Application of OMA for Low-Frequency Modes Detection in FOWT: Numerical Study on OC4-DeepCwind Semi-Submersible

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1 Motivation

- **Floating Offshore Wind Turbines** (FOWTs) have huge potential in harvesting wind energy for sites with deeper water depth (more than 50m) [1].
- However, their commercialization has been hindered by high **operational and maintenance** costs (**OPEX**) [2].

2 Scope of Research

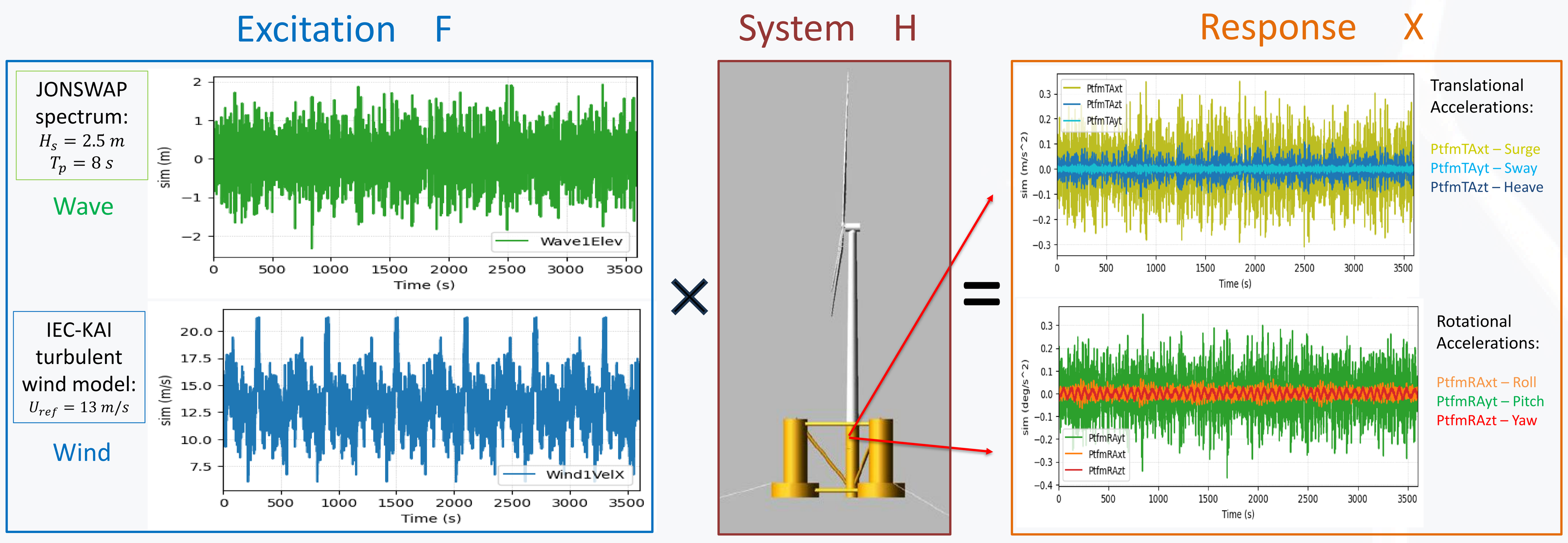
- The **dynamics** of mooring systems, floating platform and wind turbine are more complex, leading to greater uncertainties and higher costs [3].
- **Structural Health Monitoring** (SHM) systems can mitigate these uncertainties and reduce OPEX cost.

3 Research Question

Can we reliably detect the platform **low-frequency** rigid body modes (e.g., surge, sway..) using **Operational Modal Analysis (OMA)**?

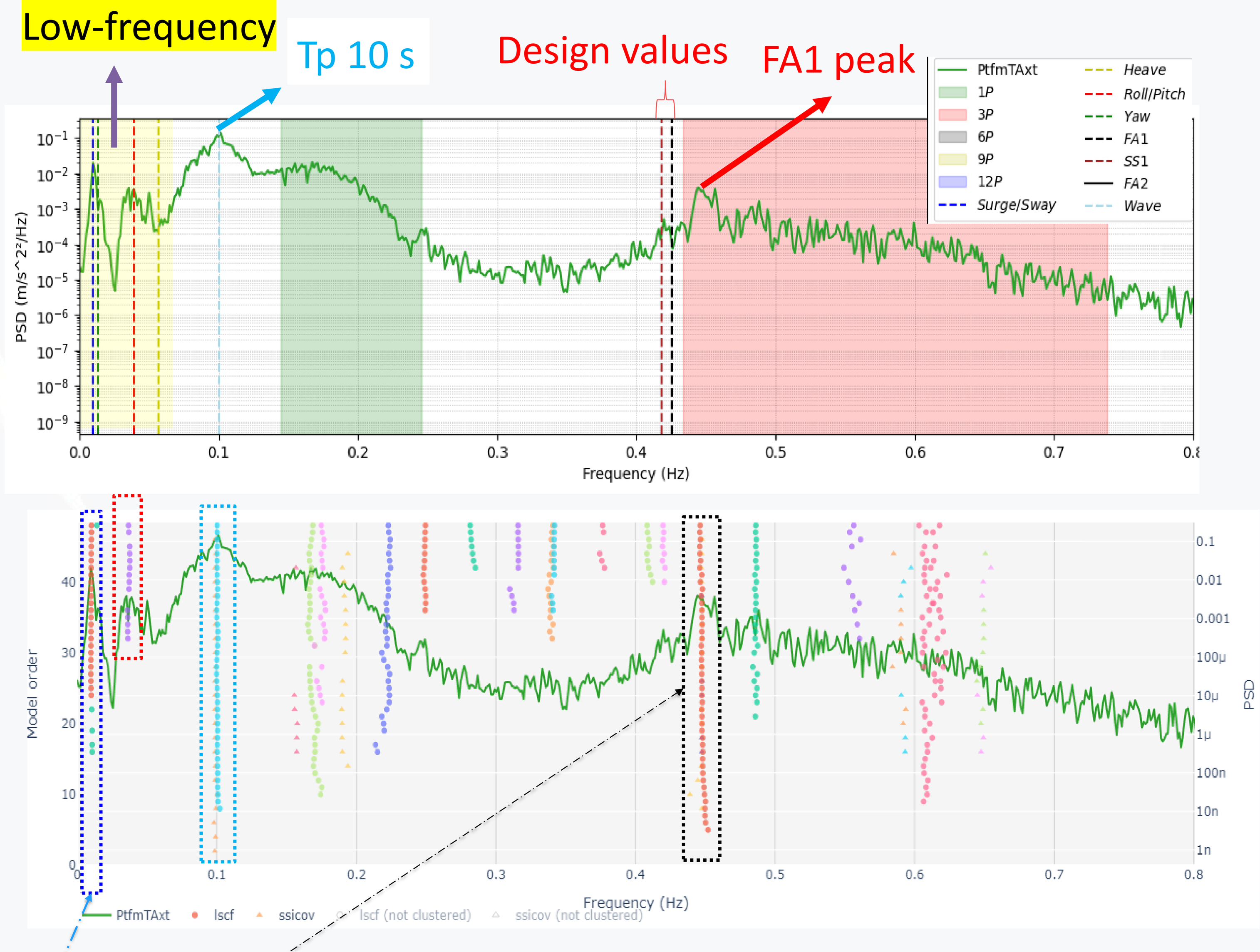
3 Methodology

3.1 Time-domain Analysis (OpenFAST)



1. **OpenFAST** is used to simulate the response under wave and wind loading.
2. Response is collected at several points, resampling placing **accelerometers**.
3. PSD of surge acceleration sensor shows peaks at **the low-frequency region**.
4. Using **OMA** algorithm (LSCF), **poles** are stabilizing around the physical modes.

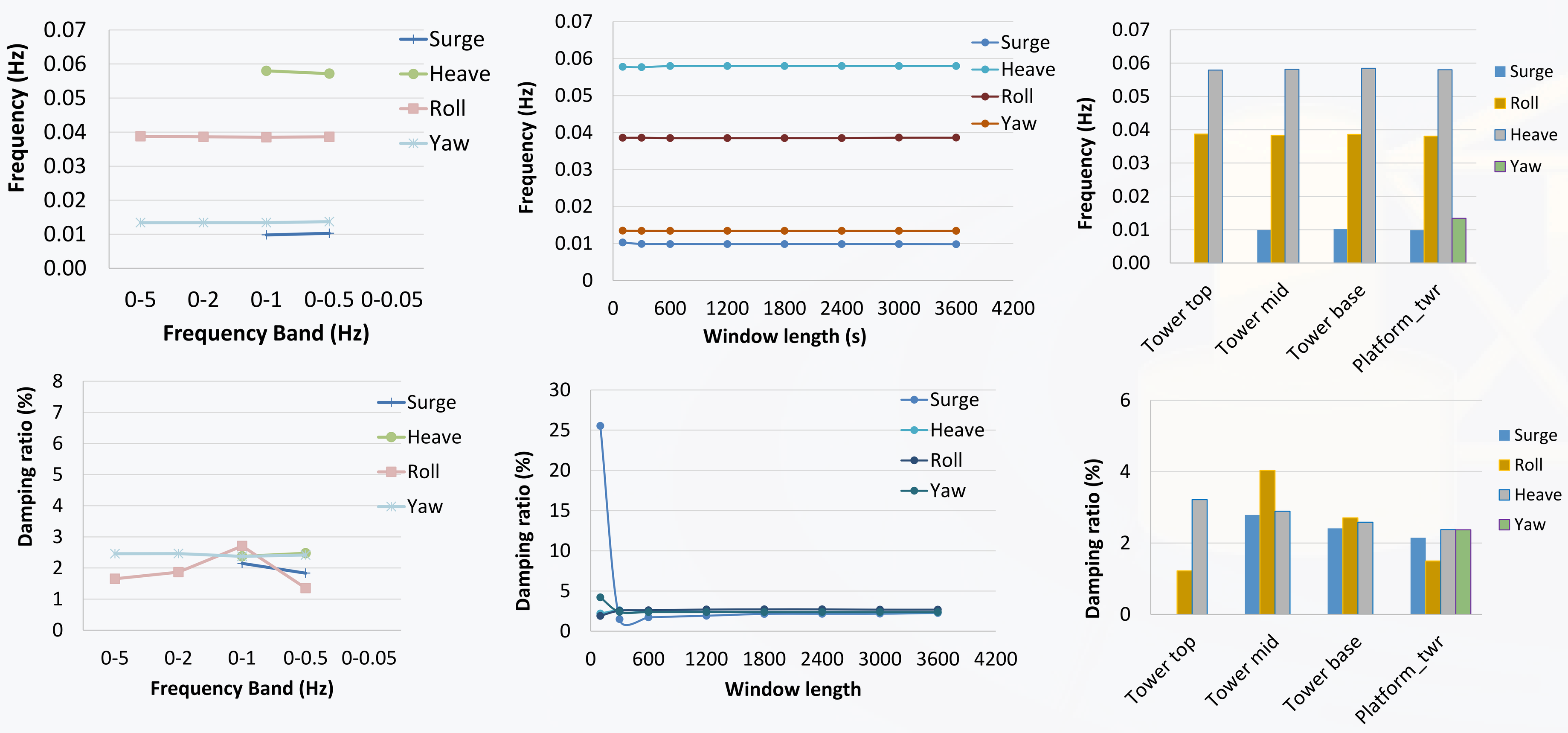
3.2 PSD & Stabilization diagram



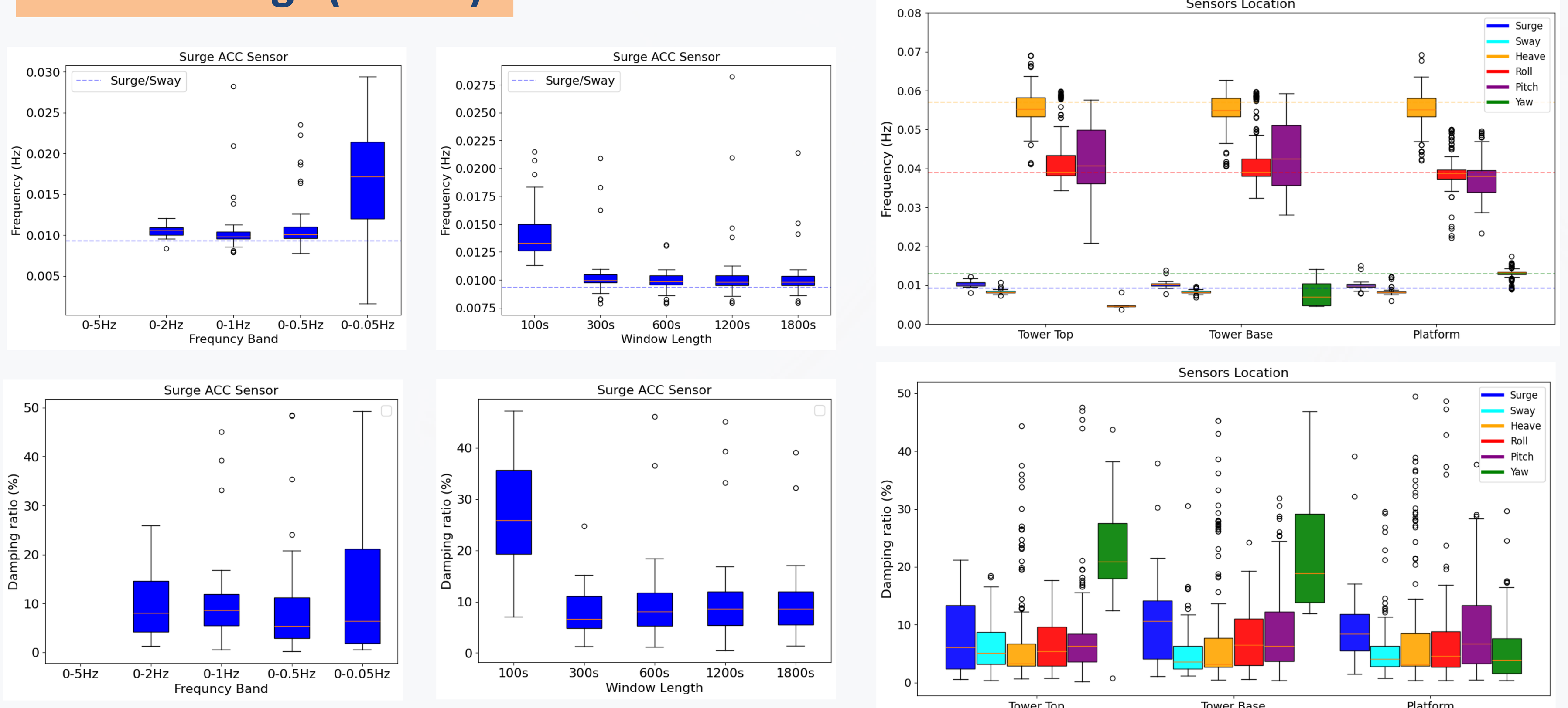
4 Results

4.1 OMA Settings

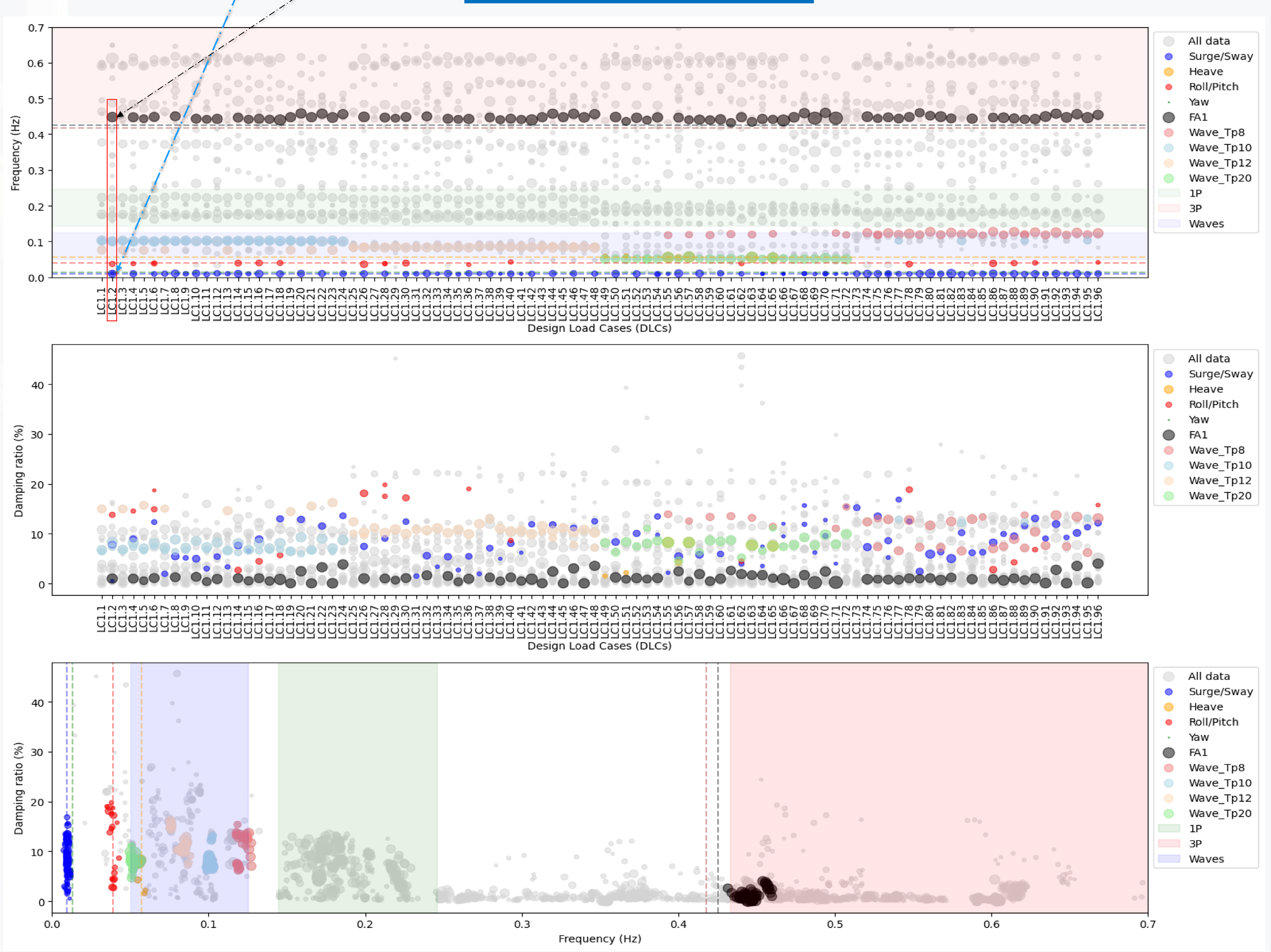
Initial settings (1 LC)



Final settings (96 LCs)



4.2 Tracking Chart



1. OMA-LSCF algorithm is applied to response signals of **96 Load Cases (LCs)**
2. **LCs** include different **wind** speed, heading, model and **wave** height and period.
3. **Low-frequency** and 1st **tower** modes are estimated across the LCs.
4. Higher **damping** values of **surge** mode are noticed compared to **FA1**.
5. **Rotor** harmonics and **wave** frequencies are also visible in the chart.

5 Conclusion

- **Window length** above **300s** is needed for the modal parameter estimation.
- **Frequency band** of **0-1 Hz** yielded a good estimation of the low-frequency modes.
- **Surge** and **Sway** are the most **sensitive** modes to the **OMA settings** for accurate detection.
- Placing **accelerometers** in platform is essential to detect the FOWT motions, particularly **yaw**.
- The tracking chart shows the **low-frequency** modal properties are **sensitive** to the specific **LC**.

Acknowledgements

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References

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