

# Experimental validation of take-off distance and rate of climb of a light unmanned aircraft

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The aim of this study is to experimentally verify take off distance, rate of climb, and minimum speed of a light unmanned aircraft against values calculated both analytically and numerically. The study was inspired by participation of the authors in Society of Automotive Engineers (SAE) Aero Design international student competition, held annually in the United States of America. Students' objective is to design and build a Short Take-Off and Landing (STOL) aircraft that carries a heavy payload. Limitation of the take-off distance by the rules of the competition necessitates a precise prediction of this parameter. Presented topic is, nonetheless, important in case of commercial unmanned airplanes, which, as opposed to multicopter aircraft, require a specific space for take-off and landing.

Experiences gained throughout numerous editions of the SAE Aero Design competition revealed that performance of the aircraft calculated with classic methods of flight mechanics are, in most cases, significantly overestimated. Actual take-off distance was usually considerably longer than the estimates indicated. The authors decided to empirically examine the subject and present results of the analysis in this article. Experimental verification was based on calculations made in engineering software utilizing CFD methods and flight mechanics equations solved analytically or numerically.

Empirical study consists of:

- a series of flights using a test bench aircraft, that is a vehicle built for the SAE Aero Design competition, equipped with additional hardware allowing to conduct said tests,
- analysis of rolling friction coefficient between aircraft's wheels and runway's surface.

An onboard computer – 3DR Pixhawk 2 – was used for precise acquisition of flight parameters and real time data transmission to a ground station.

An indirect goal of the study is to compare experimental values with calculations and determine factors causing observed differences, which could be:

- thrust loss of the propulsion system due to aircraft's components obstructing the flow downstream of the propeller,
- inaccurate prediction of aerodynamic forces.

The analysis described in the article will allow to estimate the space required to conduct a mission of an unmanned aerial vehicle more precisely.