G97 90m
Load Validation Campaign
Bladed 3.72

Bladed User Conference, 24/09/2014
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G9X Loads & Dynamics Team Leader

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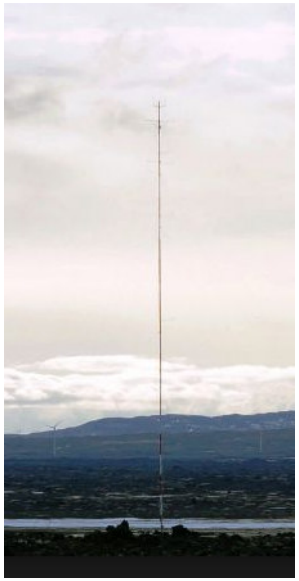
0.0 INTRODUCTION

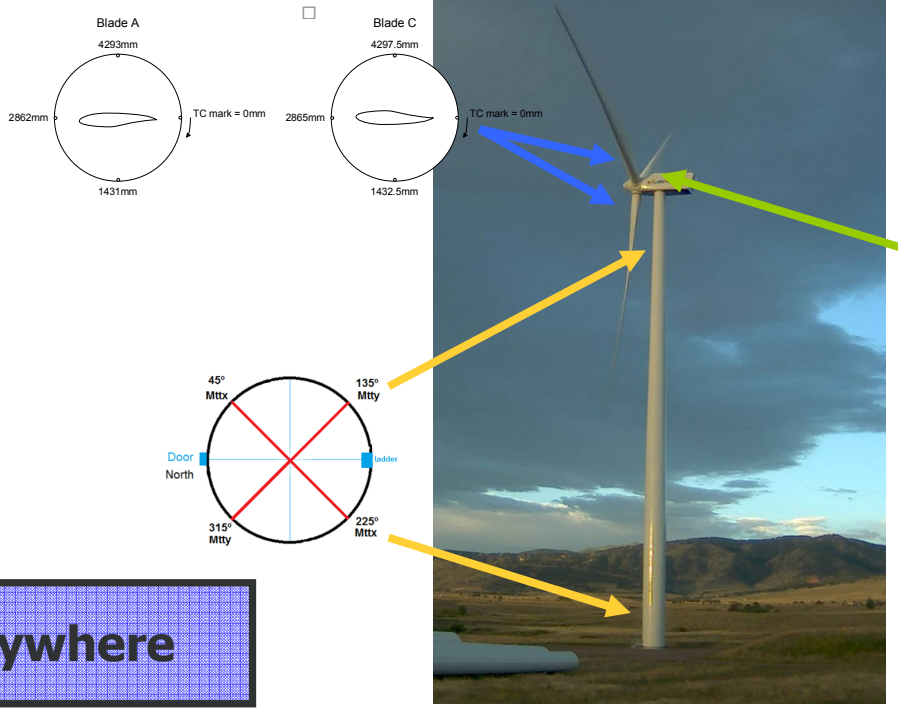
97 90m at NREL NWTC (USA)

Are our models and aeroelastic codes reproducing the dynamic behaviour of the WT? Are the load levels accurate?

→ **Met mast**



→ **Prototype**



Uncertainties are everywhere

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0.0 INDEX

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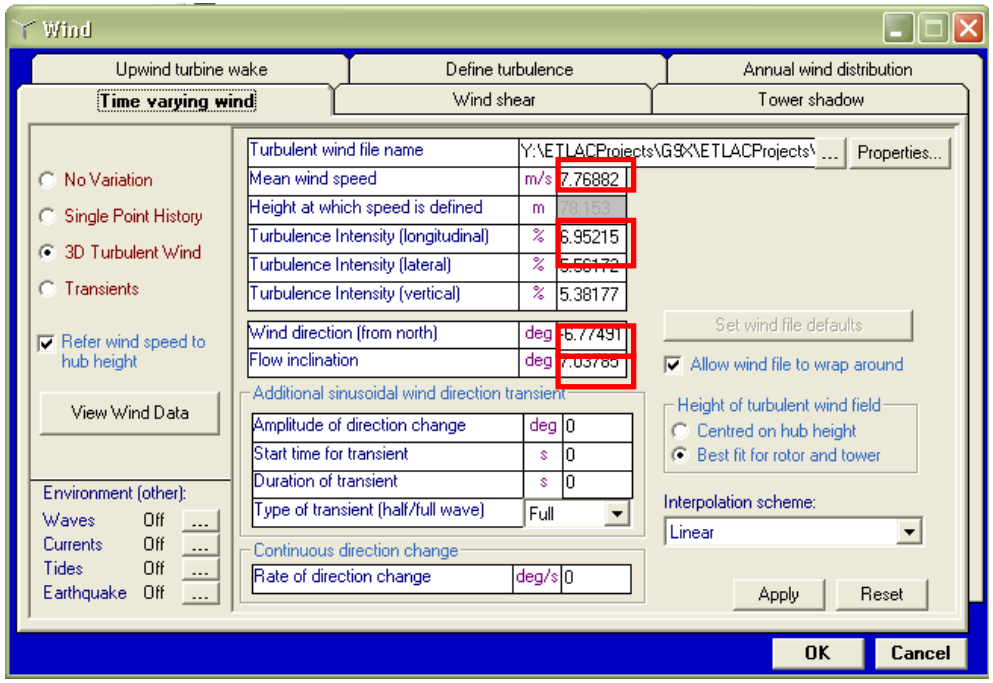
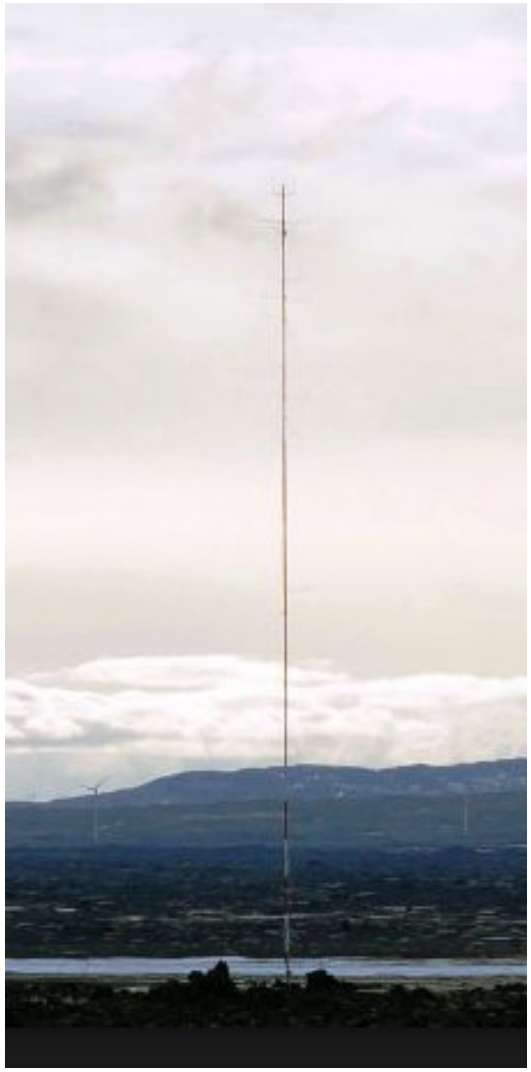
1.0 WIND CONDITIONS RECREATION

→ **Necessary wind data for the simulations are measured from the Met Mast: the mean values of**

- Density
- Wind Shear
- Wind Direction
- TI: longitudinal, vertical and lateral
- Upflow





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2.0 AEROELASTIC MODEL ADAPTATION TO PROTOTYPE

→ **Blade Adaptation:**

- o Mean Blade definition from the mounted three blades.
- o Imbalance setting.

→ **Drive Train adaptation**

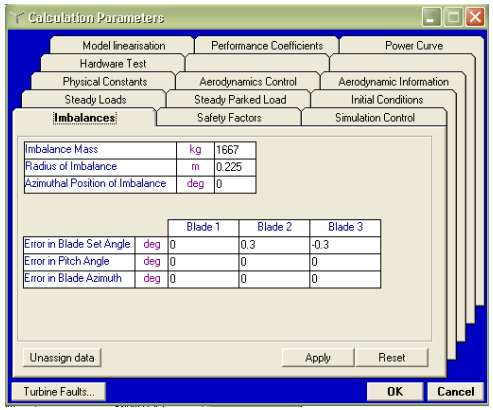
- o Drive Train frequency: the aeroelastic model Drive Train Stiffness can be modified to match the frequency measured in field.

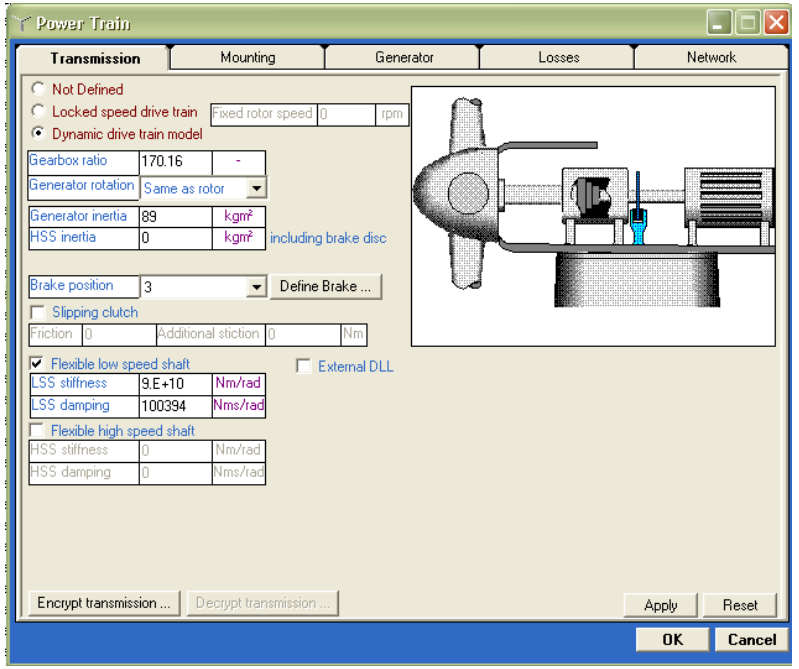
→ **Others**

- o In other to minimize error sources: pitch TC…

→ **Frequency verification**

- o The Campbell diagram can be performed to guarantee deviations of the prototype are low.





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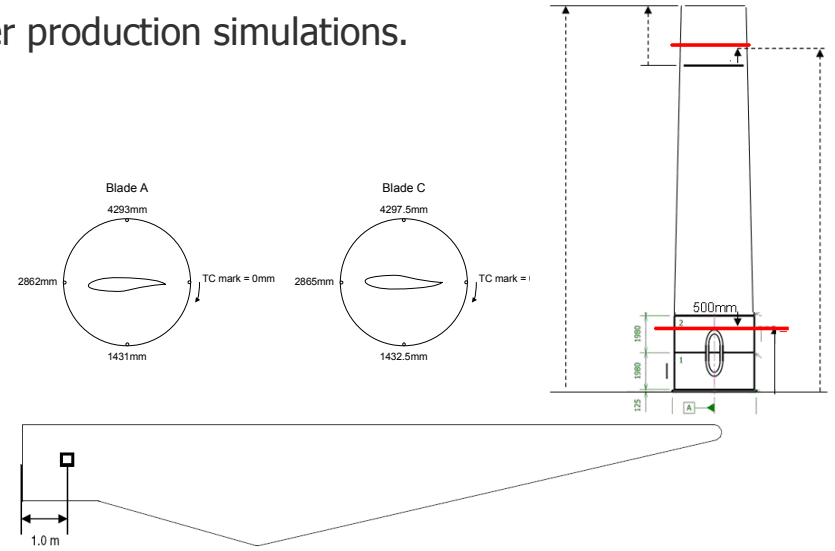
3.0 POWER PRODUCTION SIMULATIONS AND POST PROCESSING

→ Winds and Simulations

- 585 10min measurements, Capture Matrix Fulfilled!
- 585x6 seeds = 3510 turbulent winds and power production simulations.

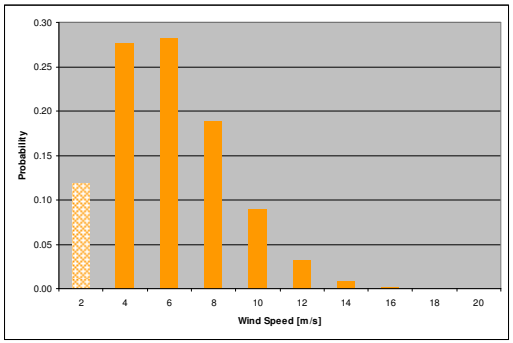
→ Channel Combination

- Shaft Gauges: MSMy and MSMz calculation.
- Tower and Blade Gauges:
  1. intermediate sections .
  2. Different reference systems (Blade).
  3. Rotation due to gauges positionning.



→ Fatigue Equivalent Load calculation

- 1Hz Rainflow Cycle Counting for 10min Measurements & Simulations.
- Representative Equivalent Load per Wind Speed bin.
- 20 year partial equivalent load.



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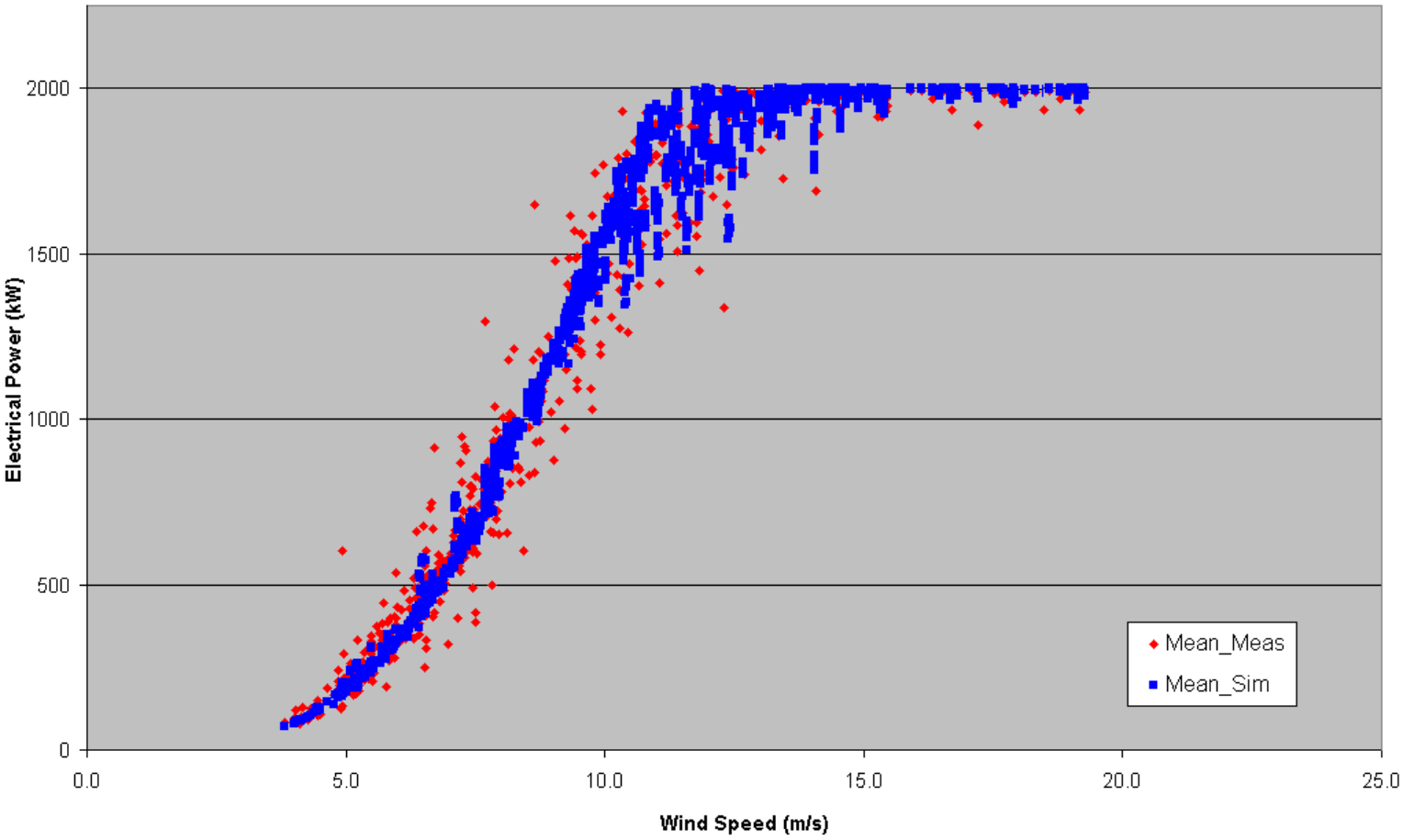
4.0 COMPARISON MEASUREMENTS VS SIMULATIONS

4.1 OPERATING PARAMETERS

→ **Electrical Power vs. Wind Speed**



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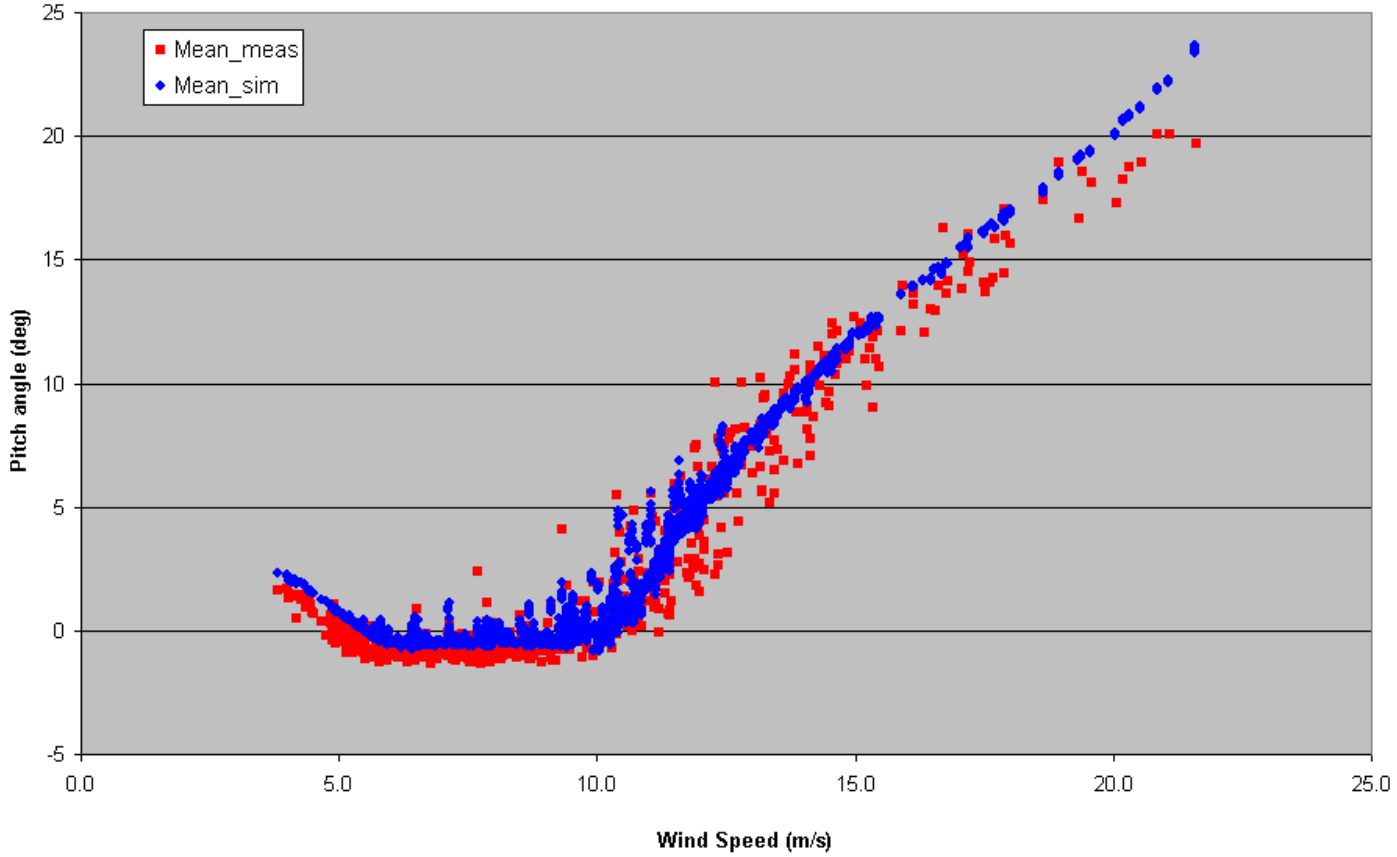
4.0 COMPARISON MEASUREMENTS VS SIMULATIONS

4.1 OPERATING PARAMETERS

→ **Mean values of the Pitch**



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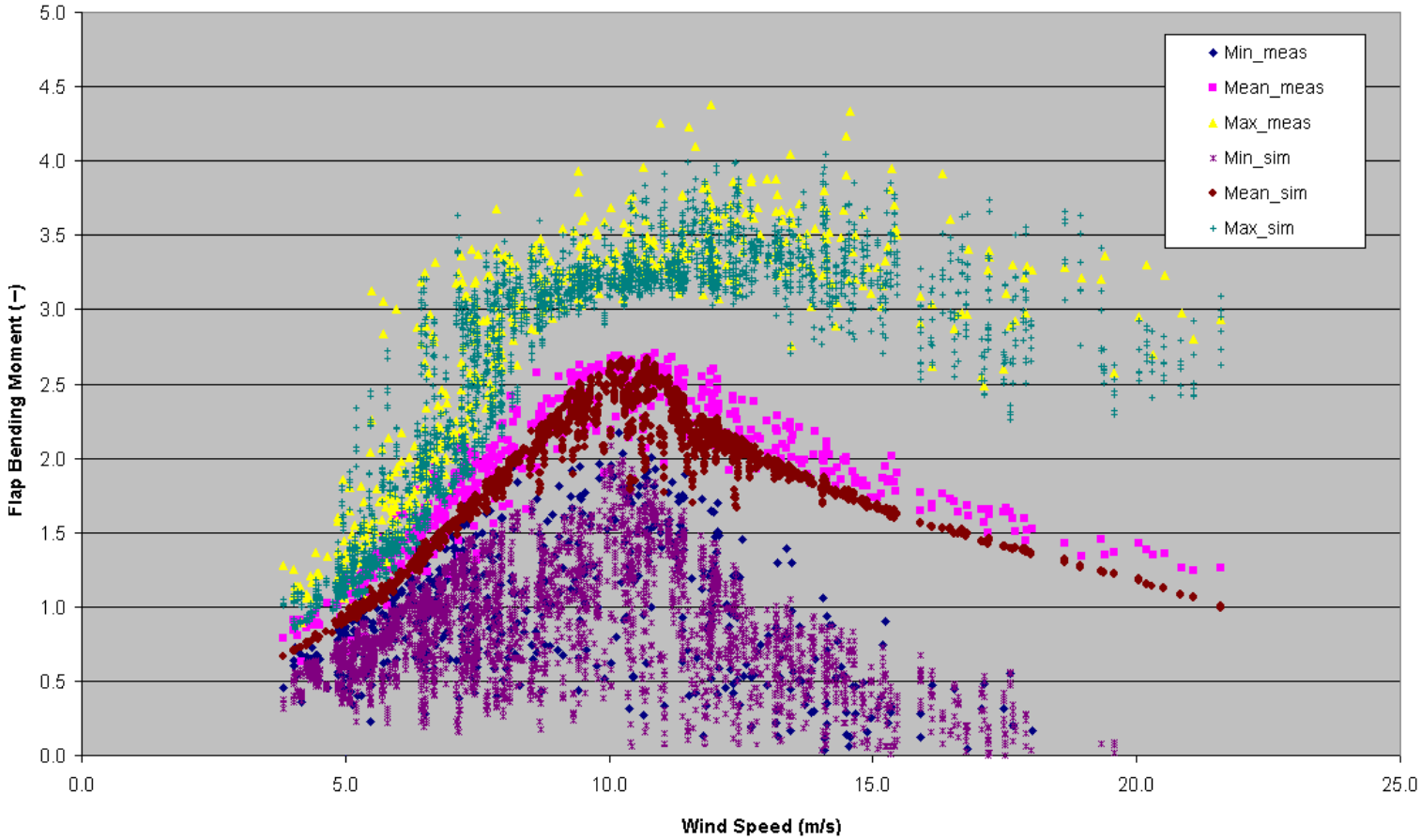
4.0 COMPARISON MEASUREMENTS VS SIMULATIONS

4.2 LOADS

→ **FBM STATISTICS: MAX, MEAN & MIN**



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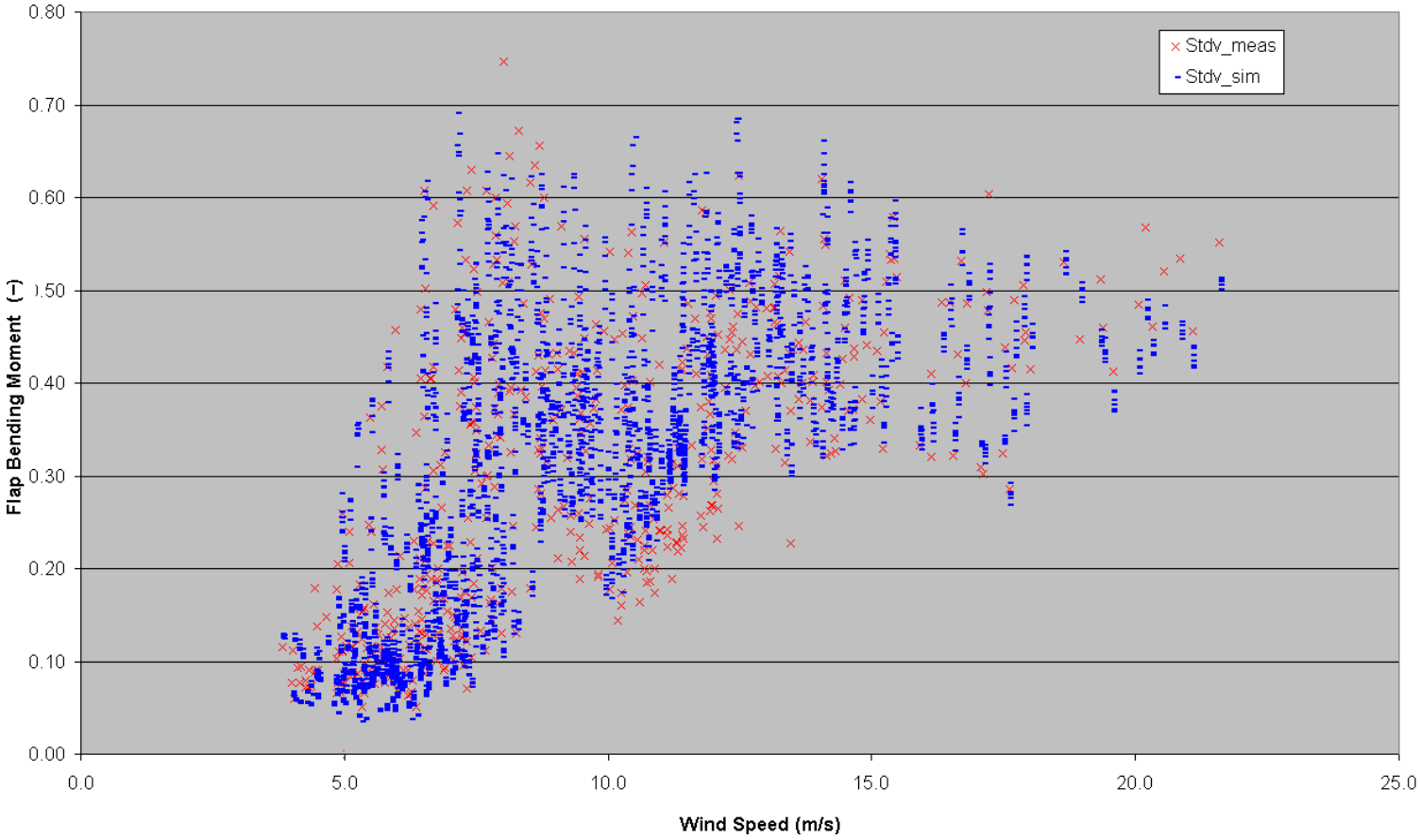
4.0 COMPARISON MEASUREMENTS VS SIMULATIONS

4.2 LOADS

→ **FBM STATISTICS: STD DEVIATION**



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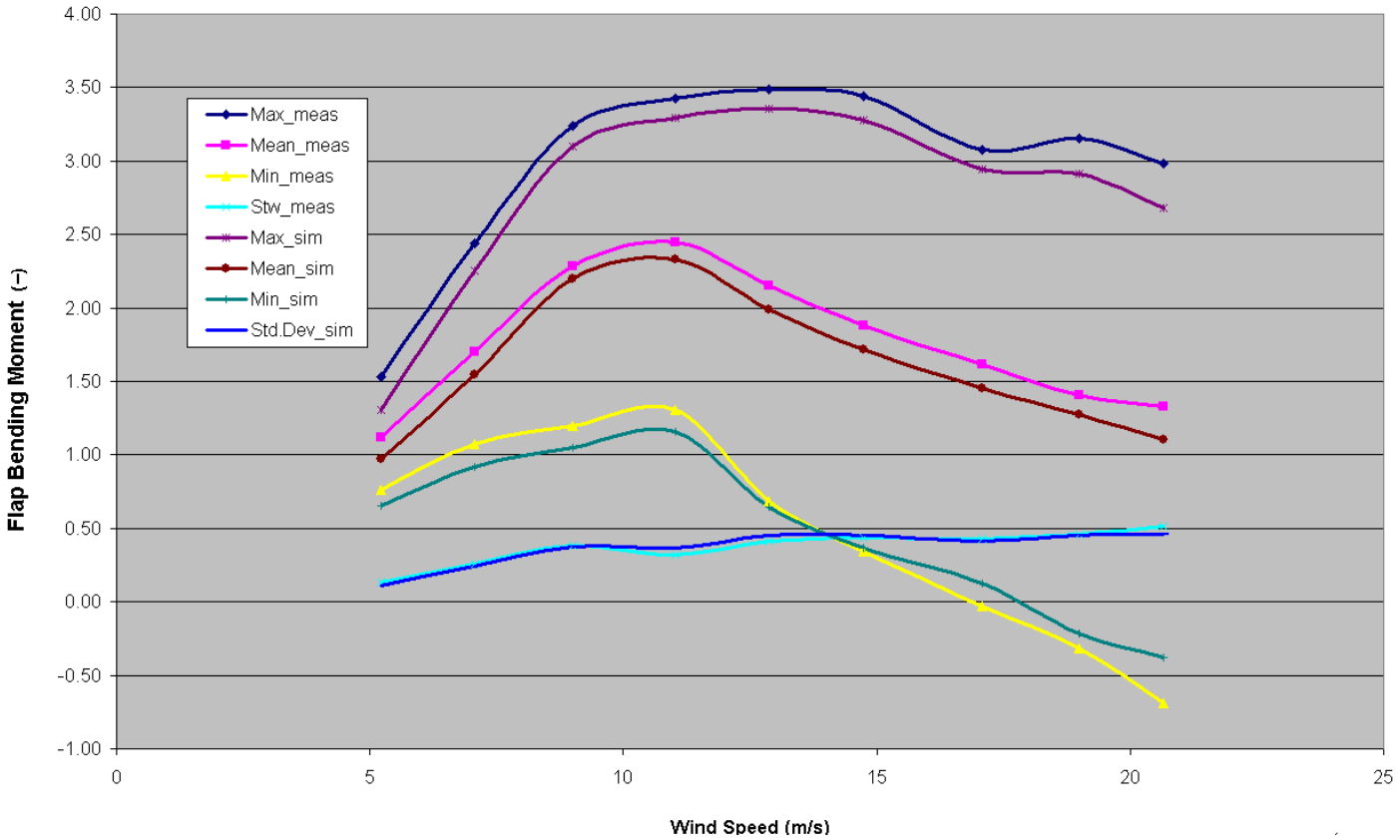
4.0 COMPARISON MEASUREMENTS VS SIMULATIONS

4.2 LOADS

→ **FBM STATISTICS: MEAN VALUES PER BIN**



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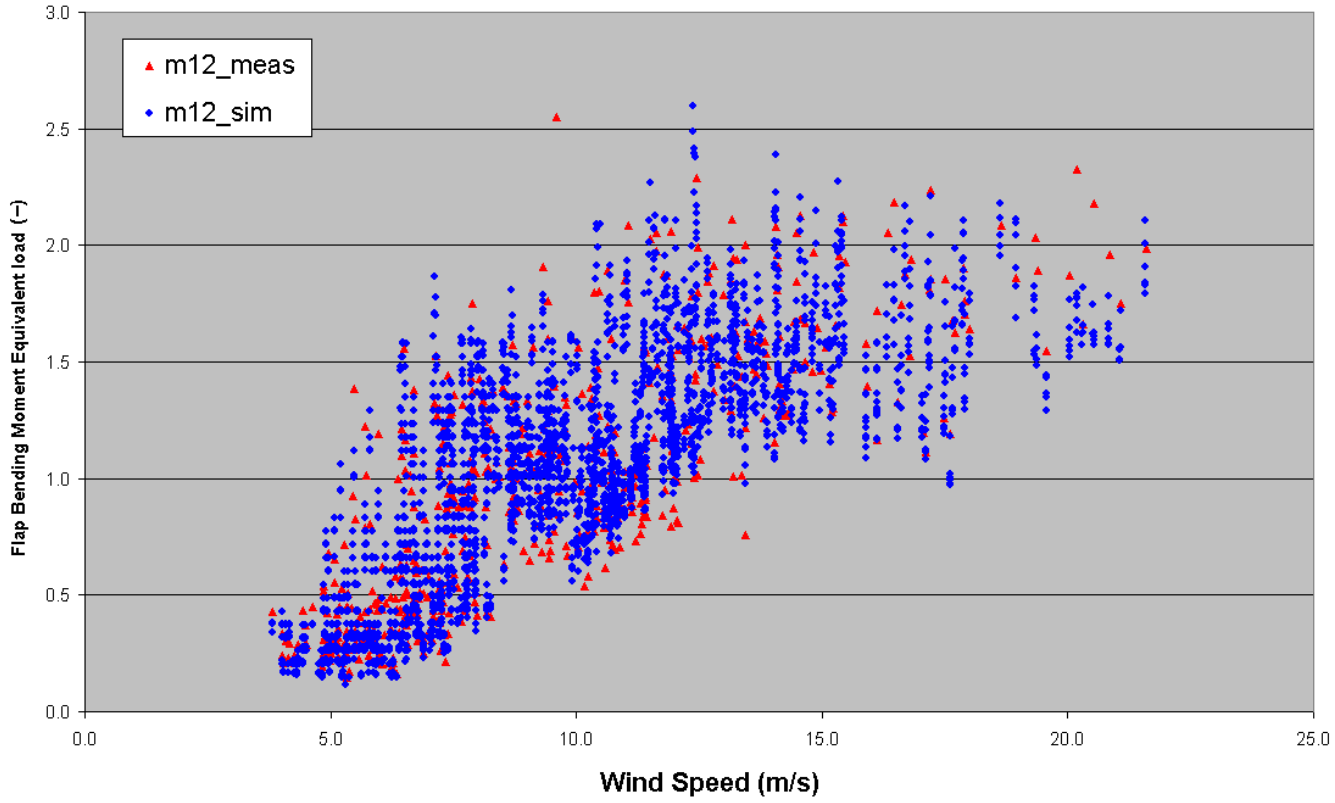
4.0 COMPARISON MEASUREMENTS VS SIMULATIONS

4.2 LOADS

→ **FBM FATIGUE LOADS**

		Blade_My		
		Leq4	Leq8	Leq12
Sims	EqL 20 Years 1Hz	0.913	1.117	1.214
Measured	EqL 20 Years 1Hz	0.895	1.134	1.251
		2.0%	-1.5%	-3.0%



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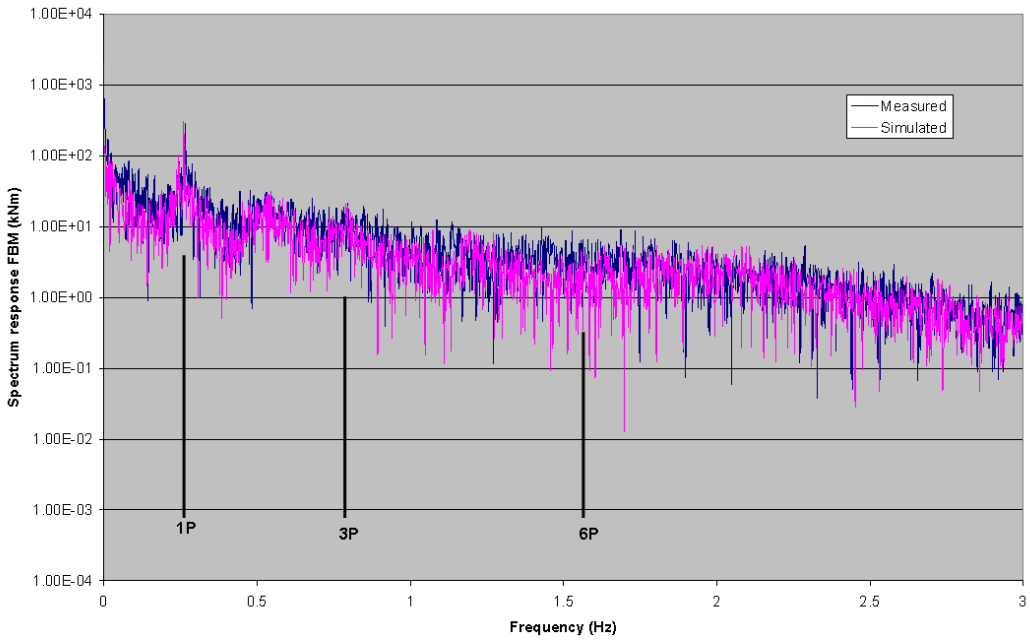
4.0 COMPARISON MEASUREMENTS VS SIMULATIONS
4.3 FREQUENCY ANALYSIS

→ FBM FFT analysis

- A 10min measurement time serie is selected ($V=15m/s>V_{rated}$) → a power production simulation is created with the same wind conditions.
- An FFT analysis is performed for all the variables involved in the comparison with both time series, measurements and simulations.
- Response Spectra are compared in order to identify dynamic discrepancies.



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5.0 CONCLUSIONS AND IMPROVEMENTS

→ Conclusions

- Despite all the uncertainties involved in the process, good agreement is observed in general.
- Strong interaction with the instrumentation entity is essential to find the sources of discrepancies.
- The selection of the Wind Site for the prototype is important (avoid Complex Terrain).
- A lot of data involved in measurements and, specially, in simulations → a good data management (preprocessing, filtering, post processing…) is essential for efficiency.
- A lot of useful information gathered → Maximise its use!

→ Improvements

- Grow the possiblities of the simulations (wind shear, wind direction, input different blades…).
- Quantify the uncertainties in order to have a better idea of where we really are.

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AKNOWLEDGEMENTS AND QUESTIONS

→**Aknowledgements**

- G9X Loads and Dynamics Team, especially Jesús Javier Guerrero and Roberto Santivañez.

→**Thank you very much for your attention**

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