

# ***Interactive comment on “Automatic Measurement and Characterization of the Dynamic Properties of Tethered Membrane Wings” by Jan Hummel et al.***

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## **1 general comments**

The article presents an original and well-designed experimental setup to assess the flight dynamic properties of kites used for airborne wind energy system. This full-scale experimental setup shows great promises for reliable and repeatable experiments of general performance and dynamic maneuvers.

I found this paper well written with clear figures to explain this complex test bench and the first results. I was sometimes a bit confused with the structure of the article but the main story can easily be followed.

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## 2 specific comments

To improve the overall good quality of this paper, I would have a few remarks:

### 2.1 terms in introduction part

In the introduction, there are many specific terms specific to kite/flexible membrane of airborne wind energy system (ex: Leading-Edge Inflatable tube kites, ram air wing, chambered design, ribs, ...) As the readers of this journal might not be completely aware of all these terms, either explaining a bit more the most important terms or an extra figure describing the general type of kite used with this test bench might help to visualize the topic. A photograph or a figure inspired from Figure 2 could be an idea.

### 2.2 control of the control bar

I don't really understand how the control bar is controlled and slides along the power line.

### 2.3 load cell precision

The load cells are presented in section 3.2 with the dimensionless precision. Their absolute error in Newton are explained a few pages after. It would be more convenient to briefly insert these absolute errors in section 3.2.

## 2.4 wind speed error

I don't really understand the paragraph page 12 from line 16 to 23. What is your point in this explanation? Why is it safe to overestimate the roughness?

## 2.5 elevation angle

As you know the measuring error of the angle sensors, and you have the formulas to determine the azimuth angle, did you use a GUM ( Guide to the expression of uncertainty in measurement) analysis?

## 2.6 data processing system

It is written: "A network interface is used to communicate with the host computer as well as retrieving measured values of the spherical camera array". What are the measured values of the spherical camera array? The images?

## 2.7 synchronization of the measurements

Do you record data "on the flow" i.e. sensors send raw data as fast as they can, or does the sbRIO control them using a "master-slave" communication? What are the sampling frequencies of the sensors? As this test bench will be used for dynamic measurements, the dynamics of the sensors and of the recording might be relevant to add in the article.

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## 2.8 results presentation

It is written: "Only maneuvers lasting a given minimal timespan were taken into account. During some maneuvers an unintentional change of position or orientation (e.g. caused by gusts) led to the pilot aborting the maneuver. The valid results are plotted..."

What is the minimal timespan?

To clearly understand: the maneuvers affected by gusts are not part of the valid results?

## 2.9 presentation of the tested kites

It is written: "a figure is shown which summarizes all measurement data into a single curve... Additionally, these figures show the resulting error for a confidence interval of 95%".

Does this single curve is the average of all the tests for each kite?

Is the confidence interval of 95% coming from the deviation between the different tests, or from the uncertainty measured in section 3.3.3?

## 2.10 discussion on the elevation angle offset

It is written: "The only significant deviation was found after a long period between two test runs".

Are these 2 test runs described here are the same than the 2 different days (day 1 and day 2) presented in the figures?

I don't really understand what a "reference wing" could be.

More as a suggestion: would it be possible to rotate "manually" the 3 rotations axes (universal joint and rotary axle)? By recording independently the angles purposely set,

a calibration of the 3 angle sensors might be able to calibrate and check any potential offset?

### 2.11 Results of lift coefficient

It is written: "The airflow velocity is assumed to equal the measured wind speed of the weather station." For these results, do you neglect the wind power law equation (equation 13)?

### 2.12 force ratio

Are the angles of the steering lines relative to the power line taken into account? Or as the kite is high enough, are they considered parallel to the power line?

### 2.13 Conclusions

It is written: "So far the reproducible measurement of flight dynamic properties of tethered flexible wings was not feasible".

Was it not feasible? Or not done yet? It sounds in contradiction with the abstract: "We can conclude from this study that an objective measurement of specific dynamic properties of highly flexible membrane wings is feasible".

## 3 technical corrections

I did not detect any typing errors or wrong sentences. There is only one small typing error in figure 10: "Wheater station"

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