A dynamic model for a tension-leg platform (TLP) floating offshore wind turbine is proposed. The model includes three-dimensional wind and wave loads and the associated structural response. The total system is formulated using 17 degrees of freedom (DOF), 6 for the platform motions and 11 for the wind turbine. Three-dimensional hydrodynamic loads have been formulated using a frequency- and direction-dependent spectrum. While wave loads are computed from the wave kinematics using Morison’s equation, aerodynamic loads are modelled by means of unsteady Blade-Element-Momentum (BEM) theory, including Glauert correction for high values of axial induction factor, dynamic stall, dynamic wake and dynamic yaw. The aerodynamic model takes into account the wind shear and turbulence effects. For a representative geographic location, platform responses are obtained for a set of wind and wave climatic conditions. The platform responses show an influence from the aerodynamic loads, most clearly through a quasi-steady mean surge and pitch response associated with the mean wind. Further, the aerodynamic loads show an influence from the platform motion through more fluctuating rotor loads, which is a consequence of the wave-induced rotor dynamics.

In the absence of a controller scheme for the wind turbine, the rotor torque fluctuates considerably, which induces a growing roll response especially when the wind turbine is operated nearly at the rated wind speed. This can be eliminated either by appropriately adjusting the controller so as to regulate the torque or by optimizing the floater or tendon dimensions, thereby limiting the roll motion. Loads and coupled responses are predicted for a set of load cases with different wave headings. Based on the results, critical load cases are identified and discussed. As a next step (which is not presented here), the dynamic model for the substructure is therefore being coupled to an advanced aero-elastic code Flex5, Øye (1996), which has a higher number of DOFs and a controller module.