European Bladed User Conference 2016

10th November 2016

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 DNV GL © 2014

- Introduction
- Bladed Cloud
- Results animation
- Superelement
- Dynamic wake

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The team

Paul Martin

William Sardar

William Collier

Philip Bradstock

Douglas McCowen

Jamie Badar

Andrew Cordle

Menno Kloosterman

Alec Beardsell

Oscar Hugues Salas

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Agenda

Registration and coffee		
Bladed 4.8 – what's new?	Patrick Rainey	DNV GL
Multi-part blade: validation and loads study	William Collier	DNV GL
Multi-part blade modelling and blade stability	Jelmer Cnossen	GE
Coffee Break		
New blade stability tool	Philip Bradstock	DNV GL
Bladed 5	Patrick Rainey	DNV GL
Workshop 1 / discussions on selected topics	All	
Lunch		
New Aerodynamics verification	Menno Kloosterman	DNV GL
Trailing Edge Flaps on Multi-MW Turbine Blades	Sebastian Perez-Becker	WINDnovation
Floating wind and new dynamic mooring line model in Bladed	Douglas McCowen Andrew Cordle	DNV GL
LiDAR simulation and hardware testing in Bladed	Oscar Hugues Salas	DNV GL
Coffee Break		
Earthquake simulation in Bladed	Alfredo Martinez Cia	Acciona
Workshop 2 / discussions on selected topics	All	
Closing presentation	Patrick Rainey	DNV GL
Drinks Reception		

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Bladed 4.8

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Bladed 4.8

- Multi-part Blade
  - Work begun 2013
  - Working model 2015
  - New integrators 2015
  - GUI 2016
- New Aerodynamics
  - Work begun 2011
  - Working model 2013
  - Optimised and beta released in 2015
  - Verification and testing continued – official release in 4.8
- Dynamic Wake Meandering
- Dynamic mooring line
- Superelements

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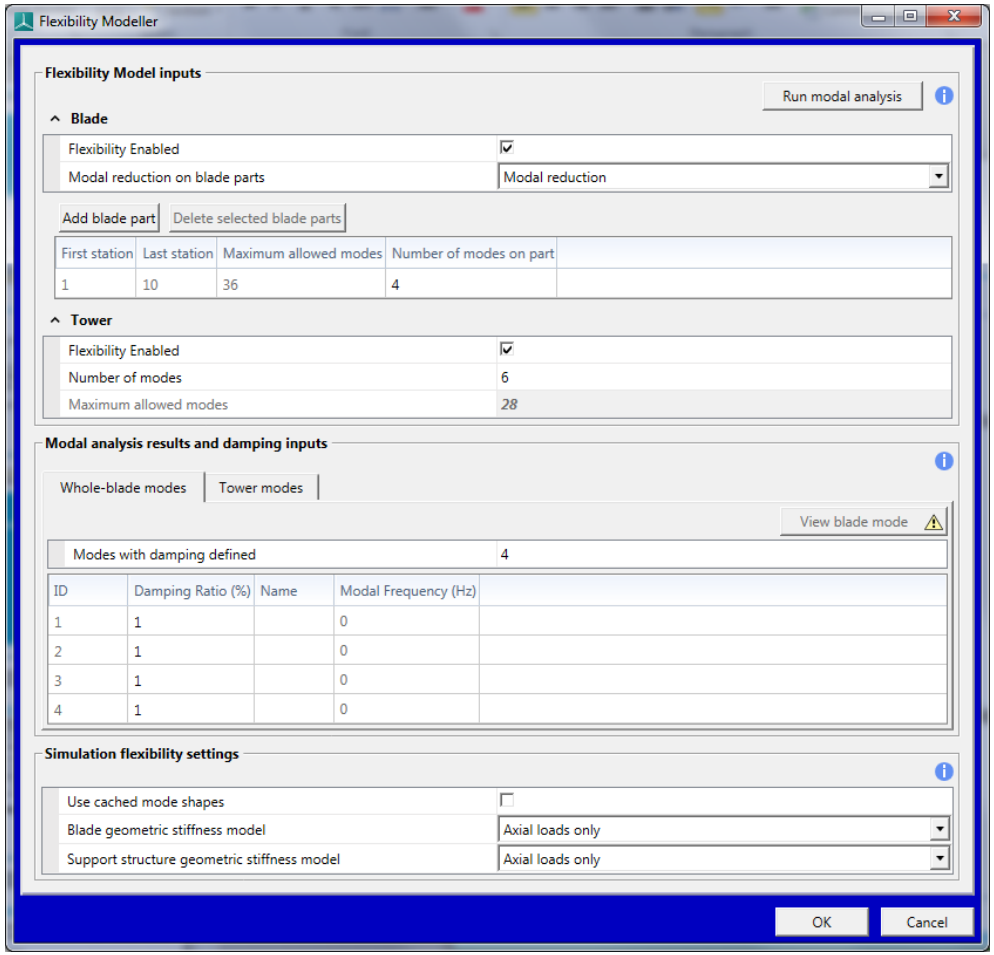
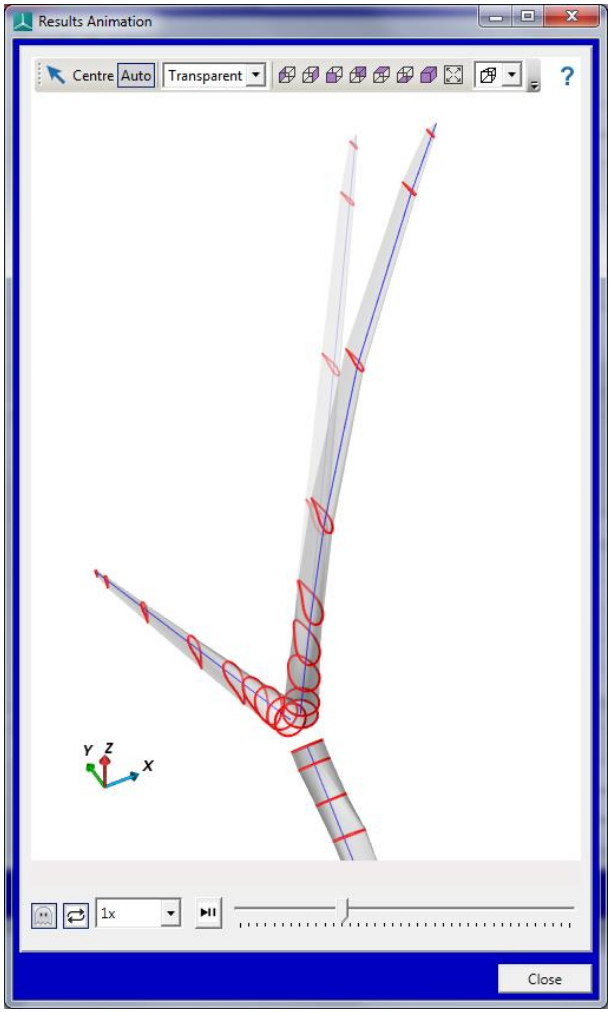
Bladed 4.8

Defining modes:



Viewing modes:



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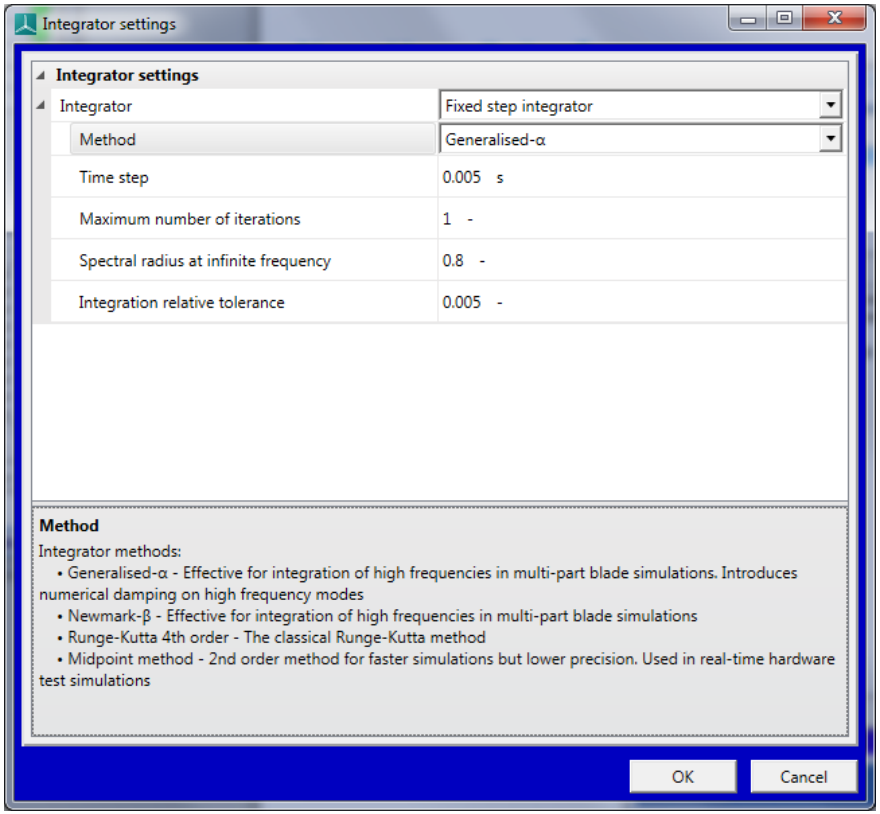
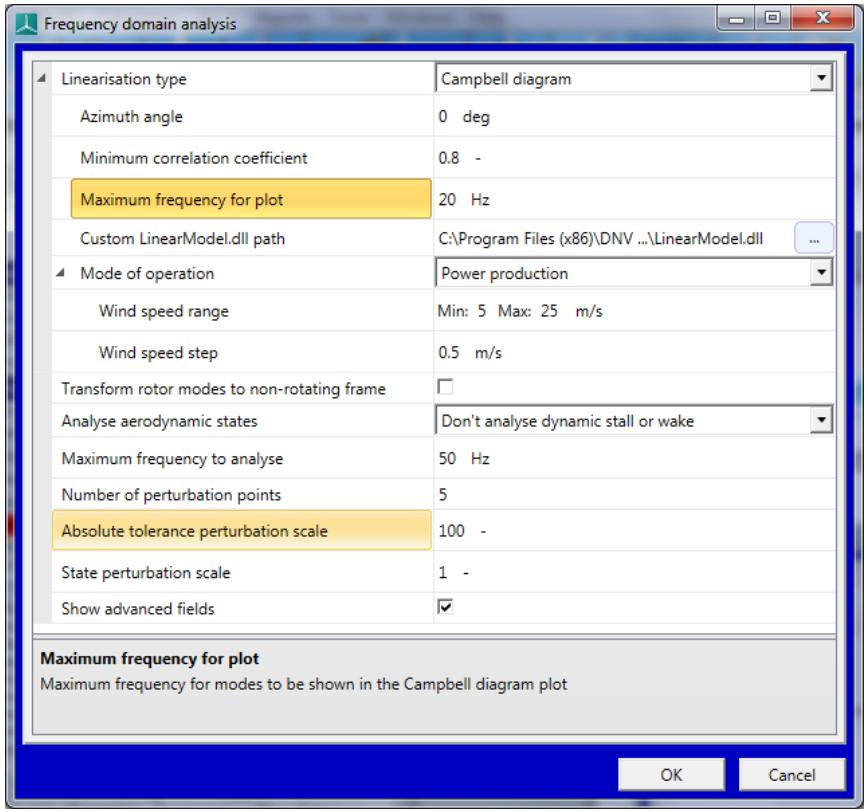
Integrator settings:



Frequency domain analysis:



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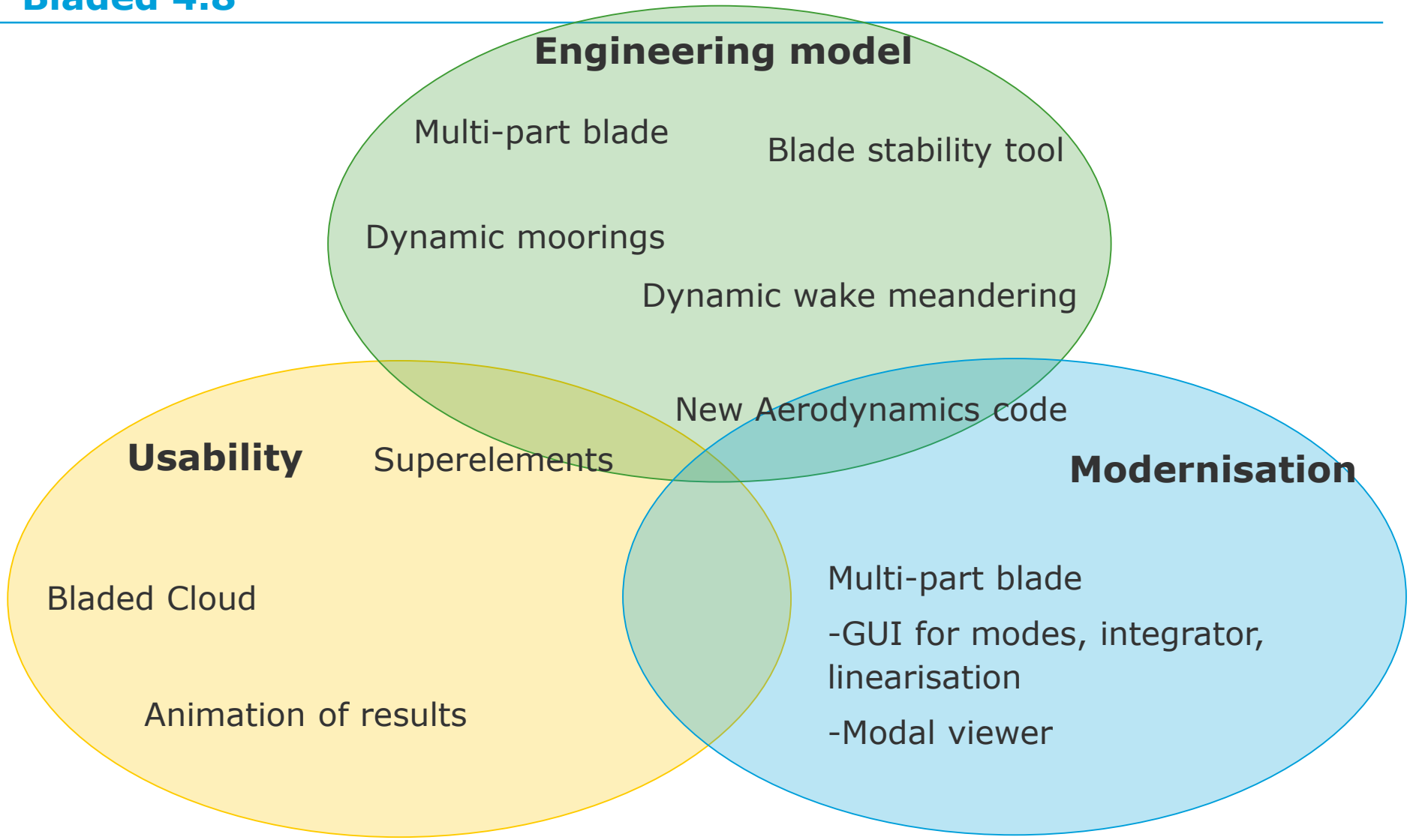
Bladed 4.8



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Bladed Cloud

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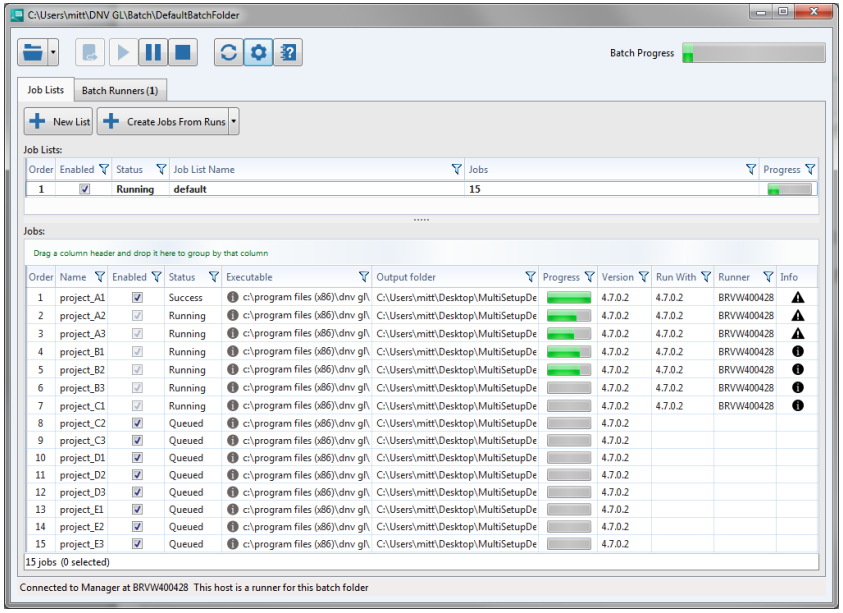
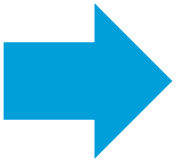
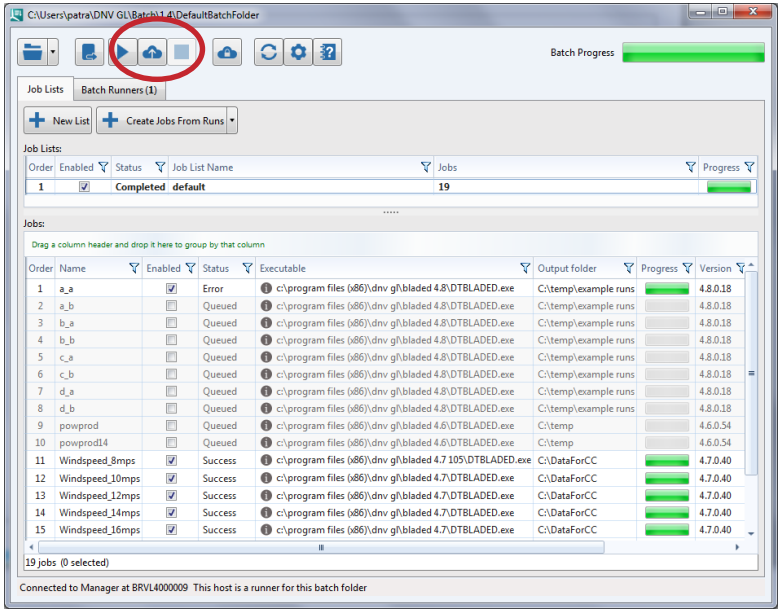
Bladed Cloud User Interface







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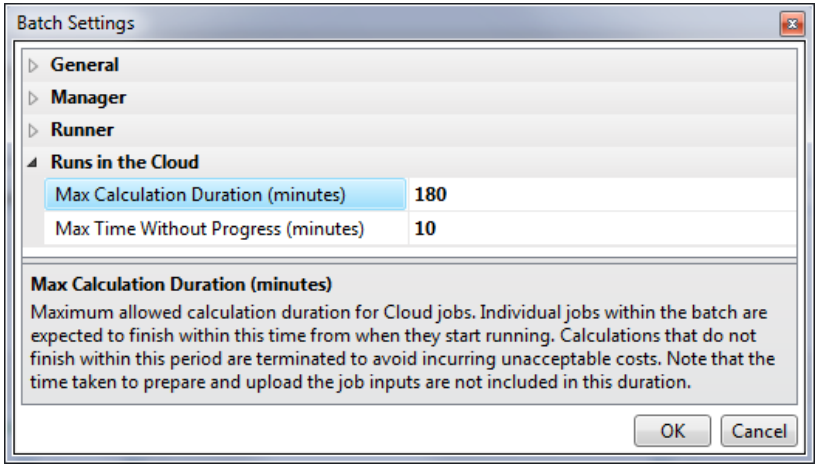
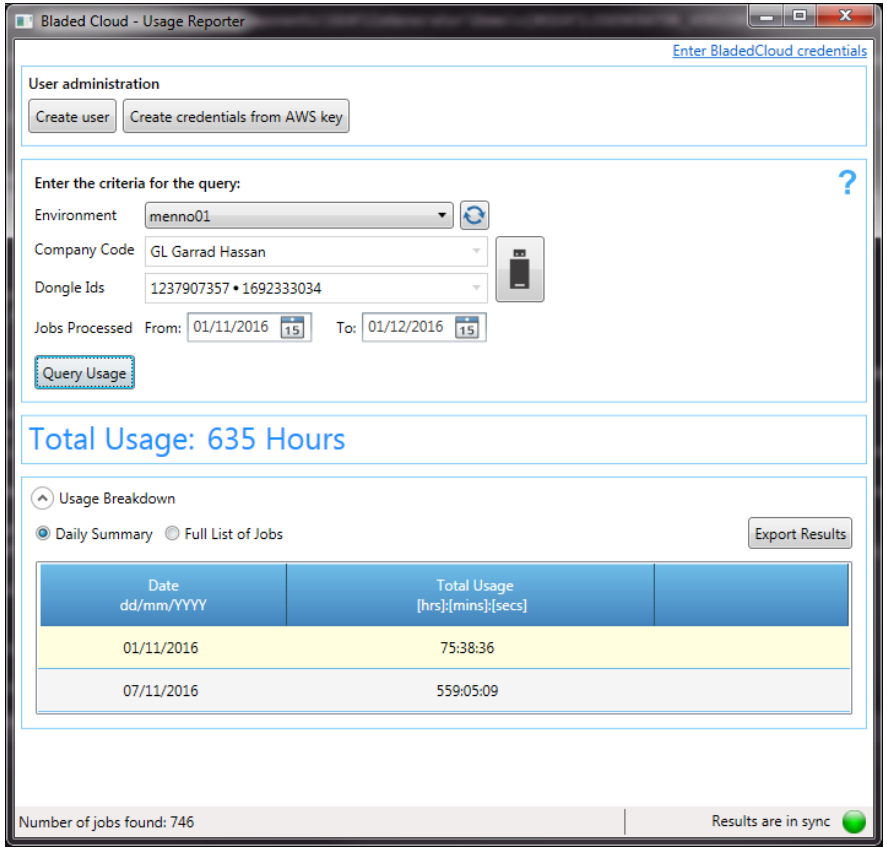
Bladed Cloud User Interface





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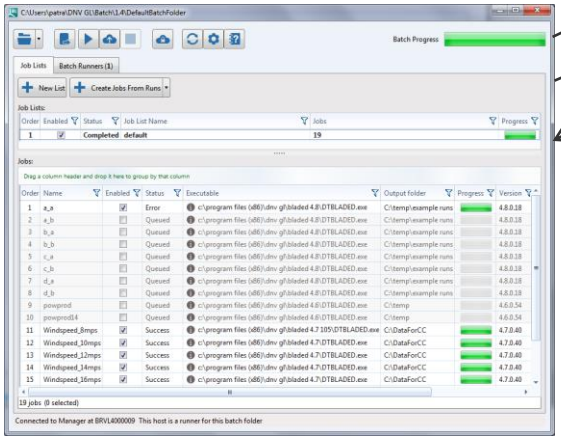
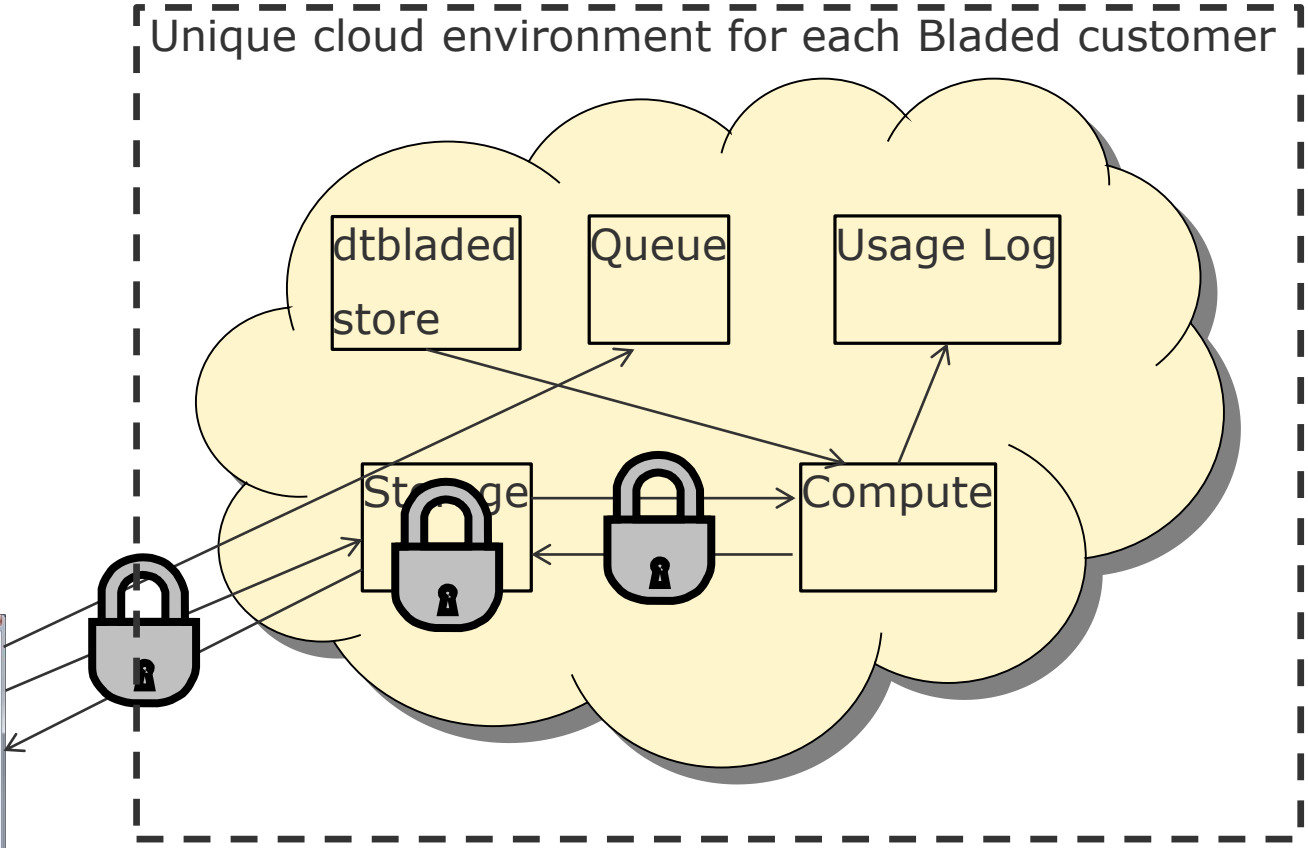
Bladed Cloud





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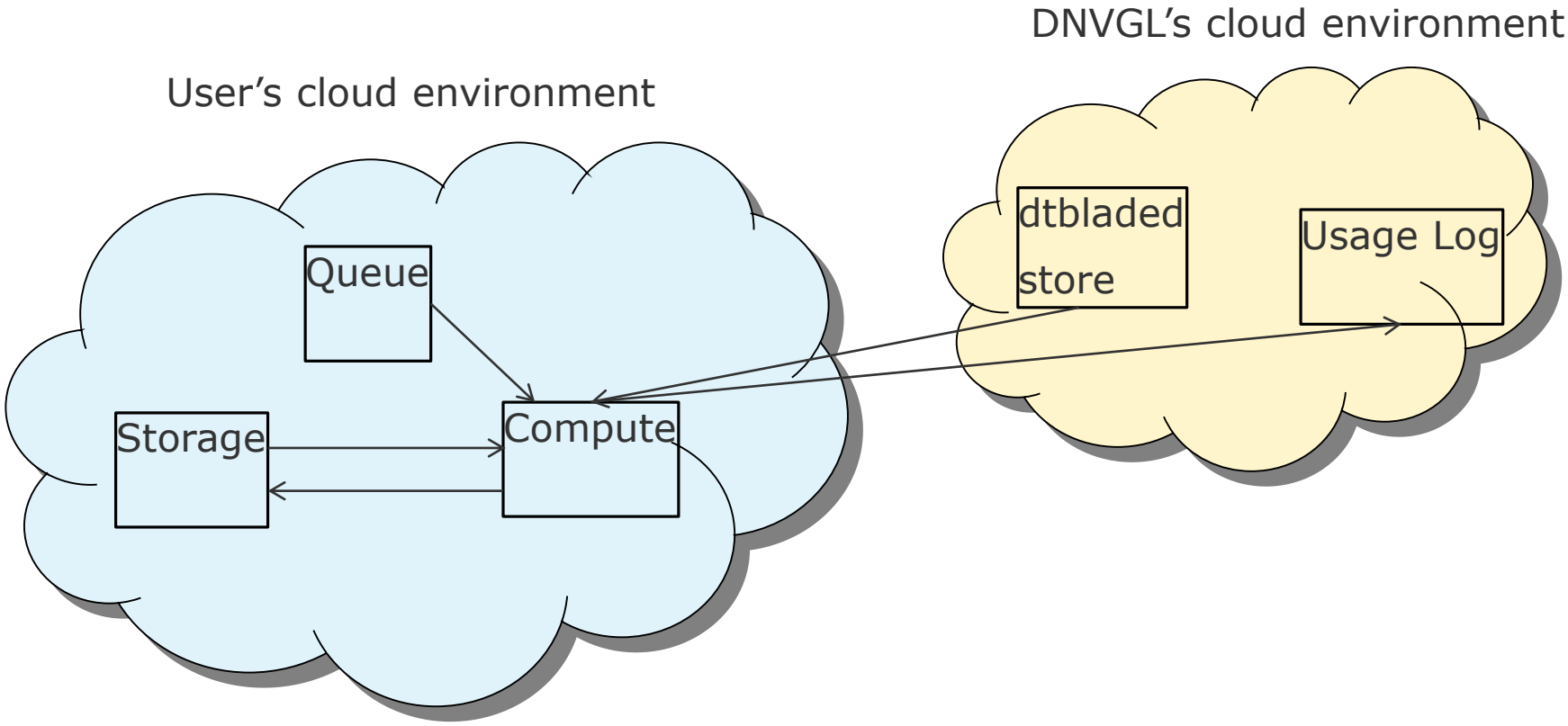
Build your own Bladed Cloud



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Superelemets

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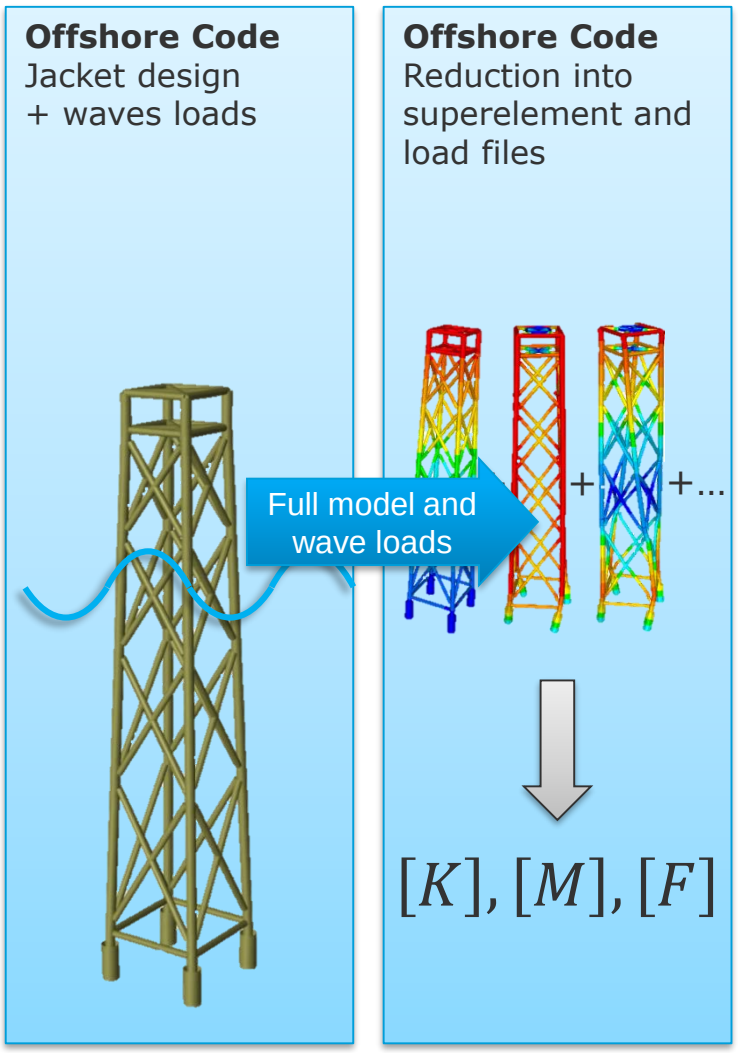
Creating a Superelement



- Superelement created using Craig-Bampton reduction
  - **Constraint modes**: applied displacements at jacket top
  - **Normal models**: Eigen modes with jacket top constrained
  - Modes give reduced [K], [M], [F] for use directly in Bladed

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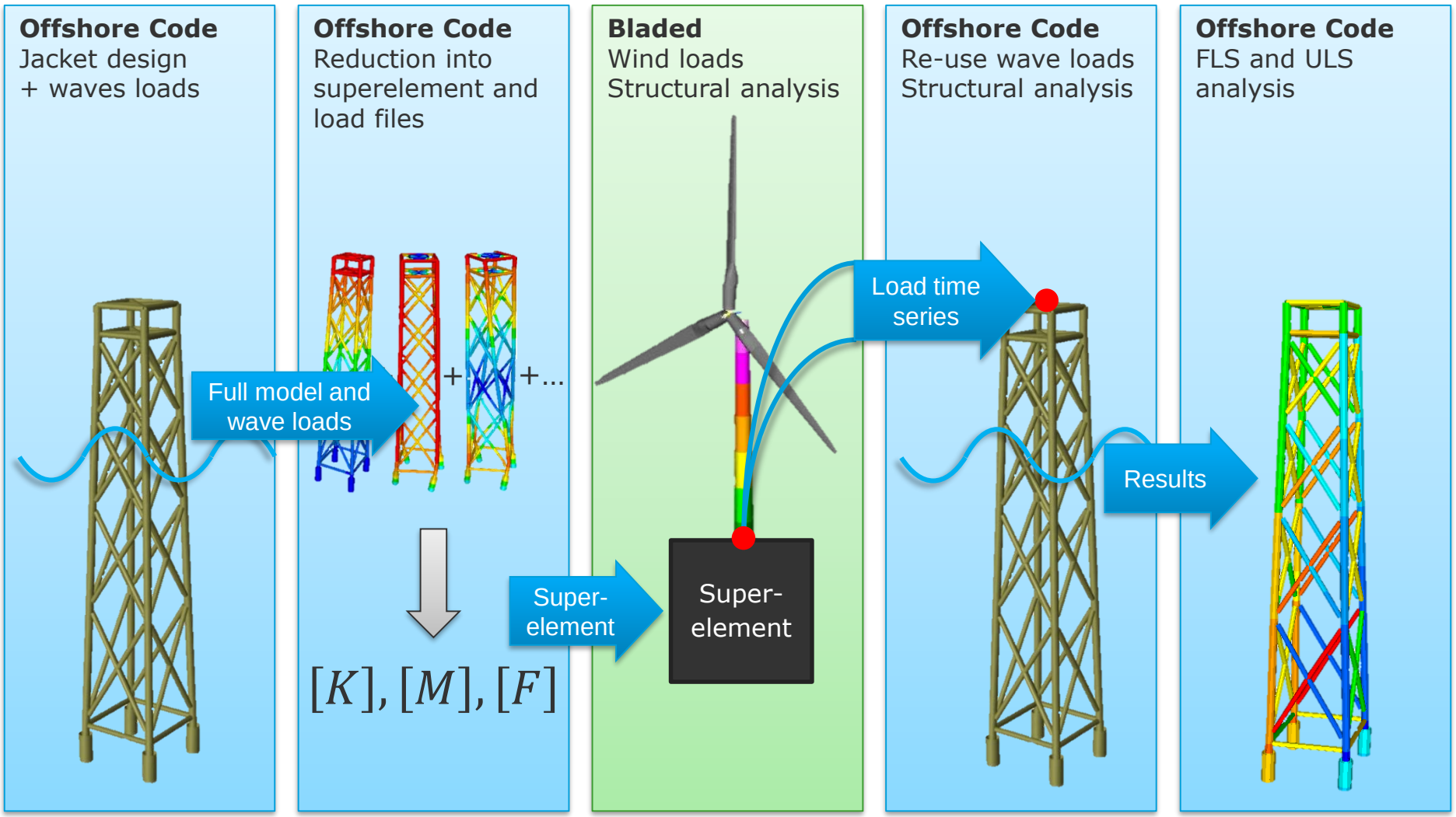
Superelement Analysis



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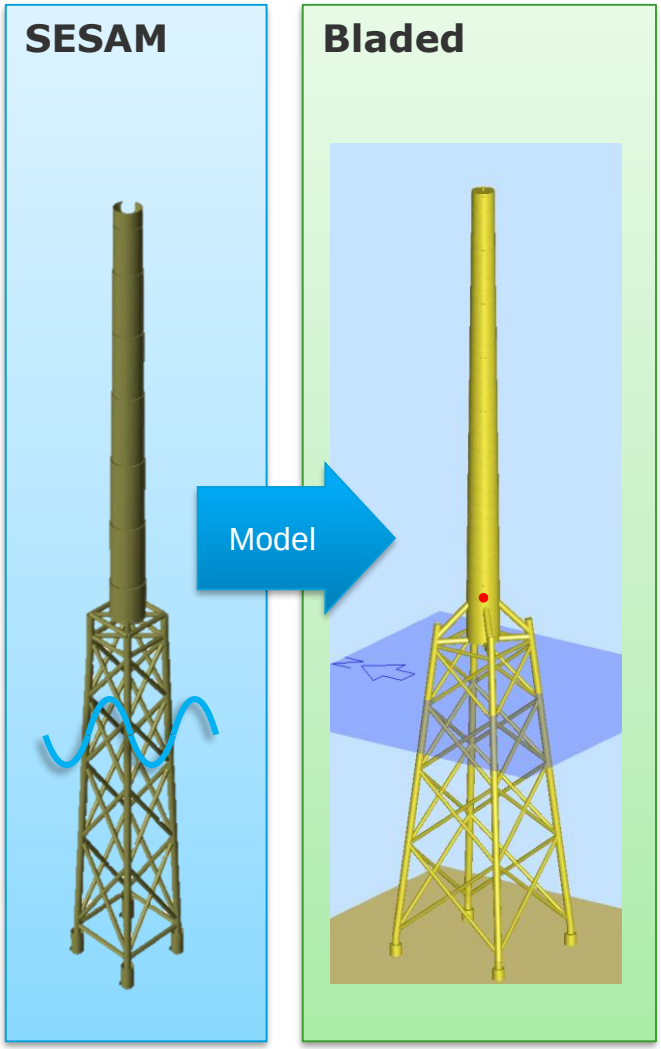
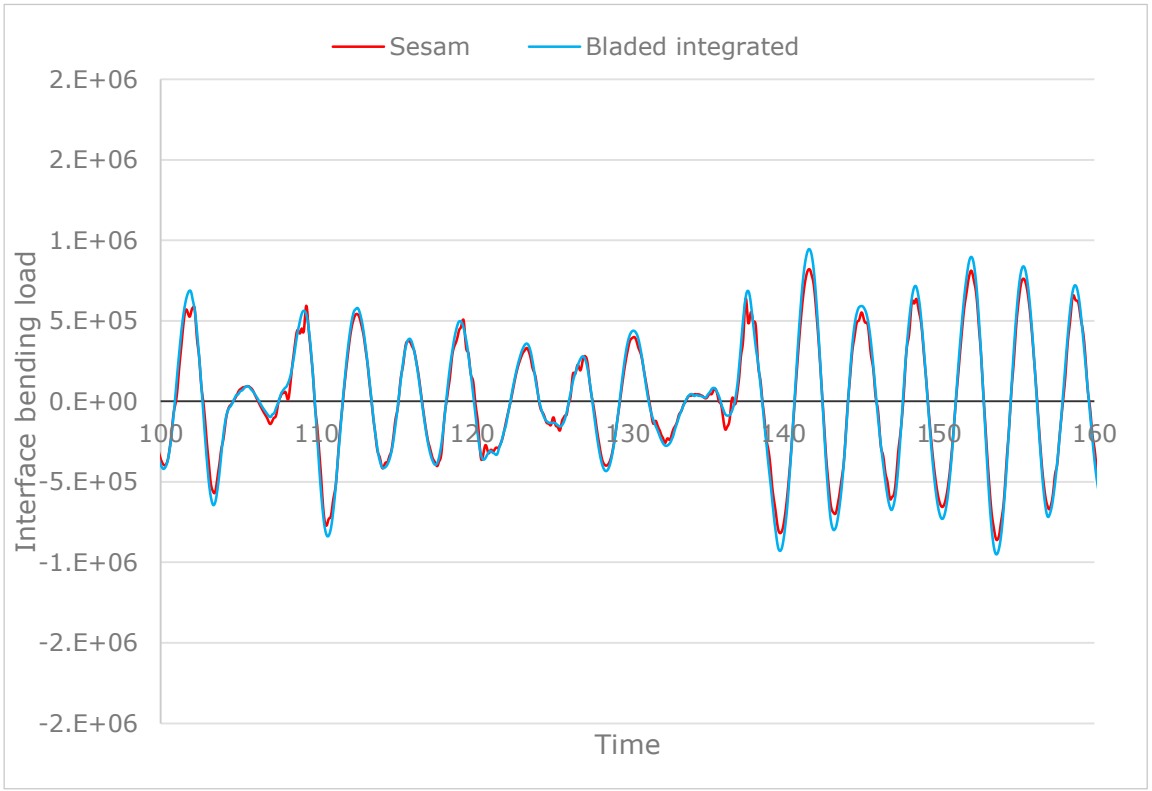
Superelement testing 1 – test integrated model



1. Check for equivalent modelling in Bladed / SESAM
2. Take full model & sea surface (waves) SESAM -> Bladed
3. Compare interface loads



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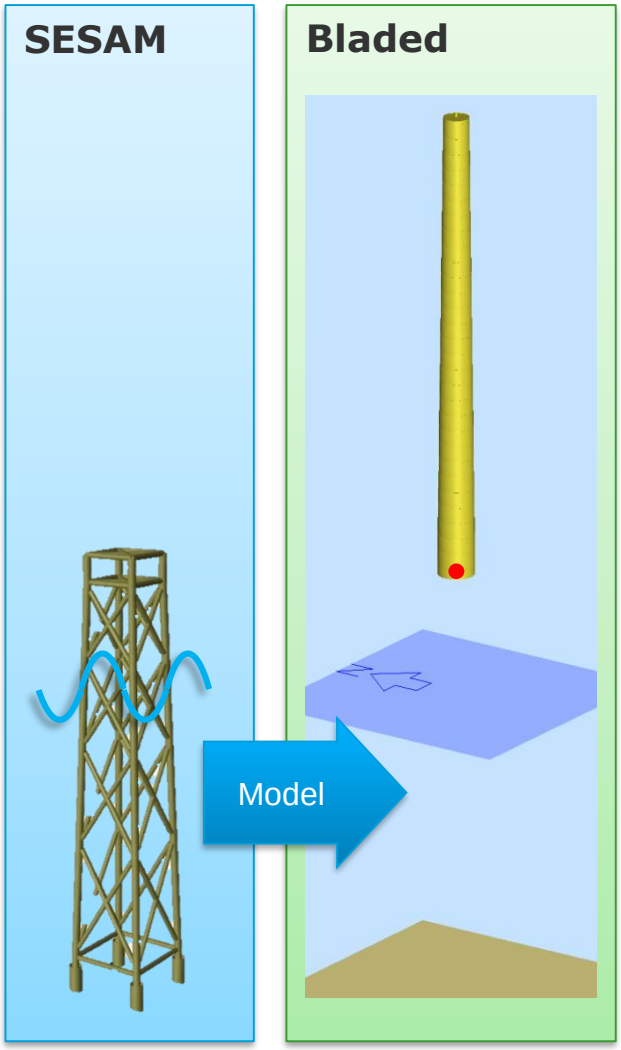
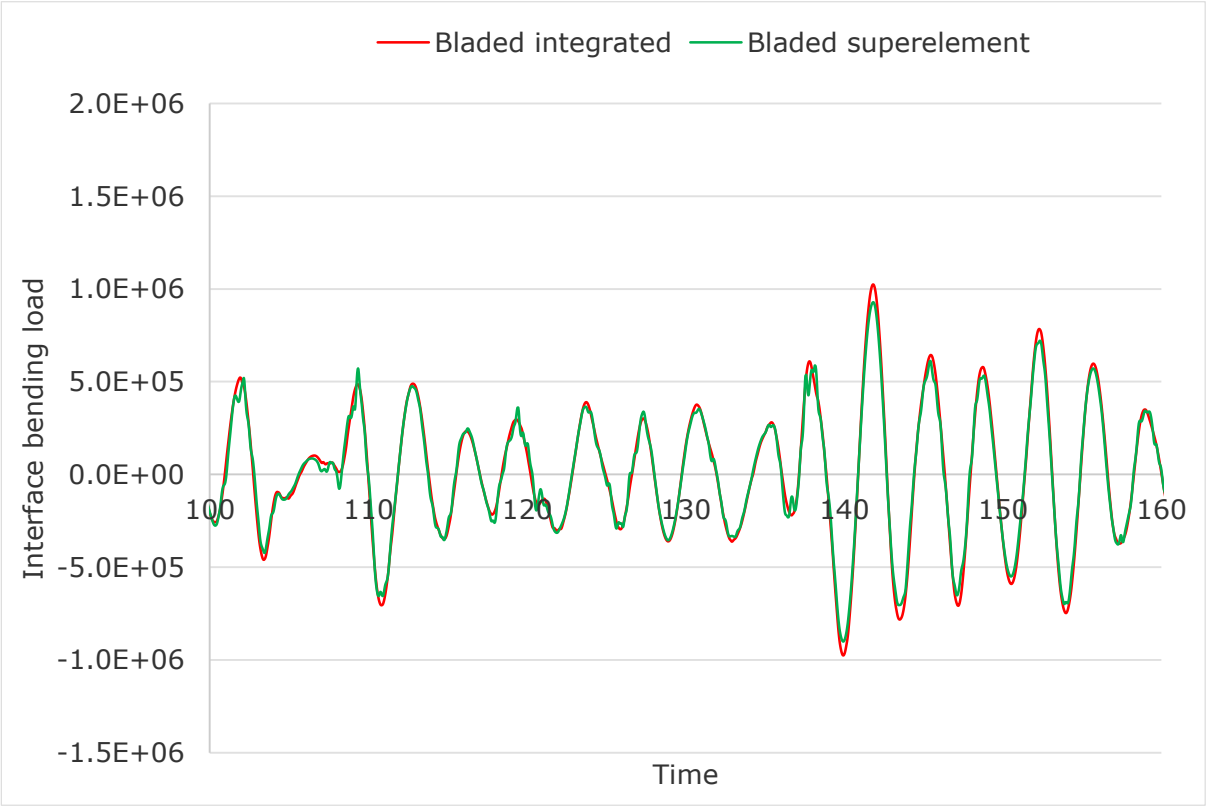
Superelement testing 2 – test superelement model



1. Compare Bladed integrated and Bladed superelement
2. Take jacket and wave loads SESAM -> Bladed
3. Compare interface loads to integrated case



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Results animation

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Results animation

Live Demo

Dynamic Wake Meandering

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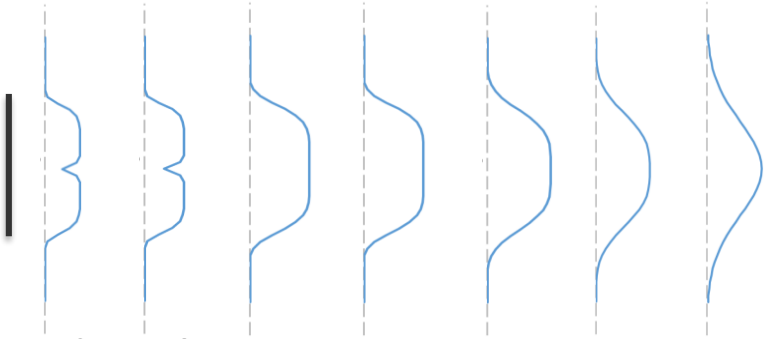
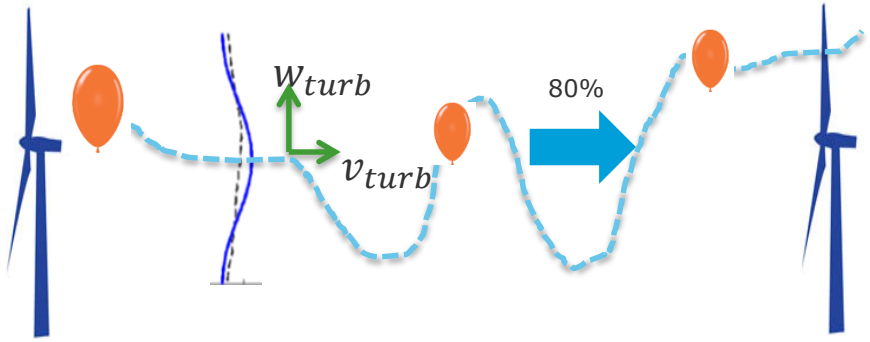
Dynamic Wake Meandering

- **Eddy viscosity model**
  - Navier-Stokes model of how the wake propagates downstream
  - Steady wake profile calculated for mean wind conditions of simulation



- **Meandering wake**
  - Variation of wake position with simulation time
  - Due to ambient turbulence
  - Assumed independent of wake deficit profile



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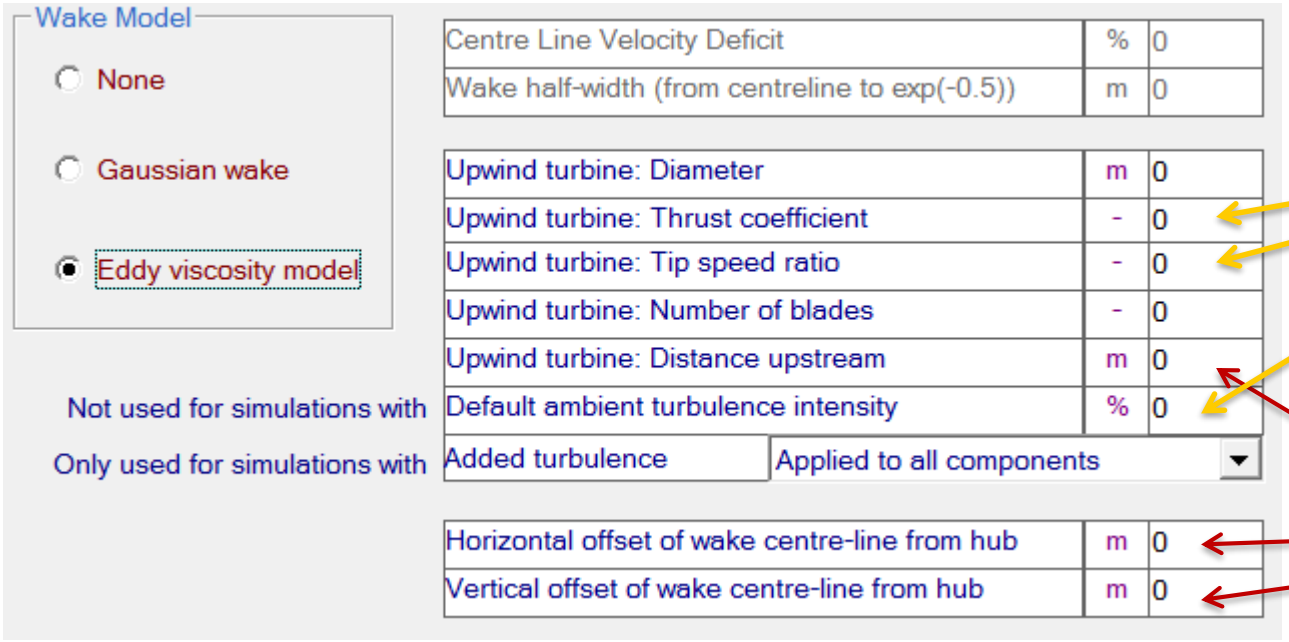
How is it "dynamic"?

1. The "meandering" wake means position of wake dynamically varies with simulation time. (Wake deficit profile is static)
2. Load-case dynamic – don't have to change the properties for every simulation!

Legacy Bladed model:



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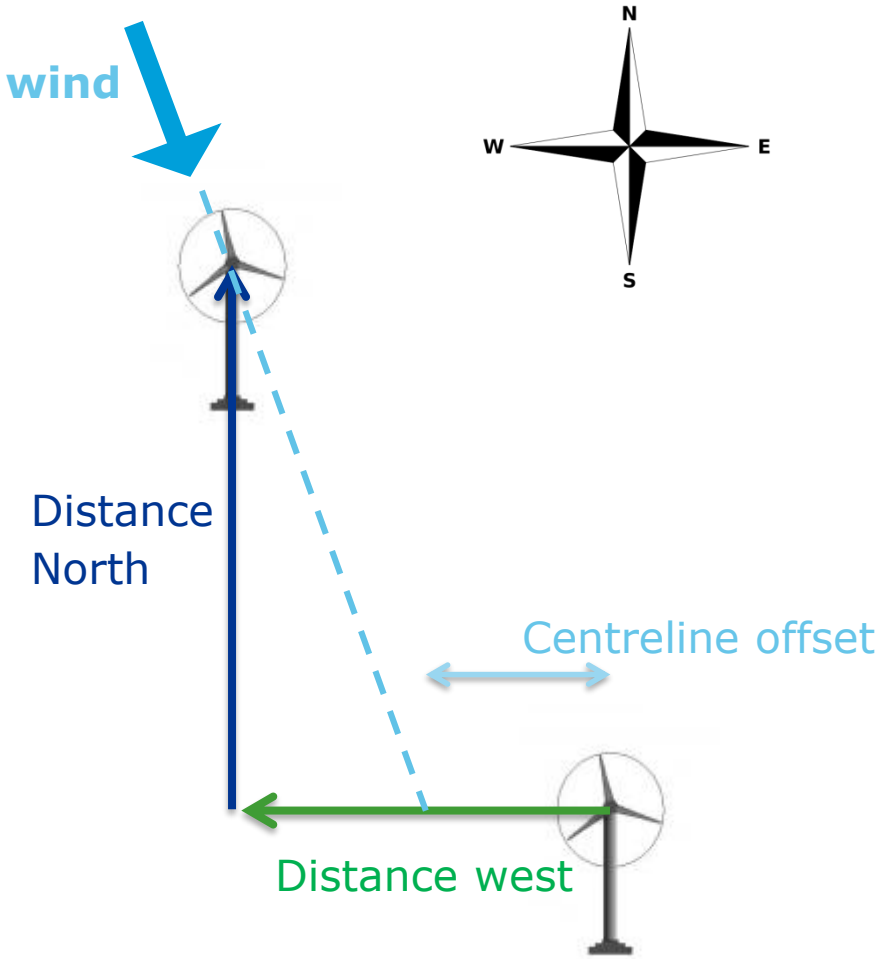
Bladed 4.8 - Set up in terms of eternal constants

Wake Definition	
Enable dynamic wake	☑
Distance of upstream turbine North	800 m
Distance of upstream turbine West	200 m
Relative hub height of upstream turbine	0 m
Use steady operational loads for wake deficit	☑
Aerodynamic information results set	
Steady operational loads aerodynamic informatior	P:\STP\Bladed\Dyna...
Meandering Wake	
Enable wake meandering	☐
Wind file for meandering wake	
Speed of wake propagation relative to ambient wi	80 %

Distance of upstream turbine West

Distance of turbine generating the wake relative to the modelled turbine in t



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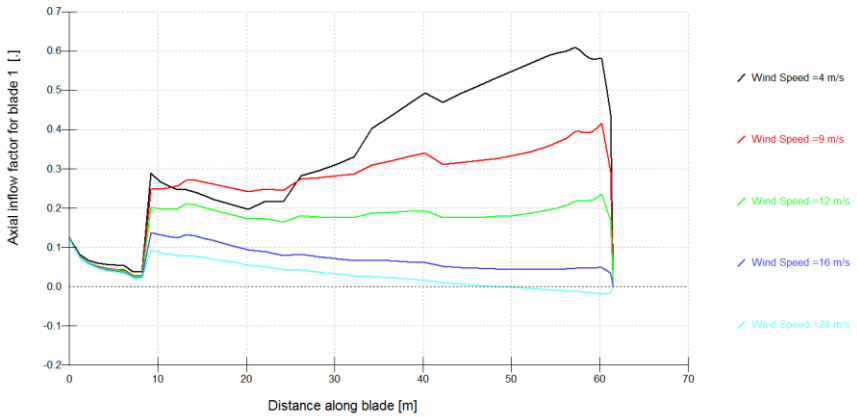
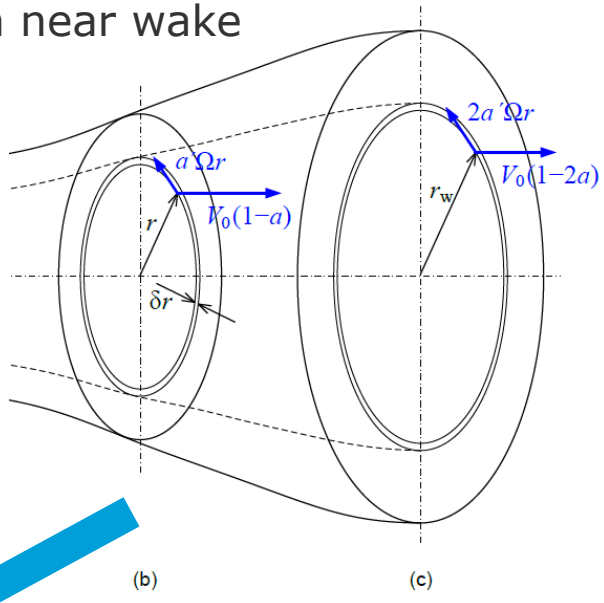
Wake Profile Propagation (Eddy-Viscosity)

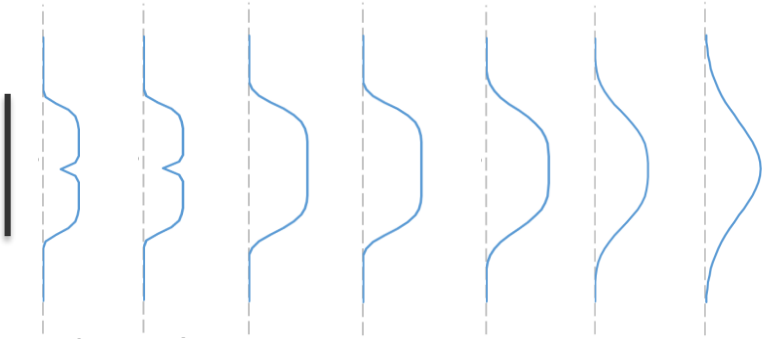
Initial wake profile generated from steady operational loads calculation



Expand in near wake



Propagate in far wake



Eddy-viscosity model – thin-shear layer approximation of Navier-Stokes equation

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial r}=\frac{1}{r}\frac{\partial}{\partial r}\left(\varepsilon r\frac{\partial u}{\partial r}\right)$$

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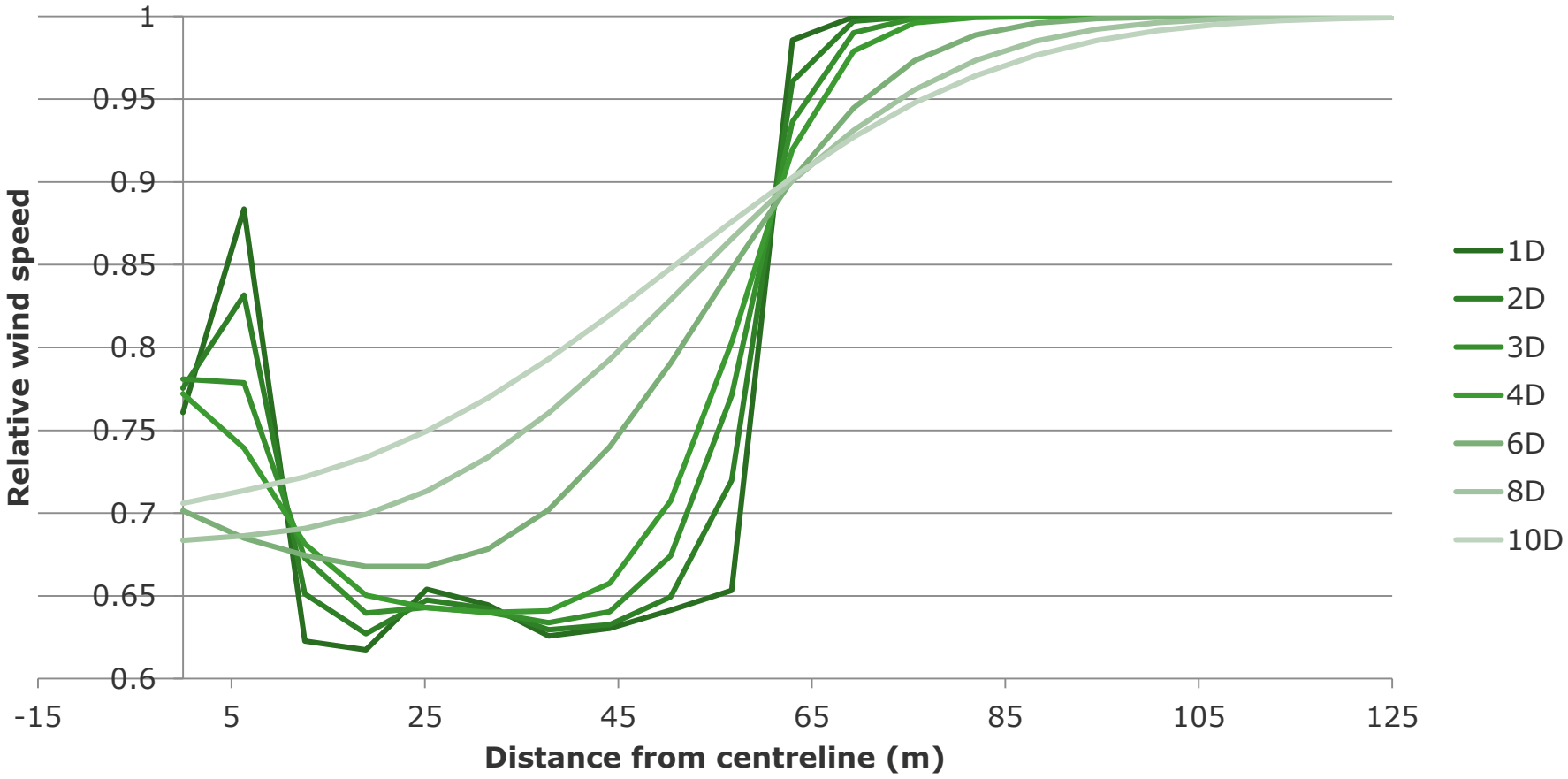
Example Wake Propagation



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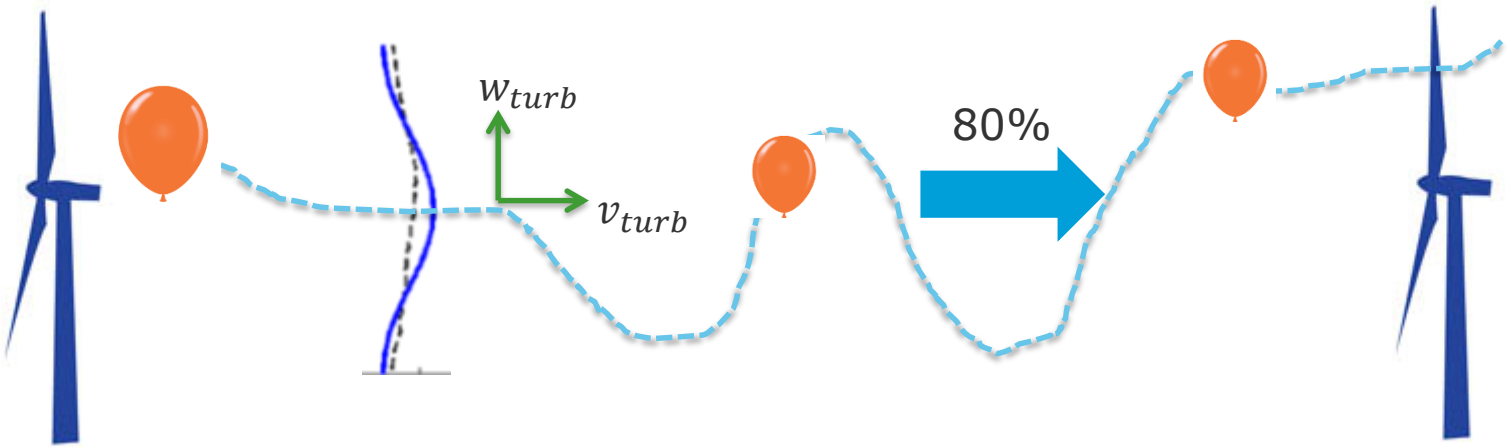
Meandering Wake

- Use low-pass filtered wind file to fluctuate the entire wake around in wind field
- Doesn't modify wake profile shape



$$\int dx = (U_{wake} + u'_{wake})dt$$

$$dy = v'_{wake}dt$$

$$dz = w'_{wake}dt$$

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Thanks you for attending

Keep in touch!

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