Response to reviewers, paper wes-2021-4

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1 Referee # 1

General comments

In this manuscript, the authors intend to show the ability of the full scale e-Telltale sensor to detect the separation state of the flow on turbine blades.

The wind tunnel experiment of 2D NACA 65_4-421 with $0.693m$ in chord length was conducted at Reynolds number of $8.85.10^5$ with pressure measurement. Several configurations of e-Telltale sensor are tested on the surface and the signal was measured for each configuration. The result shows that the sensors are able to detect the separation states from both leading edge and trailing edge. It is also found that its sensitivity for different states are depend on its configuration.

This work presents an important evaluation of the innovative device for the progress of the sophisticated turbine control including active flow control technologies on the blade.

I strongly recommend this paper for publication with however revised to raise the reliability of the work. I hope the following comments help the authors for their revision.

Specific comments

Q1 : The authors failed to convince readers the above explanation in Section 3 because there are no data. The authors should show the pressure distribution taken in this experiment to show the flow separation state for each slope of Cl.

The mean pressure distribution corresponding to the Cl curve has been added as suggested. Descriptions related to these quantities have been updated accordingly and shown in red in the final document. It should be emphasized that this description is only there to give a rough description of the stall scenario as it highly depends on the airfoil shape as found by the early study of Gault (1957).

Q2 : The inconsistency between Cls in Figure 8, 9 is also confusing for the readers to believe the reliability of this manuscript.

Thank you for noticing. The inconsistency comes from two main problems. The first confusion is due to an AoA correction we unfortunately did not reported in the figures of the original manuscript. The other inconsistency comes from the use of two distinct wind tunnel campaigns in the manuscript. As shown in figure 2, one campaign is relatively well 2D, the other one (figure 1 below) exhibit more 3D effects in the spanwise direction. As recalled in the final article, as soon as the flow separates, the flow becomes 3D (see e.g. Manolesos et al. (2014)), leading to lift discrepancies, which origin are still under investigation (see e.g. Olsen et al. (2020)). In the present study, it is though that changing the e-Telltale configuration modify slightly the blade shape and thus the lift level. However, understanding these 3D effects is out of the scope of the present paper. In order to be consistent in the description of the e-Telltale sensor's response, the simultaneous and local measure of the CL curve (via the closest pressure measurements) is now shown instead of the spanwise averaged CL value. However, for a rough presentation of stalled scenario of the present blade shape (see e.g. Gault (1957) for example of stall scenario with the Reynolds number and the airfoil geometry), the averaged CL value for the two campaign test is presented in section 3.

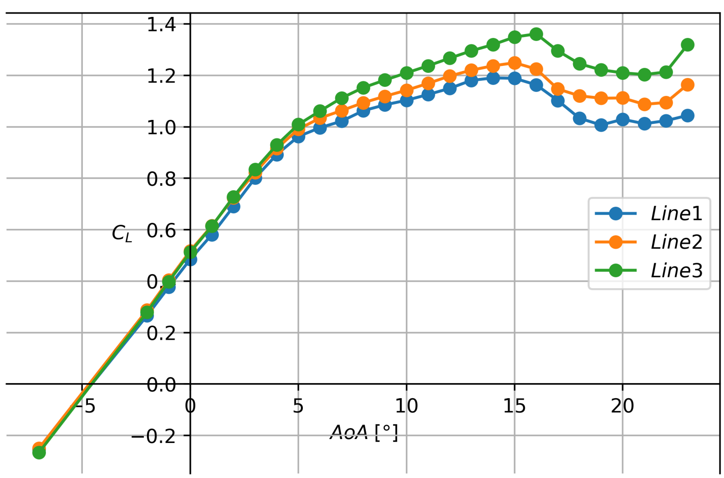

Figure 1. Lift coefficient of 3 lines with out e-Telltales, selected wind tunnel test campaign

Q3 : Cl's for Figure 10-12 seems to use the same data. The authors should show measured Cl slope for each experiment as explained in l.126 to show the ability of the sensor to detect the slope for each configuration. Otherwise, the authors should show the slope for each configuration are the same in another Figure.

The plot have been changed, for each e-Telltale configuration, the corresponding Cl is now presented

Q4 : The authors should explain some features in Figures to make them reliable. For Figure 12, the authors should explain the reason why the Mean LENSL signal is 0.1 for low AoAs

The offset of the sensor signal is really sensitive to its environment as the way it is mounted. This is why the analysis focuses on the changes of slope and the main features of the curve.

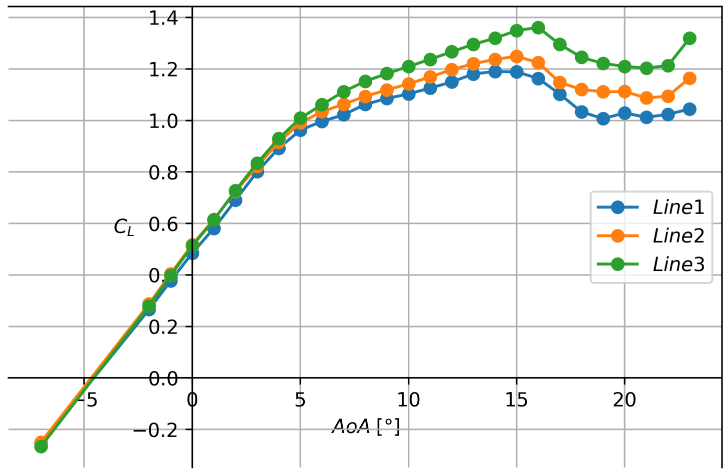

Figure 2. Lift coefficient of 3 lines with out e-Telltales, former version, non-selected wind tunnel test campaign

Q5 : For Figure 13, the authors should explain the possibility of interaction of the Shell of the sensor for the Standard deviation of TENSS signal at low AoAs

The interaction of the shell with the sensor is not raised in the article because no data could either confirm or deny the effects of the interaction. However what have been observed at least visually is that the behavior of the silicon strip is significantly different between a shell and a no shell e-Telltale. To go further into this analysis, additional dedicated measurements are needed such as 3D drag measurements or/and spatio-temporal measure of the flow field together with a measure of the strip movement, similarly as what has been performed at a lower scale experiment (see Soulier et al. (2021a)). This is however out of the scope of the present paper.

Technical corrections The technical corrections have been treated directly in the manuscript

2 Referee #2

Q6 : In section 2.3, line 64, the authors mention, that the measuring time was either 1 or 2 minutes. An explanation for the two different measuring times should be given and the approach how to calculate comparable standard deviations from different measuring times should be made clear to the readers.

As explained in answer Q2 from the first reviewer, results from several wind tunnel test sessions were used in the former version of the manuscript. For this updated version, data from a unique wind tunnel campaign are used, all the signals were acquired with a duration of 2 minutes. It has been updated in the manuscript.

Q7 : On page 6, fig.4, a picture of the device with shell is presented. Since most of the results focus on the no-shell version, a picture of this setup should be included to provide the reader an improved understanding.
The figure has been modified with an additional picture of the no-shell case.

Q7 : On page 6, lines 92ff, the authors mention, that a version of the used blade profile with modified trailing edge has been used in other research. The relevance of this information is unclear and it should either be explained or ommitted.
It has no specific relevance and has been omitted as suggested by the reviewer.

Q8 : On page 8, line 102, the authors claim that the flow is transitioning from separated state to attached state between AoAs of 6 ◦ to 8 ◦ . With increasing AoA the transition should be towards flow separation.
Thank you for noticing. This error has been corrected in the manuscript

Q9 : On page 8, line 105, the authors mention, that flow separation moves progressively towards the LE up to an AoA of 18 ◦ . The decrease in CL is already starting at 18 ◦ (fig. 8), though.
We agree with the reviewer, the AoA of 18° is, in this case, not the good one, the stall begin at the AoA of 17° corresponding, to the maximum lift. This have been changed in the manuscript.

Q10 : The lift coefficients derived form the pressure taps in fig.8 deviate from the lift curves for the two cases with and without the mounted device in fig 9. Figure 9 shows a later transition to a lower slope in the linear region (6 ◦ vs. 7 ◦) and also shows a higher maximum C L (<1.2 vs. >1.2). This leaves the readers with some questions about the reproducibility and reliabilty of the results. The authors should discuss these deviations and give an explanation. Also, since the device is mounted between two lines of 1pressure taps, the comparison of lift curves for individual lines of pressure taps instead of just averaged data would add value.

Please refer to our answer of Q2 from the referee #1

Q11 : In section 4.3 on page 11 the authors discuss the performance of the sensor when applied close to the leading edge. The finding of no detected separation for low AoAs should be expected, since the sensor is mounted in the region of the blade profile, where the flow is still attached. The finding seems obvious and this should be mentioned. The same holds for the finding, that separation close to the LE is detected once the AoA increases.
Thank you the advice, it has been added in the final version.

Q12 : The description of the impact of the shell in section 4.4 is very brief and superficial. From fig. 13 it is clearly visible, that the shell impacts the flow and thus the signal of the sensor. It can be expected, that the shell impact results in higher standard deviations for low AoAs. However, it is not clear why the signal is higher for fully separated flow in high AoA cases. No shell effect should be expected once the shell is located in the fully separated region. The authors unfortunately do not address the visible effects besides mentioning higher signal and standard deviation values for the shell case. A hypothesis and possible explanation of the effects would be helpful here. Unless this is addressed, this section provides no meaningful value to the paper and should be omitted.

It is true that we cannot explain the differences between the two configurations with the available measurements. However, it is still interesting to point-out that the differences, that cannot be seen in the lift level (figure 10), are so strong in the e-Telltale signal. Too many parameters are involved here to conclude. It should however be noticed that the strip of the e-Telltale in the integrated case was observed to have difficulties to initiate a movement. This may be attributed to a complex interaction between the boundary layer with the cavity in which the sensor is integrated. More dedicated measurements are needed for further understanding. This hypothesis is addressed in the final document

Q13 : In the final sentence of the conclusion (p.13, line 202f), the authors claim, that the sensor with shell is also capable of detecting the TE separation angle and stall angle. This conclusion is not fully supported by the plots in fig. 13 and the brief mention in section 4.4. While the local maximum of the standard deviation and the first increase of the signal value seem to be an indicator for TE separation, these increases occur with a slight delay compared to the CL curve used as a reference. The authors should be more precise in distinguishing the results for the different setups.

The reviewer raised an interesting question that we unfortunately cannot answer with the available measurements. Indeed, if the pressure distribution is able to tell us when the flow separates, we do not have any information on the motion of the e-Telltale strip within the flow field, which prescribe any understanding of this sensor response delay. This is something we addressed at lower scale for the second peak of the e-Telltale signal (stall phenomena), with analysis of the strip motion using TRPIV measurements (Soulier et al., 2021b). Dedicated measurements should be performed for further investigations of this delay.

Technical corrections The technical corrections have been treated directly in the manuscript

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