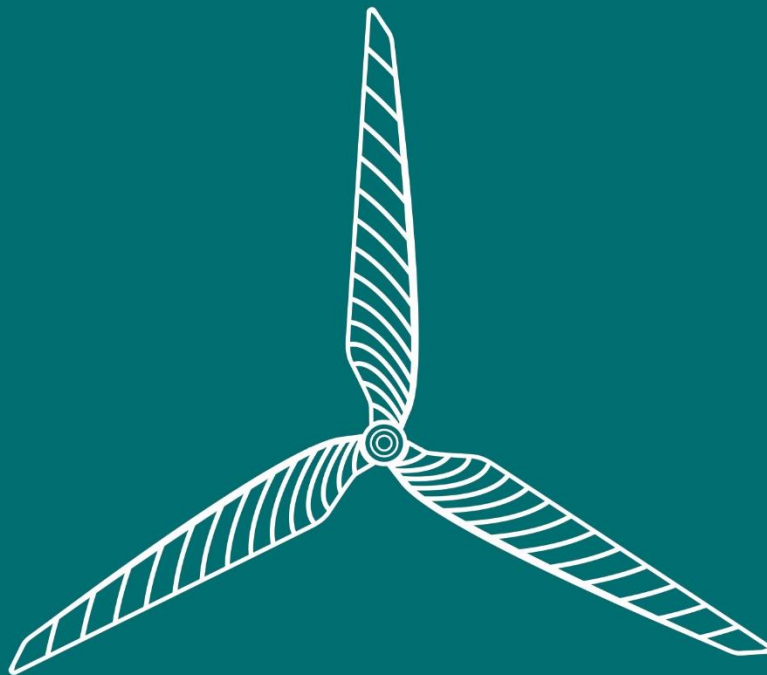# BLADED

Multi-Rotor user manual

Bladed Multi-Rotor User Manual

Version 1.0

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Contents

1   Overview of the multi-rotor functionality

A multi-rotor concept is a wind turbine that has multiple rotor nacelle assemblies (RNA) attached to a support structure. A rotor nacelle assembly consists of blades, hub, nacelle, transmission, and control system. The RNA attached to the support structure may be defined as a lattice structure or cross beams from a central monopile.

The multi-rotor user manual explains how to use the multi-rotor functionality in the Bladed. Here are the key assumptions made by Bladed.

- The input definition of each RNA is identical (for example, the blade mass, geometry, control strategies, etc.). Although, during the simulation dynamic response of each RNA will be modelled separately depending on the environmental conditions and control response.
- The external controller can be used to control each RNA individually.
- The aerodynamic interaction between the rotors is not modelled explicitly. The induction calculation assumes one turbine, and this may not be valid for multiple rotors. In addition, the wake interaction between multiple rotors is not considered.

This document begins with how to setup a model in Bladed. The modelling options are then described along with limitations. This documentation applies to Bladed 4.14 and later.

2   Setting up a multi-rotor model

The user will have to define the structure in the Tower screen such that it can accommodate the multiple rotors. Each rotor will need to be connected to a node that is used to define the geometry of the structure.

In the Bladed user interface navigate to the *Rotor* window. Once this window is open increase the "Number of rotors" by the desired amount.
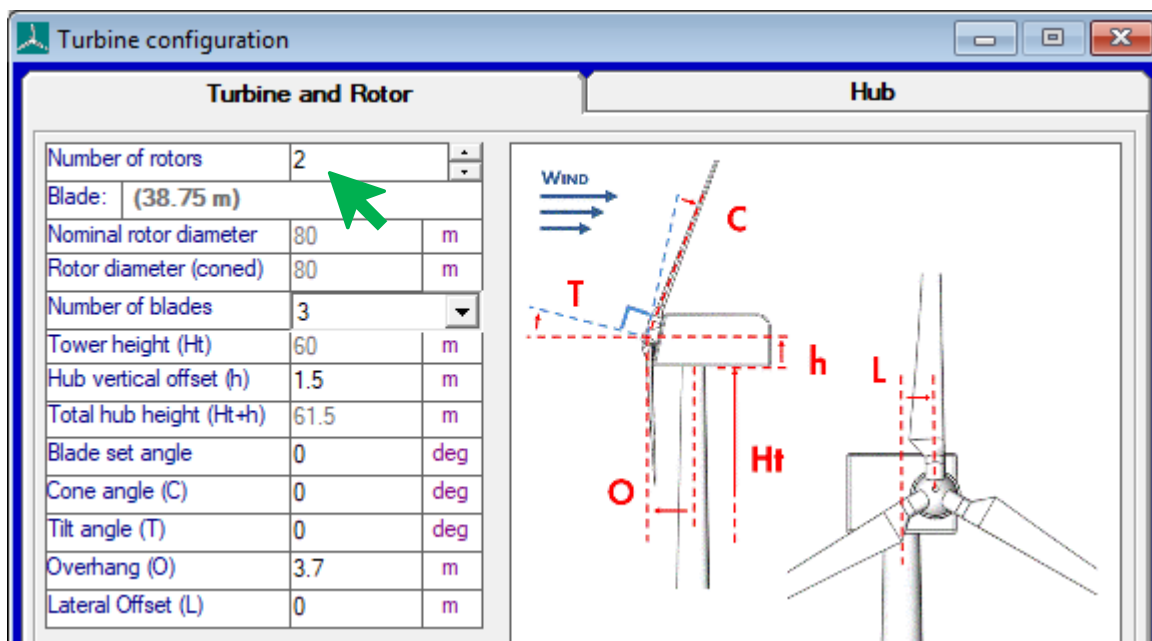
Next, open the *Tower* window. To use the multi-rotor functionality, it is necessary to specify the tower geometry using the "multi-member" tower option.
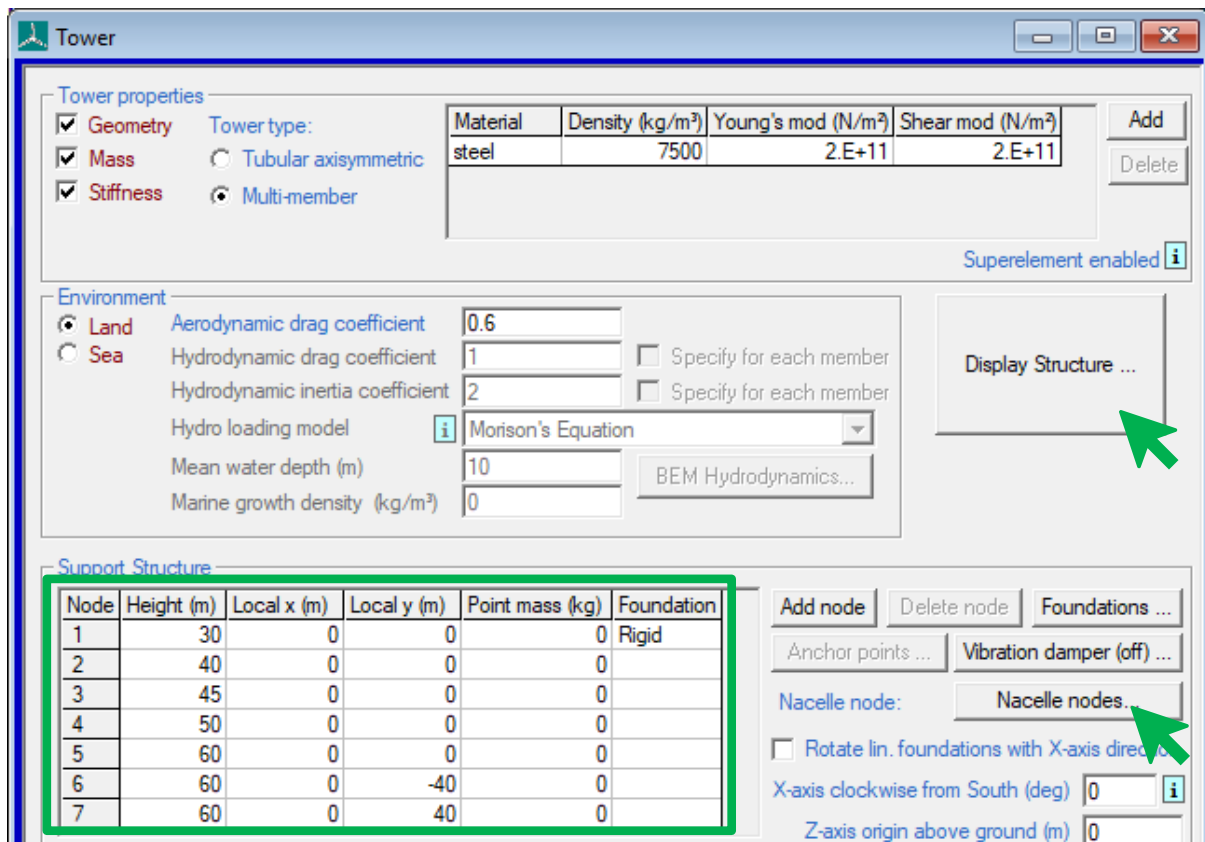
Once the structure geometry is well defined the user should specify the nacelle nodes for each rotor. By clicking on the "Nacelle nodes…" button in the Tower screen another window will open. There will be an entry for each rotor. The user should specify the appropriate nacelle node that the rotor will be "connected" to.
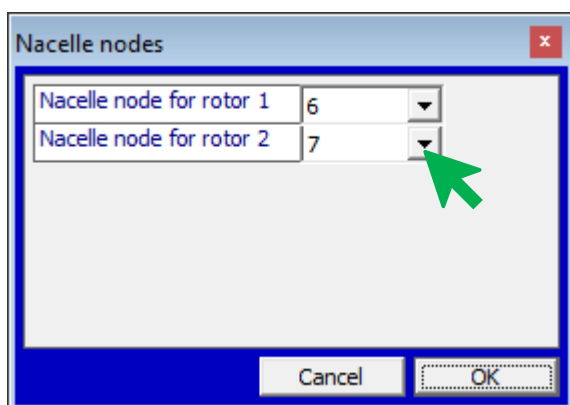
Once the edits have been completed successfully the user can check the structure by clicking on the "Display Structure …" button.
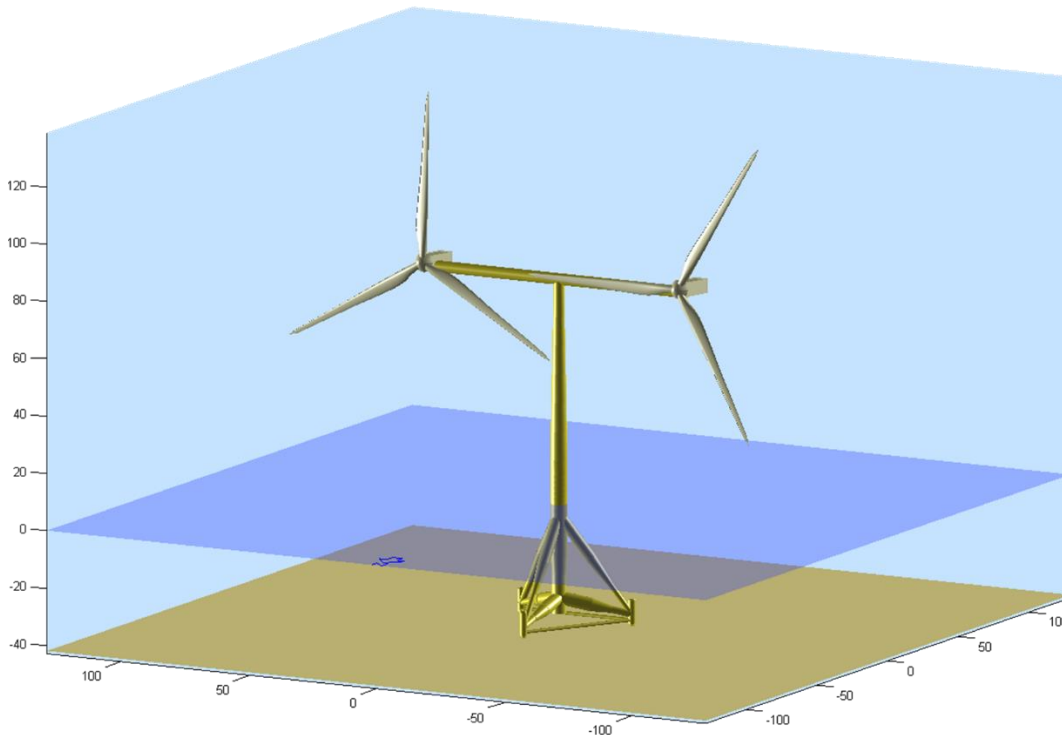
After the turbine is well defined, user needs to set the Project Info data to introduce the new rotor(s) to the Bladed calculation code. Details of it is presented in the next section.

3 Modelling options

3.1 Project info set up

This section will explain how to set up Project Info data for multi-rotor turbines. For more information, please refer to *"Bladed Project Info Options"*.

In Bladed user interface, navigate to the *File* window. Once it is open select *Project info*, check the box in front of the *Turbine calculations (dtbladed.exe)* and use the *Define* button to open the *Non-standard options* window to introduce the properties of the new rotor(s) to bladed.
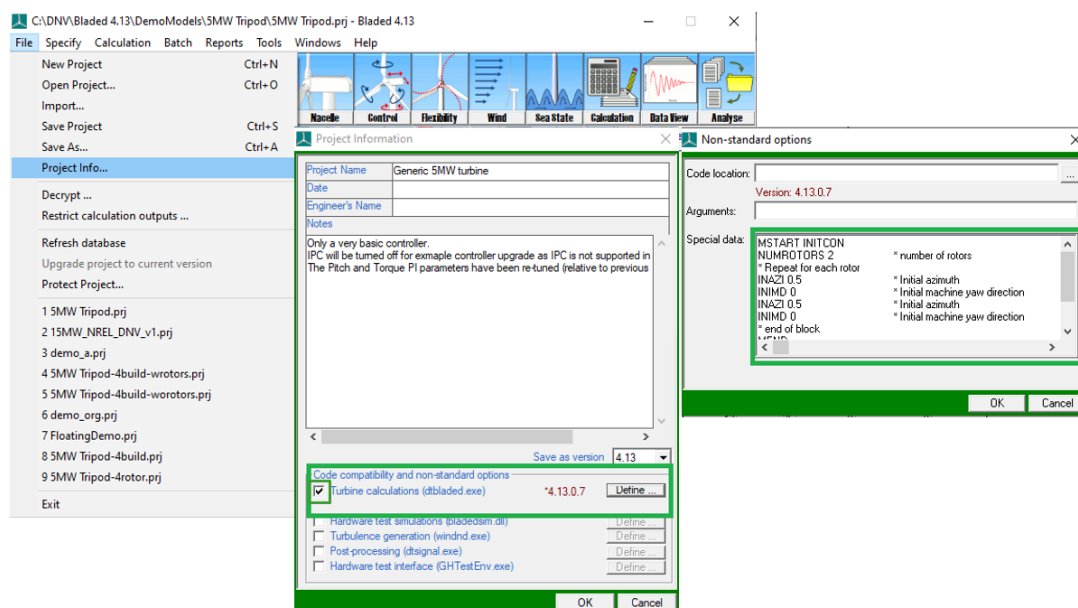
3.2 Commands

To initialize new rotor(s) following commands can be used in the project info file.

Initial azimuth angle (power production)

The initial azimuth angle can be set per rotor. For example, with two rotors

```
MSTART EXTRA
MULTIINITAZI 0.1, 1.5     * Initial azimuth angles (radians) for each
*rotor
MEND
```

Rotor rotational directions

The rotational direction can be specified for each rotor. For example, with two rotors

```
MSTART EXTRA
MULTIROTORDIRS C,A        * Direction of each rotor (C = clockwise, A =
anti-clockwise)
MEND
```

Note that the first rotor direction in MULTIROTORDIRS must be the same as the rotor direction specified in the UI to ensure correct elastic axis information is passed to the UI.

Sign convention for counter-rotating rotors:

- **Rotor speed** should generally be positive during operation. The rotor speed is defined as positive in the direction of expected rotation when operating. **Rotor torque** should generally be positive during operation for the same reason.

- For upstream rotors, the x direction is downstream, so hub Mx is clockwise when viewed from upstream (for both clockwise and anticlockwise rotors). **Rotating hub Mx** should take an opposite sign for the clockwise and anticlockwise rotors.

3.3 Yaw Bearing

For single rotor turbines Bladed provides yaw bearing options to rotate the RNA. However, for multi-rotor turbines it may not be possible to rotate the RNAs individually to avoid tower strike. Alternatively, yaw bearing may be mounted midway along the tower such that the RNAs collectively rotate with a section of the support structure.

Bladed provides the facility for users to model a tower base geared yaw bearing in single or multi-rotor turbines that can be used to collectively rotate the RNAs. This is modelled within the Bladed multibody structural model. This functionality, is available in Bladed 4.11 and later, is activated via a new module written into project info. For more information, please refer to *Bladed Tower Base Geared Yaw Bearing User Manual.*

3.4 Turbine faults

This section will explain how Bladed handle fault cases with multi-rotor functionality.

Pitch faults can be applied to either a single or all rotors on a multi-rotor turbine. The following project info command can be used to limit the faults to any one rotor.

```
MSTART EXTRA
FaultOnRotorNum 2
MEND
```

Grid loss applies to all rotors present in the configuration. Generator short circuit fault only applies to rotor number 1, it cannot be applied to multiple rotors. In addition, fault cases can also be handled via the external controller.

3.5 Controller options

For versions prior to 4.13, Bladed internal controller can be used however same control gains will apply to rotors and it is not possible to control rotors individually. Internal controller feature is not supported from version 4.13 and onwards.

External controller can be used to control the rotors. External controller can be set in a such way that rotors can be controlled either separately or together. Following commands can be used to distinguish between different rotors onNacelleN, …onHubN etc. For more information, please refer to *External Controller User Manual.*

3.6 Output groups

All output groups related to the rotor are repeated for each rotor (blade, hub, drivetrain, …).
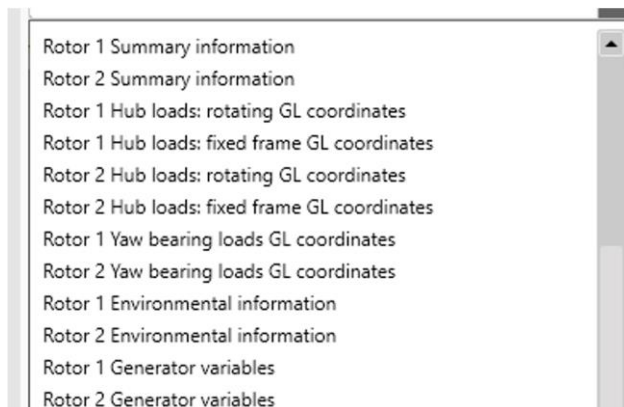
3.7 Defining the Wind

This section will explain how to define wind for multi-rotor structure.

While applying **3D Turbulent wind** to turbines in Bladed, the lateral centre of the turbulent field is y=0 in the global coordinate system. However, the vertical centre depends on the option selected in the user interface. These are *Centred on hub height* and *Best fit for rotor and tower.*

- **Centred on hub height:** The centre of the turbulent wind field is placed at hub height. In case of rotors placed in different hub heights, Bladed will automatically select the largest hub height.

- **Best fit for rotor and tower:** If the turbulence field vertical dimension is less than the height of the turbine, the top of the turbulence field will be located at the height of the top of the rotor, so that the turbulence field extends as far down the tower as possible. If there are rotors at different hub heights, the turbine's height is computed based on the rotor at the highest point. If the turbulence field vertical dimension is greater than the turbine height, the turbulence field will start at ground level and will envelop the whole turbine.

Other wind definitions, such as **No Variation**, **Single Point History**, and **Transients**, might require users to perform some geometric calculations to determine which node to match the time series in order for the hub flow speed to match the measured time series.

3.8   Unsupported Options

The following features are not compatible with the multirotor calculation and are therefore not supported when used with a multirotor model:

1. Simulations using the BHTM module.
2. Simulations using the following external interfaces:
   a. Pitch DLL,
   b. Generator DLL, and
   c. 1DOF & 6DOF gearbox DLL.