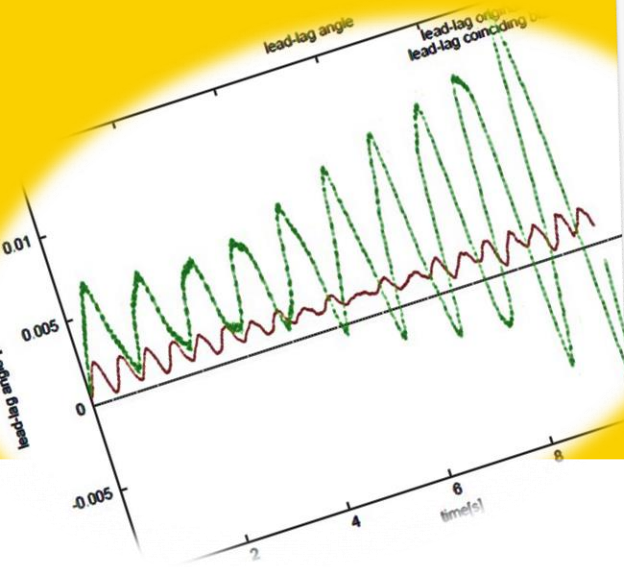
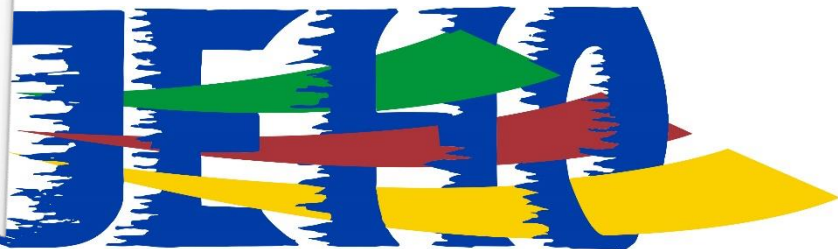
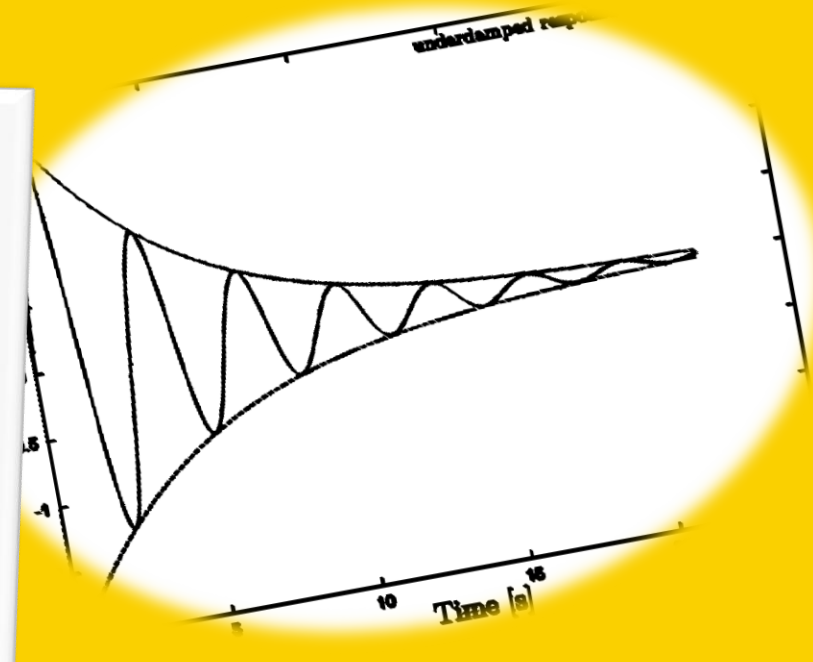


Wind Turbine Aeroelasticity Workshop



Essential: preventing aeroelastic issues

- Avoiding resonance is never enough to avoid all possible issues
- For every design the aeroelastic stability should be checked
- This evaluation is currently **NOT** part of the design process, it is done only implicitly through load calculations, this does not suffice!!!
- Knowledge of possible instabilities is vital (what you do not know, you cannot prevent)
- Know enough about resonances, including relevance of change in frequency due to whirling!
- Knowing what causes the instability makes it possible to develop the solution



Contents of this leaflet

- This leaflet provides detailed information about a **2-day works shop** concerning wind turbine aeroelasticity
- First some general information is provided about the course, [who](#) should attend, [who](#) gives the course, [tools](#), [costs](#), etc.
- Then the contents of the 2-day workshop are provided in [detail](#)
- Finally an overview is given of the [complete training programme](#) we provide



Assume the reaction force to be:

- $F_{xR} = A \sin \omega t$; $F_{yR} = 0$

Transforming to non-rotating frame gives:

- $F_{xNR} = A \sin \omega t \cos \Omega t$
- $F_{yNR} = A \sin \omega t \sin \Omega t$

Using basic mathematics:

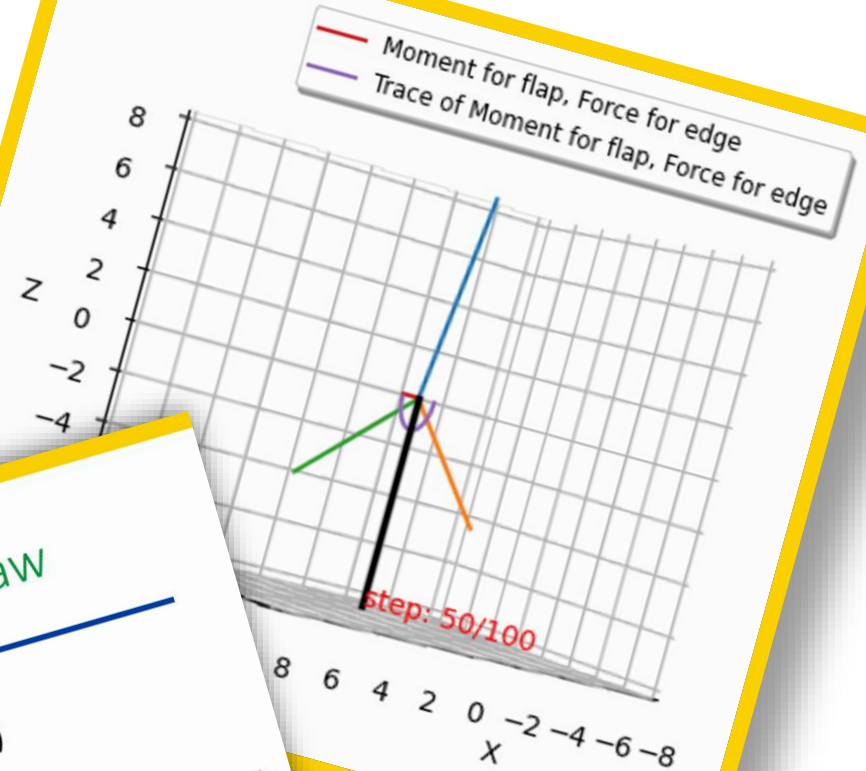
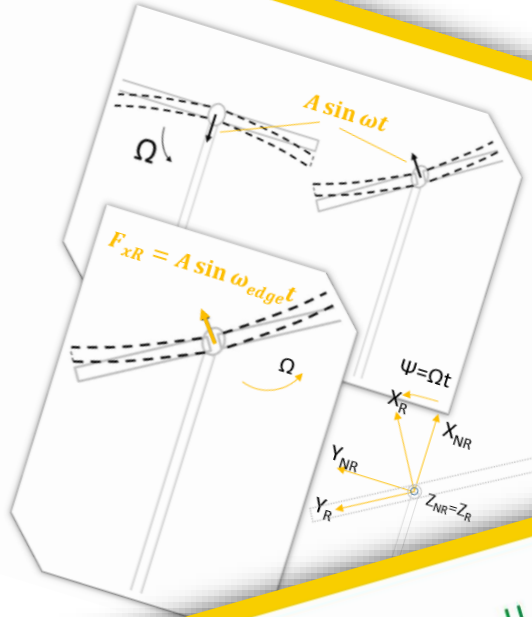
- $F_{xNR} = \frac{1}{2} A \sin((\omega - \Omega)t) + \frac{1}{2} A \sin((\omega + \Omega)t)$
- $F_{yNR} = \frac{1}{2} A \cos((\omega - \Omega)t) - \frac{1}{2} A \cos((\omega + \Omega)t)$

This change in frequency occurs only if the **reaction force is in-plane**

$$\sin(a)\cos(b) = 0.5(\sin(a+b) + \sin(a-b))$$

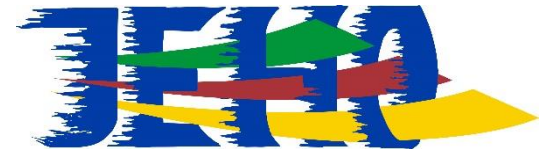
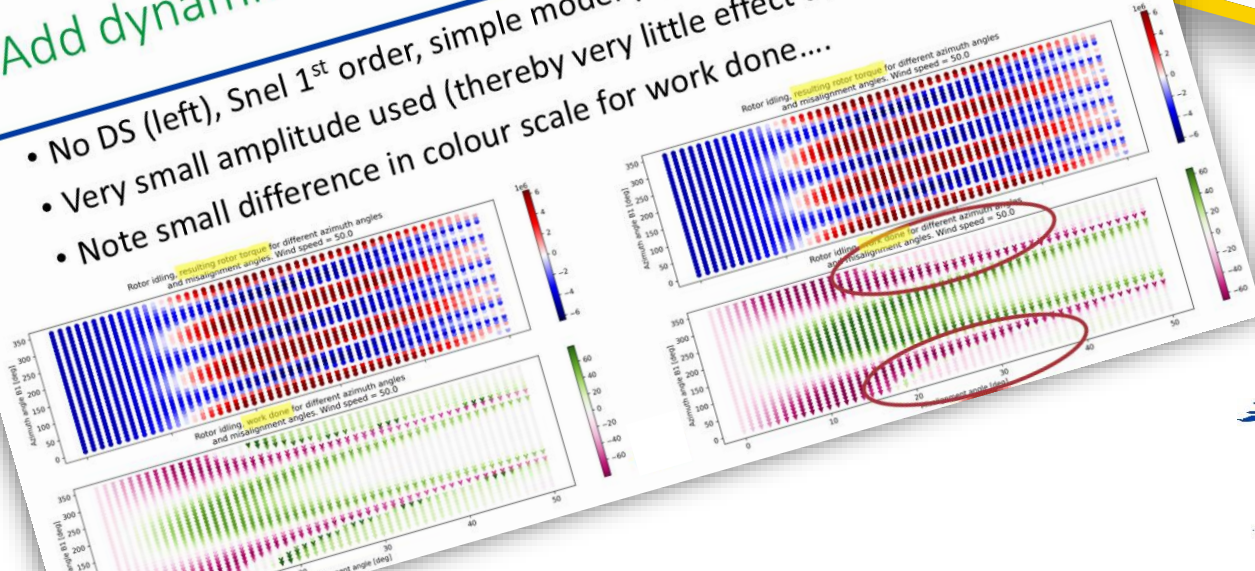
$$\cos(a)\sin(b) = 0.5(\cos(a-b) - \cos(a+b))$$

$$\cos(a)\cos(b) = 0.5(\cos(a+b) + \cos(a-b))$$



Add dynamic stall and smaller steps in yaw

- No DS (left), Snel 1st order, simple model (right)
- Very small amplitude used (thereby very little effect of DS)
- Note small difference in colour scale for work done....



Course content

- The workshop content is based on many years of knowledge and experience in aeroelastic analyses and research
- All the experience in teaching courses to students as well as to professionals has been used to continuously improve material and methodology
- The focus of the entire workshop is on how to evaluate a wind turbine design from an aeroelastic point of view. Are there any possible instabilities that should be prevented, is the classical flutter speed high enough. And how can any issues be improved.
- The course **DOES NOT** concern how to perform certification calculations. Rain flow count will not be discussed, ultimate loads will not be addressed. It really concerns evaluating possible resonances and instabilities and understanding what is happening on a wind turbine from an aeroelastic point of view.



Who should participate?

- The wind turbine aeroelasticity workshop is designed for engineers that already have some experience in wind energy, specifically wind turbine design or wind turbine loads. They should also have already followed the aeroelasticity course provided by JEHO BV or have gained understanding of wind turbine aeroelastic phenomena.
- Basic knowledge of aerodynamics, dynamics and wind energy is expected
- The participants should have a laptop at their disposal

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Who will give the course?

- Dr. ir. Jessica Holierhoek has well over 20 years of experience in wind turbine aeroelasticity, focussing on instability and resonance.
- Currently managing director of JEHO BV specialising in bringing this knowledge to the industry.
- Experience gained at Delft University of Technology (including PhD), at ECN and of course as director of JEHO BV
- Experience in research, tool development and teaching/training

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Two options

- We provide this workshop in two different ways:
 - OPEN session: for all engineers, so engineers from different companies come and take part in the course or workshop. For the aeroelastic courses a ready model can be supplied, though it is also possible for the engineers can work on their own design, nothing will be shared with other participants
 - PRIVATE: organised for one company only. In this case the expert can provide more support in the analysis of the companies own design and discuss it more easily. It is also possible to add a certain focus to the course based on current issues relevant for the company.



Tools

- Tools that are used in the workshop:
 - Either your own licensed tool (e.g. Bladed, FOCUS Phatas,...)
 - Or the open-source tool OpenFAST or FAST from NREL can be used
- Some open-source tools / free tools will also be required and some recommended, all tools or links to these tools and will be provided well before the course

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Costs for different options (2025)

- OPEN introduction to wind energy course on-line (2 * 4 hours), including lunch: €600 per person (not yet scheduled)
- OPEN Live web training aeroelasticity (six sessions, max 6 participants): €2040 per person ([schedule](#))
- PRIVATE Live web training aeroelasticity (six/eight sessions, max 8 participants): €8150¹
- OPEN Live web workshop aeroelasticity (4 * 4 hours): € 1450 per person (not yet scheduled)
- PRIVATE Live web workshop aeroelasticity for a max 6 participants: € 6800
- Evaluation training, costs depend on your requirements

All prices mentioned are excluding VAT and possible other taxes (e.g. withholding tax). Please contact us if you would like to receive a personal offer for any of these products.

¹ If you would like all participants to pass a test at the end of the training, to check if they have actively and effectively participated, we can provide individual (unique) final tests at €75 each



Wind Turbine Aeroelasticity Workshop



WT aeroelasticity workshop set-up

Part 1

- Summary of the wind turbine aeroelasticity course
- Perform aeroelastic evaluation
 - Normal operating conditions
 - Idling
 - Classical flutter
- Look at results: see any issues?

Part 2

- Recap post-processing from course
- Further post process results
- Issues found? Solve the issue, based on knowledge gained
- No issue found, create an issue
- Do you have a resonance issue and/or instability?

Throughout the days theory will be explained, what can you find, how you can post-process, how to find the cause and then the solution



WT aeroelasticity workshop set-up

- These four sessions will be filled with perform all types of analyses and looking at these results.
- Then trying to explain these results.
- And decide if you need additional simulations to find out if there is a possible problem or to find out what the cause of the problem is
- Depending on confidentiality of your calculations, the trainer will discuss the situation in the group or in private.
- Theory discussed in the 6-sessions course will be repeated using practical examples.
- During the workshop you can really get some experience in how to perform an aeroelastic evaluation.





Aeroelasticity training overview



Wind turbine aeroelasticity

- Wind turbines are flexible structures that have a strong interaction between elasticity and aerodynamics
- Therefore aeroelastic instabilities and resonance problems are a real risk
- This is often underestimated, until it happens
- The quickest way to get familiar with the risk, to gain knowledge of the most likely issues and how to prevent them, we provide several specialist courses/activities in this field.



JEHO training: a complete route

- Based on years of experience in wind turbine aeroelasticity as well as providing courses and workshops to the industry, we have set up a complete set of educational activities to effectively train wind turbine design engineers in finding and solving aeroelastic issues
- **The first step is a course of six sessions.** Then, preferably after a few months, this is followed by a workshop of four sessions. Finally during an evaluation training we can perform a full aeroelastic evaluation in close cooperation which will provide significant experience.
- All courses will always be for small groups (no more than 8 participants) to enable good interaction.
- When designing a new wind turbine (blade) a complete aeroelastic evaluation is an absolute must, to prevent many problems that are often not found until the prototype tests are performed.



JEHO Training programme

Wind turbine aeroelasticity (6 sessions)

Introduction course

6 sessions of intensive LIVE web training for 4 hours

Theory and practise are treated

Also possible to arrange confidential course for your company

The main issues are discussed: types of instabilities, their causes, their solutions as well as resonance issues

Participants will get hands on experience to identify some of the issues presented

Workshop (4 sessions)

Continuation of the initial course

Analyse your own turbine design to find possible issues

Or in an open setting an adjusted public design is evaluated

Step by step it is explained how issues can be found, identified and solved

A perfect course for people that have participated in the WT aeroelasticity course and want to refresh and extend their knowledge

Evaluation training ($\approx$ 4 weeks)

We cooperate with one or more of your engineers and perform a complete aeroelastic evaluation of the design.

The engineers will gain significant experience and the design is checked for possible resonance and stability issues



Wind turbine aeroelasticity course

- A four-hour course or 6 four hour sessions for the LIVE web training
- Start with the relevant aerodynamics, this includes a discussion of engineering models that are included in many codes, how do they work, are there possible issues with these.
- The whirling of wind turbines will be explained, why does the frequency change its value when measured in rotating frame compared to fixed frame?
- Wind turbine aeroelasticity issues such as resonance and instabilities will be explained, covering all instabilities and resonances currently known to be relevant
- In several interactive sessions participants will try to find and identify issues as well as solve them efficiently by changing design
- Participants will become aware of possible issues, how to find issues and how to solve them
- This can result in significant load reductions as well as preventing loss of prototypes.



Workshop

- A 4 sessions workshop
- Wind turbine aeroelasticity issues such as resonance and instabilities will be explained
- Your own wind turbine design can be analysed by the participants under the supervision of an expert
- Participants will become able to find issues and increase their capabilities on identifying the causes. This will allow them to find out how to solve them
- This can result in significant load reductions as well as preventing loss of prototypes.



Evaluation training ($\approx$ 4 weeks)

- Together with one or a few engineers, a full aeroelastic evaluation of your wind turbine design will be performed
- The engineers will learn by closely following the process and by actually helping during the evaluation. At the same time your design will be evaluated and the results presented by JEHO BV in a report or presentation.
- Performing a full aeroelastic analysis of a wind turbine is a typical job that actually requires many years of experience, however by following the process closely, your engineers will become more and more able to do at least large parts of the evaluation themselves.
- JEHO BV also provides the service of performing a full aeroelastic evaluation, please contact us for more information or look on our website: www.jeho.nl



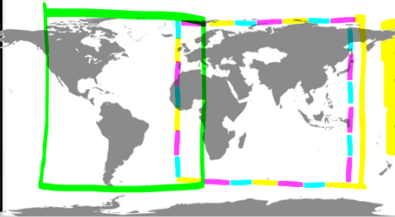
Schedule 2025 open courses ON-LINE

Online live web training sessions **wind turbine aeroelasticity course**. Small groups of participants, allowing pleasant interaction between instructor and participants.

Six times, each week a four-hour training session or eight times twice a week a three-hour training.

Scheduled training times are suitable for different locations, as indicated in the world map

February						
M	T	W	T	F	S	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28		



8x3 hours: Mondays & Thursdays in February
Time: 9-12 CET

April						
M	T	W	T	F	S	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

May						
M	T	W	T	F	S	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

6x4 hours: Tuesdays April 15 – May 20
Time: 18-22 CEST

September						
M	T	W	T	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

October						
M	T	W	T	F	S	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

6x4 hours: Thursdays
September 25 – October 30
Time: 9-13 CEST (Sep 25-Oct 23) & 9-13 CET (Oct 30)

November						
M	T	W	T	F	S	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

December						
M	T	W	T	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

6x4 hours: Fridays November 14 – December 19
Time: 9-13 CET

Interested in attending?
Contact us: workshop@jeho.nl



Interested?

- If you have any questions or are interested in any of the training options we provide, please get in touch with us: workshop@jeho.nl
- If you want to receive a more detailed description of any of the other training products at offer, please contact us and we can send you a presentation for that specific product: workshop@jeho.nl
- If you are interested in our other services, please do not hesitate to contact us with your questions: info@jeho.nl



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