AeroDeeP 2.2
User Manual

January 2021

PRINCIPIA

IFP Energies nouvelles

Table of Contents

1 Introduction

AeroDeeP is an aerodynamic library, whose purpose is to be coupled with hydro-servo-elastic solvers in order to simulate a complete offshore floating wind turbine, including the floater and the rotor. It currently uses Blade Element Momentum (BEM) method to compute the aerodynamic loadings on the blade elements, as described in the theoretical manual (1). As an input, **AeroDeeP** requires positions, orientations and velocities of the blade elements and turbine components, such as the hub, the nacelle and the tower in a global reference frame, as well as information about the incoming wind.

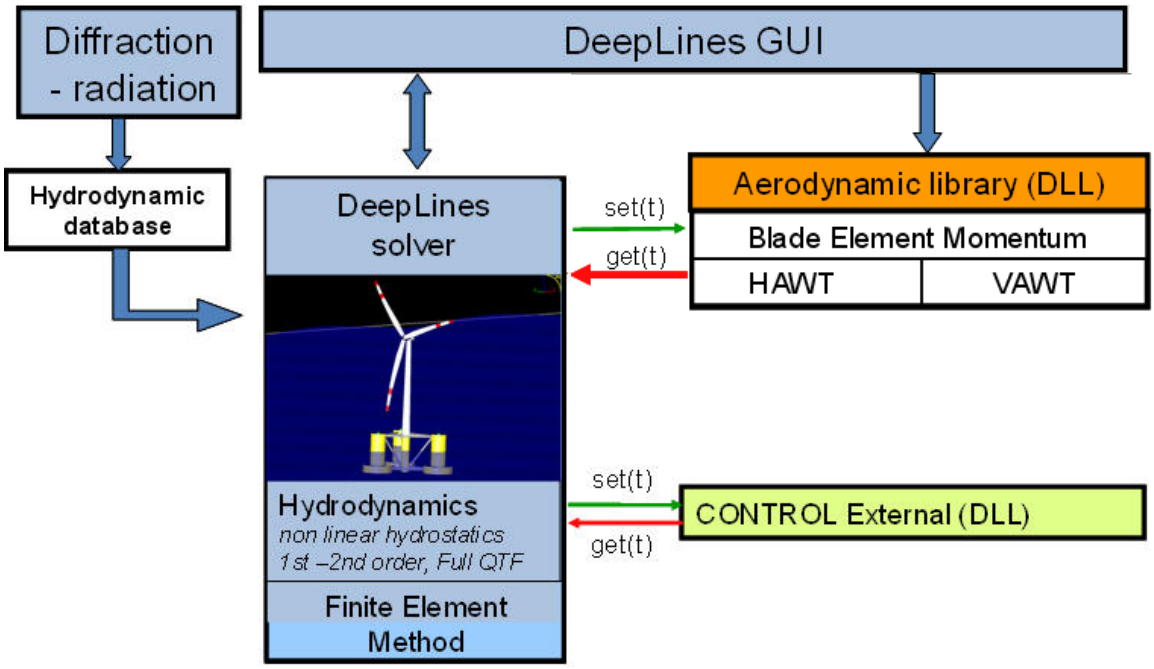

Figure 1 : Schematics of the coupling between DeepLines and AeroDeeP

To be able to compute the blade loads, some other information, not sent by the FEM solver, are required. Some information, that are mostly of aerodynamic type, are thus given in xml formatted input files.

Actually, **AeroDeeP** uses two files. The first one contains a description of the wind farm, including the rotors with their airfoils, as well as the tower, hub and nacelle properties (see Figure 1). The second one is related to the aerodynamic model, fluid properties, and corrections of the aerodynamic model (see Figure 2).

2 Rotor definition

One presents the graph description of a wind farm.

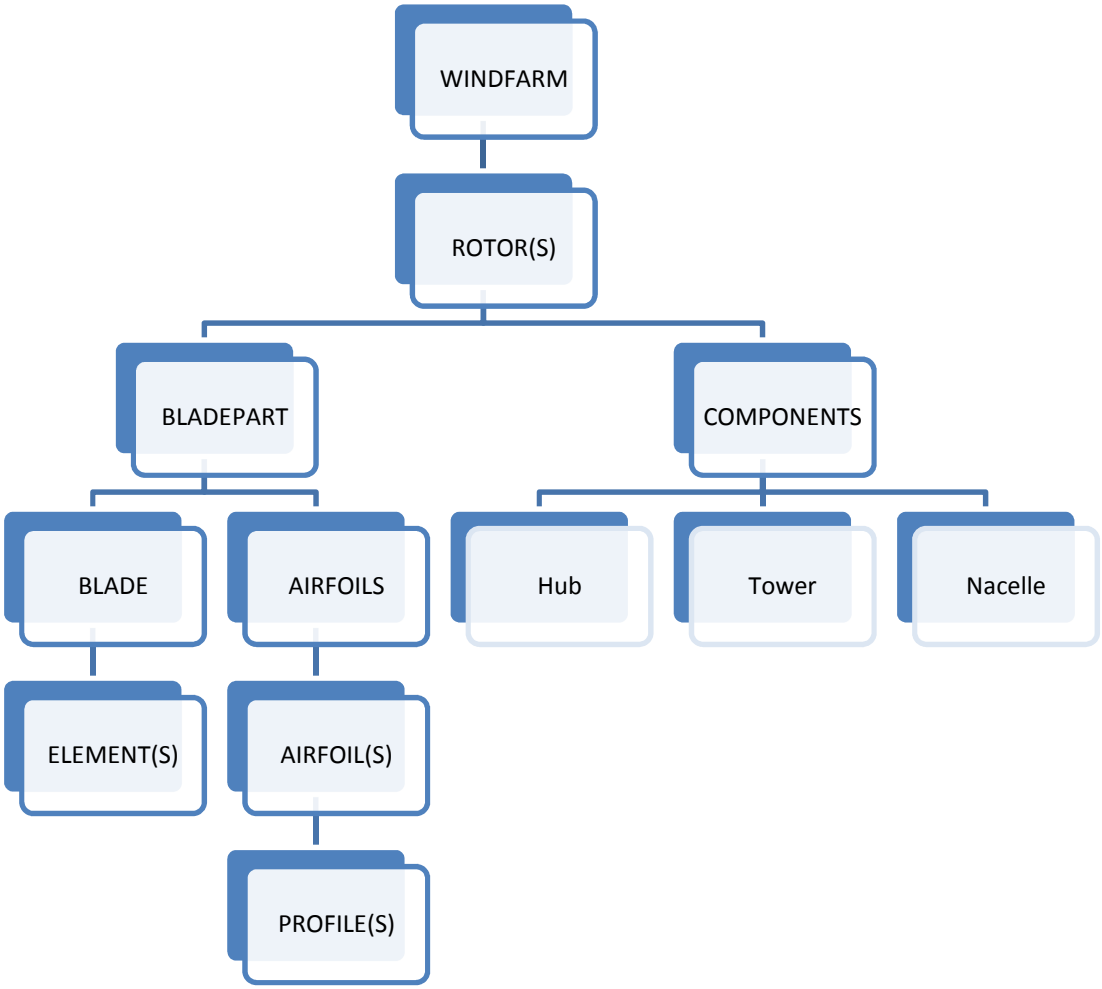

Figure 1: Structure of the rotor definition input file

2.1 Wind Farm

<WINDFARM></WINDFARM>	ROOT	
Arguments list: ▪ <ROTOR></ROTOR> *Description:* *List of all the rotors used in the simulation (no interactions between rotors).*		

2.2 Rotor

<ROTOR></ROTOR>	Required Multiple	*Parent:*<WINDFARM>

Arguments list:

- <BLADEPART></BLADEPART>
- <COMPONENTS></COMPONENTS>

Description:

Describes a rotor given its blade parts and components.

2.3 Blade Part

<BLADEPART></BLADEPART>	Required	*Parent:<ROTOR>*

Arguments list:

- <BLADE> </BLADE>
- <AIRFOILS> </AIRFOILS>

Description:

List of all blades and airfoils used in the simulation.

2.3.1 Blade

<BLADE></BLADE	Required	*Parent:<BLADEPART>*

Arguments list:

- <ELEMENT … />

Description:

Defines a new blade, composed of elements.

<ELEMENT arg1="value" arg2="value" …/>	Required Multiple	*Parent:<BLADE>*

Arguments list:

- center
- chord
- airfoil

Description:

Description of a blade element (relative position of element center along the blade, chord, and airfoil, normalized by the blade length) belonging to the blade.

"center"	Required argument	*Parent:<ELEMENT/>*

- Default value : None
- Possible values : "double", unit=none

Description:

Position of the center of the element currently described along the blade, normalized by the blade length.

Example:

```
center="0.50"
```

"chord"	Required argument	*Parent:<ELEMENT/>*

- Default value : None
- Possible values : "double", unit=meters

Description:

Chord of the airfoil element currently described, in meter.

Example:

```
chord="2.5"
```

"airfoil"	Required argument	*Parent:<ELEMENT>*

- Default value : None
- Possible values : "string"

Description:

Name of the airfoil present in the <AIRFOILS> list below

Example:

```
airfoil="NACA_0012"
```

Complete example:

```
<BLADE>
  <ELEMENT center="0.022" chord="3.542" airfoil="Cylinder1" />
  <ELEMENT center="0.111" chord="4.167" airfoil="Cylinder2" />
  <ELEMENT center="0.233" chord="4.652" airfoil="DU35_A17"  />
  <ELEMENT center="0.366" chord="4.249" airfoil="DU30_A17"  />
  <ELEMENT center="0.500" chord="3.748" airfoil="DU25_A17"  />
  <ELEMENT center="0.633" chord="3.256" airfoil="DU21_A17"  />
  <ELEMENT center="0.766" chord="2.764" airfoil="NACA64_A17"/>
  …
</BLADE>
```

2.3.2 Airfoils

<AIRFOILS></AIRFOILS>	Required	*Parent:<BLADEPART>*

Arguments list:

- <AIRFOIL> </AIRFOIL>

Description:

List of all the defined airfoils.

<AIRFOIL arg1="value" arg2="value" …/>	Required Multiple	*Parent:*<AIRFOILS>

Arguments list:

- name
- use_stall
- separated_flow_aoa
- lift_slope
- <PROFILE arg1="value" arg2="value" …"/>

Description:

Creates a new airfoil, given its name and information for dynamic stall model.

"name"	Required argument	*Parent:*<AIRFOIL>

- Default value : None
- Possible values : "string"

Description:

Name of the airfoil

Example:

name="NACA_0012"

"use_stall"	Optional argument	*Parent:*<AIRFOIL>

- Default value : "YES"
- Possible values : "YES", "NO"

Description:

Use stall model for the airfoil (recommended: YES for Airfoils, NO for Cylinders)

Example:

use_stall="YES"

"separated_floaw_aoa"	Optional argument	*Parent:*<AIRFOIL>

- Default value : "25." (If argument separated_flow_aoa not defined)
- Possible values : "double", unit=degree

Description:

Angle of attack at which the flow is fully separated

Example:

separated_flow_aoa="30."

"lift_slope"	Optional argument	*Parent:*<AIRFOIL>

- Default value : computed by aerodynamic module if argument lift_slope not defined
- Possible values : "double" , unit=1./radian

Description:

User impose slope value used for lift curve in Oye and Risoe dynamic stall function

Example:

```
lift_slope="6.28"
```

<PROFILE arg1="value" arg2="value" …/>	Required Multiple	*Parent:<AIRFOIL>*

Arguments list:

- angle
- reynolds
- lift
- drag
- moment

Description:

List of the properties of an Airfoil at a given angle of attack and Reynolds number

"angle"	Required argument	*Parent:<PROFILE>*

- Default value : None
- Possible values : "double", unit=degree

Description:

Current angle of attack

Example:

```
angle= "10.0"
```

"reynolds"	Required argument	*Parent:<PROFILE>*

- Default value: None
- Possible values: "double", unit=none

Description:

Reynolds number

Example:

```
reynolds="1e6"
```

"lift"	Required argument	*Parent:<PROFILE>*

- Default value : None
- Possible values : "double", unit=none

Description:

Lift coefficient

Example:

```
lift="0.128"
```

"drag"	Required argument	*Parent:<PROFILE>*

- Default value: None
- Possible values: "double", unit=none

Description:

Drag coefficient

Example:

```
drag="0.012"
```

"moment"	Required argument	*Parent:<PROFILE>*

- Default value : None
- Possible values : "double", unit=none

Description:

Pitching moment coefficient

Example:

```
moment="-0.072"
```

Complete example:

```
<AIRFOILS>
   <AIRFOIL name="Cylinder1" use_stall="NO">
      <PROFILE angle="-180" reynolds="1e5" lift="0.0" drag="0.5" moment="0.0"/>
      <PROFILE angle="+0.0" reynolds="1e5" lift="0.0" drag="0.5" moment="0.0"/>
      <PROFILE angle="+180" reynolds="1e5" lift="0.0" drag="0.5" moment="0.0"/>
      <PROFILE angle="-180" reynolds="1e6" lift="0.0" drag="0.2" moment="0.0"/>
      <PROFILE angle="+0.0" reynolds="1e6" lift="0.0" drag="0.2" moment="0.0"/>
```

2.4 Components

<COMPONENTS></COMPONENTS>	Required	*Parent:<ROTOR>*

Arguments list:

- <COMPONENT… />

Description:

List containing all the components of the wind turbine.

<COMPONENT arg1="value"/>	Required Multiple	*Parent:<COMPONENTS>*

Arguments list:

- type

- <PROPERTY arg1="value" arg2="value"…/>

Description:

List the properties of a new component (hub, tower, or nacelle).

"type"	Required argument	Parent:<COMPONENT>

- Default value : None
- Possible values : "Hub", "Tower", "Nacelle"

Description:

Type of component described

Example:

type="Hub"

<PROPERTY arg1="value" arg2="value" …/>	Required Multiple	*Parent:<COMPONENT>*

Arguments list:

- center
- radius
- drag

Description:

List of all the properties of the components.

"center"	Required argument	*Parent:<PROPERTY/>*

- Default value: None
- Possible values: "double", unit=none

Description:

Center position along the component, of the currently described component element, normalized by component length

For rigid body components, Hub and Nacelle, value can be 0 (unused value)

Example:

center="0.50"

"radius"	Required argument	*Parent:<PROPERTY/>*

- Default value : None
- Possible values : "double", unit=meter

Description:

Radius of the currently described component element

Example:

radius="1.50"

"drag"	Required argument	*Parent:<PROPERTY/>*

- Default value: None
- Possible values: "double", unit=none

Description:

Drag coefficient of the currently described component element. Tower drag coefficients are used by the tower-shadow model. Hub and nacelle drag coefficients are currently unused by the aerodynamic model.

Example:

```
drag="0.70"
```

Complete example:

```
<COMPONENTS>
  <COMPONENT type="Hub">
    <PROPERTY center="0.5" radius="1.5" drag="0.0"/>
  </COMPONENT>
  <COMPONENT type="Tower">
    <PROPERTY center="0.25" radius="4.0" drag="0.7"/>
    <PROPERTY center="0.50" radius="3.0" drag="0.5"/>
    <PROPERTY center="0.75" radius="2.0" drag="0.3"/>
  </COMPONENT>
```

3 Model definition

One presents the file structure for model definition.

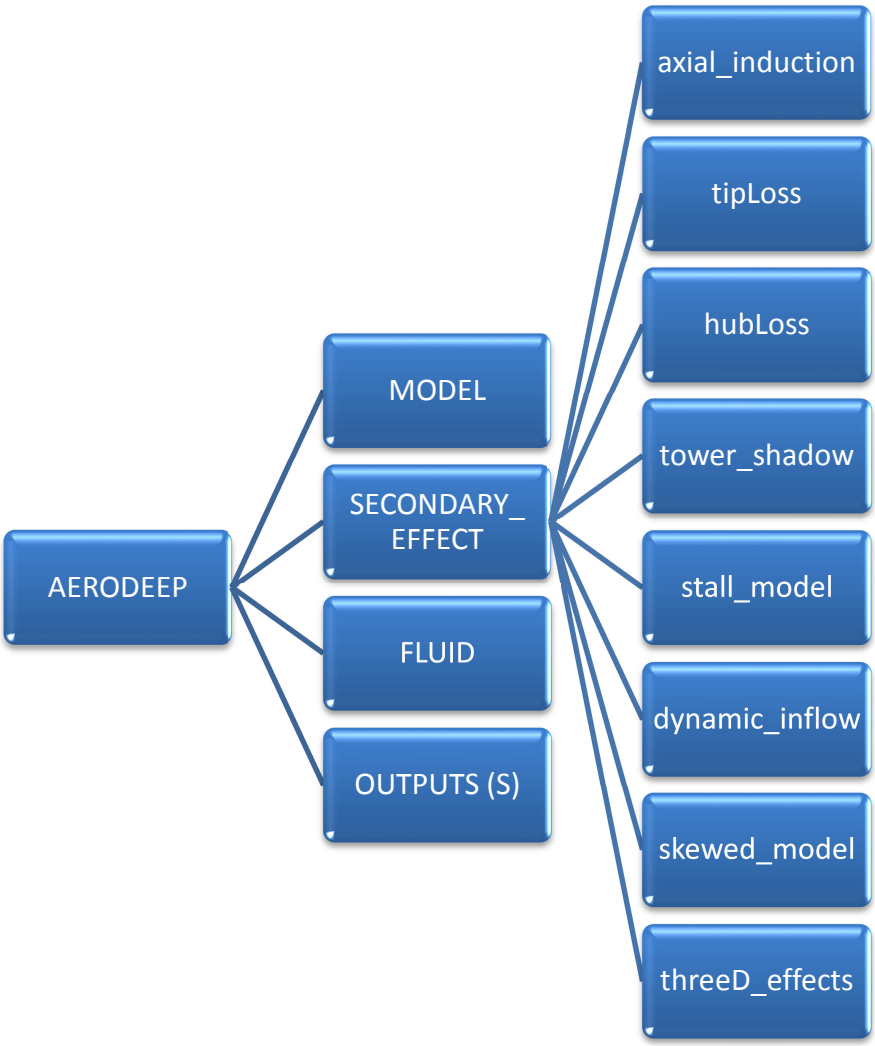

Figure 2: Structure of the aerodynamic input file

3.1 Main aerodynamic model

<AERODEEP></AERODEEP>	ROOT	
Arguments list: ▪ <MODEL> </MODEL> ▪ <SECONDARY_EFFECT> </SECONDARY_EFFECT> ▪ <FLUID> </FLUID> ▪ <AXIAL_INDUCTION_MODEL> </AXIAL_INDUCTION_MODEL> ▪ <STALL_MODEL> </STALL_MODEL> ▪ <YAW_MODEL> </YAW_MODEL> ▪ <DYNAMIC_INFLOW_MODEL> </DYNAMIC_INFLOW_MODEL> ▪ <STALL_DELAY_MODEL> </STALL_DELAY_MODEL>		

- <OUTPUTS> </OUTPUTS>
- <AERO_OUTPUTS> </AERO_OUTPUTS>

Description:

AeroDeeP simulation model definition (root node).

<MODEL arg1="value" arg2="value" …/>	Required	*Parent:<AERODEEP>*

Arguments list:

- name
- min_tsr
- max_tsr

Description:

The aerodynamic model to be used in the simulation with optional minimum TSR value which inductions are not computed

"name"	Required argument	*Parent:<MODEL/>*

- Default value : None
- Possible values : "BladeElementMomentum", "BEMad"

Description:

Defines the aerodynamic model to be used in the simulation.

- "BladeElementMomentum": the standard and recommended model, in which the structural element velocities are taken into account.
- "BEMad": similar to the "BladeElementMomentum" model, but structural velocities are not taken into account.

Example:

```
<MODEL name="BladeElementMomentum"/>
```

"min_tsr"	Optional argument	*Parent:<MODEL/>*

- Default value : "0." (default value if argument min_tsr not defined)
- Possible values : "double", unit=none

Description:

Minimal TSR below which inductions are NOT computed

Example:

```
min_tsr="1."
```

"max_tsr"	Optional argument	*Parent:<MODEL/>*

- Default value : "1e6" (default value if argument max_tsr not defined)
- Possible values : "double", unit=none

Description:

Maximal TSR below which inductions are NOT computed

Example:

```
max_tsr="30."
```

Complete example:

```
<MODEL name="BladeElementMomentum"        min_tsr="1." max_tsr="30."/>
```

3.2 Secondary Effects

<SECONDARY_EFFECT arg1="value" arg2="value" …/>	Required	*Parent:<AERODEEP>*

Arguments list:

- axial_induction
- tipLoss
- hubLoss
- tower_shadow
- stall_model
- dynamic_inflow
- skewed_model
- threeD_effects

Description:

List of all the secondary effects applied to the BEM models.

"axial_induction"	Optional argument	*Parent:<SECONDARY_EFFECT/>*

- Default value : "Polyfit"
- Possible values : "Polyfit", "RootFinding", "v151" (deprecated)
- Recommended value: "Polyfit"

Description:

Defines the axial induction model

Example:

```
axial_induction="Polyfit"
```

"tipLoss"	Optional argument	*Parent:<SECONDARY_EFFECT/>*

- Default value : "Prandtl"
- Possible values : "None", "Prandtl"
- Recommended value: "Prandtl"

Description:

Activates the Prandtl's correction for tip losses

Example:

```
tipLoss="Prandtl"
```

"hubLoss" Optional argument *Parent:<SECONDARY_EFFECT/>*

- Default value : "Prandtl"
- Possible values : "None", "Prandtl"
- Recommended value: "Prandtl"

Description:

Activates the Prandtl's correction for hub losses

Example:

```
hubLoss="Prandtl"
```

"tower_shadow" Optional argument *Parent:<SECONDARY_EFFECT/>*

- Default value : Deactivated"
- Possible values : "Deactivated", "Activated", "IFPEN"
- Recommended value: "Activated"

Description:

Activates the tower shadow model (effects of the tower on the wind)

Example:

```
tower_shadow ="Activated"
```

"stall_model" Optional argument *Parent:<SECONDARY_EFFECT/>*

- Default value : "Oye"
- Possible values : "Oye", "Risoe", "None", "Boeing_Vertol" (deprecated)
- Recommended value: "Oye"

Description:

Activates the dynamic stall model

Example:

```
stall_model="Oye"
```

"dynamic_inflow" Required argument *Parent:<SECONDARY_EFFECT/>*

- Possible values : "Activated", "Deactivated"
- Recommended value : "Activated"

Description:

Activates the Øye model for dynamic inflow

Example:

```
dynamic_inflow="Activated"
```

"skewed_model"	Optional argument	*Parent:<SECONDARY_EFFECT/>*

- Default value: "IFPEN"
- Possible values: "Glauert", "IFPEN", "Deactivated", "Activated" (deprecated)
- Recommended value: "IFPEN"

Description:

Activates the correction for skewed wake (yawed rotor)

Example:

```
skewed_model="IFPEN"
```

"threeD_effects"	Optional argument	*Parent:<SECONDARY_EFFECT/>*

- Default value : "None"
- Possible values : "Snel", "Dumitrescu", "None"
- Recommended value : "Snel"

Description:

Activates the correction for three dimensional and rotation effects. Should not be activated if the airfoils properties are already corrected.

Example:

```
threeD_effects="Dumitrescu"
```

Complete example with recommended values:

```
<SECONDARY_EFFECT
                  axial_induction = "Polyfit"
                  tipLoss         = "Prandtl"
                  hubLoss         = "Prandtl"
                  tower_shadow    = "Activated"
                  stall_model     = "Oye"
                  skewed_model    = "IFPEN"
                  dynamic_inflow  = "Activated"
                  threeD_effects  = "Dumitrescu"
                  />
```

3.3 Axial induction parameters

<AXIAL_INDUCTION_MODEL> </AXIAL_INDUCTION_MODEL>	Optional	

Arguments list:

- < ROOT_FINDING arg1="value"/>

Description:

Axial induction model user parameters definition

<ROOT_FINDING arg1="value" />	Optional	*Parent:<* AXIAL_INDUCTION_MODEL>

Arguments list:

- Beta
- PY_1
- PY_2

Description:

User parameters dedicated to Rootfinding axial induction model

"Beta"	Required argument	*Parent:*<ROOT_FINDING/>

- Possible values : "double", unit=none
- Recommended value : "0.35"

Description:

See theory guide section 1.5

Example:

```
Beta="0.35"
```

"PY_1"	Required argument	*Parent:*<ROOT_FINDING/>

- Possible values : "double", unit=none
- Recommended value : "2.0"

Description:

See theory guide section 1.5

Example:

```
PY_1="2.0"
```

"PY_2"	Required argument	*Parent:*<ROOT_FINDING/>

- Possible values : "double", unit=none
- Recommended value : "0.0"

Description:

See theory guide section 1.5

Example:

```
PY_2="0.0"
```

Complete example:

```
<AXIAL_INDUCTION_MODEL>
  <ROOT_FINDING Beta="0.35" PY_1="2.0" PY_2="0.0"/>
<AXIAL_INDUCTION_MODEL/>
```

3.4 Skewed model parameters

<SKEWED_MODEL>	Optional	

</SKEWED_MODEL>		

Arguments list:

<IFPEN arg1="value"/>

Description:

Skewed wake model user parameters definition

<IFPEN arg1="value"/>	Optional	*Parent:*< YAW_MODEL>

Arguments list:

- A1
- Phi_1
- Phi_2

Description:

User parameters dedicated to IFPEN skewed wake model

"A1"	Required argument	*Parent:*<IFPEN/>

- Possible values : "double", unit=none
- Recommended value : "0.35"

Description:

See theory guide section 2.3.2

Example:

A1="0.35"

"Phi_1"	Required argument	*Parent:*<IFPEN/>

- Possible values : "double", unit=degrees
- Recommended value : "180."

Description:

See theory guide section 2.3.2

Example:

Phi_1="180."

"Phi_2"	Required argument	*Parent:*<IFPEN/>

- Possible values : "double", unit=degrees
- Recommended value : "0."

Description:

See theory guide section 2.3.2

Example:

Phi_2="0."

Complete example:

```
<SKEWED_MODEL>
  <IFPEN A1="0.35" Phi_1="180." Phi_2="0."/>
<SKEWED_MODEL/>
```

3.5 Dynamic stall parameters

<STALL_MODEL></STALL_MODEL>	Optional	

Arguments list:

- <OYE arg1="value"/>
- <RISOE arg1="value"/>

Description:

Dynamic stall model user parameters definition

<OYE arg1="value" />	Optional	*Parent:*<STALL_MODEL>

Arguments list:

- A1

Description:

User parameters dedicated to Oye family dynamic stall model

"A1"	Required argument	*Parent:<OYE/>*

- Possible values : "double", unit=none
- Recommended value : "4.0"

Description:

See theory guide section 2.4.1

Example:

A1="4."

<RISOE arg1="value" arg2="value" …/>	Optional	*Parent:*<STALL_MODEL>

Arguments list:

- A1
- A2
- b1
- b2
- Tf_coeff
- Tp_coeff

Description:

User parameters dedicated to Risoe family dynamic stall model.

"A1"	Required argument	*Parent:*<RISOE/>

- Possible values : "double", unit=none
- Recommended value : "0.165"

Description:

See theory guide section 2.4.2

Example:

```
A1="0.165"
```

"A2"	Required argument	*Parent:*<RISOE/>

- Possible values : "double", unit=none
- Recommended value : "0.335"

Description:

See theory guide section 2.4.2

Example:

```
A2="0.335"
```

"b1"	Required argument	*Parent:*<RISOE/>

- Possible values : "double", unit=none
- Recommended value : "0.0455"

Description:

See theory guide section 2.4.2

Example:

```
B1="0.0455
```

"b2"	Required argument	*Parent:*<RISOE/>

- Possible values : "double", unit=none
- Recommended value : "0.3"

Description:

See theory guide section 2.4.2

Example:

```
B2="0.3"
```

"Tf_coeff"	Required argument	*Parent:*<RISOE/>

- Possible values : "double", unit=none
- Recommended value : "6.0"

Description:

See theory guide section 2.4.2

Example:

```
Tf_coeff="6."
```

"Tp_coeff"	Required argument	*Parent:<RISOE/>*

- Possible values : "double", unit=none
- Recommended value : "1.7"

Description:

See theory guide section 2.4.2

Example:

```
Tp_coeff="1.7"
```

Complete example:

```
<STALL_MODEL>
  <OYE A1="4." />
  <RISOE A1="0.165" A2="0.335" b1="0.0455" b2="0.3" Tf_coeff="6." Tp_coeff="1.7"/>
</STALL_MODEL>
```

3.6 Dynamic inflow model parameters

< DYNAMIC_INFLOW_MODEL></ DYNAMIC_INFLOW _MODEL>	Optional	

Arguments list:

<OYE_INFLOW arg1="value"/>

Description:

Dynamic inflow model user parameters definition

<OYE_INFLOW arg1="value"/>	Optional	*Parent:< DYNAMIC_INFLOW_MODEL>*

Arguments list:

- k1_tau1
- k2_tau1
- k1_tau2
- k2_tau2
- k

Description:

User parameters dedicated to Øye dynamic inflow model

"k1_tau1"	Required argument	*Parent:<OYE/>*

- Possible values : "double", unit=none
- Recommended value : "1.1"

Description:

See theory guide section 2.6

Example:

```
k1_tau1="1.1"
```

"k2_tau1" Required argument *Parent:*<OYE/>

- Possible values : "double", unit=none
- Recommended value : "1.3"
-

Description:

See theory guide section 2.6

Example:

```
k2_tau1="1.3"
```

"k1_tau2" Required argument *Parent:*<OYE/>

- Possible values : "double", unit=none
- Recommended value : "0.39"

Description:

See theory guide section 2.6

Example:

```
k1_tau2="0.39"
```

"k2_tau2" Required argument *Parent:*<OYE/>

- Possible values : "double", unit=none
- Recommended value : "0.26"

Description:

See theory guide section 2.6

Example:

```
k2_tau2="0.26"
```

"k" Required argument *Parent:*<OYE/>

- Possible values : "double", unit=none
- Recommended value : "0.6"

Description:

See theory guide 2.6

Example:

```
k="0.6"
```

Complete example:

```
<DYNAMIC_INFLOW_MODEL>
  <OYE k1_tau1="1.1" k2_tau1="1.3" k1_tau2="0.39" k2_tau2="0.26" k="0.6"/>
```

```
</DYNAMIC_INFLOW_MODEL>
```

3.7 Stall delay (three-dimensional) model parameters

< STALL_DELAY_MODEL></ STALL_DELAY_MODEL>	Optional	

Arguments list:

<SNEL arg1="value"/>

<DUMITRESCU arg1="value"/>

Description:

Dynamic inflow model user parameters definition

<SNEL arg1="value"/>	Optional	*Parent:*< STALL_DELAY_MODEL>

Arguments list:

- tip_correction
- Snel_cst

Description:

User parameters dedicated to the Snel stall delay (3D) model

"tip_correction"	Required argument	*Parent:*<SNEL/>

- Possible values : "Activated", "Dectivated", unit=none
- Recommended value : "Deactivated"

Description:

See theory guide section 2.5.3 (Lindenburg tip correction)

Example:

tip_correction="Deactivated"

"Snel_cst"	Required argument	*Parent:*<SNEL/>

- Possible values : "double", unit=none
- Recommended value : "3.1"

Description:

See theory guide section 2.5

Example:

Snel_cst="3.1"

<DUMITRESCU arg1="value"/>	Optional	*Parent:*< STALL_DELAY_MODEL>

Arguments list:

- tip_correction
- Gamma

Description:

User parameters dedicated to the Dumitrescu stall delay (3D) model

"tip_correction"	Required argument	*Parent:*<DUMITRESCU/>

- Possible values : "Activated", "Deactivated", unit=none
- Recommended value : "Deactivated"

Description:

See theory guide section 2.5.3 (Lindenburg tip correction)

Example:

tip_correction="Deactivated"

"Gamma"	Required argument	*Parent:*<DUMITRESCU/>

- Possible values : "double", unit=none
- Recommended value : "1.25"

Description:

See theory guide 2.5

Example:

Gamma="1.25"

Complete example:

```
<STALL_DELAY_MODEL>
  <DUMITRESCU tip_correction="Deactivated" Gamma="1.25"/>
</STALL_DELAY_MODEL>
```

3.8 Fluid properties

<FLUID arg1="value" arg2="value"/>	Required	*Parent:*<*AERODEEP*>

Arguments list:

- density
- viscosity

Description:

Defines the fluid's physical properties.

"density"	Required argument	*Parent:*<*FLUID*/>

- Default value : None
- Possible values : "double", unit= kg/m^3

Description:

Fluid's density, in kg/m^3

Example:

Density="1.225"

"viscosity"	Required argument	*Parent:<FLUID/>*

- Default value : None
- Possible values: "double", unit= *m^2/sec*

Description:

Fluid's kinematic viscosity, in m^2/sec.

Example:

Viscosity="1.81206e-5"

Complete example:

```
<FLUID density="1.225" viscosity="1.81206e-5"/>
```

3.9 User outputs

<OUTPUTS arg1="value" arg2="value" …/>	Optional Multiple	*Parent:<AERODEEP>*

Arguments list:

- status
- blade
- nodes

Description:

Previous output version, see section 3.10 for updated version

Activate aerodynamic user outputs for a specified blade and a list of nodes

Optional/Multiple keyword, default: deactivated outputs

Max <OUTPUTS> keyword allowed: 100

See section 4.1 for detailed output description

"status"	Optional argument	*Parent:<OUTPUTS/>*

- Default value : "Deactivated"
- Possible values : "Activated", "Deactivated"

Description:

Activate or Deactivate aerodynamic user outputs

Example:

```
status="Activated"
```

"blade"	Required argument	*Parent:*<OUTPUTS/>

- Default value : "1"
- Possible values: "int", unit=none

Description:

Blade ID (starting at 1) for outputs.

Example:

```
blade="1"
```

"nodes"	Optional argument	*Parent:*<OUTPUTS/>

- Default value : ""

Description:

Nodes id for outputs, all nodes by default. The nodes id list form is inspired from the pages id definition in print operation (";" separator and "-" for set of values).

Example:

```
nodes="1;5-7;14"
```

Complete example:

```
<OUTPUTS status="Activated" blade="1" nodes=""/>
<OUTPUTS status="Activated" blade="2" nodes="4-9"/>
<OUTPUTS status="Activated" blade="3" nodes="1;5-7;14"/>
```

3.10 Aerodynamic outputs

<AERO_OUTPUTS></AERO_OUTPUTS>	Optional	

Arguments list:

```
<ROTOR_OUTPUTS arg1="value"/>
<BLADE_OUTPUTS arg1="value"/>
<NODES_OUTPUTS arg1="value"/>
```

Description:

Activate updated aerodynamic user outputs

<ROTOR_OUTPUTS arg1="value"/>	Optional	*Parent:*<AERO_OUTPUTS>

Arguments list:

- status

- rotor

Description:

User parameters dedicated to the rotor outputs

See section 4.3 for detailed output description

"status"	Required argument	*Parent:*<ROTOR_OUTPUTS/>

- Default value : "Deactivated"
- Possible values : "Activated", "Deactivated"

Description:

Activate or Deactivate rotor outputs

Example:

status="Activated"

"rotor"	Optional argument	*Parent:*<ROTOR_OUTPUTS/>

- Default value : "1"
- Possible values: "int", unit=none

Description:

Rotor ID (starting at 1) for outputs.

Example:

rotor="1"

<BLADE_OUTPUTS arg1="value"/>	Optional	*Parent:*<AERO_OUTPUTS>

Arguments list:

- status
- rotor
- blade

Description:

User parameters dedicated to the blade outputs

See section 4.2 for detailed output description

"status"	Required argument	*Parent:*<BLADE_OUTPUTS/>

- Default value : "Deactivated"
- Possible values : "Activated", "Deactivated"

Description:

Activate or Deactivate blade outputs

Example:

status="Activated"

"rotor"	Optional argument	*Parent:*<BLADE_OUTPUTS/>

- Default value : "1"
- Possible values: "int", unit=none

Description:

Rotor ID (starting at 1) for outputs.

Example:

```
rotor="1"
```

"blade"	Required argument	*Parent:*<BLADE_OUTPUTS/>

- Default value : "1"
- Possible values: "int", unit=none

Description:

Blade ID (starting at 1) for outputs.

Example:

```
blade="1"
```

<NODES_OUTPUTS arg1="value"/>	Optional	*Parent:*<AERO_OUTPUTS>

Arguments list:

- status
- rotor
- blade
- nodes

Description:

User parameters dedicated to the node outputs

See section 4.1 for detailed output description

"status"	Required argument	*Parent:*<NODES_OUTPUTS/>

- Default value : "Deactivated"
- Possible values : "Activated", "Deactivated"

Description:

Activate or Deactivate nodes outputs

Example:

```
status="Activated"
```

"rotor"	Optional argument	*Parent:*<NODES_OUTPUTS/>

- Default value : "1"
- Possible values: "int", unit=none

Description:

Rotor ID (starting at 1) for outputs.

Example:

```
rotor="1"
```

"blade" Required argument *Parent:*<NODES_OUTPUTS/>

- Default value : "1"
- Possible values: "int", unit=none

Description:

Blade ID (starting at 1) for outputs.

Example:

```
blade="1"
```

"nodes" Optional argument *Parent:*<NODES_OUTPUTS/>

- Default value : ""

Description:

Nodes id for outputs, all nodes by default. The nodes id list form is inspired from the pages id definition in print operation (";" separator and "-" for set of values).

Example:

```
nodes="1;5-7;14"
```

Complete example:

```
<AERO_OUTPUTS>
  <ROTOR_OUTPUTS status="Activated" rotor="1"/>
  <BLADE_OUTPUTS status="Activated" rotor="1" blade="2"/>
  <NODES_OUTPUTS status="Activated" rotor="1" blade="2" nodes=""/>
</AERO_OUTPUTS>
```

3.11 Full aerodynamic file example

AeroDeeP v2.1 example

```
<?xml version="1.0" encoding="utf-8"?>

<AERODEEP
          xsi:noNamespaceSchemaLocation="aerodeep_v21.xsd"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">

  <MODEL name="BladeElementMomentum" min_tsr="1." max_tsr="30."/>

  <SECONDARY_EFFECT
                    axial_induction = "Polyfit"
                    tipLoss         = "Prandtl"
                    hubLoss         = "Prandtl"
                    tower_shadow    = "Activated"
                    stall_model     = "Oye"
```

```
                    skewed_model    = "IFPEN"
                    dynamic_inflow  = "Activated"
                    threeD_effects  = "Dumitrescu" />

  <FLUID density="1.225" viscosity="1.81206e-5"/>

  <OUTPUTS status="Activated" blade="1" nodes=""/>
  <OUTPUTS status="Activated" blade="2" nodes="4-9"/>
  <OUTPUTS status="Activated" blade="3" nodes="1;5-7;14"/>

  <AERO_OUTPUTS>
    <ROTOR_OUTPUTS status="Activated" rotor="1"/>
    <BLADE_OUTPUTS status="Activated" rotor="1" blade="2"/>
    <NODES_OUTPUTS status="Activated" rotor="1" blade="2" nodes=""/>
  </AERO_OUTPUTS>

  <AXIAL_INDUCTION_MODEL>
    <ROOT_FINDING Beta="0.35" PY_1="2.0" PY_2="0.0"/>
  <AXIAL_INDUCTION_MODEL/>

  <YAW_MODEL>
    <IFPEN A1="0.35" Phi_1="180." Phi_2="0."/>
  <YAW_MODEL/>

  <STALL_MODEL>
    <OYE A1="4."/>
    <RISOE A1="0.165" A2="0.335" b1="0.045" b2="0.3"
           Tf_coeff="6." Tp_coeff="1.7"/>
  </STALL_MODEL>

  <DYNAMIC_INFLOW_MODEL>
    <OYE_INFLOW k1_tau1="1.1" k2_tau1="1.3"
                k1_tau2="0.39" k2_tau2="0.26" k="0.6"/>
  </DYNAMIC_INFLOW_MODEL>

  <STALL_DELAY_MODEL>
    <SNEL       tip_correction="Deactivated" Snel_cst="3.1"/>
    <DUMITRESCU tip_correction="Deactivated" Gamma="1.25"/>
  </STALL_DELAY_MODEL>

</AERODEEP>
```

AeroDeeP v1.4 example

```
<?xml version="1.0" encoding="utf-8"?>

<AERODEEP DTDRevision="v1.1"
          xsi:noNamespaceSchemaLocation="aerodeep_v14.xsd"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">

  <MODEL name="BladeElementMomentum" min_tsr="1." />

  <SECONDARY_EFFECT tipLoss        = "Prandtl"
                    hubLoss        = "Prandtl"
                    tower_shadow   = "Deactivated"
                    stall_model    = "None"
                    skewed_model   = "Deactivated"
                    dynamic_inflow = "Deactivated"
```

```
                    threeD_effects = "None" />

  <STALL_MODEL>
     <OYE A1="4."/>
     <RISOE A1="0.165" A2="0.335" b1="0.0455" b2="0.3"
            Tf_coeff="6." Tp_coeff="1.7"/>
     <BOEING_VERTOL constant="0.87"/>
  </STALL_MODEL>

  <FLUID density="1.225" viscosity="1.81206e-5"/>

  <OUTPUTS status="Activated" blade="1" nodes=""/>
  <OUTPUTS status="Activated" blade="2" nodes="4-9"/>
  <OUTPUTS status="Activated" blade="3" nodes="1;5-7;14"/>


  <AXIAL_INDUCTION_MODEL>
    <ROOT_FINDING Beta="0.35" PY_1="2.0" PY_2="0.0"/>
  <AXIAL_INDUCTION_MODEL/>

</AERODEEP>
```

Previous AeroDeeP v1.3 example

```
<?xml version="1.0" encoding="utf-8"?>

<AERODEEP DTDRevision="v1.1"
          xsi:noNamespaceSchemaLocation="aerodeep_v13.xsd"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">

  <MODEL name="BladeElementMomentum"/>

  <SECONDARY_EFFECT tipLoss        = "Prandtl"
                    hubLoss        = "Prandtl"
                    tower_shadow   = "Deactivated"
                    stall_model    = "None"
                    skewed_model   = "Deactivated"
                    dynamic_inflow = "Deactivated"
                    threeD_effects = "None" />

  <FLUID density="1.225" viscosity="1.81206e-5"/>

  <OUTPUTS status="Activated" blade="1" nodes=""/>
  <OUTPUTS status="Activated" blade="2" nodes="4-9"/>
  <OUTPUTS status="Activated" blade="3" nodes="1;5-7;14"/>

</AERODEEP>
```

Previous AeroDeeP v1.1 example

```
<?xml version="1.0" encoding="utf-8"?>

<!DOCTYPE AERODEEP SYSTEM "./dtd/aerodeep_v11.dtd">

<AERODEEP DTDRevision="v1.1">
```

```
  <MODEL name="BladeElementMomentum"/>

  <SECONDARY_EFFECT tipLoss        = "Prandtl"
                    hubLoss        = "Prandtl"
                    tower_shadow   = "Deactivated"
                    stall_model    = "None"
                    skewed_model   = "Deactivated"
                    dynamic_inflow = "Deactivated"
                    threeD_effects = "None" />

  <FLUID density="1.225" viscosity="1.81206e-5"/>

  <OUTPUTS status="Activated" blade="1”/>

</AERODEEP>
```

4 Outputs

User outputs are written in the directory [aero_nodes] included in the simulation directory.

4.1 Node outputs

Time (s)	Time simulation. All time simulation are kept.
Position x (m)	Node position x in global frame.
Position y (m)	Node position y in global frame.
Position z (m)	Node position z in global frame.
Wind x (m/s)	Wind velocity in x global frame direction.
Wind y (m/s)	Wind velocity in y global frame direction.
Wind z (m/s)	Wind velocity in z global frame direction.
Rel. Velocity x (m/s) [elt]	Wind relative velocity in x element frame direction.
Rel. Velocity y (m/s) [elt]	Wind relative velocity in y element frame direction.
Rel. Velocity z (m/s) [elt]	Wind relative velocity in z element frame direction.
Inflow_Angle (o)	Inflow angle in degree.
Attack angle (o)	Attack angle in degree.
Cl	Lift coefficient.
Cd	Drag coefficient.
Cm	Pitching Moment coefficient.
Lineic Force x (N/m) [elt]	Lineic force x in element frame. Remark, in element frame the lineic force z is null.
Lineic Force y (N/m) [elt]	Lineic force y in element frame.
Lineic Moment z (N.m/m) [elt]	Lineic moment z in element frame.
Lineic Force x (N/m) [glo]	Lineic force x in global frame.
Lineic Force y (N/m) [glo]	Lineic force y in global frame.
Lineic Force z (N/m) [glo]	Lineic force z in global frame.
Lineic Moment x (N.m/m) [glo]	Lineic moment x in global frame.
Lineic Moment y (N.m/m) [glo]	Lineic moment y in global frame.
Lineic Moment z (N.m/m) [glo]	Lineic moment z in global frame.

4.2 Blade outputs

Time (s)	Time simulation. All times are kept.
Force x (N) [bld]	Force x in blade root frame.
Force y (N) [bld]	Force y in blade root frame.
Force z (N) [bld]	Force z in blade root frame.
Moment x (N.m) [bld]	Moment x in blade root frame.
Moment y (N.m) [bld]	Moment y in blade root frame.
Moment z (N.m) [bld]	Moment z in blade root frame.

4.3 Rotor outputs

Time (s)	Time simulation. All times are kept.
Power (Watt)	Evaluated power in aerodynamic module.
Torque (N.m)	Evaluated torque on rotor in aerodynamic module.
Thrust (N)	Rotor thrust.
Velocity (rad/s)	Rotor rotation velocity in rad/s.
Velocity (RPM)	Rotor rotation velocity in RPM.
Hub Position x (m)	Hub position x in global frame.
Hub Position y (m)	Hub position y in global frame.
Hub Position z (m)	Hub position z in global frame.
Hub Wind x (m/s)	Hub mean wind velocity x in global frame.
Hub Wind y (m/s)	Hub mean wind velocity y in global frame.
Hub Wind z (m/s)	Hub mean wind velocity z in global frame.

5 What's new

5.1 In current version

A new option with crypted airfoils description file is available in DeepLines. Using crypted files, user outputs are deactivated in AeroDeeP.

5.2 Version 2.1

AeroDeeP version 2.1 is a new implementation of the aerodynamic library. This version provides a better robustness for aerodynamic calculation loads and the ability to parametrized more secondary effects models for expert usage.

In addition, new secondary effect models have been implemented.

- Inductions: in version 1 the induction factor, axial and tangential, are part of the BEM model. In version 2.1, one can select the model used: Polyfit (similar as version 1) or RootFinding. This revised implementation includes the effect of the wind turbine yaw angle in the estimation of the thrust coefficient, which in turns affects the inductions.

- Tower shadow : a new model is available that includes blending functions.

- Skewed wake: in version 1 the skewed wake correction was activated/deactivated. In the current version, one can select one of the two following models for skewed wake: Glauert (same as previous Activated option) or IFPEN.

- Dynamic Stall: the Øye stall model robustness has been improved. Now one recommends this usage when dynamic stall effect is activated in AeoDeeP.

- Stall delay: the Dumitrescu model is now available.

For outputs, the .csv aerodynamic outputs file management has been improved. All the files are written in a dedicated directory [aero_nodes]. A global output file for rotor presents values that are exchanged with the control module.

6 Bibliography

1. **F. Blondel, G. Ferrer, D. Teixeira.** *AeroDeeP V2R1 - Theory Guide*. 2020.

www.principia.fr
deeplines@principia.fr

Head Office
Principia SAS
215 Voie Ariane, ZI Athelia 1
13705 La Ciotat
France
Tel: +33 442 98 11 80
Fax: +33 442 98 11

Nantes
Principia SAS
Rue de la Noë
44000 Nantes
France
Tel: +33 240 14 50 14
Fax: +33 240 14 34 00

Denmark
Principia North A/S
Gronlandsvej 10
DK-5700 Svendborg
Denmark
Tel: +45 62 228 228
Mob: +65 22 169 811

Kuala Lumpur
Principia Asia Sdn Bhd
Level 32 - Menara Binjai
No. 2 Jalan Binjai
50450 Kuala Lumpur
Malaysia