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FLOATECH

D2.3. Design Load Case Database for Code-to-Code Comparison

31/10/2022

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FLOATECH
THE FUTURE OF FLOATING WIND TURBINES

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Background: about the FLOATECH project

The FLOATECH project is a Research and Innovation Action funded by the European Union's H2020 programme aiming to increase the technical maturity and the cost competitiveness of floating offshore wind (FOW) energy. This is particularly important because, due to the limitations of available installation sites onshore, offshore wind is becoming crucial to ensure the further growth of the wind energy sector.

The project is implemented by a European consortium of 5 public research institutions with relevant skills in the field of offshore floating wind energy and 3 industrial partners, two of which have been involved in the most recent developments of floating wind systems.

The approach of FLOATECH can be broken down into three actions:

- The development, implementation and validation of a user-friendly and efficient design engineering tool (named QBlade-Ocean) performing simulations of floating offshore wind turbines with an unseen combination of aerodynamic and hydrodynamic fidelity. The advanced modelling theories will lead to a reduction of the uncertainties in the design process and an increase of turbine efficiency.
- The development of two innovative control techniques (i.e., Active Wave-based feed-forward Control and the Active Wake Mixing) for Floating Wind Turbines and floaters, combining wave prediction and anticipation of induced platform motions. This is expected to improve the performance of each machine and to minimize wake effects in floating wind farms, leading to a net increase in the annual energy production of the farm.
- The economic analysis of these concepts to demonstrate qualitatively and quantitatively the impact of the developed technologies on the Levelized Cost of Energy (LCOE) of FOW technology.

In addition to the technological and economic impacts, the project is expected to have several impacts at societal, environmental and political levels, such as: public acceptance, due to no noise and visibility issues of FOWT; very low impact on biodiversity and wildlife habitat because no piles are needed be to installed into the seabed; the use of less material and space thanks to an environmentally friendly design; the promotion of the installation of FOW in transitional water depths (30-50 meters), as the costs for FOW at those locations will become more competitive compared to the fixed bottom foundations.

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List of acronyms and abbreviations

Acronym / Abbreviation	Meaning / Full text
DLC	Design Load Case
ECN	Ecòle Centrale Nantes
FOW	Floating Offshore Wind
FOWT	Floating Offshore Wind Turbine
CoG	Center of Gravity
LCOE	Levelized Cost of Energy
WP2	Work Package 2

EXECUTIVE SUMMARY

This document is a deliverable of the FLOATECH project, funded under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101007142.

In work package 2 (WP2) a detailed validation and verification of the capabilities of QBlade-Ocean is ongoing. Thereby, three wind turbine models mounted on floating substructures with differing characteristics serve as the means for the validation. A detailed description of the models and an initial comparison of results to other state-of-the-art simulation codes is provided in Deliverable 2.1 [1] and 2.2 [2], respectively. This document builds upon the work that is described in the previous deliverables and is the first milestone towards a comprehensive code-to-code comparison and uncertainty quantification study that is being carried out within the work package. In particular, this report acts as a supporting documentation to a dataset containing Floating Offshore Wind Turbine (FOWT) calculations in various design situations, computed with three different codes. In more detail, as presented in Deliverables 2.1 and 2.2, three floating platform archetypes are used in the code-to-code comparison ongoing in work package 2: a semi-submersible-type floater and a spar-type floater as well as the Hexafloat® concept recently proposed by Saipem®. The three test-cases are based on the concepts described in [1]. As presented in the following, two of the three models required adaptations. In fact, during the work leading to Deliverable 2.2, the numerical models were built and tuned to match the characteristic of scaled wave-basin experimental articles. Therefore, some of the assumptions that were made would not be realistic on a full-scale prototype and needed to be changed. The three concepts are simulated in a variety of design load cases (DLCs), as explained in the following. Results of the numerical investigation constitute this dataset.

The current document acts as a companion description of the dataset of calculations that is provided for the three test cases. In particular, it provides information about the contents of each output, the naming scheme used to identify the different outputs, the Design Load Cases (DLCs) that were simulated and the reference environmental conditions that were used.

1. DESCRIPTION OF DATASET

The dataset contains the results produced during the code-to-code comparison in Work Package 2 of the FLOATECH H2020 project. The dataset contains the raw outputs of three wind turbine simulation codes, QBlade-Ocean [3,4], OpenFAST [5] and DeepLines Wind™. In the dataset, results for three different Floating Offshore wind turbines (FOWT) can be found, as described in the following. The testcases are simulated in a range of Design Load Cases (DLCs) defined with international wind turbine certification standards in mind [6]. The full dataset can be found at:

https://doi.org/10.5281/zenodo.7254241

2. WIND TURBINE MODELS

2.1. NREL 5MW OC4

This section describes the NREL 5MW RWT mounted on the DeepCWind semi-submersible platform, henceforth called the 5MW OC4 testcase. This wind turbine model was extensively used in the OC4 code-to-code comparison [7] and hence the model definition is publicly available [8]. The wind turbine rotor and tower are described in [9], while the semi-submersible and mooring line layout is described in [8].

2.2. DTU 10MW SOFTWIND

This section describes the DTU 10MW RWT mounted on the SOFTWIND spar platform, henceforth called the 10MW SOFTWIND testcase. This wind turbine model was experimentally tested at Ecòle Centrale Nantes (ECN) [10] and was used in WP2.1 of the current project [1,2]. The wind turbine rotor is described in [11], while the semi-submersible and mooring line layout is described in [1,10]. Some adaptations to the model have been done so that it can be used in a full design load calculation. Firstly, the tower that was defined for the DTU 10MW RWT mounted on the OO-Star semi-submersible platform was used [12]. In fact, the first fore-aft and side-side frequencies of the tower matching the definition of the wave-basin model, used in the validation of QBlade-Ocean [2] are located in the 3P operating range. The tower designed for the OO-Star semi-submersible platform on the other hand is much stiffer with natural frequencies well above the 3P excitation range. The masses and inertias of the Nacelle are also changed, they are now the same as defined in the DTU 10MW RWT definition [11], rather than being defined to match the wave-basin model mass and inertia [10]. While its outer shape was left unchanged, the mass and inertia of the floater were modified. In particular, mass is reduced by approximately 1% in order to partially compensate for the increase in tower weight. At the same time the center of mass is also lowered. The mass and inertia properties of the floater are defined based on the following hypothesis:

- Uniform steel wall thickness of the floater of 100 mm. A plate of 100 mm of thickness is placed also at the connection between floater and tower to model the transition piece weight. A density of 8000 kg/m3 is considered, larger than 7800 kg/m3 of steel to account for the additional weight of welds of connections between floater pieces. This approach was followed based on the considerations in [13], where a similar approach is proposed.

- Concrete ballast. In particular MagnaDense® ballast is used, similarly to [13].

The resulting Center of Gravity (CoG), overall mass and inertias of the floater are calculated based on a CAD model of the spar. The system mass and inertia characteristics of the floater are summarized in table 1.

The final modification to the wave-basin model is the removal of the additional weights that are placed at the delta-connection of the mooring lines. These weights were added in the numerical models in order to consider the weight of the load-cell that is present in the experiments.

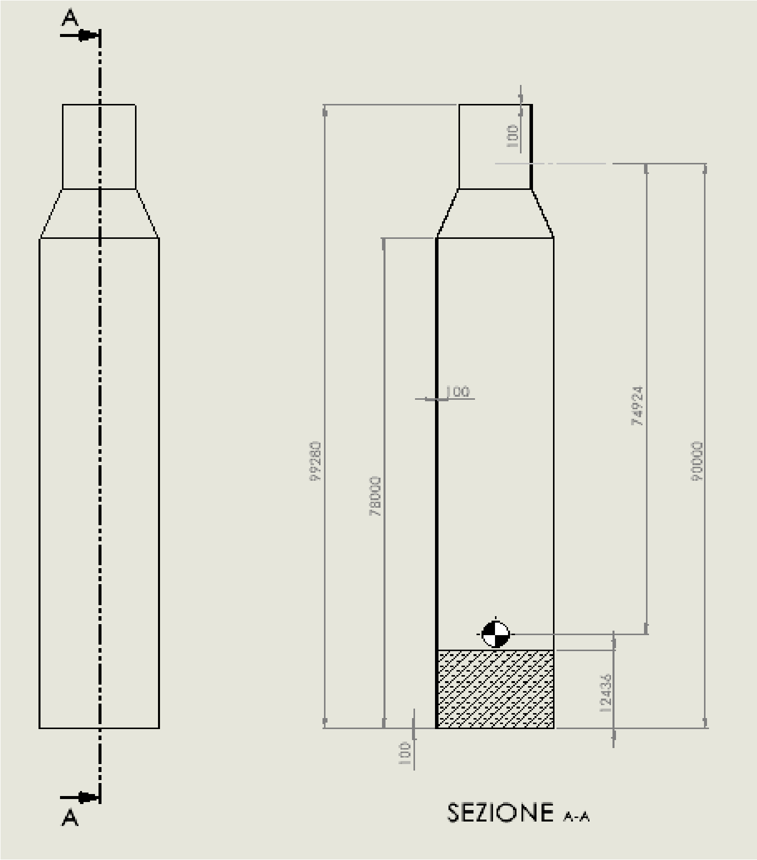

Figure 1: SOFTWIND spar floater geometry for code-to-code comparisons.

Table 1: SOFTWIND spar floater mass & inertia characteristics

Parameter	WP2.1 floater	WP2.2 floater
Mass (kg)	2.012E+07	19918800
CoG (m)	-68.8	-74.92
I_{XX} (CoG) (kg m^2)	2.37E+10	9751766928
I_{YY} (CoG) (kg m^2)	2.37E+10	9751766928
I_{ZZ} (CoG) (kg m^2)	6.2E+8	930499505
Pitch nat. Freq. (s)	33	28

2.3. DTU 10MW HEXAFLOAT

The DTU 10MW Hexafloat model description can be found in Deliverables 2.1 and 2.2 of the FLOATECH project [1,2].

2.4. ROSCO CONTROLLER

For all three wind turbine models the ROSCO open-source controller [14] is used. More specifically, ROSCO v2.4.1 is used. This controller has been selected as it is open-source and it includes an automatic tuning toolbox that can be used to determine the proportional and integral gains of the blade pitch controller in a simple manner [14].

A traditional $K - \omega^2$ law is used for the torque controller below rated windspeed. Above rated windspeed constant-torque control strategy is used. The pitch controller gains are tuned using ROSCO controller's automatic pitch-tuning routine [14,15], based on the OpenFAST models of the two rotors. The controller includes a nacelle-velocity feedback loop developed especially for FOWTs, with the objective of avoiding negative blade-pitch controller damping that can occur in the case of FOWTs. However, this feature is not used in this work package but rather, the more traditional strategy of de-tuning the pitch controller is used. The natural frequencies and damping ratios of the pitch controller used for the three models are shown in table 2. For all three models the natural frequency of the blade pitch controller is set below the platform pitch natural frequency, mitigating possible controller-driven system instabilities.

Table 2: Natural frequency and damping ration of the ROSCO pitch controller

Model	Nat. f. (ω)	Damping ratio (β)
NREL 5MW OC4	0.2 [rad/s]	1 [-]
DTU 10MW SOFTWIND	0.14 [rad/s]	1 [-]
DTU 10MW HEXAFLOAT	0.114 [rad/s]	1 [-]

3. ENVIRONMENTAL CONDITIONS

Calculations in the current dataset are performed for an offshore installation site west of the islad of Barra (Scotland).

The West of Barra site is located on the European continental shelf and therefore, water depths are limited to about 120-130 m. According to [16], average depth at the site is 95 m and within the identified installation area depth varies between 56 and 118 m. Water depth in the point where met-ocean conditions were sampled for the FLOATECH project is 123 m according to [17]. Importantly for WP2, this depth allows for the sampling of mid-depth wave characteristics, representative of sites where FOWT wind parks are planned to be installed. As a matter of fact, if we look at the only two operating commercial FOWT wind farms in Europe at the current date, the Hywind Scotland [18] and WindFloat ATLANTIC [19] wind farms, reported water depth is 90 and 100 m [18,19] respectively. For the generation of the current dataset, water depth is ignored, and the West of Barra site is used only to extract wave and wind characteristics. The considered water depth is defined based on the nominal installation depth of the three testcases that were considered: 200 m for the NREL 5MW OC4 and DTU 10MW SOFTWIND models and 250 m for the DTU 10MW HEXAFLOAT model. Moreover, no currents are considered in the calculations. A water density of 1025 kg/m^3 is assumed.

3.1. ENVIRONMENTAL CONDITION DATABASE

The combination of wind speed, significant wave height and wind-wave misalignment are defined on a Design Load Case basis with the procedure described in [20]. Starting from hindcast wind and wave data for the West of Barra site, a joint probabilistic model of the four environmental variables (wind speed, significant wave height, peak spectral period, wind-wave misalignment) is derived. The model is then used to compute environmental contours that define the extreme met-ocean conditions (DLC 1.6, 6.1, 6.2, 6.3). The expected or normal met-ocean conditions are instead used in DLCs 1.2 and 1.3.

The complete dataset is available at the following link:

https://doi.org/10.5281/zenodo.6972014

4. LIST OF SIMULATED DLCS

The DLCs that make up the current database are selected in order to provide a good estimation of fatigue and extreme loads whilst limiting as much as possible the total number of simulations. In fact, considering the full design space is not needed since full turbine certification is out of the scopes of this project. The list of selected DLCs does not include cases where fault events are simulated. This simplifies future comparisons using this dataset.

The final list contains the same DLCs that were simulated in the design of the IEA 15MW RWT [21,22], with the addition of DLC 1.2 for fatigue loads. Except for fault cases, which are not included in the current list, they match the load cases simulated by Jonkman in [23]. In the latter reference, the authors state that these DLCs are selected to cover essential design-driving situations, which is the same objective of the current document.

A synthetic list of the simulated DLCs is shown in table 3.

Table 3: Synthetic list of DLCs

DLC	Wind Speed [m/s]	Sea Condition	Significant Wave Height [m]	Peak Period [s]	Shape Factor [-]	Wave Heading [°]	Yaw [°]	Sea Currents Condition	Total N° Seeds
1.2	3-25	NSS	1-8	8-14	1	-150°-150°	0, +10°	None	504
1.3	4	NSS	1.510079	9.70803	1	0	0, ±10°	None	9
	6		1.685018	9.88332	1	0	0, ±10°		9
	8		1.924241	10.1135	1	0	0, ±10°		9
	10		2.224114	10.3894	1	0	0, ±10°		9
	12		2.583252	10.7054	1	0	0, ±10°		9
	14		3.003619	11.0597	1	0	0, ±10°		9
	16		3.489142	11.4529	1	0	0, ±10°		9
	18		4.043038	11.8856	1	0	0, ±10°		9
	20		4.666551	12.3573	1	0	0, ±10°		9
	22		5.359436	12.8672	1	0	0, ±10°		9
	24		6.120858	13.4148	1	0	0, ±10°		9
1.4	8	NSS	1.924241	10.1135	1	0	0	None	2
	10		2.224114	10.3894	1	0	0		2
	12		2.583252	10.7054	1	0	0		2
1.6	4	SSS	8.076751	14.7818	1	0	0, ±10°	None	9
	6		8.842851	15.3075	1	0	0, ±10°		9
	8		9.468955	15.7347	1	0	0, ±10°		9
	10		9.864609	16.0038	1	0	0, ±10°		9
	12		10.02935	16.1157	1	0	0, ±10°		9
	14		10.08412	16.1529	1	0	0, ±10°		9
	16		10.21367	16.2408	1	0	0, ±10°		9
	18		10.54712	16.4668	1	0	0, ±10°		9
	20		11.1205	16.8549	1	0	0, ±10°		9
	22		11.90511	17.3854	1	0	0, ±10°		9
	24		12.84265	18.0190	1	0	0, ±10°		9
6.1	36.92	ESS	16.42	18.68	1.00	-30°/0°/30°	0, ±10°	None	18
6.3	31.9	ESS	11.93	15.95	1.00	-30°/0°/30°	0, +10°	None	16
6.2[1]	36.92	ESS	16.42	18.68	1.00	see .xlsx	0, ±20°	None	18

5. SIMULATION NAMING SCHEME

In order to distinguish the simulations, a naming scheme is defined. The selected scheme provides information on the code that is used, the testcase, the DLC, the environmental conditions (wind speed, wave height, spectral period, wind/wave misalignment, vertical inflow angle), the seed of the wind and

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[1] Simulates loss of grid in storm. Reduced number of directions and seeds. See accompanying .xslx file for details

waves as well as the operating condition (yaw error). The simulation naming scheme is shown in table 4, with an example taken from the 5MWOC4 series further below in figure 2.

Table 4: Simulation naming scheme

IDENTIFIER	EXAMPLES		
code identifier	OF	QB	DL
testcase id	5MWOC4	10MWSOFT	10MWHEXA
DLC id	LC#		
wind speed	ws#		
seed for wind & waves	s#		
significant wave height	hs#		
peak spectral period	tp#		
wind/wave misalignment	ms#		
vertical inflow angle	i#		
yaw error	y#		

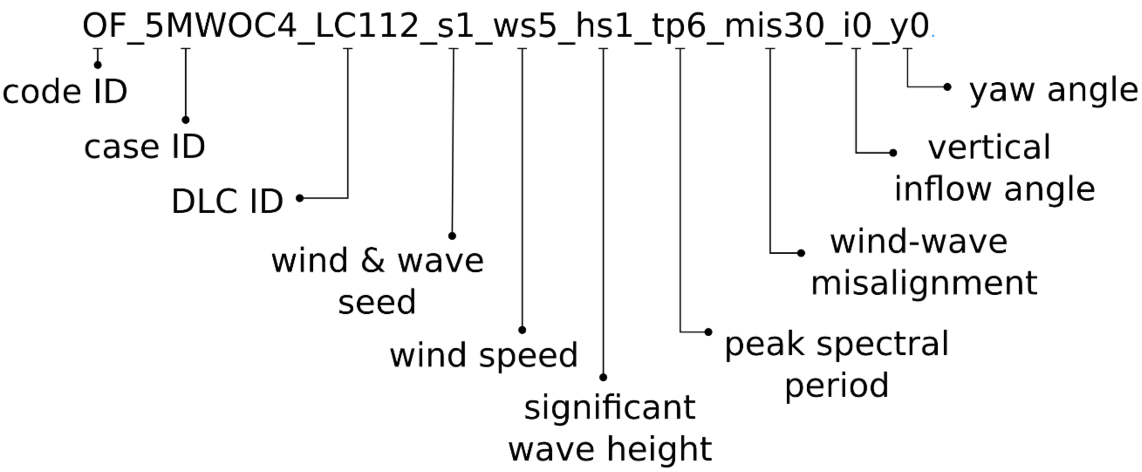

Figure 2: Example of naming scheme

6. DATA FORMAT

6.1. OUTPUTS

The list of outputs contained in the dataset can be found in table 5.

Table 5: output list

	#	NAME	OF	QB	DL	DESCRIPTION	unit	notes QB	Notes DL
	1	Time	🟩	🟩	🟩	time	s		
env.	2	Wind1VelX	🟩	🟩	🟩	wind velocity X @ hub height	m/s		at the RNA position
	3	Wind1VelY	🟩	🟩	🟩	wind velocity Y @ hub height	m/s		at the RNA position
	4	Wind1VelZ	🟩	🟩	🟩	wind velocity Z @ hub height	m/s		at the RNA position
	5	Wave1Elev	🟩	🟩	🟩	wave elevation @ platform center	m		at (0,0) position
platform	6	PtfmSurge	🟩	🟩	🟩	Platform horizontal surge (translational) displacement	m		
	7	PtfmSway	🟩	🟩	🟩	Platform horizontal sway (translational) displacement	m		
	8	PtfmHeave	🟩	🟩	🟩	Platform vertical heave (translational) displacement	m		
	9	PtfmRoll	🟩	🟩	🟩	Platform roll tilt angular (rotational) displacement.	deg		
	10	PtfmPitch	🟩	🟩	🟩	Platform pitch tilt angular (rotational) displacement.	deg		
	11	PtfmYaw	🟩	🟩	🟩	Platform yaw angular (rotational) displacement.	deg		
Moor.	12	FAIRTEN1	🟩	🟩	🟩	tension of mooring line 1 at fairlead	kN		
	13	FAIRTEN2	🟩	🟩	🟩	tension of mooring line 2 at fairlead	kN		
	14	FAIRTEN3	🟩	🟩	🟩	tension of mooring line 3 at fairlead	kN		
control	15	RotSpeed	🟩	🟩	🟩	rotor speed	rpm		
	16	BldPitch1	🟩	🟩	🟩	B1 pitch	deg		
	17	GenTq	🟩	🟩	🟩	generator torque	kNm		
	18	GenPwr	🟩	🟩	🟩	generator power	kW	No losses SW HF	No losses
Loads	19	TwrBsFxt	🟩	🟩	🟩	tower base x force	kN		@ 2.9 m from HF TB, @ 2 m from SW TB
	20	TwrBsFyt	🟩	🟩	🟩	tower base y force	kN		@ 2.9 m from HF TB, @ 2 m from SW TB

	21	TwrBsFzt	🟩	🟩	🟩	tower base z force	kN		@ 2.9 m from HF TB, @ 2 m from SW TB
	22	TwrBsMxt	🟩	🟩	🟩	tower base side-side bending moment	kNm		@ 2.9 m from HF TB, @ 2 m from SW TB
	23	TwrBsMyt	🟩	🟩	🟩	tower base fore-aft bending moment	kNm		@ 2.9 m from HF TB, @ 2 m from SW TB
	24	TwrBsMzt	🟩	🟩	🟩	tower base yaw bending moment	kNm		@ 2.9 m from HF TB, @ 2 m from SW TB
	25	YawBrFxp	🟩	🟩	🟩	yaw br. x-force (in tower top coords.)	kN		@ 106.5 m from HF TB, @ 103.6 m from SW TB
	26	YawBrFyp	🟩	🟩	🟩	yaw br. y-force (in tower top coords.)	kN		@ 106.5 m from HF TB, @ 103.6 m from SW TB
	27	YawBrFzp	🟩	🟩	🟩	yaw br. z-force (in tower top coords.)	kN		@ 106.5 m from HF TB, @ 103.6 m from SW TB
	28	YawBrMxp	🟩	🟩	🟩	yaw br. side-side bending moment (in tower top coords.)	kNm		@ 106.5 m from HF TB, @ 103.6 m from SW TB
	29	YawBrMyp	🟩	🟩	🟩	yaw br. fore-aft bending moment (in tower top coords.)	km		@ 106.5 m from HF TB, @ 103.6 m from SW TB
	30	YawBrMzp	🟩	🟩	🟩	yaw br. yaw moment (in tower top coord sys)	kN-m		@ 106.5 m from HF TB, @ 103.6 m from SW TB
	31	RootFxc1	🟩	🟥	🟩	B1 root out of plane force (in coned coord.sys)	kN		
	32	RootFyc1	🟩	🟥	🟩	B1 root in plane force (in coned coord.sys)	kN		
	33	RootFzc1	🟩	🟥	🟩	B1spanwise force (in coned coord.sys)	kN		
	34	RootFxc2	🟩	🟥	🟩	B2 root out of plane force (in coned coord.sys)	kN		
	35	RootFyc2	🟩	🟥	🟩	B2 root in plane force (in coned coord.sys)	kN		
	36	RootFzc2	🟩	🟥	🟩	B2 spanwise force (in coned coord.sys)	kN		
	37	RootFxc3	🟩	🟥	🟩	B3 root out of plane force (in coned coord.sys)	kN		
	38	RootFyc3	🟩	🟥	🟩	B3 root in plane force (in coned coord.sys)	kN		
	39	RootFzc3	🟩	🟥	🟩	B3 spanwise force (in coned coord.sys)	kN		
	40	RootMxc1	🟩	🟩	🟩	B1 root in plane bending moment (in coned coord.sys)	kNm		

	41	RootMyc1	🟩	🟩	🟩	B1 root out of plane bending moment (in coned coord.sys)	kNm		
	42	RootMzc1	🟩	🟩	🟩	B1 twist moment (in coned coord. sys)	kNm		
	43	RootMxc2	🟩	🟩	🟩	B2 root in plane bending moment (in coned coord.sys)	kNm		
	44	RootMyc2	🟩	🟩	🟩	B2 root out of plane bending moment (in coned coord.sys)	kNm		
	45	RootMzc2	🟩	🟩	🟩	B2 twist moment (in coned coord. sys)	kNm		
	46	RootMxc3	🟩	🟩	🟩	B3 root in plane bending moment (in coned coord.sys)	kNm		
	47	RootMyc3	🟩	🟩	🟩	B3 root out of plane bending moment (in coned coord.sys)	kNm		
	48	RootMzc3	🟩	🟩	🟩	B3 twist moment (in coned coord. sys)	kNm		
	49	RootFxb1	🟩	🟩	🟩	B1 root out of plane force (in Bcoord.sys)	kN		
	50	RootFyb1	🟩	🟩	🟩	B1 root in plane force (in Bcoord.sys)	kN		
	51	RootFzb1	🟩	🟩	🟩	B1spanwise force (in Bcoord.sys)	kN		
	52	RootFxb2	🟩	🟩	🟩	B2 root out of plane force (in Bcoord.sys)	kN		
	53	RootFyb2	🟩	🟩	🟩	B2 root in plane force (in Bcoord.sys)	kN		
	54	RootFzb2	🟩	🟩	🟩	B2 spanwise force (in Bcoord.sys)	kN		
	55	RootFxb3	🟩	🟩	🟩	B3 root out of plane force in Bcoord.sys)	kN		
	56	RootFyb3	🟩	🟩	🟩	B3 root in plane force (in Bcoord.sys)	kN		
	57	RootFzb3	🟩	🟩	🟩	B3 spanwise force (in Bcoord.sys)	kN		
	58	RootMxb1	🟩	🟩	🟩	B1 root in plane bending moment (in Bcoord.sys)	kNm		
	59	RootMyb1	🟩	🟩	🟩	B1 root out of plane bending moment (in Bcoord.sys)	kNm		
	60	RootMzb1	🟩	🟩	🟩	B1 twist moment (in B coord. sys)	kNm		
	61	RootMxb2	🟩	🟩	🟩	B2 root in plane bending moment (in B coord.sys)	kNm		
	62	RootMyb2	🟩	🟩	🟩	B2 root out of plane bending moment (in B coord.sys)	kNm		
	63	RootMzb2	🟩	🟩	🟩	B2 twist moment (in B coord. sys)	kNm		
	64	RootMxb3	🟩	🟩	🟩	B3 root in plane bending moment (in Bcoord.sys)	kNm		
	65	RootMyb3	🟩	🟩	🟩	B3 root out of plane bending moment (in B coord.sys)	kNm		

	66	RootMzb3	🟩	🟩	🟩	B3 twist moment (in B coord. sys)	kNm		
	67	TTDspFA	🟩	🟩	🟩	tower top fore-aft displ.	m		@ 106.5 m from HF TB, @ 103.6 m from SW TB
	68	TTDspSS	🟩	🟩	🟩	tower top side-side displ.	m		@ 106.5 m from HF TB, @ 103.6 m from SW TB
	69	NcIMUTAxs	🟩	🟩	🟩	nacelle fore-aft acceleration	m/s2		
	70	NcIMUTAys	🟩	🟩	🟩	nacelle side-side acceleration	m/s2		
	71	NcIMUTVxs	🟩	🟩	🟩	nacelle fore-aft velocity	m/s		
	72	NcIMUTVys	🟩	🟩	🟩	nacelle side-side velocity	m/s		
	73	TipDxc1	🟩	🟩	🟩	B1 tip fore-aft displacement	m		
	74	TipDyc1	🟩	🟩	🟩	B1 tip side-side displacement	m		
	75	TipDxc2	🟩	🟩	🟩	B2 tip fore-aft displacement	m		
	76	TipDyc2	🟩	🟩	🟩	B2 tip side-side displacement	m		
	77	TipDxc3	🟩	🟩	🟩	B3 tip fore-aft displacement	m		
	78	TipDyc3	🟩	🟩	🟩	B3 tip side-side displacement	m		
	79	RotThrust	🟩	🟩	🟩	LSS thrust force	kN		
	80	LSShftFxa	🟩	🟩	🟩	LSS thrust force	kN		
	81	LSShftFya	🟩	🟩	🟩	Rotating LSS shear force	kN		
	82	LSShftFza	🟩	🟩	🟩	Rotating LSS shear force	kN		
	83	LSShftFys	🟩	🟥	🟩	Nonrotating LSS shear force	kN		
	84	LSShftFzs	🟩	🟥	🟩	Nonrotating LSS shear force	kN		
	85	LSShftMxa	🟩	🟩	🟩	LSS torque	kNm		
	86	LSSTipMya	🟩	🟨	🟩	Rotating LSS bending moment at the shaft tip	kNm		
	87	LSSTipMza	🟩	🟨	🟩	Rotating LSS bending moment at the shaft tip	kNm		
	88	LSSTipMys	🟩	🟥	🟩	Nonrotating LSS bending moment at the shaft tip	kNm		
	89	LSSTipMzs	🟩	🟥	🟩	Nonrotating LSS bending moment at the shaft tip	kNm		
Aero	90	RtAeroFxh	🟩	🟩	🟥	rotor aerodynamic thrust	N		
	91	RtAeroMxh	🟩	🟩	🟥	rotor aerodynamic torque	N-m		
	92	RtAeroPwr	🟩	🟩	🟥	rotor aerodynamic power	W		
Hydro	93	B1HdSFxi	🟩	🟩	🟥	hydrostatic force in x	kN		
	94	B1HdSFyi	🟩	🟩	🟥	hydrostatic force in y	kN		
	95	B1HdSFzi	🟩	🟩	🟥	hydrostatic force in z	kN		
	96	B1HdSMxi	🟩	🟩	🟥	X hydrostatic moment	kNm		
	97	B1HdSMyi	🟩	🟩	🟥	Y hydrostatic moment	kNm		
	98	B1HdSMzi	🟩	🟩	🟥	Z hydrostatic moment	kNm		
	99	B1RdtFxi	🟩	🟩	🟥	radiation force in x	kN		
	100	B1RdtFyi	🟩	🟩	🟥	radiation force in y	kN		
	101	B1RdtFzi	🟩	🟩	🟥	radiation force in z	kN		
	102	B1RdtMxi	🟩	🟩	🟥	radiation moment around x	kNm		
	103	B1RdtMyi	🟩	🟩	🟥	radiation moment around y	kNm		

	104	B1RdtMzi	🟩	🟩	🟥	radiation moment around z	kNm		
	105	B1WvsF1xi	🟩	🟩	🟥	diffraction force in x	kN		
	106	B1WvsF1yi	🟩	🟩	🟥	diffraction force in y	kN		
	107	B1WvsF1zi	🟩	🟩	🟥	diffraction force in z	kN		
	108	B1WvsM1xi	🟩	🟩	🟥	diffraction moment around x	kNm		
	109	B1WvsM1yi	🟩	🟩	🟥	diffraction moment around y	kNm		
	110	B1WvsM1zi	🟩	🟩	🟥	diffraction moment around z	kNm		
	111	B1WvsF2xi	🟩	🟩	🟥	sum frequency force in x	kN	not for SW	not for SW& HF
			🟩	🟩	🟥	slowly varying drift force in x	kN	not for SW	not for SW & HF
	112	B1WvsF2yi	🟩	🟩	🟥	sum frequency force in y	kN	not for SW	not for SW & HF
			🟩	🟩	🟥	slowly varying drift force in y	kN	not for SW	not for SW & HF
	113	B1WvsF2zi	🟩	🟩	🟥	sum frequency force in z	kN	not for SW	not for SW & HF
			🟩	🟩	🟥	slowly varying drift force in z	kN	not for SW	not for SW & HF
	114	B1WvsM2xi	🟩	🟩	🟥	sum frequency moment around x	kNm	not for SW	not for SW& HF
			🟩	🟩	🟥	slowly varying drift moment around x	kNm	not for SW	not for SW & HF
	115	B1WvsM2yi	🟩	🟩	🟥	sum frequency moment around y	kNm	not for SW	not for SW & HF
			🟩	🟩	🟥	slowly varying drift moment around ys	kNm	not for SW	not for SW & HF
	116	B1WvsM2zi	🟩	🟩	🟥	sum frequency moment around z	kNm	not for SW	not for SW & HF
			🟩	🟩	🟥	slowly varying drift moment around z	kNm	not for SW	not for SW & HF
Specific for HEXAFLOAT	117	CwCogX		🟩	🟩	Counterweight X pos. @ CoG	m		
	118	CwCogY		🟩	🟩	Counterweight Y pos. @ CoG	m		
	119	CwCogZ		🟩	🟩	Counterweight Z pos. @ CoG	m		
	120	TendTens1		🟩	🟩	Tendon 1 Tension	N		@ 30.8 m from top fairlead
	121	TendTens2		🟩	🟩	Tendon 2 Tension	N		@ 30.8 m from top fairlead
	122	TendTens3		🟩	🟩	Tendon 3 Tension	N		@ 30.8 m from top fairlead
	123	TendTens4		🟩	🟩	Tendon 4 Tension	N		@ 30.8 m from top fairlead
	124	TendTens5		🟩	🟩	Tendon 5 Tension	N		@ 30.8 m from top fairlead
	125	TendTens6		🟩	🟩	Tendon 6 Tension	N		@ 30.8 m from top fairlead

6.2. FORMAT

The data is formatted in OpenFAST binary format. The suggested method to open the data files is trough Python (PyFAST toolbox) or using the OpenFAST matlab toolbox [24].

6.3. ADDITIONAL COMMENTS

At the time of writing some issues were encountered with the OpenFAST model of the SOFTWIND 10MW turbine in DLC6.2. In particular, some simulations did not converge due to unresolved instability issues and were therefore not included in the dataset.

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