Field test of an active flap system on a multi-MW wind turbine

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DTU Technical University of Denmark

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Siemens Gamesa – Key Facts[1]

[1] End of December 2018

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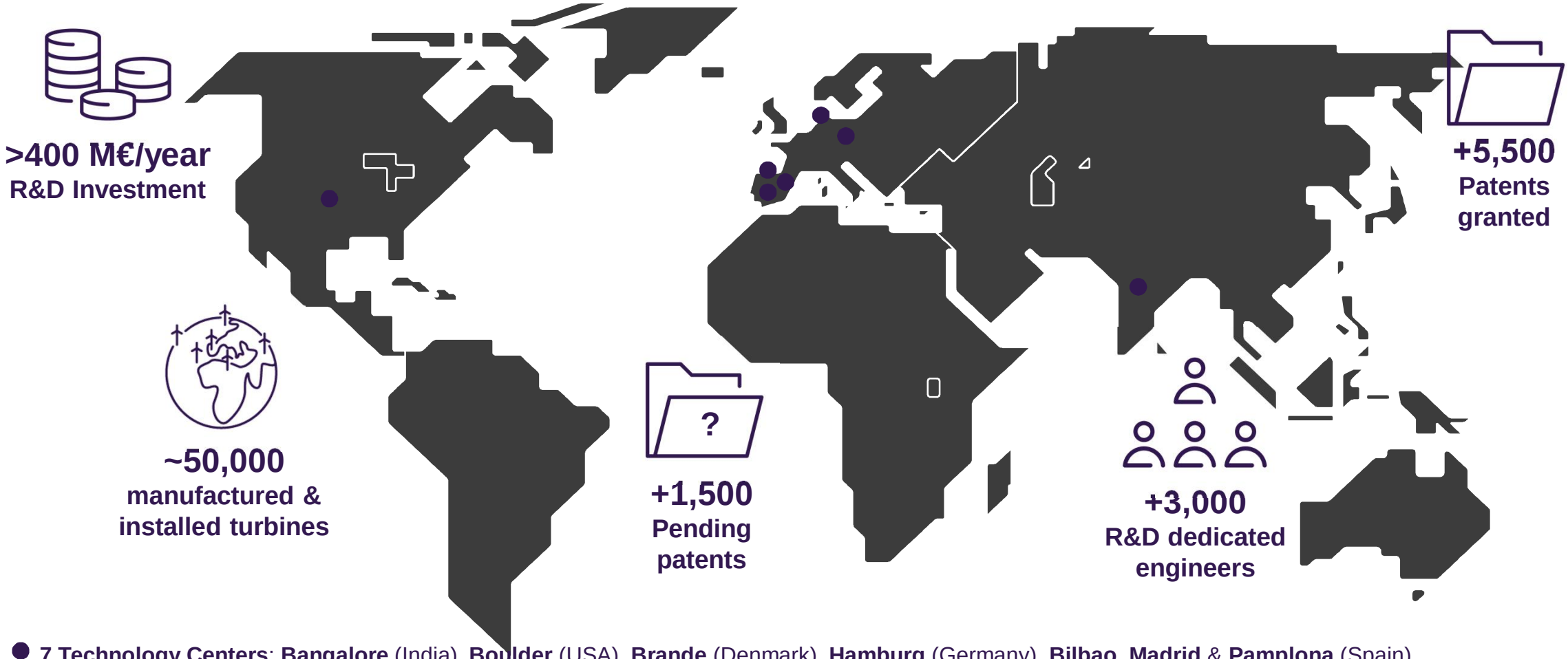
Technology & Innovation



- **7 Technology Centers**: **Bangalore** (India), **Boulder** (USA), **Brande** (Denmark), **Hamburg** (Germany), **Bilbao**, **Madrid** & **Pamplona** (Spain)

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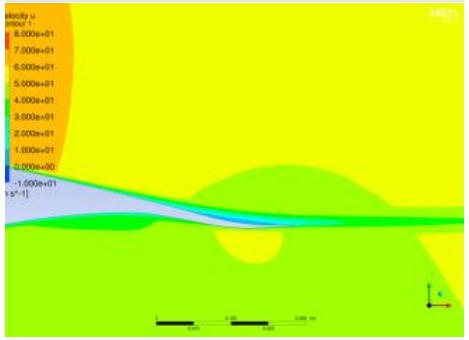
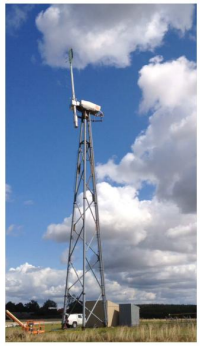
Induflap2 – Active Flap System (AFS) design and validation

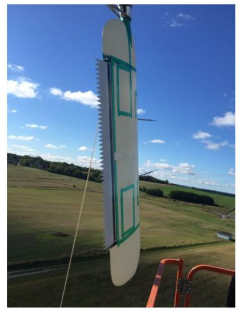
design of AFS



sub-module validation
e.g. wind tunnel testing

rotating rig





focus of today's talk (WP4)

full scale test

Simulation, modelling, and data analysis

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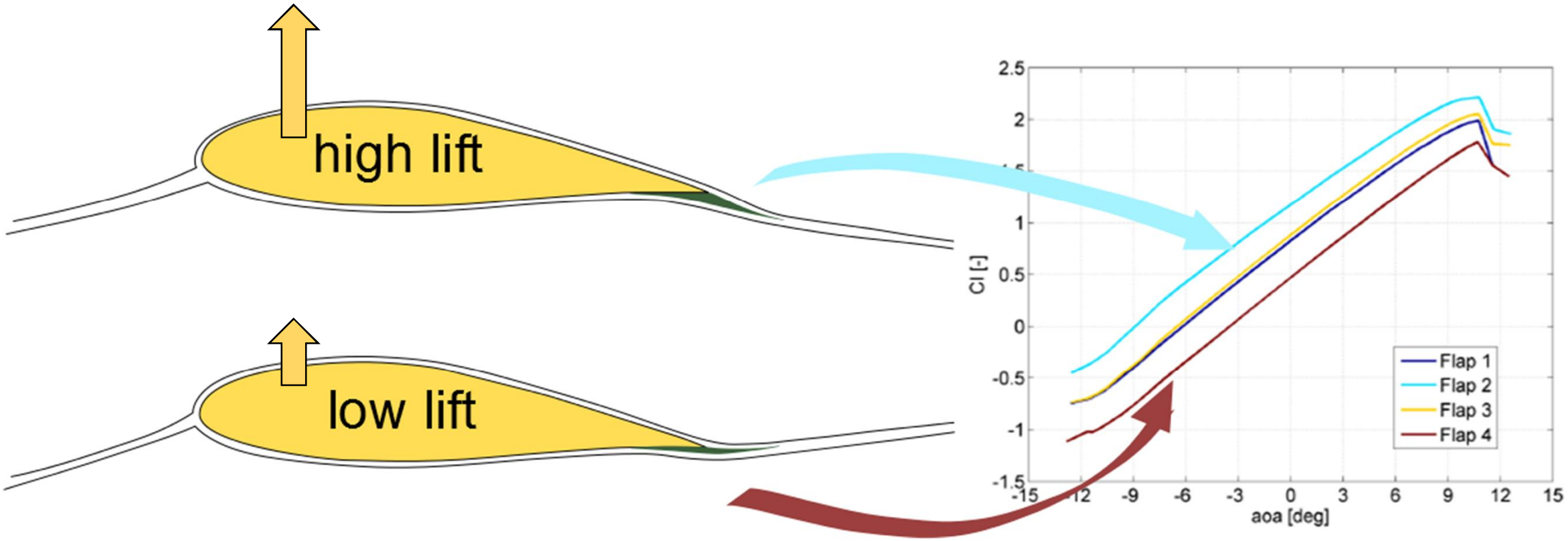
REHAU Unlimited Polymer Solutions

DTU

eUDP Energiteknologisk udvikling og demonstration

Active flaps.. How does it work



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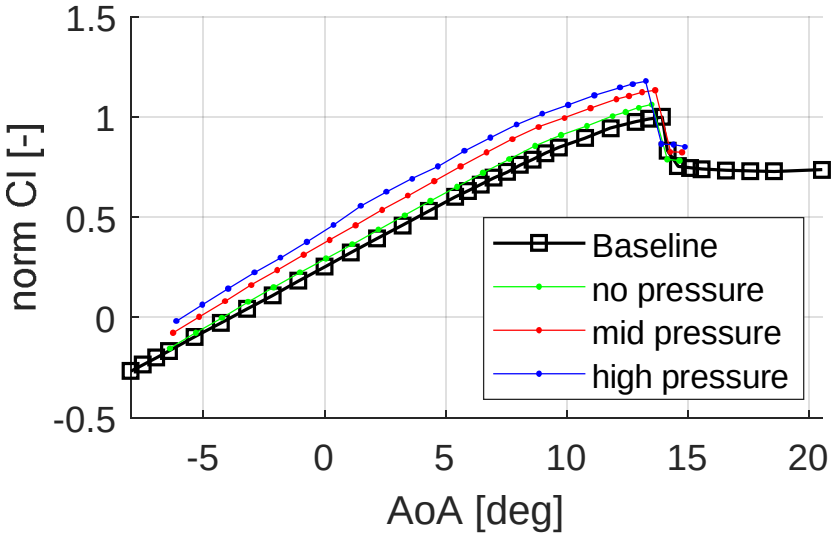
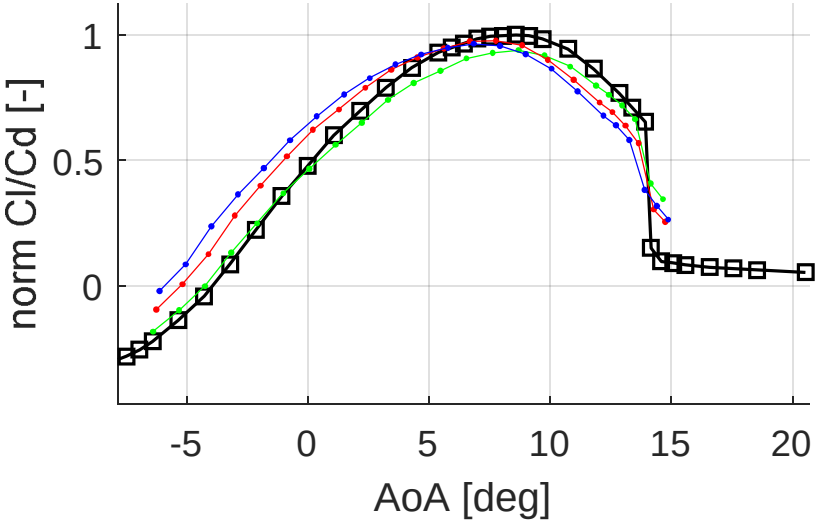
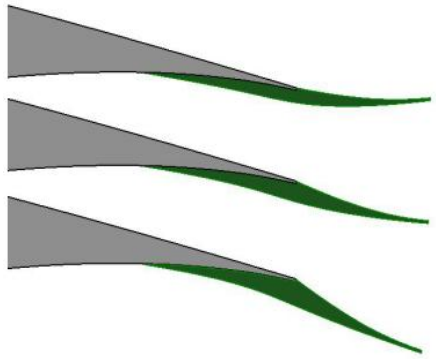
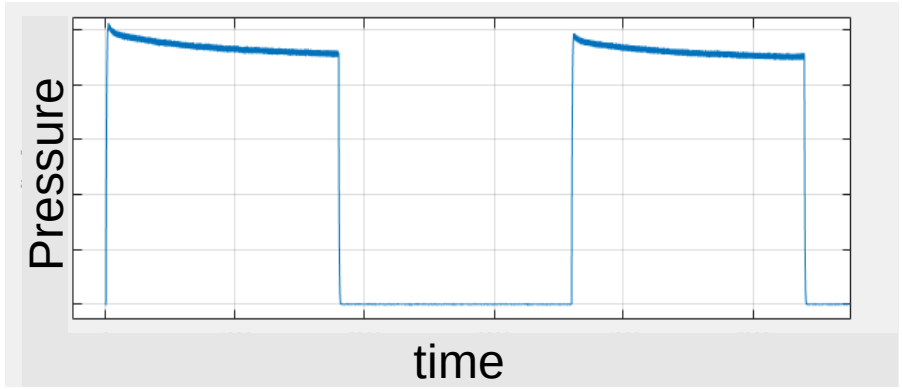
Active flap actuation







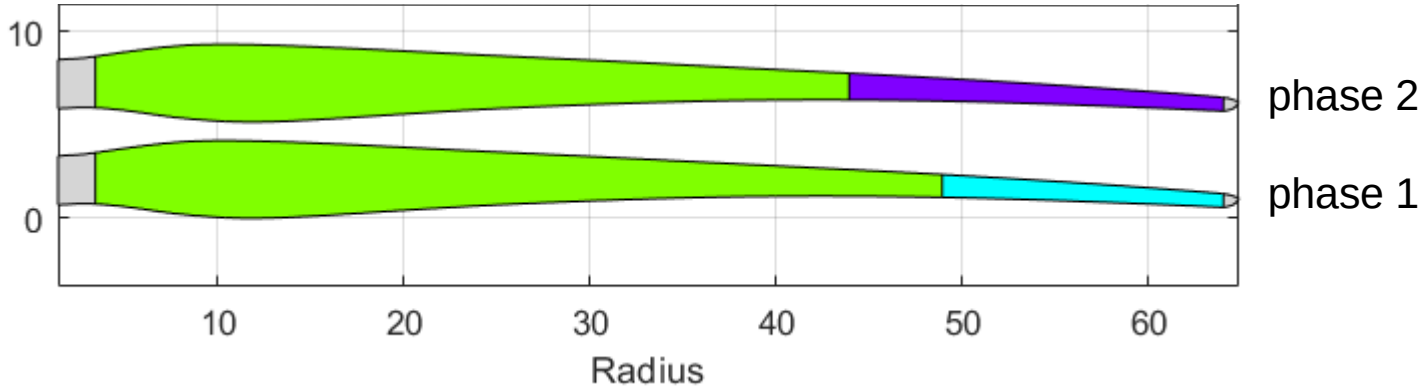


Measurement campaigns

Measurement campaigns

View of AFS during phase 1

	Phase 1	Phase 2
Date	Oct 2017 – June 2018	Dec 2018 – June 2019
Turbine	SWT-4.0-130	SWT-4.0-130
AFS type	**FT008_rev9**	**FT008_rev10**
Extension	47.5 – 62.5 m	42.5 - 62.5 m



FT008_rev9: AFS with focus on ease of manufacturing and installation

FT008_rev10: AFS with improved aerodynamic and elastic properties

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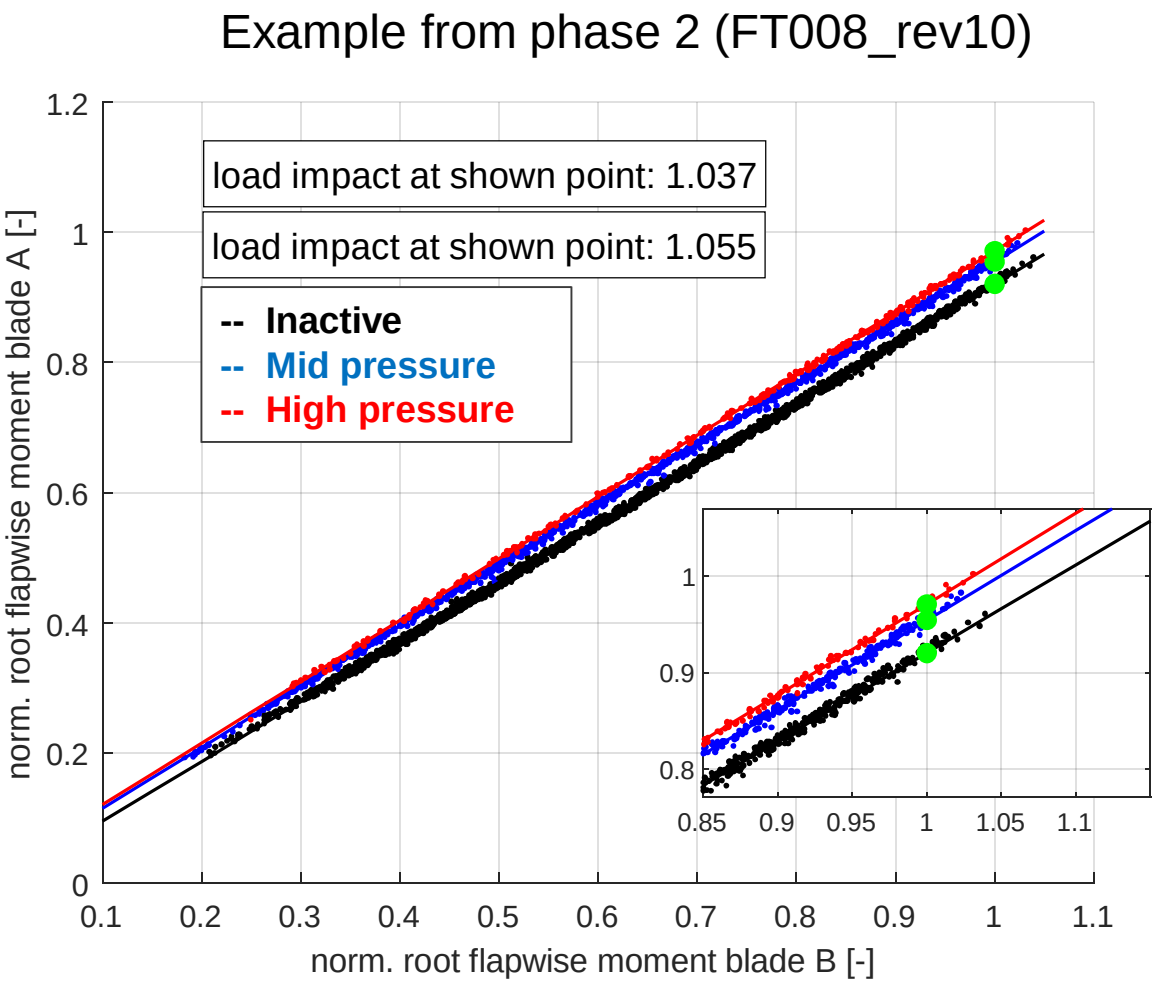
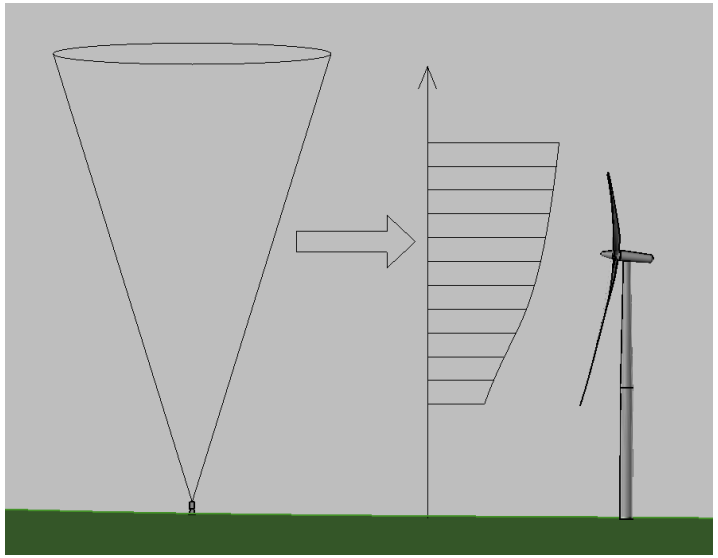
Blade-2-blade load comparison





Blade-2-blade synchronous analysis helps to:

- Reduce the uncertainty related to period-2-period analysis
- Reduce uncertainty due to met-mast / turbine distance (both due to time offset and turbulence coherence issues)

- NOTE: it is important to filter independently for wind speeds above and below rated

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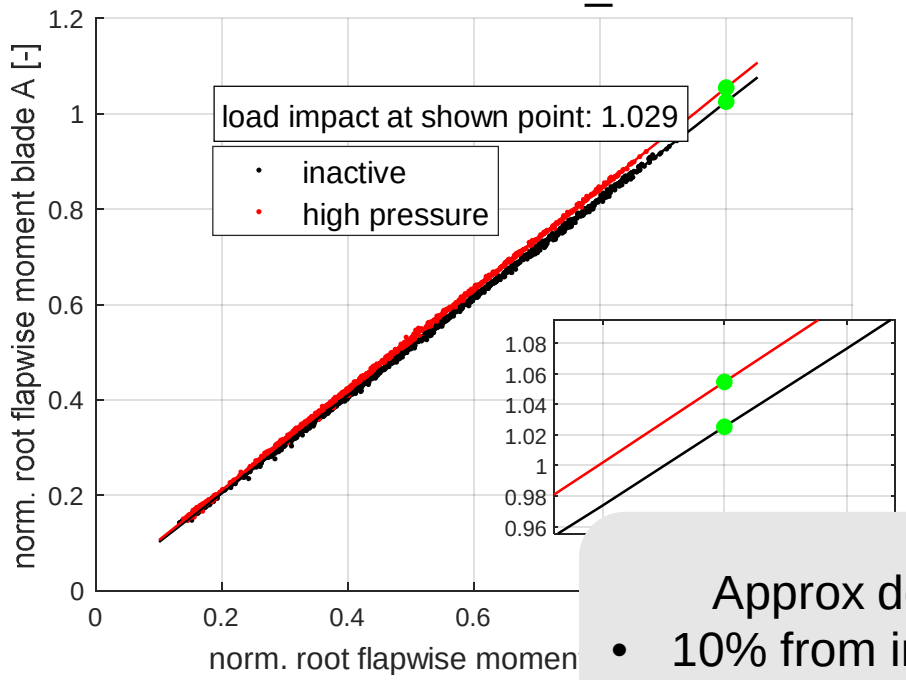
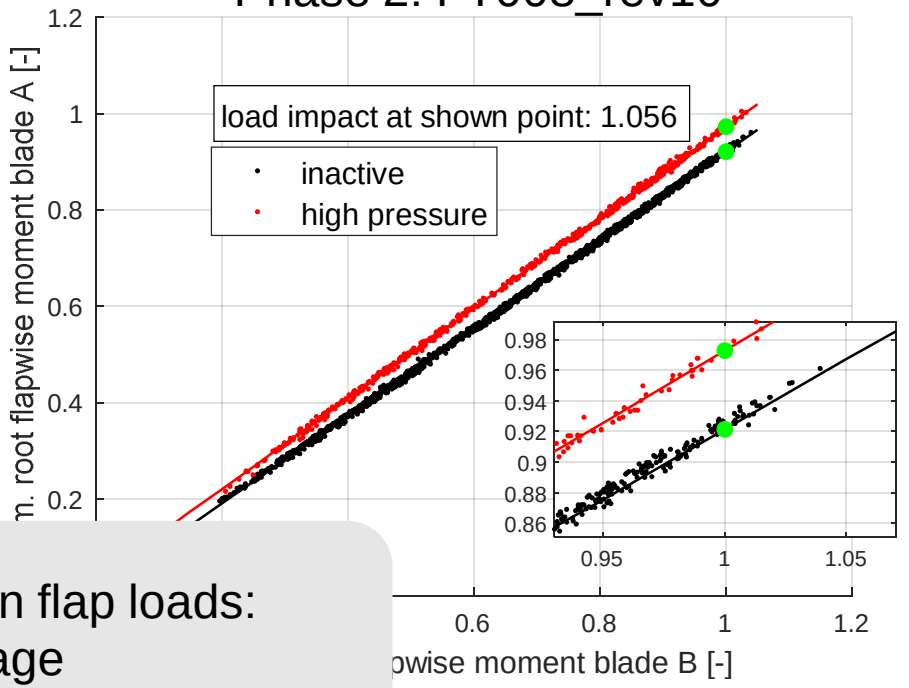
Windspeed < 9.5 m/s

Windspeed > 10 m/s

Phase 1: FT008_rev9

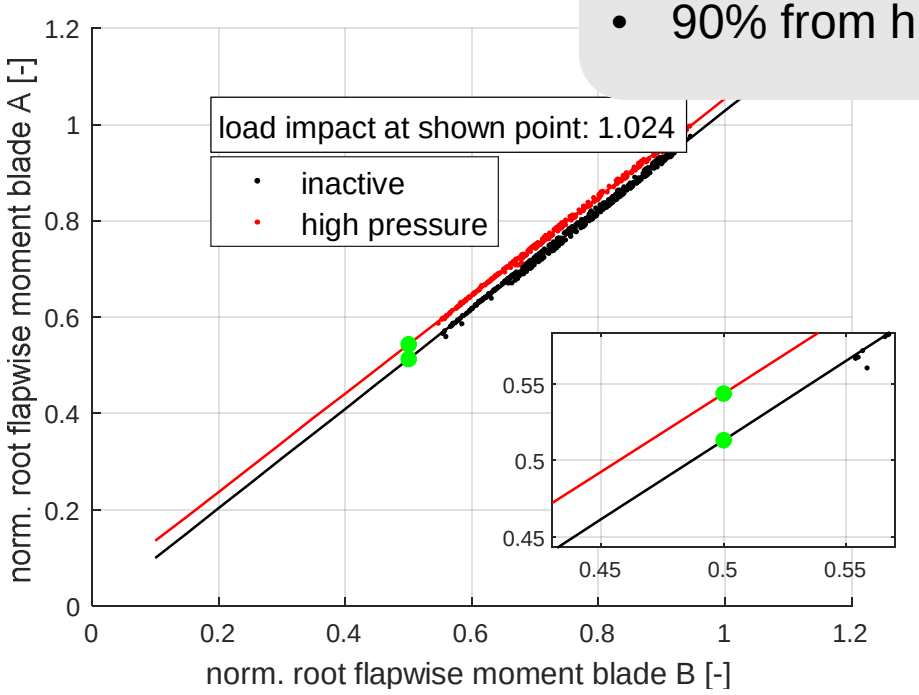


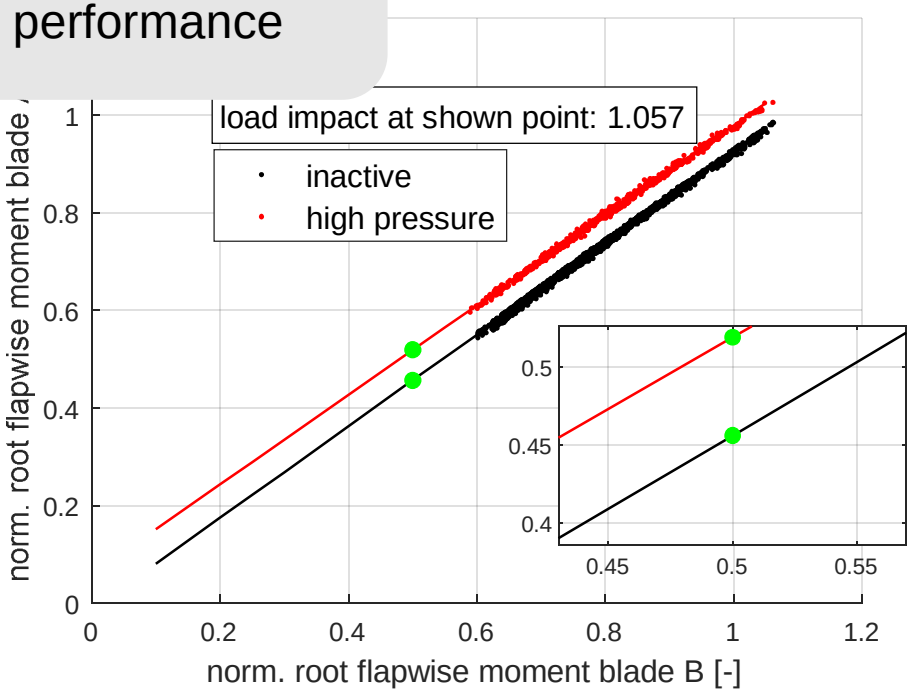
Phase 2: FT008_rev10



Approx double impact on flap loads:

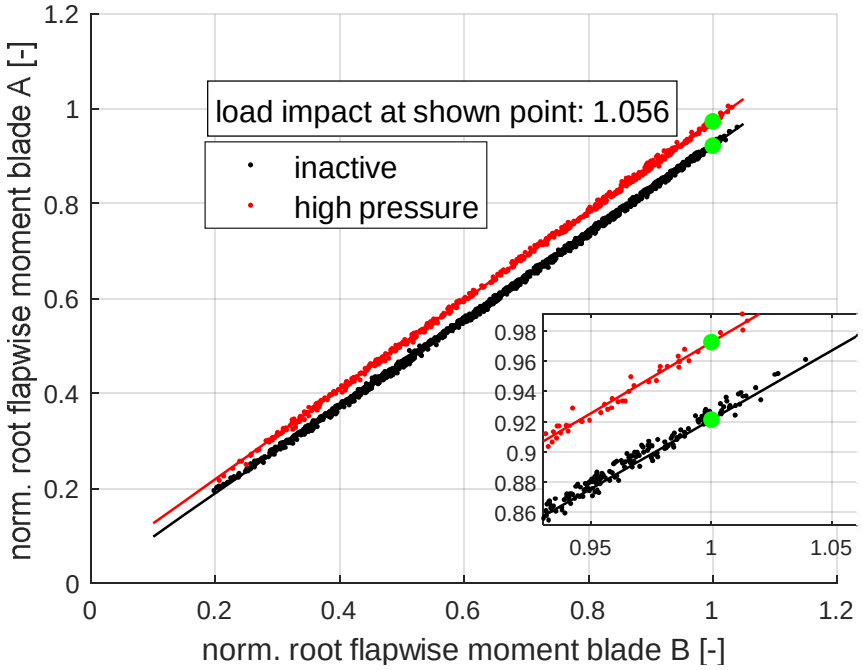
- 10% from increase coverage
- 90% from higher flap aero performance

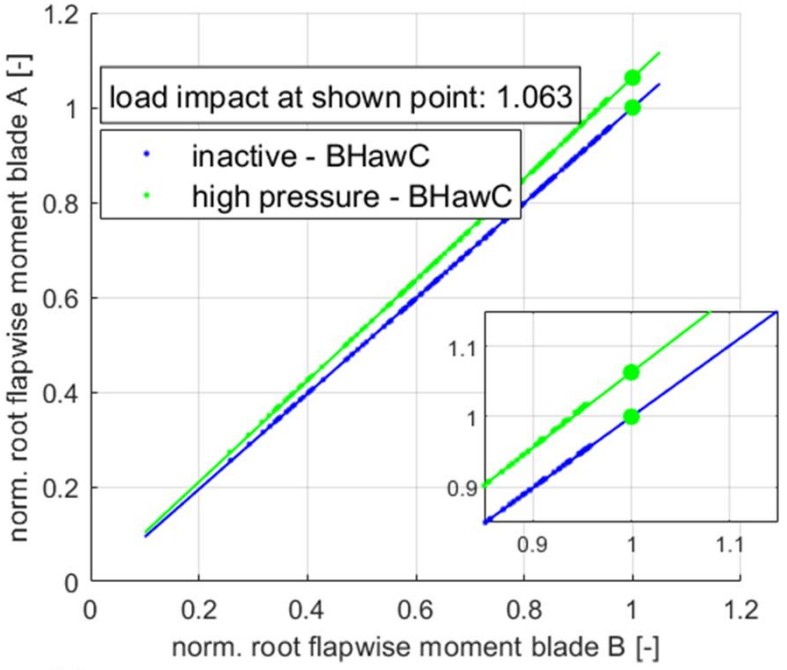




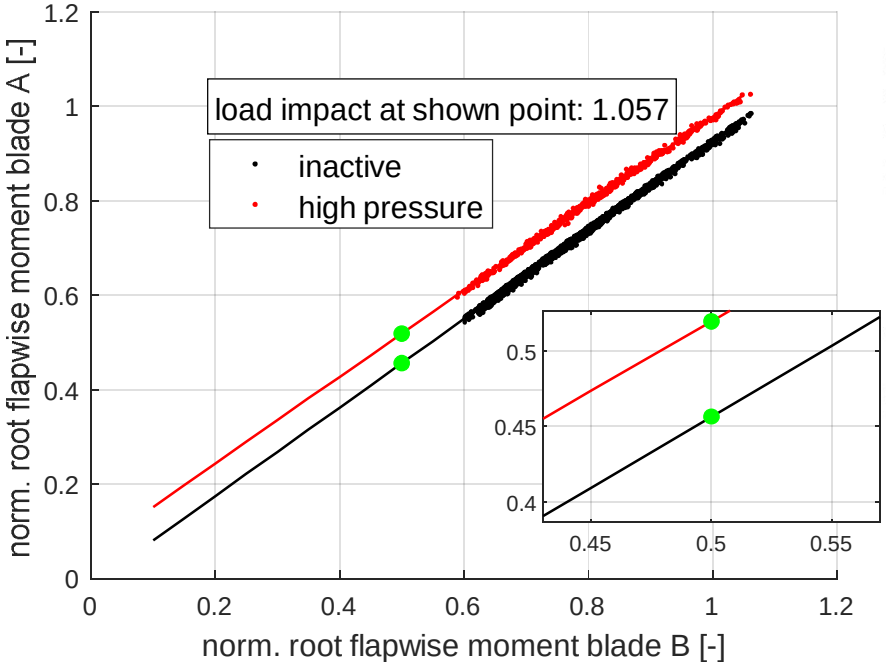
Phase 2: FT008_rev10: Measurements vs BHawC simulations

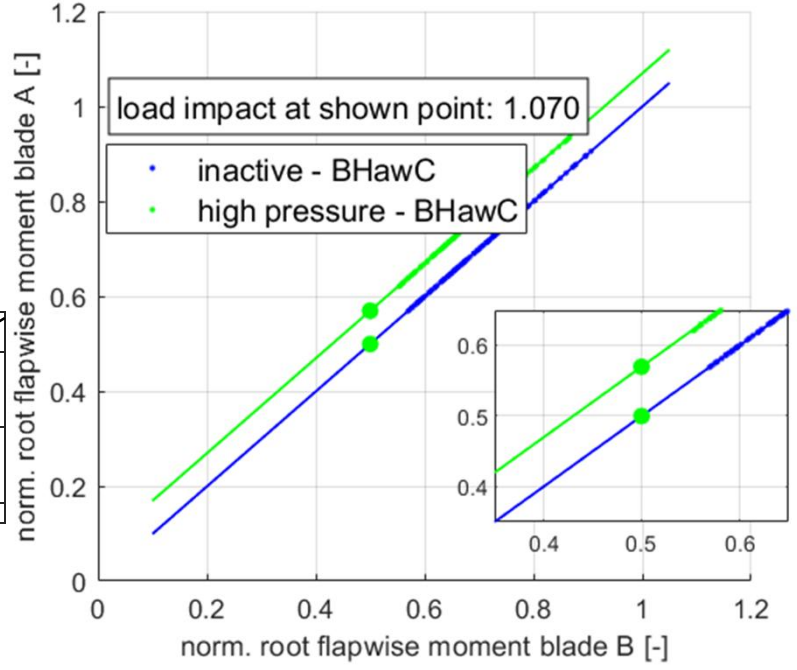
Windspeed < 9.5 m/s

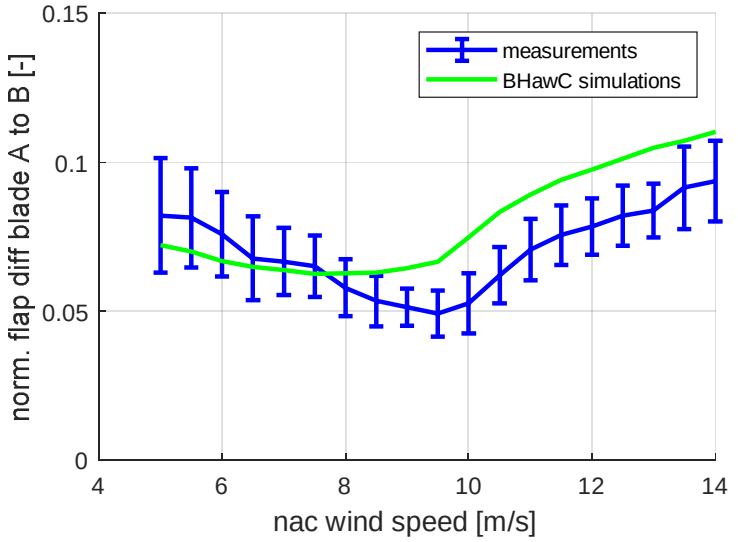




Windspeed > 10 m/s



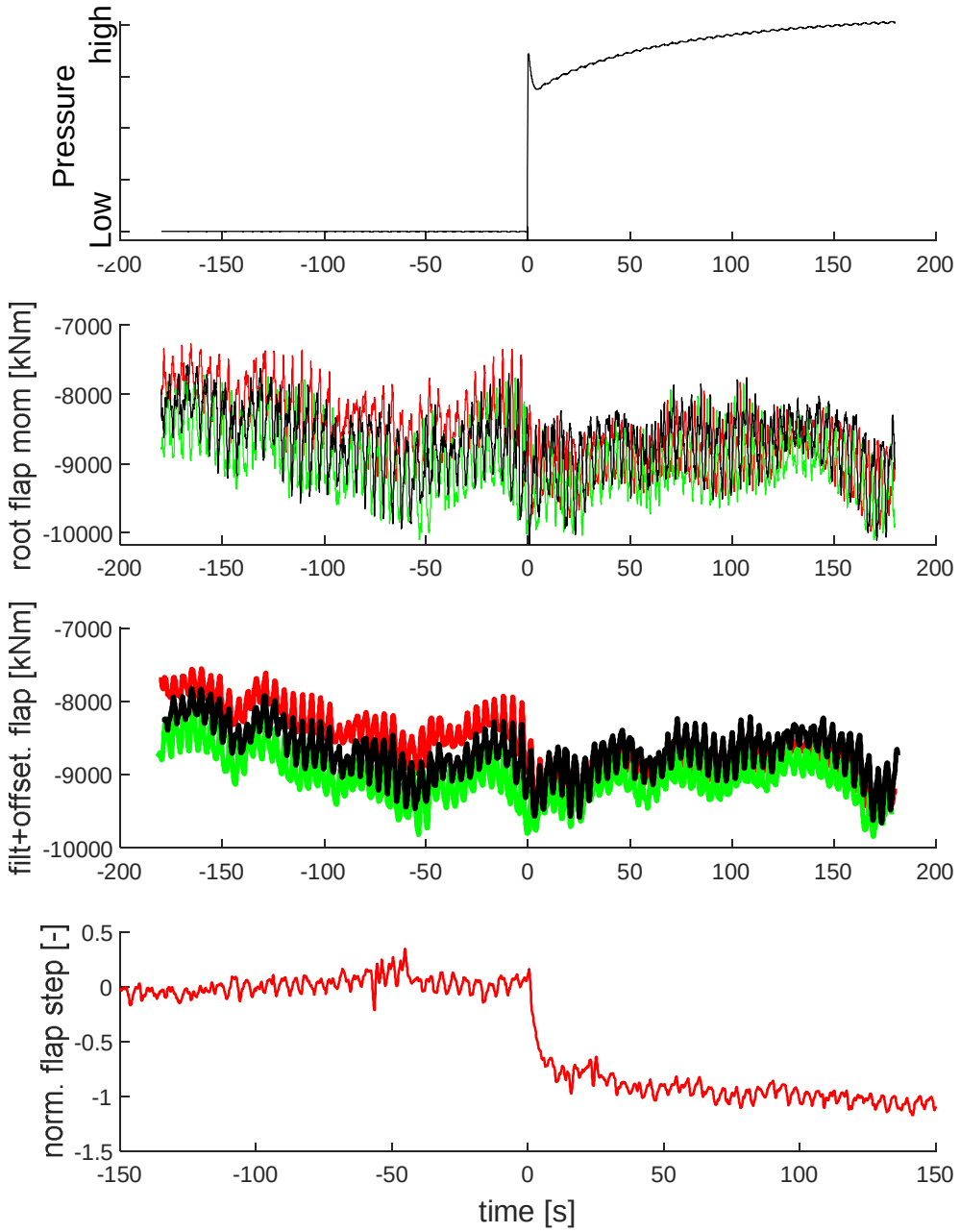




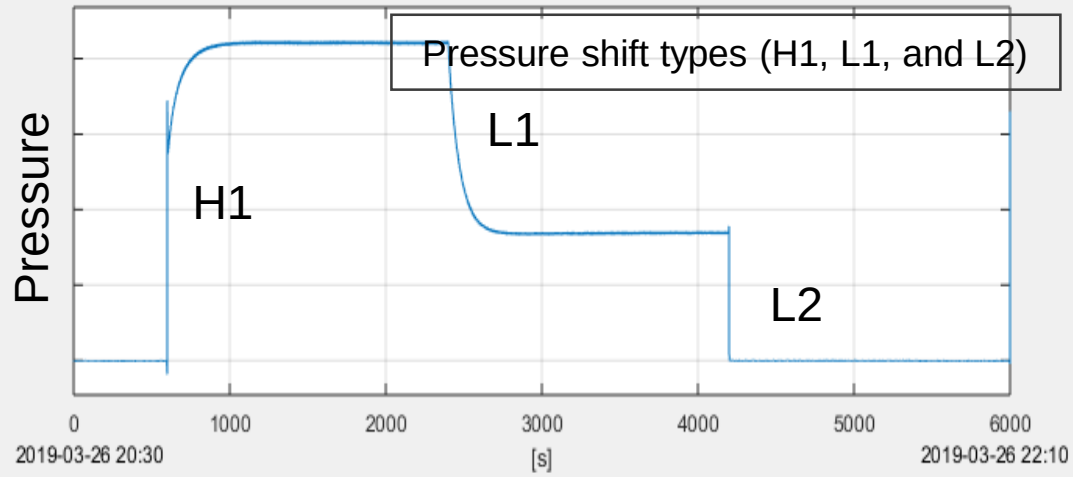
Transient step analysis methodology

1

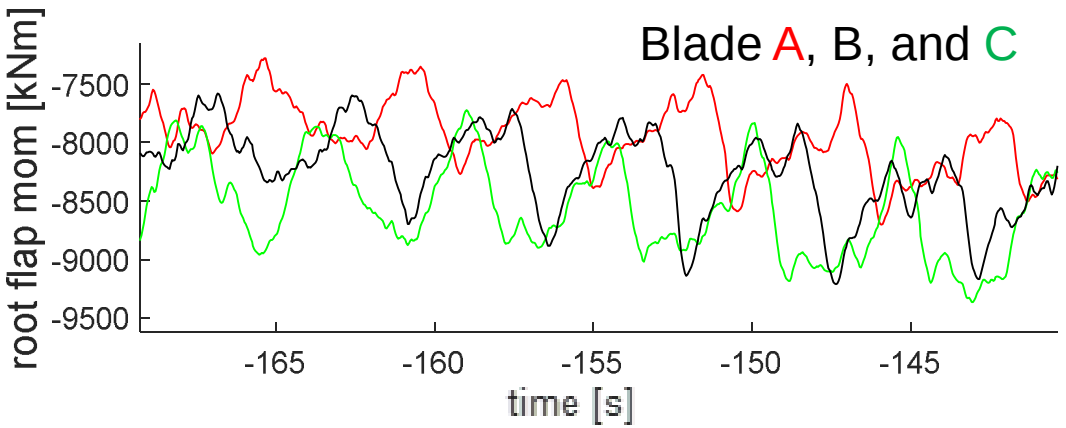
2



Step 1. Read turbine data and define thresholds for auto step detection and classification



Step 2. Read approx. 3 mins of blade loads before and after the pressure shift

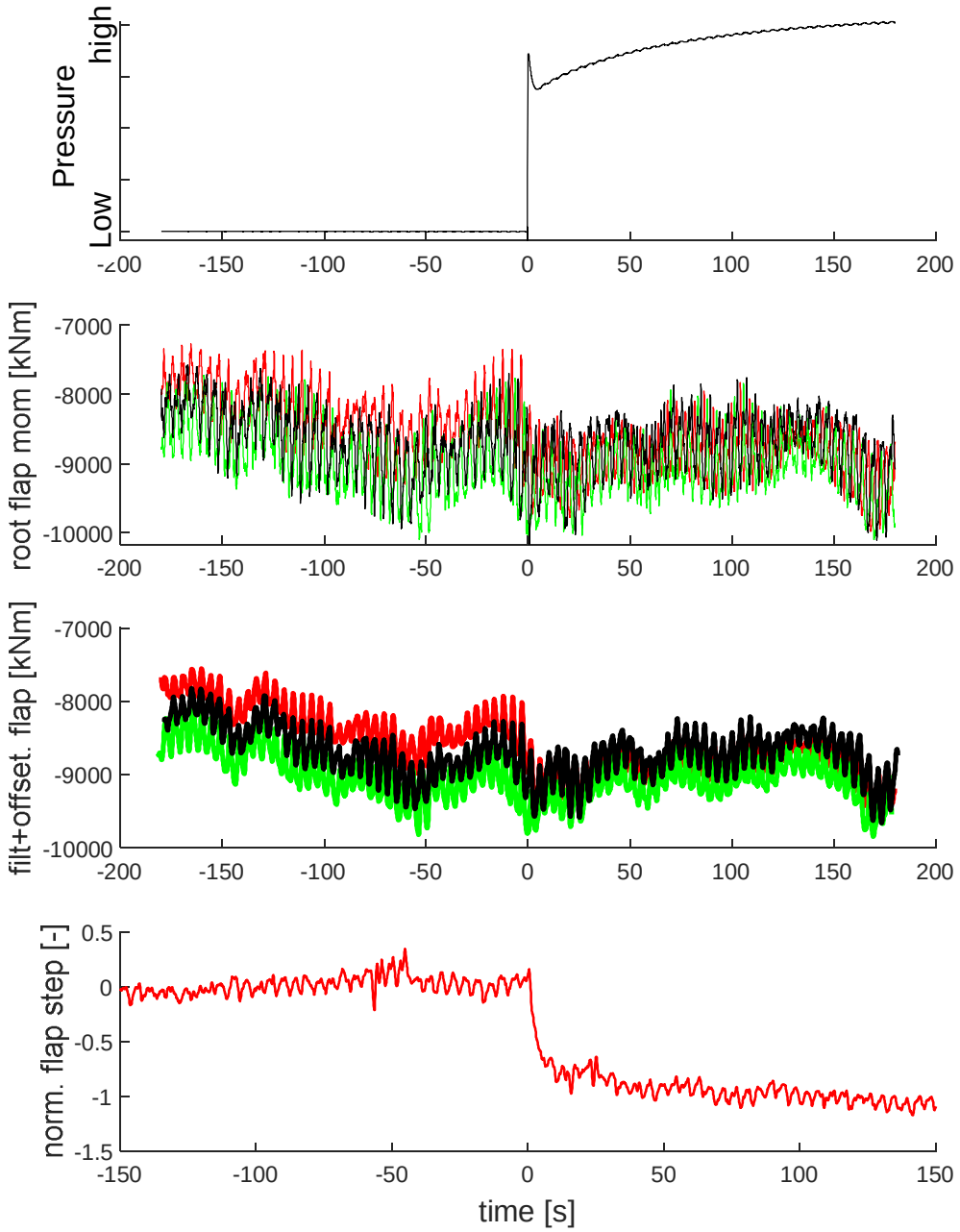


Step analysis methodology

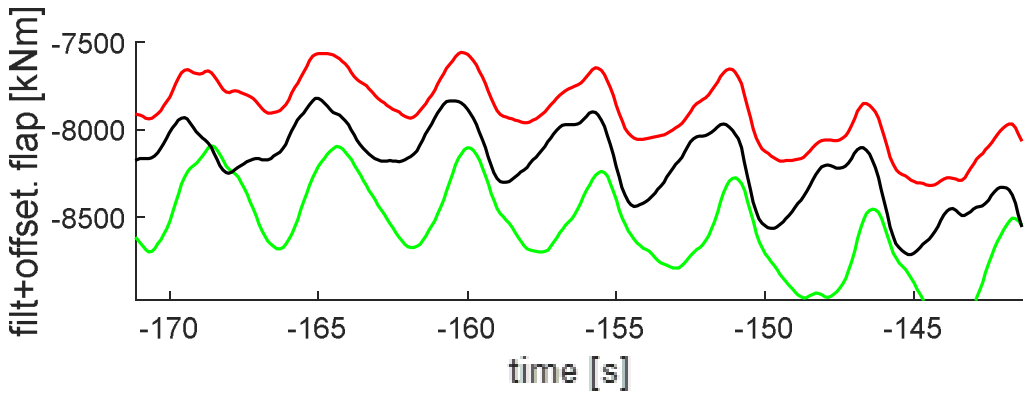
1

2

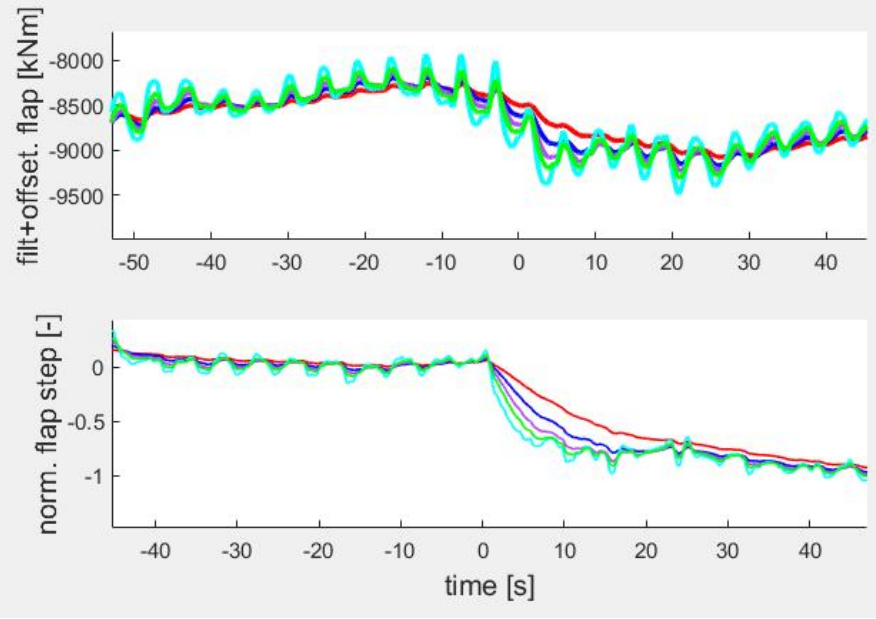
3



Step 3. Offset and filter data

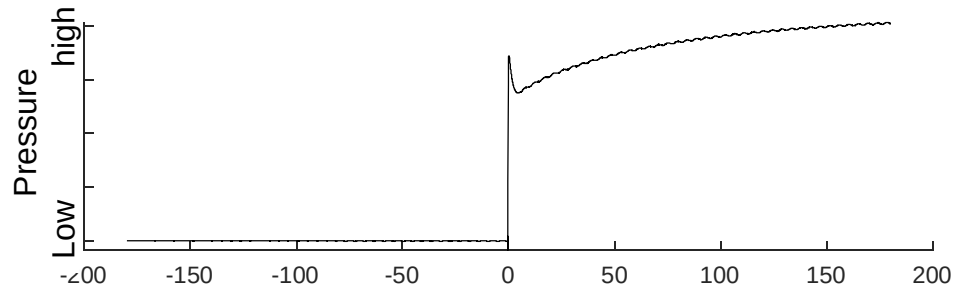


<u>Comment on filtering</u>:
impacts calculated response time!
Filtering time constants shown below: 1, 2, 3, 5, 10s



Step analysis methodology

1



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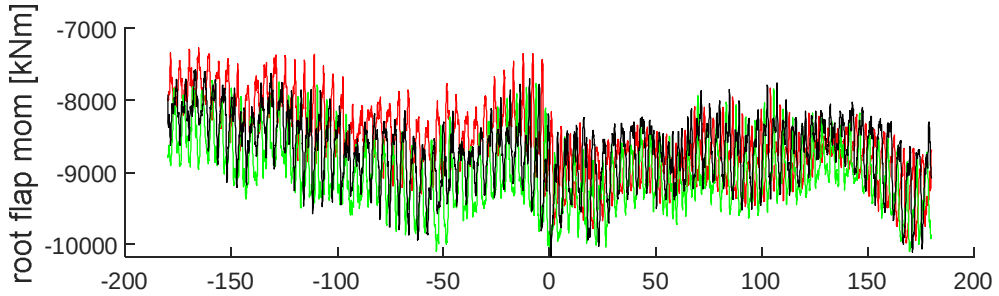

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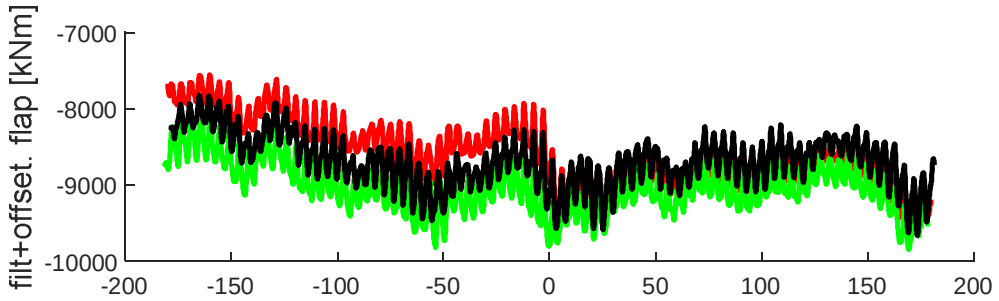

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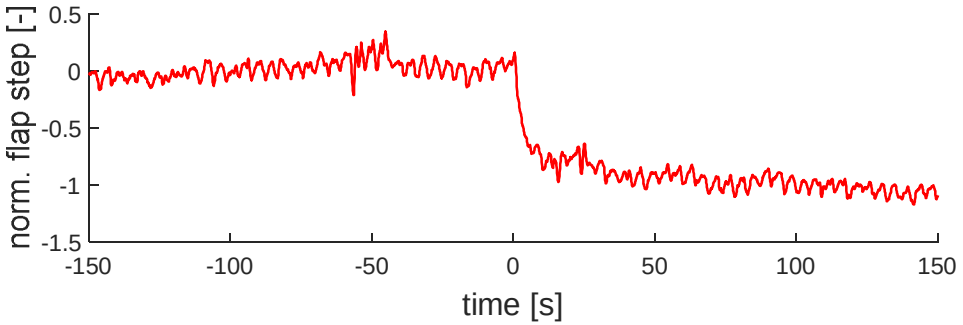
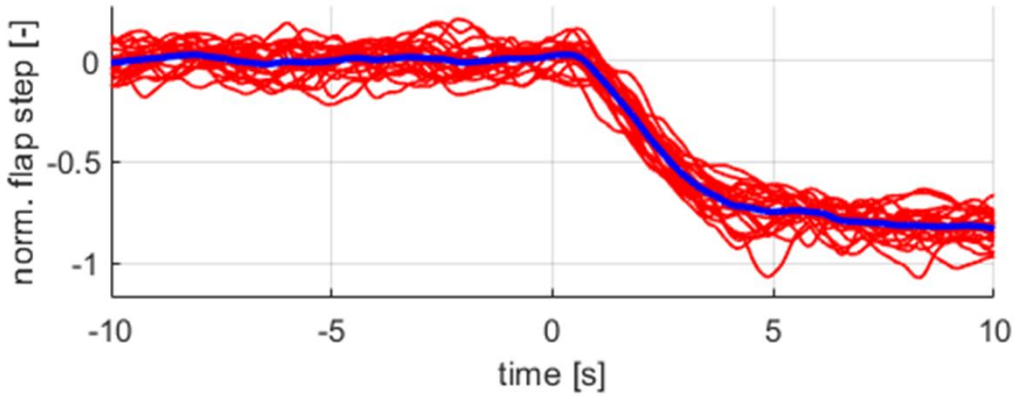


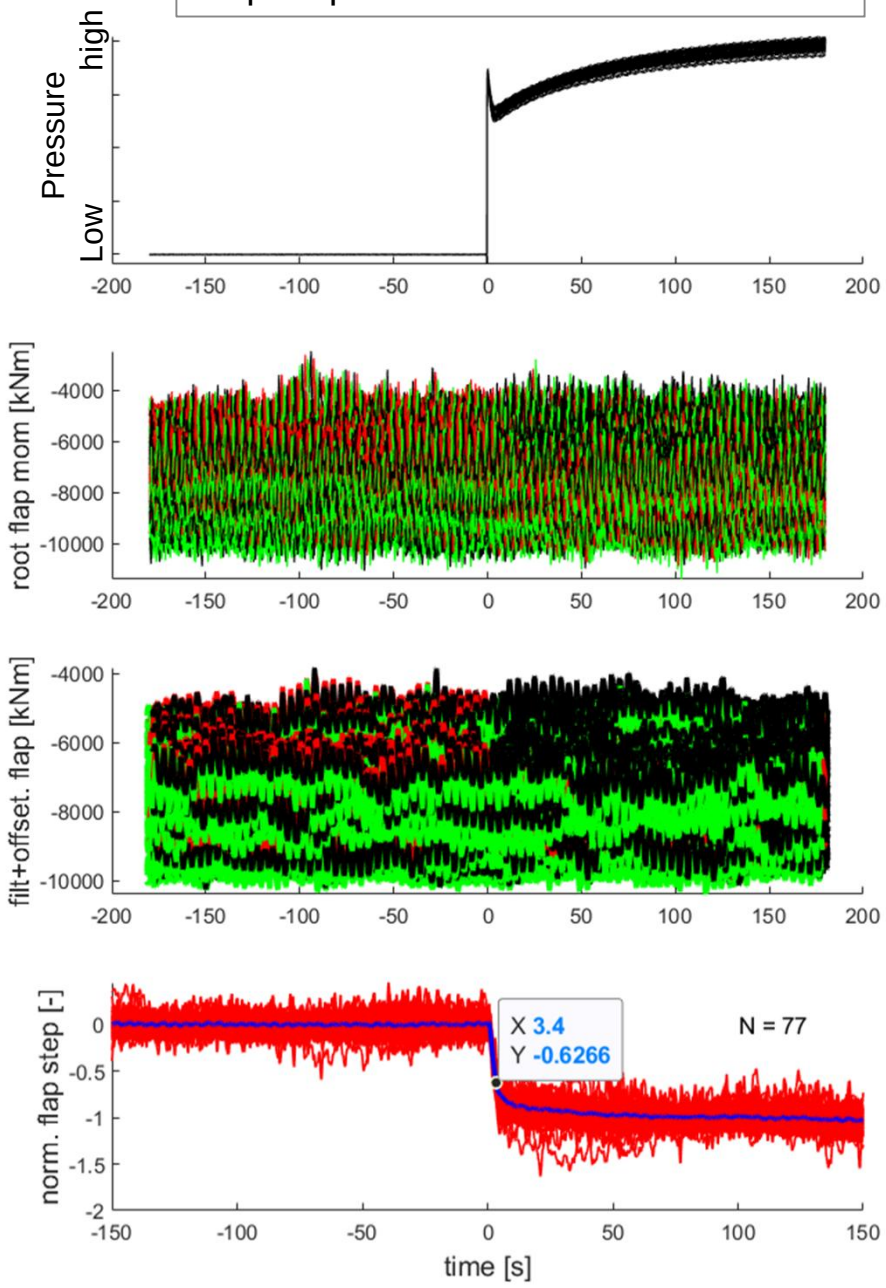
Step 4.
Difference between blade A vs average of B and C

Step 5.
Ensemble averaging among hundreds of shifts

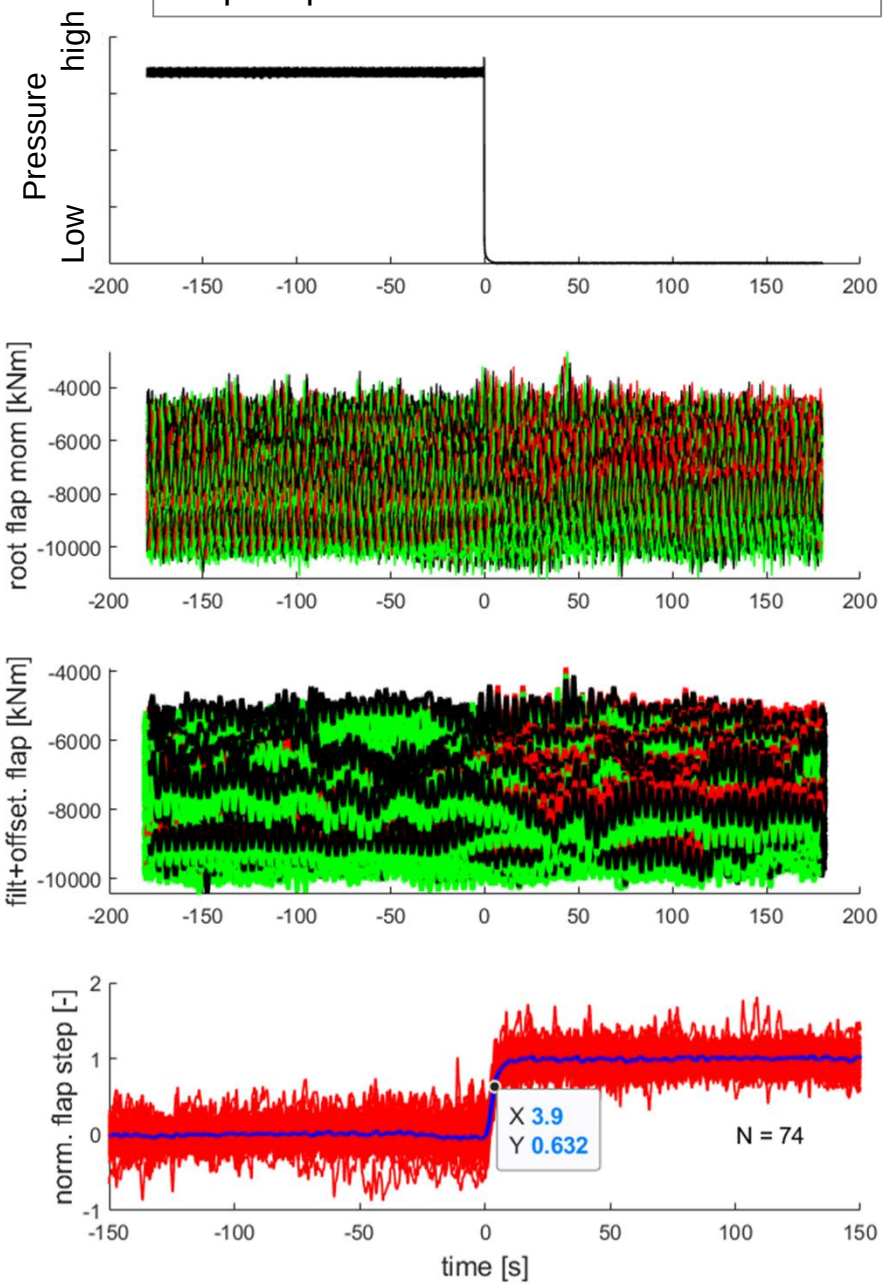
5



Ensemble average of type **H1 steps**
Flap response of order 3.4 +-0.2s



Ensemble average of type **L1 steps**
Flap response of order 3.9 +-0.2s



Summary

Two versions of an active flap system (AFS) developed within the scope of the Induflap2 project (AFS FT008rev9 and FT008rev10) were successfully tested in full scale on a SWT-4.0-130 turbine

Successful culmination of WP4, including the manufacturing of the individual active flap kits, the development of the installation method of the flaps, development and installation of a pressure supply system, on-site installation, turbine instrumentation, and two independent test campaigns (each of duration of approx. 6 months).

Development of methods to validate in an isolated manner the effects on loading of the AFS both in mean levels as well as transient behaviour

The full scale test demonstrated the ability to actively modify the mean load levels with both AFS FT008rev9 and FT008rev10

Acknowledgements

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Active flow control is a promising technology 

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Thanks!

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