UAV Performance Test and High-Altitude Test Flight

Livio Roth[1]

[1] Meteomatics AG, St. Gallen, Switzerland

lroth@meteomatics.com

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1. Project description

UAVs (unmanned aerial vehicle) are being used more and more in different applications and are constantly evolving. Accordingly, the requirements for the UAV are rising, as well. With the steadily improving battery technology, the flight time and therefore the range and altitude of flight is constantly expanding. Especially, higher altitudes pose new challenges for the UAV, such as lower air density and temperatures below 0°C. Meteomatics AG investigated the influence of low air density on different UAV propellers. Additionally, a test flight was performed starting from the platform next to the Jungfraujoch Sphinx Observatory.

The company Meteomatics AG is a swiss weather provider and uses self-developed drones, called Meteodrones, for weather measurements. Currently, the Meteodrone collects a vertical weather profile up to a height of 3000 m (9840 ft) above ground level (AGL). In order to better understand the meteorological boundary layer and to be able to create a better weather forecast based on it, Meteomatics AG aims to collect further data at a higher altitude. Due to the nature of normal drone use, high altitudes are a niche application with almost no experience. For this reason, Meteomatics AG is conducting research in this area in order to obtain information for future developments.

On a separate propeller test bench, various UAV propellers were tested at the Jungfraujoch research station (3584 m above sea level (ASL)) and the results compared with identical tests in denser air (651 m ASL).

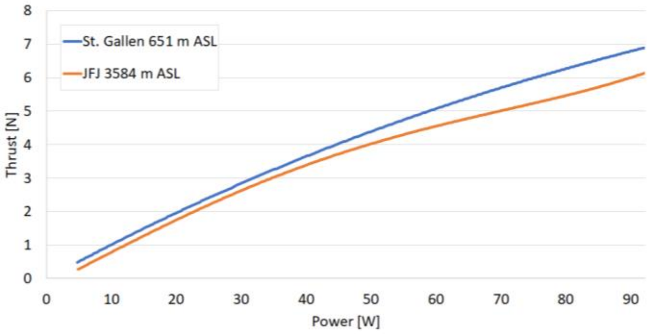

Figure 1: Comparison of UAV motor-propeller unit at two different heights ASL, namely St. Gallen and Jungfraujoch.

Figure 1 shows a comparison measurement of the standard Meteodrone propeller between St. Gallen and the research station Jungfraujoch. The generated thrust of the motor-propeller unit is compared to the power consumption of the engine.

The comparison shows how the lower air density influences the performance of a UAV system with a different offset over the measured power range. In general, all tested UAV propellers show a larger offset with higher power consumption. Not every tested propeller is suitable for every height range. Some propellers showed a more efficient thrust-power ratio at the location St. Gallen with higher air density in the lower power range, but an immensely worse ratio in the upper power range at the Jungfraujoch research station.

Figure 2 shows all logged measurements from St. Gallen and Jungfraujoch. It is notable that not all graphs cover the entire performance range. The reason is that the experimental set-up consists of electronic modules from the UAV and the speed is regulated to the specification of a throttle position of 0-100 %. The speed is achieved at lower air density with lower power consumption.

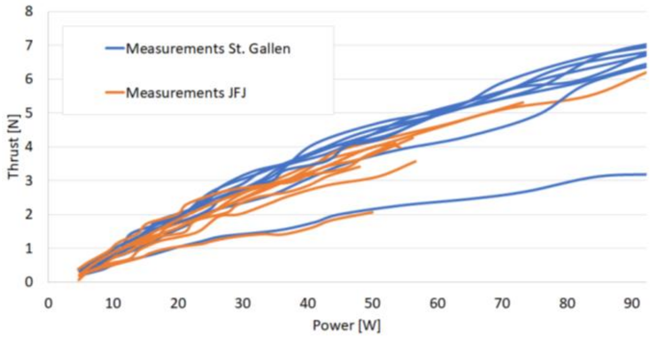

Figure 2: Overview of all measurements at St. Gallen and Jungfraujoch research station independent of propeller types.

As a first conclusion, it can be deduced that the influence can be minimized as much as possible by the best choice of the components, in particular the choice of the propeller, and the design of the power train.

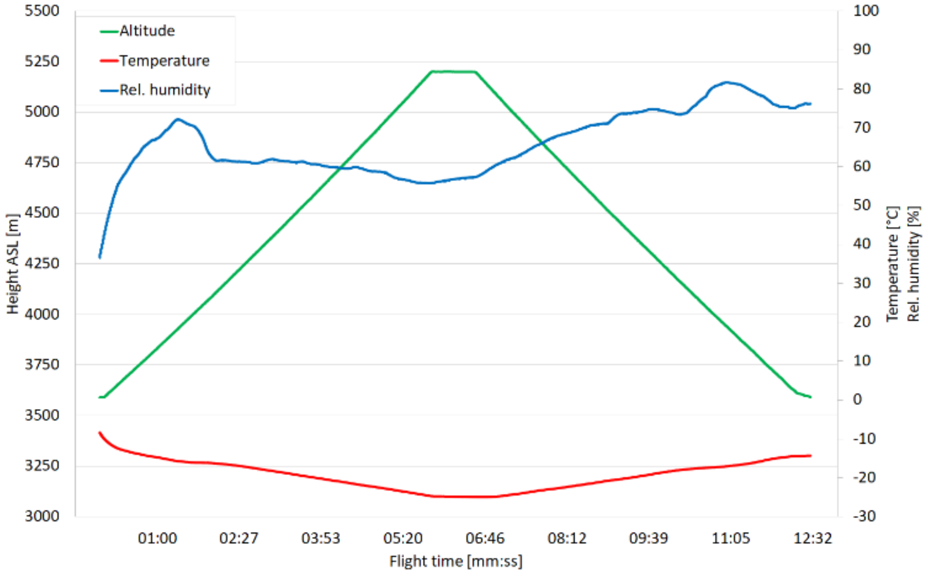

Figure 3: Altitude, temperature and rel. humidity from the Meteodrone test flight.

A second test was a Meteodrone test flight starting from the platform next to the Sphinx Observatory. Figure 4 shows the UAV system Meteodrone, which is certified by the Swiss civilian aviation authority on BVLOS (Beyond Visual Line of Sight) operations. In order to fly at these altitudes, clarifications and permits from the Swiss civilian aviation authority, Skyguide, Swiss air force and local airfields are necessary.

Figure 4: BVLOS certified UAV system Meteodrone

An impression of the weather conditions can be seen in figure 3, plotted data that was recorded by the Meteodrone during the test flight.

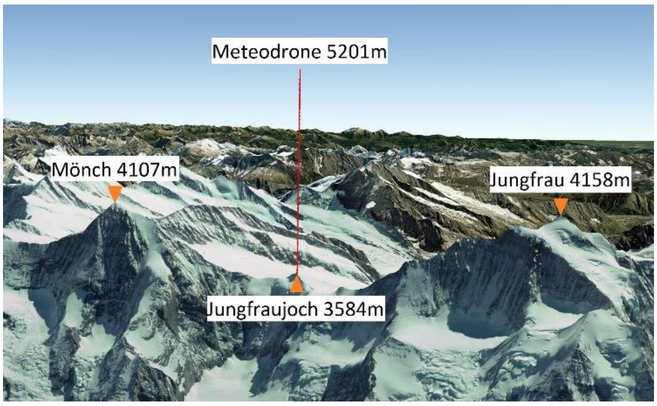

Figure 5: The red line shows the logged GPS waypoint list from the Meteodrone test flight.

The weather conditions were extreme for the UAV. However, the weather allowed a few test flights early in the morning. Figure 5 shows the logged GPS waypoint list from the Meteodrone test flight. The drone ascended 1617 m to an altitude of 5201 m above sea level. At the turning point, a temperature of -24.9°C and a relative humidity of approximately 60 % were measured. In such a cold air layer, high ambient humidity can lead to icing on the propellers, which can lead to an uncontrollable flight behavior and eventually to a crash.

Based on these high-altitude test flights, a first impression could be won. It is gratifying that the system and external influences did not cause any unexpected events. It is even more remarkably, as the test system was not configured to these heights. For example, a pressure sensor was designed only up to a certain height and reached its measuring limit during the test flight.

With an infrastructure like the research station Jungfraujoch it was possible to carry out such tests in a lower air density. The results will significantly influence the further development of the UAV.

Homepage

www.meteomatics.com

Address

Meteomatics AG
Lerchenfeldstrasse 3
CH-9014 St. Gallen
Switzerland

Contact

Dr. Martin Fengler
Tel.: +41 71 272 66 50
e-mail: info@meteomatics.com