



Prototype AWE system built by the ftero student team of ETH Zurich



ftero student team of ETH Zurich with their prototype AWE system (2019)



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Fast Prototyping Morphing Wings for Airborne Wind Energy

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The student project ftero, from the Swiss Federal Institute of Technology (ETH), has developed, designed and prototyped a fully functional small scale Airborne Wind Energy (AWE) system. The system relies on a ground-based power generation approach and an adaptive composite fixed-wing aircraft. In contrast to other research projects, ftero is entirely run by engineering students as part of the final year of their undergraduate education. Within the two semesters of the project, the current team had to raise the required financial means, fabricate a new aircraft, adapt the ground station and implement the necessary controllers for full autonomous power production. The additional implementation of a morphing wing, replacing the control surfaces of a conventional design by a continuously deforming carbon-fibre reinforced plastic (CFRP) structure, enabled decreasing drag and allowed an adaptation of the wing profile for different flight conditions.

The limited resources in combination with the ambitious goals created a unique and demanding, yet comprehensive learning experience, while setting up an experimental framework for innovative ideas in the field of AWE.

To meet the given challenges, rapid manufacturing and ease of repair were key elements in achieving 141 conducted flight tests with three self-manufactured CFRP and three styrofoam aircraft. The innovative manufacturing approach uses additively manufactured (AM) parts and the newly developed manufacturing technique Cured Carbon Folding (CCF). In combination with a modular design, the proposed concept provides sufficient mechanical and aerodynamic performance while minimizing the manufacturing and repair time. In fact, a morphing wing with a span of two meters could be produced within only two manweeks.

The latest build prototype has a total wingspan of 4.6 m consisting of a 2 m base wing and 1.3 m wing-extensions, making use of a modular assembly concept. With this aircraft, all flight phases were flown manually, using the chosen quadplane approach for vertical take-off and landing (VTOL) as well as the implemented morphing structure. Furthermore, with a smaller prototype, a tethered autonomous power cycle was flown, yielding usable electrical energy on the ground station.