TECHNICAL NOTE: WAKEREQ / WAKEREQ
Generalized i/o-format for wake calculations

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Introduction

In windPRO 4.1, we implement an interchange format to allow for 3rd party wake models. These models can then be executed from a subset of data exported from a windPRO project.

This document describes the WAKEREQ and WAKERES formats. Together they comprise a wake exchange format with wakereq being the one that provides information for a 3rd party wake model and wakeres containing the results.

The intention of a clear interface also extends to what windPRO is supposed to decide and what freedoms the external wake models have. The guiding principle here is that decisions about the wind turbines and how they are running are taken in windPRO. The mode of the power curve is decided in windPRO.

All csv files are comma separated with "." as decimal separator and no thousand separator.

The request and results files are meant to carry basic and needed data only. It is assumed that the 3rd party wake model will prompt for any missing data – and furthermore give the user access to additional model options as well as documentation and reporting.

1. Wake Request Format

The wake request format is a windPRO export format that contains the following:

- Meta data and coordinate system information
- Turbine positions and Ct curves
- Climate data at reference and turbines positions

The wakereq file does not contain specific information on the wake model that should be used but is rather a generic export format. Data can be exported for time series based PARK calculation either as an explicit timeseries or as scenarios. All information is contained in a single file (a zipped file, with the extension wakereq). Figure 1 shows the content of an example wakereq file. All csv files are comma separated.
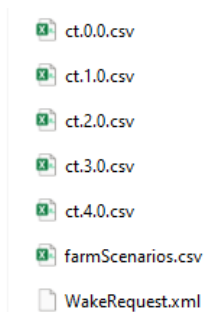

Figure 1 Example file structure of a wake request file (.wakereq)

The wakereq always contains a file called "WakeRequest.xml" containing meta information and information how to interpret the files. Figure 2 shows an outline of the schema. In the following we are presenting each of the elements with examples
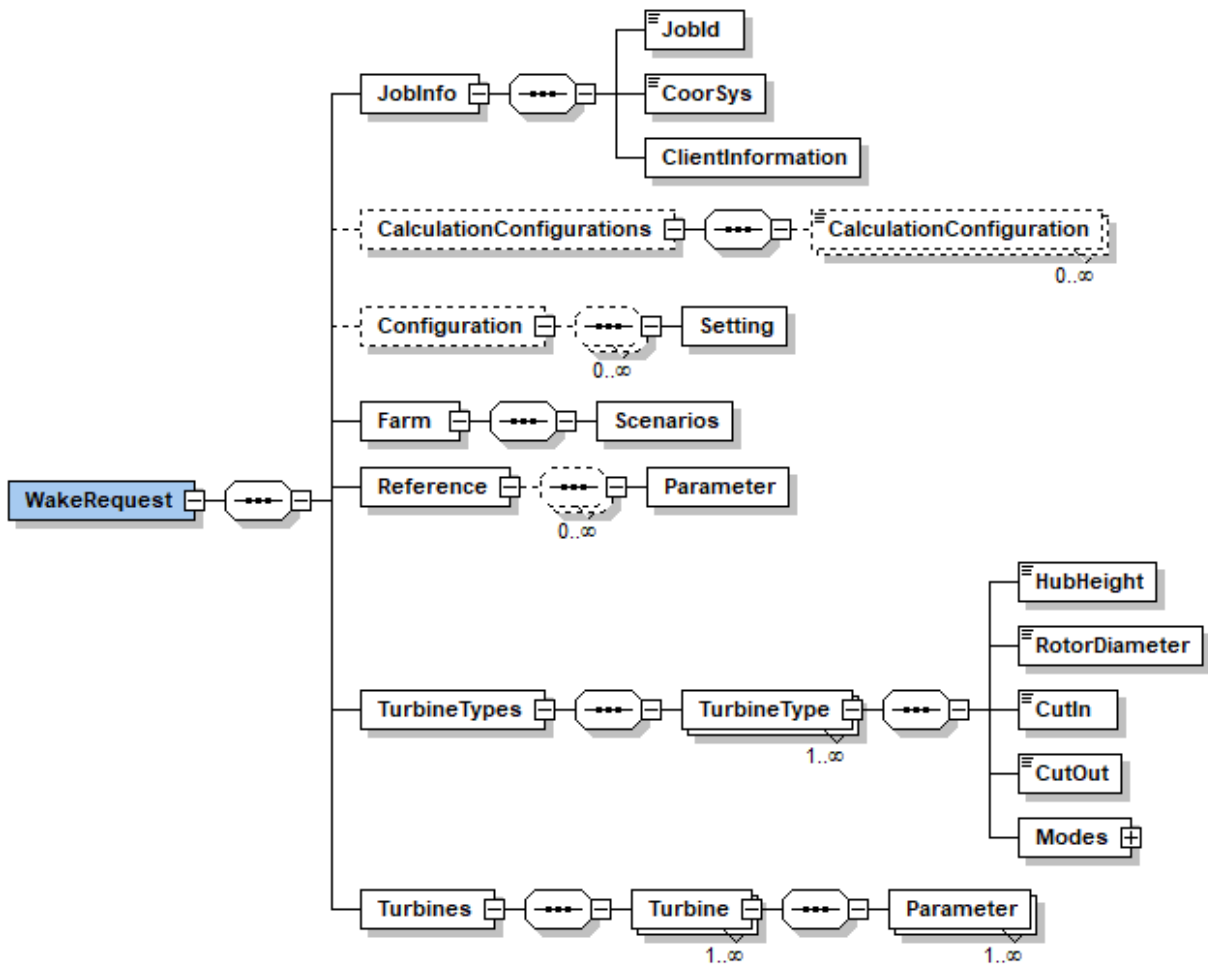
Figure 2 Outline of the wakereq XML schema

WakeRequest needs as attribute version with the correct version number (1.2) for windPRO to interpret the results correctly.

Jobinfo

This field contains meta information about the calculation job. It includes a UID that can be used to identify the calculation. CoorSys can be type "EPSG" or "WINDPRO", corresponding to the EPSG number or the windPRO internal coordinate system string. ClientInformation gives the name of the software generating the file and its version and user name.

```xml
<JobInfo>
  <JobId>{2CF49FD0-106B-4D18-9E11-7222766510EE}</JobId>
  <CoorSys type="EPSG">32632</CoorSys>
  <ClientInformation name="windPRO" version="4.0.422" userName="rk@emd.dk"/>
</JobInfo>
```

Configuration

This space is for extra settings. At present there is always a setting with the *name* "ScenarioMode". The *value* can be "Statistics" or "TimeVarying". *ScenarioMode* gives cases over wind speed and direction and *TimeVarying* mode gives cases for each time step. Time varying calculation have the option of using curtailment (not implemented at the moment).

```xml
<Configuration>
  <Setting name="ScenariosMode" value="Statistics"/>
</Configuration>
```

Farm

Information on the Scenarios and turbulence data. Scenarios points to the csv file that contains all information of each scenario that the wake model should run. Each scenario is one row in the file. The columns are referenced by name in later both for the reference site and the turbines.

```
<Farm>
  <Scenarios file="farmScenarios.csv"/>
</Farm>
```

Scenarios

File holding all the data for *Reference* and *Turbines*. The columns are referenced in the respective entries under *Parameter* and *col.* The available parameter types are given there as well.

References

A reference location is given with its position and the height above ground level for signals. Entries in *Parameter* point to the name of the column used in *Farm/Scenarios* csv file.

The *Reference* has a location identified by the location in *x, y, z*. Coordinates are cartesian and in meters. x refers to the easting and y to the northing.

```
<Reference x="317021.41" y="5179077.00" z="687.30" height="80.00">
     <Parameter col="windSpeedX" type="windSpeed"/>
     <Parameter col="windDirectionX" type="windDirection"/>
     <Parameter col="turbulenceStdDevX" type="turbulenceStdDev"/>
</Reference>
```

Several types are available:

Type	Description	Required
windSpeed	wind speed in m/s	yes
windDirection	wind direction in degree	yes
turbulenceStdDev	Standard deviation of the wind speed in m/s	yes
dateTime	datetime in format YYYY-MM-DDTHH:mm:ssZ	yes (if time series)
curtailmentIndex	Index for curtailment within that time stamp	yes (if time series)
airDensity	Air density in kg/m3	no

turbulenceStdDev is a turbulence set from windPRO either from the measurements or set directly by wind direction and speed.

The variable *curtailmentIndex* starts at 0 for each time step. It indicates that there are multiple different curtailment strategies within that time step to consider.

> Note: The setting of curtailments is not yet implemented in windPRO. In the future, curtailments will lead to multiple entries for each time stamp.

TurbineTypes

There can be multiple turbines included in a calculation. Each *TurbineType* has an *id* and potentially multiple *Modes*. Each mode has an *id* referencing it. A thrust curve is referenced as a csv file with the columns "wind speed" and "thrust coefficient".

```
<TurbineTypes>
  <TurbineType id="0">
    <HubHeight>84.00</HubHeight>
    <RotorDiameter>112.00</RotorDiameter>
    <CutIn>2.00</CutIn>
    <CutOut>25.00</CutOut>
    <Modes defaultMode="0">
      <Mode id="0" airDensity="1.225" stationaryThrustCoefficient="0.050" ctFile="ct.0.0.csv"/>
    </Modes>
```

Turbines

This lists the position of the turbines and the column under the Scenarios file that describe their ambient conditions. There is a list with *Turbine* entries. The *id* is a unique identifier for the turbine. *type* refers to the *id* of the *TurbineType* type. The operational mode is given within the *Farm/Scenarios* file and the column is identified from the entry in *Turbine/Parameter* with the *type* "operationMode". This needs to match the *id* in *TurbineType/Modes* identifying the correct thrust curve to be used.

Each turbine has a location identified by the location in *x, y, z*.

```xml
<Turbines>
  <Turbine id="0" type="0" x="528909.19" y="6242425.50" z="44.68">
      <Parameter col="windSpeed0" type="windSpeed"/>
      <Parameter col="windDirection0" type="windDirection"/>
      <Parameter col="operationMode0" type="operationMode"/>
  </Turbine>
  <Turbine id="1" type="1" x="530789.81" y="6240743.00" z="46.40">
      <Parameter col="windSpeed1" type="windSpeed"/>
      <Parameter col="windDirection1" type="windDirection"/>
      <Parameter col="operationMode1" type="operationMode"/>
  </Turbine>
```

Several types are available:

Type	Description	Required
windSpeed	wind speed in m/s	yes
windDirection	wind direction in degree	yes
operationMode	Id of the mode in *TurbineType*	no
operationState	Binary, 1 if turbine is running 0 if shut down	no

If *operationMode* is not given the default mode should be assumed. If *operationState* is not provided the turbine should be assumed to be running.

2. Wake result format

This description is valid for wake exchange format version 1.2.

The wake result format (wakeres) is intended to give information back to windPRO on the result of the wake calculations. It contains the wakereq file that was used to generate it, so all the meta data there is included. The format contains the following:

- Meta information on the model
- Turbines ids

All information necessary for windPRO to continue with the PARK calculation are included in the wakeres file. This is mainly the reduced wind speed that is used to get the power production. All information is contained in a single file (a zipped file, with the extension wakeres). Figure 3 shows the content of an example wakereq file. All csv files are comma separated.
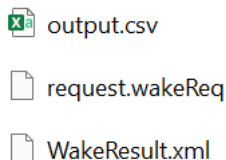
output.csv

request.wakeReq

WakeResult.xml

Figure 3 Example of files in a wakeres file

The wakeres always contains a file called "WakeResult.xml" containing meta information and information on how to interpret the files. Figure 4 shows an outline of the schema. In the following we are presenting each of the elements with examples.
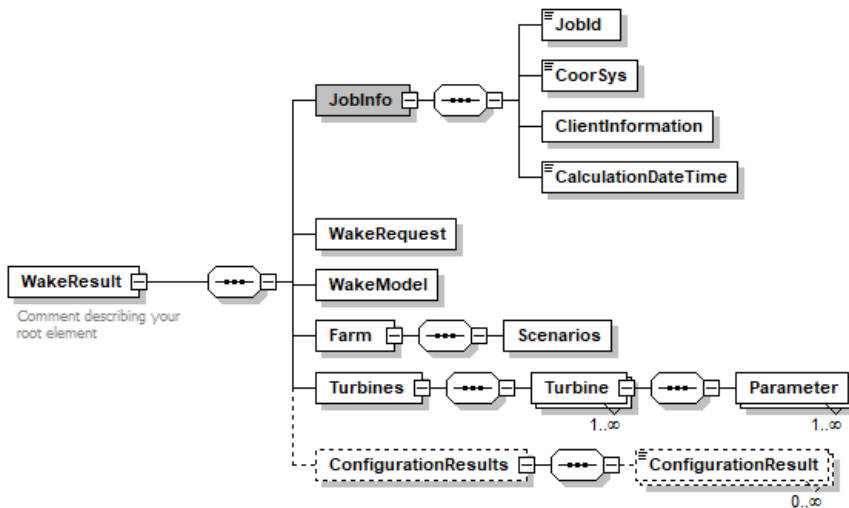
Figure 4 XML schema for wakeres xml files

WakeResult needs as attribute *version* with the correct version number (1.2) for windPRO to interpret the results correctly.

Jobinfo

This field contains meta information about the calculation job. It includes an UID that can be used to identify the calculation. CoorSys can be type "EPSG" or "WINDPRO", corresponding to the EPSG number or the windPRO internal coordinate system string. ClientInformation gives the name of the software generating the file and its version and user name (should be a copy from the same field in the wakereq file).

```xml
<JobInfo>
    <JobId>{2CF49FD0-106B-4D18-9E11-7222766510EE}</JobId>
    <CoorSys type="EPSG">32632</CoorSys>
    <ClientInformation name="windPRO" userName="rk@emd.dk" version="3.6.1166"/>
    <CalculationDateTime>2022-01-19T12:08:36.354012</CalculationDateTime>
</JobInfo>
```

Wakerequest

This contains the file name for the wakereq file. It is there to make the format self-containing. It is used to get the scenario files and the corresponding climate parameters.

```xml
<WakeRequest file="request.wakeReq"/>
```

WakeModel

Information on the wake model, name and version.

```xml
<WakeModel name="ModleName" version="2.5.0-emd-time-series"/>
```

Farm

Farm level file with the scenarios that are used to store the information about the result of the wake model. This file needs to contain the same number of lines as the *scenarios* in the wakereq file and in the same order.

```xml
<Farm>
    <Scenarios file="output.csv"/>
</Farm>
```

Turbines

List of turbines with id (same as in the wakereq file). The entry *Parameter/col* refers to the name of the column in the file given in *Farm/Scenarios*.

```xml
<Turbines>
    <Turbine id="0">
        <Parameter col="reduced_wind_speed_0" type="reducedWindSpeed"/>
        <Parameter col="turbulence_intensity_0" type="turbulenceIntensity"/>
    </Turbine>
```

The following entries are required. *Windspeed* is the wake reduced wind speed at the individual turbines. The free wind speed is part of the wakereq file that is used to generate the wakeres file. Turbulence intensity can also be part of the wakeres file but does not have to.

Type	Description	Required	
reducedWindSpeed	wind speed in m/s after wake	yes	
turbulenceIntensity	TI [-]	no	

3. Document History

2019-2020: First version for WakeBlaster wake model

2024-08-28: Updated to version 1.2 for general public use.