Dominik Felix Duda

PhD Researcher
RWTH Aachen University
Institute of Flight System Dynamics

Wüllnerstraße 7
52062 Aachen
Germany

duda@fsd.rwth-aachen.de
www.fsd.rwth-aachen.de

Institut für Flugsystemdynamik

Flight Guidance Concept for the Starting Phase of a Flying Wing Within an Airborne Wind Energy System

Dominik Felix Duda, Hendrik Fuest, Tobias Islam, Dieter Moormann
RWTH Aachen University

In the search for a suitable flight system configuration for airborne wind energy, no configuration has yet prevailed. The use of "flying wings" in these specialized wind energy systems is a promising approach in terms of system performance. Because these flight systems have less drag intensive components, they are expected to have particularly high aerodynamic performance. In addition, when designed as tailsitters, they offer vertical takeoff and landing capabilities. However, the handling of these particular flight systems, especially at low airspeeds during vertical takeoff and landing, as well as during the transition from such a thrust-borne state to a wing-borne state, poses great challenges in terms of controllability [1].

In order to safely operate such a flight system during this transition, a guidance controller must take into account the controllability at high wind speeds and the constraints imposed by the tether. In accordance with [2], a curved yaw-roll maneuver is selected to operate the flight system through this transition. As shown in Fig. 1, when performing this maneuver, the flight system accelerates with a yaw motion in a tangential upwind direction until sufficient airspeed is reached and it initiates a roll dominant motion. In doing so, it transitions from thrust-borne to wing-borne flight while the tether is sagging and the flight is considered to be close to untethered. Subsequently, the transition to a fully tethered flight is achieved by increasing the turn radius. A trim calculation with an element-based flight dynamics model of the flight system is used to determine the flight envelope for this maneuver at different wind speeds. Based on this specific envelope, an appropriate guidance controller is developed. This guidance controller forms the top level of the cascaded flight controller, while the lower levels consist of a translational and a rotational Incremental Nonlinear Dynamic Inversion controller. The control performance of the overall controller is analyzed using model-in-the-loop simulations. It is shown that the developed controller architecture allows the control of this multi-axial transition maneuver at different wind speeds.

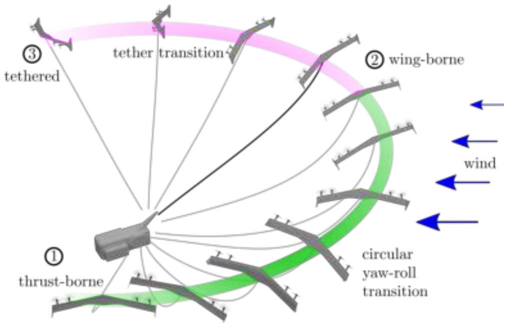

Illustration of the circular yaw-roll transition followed by a transition to a tethered flight.

References:

[1] Fuest, H., Duda, D. F, Islam, T., Moormann, D. : Flight control architecture of a flying wing for vertical take-off and landing of an airborne wind energy system. AIAA Scitech 2021 Forum (p. 1816).

[2] Fuest, H., Duda, D. F, Islam, T., Moormann, D. : Flight path and flight dynamic analysis of the starting procedure of a flying wing as airborne wind energy system. DLRK 2023, Stuttgart, Germany.