Non-linear stall-induced instability analysis of a parked rotor

Main supervisor Qingshen Meng (TU Delft)
Co-supervisors Wei Yu (TU Delft), Georg Pirrung (DTU)
Student Jonas Lohmann

Background

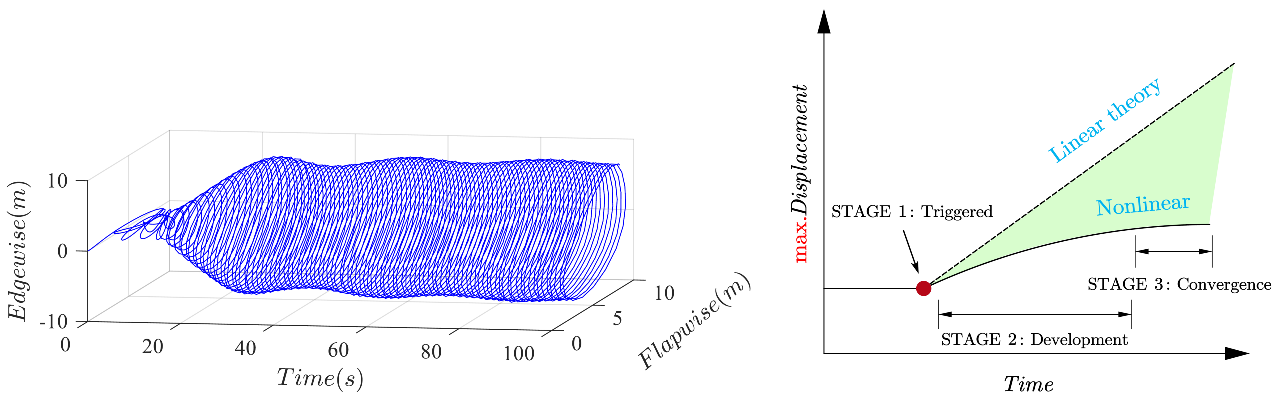
With the gradual increase in the size of wind turbine structures, especially the development of onshore wind turbines towards offshore, the blades are becoming longer and slender, leading to a shift in the design principles of traditional load-driven towards stability-driven design [1]. The instability issue in wind turbines is not new; it has been demonstrated that the parked wind turbine rotor faces a higher risk of stall-induced instability, especially in the edgewise direction [1]. Stall-induced edgewise instability emerges due to negative aerodynamic damping, a principle traditionally established within the domain of linear systems. The evaluation of this instability is contingent upon determining the aerodynamic damping, which manifests as an eigenvalue problem. However, the advent of enhanced computational capabilities has unveiled the inherent inadequacies of linear prediction in accurately discerning the onset of stall-induced edgewise instability. This heightened computational capacity now empowers researchers with expanded avenues for investigating the veiled territory beyond the confines of negative damping. Consequently, they can delve into and unravel the intricacies associated with this elusive region. This proposal explores the nonlinear phenomena behind the linear critical point for a standstill wind turbine, see Fig. 1.

Objectives

1. Identify the influencing factors that lead to nonlinear development after edgewise instability and conduct preliminary quantitative analysis to determine when they occur.

2. Determine the mechanism that influences the fluid and structure balance during the transition from stability to the LCO state.

3. Evaluate existing linear edgewise instability assessment methods and establish new nonlinear definitions and criteria for stall-induced edgewise instability. Find out to what extent we overestimated the risk of stall-induced edgewise instability.



(a) (b)

Figure 1: Fig (a): limit cycle oscillations of a blade tip enabled by aerodynamic non-linearities. Fig (b): potential comparison of a blade's response using linear and non-linear theories.

[1] Gunjit Bir and Jason Jonkman. Aeroelastic instabilities of large offshore and onshore wind turbines. In Journal of Physics: Conference Series, volume 75, page 012069. IOP Publishing, 2007.