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The M^3EA project: A new large floating platform dedicated to LiDAR and environmental measurements

Jeremy Tolu, Jacques Barreau

Nass&Wind Offshore, 56 100 Lorient, FRANCE

Introduction

The cost of energy reduction is probably the most important factor of success for the European offshore wind industry. One of the upstream key parameter that allows to optimize and reduce the LCOE (Levelized Cost of Energy), is a high quality wind measurement campaign.

However, the offshore windfarm projects are implemented on deeper and deeper sites, and much more for the future floating wind projects. An alternative to offshore met mast must be found with two main prerequisites: cheaper cost and equal quality of data compared with those provided by conventional offshore met masts.

For more than 2 years now, Nass&Wind Offshore has launched an internal R&D program that aims at designing an innovating floating platform dedicated to LiDAR wind measurements and other environmental parameters. In particular, we have designed a large floating platform in order to easily accommodate many environmental instruments in addition to the LiDAR system.

This project is named **M^3EA**: **Marine Measurements for Meteorological and Environmental Assessment**.

Key figures of M^3EA

The platform key features can be summarized as follow:

- **A large float:** 70 tons, 12 m in diameter with natural stability and an easy access for maintenance,
- **A powerful and autonomous electrical system:** 4 wind turbines, 18 solar panels, a 5 KW diesel generator and a 1000 Ah battery pack, that can provide more than 500 W continuously.
- **A large and flexible upper instrumentation deck:** 17 m² available to accommodate the LiDAR and many other instruments (position and attitude sensor, CCTV, AIS …). Thus, the platform can be considered as a real floating and flexible offshore laboratory.

M^3EA has been installed in our test site located in the North of French coasts, and it is still **in operation since January 2014**. The test site consists in a very small uninhabited island at about 8 km from the coast, on which a reference lidar has been installed; M^3EA is anchored close to this island.

Due to the large size of M^3EA, all curative and preventive maintenance operations - even sensitive operations as a repair and replacement of defective parts in the PC rack of the LiDAR - have been realized on site. Therefore, the availability of the system was optimal. We can even note that due to the large and redundant electrical system, no power cut occurred.

Moreover, thanks to its characteristics (size and electrical power > 500 W), **we expect to implement innovative sensors in the coming months, such as bird radar.** Indeed, the effects of offshore wind projects on birds are poorly understood and it is one of the main strategic issues for the success of wind projects.

Wind measurement performances

A critical analysis of the recorded data from both LiDARs (the reference one and M^3EA's one) and the floating platform performances (attitude and position of the floating platform from a three antenna GPS system, sea states from an ADCP) has been done in compliance with offshore measurement standards. Indeed, the test protocol is based on the Carbon Trust offshore wind accelerator roadmap for the commercial acceptance of floating LiDAR technology [1].

Eleven months of wind measurements have been analyzed and results meet relevant industry standards. **M^3EA is able to reproduce onshore LiDAR wind speeds and wind directions at a very accurate and acceptable level.**

Availability / Reliability

About the Key Performance Indicators (KPIs) defined in [1] relating to the availability of M^3EA, acceptance criteria for $OPDA_{CA}$ (>85%, Overall Post-processed Data Availability) are met for each measurement height (up to 200 m). The $OPDA_{CA}$ is the most important criteria for availability because it represents the amount of useful data (data filtered) required as part of a wind resource analysis.

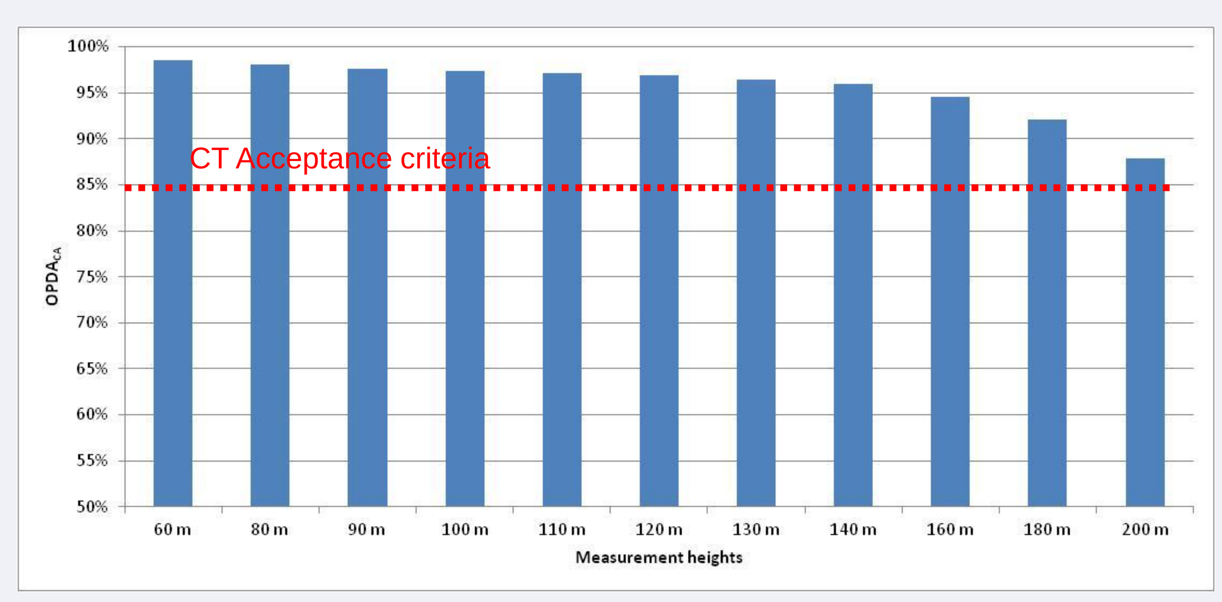

Figure 1 – Overall post-processed data availability ($OPDA_{CA}$) for the measurement campaign

Accuracy assessment

The KPIs relating to the accuracy of M^3EA have been reviewed and compared to the Acceptance Criteria defined in [1]. Finally, over a period of 11 months, the 'best practice" acceptance criteria [1] for accuracy are met at all comparable measurement heights.

	X_{mws}				R^2_{mws}			
	Corrected Data		Uncorrected Data		Corrected Data		Uncorrected Data	
Height of measure (m LAT)	Wind speed between 4 and 16 m/s	All wind speeds above 2 m/s	Wind speed between 4 and 16 m/s	All wind speeds above 2 m/s	Wind speed between 4 and 16 m/s	All wind speeds above 2 m/s	Wind speed between 4 and 16 m/s	All wind speeds above 2 m/s
60	1.005	1.004	1.004	1.004	0.983	0.989	0.983	0.989
80	1.009	1.009	1.009	1.009	0.983	0.990	0.983	0.990
90	1.010	1.010	1.010	1.010	0.984	0.990	0.984	0.990
100	1.010	1.009	1.010	1.009	0.984	0.990	0.984	0.990
110	1.011	1.010	1.011	1.010	0.984	0.991	0.984	0.991
120	1.010	1.009	1.010	1.009	0.985	0.991	0.985	0.991
130	1.009	1.009	1.009	1.009	0.985	0.991	0.985	0.991
140	1.009	1.009	1.009	1.009	0.985	0.991	0.985	0.991
160	1.010	1.009	1.010	1.010	0.986	0.992	0.986	0.992
180	1.008	1.008	1.008	1.008	0.987	0.992	0.986	0.992
Acceptance criteria	Best practice : 0.98 to 1.02				Best practice : > 0.98			
	Minimum : 0.97 to 1.03				Minimum : > 0.97			

Figure 2 – Mean wind speed accuracy assessment

	M_{mwd}		OFF_{mwd}		R^2_{mwd}	
Height of measure (m LAT)	All wind speed	Wind speed above 2 m/s	All wind speed	Wind speed above 2 m/s	All wind speed	Wind speed above 2 m/s
60	1.012	1.014	-2.5	-2.8	0.988	0.990
80	1.011	1.013	-2.4	-2.8	0.988	0.990
90	1.012	1.013	-2.7	-3.0	0.989	0.990
100	1.012	1.014	-2.8	-3.2	0.989	0.990
110	1.013	1.014	-2.9	-3.2	0.989	0.990
120	1.012	1.014	-2.8	-3.2	0.989	0.990
130	1.012	1.014	-2.8	-3.2	0.988	0.991
140	1.012	1.014	-2.8	-3.2	0.988	0.990
160	1.012	1.014	-2.9	-3.2	0.988	0.991
180	1.013	1.014	-2.9	-3.2	0.989	0.991
Acceptance Criteria	Best practice : 0.97 to 1.03		Best practice : |OFF| < 5		Best practice : > 0.97	
	Minimum : 0.95 to 1.05		Minimum : |OFF| < 10		Minimum : > 0.95	

Figure 3 – Mean wind direction accuracy assessment

The LiDAR installed on M^3EA is equipped with a movement-correction system for wind measurements. Figure 2 shows results relating to the analysis of the data corrected with this system, and data not corrected.

Therefore, there is no significant difference for the acceptance criteria which remained within the 'best practice" figures. For movements of the floating platform met during the test campaign, no movement compensation system is necessary.

Indeed, **the M^3EA design and size induce a low and limited tilt** as shown on figure 4, even for high wind speeds. The average tilt (average over 10 minutes) is always lower than 5° for wind speeds up to about 30 m/s. The maximum tilt (1 second) is about 20° for wind speeds up to about 30 m/s.

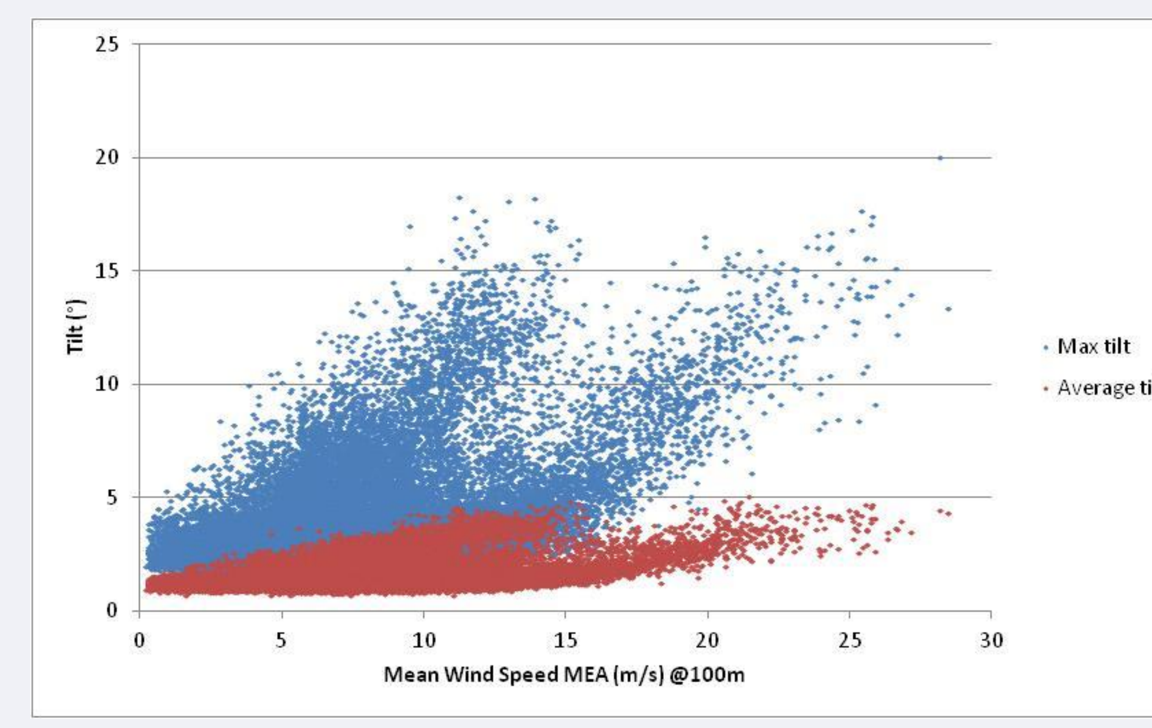

Figure 4 – Relation between wind speed at the M3EA @100 m and tilt of the platform

Looking at the influence of the tilt on the wind speed measured by M^3EA (see figure below), there is no significant impact of the tilt on wind accuracy.

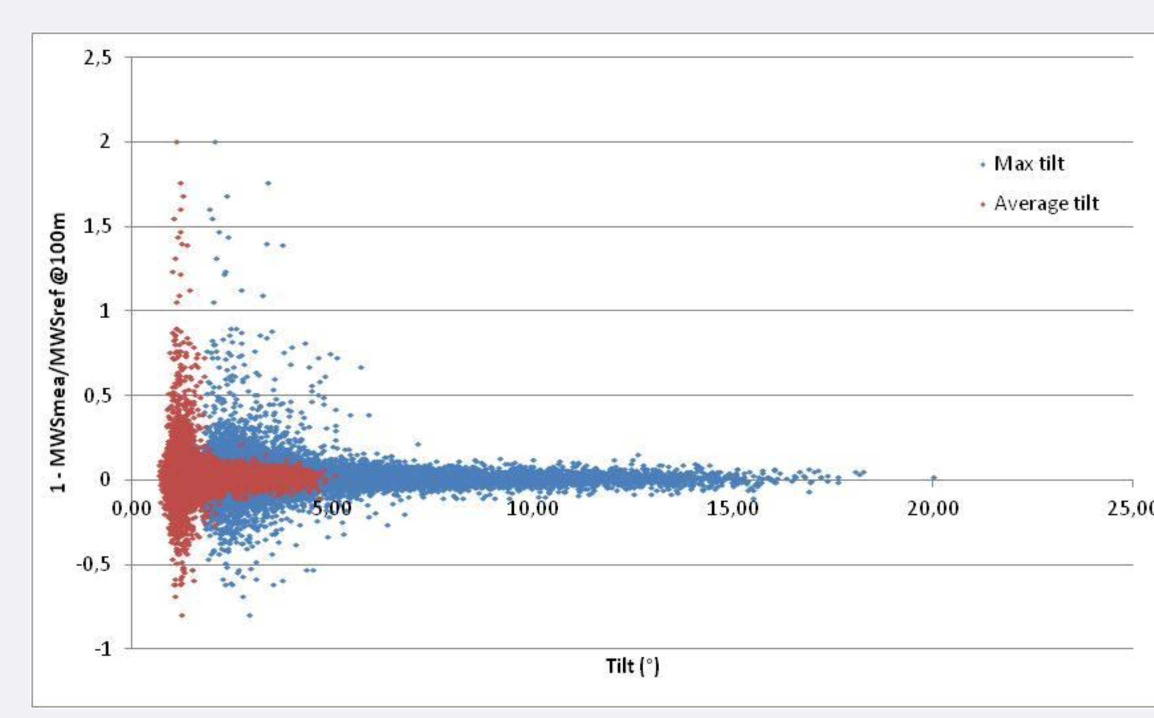

Figure 5 – Relation between wind speed ratio between M^3EA and the reference LiDAR (1- MWS_{MEA}/MWSref) @100 m and tilt of the platform

Conclusions

For wind measurements, our floating platform M^3EA has been shown to pass all accuracy acceptance criteria given in [1]. M^3EA is able to reproduce onshore LiDAR wind speeds and wind directions with a high level of accuracy, comparable with conventional offshore met masts.

Now, Nass&Wind Offshore is about to design and implement new sensors on M^3EA (birds and bats radar, hydrophones, water quality sensors…) in order to collect environmental data. **Thanks to its large size and its powerful electrical system, M^3EA will bring a real alternative to offshore met masts, collecting the same measurements (wind and wave climate, environmental) at a reduced cost.**

References

1. 'CTC819, OWA, Roadmap for the commercial acceptance of floating LIDAR technology, Carbon Trust Offshore Wind Accelerator, November 2013

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