4.8.2. Input Files

The user configures the structural model parameters via a primary ElastoDyn input file, as well as separate input files for the tower and *other stuff that will be documented here later.*

No lines should be added or removed from the input files.

4.8.2.1. Units

ElastoDyn uses the SI system (kg, m, s, N). Angles are assumed to be in radians unless otherwise specified.

4.8.2.2. ElastoDyn Primary Input File

The primary ElastoDyn input file defines modeling options and geometries for the OpenFAST structure including the tower, nacelle, drivetrain, and blades (if BeamDyn is not used). It also sets the initial conditions for the structure.

4.8.2.2.1. Simulation Control

Set the **Echo** flag to TRUE if you wish to have ElastoDyn echo the contents of the ElastoDyn primary, airfoil, and blade input files (useful for debugging errors in the input files). The echo file has the naming convention of *OutRootFile.ED.ech*. **OutRootFile** is either specified in the I/O SETTINGS section of the driver input file when running ElastoDyn standalone, or by the OpenFAST program when running a coupled simulation.

Method

dT

4.8.2.2.2. Degrees of Freedom

FlapDOF1 - First flapwise blade mode DOF (flag)

FlapDOF2 - Second flapwise blade mode DOF (flag)

EdgeDOF - First edgewise blade mode DOF (flag)

TeetDOF - Rotor-teeter DOF (flag) [unused for 3 blades]

DrTrDOF - Drivetrain rotational-flexibility DOF (flag)

GenDOF - Generator DOF (flag)

YawDOF - Yaw DOF (flag)

TwFADOF1 - First fore-aft tower bending-mode DOF (flag)

TwFADOF2 - Second fore-aft tower bending-mode DOF (flag)

TwSSDOF1 - First side-to-side tower bending-mode DOF (flag)

TwSSDOF2 - Second side-to-side tower bending-mode DOF (flag)

PtfmSgDOF - Platform horizontal surge translation DOF (flag)

PtfmSwDOF - Platform horizontal sway translation DOF (flag)

PtfmHvDOF - Platform vertical heave translation DOF (flag)

PtfmRDOF - Platform roll tilt rotation DOF (flag)

PtfmPDOF - Platform pitch tilt rotation DOF (flag)

PtfmYDOF - Platform yaw rotation DOF (flag)

4.8.2.2.3. Initial Conditions

OoPDefl - Initial out-of-plane blade-tip displacement (meters)

IPDefl - Initial in-plane blade-tip deflection (meters)

BlPitch(1) - Blade 1 initial pitch (degrees)

BlPitch(2) - Blade 2 initial pitch (degrees)

BlPitch(3) - Blade 3 initial pitch (degrees) [unused for 2 blades]

TeetDefl - Initial or fixed teeter angle (degrees) [unused for 3 blades]

Azimuth - Initial azimuth angle for blade 1 (degrees)

RotSpeed - Initial or fixed rotor speed (rpm)

NacYaw - Initial or fixed nacelle-yaw angle (degrees)

TTDspFA - Initial fore-aft tower-top displacement (meters)

TTDspSS - Initial side-to-side tower-top displacement (meters)

PtfmSurge - Initial or fixed horizontal surge translational displacement of platform (meters)

PtfmSway - Initial or fixed horizontal sway translational displacement of platform (meters)

PtfmHeave - Initial or fixed vertical heave translational displacement of platform (meters)

PtfmRoll - Initial or fixed roll tilt rotational displacement of platform (degrees)

PtfmPitch - Initial or fixed pitch tilt rotational displacement of platform (degrees)

PtfmYaw - Initial or fixed yaw rotational displacement of platform (degrees)

4.8.2.2.4. Turbine Configuration

NumBl - Number of blades (-)

TipRad - The distance from the rotor apex to the blade tip (meters)

HubRad - The distance from the rotor apex to the blade root (meters)

PreCone(1) - Blade 1 cone angle (degrees)

PreCone(2) - Blade 2 cone angle (degrees)

PreCone(3) - Blade 3 cone angle (degrees) [unused for 2 blades]

HubCM - Distance from rotor apex to hub mass [positive downwind] (meters)

UndSling - Undersling length [distance from teeter pin to the rotor apex] (meters) [unused for 3 blades]

Delta3 - Delta-3 angle for teetering rotors (degrees) [unused for 3 blades]

AzimB1Up - Azimuth value to use for I/O when blade 1 points up (degrees); for floating MHK turbines, blade 1 will be pointed up (opposite gravity) when *AzimB1Up* = 0; the user can set *AzimB1Up* to 180 degrees to give the same azimuth convention relative to the tower for floating MHK turbines as for fixed MHK turbines

OverHang - Distance from yaw axis to rotor apex [3 blades] or teeter pin [2 blades] (meters)

ShftGagL - Distance from rotor apex [3 blades] or teeter pin [2 blades] to shaft strain gages [positive for upwind rotors] (meters)

ShftTilt - Rotor shaft tilt angle (degrees)

NacCMxn - Downwind distance from the tower-top to the nacelle CM (meters)

NacCMyn - Lateral distance from the tower-top to the nacelle CM (meters)

NacCMzn - Vertical distance from the tower-top to the nacelle CM, typically negative for floating MHK turbines (meters)

NcIMUxn - Downwind distance from the tower-top to the nacelle IMU (meters)

NcIMUyn - Lateral distance from the tower-top to the nacelle IMU (meters)

NcIMUzn - Vertical distance from the tower-top to the nacelle IMU, typically negative for floating MHK turbines (meters)

Twr2Shft - Vertical distance from the tower-top to the rotor shaft, typically negative for floating MHK turbines (meters)

TowerHt - Height of tower relative to ground level [onshore], MSL [offshore wind or floating MHK], or seabed [fixed MHK] (meters)

TowerBsHt - Height of tower base relative to ground level [onshore], MSL [offshore wind or floating MHK], or seabed [fixed MHK] (meters)

PtfmCMxt - Downwind distance from the ground level [onshore], MSL [offshore wind or floating MHK], or seabed [fixed MHK] to the platform CM (meters)

PtfmCMyt - Lateral distance from the ground level [onshore], MSL [offshore wind or floating MHK], or seabed [fixed MHK] to the platform CM (meters)

PtfmCMzt - Vertical distance from the ground level [onshore], MSL [offshore wind or floating MHK], or seabed [fixed MHK] to the platform CM (meters)

PtfmRefzt - Vertical distance from the ground level [onshore], MSL [offshore wind or floating MHK], or seabed [fixed MHK] to the platform reference point (meters)

4.8.2.2.5. Mass and Inertia

TipMass(1) - Tip-brake mass, blade 1 (kg)

TipMass(2) - Tip-brake mass, blade 2 (kg)

TipMass(3) - Tip-brake mass, blade 3 (kg) [unused for 2 blades]

HubMass - Hub mass (kg)

HubIner - Hub inertia about rotor axis [3 blades] or teeter axis [2 blades] (kg m^2)

GenIner - Generator inertia about HSS (kg m^2)

NacMass - Nacelle mass (kg)

NacYIner - Nacelle inertia about yaw axis (kg m^2)

YawBrMass - Yaw bearing mass (kg)

PtfmMass - Platform mass (kg)

PtfmRIner - Platform inertia for roll tilt rotation about the platform CM (kg m^2)

PtfmPIner - Platform inertia for pitch tilt rotation about the platform CM (kg m^2)

PtfmYIner - Platform inertia for yaw rotation about the platform CM (kg m^2)

4.8.2.2.6. Blade

BldNodes - Number of blade nodes (per blade) used for analysis (-)

BldFile(1) - Name of file containing properties for blade 1 (quoted string)

BldFile(2) - Name of file containing properties for blade 2 (quoted string)

BldFile(3) - Name of file containing properties for blade 3 (quoted string) [unused for 2 blades]

4.8.2.2.7. Rotor-Teeter

TeetMod - Rotor-teeter spring/damper model {0: none, 1: standard, 2: user-defined from routine UserTeet} (switch) [unused for 3 blades]

TeetDmpP - Rotor-teeter damper position (degrees) [used only for 2 blades and when TeetMod=1]

TeetDmp - Rotor-teeter damping constant (N-m/(rad/s)) [used only for 2 blades and when TeetMod=1]

TeetSStP - Rotor-teeter soft-stop position (degrees) [used only for 2 blades and when TeetMod=1]

TeetHStP - Rotor-teeter hard-stop position (degrees) [used only for 2 blades and when TeetMod=1]

TeetSSSp - Rotor-teeter soft-stop linear-spring constant (N-m/rad) [used only for 2 blades and when TeetMod=1]

TeetHSSp - Rotor-teeter hard-stop linear-spring constant (N-m/rad) [used only for 2 blades and when TeetMod=1]

4.8.2.2.8. Yaw-Friction

YawFrctMod - Yaw-friction model {0: none, 1: does not use Fz at yaw bearing, 2: does, 3: user defined model}

M_CSmax - Maximum Coulomb friction torque (N-m)[Fz*mu_s*D_eff when YawFrctMod=1 and mu_s*D_eff when YawFrctMod=2]

M_CD - Dynamic friction moment at null yaw rate (N-m) [Fz*mu_d*D_eff when YawFrctMod=1 and mu_d*D_eff when YawFrctMod=2]

sig_v - Viscous friction coefficient (N-m/(rad/s))

4.8.2.2.9. Drivetrain

GBoxEff - Gearbox efficiency (%)

GBRatio - Gearbox ratio (-)

DTTorSpr - Drivetrain torsional spring (N-m/rad)

DTTorDmp - Drivetrain torsional damper (N-m/(rad/s))

4.8.2.2.10. Furling

Furling - Read in additional model properties for furling turbine (flag) [must currently be FALSE)

FurlFile - Name of file containing furling properties (quoted string) [unused when Furling=False] An example of furling input file is given in Section 4.8.2.3.

4.8.2.2.11. Tower

TwrNodes - Number of tower nodes used for analysis (-)

TwrFile - Name of file containing tower properties (quoted string)

4.8.2.2.12. Outputs

SumPrint [flag] Set this value to TRUE if you want ElastoDyn to generate a summary file with the name **OutFileRoot**.ED.sum*. **OutFileRoot** is specified by the OpenFAST program when running a coupled simulation.

OutFile [switch] is currently unused. The eventual purpose is to allow output from ElastoDyn to be written to a module output file (option 1), or the main OpenFAST output file (option 2), or both. At present this switch is ignored.

TabDelim [flag] is currently unused. Setting this to True will set the delimeter for text files to the tab character for the ElastoDyn module **OutFile**.

OutFmt [quoted string] is currently unused. ElastoDyn will use this string as the numerical format specifier for output of floating-point values in its local output specified by **OutFile**. The length of this string must not exceed 20 characters and must be enclosed in apostrophes or double quotes. You may not specify an empty string. To ensure that fixed-width column data align properly with the column titles, you should ensure that the width of the field is 10 characters. Using an E, EN, or ES specifier will guarantee that you will never overflow the field because the number is too big, but such numbers are harder to read. Using an F specifier will give you numbers that are easier to read, but you may overflow the field. Please refer to any Fortran manual for details for format specifiers.

TStart [s] sets the start time for **OutFile**. This is currenlty unused.

DecFact [-] This parameter sets the decimation factor for output. ElastoDyn will output data to **OutFile** only once each DecFact integration time steps. For instance, a value of 5 will cause ElastoDyn to generate output only every fifth time step. This value must be an integer greater than zero.

NTwGages [-] The number of strain-gage locations along the tower indicates the number of input values on the next line. Valid values are integers from 0 to 5 (inclusive).

TwrGagNd [-] The virtual strain-gage locations along the tower are assigned to the tower analysis nodes specified on this line. Possible values are 1 to TwrNodes (inclusive), where 1 corresponds to the node closest to the tower base (but not at the base) and a value of TwrNodes corresponds to the node closest to the tower top. The exact elevations of each analysis node in the undeflected tower, relative to the base of the tower, are determined as follows:

Elev. of node J = TwrRBHt + (J – ½) • [(TowerHt + TwrDraft – TwrRBHt) / TwrNodes]

(for J = 1,2,…,TwrNodes)

You must enter at least NTwGages values on this line. If NTwGages is 0, this line will be skipped, but you must have a line taking up space in the input file. You can separate the values with combinations of tabs, spaces, and commas, but you may use only one comma between numbers.

NBlGages [-] specifies the number of strain-gague locations along the blade, and indicates the number of input values expected in **BldGagNd**. This is only used when the blade structure is modeled in ElastoDyn.

BldGagNd [-] specifies the virtual strain-gage locations along the blade that should be output. Possible values are 1 to **BldNodes** (inclusive), where 1 corresponds to the node closest to the blade root (but not at the root) and a value of BldNodes corresponds to the node closest to the blade tip. The node locations are specified by the ElastoDyn blade input files. You must enter at least NBlGages values on this line. If NBlGages is 0, this line will be skipped, but you must have a line taking up space in the input file. You can separate the values with combinations of tabs, spaces, and commas, but you may use only one comma between numbers. This is only used when the blade structure is modeled in ElastoDyn.

The **OutList** section controls output quantities generated by ElastoDyn. Enter one or more lines containing quoted strings that in turn contain one or more output parameter names. Separate output parameter names by any combination of commas, semicolons, spaces, and/or tabs. If you prefix a parameter name with a minus sign, "-", underscore, "_", or the characters "m" or "M", ElastoDyn will multiply the value for that channel by –1 before writing the data. The parameters are written in the order they are listed in the input file. ElastoDyn allows you to use multiple lines so that you can break your list into meaningful groups and so the lines can be shorter. You may enter comments after the closing quote on any of the lines. Entering a line with the string "END" at the beginning of the line or at the beginning of a quoted string found at the beginning of the line will cause ElastoDyn to quit scanning for more lines of channel names. Blade and tower node-related quantities are generated for the requested nodes identified through the **BldGagNd** and **TwrGagNd** lists above. If ElastoDyn encounters an unknown/invalid channel name, it warns the users but will remove the suspect channel from the output file. Please refer to the ElastoDyn tab in the Excel file OutListParameters.xlsx for a complete list of possible output parameters.

4.8.2.2.13. Nodal Outputs

In addition to the named outputs in Section 4.8.2.2.12 above, ElastoDyn allows for outputting the full set blade node motions and loads (tower nodes unavailable at present). Please refer to the ElastoDyn_Nodes tab in the Excel file OutListParameters.xlsx for a complete list of possible output parameters.

This section follows the *END* statement from normal Outputs section described above, and includes a separator description line followed by the following optinos.

BldNd_BladesOut specifies the number of blades to output. Possible values are 0 through the number of blades ElastoDyn is modeling. If the value is set to 1, only blade 1 will be output, and if the value is 2, blades 1 and 2 will be output.

BldNd_BlOutNd specifies which nodes to output. This is currently unused.

The **OutList** section controls the nodal output quantities generated by ElastoDyn. In this section, the user specifies the name of the channel family to output. The output name for each channel is then created internally by ElastoDyn by combining the blade number, node number, and channel family name. For example, if the user specifies **TDx** as the channel family name, the output channels will be named with the convention of **B**β**N###TDx** where β is the blade number, and **###** is the three digit node number.

4.8.2.2.13.1. Sample Nodal Outputs section

This sample includes the `END` statement from the regular outputs section.

```
END of input file (the word "END" must appear in the first 3 columns of this last OutList line)
---------------------- NODE OUTPUTS --------------------------------------------
          3   BldNd_BladesOut  - Blades to output
         99   BldNd_BlOutNd    - Blade nodes on each blade (currently unused)
              OutList     - The next line(s) contains a list of output parameters. See OutListParameters.xlsx, ElastoDyn_Nodes tab for a listing of available output channels, (-)
"ALx"    -  local flapwise acceleration (absolute) of node
"ALy"    - local flapwise acceleration (absolute) of node
"ALz"    - local flapwise acceleration (absolute) of node
"TDx"    - local flapwise (translational) deflection (relative to the undeflected position) of node
"TDy"    - local edgewise (translational) deflection (relative to the undeflected position) of node
"TDz"    - local axial (translational) deflection (relative to the undeflected position) of node
"RDx"    - Local rotational displacement about x-axis (relative to undeflected)
"RDy"    - Local rotational displacement about y-axis (relative to undeflected)
"RDz"    - Local rotational displacement about z-axis (relative to undeflected)
"MLx"    - local edgewise moment at node
"MLy"    - local flapwise moment at node
"MLz"    - local pitching moment at node
"FLx"    - local flapwise shear force at node
"FLy"    - local edgewise shear force at node
"FLz"    - local axial force at node
"MLxNT"  - Edgewise moment in local coordinate system (initial structural twist removed)
"MlyNT"  - Flapwise shear moment in local coordinate system (initial structural twist removed)
"FLxNT"  - Flapwise shear force in local coordinate system (initial structural twist removed)
"FlyNT"  - Edgewise shear force in local coordinate system (initial structural twist removed)
END of input file (the word "END" must appear in the first 3 columns of this last OutList line)
-------------------------------------------------------------------------------------
```

4.8.2.3. ElastoDyn furl input file

This section describes the furl input file indicated by the input `FurlFile` from the ElastoDyn input file. OpenFAST will only read this file if the model is designated as a furling machine (when Furling from the primary input file is set to True). The input file defines the geometry and stuctural properties of the rotor-furl and tail-furl.

The rotor-furl and tail-turl coordinate systems and the geometrical inputs are described in Section 4.8.1.1 and Section 4.8.1.2, respectively.

An example of ElastoDyn furl input file is provided below:

```
---------------------- FAST FURLING FILE ---------------------------------------
Comment
---------------------- FEATURE FLAGS (CONT) ------------------------------------
False        RFrlDOF     - Rotor-furl DOF (flag)
True         TFrlDOF     - Tail-furl DOF (flag)
---------------------- INITIAL CONDITIONS (CONT) -------------------------------
   0.0       RotFurl     - Initial or fixed rotor-furl angle (deg)
   0.0       TailFurl    - Initial or fixed tail-furl angle (deg)
---------------------- TURBINE CONFIGURATION (CONT) ----------------------------
   0.1       Yaw2Shft    - Lateral distance from the yaw axis to the rotor shaft (m)
   0.0       ShftSkew    - Rotor shaft skew angle (deg)
0., 0., 0.   RFrlCM_n    - Position of the CM of the structure that furls with the rotor [not including rotor] from the tower-top, in nacelle coordinates (m)
1.7,0.1,0.   BoomCM_n    - Postion of the tail boom CM from the tower top, in nacelle coordinates (m)
0., 0., 0.   TFinCM_n    - Position of tail fin CM from the tower top, in nacelle coordinates (m)
0., 0., 0.   RFrlPnt_n   - Position of an arbitrary point on the rotor-furl axis from the tower top, in nacelle coordinates (m)
   0.0       RFrlSkew    - Rotor-furl axis skew angle (deg)
   0.0       RFrlTilt    - Rotor-furl axis tilt angle (deg)
0.3, 0., 0. TFrlPnt_n    - Position of an arbitrary point on the tail-furl axis from the tower top, in nacelle coordinates (m)
 -45.2       TFrlSkew    - Tail-furl axis skew angle (deg)
  78.7       TFrlTilt    - Tail-furl axis tilt angle (deg)
---------------------- MASS AND INERTIA (CONT) ---------------------------------
   0.0       RFrlMass    - Mass of structure that furls with the rotor [not including rotor] (kg)
  86.8       BoomMass    - Tail boom mass (kg)
   0.0       TFinMass    - Tail fin mass (kg)
   0.0       RFrlIner    - Inertia of the structure that furls with the rotor about the rotor-furl axis (kg m^2) [not including rotor]
 264.7       TFrlIner    - Tail boom inertia about tail-furl axis (kg m^2)
---------------------- ROTOR-FURL ----------------------------------------------
   0         RFrlMod     - Rotor-furl spring/damper model {0: none, 1: standard, 2:user-defined routine} (switch)
   0.0       RFrlSpr     - Rotor-furl spring constant (N-m/rad) [used only when RFrlMod=1]
   0.0       RFrlDmp     - Rotor-furl damping constant (N-m/(rad/s)) [used only when RFrlMod=1]
   0.0       RFrlUSSP    - Rotor-furl up-stop spring position (deg) [used only when RFrlMod=1]
   0.0       RFrlDSSP    - Rotor-furl down-stop spring position (deg) [used only when RFrlMod=1]
   0.0       RFrlUSSpr   - Rotor-furl up-stop spring constant (N-m/rad) [used only when RFrlMod=1]
   0.0       RFrlDSSpr   - Rotor-furl down-stop spring constant (N-m/rad) [used only when RFrlMod=1]
   0.0       RFrlUSDP    - Rotor-furl up-stop damper position (deg) [used only when RFrlMod=1]
   0.0       RFrlDSDP    - Rotor-furl down-stop damper position (deg) [used only when RFrlMod=1]
   0.0       RFrlUSDmp   - Rotor-furl up-stop damping constant (N-m/(rad/s)) [used only when RFrlMod=1]
   0.0       RFrlDSDmp   - Rotor-furl down-stop damping constant (N-m/(rad/s)) [used only when RFrlMod=1]
---------------------- TAIL-FURL -----------------------------------------------
   1         TFrlMod     - Tail-furl spring/damper model {0: none, 1: standard, 2:user-defined routine} (switch)
   0.0       TFrlSpr     - Tail-furl spring constant (N-m/rad) [used only when TFrlMod=1]
   10.0      TFrlDmp     - Tail-furl damping constant (N-m/(rad/s)) [used only when
TFrlMod=1]
   85.0      TFrlUSSP    - Tail-furl up-stop spring position (deg) [used only when
TFrlMod=1]
    3.0      TFrlDSSP    - Tail-furl down-stop spring position (deg) [used only when
TFrlMod=1]
    1.0E3    TFrlUSSpr   - Tail-furl up-stop spring constant (N-m/rad) [used only when
TFrlMod=1]
    1.7E4    TFrlDSSpr   - Tail-furl down-stop spring constant (N-m/rad) [used only when
TFrlMod=1]
   85.0      TFrlUSDP    - Tail-furl up-stop damper position (deg) [used only when
TFrlMod=1]
    0.0      TFrlDSDP    - Tail-furl down-stop damper position (deg) [used only when
TFrlMod=1]
    1.0E3    TFrlUSDmp   - Tail-furl up-stop damping constant (N-m/(rad/s)) [used only
when TFrlMod=1]
  137.0      TFrlDSDmp   - Tail-furl down-stop damping constant (N-m/(rad/s)) [used only
when TFrlMod=1]
```

Feature Flags

RFrlDOF The rotor-furl DOF will be enabled when this is True. The initial rotor-furl angle is specified with RotFurl. If RFrlDOF is disabled, the rotor-furl angle will be fixed at RotFurl. (flag)

TFrlDOF The tail-furl DOF will be enabled when this is True. The initial tail-furl angle is specified with TailFurl. If TFrlDOF is disabled, the tail-furl angle will be fixed at TailFurl. (flag)

Initial Conditions

RotFurl This is the fixed or initial rotor-furl angle. It is positive about the rotor-furl axis as shown in Fig. 4.45. The rotor-furl axis is defined through input `RFrlPnt_n` RFrlSkew, and RFrlTilt below. This value must be greater than -180 and less than or equal to 180 degrees. (deg)

TailFurl This is the fixed or initial tail-furl angle. It is positive about the tail-furl axis as shown in Fig. 4.45. The tail-furl axis is defined through inputs `TFrlPnt_n`, `TFrlSkew`, and `TFrlTilt` below. This value must be greater than -180 and less than or equal to 180 degrees. (deg)

Turbine Configuration

Inputs `RFrlPnt_n`, `RFrlSkew`, and `RFrlTilt` define the orientation of the rotor-furl axis and associated DOF, `RFrlDOF`. Inputs `TFrlPnt_n`, `TFrlSkew`, and `TFrlTilt` define the orientation of the tail-furl axis and associated DOF, `TFrlDOF`. See Fig. 4.45.

Yaw2Shft This is the lateral offset distance from the yaw axis to the intersection of the rotor shaft axis with the yn-/zn-plane. The distance is measured parallel to the yn-axis. It is positive to the left when looking downwind as shown in Fig. 4.46. For turbines with rotor-furl, this distance defines the configuration at a furl angle of zero. (m)

ShftSkew This is the skew angle of the rotor shaft in the nominally horizontal plane. Positive skew acts like positive nacelle yaw as shown in Fig. 4.46; however, `ShftSkew` should only be used to skew the shaft a few degrees away from the zero-yaw position and must not be used as a replacement for the yaw angle. This value must be between -15 and 15 degrees (inclusive). For turbines with rotor-furl, this angle defines the configuration at a furl angle of zero. (deg)

RFrlCM_n Position of the center of mass of the structure that furls with the rotor (not including the rotor-reference input `RFrlMass`) measured from the tower top and expressed in the nacelle coordinate system. See Fig. 4.46. For turbines with rotor-furl, this position defines the configuration at a furl angle of zero. (m)

BoomCM_n Position of the tail boom mass center (reference input `BoomMass`) with respect to the tower top, expressed in the nacelle coordinate system. See Fig. 4.47. For turbines with tail-furl, this distance defines the configuration at a furl angle of zero. (m)

TFinCM_n Position of the tail fin mass center (reference input `TFinMass`) with respect to the top, expressed in the nacelle coordinate system. See Fig. 4.47. For turbines with tail-furl, this distance defines the configuration at a furl angle of zero. (m)

RFrlPnt_n Position of an arbitrary point on the rotor-furl axis expressed from the tower top and in the nacelle coordinate system. See Fig. 4.45. (m)

RFrlSkew This is the skew angle of the rotor-furl axis in the nominally horizontal plane. Positive skew orients the nominal horizontal projection of the rotor-furl axis about the zn-axis. See Fig. 4.45. This value must be greater than -180 and less than or equal to 180 degrees. (deg)

RFrlTilt This is the tilt angle of the rotor-furl axis from the nominally horizontal plane. This value must be between -90 and 90 degrees (inclusive). See Fig. 4.45. (deg)

TFrlPnt_n Position from the tower top to an arbitrary point on the tail-furl axis, in nacelle coordinates. See Fig. 4.45. (m)

TFrlSkew This is the skew angle of the tail-furl axis in the nominally horizontal plane. Positive skew orients the nominal horizontal projection of the tail-furl axis about the zn-axis. See Fig. 4.45. This value must be greater than -180 and less than or equal to 180 degrees. (deg)

TFrlTilt This is the tilt angle of the tail-furl axis from the nominally horizontal plane. See Fig. 4.45. This value must be between -90 and 90 degrees (inclusive). (deg)

Mass and Inertia

RFrlMass This is the mass of the structure that furls with the rotor (not including the rotor). The center of this mass is located at the point specified by input `RFrlCM_n` relative to the tower-top at a rotor-furl angle of zero. It includes everything that furls with the rotor excluding the rotor (blades, hub, and tip brakes). This value must not be negative. (kg)

BoomMass This is the mass of the tail boom. The center of the tail boom mass is located at the point specified by input `BoomCM_n` relative to the tower-top at a tail-furl angle of zero. It includes everything that furls with the tail except the tail fin (see next input). This value must not be negative. (kg)

TFinMass This is the mass of the tail fin. The center of the tail fin mass is located at the point specified by input `TFinCM_n` relative to the tower-top at a tail-furl angle of zero. TFinMass and BoomMass combined should include everything that furls with the tail. This value must not be negative. (kg)

RFrlIner This is the moment of inertia of the structure that furls with the rotor (not including the rotor) about the rotor-furl axis. It includes all mass contained in `RFrlMass`. This value must be greater than: `RFrlMass*d^2` where d is the perpendicular distance between rotor-furl axis and C.M. of the structure that furls with the rotor [not including the rotor]. (kg·m2)

TFrlIner This is the tail boom moment of inertia about the tail-furl axis. It includes all mass contained in BoomMass. This value must be greater than: `BoomMass*d^2` where d is the perpendicular distance between tail-furl axis and tail boom C.M. (kg·m2)

Rotor-Furl

The rotor-furl bearing can be an ideal bearing with no friction by setting `RFrlMod` to 0; by setting `RFrlMod` to 1, it also has a standard model that includes a linear spring and linear damper, as well as up- and down-stop springs, and up- and down-stop dampers. The formulae are provided in Section 4.8.3.3. ElastoDyn models the stop springs with a linear function of rotor-furl deflection. The rotor-furl stops start at a specified angle and work as a linear spring based on the deflection past the stop angles. The rotor-furl dampers are linear functions of the furl rate and start at the specified up-stop and down-stop angles. These dampers are bidirectional, resisting motion equally in both directions once past the stop angle.

A user-defined rotor-furl spring and damper model is also available. To use it, set *RFrlMod* to 2 and create a subroutine entitled *UserRFrl()* with the parameters `RFrlDef`, `RFrlRate`, `DirRoot`, `ZTime`, and `RFrlMom`:

- `RFrlDef`: Current rotor-furl angular deflection in radians (input)
- `RFrlRate`: Current rotor-furl angular rate in rad/sec (input)

- `ZTime` : Current simulation time in sec (input)
- `DirRoot` : Simulation root name including the full path to the current working director (input)
- `RFrlMom` : Rotor-furl moment in N·m (output)

The source file `ED_UserSubs.f90` contains a dummy `UserRFrl()` routine; replace it with your own and rebuild ElastoDyn.

RFrlMod The rotor-furl springs and dampers can be modeled three ways. For a value of 0 for `RFrlMod`, there will be no rotor-furl spring nor damper and the moment normally produced will be set to zero. A `RFrlMod` of 1 will invoke simple spring and damper models using the inputs provided below as appropriate coefficients. If `RFrlMod` is set to 2, ElastoDyn will call the routine `UserRFrl()` to compute the rotor-furl spring and damper moments. You should replace the dummy routine supplied with the code with your own, which will need to be linked with the rest of ElastoDyn. Using values other than 0, 1, or 2 will cause ElastoDyn to abort. (switch)

RFrlSpr The linear rotor-furl spring restoring moment is proportional to the rotor-furl deflection through this constant. This value must not be negative and is only used when `RFrlMod` is set to 1. (N·m/rad)

RFrlDmp The linear rotor-furl damping moment is proportional to the rotor-furl rate through this constant. This value must not be negative and is only used when `RFrlMod` is set to 1. (N·m/(rad/s))

RFrlCDmp This Coulomb-friction damping moment resists rotor-furl motion, but it is a constant that is not proportional to the rotor-furl rate. However, if the rotor-furl rate is zero, the damping is zero. This value must not be negative and is only used when `RFrlMod` is set to 1. (N·m)

RFrlUSSP The rotor-furl up-stop spring is effective when the rotor-furl deflection exceeds this value. This value must be greater than -180 and less than or equal to 180 degrees and is only used when `RFrlMod` is set to 1. (deg)

RFrlDSSP The rotor-furl down-stop spring is effective when the rotor-furl deflection exceeds this value. This value must be greater than -180 and less than or equal to `RFrlUSSP` degrees and is only used when `RFrlMod` is set to 1. (deg)

RFrlUSSpr The linear rotor-furl up-stop spring restoring moment is proportional to the rotor-furl up-stop deflection by this constant and is effective when the rotor-furl deflection exceeds `RFrlUSSP`. This value must not be negative and is only used when `RFrlMod` is set to 1. (N·m/rad)

RFrlDSSpr The linear rotor-furl down-stop spring restoring moment is proportional to the rotor-furl down- stop deflection by this constant and is effective when the rotor-furl deflection exceeds `RFrlDSSP`. This value must not be negative and is only used when `RFrlMod` is set to 1. (N·m/rad)

RFrlUSDP The rotor-furl up-stop damper is effective when the rotor-furl deflection exceeds this value. This value must be greater than -180 and less than or equal to 180 degrees and is only used when `RFrlMod` is set to 1. (deg)

RFrlDSDP The rotor-furl down-stop damper is effective when the rotor-furl deflection exceeds this value. This value must be greater than -180 and less than or equal to `RFrlUSDP` degrees and is only used when `RFrlMod` is set to 1. (deg)

RFrlUSDmp The linear rotor-furl up-stop damping moment is proportional to the rotor-furl rate by this constant and is effective when the rotor-furl deflection exceeds `RFrlUSDP`. This value must not be negative and is only used when `RFrlMod` is set to 1. (N·m/(rad/s))

RFrlDSDmp The linear rotor-furl down-stop damping restoring moment is proportional to the rotor-furl rate by this constant and is effective when the rotor-furl deflection exceeds `RFrlDSDP`. This value must not be negative and is only used when `RFrlMod` is set to 1. (N·m/(rad/s))

Tail-Furl

The tail-furl bearing can be an ideal bearing with no friction by setting `TFrlMod` to 0; by setting `TFrlMod` to 1, it also has a standard model that includes a linear spring and damper , as well as up- and down-stop springs, and up- and down-stop dampers. The formulae are provided in Section 4.8.3.3. ElastoDyn models the stop springs with a linear function of tail-furl deflection. The tail-furl stops start at a specified angle and work as a linear spring based on the deflection past the stop angles. The tail-furl dampers are linear functions of the furl rate and start at the specified up-stop and down-stop angles. These dampers are bidirectional, resisting motion equally in both directions once past the stop angle.

A user-defined tail-furl spring and damper model is also available. To use it, set `TFrlMod` to 2 and create a subroutine entitled `UserTFrl()` with the arguments `TFrlDef`, `TFrlRate`, `ZTime`, `DirRoot`, and `TFrlMom`:

- `TFrlDef`: Current tail-furl angular deflection in radians (input)
- `TFrlRate`: Current tail-furl angular rate in rad/sec (input)
- `ZTime`: Current simulation time in sec (input)
- `DirRoot`: Simulation root name including the full path to the current working directory (input)

- `TFrlMom`: Tail-furl moment in N.m (output)

The source file `ED_UserSubs.f90` contains a dummy `UserTFrl()` routine; replace it with your own and rebuild ElastoDyn.

TFrlMod The tail-furl springs and dampers can be modeled three ways. For a value of 0 for `TFrlMod`, there will be no tail-furl spring nor damper and the moment normally produced will be set to zero. A `TFrlMod` of 1 will invoke simple spring and damper models using the inputs provided below as appropriate coefficients. If you set `TFrlMod` to 2, ElastoDyn will call the routine `UserTFrl()` to compute the tail-furl spring and damper moments. You should replace the dummy routine supplied with the code with your own, which will need to be linked with the rest of ElastoDyn. Using values other than 0, 1, or 2 will cause ElastoDyn to abort. (switch)

TFrlSpr The linear tail-furl spring restoring moment is proportional to the tail-furl deflection through this constant. This value must not be negative and is only used when `TFrlMod` is set to 1. (N·m/rad)

TFrlDmp The linear tail-furl damping moment is proportional to the tail-furl rate through this constant. This value must not be negative and is only used when `TFrlMod` is set to 1. (N·m/(rad/s))

TFrlCDmp This Coulomb-friction damping moment resists tail-furl motion, but it is a constant that is not proportional to the tail-furl rate. However, if the tail-furl rate is zero, the damping is zero. This value must not be negative and is only used when `TFrlMod` is set to 1. (N·m)

TFrlUSSP The tail-furl up-stop spring is effective when the tail-furl deflection exceeds this value. This value must be greater than -180 and less than or equal to 180 degrees and is only used when `TFrlMod` is set to 1. (deg)

TFrlDSSP The tail-furl down-stop spring is effective when the tail-furl deflection exceeds this value. This value must be greater than -180 and less than or equal to `TFrlUSSP` degrees and is only used when `TFrlMod` is set to 1. (deg)

TFrlUSSpr The linear tail-furl up-stop spring restoring moment is proportional to the tail-furl up-stop deflection by this constant and is effective when the tail-furl deflection exceeds `TFrlUSSP`. This value must not be negative and is only used when `TFrlMod` is set to 1. (N·m/rad)

TFrlDSSpr The linear tail-furl down-stop spring restoring moment is proportional to the tail-furl down-stop deflection by this constant and is effective when the tail-furl deflection exceeds `TFrlDSSP`. This value must not be negative and is only used when `TFrlMod` is set to 1. (N·m/rad)

TFrlUSDP The tail-furl up-stop damper is effective when the tail-furl deflection exceeds this value. This value must be greater than -180 and less than or equal to 180 degrees and is only used when `TFrlMod` is set to 1. (deg)

TFrlDSDP The tail-furl down-stop damper is effective when the tail-furl deflection exceeds this value. This value must be greater than -180 and less than or equal to `TFrlUSDP` degrees and is only used when `TFrlMod` is set to 1. (deg)

TFrlUSDmp The linear tail-furl up-stop damping moment is proportional to the tail-furl rate by this constant and is effective when the tail-furl deflection exceeds `TFrlUSDP`. This value must not be negative and is only used when `TFrlMod` is set to 1. (N·m/(rad/s))

TFrlDSDmp The linear tail-furl down-stop damping restoring moment is proportional to the tail-furl rate by this constant and is effective when the tail-furl deflection exceeds `TFrlDSDP`. This value must not be negative and is only used when `TFrlMod` is set to 1. (N·m/(rad/s))