Multibody Diagrams

1 INTRODUCTION

Since version 4.0, Bladed uses a Multibody dynamics approach. This approach consists of connecting many independent “bodies” or “components” together to represent the dynamics of a complex system.

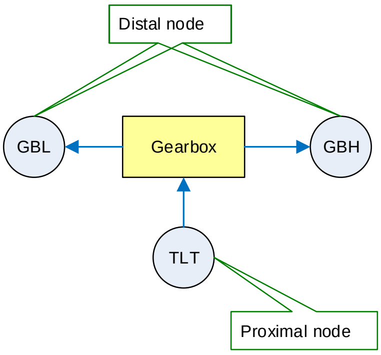
Each component has one or more of the following properties:

- Rotational or translational flexibility
- Rigid rotation and translation
- Mass and Inertia

Components are connected to one another with “nodes”. Each node has fully defined kinematics at all times. Structural motion is typically outputted at the nodes.

The Multibody formulation in Bladed is a tree structure, which means that it has no closed loops. Each component has:

- One **proximal** node on the *inboard* side of the component.
- Any number of **distal** nodes on the *outboard* side of the component.



The mathematical descriptions of the components describe the physical relationships between the proximal and distal nodes of each component.

2 KEY

2.1 Components

Ground	Fixes the inertial frame reference for the structure. The only component with no proximal node.
Node	Connects different components together. Each node has fully defined kinematics and orientation.
Rigid link	A rigid translation and orientation offset between the component's proximal node and its distal nodes.
Rigid body	Mass and inertia defined in relation to a single point (node).
Hinge	Single degree of freedom rotational flexibility.
Slider	Single degree of freedom translational flexibility.
Free joint	Six degree of freedom (3 translational and 3 rotational) flexibility.
Gearbox	A single rotational degree of freedom between the mounting and one distal node. The first and second distal nodes (low-speed and high-speed shafts) have kinematics related by a fixed (gear) ratio.
Flexible body	The most complex component, used to represent towers and blades, which is made up of a system of linear finite element beams each with full stiffness and mass definitions. Modal reduction is used to reduce the number of degrees of freedom of the complete component.
Optional	Dashed perimeter indicates that the component may or may not exist dependent on an option in the Bladed user interface. E.g. '*Low speed shaft torsional flexibility*' in the power train screen adds the '*LSS Flexibility*' hinge component. The colour depends on what type of component is selected.

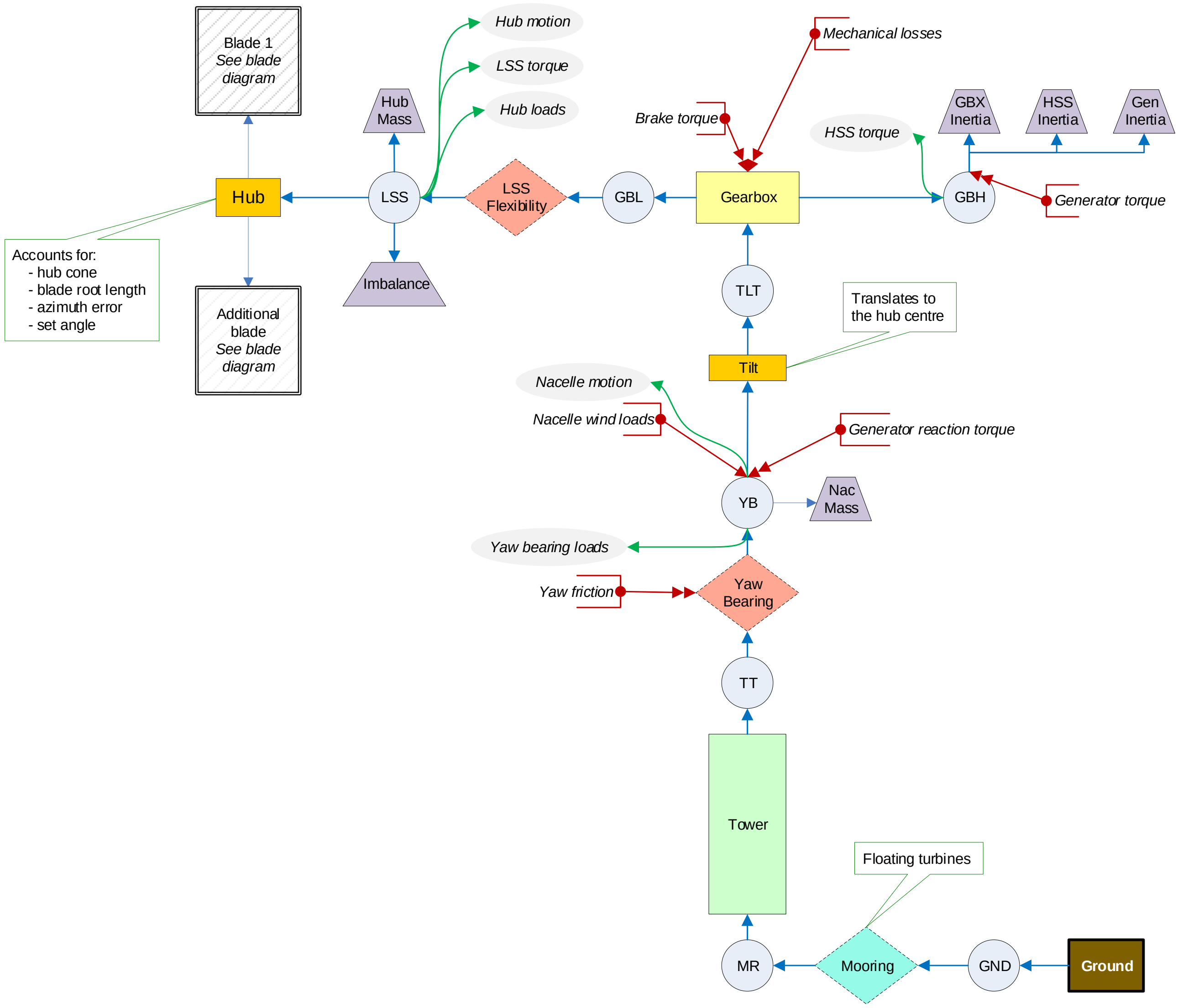
2.2 Applied Loads and Outputs

<table>
<tr><td>Applied force or load</td><td>An external force applied on the structural system</td><td rowspan="2">Loads can be applied either:
• Between a component and node
• As a stress across a component flexibility, which is defined as an action and equal reaction load on each side of the flexibility</td></tr>
<tr><td>Applied torque</td><td>An external torque applied on the structural system</td></tr>
</table>

	Output kinematics or loads. These can either come from a node, or from a flexibility within a component. In the latter it is the stress or relative kinematics across the flexibility.

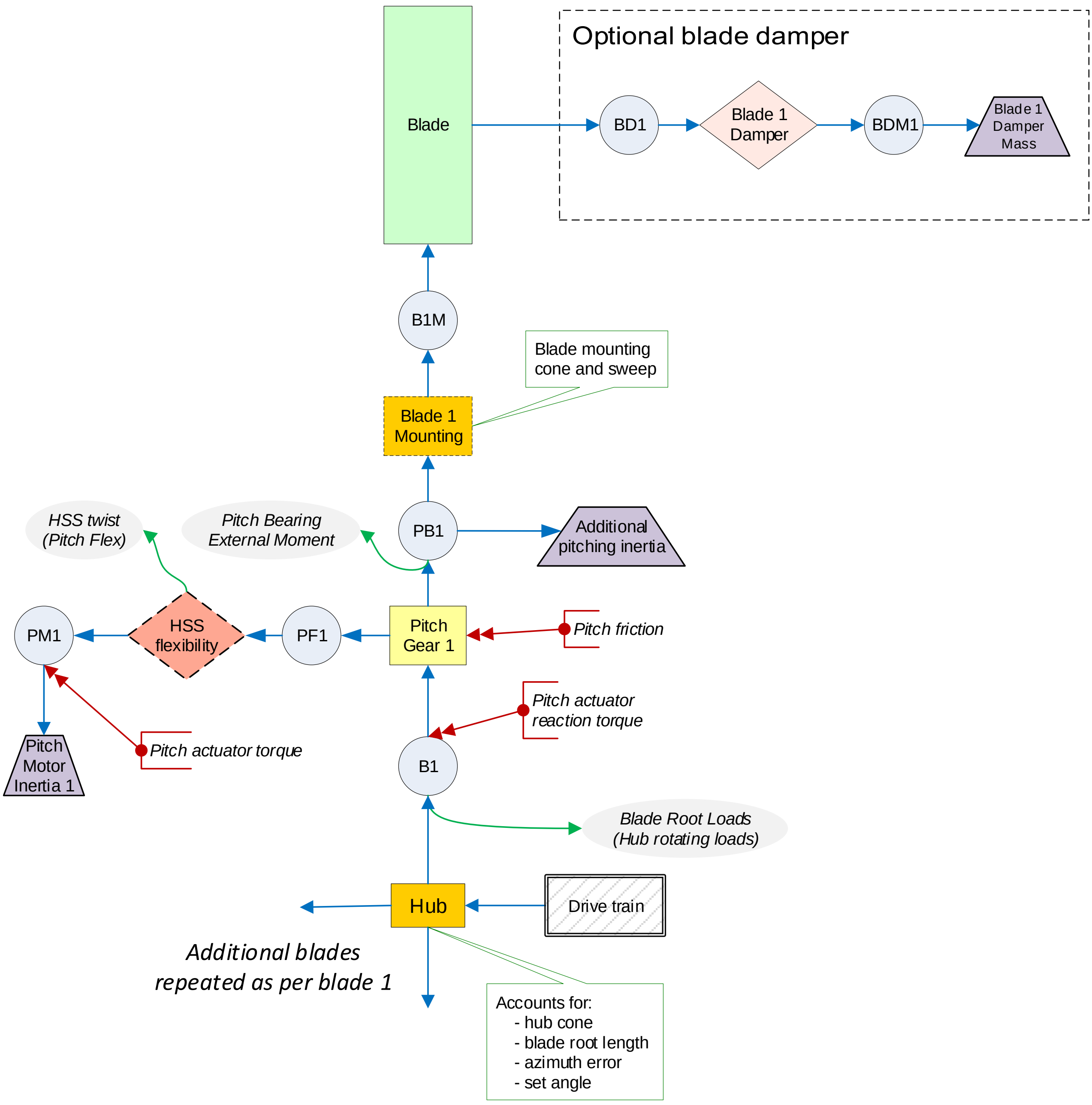
3 TURBINE DIAGRAM

This is the complete model (excluding blades) of a typical turbine configuration with many optional features disabled.



4 BLADE DIAGRAM

This is a detailed diagram of one blade including the pitch actuator system



5 DETAILED DRIVE-TRAIN DIAGRAM

This is a complete diagram of the drive train with the majority of drive train flexibilities turned on.