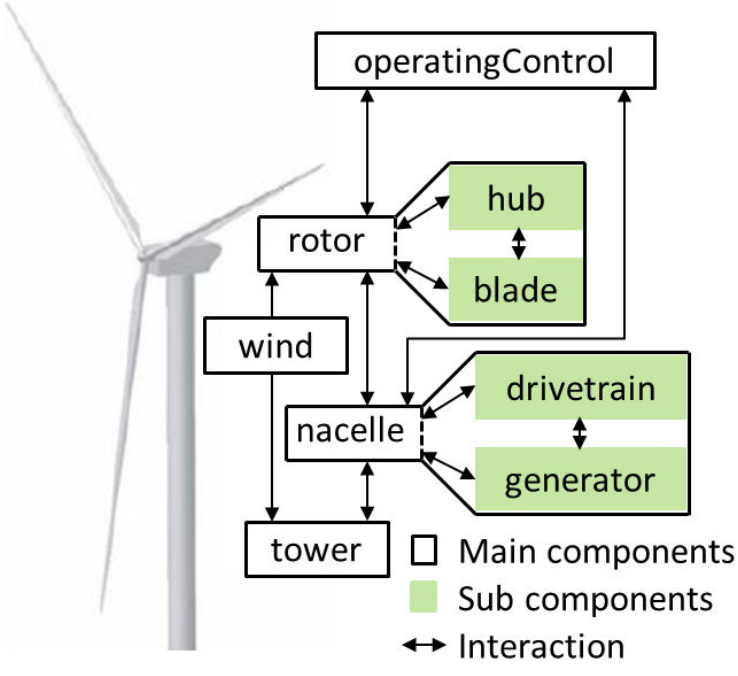
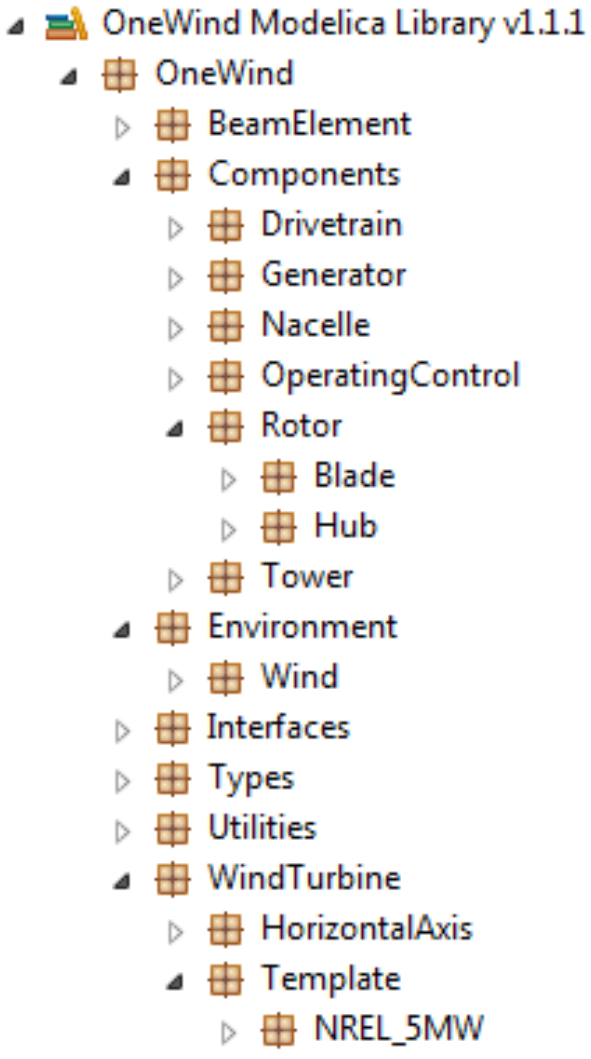
Agenda

OneWind Modelica Library

- Modelica based
- Component based (exchangeable, extendible)
- Source code / no blackbox
- Modal reduction of blades and towers
- Including NREL offshore 5MW baseline wind turbine
- Verification OCx





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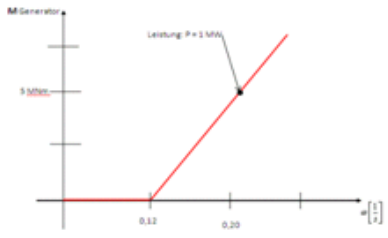
Modelica Example: Generator

Characteristics



Equation of motion

$$M_{Rotor} - J_{Rotor} \cdot \dot{\omega} - J_{Generator} \cdot \dot{\omega} - M_{Generator} = 0$$

```
model Generator
...
equation
  if omega <= 0.12 then
    Mgenerator = 0;
  else
    Mgenerator = (62500000 * omega) - 7500000;
  end if;
  omega = der(rotFlangeShaft.phi);
  Mrotor-(Jrotor + Jgenerator)*der(omega)-Mgenerator = 0;
end Generator;
```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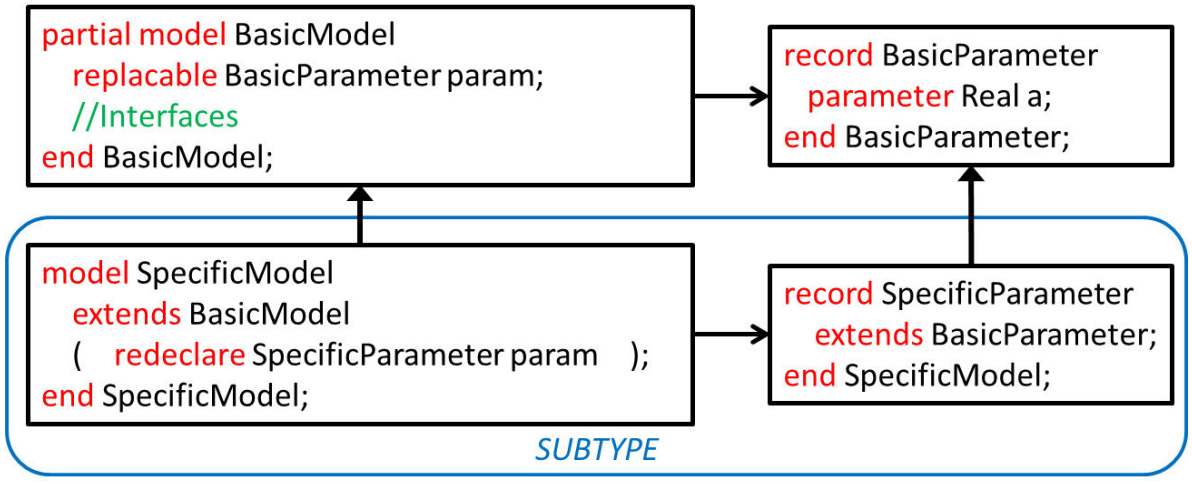
Inheritance concept of library



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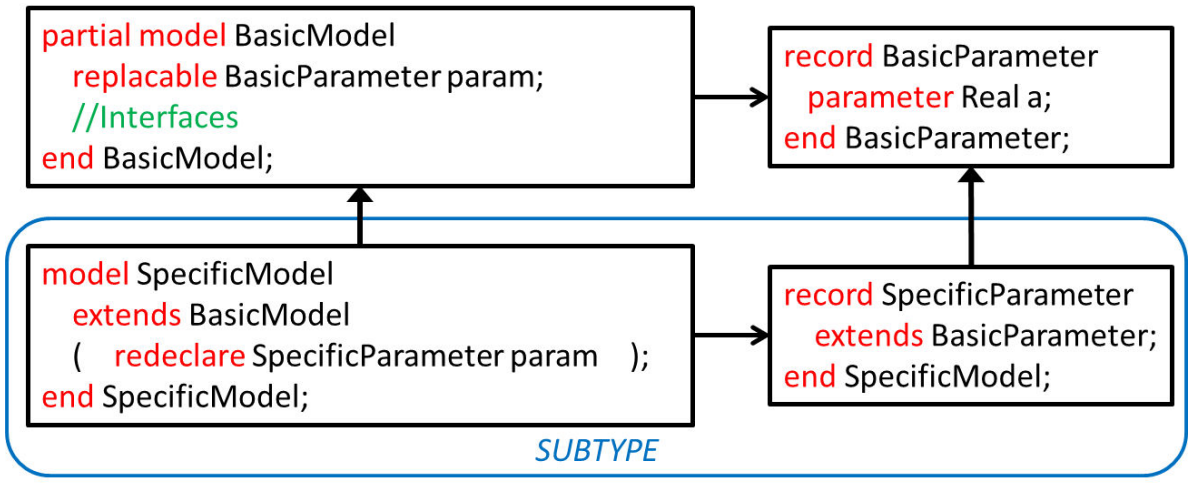
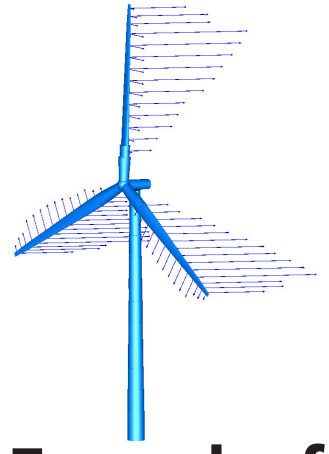


Example Code

```
model WindTurbine
 extends OneWind.OnshoreWindTurbine
  (
    //=== rotor ===
    redeclare OneWind.RotorModal rotor
    //=== tower ===
    ,redeclare OneWind.TowerModal tower
    //=== nacelle ===
    ,redeclare OneWind.NacelleRigid nacelle
    //=== operating control ===
    ,redeclare OneWind.Control operatingControl
    //=== wind ===
    ,redeclare OneWind.WindTurbulent wind
  );
end WindTurbine;
```

Graphical output



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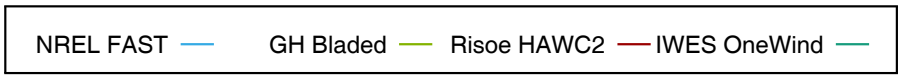
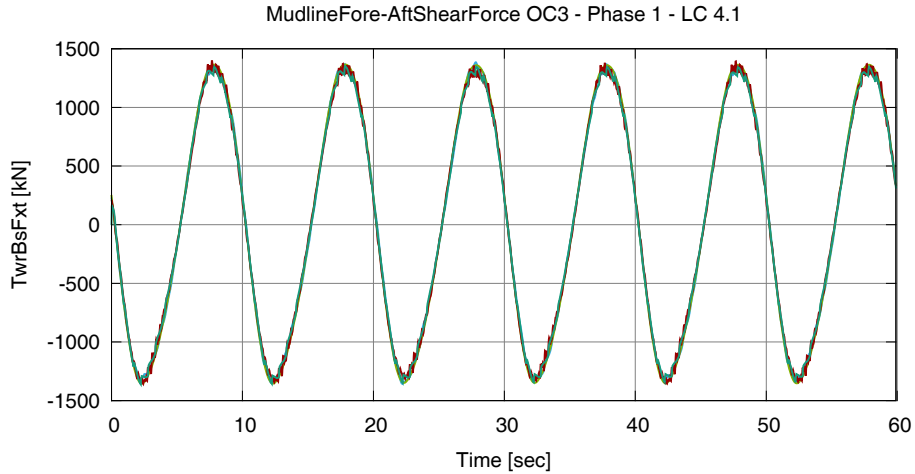
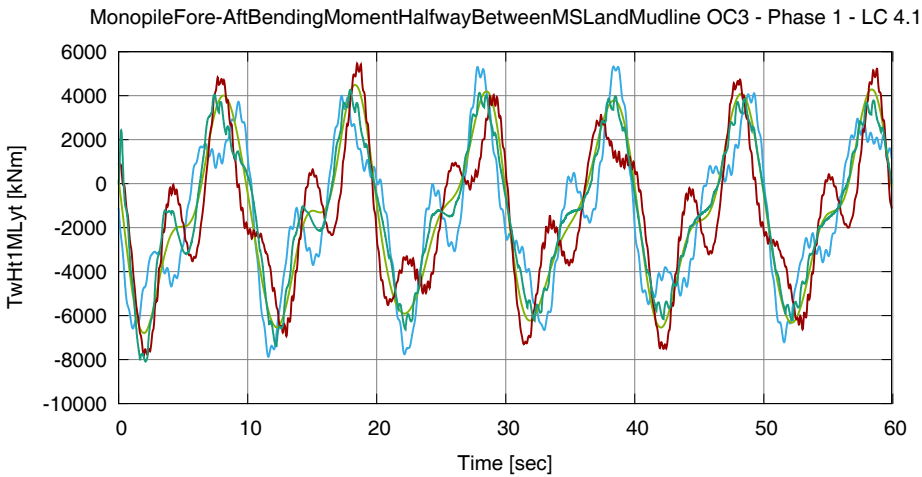
Verification

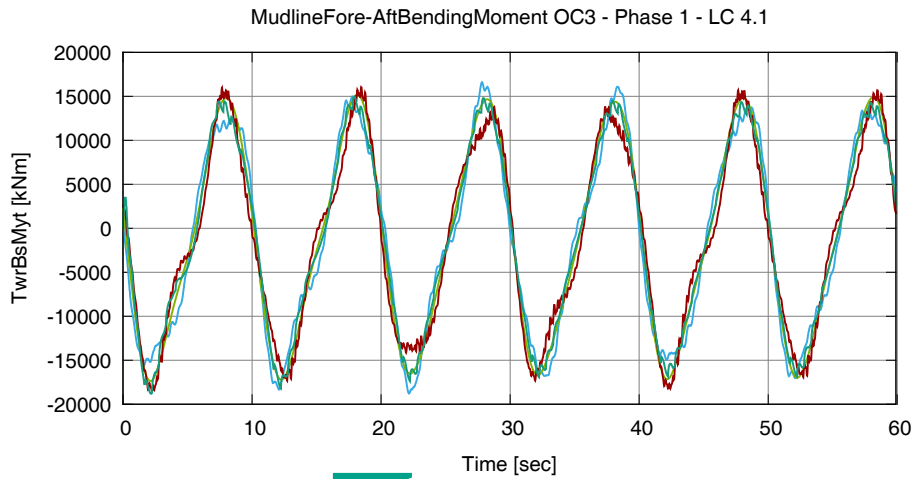
OC3 Phase 1 loadcase 4.1

- Flexible offshore structure
- constant wind
- no waves









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Agenda

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OneWind Concept

OneWind Modelica Library

OneWind Software Products
- Framework
- Product overview
- Look and feel

Extensions

Conclusion

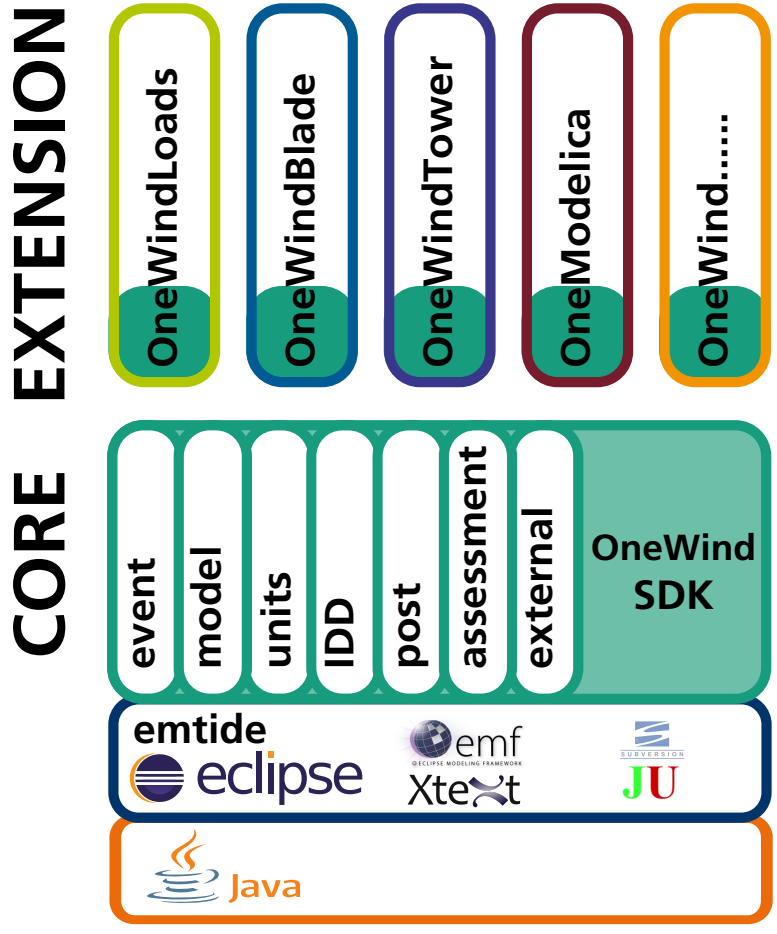
OneWind-framework structure

Concept

- Modeling windturbines and workflow
- Engineering Design Data
- Core / extension

Software engineering

- Eclipse Rich Client Platform (RCP)
- Continuous integration build
- Documentation within products
- Tests within the products



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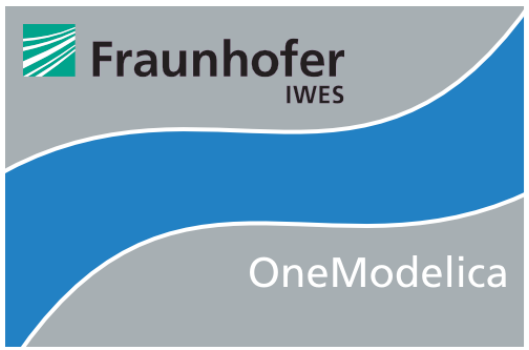
OneWind-Products

- OneWindLoads Load calculation
- OneWindBlade Structure design of rotorblades
- OneModelica Integrated development environment for Modelica
- OneWindSDK Software Development Kit for OneWind products



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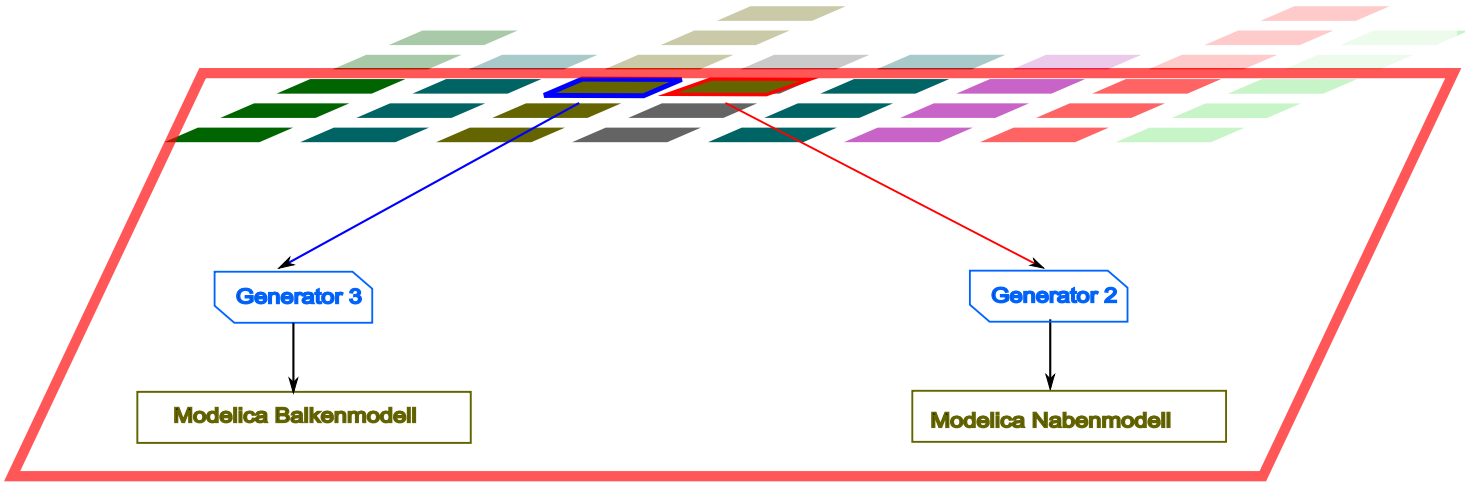

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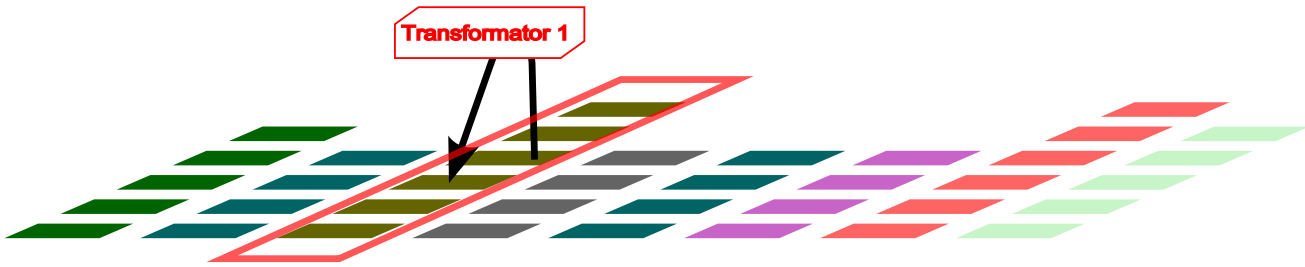

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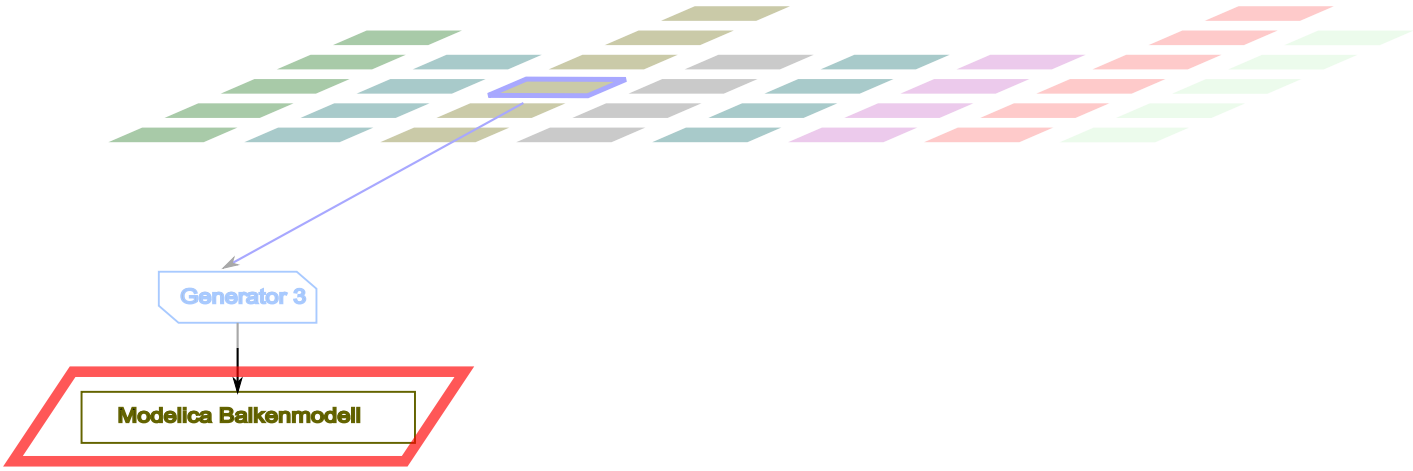

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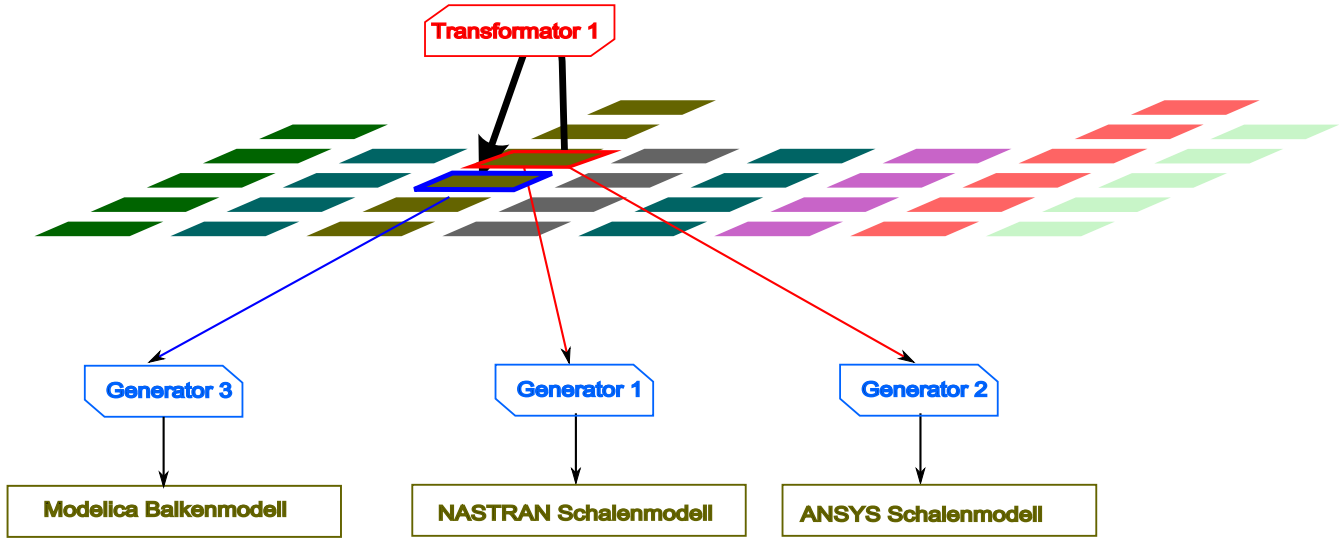
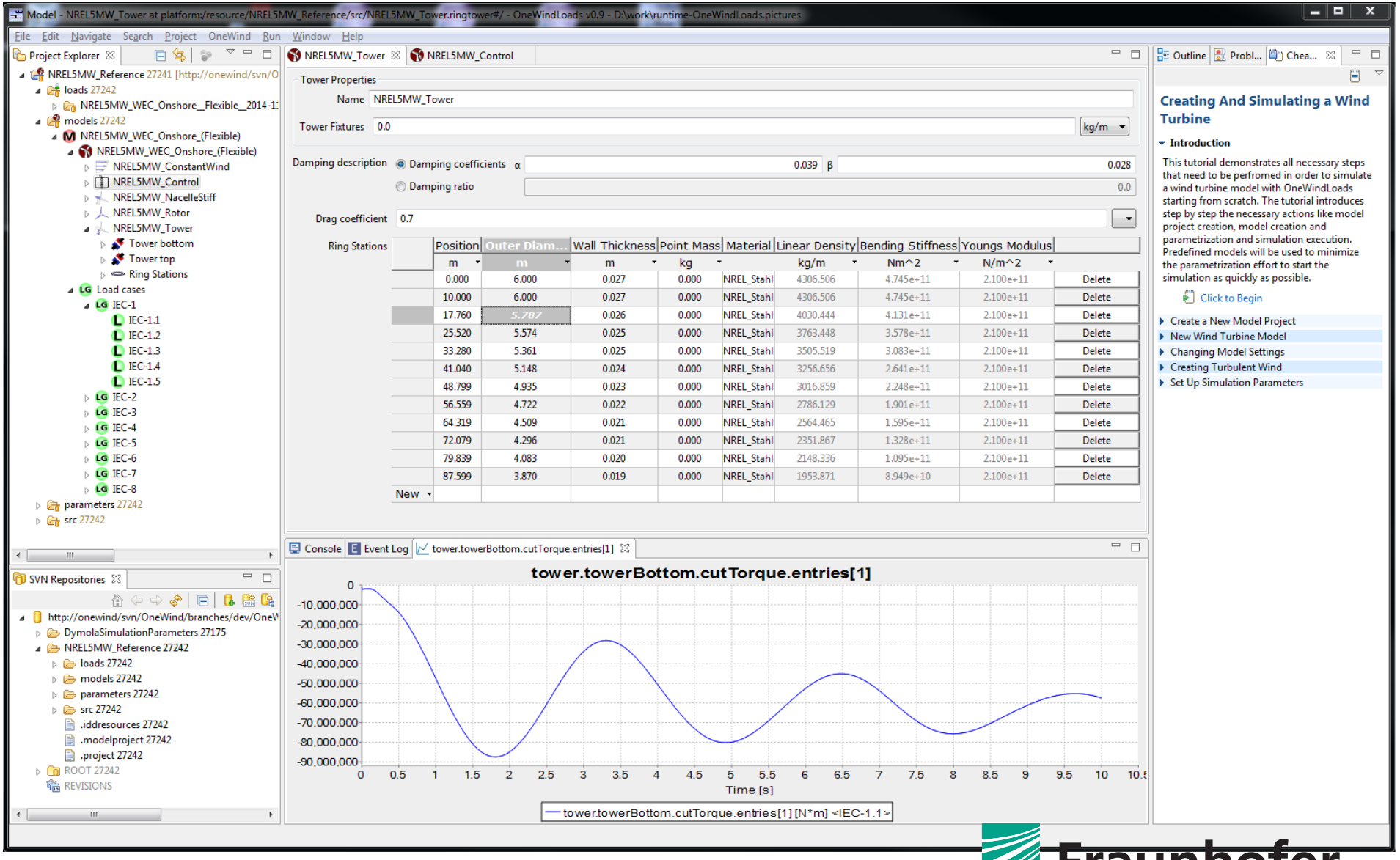
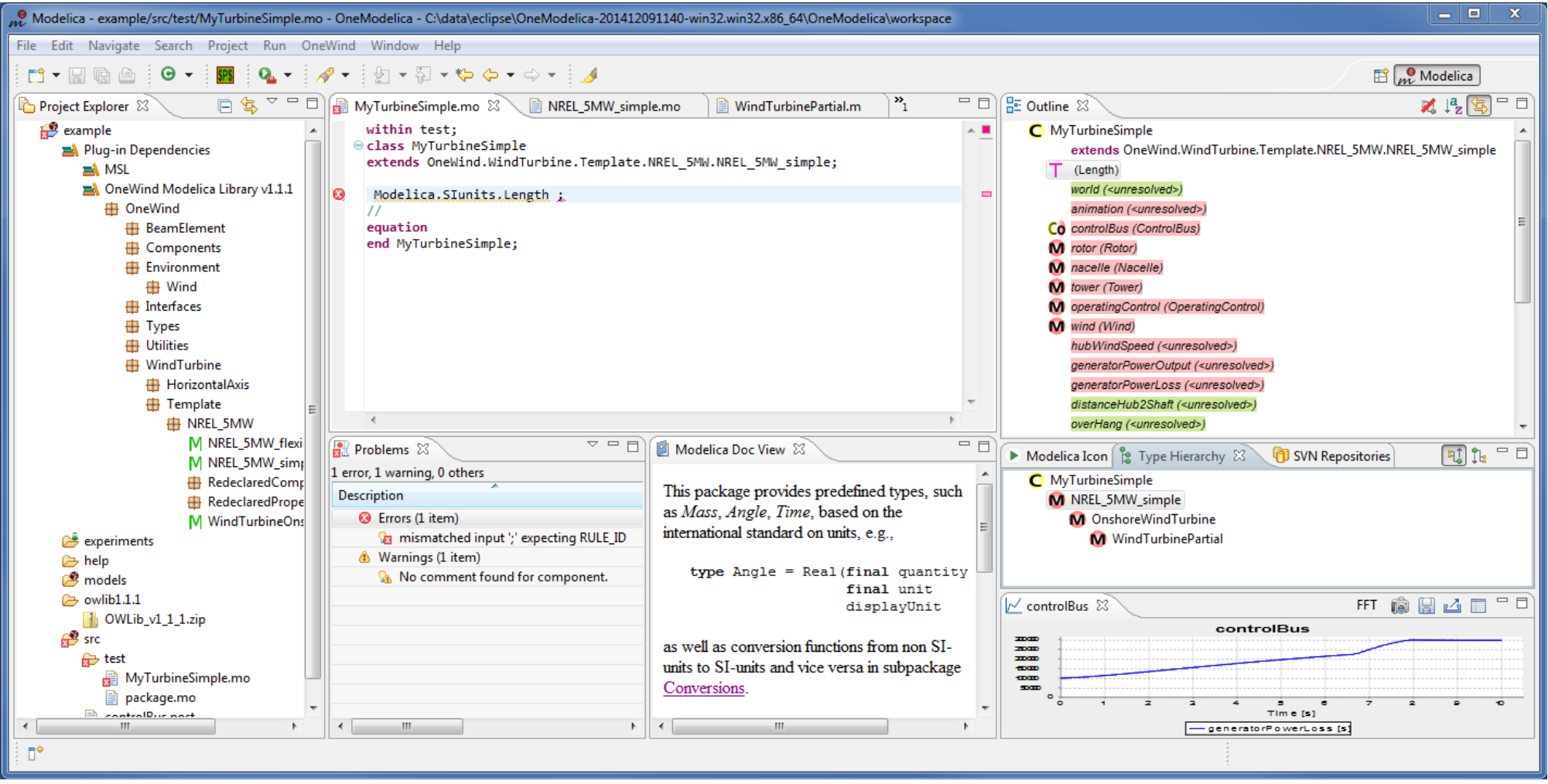


Look and Feel of OneWindLoads



Look and Feel of OneModelica



Agenda

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OneWind Concept

OneWind Modelica Library

OneWind Software Products

Extensions
- Approaches to extend
- Ongoing work
- Dual license

Conclusion

Extension of the framework

“Fast approach” – Modelica based

- Enhancements of single component
- Usage within library for loads calculation
- OneModelica

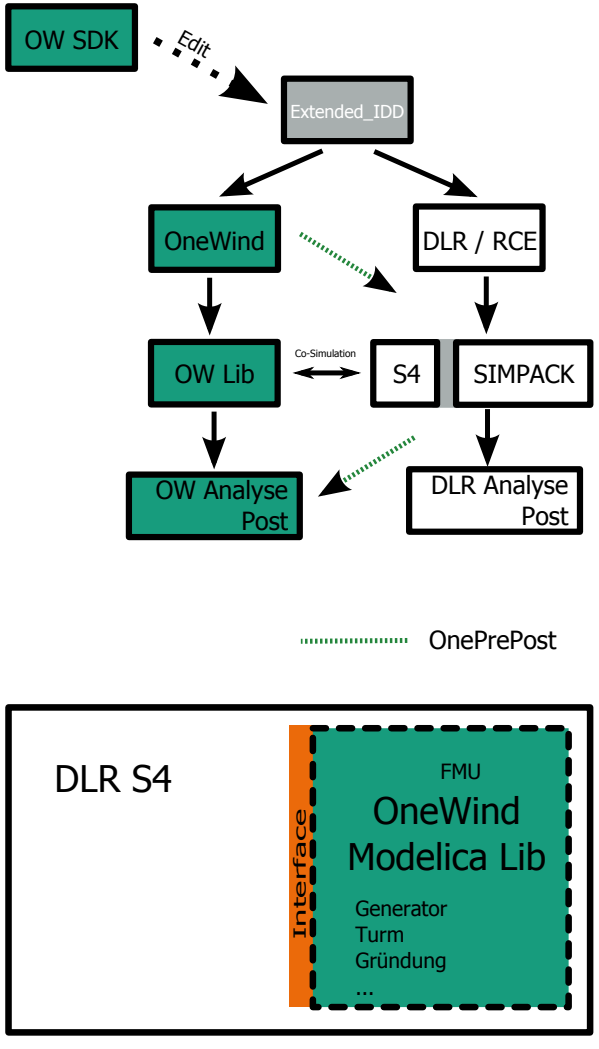
“Complete approach” – OneWind-Framework based

- Engineer Design Data – model for new component
- Transformations, generators and assessments
- Core / Extension based ⇒ OneWind Product
- OneWindSDK

Ongoing work

Project Wind Muse

- Cooperation IWES – DLR
- Combine tools from IWES and DLR
- Modelica model exchange via Functional Mock-up Interface (FMI)
- combined parametric model `Extended_EDD`
- Enhanced load case management
- OnePrePost (alternative simulator)



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  - Extensions / Modifications
  - Reference to "OneWind"

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IV. MISCELLANEOUS

1. **Duration and Termination of Agreement**

Agenda

Conclusion

OneWind is

- Consistent modeling with different levels of details
- "OneWind Modelica Library" tool for loads calculation
- Extensible software framework for wind-energy applications

THANK YOU FOR YOUR ATTENTION

Any questions?

urs.wihlfahrt@iwes.fraunhofer.de

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