

EWIS

Being one of the leading institutes on wind energy research, ECN has established the new EWIS (ECN Wind Industrial Support) group in 2009 to better bring the R&D results to the market. During the last three decades, ECN has developed expertise on aerodynamics, structural analyses, turbine control, offshore operation and maintenance, and grid connection. With the growing wind industry, ECN received more requests for assistance and EWIS has become the vehicle to support the wind energy industry in their product developments.

EWIS's focus is on the high end of the market which means that we will make use of tools and knowledge that have been developed in-house and include the latest R&D results!

The EWIS team is a mixture of young professionals and experienced researchers which ensures a fast response and high quality.

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Bladmode

The Software

The computer program Bladmode has been developed for the prediction of the eigenmodes, frequencies, and aeroelastic damping of wind turbine rotor blades. The program is based on a description of a rotor blade following engineering bending theory of beams, in which torsional deformation and transverse shear flexibility as well as many aerodynamic and structural dynamic coupling terms for bending and torsion dynamics are included.

Because of its speed compared to time-domain codes and because for instance a power curve can already be calculated without developing/programming a variable speed controller, Bladmode can be used to analyse several design variants within a reasonable amount of time. Bladmode is therefore ideally suited for use in the pre-design phase of a rotor blade, or for performing fast sensitivity analyses.

The code of the program Bladmode is structured such that it can be used to analyse either:

- Eigenmodes and frequencies of blades without any aerodynamics.
- Aerodynamic performance of a rotor blade without structural dynamic properties.
- Solve the combined aerodynamic and structural dynamic state as required.

The Model

Following engineering theory of beams the structural mechanical properties of the beam/blade are a function of the span-wise coordinate only. In addition to the 'slender-beam' properties such as the distribution of sectional mass and bending stiffnesses (flat, edge, and coupling) the following blade properties are modelled in Bladmode:

- Transverse shear deformation of a cross section.
- Cross-sectional moments of inertia.
- Torsional stiffness and location of the shear centre.
- Location of the mass centre line.
- Bending-Torsion coupling terms following Karaolis and Tension-Torsion coupling (zero for conventional blades).
- Centrifugal effects (in lead-lag direction different from flap direction).

The flexibility of the pitch mechanism about the blade axis and the flapping flexibility of a hinge are implemented as edge constraints at the blade root.



Specifications

Description of Software:	- Bladmode executable - User manual - Directory with examples
Designated sites:	Single user (company)
Licence fee:	€ 7.000,--
Licence term:	unlimited use
Additional maintenance fee:	Optional additional maintenance consisting of an update of the software and support for one year with a maximum of 16 man-hours can be requested for € 2.500,-- per year.
Additional options:	A two-day training Aeroelasticity of wind turbines given by ECN experts is also available from EWIS.

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The structure of the algorithm is organised in the subsequent steps:

1. Analysis of the quasi-steady state, if applicable for a given wind speed. This quasi-steady state may include the deformed shape of the blade (with bending and torsion), the aerodynamic solution for a uniform wind, and the rotor speed with the associated blade pitch angle. Whether each of these aspects is included depends on the settings in the Bladmode input. For the aerodynamic solution the user may choose between a BEM (Blade Element Momentum theory) model and a vortex-wake model.
2. Analysis of the eigenmodes. Depending on the input settings, the eigenmodes include blade torsion or not. Also the response of the 1P gravity loading on a rotating blade is analysed, which is not an eigenmode but rather dominant for rotor blade dynamics.
3. Calculation of the aerodynamic damping for each of the eigenmodes. This damping can be calculated with or without dynamic stall model, while one can also choose between damping from the linearised aerodynamics and damping integrated for finite amplitude loops.

The option in Bladmode to solve the rotor-speed of the quasi-steady state uses a table with generator torque and pitch-angles as function of rotor speed. This replaces the need for a dedicated controller.

The Experience

Practical applications of Bladmode for wind turbine design are:

- Design of blade tip shape with smooth trailing vorticity, which is possible because of the vortex wake model.
- Calculation of power curve, without having the controller.
- Design of peak-shave pitch strategy.
- Calculation of dynamic rotor properties (rotor inertia, rotor frequencies, and partial load pitch strategy) which are required for wind turbine control design.

Licences for Bladmode have been sold to blade manufacturers who use the software to predict the dynamic behaviour of newly designed blades before they go into production. In a European study its prediction of the aerodynamic damping of rotor blades has been compared to results obtained with tools developed by other leading research institutes, showing very similar results.

Bladmode generates output that can be used as input for the SILANT program, which has been developed by ECN to predict wind turbine noise emissions.