Universität Rostock Traditio et Innovatio

LWET STIFTUNGSLEHRSTUHL WINDENERGIETECHNIK

# Using FAST for the design of a TLP substructure made out of steel reinforced concrete composite components

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- in collaboration with GICON® Group -

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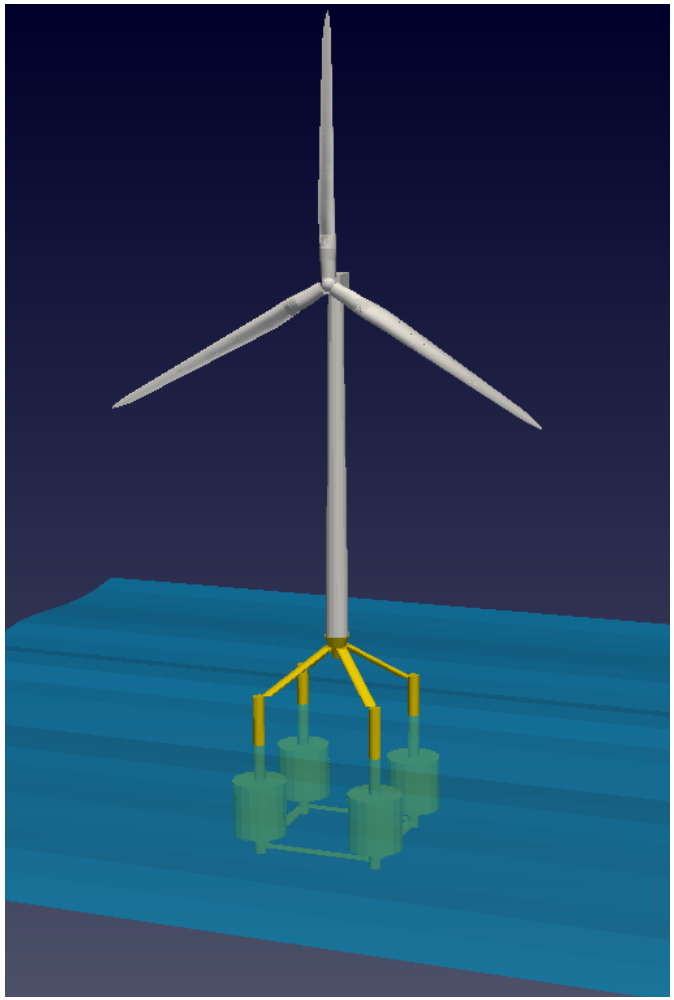
1. Introduction to the new GICON® TLP

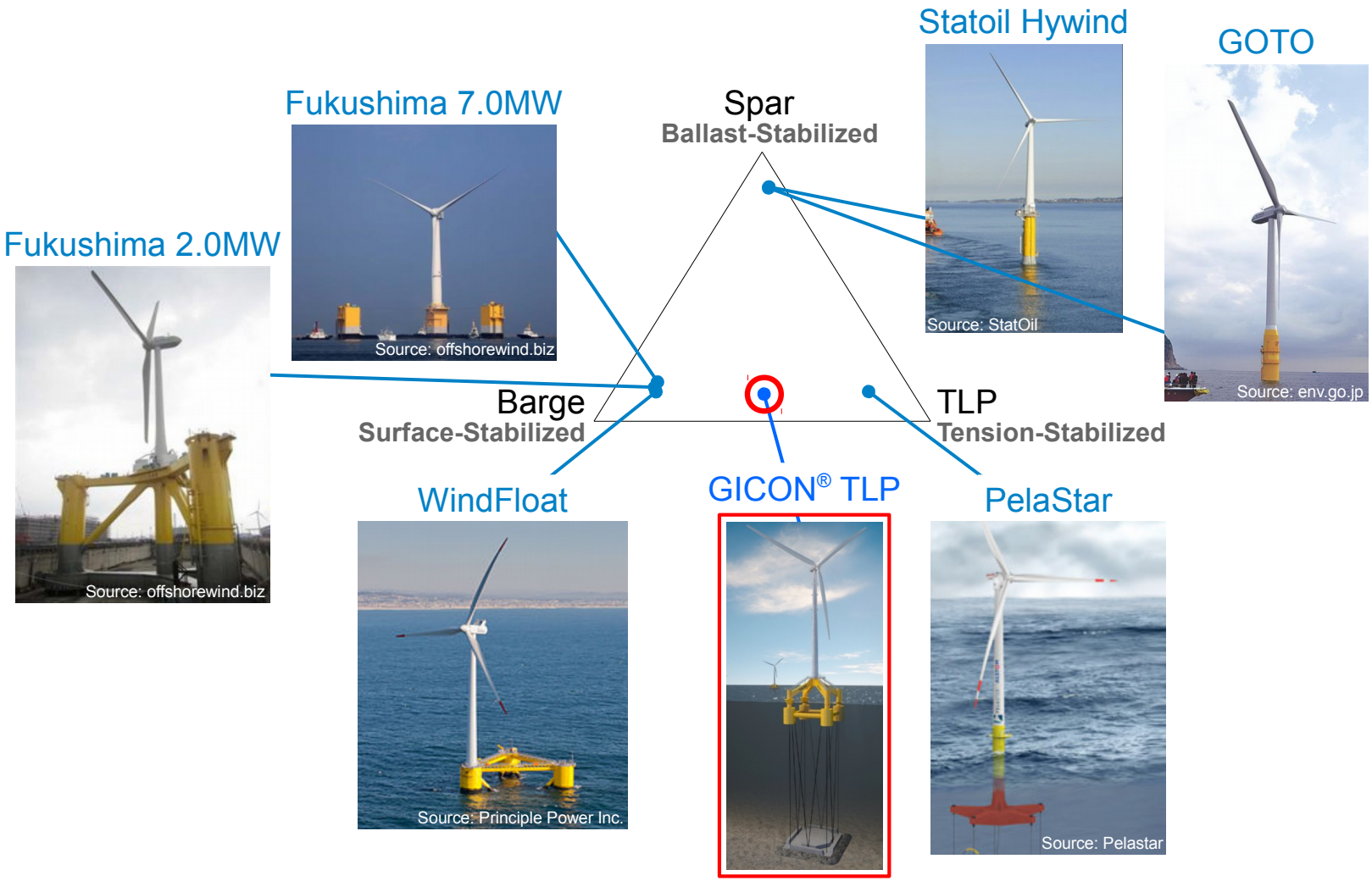
2. Description of the Wind Turbine

3. Simulation Results

4. Outlook



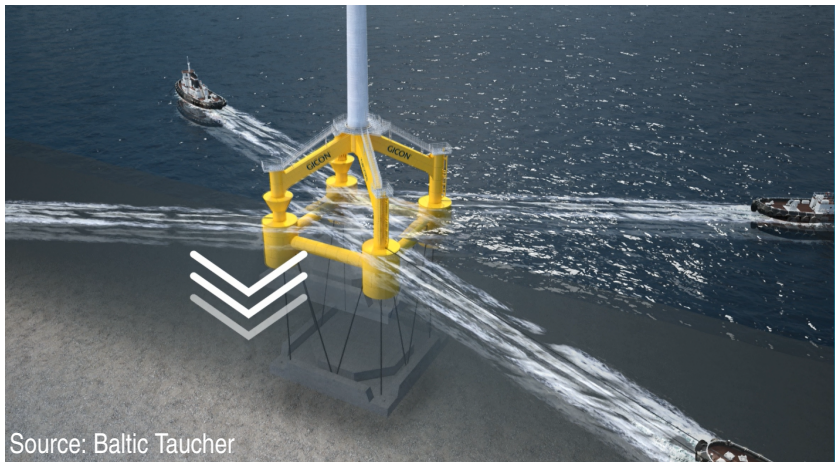
# General Concept of the GICON® TLP



# Key Features of the GICON® TLP

- Water depths: 30 m - 500 m
- One step installation
- High modularity
- Reinforced concrete components with Ultra High Performance Concrete (UHPC)

Source: Baltic Taucher

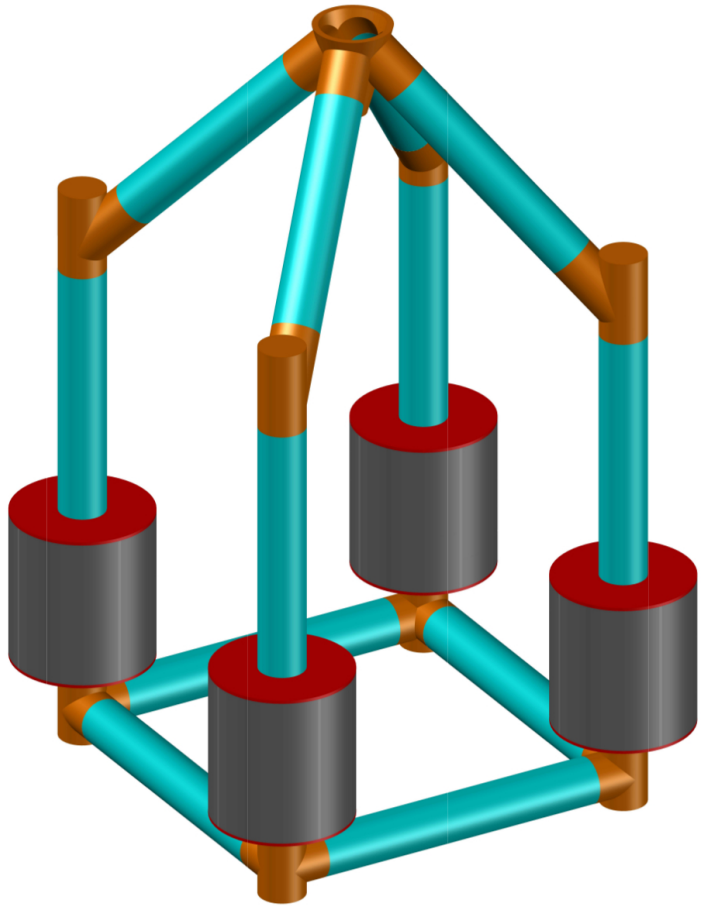


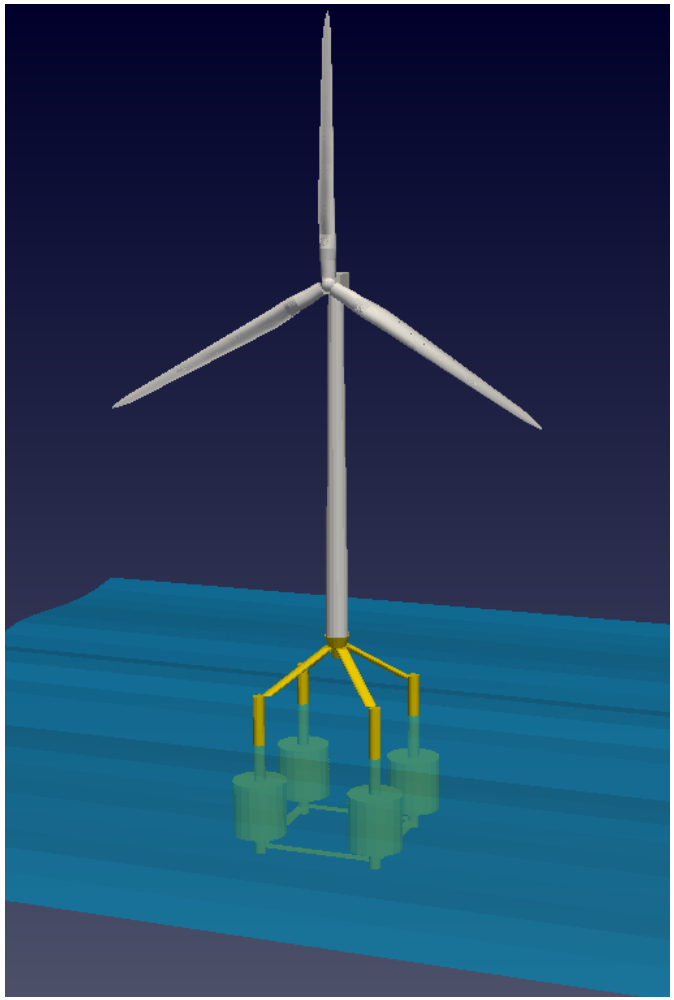
Source: Baltic Taucher

$\Rightarrow$ reduced fabrication time + reduced $CO_2$ emissions + reduced costs

# Components of the GICON® TLP

- Prestressed concrete columns (UHPC)
- Reinforced concrete shell segments
- Steel cover and bottom plate
- Steel TP and nodes





# Summary of Wind Turbine Properties

- Based on the 6 MW turbine of the DOWEC project

| | |
|---|---|
| Rotor | Upwind, 3 Blades |
| Rotor Diameter | 129 m |
| Hub Height, Overhang | 114 m (above MSL), 5 m |
| Cone, Shaft Tilt | 4.5°, 5° |
| Drivetrain | Gearbox |
| Control | Variable Speed, Collective Pitch |
| Rated Wind Speed | 12.1 m/s |
| RNA Mass | 416 658 kg |
| Tower Mass | 345 080 kg |

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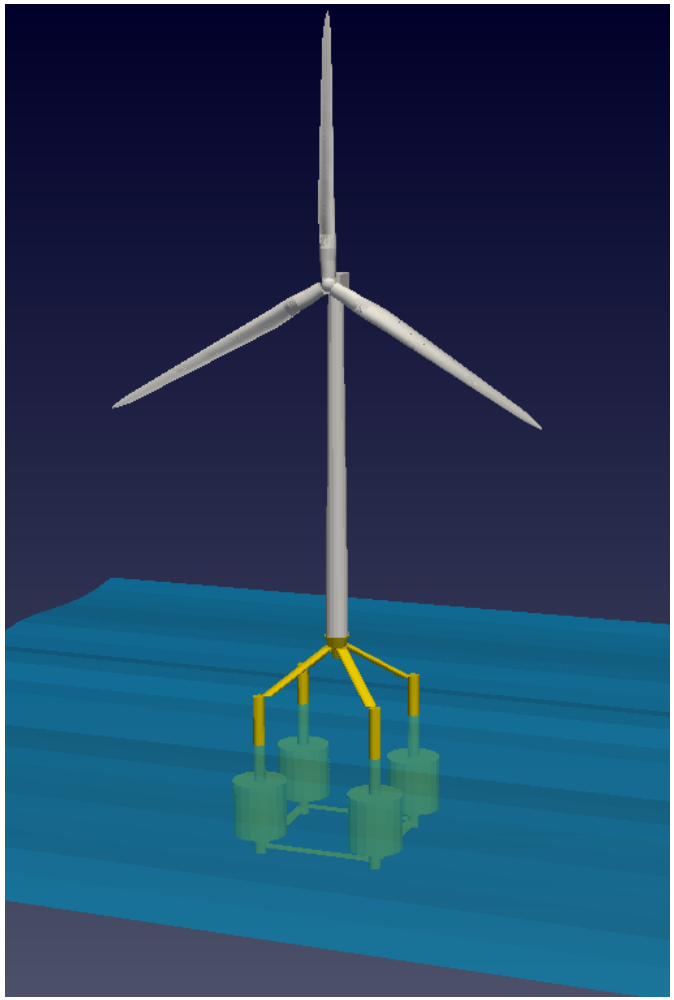


# General Settings of the Simulation

- Aerodynamics $\Rightarrow$ AeroDyn v15
- Structural Dynamics $\Rightarrow$ ElastoDyn
- Control Dynamics $\Rightarrow$ ServoDyn (DLL)
- Hydrodynamic Loads $\Rightarrow$ HydroDyn (only strip-theory solution)
- Mooring System $\Rightarrow$ MoorDyn

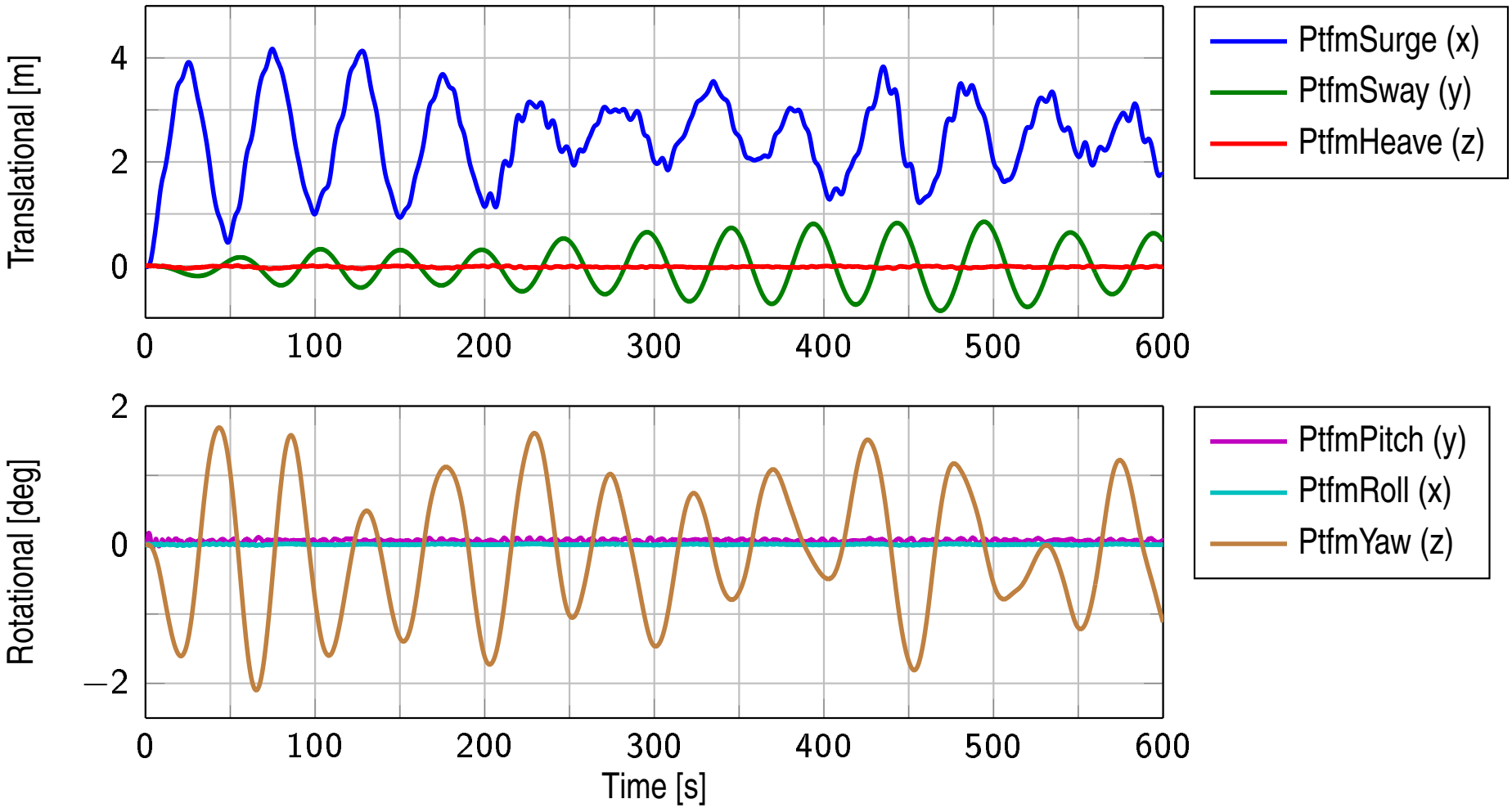
$\Downarrow$

- 2 Load Cases
  - LC 1: Power Production at Rated Conditions ($\approx$ DLC 1.1)
  - LC 2: Parked Turbine at 50-Years-Storm ($\approx$ DLC 6.1a)

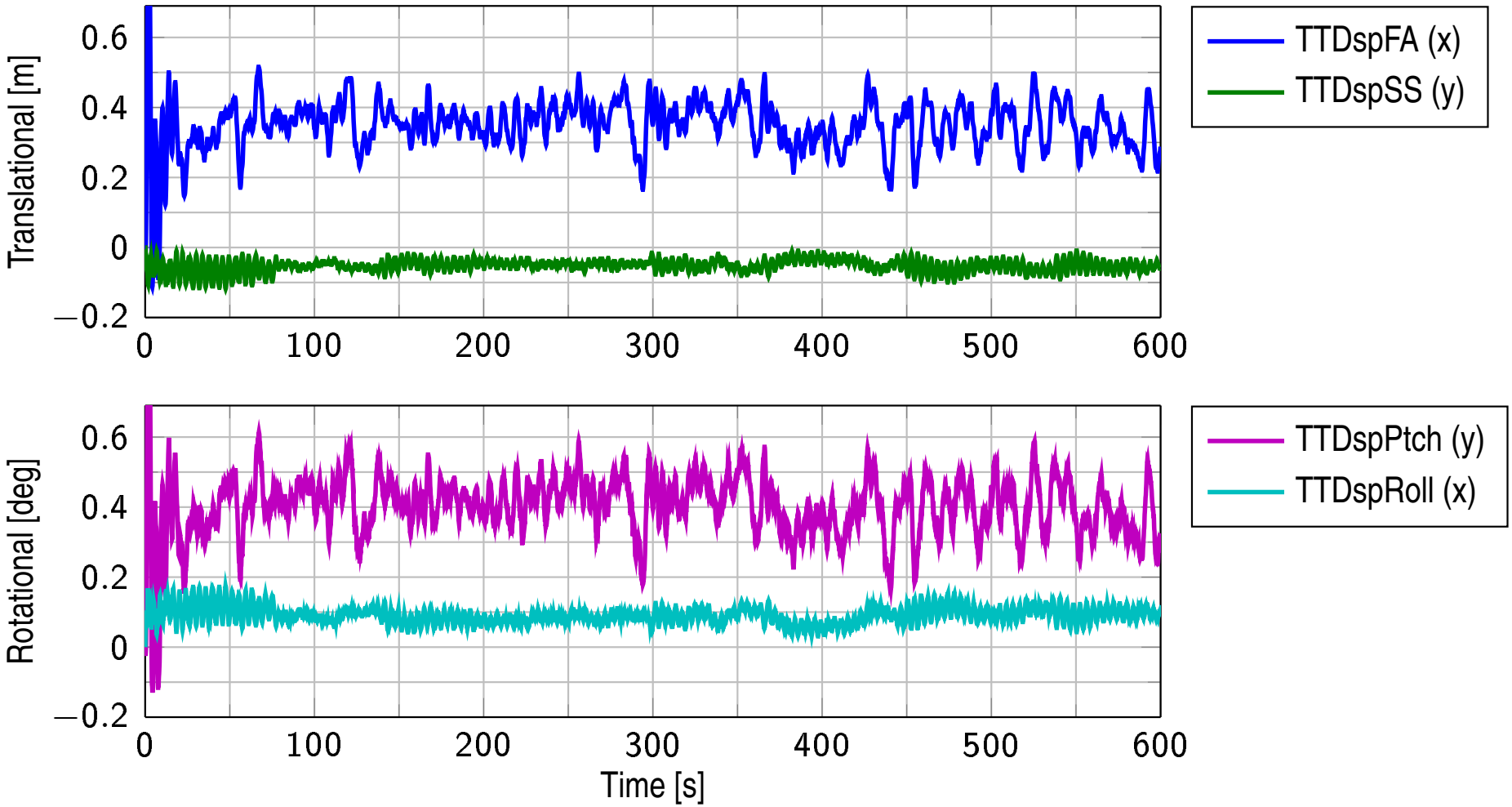
# Definition of LC 1 - Power Production at Rated Cond.

- Structural Model
  - No rotor mass imbalance, no aerodynamic imbalance (pitch error), no yaw error
  - All DOFs enabled
- Wind
  - Turbulent wind with $u_{ref} = 12.1\,\mathrm{m/s}$ (rated)
  - NTM with turbulence category „A“ (IEC 61400-1, ed3)
  - Wind direction: $0^\circ$
- Waves
  - Water Depth: 200 m
  - Irregular Waves based on JONSWAP-Spectrum ($H_s = 1.92\,\mathrm{m}$, $T_p = 7.29\,\mathrm{s} \rightarrow L_0 \approx 83\,\mathrm{m}, \gamma = 3.3$)
  - Wave direction: $0^\circ$
  - Without Current, 2nd order waves and marine growth

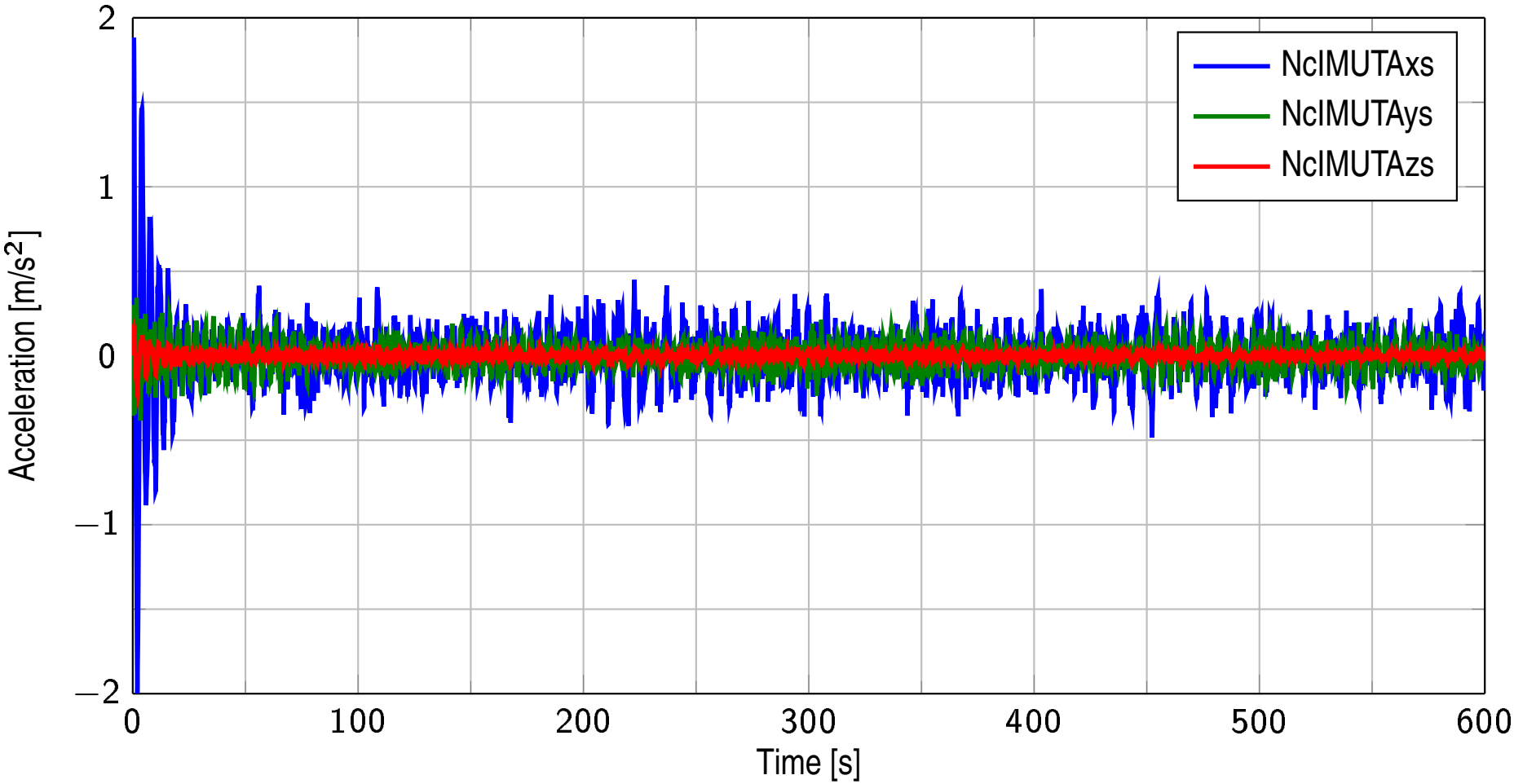
# LC 1: Platform Motion



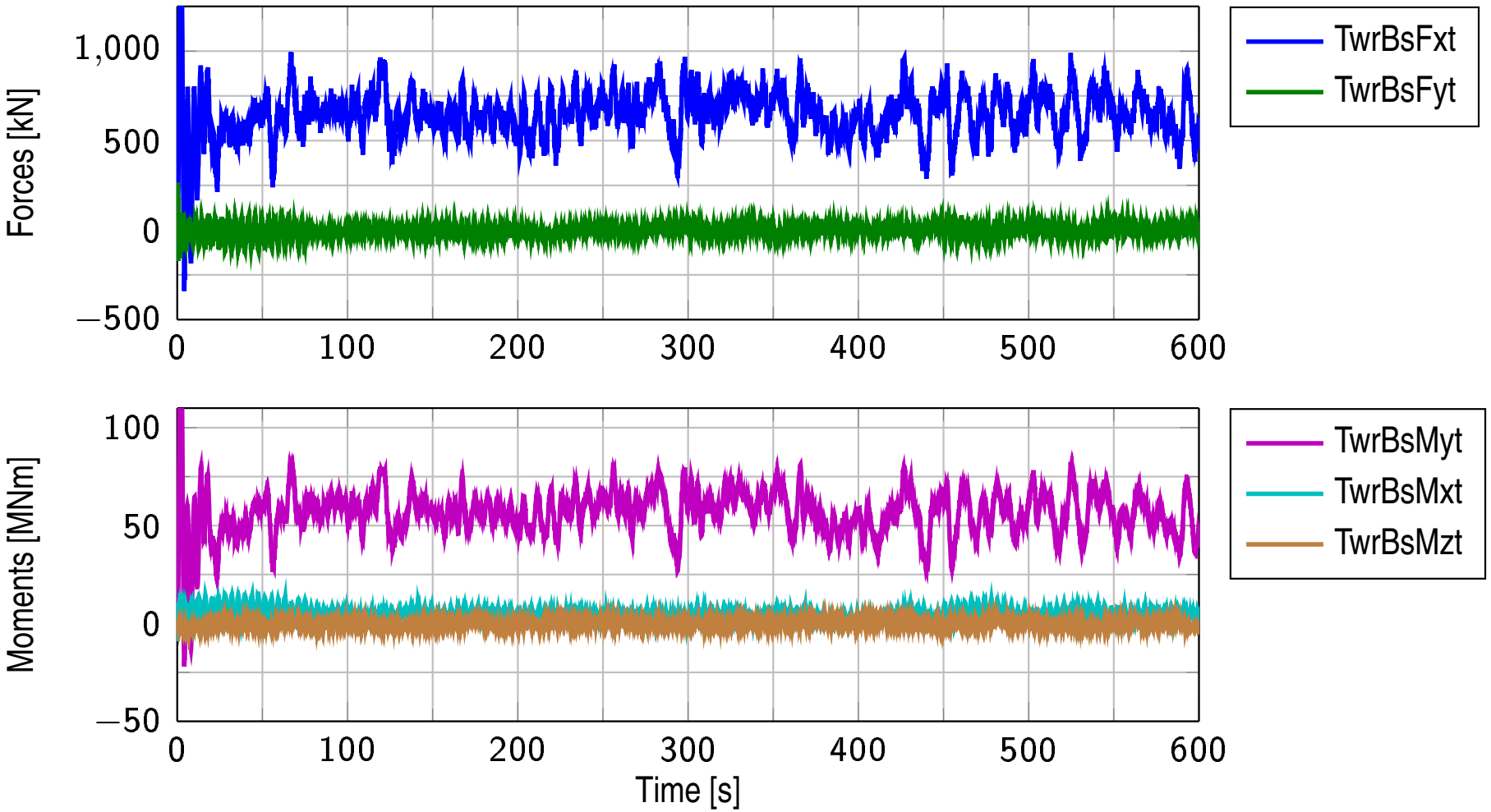
# LC 1: Tower-Top Motion



# LC 1: Tower-Top Acceleration



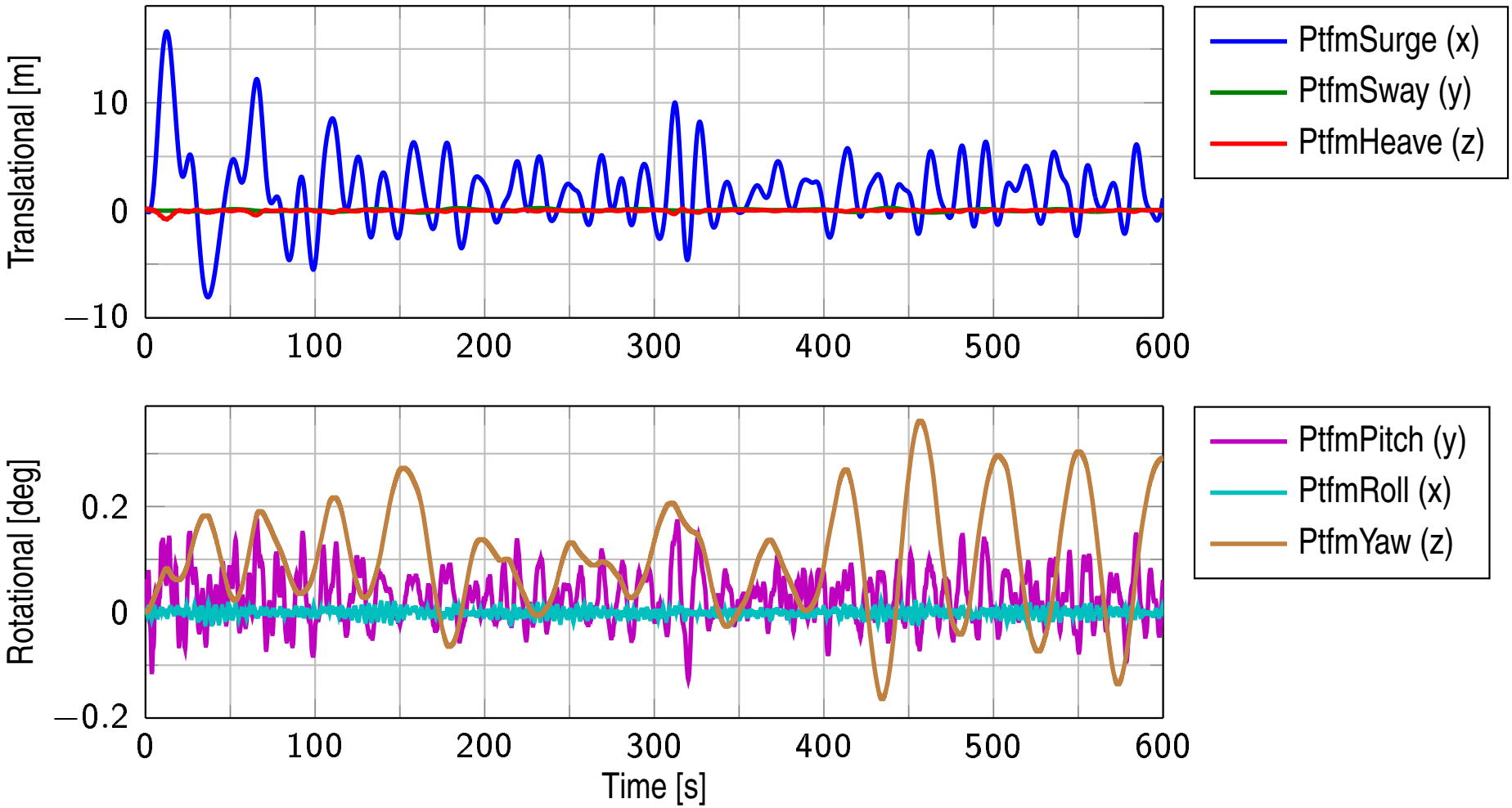
# LC 1: Tower-Base Loads



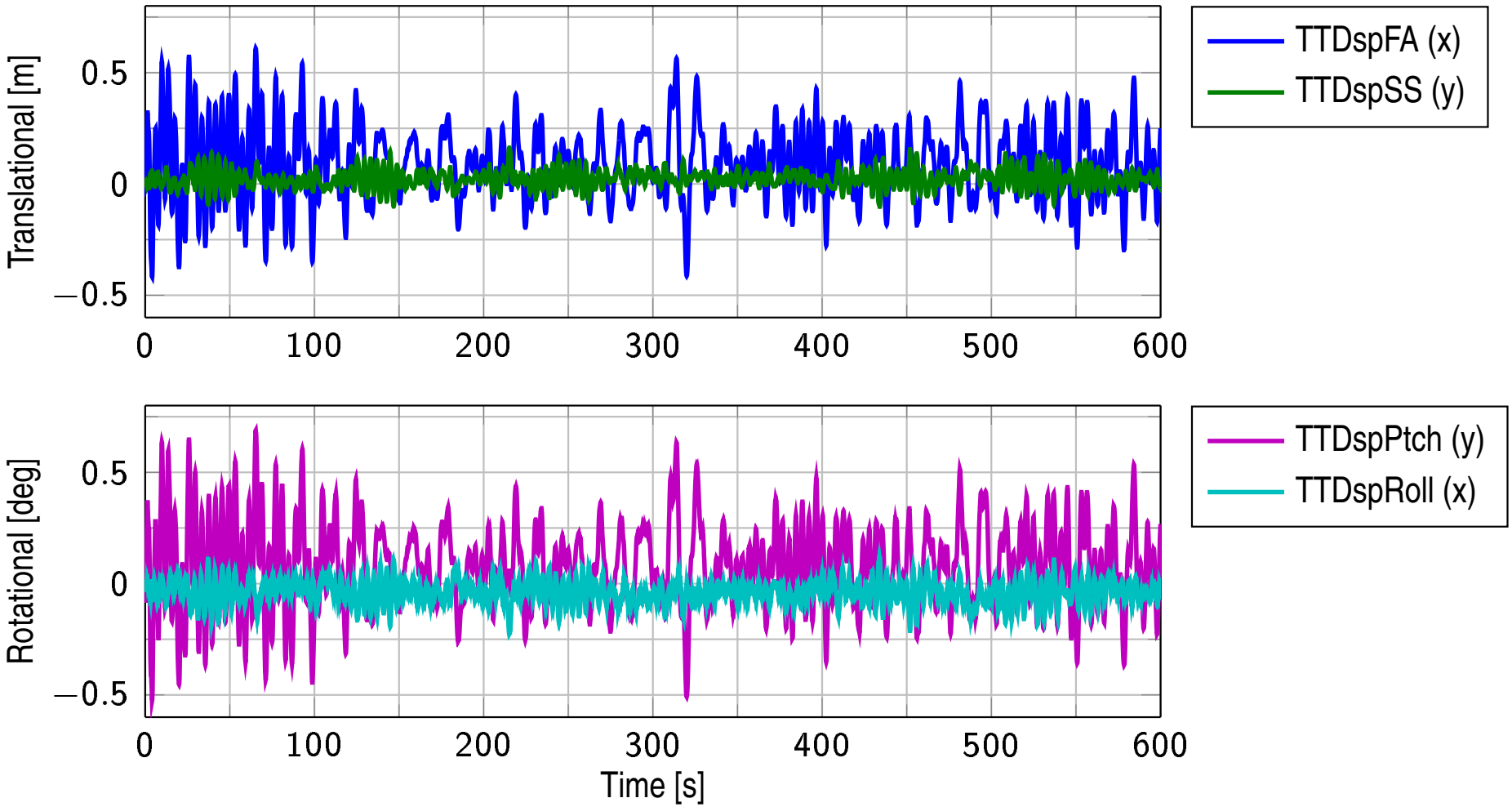
# Definition of LC 2 - Parked Turbine at 50-Years-Storm

- Structural Model
  - No rotor mass imbalance, no aerodynamic imbalance (pitch error), no yaw error
  - All DOFs, except of Generator DOF, enabled; Pitch angle fixed at 90°
- Wind
  - Turbulent wind
  - EWM for wind turbine class „IIA“ (IEC 61400-1, ed3)
  - Wind direction: 0°
- Waves
  - Water Depth: 200 m
  - Irregular Waves based on JONSWAP-Spectrum (50-year-storm) ($H_s = 9.72\,\text{m}$, $T_p = 17.72\,\text{s} \rightarrow L_0 \approx 490\,\text{m}, \gamma = 3.3$)
  - Wave direction: 0°
  - Without Current, 2nd order waves and marine growth

# LC 2: Platform Motion



# LC 2: Tower-Top Motion



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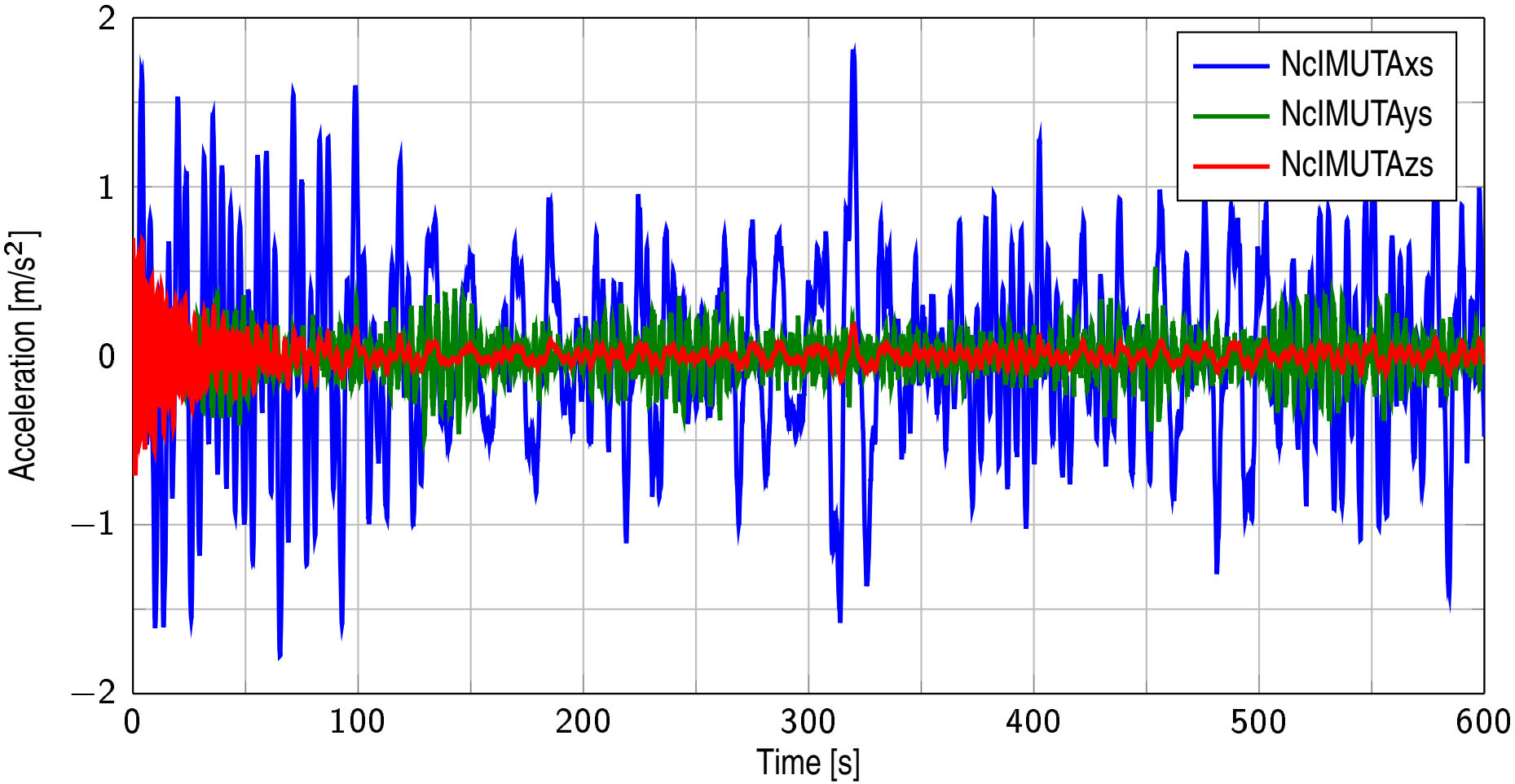

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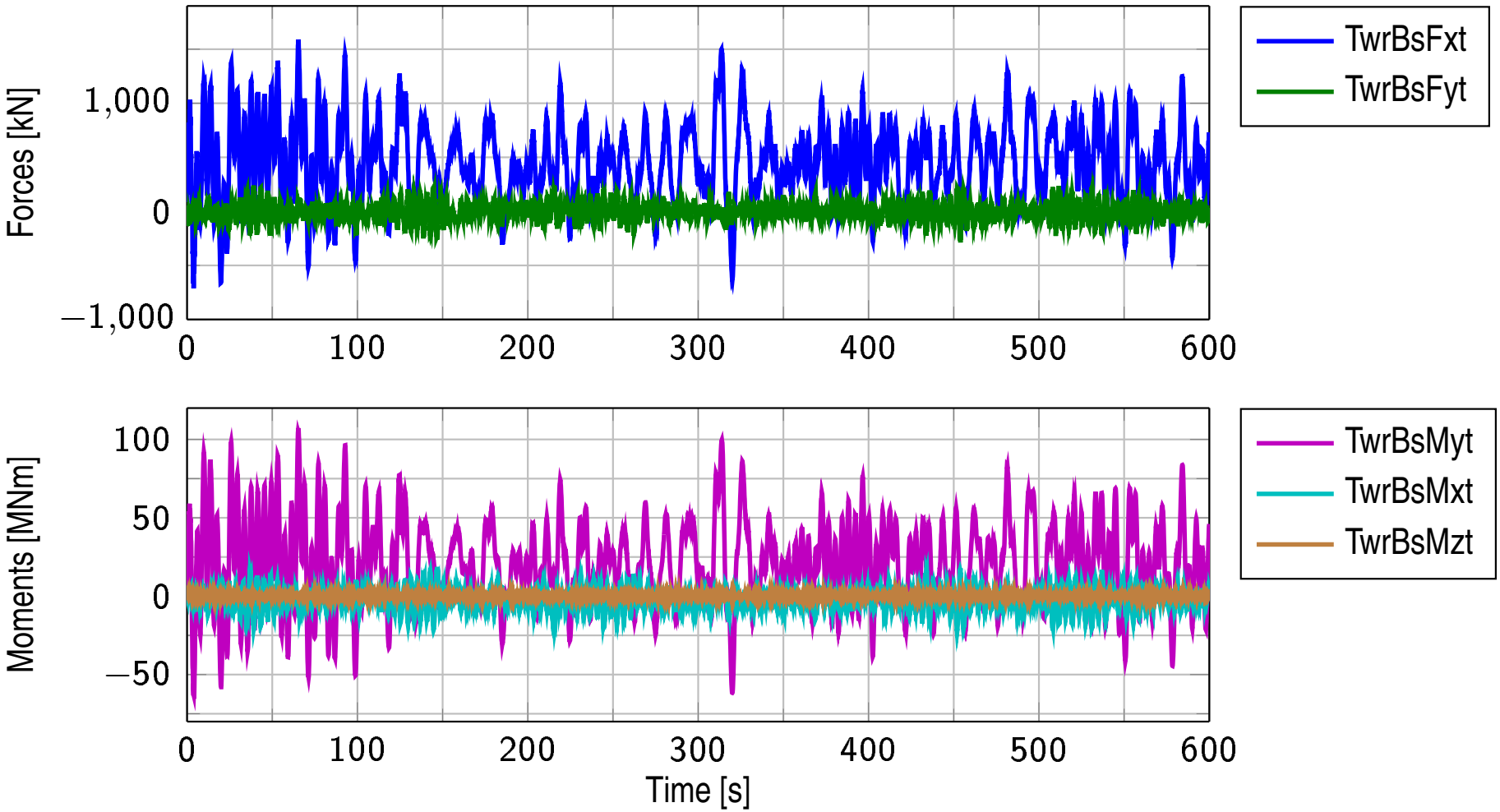

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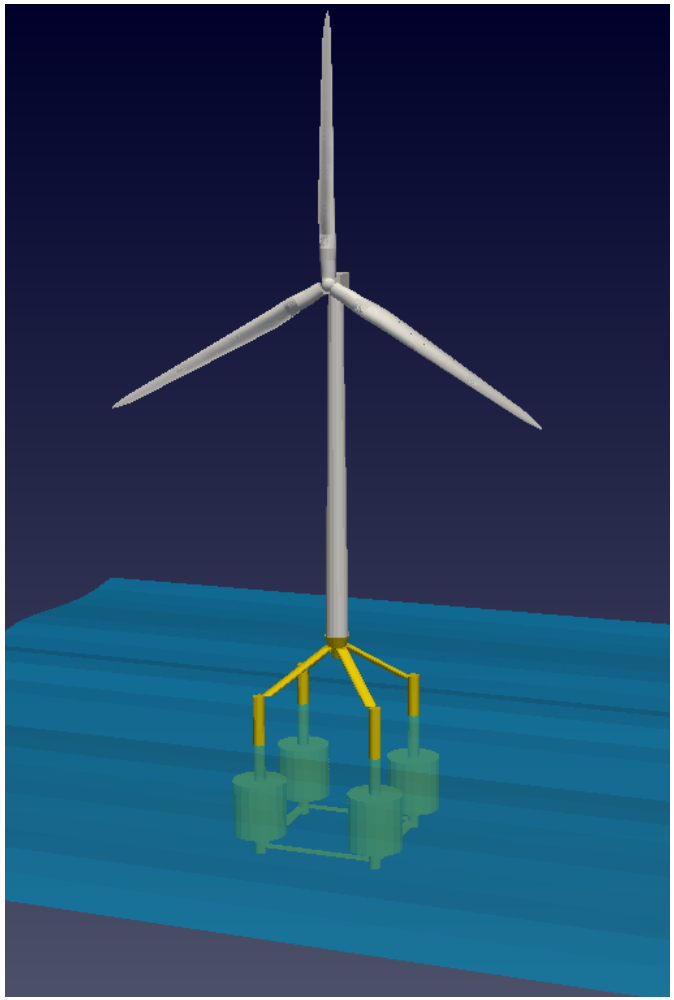

# Outlook

- Improving the used Model (e.g. including potential flow solution)
- Investigate more load cases (e.g. with imbalances, wind-wave-misalignment, special events, ...)
- Detailed design of the substructures components with the dynamic loads from the coupled simulations
- Calibration of simulation results with tank tests planned this summer

# Thank you very much for your attention!

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