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Interactive comment on "Ability of the e-TellTale sensor to detect flow features over wind turbine blades: flow stall/reattachment dynamics" *by* Antoine Soulier et al.

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Anonymous referee #1 General comments

Q1 : The importance of this work lies on the evaluation for e-TellTale but not for a tuft. It should be explained if there are any difficulties specific for e-TellTale to follow the flow dynamics, or to be recognized by image processing conducted in this work.

The most important feature of the sensor is the electrical sensing. But the electrical signals were not evaluated in this work. The correlation of the signals to the strip position should be described more in detail especially if there are some issues left.

A1 : We agree with the reviewer, this work was firstly conducted with full e-TellTale with the electronic sensing, unfortunately, the strain gauge sensor was damaged by the laser sheet during the first tests. To make it clearer to the reader, this was changed in the title. "Low Reynolds investigations on the ability of the strip of e-Telltale sensor to detect flow features over wind turbine blade section: flow stall and reattachment dynamics" instead of "Ability of the strip of e-TellTale sensor to detect flow features over wind turbine blades: flow stall/reattachment dynamics" Therefore the rest of the experiments were performed without the electronic sensing and with a nylon strip. However working with the strip provide a lot of information which was a great help for the development of a future scaled down functional e-TellTale. Preliminary tests (without records unfortunately) were performed before the e-Telltale damage to check that the down scaled e-Telltale signal has a similar qualitative behavior than for the full size e-Telltale has explained in the article L75: "The signal from the strain gauge sensor was not acquired simultaneously during PIV measurements, however, it has been checked before experiments that the signal from this strip, made of a nylon fabric, behaves similarly as full-scale experiments from (Soulier et al., 2017). In particular it was checked that it was possible to distinguish two levels of the signal within the blade oscillation cycle, corresponding to two different flow states over the aerodynamic surface: attached at least at the leading edge/stalled."

To make it clearer, the reference to figure 1b has been added: "The signal from the strain gauge sensor was not acquired simultaneously during PIV measurements, however, it has been checked before experiments that the signal from this strip, made of a nylon fabric, behaves similarly as full-scale experiments from (Soulier et al., 2017). In particular it was checked that it was possible to distinguish two levels of the signal within the blade oscillation cycle, corresponding to two different flow states over the aerodynamic surface: attached/stalled (see figure 1b)."

The correlation between the position of the strip and the signal have not been registered in this study and the will be done in some future studies

Finally the scope of the paper is to demonstrate that the strip is following the flow with regard to the separation and stall aerodynamic properties. As explained in the conclusion: what is missing now is the relation between the strip and the strain gauge signal.

Q2 : If the authors intended to scale-down the full-scale device, the way of design to scale-down should be explained. The experimental condition or the configuration of the sensor for the full-scale wind tunnel test is not clear because the cited reference seems not yet published.

A2 : The down-scaling of the e-Telltale signal was made with the intention to reproduce the main characteristics of the full scale e-Telltale signal which are: - first rise of the e-Telltale signal at the trailing edge separation angle - sudden increase of the e-Telltale signal at the stall angle These tests were performed prior to PIV measurements from visualisation of the strain gauge signal and using wool tuft distributed on the suction side of the blade (for a fast evaluation of the trailing edge separation angle and the stall angle). Indeed, full scale experiments are not yet published, we reported the important properties needed for the present article in figure 1, which presents the e-TellTale signal first rise and sudden increase.

Q3 : The TR-PIV is conducted in 2D. Does the 3D motion affect the electrical signals? To think about this, it is recommended to describe more about the configuration of the e-TellTale in detail including the ‘stainless sheet’ and the ‘small part’.

A3 : As explained in A1, the scope of the paper is the strip motion, not the electronic signal, which was not registered. The full scale measurements, that will be published soon, show an increase of the variance for stall angles, which may be related to what is observed on the downscale strip using PIV (out of plan motions of the strip). However, this should be confirmed with e-TellTale electronic signal.

Q4 : The position detection is the most important technique in this work. To ensure the validity of the experiment, clear and correct explanation is necessary. For example, why

sx replaced to sxmax instead of sxmin for the state beyond the stall in Fig.15 while sx is decreasing when the flow is detached according to Fig.4.? Is the sx really reaches to 0 at around 0.9s and 5.0s as shown in Fig.15 while the length of the strip is only 0.3c?

A4 : The inconsistencies pointed out by the reviewer are due to the merger of different versions of the manuscript. Indeed the choice for the direction of sx was changed during the writing of the article some old figures/errors have not been corrected yet, It has been corrected in the article (Section 3.1 and Figure 4). Fig 15 is not about sx, but at the end of the article the Fig 21 deals with sx and was already right. sx/smax= 0 does not correspond to the strip at the leading edge. There is here a shortcut that is misleading the reader: sx/sxmax in figure 4. is expressed with the origin of the coordinate system placed at a position at which the minimum of sx is 0. To make it clearer to the reader, it has been modified as follow: - sxp (in pixels in a coordinates system corresponding to the image sides) variable has been introduced and the change of coordinate system is explained

Q5 : The objective and the result of the three postprocessing analysis is not clear.The discussion about these analyses is too long and confusing while this manuscript is worthwhile enough for publishing even without these analyses.

A5 : From PIV measurements there are many methods developed to detect the flow separation. But none of them were compared with each others. Moreover, these existing methods were adapted in the present paper. Because the purpose of the paper is an evaluation of the strip to detect flow separation, it was found necessary to have a first assessment of the developed detection methods. This have been modified in the article to make it clearer: “To be able to study the ability of the strip to detect the instants of the flow stall/reattachment phenomena it was necessary to use methods allowing to detect these flow characteristics from PIV velocity fields. Several methods were identified from the literature but never compared and not completely adapted to our needs They were adapted here and compared between each others, providing a first assessment of the methods before comparisons with the strip movements.” instead of “To be able to study the ability of the strip to detect the instants of the flow stall/reattachment phenomena, three robust detection methods were applied to the flow field obtained from the TR-PIV measurements”

Q6 : ’Because the definition of stall and reattachment instants is a complex problem’ at l.321 is not clear to understand the objective because ‘the definition’ shown in section 4.1 is not complex.

A6 : Although the description of stall given in section 4.1 is relatively straightforward, in practice it may be difficult to identify the onset of stall and reattachment directly from PIV measurements. Assessing the relevance of different identification methods that are relatively new is useful. In order to do this, we compared four different methods. We agree with the reviewer, the world complex is not suitable. The sentence has been modified as follow: “From PIV measurements there is no unique criteria to detect stall instants.”

Q7 : If the objective of the analysis is to investigate the local flow phenomena which governs the motion of the strip, you might mention something more from the small l/c results of the method 1.

If the objective of the analysis is to evaluate the accuracy of each methods to detect the instants, the parameters for each method (such as x=c or l=c for the method 1) should be optimized before the comparison.

A7 : l/c has firstly been chosen to be of the order on magnitude of the mean recirculation width in the normal direction. Different values of l/c in the range [0.07, 0.7] were considered in order to check for possible dependence of the detection instants. To make it clearer to the reader, this is now explained in the article Since the purpose of the present article is to evaluate the detected instants at the strip location, so to avoid any possible delays, the chosen x/c is the location of the strip. No exploration of x/c were performed, which is out of the scope of the paper.

Q8 : In section 5, there are no explanation that the exact instants tref was defined by the visualization of the velocity field. Moreover, it is concluded that the strip capabilities to follow the stall/reattachment dynamics was validated by comparison to the three methods while the most direct validation seems to come from the comparison to tref . These are very confusing.

A8 : Tref definition is present in the section 4.1. We do use as a reference a simple visual technique, however it may not always be possible to rely on such approaches, in particular in the case of very large data-sets, which is why we consider different methods.

Q9 : The validity of the zero-crossing criteria is not clear. For about the ‘resolution’, describe the way of evaluation of 3.5c/U at l.262. Clarify the meaning of the phrase ‘at the limit of the measurement precision’ in l.265.

A9 : 3.5c/U is the dimensionless temporal resolution from the PIV sampling frequency, i.e the time between two PIV flow fields (corresponding to a physical separation of 0,01s as the sampling frequency is 100Hz). This has been added to the revised version of the manuscript.

Q10 : It should be described if there are reasons to set the detection threshold as zero. I think it should be optimized for each stall/reattachment instants for each method. Maybe this causes the ‘bias’ in l.350. Ideally, those instants should be compared to tref after the optimization.

A10 : The intended objective of the chosen threshold (zero crossing method) is to be able to have a way to compare detection methods with each others. Moreover, changing the threshold value won’t bring a universal threshold value to use in other datasets whereas using the zero-crossing method can be used anywhere without arbitrary values. It is true that we could try to find an optimal criterion for each method. However, it is not true that :I) there is some arbitrariness in the fact that we are choosing the mean as a threshold, II) the results could depend on the value of the sampled mean, as the signals are not exactly cyclic. Regarding I), The criterion – zero-crossing – has the advantage that it is the same for all methods, and that it does not depend on the signal intensity or on the particular cycle considered. Regarding ii) we show that the results presented in the paper, which were obtained using the average over the full signal length (18 cycles), were not significantly modified when the average was taken only over a small fraction of the signal length (corresponding to the first few cycles). The chosen criterion therefore appears to be both universal and robust.

Q11 : Moreover, if zero is calculated using the mean value in one cycle, the strategy on how to apply this to the field should be explained because the motion is not cyclic in the field.

A11 : It is true that the motions are not entirely cyclic. In the paper, the mean value was taken over the full signal length (all cycles). However we found that a good estimate for this value was obtained by taking the average of the signal over only a few cycles (for instance the first three or four), so that the separation and reattachment onset times were not significantly modified.

Q12 : The delay of the reattachment instances is described to be owing to the smoothing procedure in many sections. But I think the reason lies not only in the smoothing procedure but also in this threshold setting.

A12 : We agree with the reviewer, that the times could be influenced by several factors, such as the threshold (mean) value and the smoothing procedure. However, preliminary sensitivity analysis suggested that the length of the moving average window used reduces the noise which has a stronger effect on the detection times than the small variations in the sampled mean value of the signal, which is relatively well approximated with only a few cycles. To be clearer to the reader, the following sentence has been modified : "The main bias of this smoothing procedure is to reduce the slope during the change of flow state as illustrated in figure 15 and because of the modification of the slope, a constant bias is introduced in the detected instants. Another bias can also be

introduced due to the chosen threshold value (zero-crossing method) However, filter size as high as 21 time steps were found necessary to have an automatic procedure to extract stall and reattachment instants for all detection methods and thus having comparable results. In that case, the most important bias on the detected instants comes from the smoothing procedure. instead of : "The main bias of this smoothing procedure is to reduce the slope as illustrated in figure 15. Larger filter size have a larger impact on the gradients, however, filter size as high as 21 time steps were found necessary to have an automatic procedure to extract stall and reattachment instants for all detection methods and thus having comparable results"

Q13 : To think more about the interesting results that the dispersion of the delay is larger for reattachment than for stall, showing the average and the dispersion of the (td-tc) and the (th-tg) not only (tc+td) and (tg+th) is recommended to understand the rapidity of each phenomena.

A13 : We agree that this would be an interesting investigation, however we would like to emphasize that the acquisition frequency of the present results is 100Hz, so that the time resolution is too small for that purpose.

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