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Dedicated to innovation in aerospace

The challenges of helicopter operations near wind turbines

HeliTech 2016, Richard Bakker, 13 October 2016

Overview

An introduction

The issues from a helicopter operators viewpoint

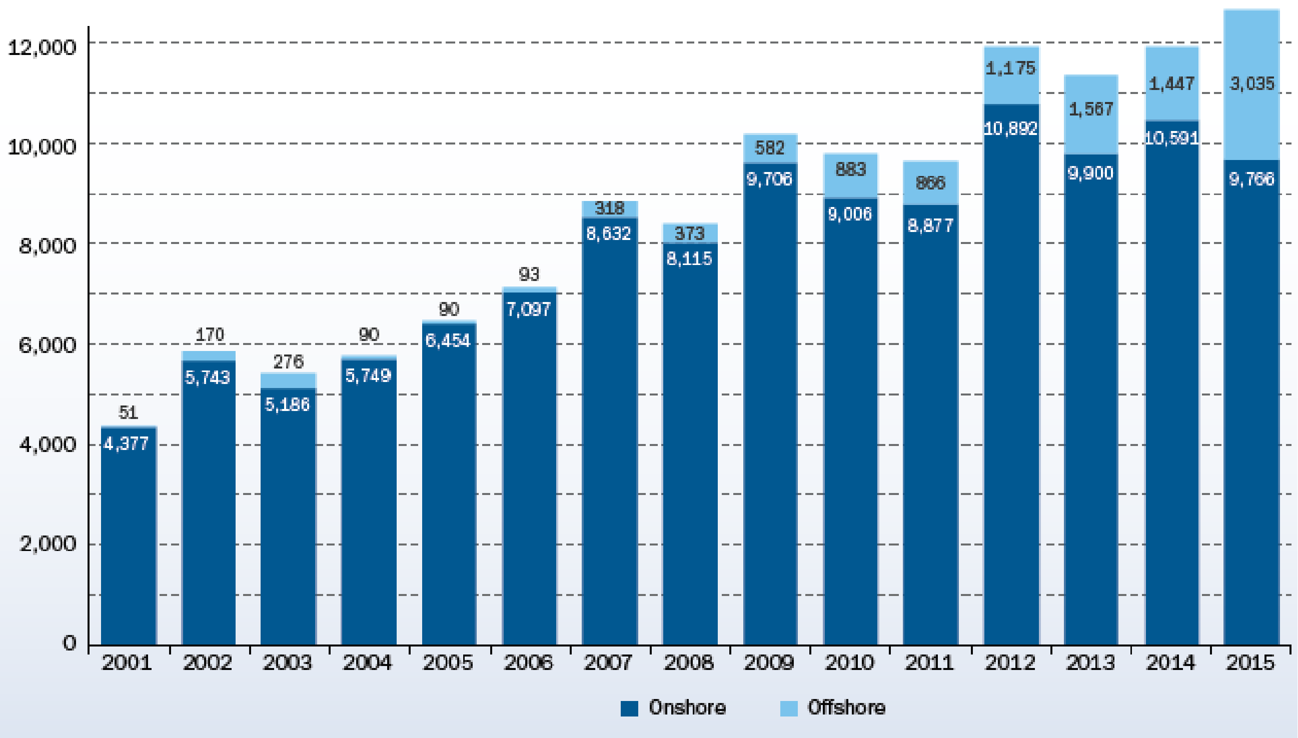
The physical phenomena of a wind turbine wake

Recent research activities and some preliminary results

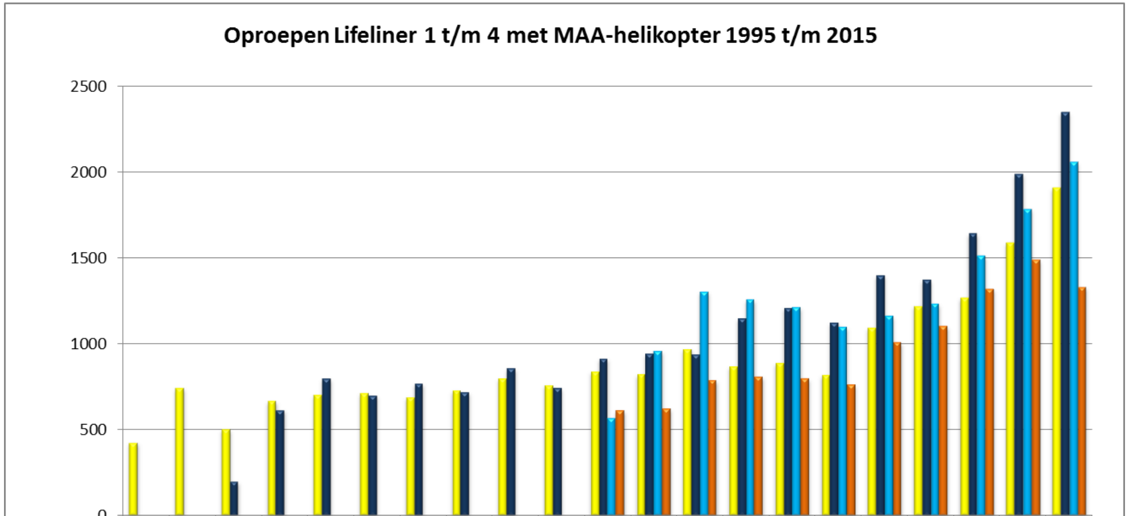
Conclusions and outlook

Introduction

- New wind power installations in Europe by end of 2015
  - *Source: EWEA, European Wind Energy Association, Wind in Power, 2015 European statistics, February 2016*
- *Offshore* and *Onshore*



- Air medical services have expanded
- Police forces increasingly employ helicopters
- Fire fighting operations and military low flying exercises.
- Wind energy park operation & maintenance increasingly dependent on helicopter aerial support



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Lifeliner 1	428	746	506	669	704	715	691	731	802	763	843	824	972	870	892	821	1096	1223	1270	1591	1909
Lifeliner 2			201	618	800	703	772	721	859	747	918	945	939	1151	1213	1126	1400	1373	1644	1991	2349
Lifeliner 3											571	961	1306	1260	1214	1100	1164	1235	1513	1787	2059
Lifeliner 4											614	626	790	811	800	765	1010	1104	1322	1490	1333

- During period October through March 2011-2012 **offshore wind turbines in** some areas of the North Sea were **not accessible by vessels 49 percent of the time**

- General consensus in the offshore wind energy sector industry is that **support to wind farms is best conducted by a mix of maritime vessel transfer and helicopter hoist operations**

- Deciding factor for maritime/aerial service is dependent on task and weather i.e. wave height and weather limitations

- CAP 764, CAA Policy and Guidelines on Wind Turbines
  - *“The physical characteristics of wind turbines, coupled with the size and siting of the developments, can result in effects that can have a* ***negative impact on aviation****”*
  - *“The CAA is currently* ***investigating the effects of wind turbine wakes on aircraft****.“*
  - *Identified physical effects*
    - *Obstructions; the generation of unwanted returns on Primary Surveillance Radar (PSR)*
    - *Adverse affects on the overall performance of communication, navigation, and surveillance (CNS) equipment*
    - ***Turbulence***

- Eurocontrol and EASA indicate execution of a Flight Operational Safety Assessment (FOSA)
  - “*if the application of the default procedure design criteria is in an* ***operating environment with special challenges*** *or demands*.”

FOSA, NLR experience

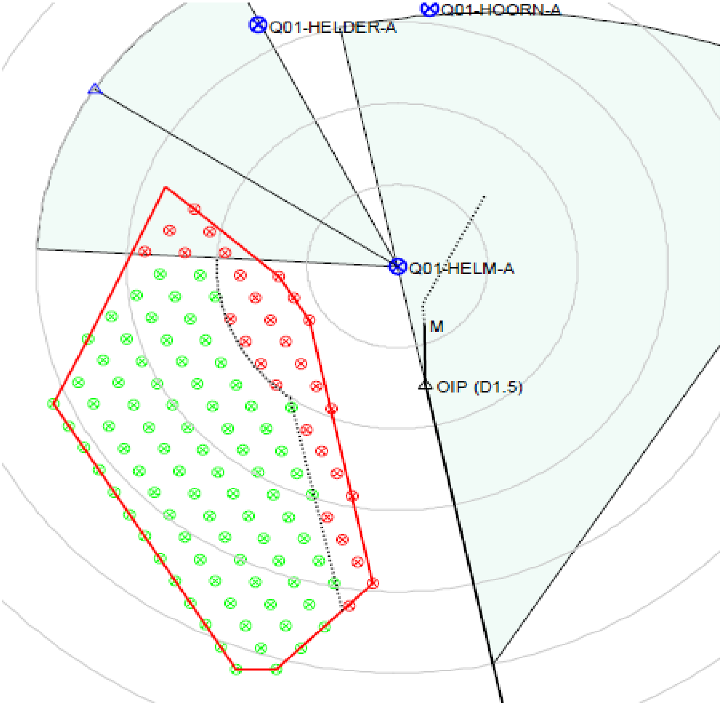
Risk analyses carried out for wind turbine placements near
- Airport Teuge (NL)
- Airport Oostende-Brugge (B), Airport Limburg Sint-Truiden (B)

Obstacle clearance, determined by geometric planes/cones, **well defined (ICAO)**

Wind turbine wake interfering with aircraft at helicopter landing sites and airports causing safety hazards, **no (objective) information available**

Flight Operational Safety Assessment for Airborne Radar Approach and Departure from wind turbine park Q01-HELM-A Helmveld

- Turbine placement affected by lateral distance to approach path
- 5 Nm exclusion zone for obstacles



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Workshop with Helicopter Operators operating at the North Sea (2014)

Challenges of helicopter operations and offshore wind energy

- 4 Operators operating at the North Sea

- 3 Themes
  - Influence of wind turbine wake on helicopter operations
  - Helicopter hoist operations peculiarities
  - Regulations

CHC

schreiner

NHV

DanCopter

What are the Challenges of helicopter operations and offshore wind energy?

Operating above the North sea means 4 National authorities requiring 4 Aircraft Operator Certificates. On top of that there are procedures per operator, per OEM and per helicopter type. **Need for standard procedures**.

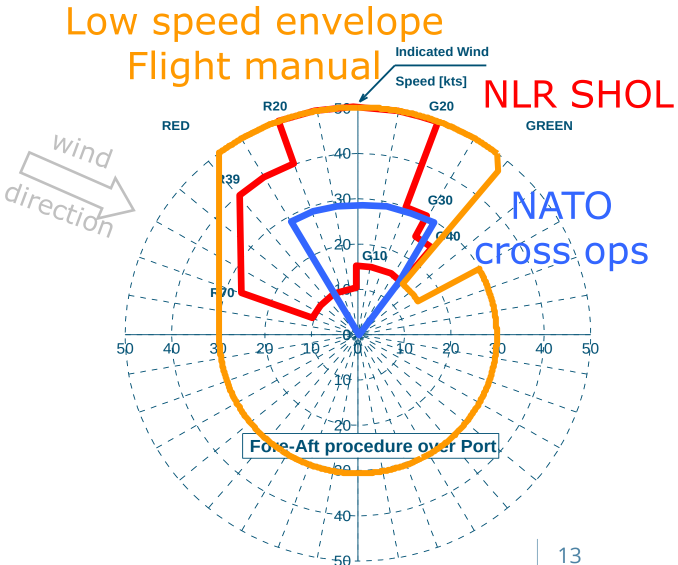
Regulations have been **stricter** after a number of accidents. Large consequences for commercial flight. CAA-UK directives **CAP 1145**; less passengers, no operations allowed at relatively low sea states (<4).

CAP 1145 Civil Aviation Authority – Safety review of offshore public transport helicopter operations in support of the exploitation of oil and gas

- Operations be **prohibited** when the helicopter is operating to/from **exceed sea state 6**.
- Operations be **prohibited** when the helicopter is operating to/from **exceed the certificated ditching performance** of the helicopter.
- Helicopter operators' operating procedures will **require the EFS to be armed** for all overwater departures and arrivals.
- All offshore helicopter operations **only passenger seats adjacent to pushout window** emergency exits **are to be occupied**. This restriction will not apply when either:
  - i) EBS meeting CAP 1034 Category 'A' performance specification is worn by all passengers; or
  - ii) side-floating EFS is fitted.
- With effect from 01 April 2016; Helicopter operators are to ensure that for all offshore helicopter operations **all occupants (passengers and crew) wear EBS** that meets the CAP 1034 Category 'A' performance specification. This restriction will not apply when the helicopter is equipped with side-floating EFS.

Flight training ‘near deck operations’ is not representatively modelled in training simulators for a oil/gas- and wind turbine platform landing, not realistic. Most simulators have slow visuals (high speed turn)

Limits for operating in a oil/gas platform wake are based on (subjective) experience. The platform manager provides tables that are created and updated by pilot feedback and FDM information. Data is shared by operators and platform owner



Operators are in need of objective data regarding wind turbine wake interference. Engine failure during hoisting on wind turbines could cause the helicopter to end up near the wake of the upstream wind turbine. It is not clear what distance should be advised to keep away from wind turbine wakes. Also wind turbine wake crossings during approach is regarded an issue

With regard to location of wind turbine parks near oil/gas installations the **operators**, taking into account current day navigation device capabilities, **question if the safe distance between the two should be discussed**

- CAP 764, CAA ‘Policy and Guidelines on Wind Turbines’ on wind turbine wake turbulence:

  - *“A thorough* ***literature survey would be necessary*** *to establish the scale and the advances of the research findings.”*

  - *“It is recognised that* ***aircraft wake vortices can be hazardous*** *to other aircraft, and that* ***wind turbines produce wakes of similar, but not identical, characteristics to aircraft****.”*

  - *“There are currently no Mandatory Occurrence Reports (MOR) or aircraft accident reports related to wind turbines in the UK. However, the CAA has received anecdotal reports of aircraft encounters with wind turbine wakes representing a* ***wide variety of views as to the significance of the turbulence****.”*

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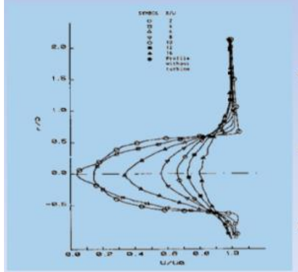
The physical phenomena present in a wind turbine wake

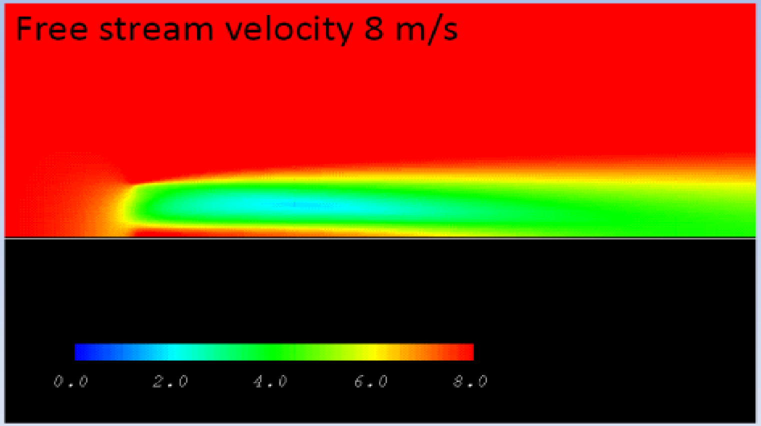
- ***Velocity deficit (contours and profiles*)***
- ***Velocity deficit (versus distance in the wake)***
- *Near wake tip vortices*
- *Far wake turbulence and meandering*



- A plume, almost contained within the diameter of the blades, extends downstream behind the turbine
- velocity is 0.33 times free stream velocity at 6 blade diameters (558/600 m) downstream
- velocity is 0.55 times free stream velocity at 10 blade diameters (930/1200 m) downstream
- velocity is 0.63 times free stream velocity at 16 blade diameters (1488/1920 m) downstream

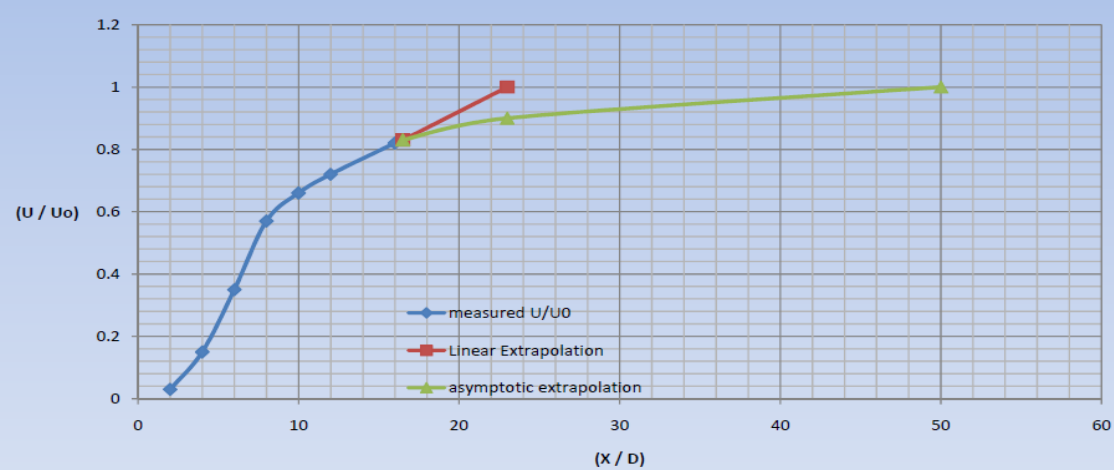
Hand M et al – Ref 4.

Turbine Wake



From M Pawlka and F Richert – ref. 1

Velocity change versus axial distance from wind tunnel measurements



*Ralph Holland, B Sc., Dip Ed., Dip. Com. Sc., ACT Australia. Nov 2009

The physical phenomena present in a wind turbine wake

- ***Near wake tip vortices***

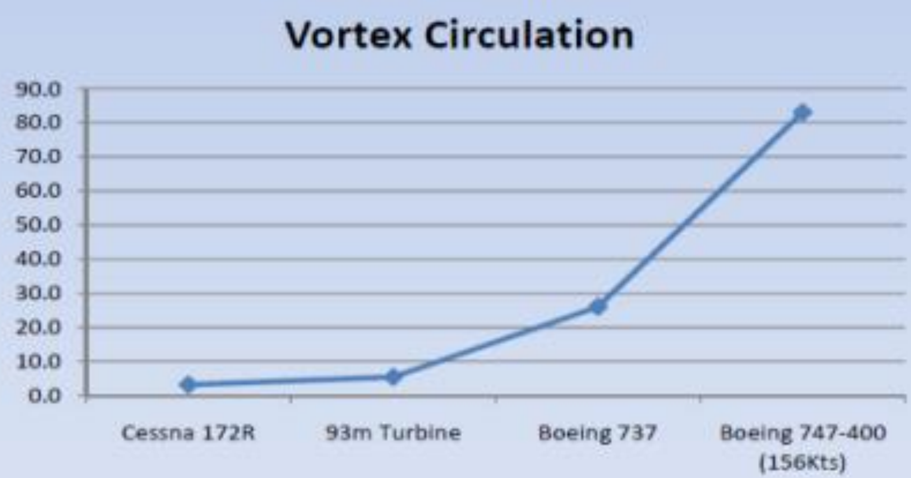
$$\text{Vortex Circulation} = 4L/(\pi \rho b V)$$

(Ref. 6)

where

- L = lift (kg)
- ρ = air density (kg / m^3)
- b = wingspan (m)
- V = speed (m/s)

Examples	Vortex Circulation
Cessna 172R	3.1
93m Turbine	5.4
Boeing 737	26.0
Boeing 747-400 (156Kts)	83.0

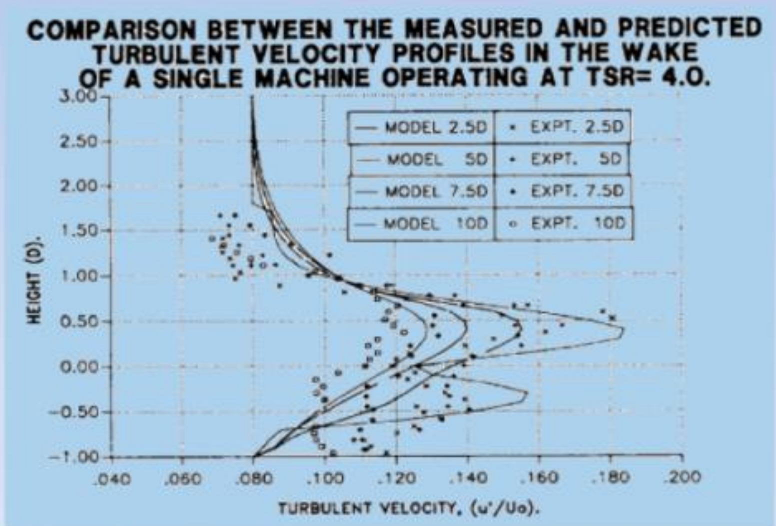


The physical phenomena present in a wind turbine wake

- ***Far wake turbulence and meandering***

Turbulence

- The wake turbulence is generated as a side-effect of the rotation and power.
- The wake turbulence at 10 blade diameters downstream is 12% of the velocity at that point (variation of 12% in wind speed @ 930/1200 m)



Hand M et al. – Ref 4

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Garteur Action Group 23
Wind turbine wake and helicopter operations

Partners

– **CIRA**	(Italy)
– **DLR**	(Germany)
– **ONERA**	(France)
– **NLR**	(Netherlands)
– **PoliTecnico di Milano**	(Italy)
– **Technical University of Munich**	(Germany)
– **Technical University Delft**	(Netherlands)
– **University of Liverpool/Glasgow**	(United Kingdom)
– **National Technical University of Athens**	(Greece)

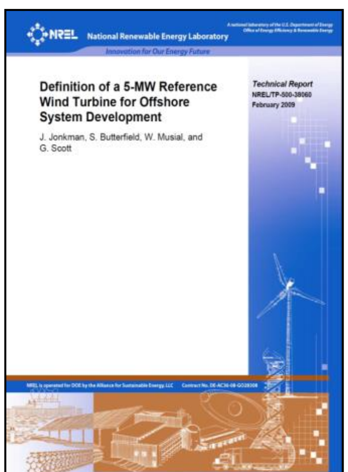
AG23 Objectives

- To understand the **behaviour of helicopters in a wind turbine wake**
- To **identify the safety hazards** of helicopter wind turbine wake encounters
- To define the measures to **mitigate the identified safety issues**
- **Dissemination** of the findings to the appropriate authorities and parties concerned

AG23 Activities

Wind turbine wake identification

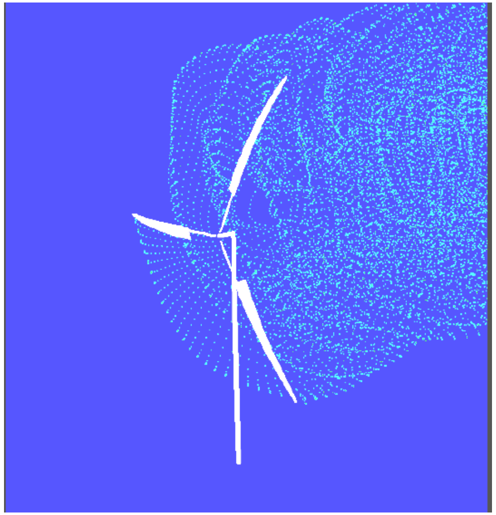
- To perform a survey for available experimental and analytical (engineering) or CFD methods to determine velocity fields of single and multiple wind turbine(s)
- To identify shortcomings/omissions in available data bases for wind turbine wakes
- To analyse the wake data to classify wind turbine wakes and generate a reference wake
- To identify the flow phenomena in a wind turbine wake relevant to helicopter operations.

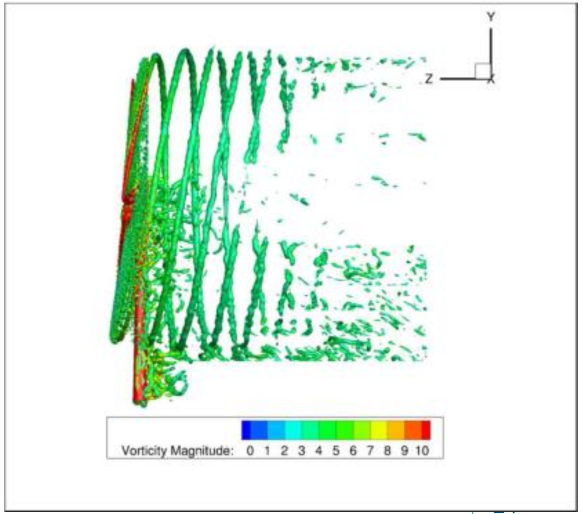


AG23 Activities

Wind turbine wake substantiation by experiments; generation of additional indispensable data

- To substantiate wake data by means of experiments or computations
- To define test cases and perform a wind tunnel or full scale experiment
- To define test cases and perform computations of a wind turbine wake
- To process and analyse the data

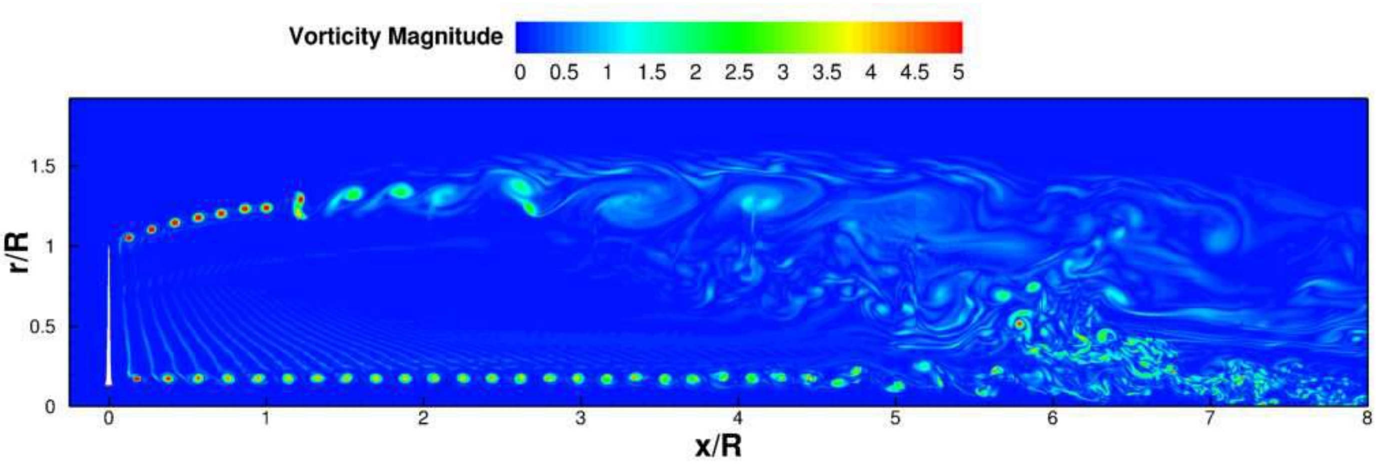




AG23 Activities

Theoretical/computational analyses and off-line simulations

- To define test cases for helicopter-wake offline simulations
- To define the reference wind turbine wake and reference helicopter
- To perform the simulations
- To study rotor wake – turbine wake interaction



AG23 Activities

Piloted simulations

- To define test cases for the piloted simulations
- To define objective criteria for handling qualities assessments
- To prepare representative and manageable wake velocity fields to be used in piloted simulations
- To perform piloted simulations



AG23 Activities

Dissemination

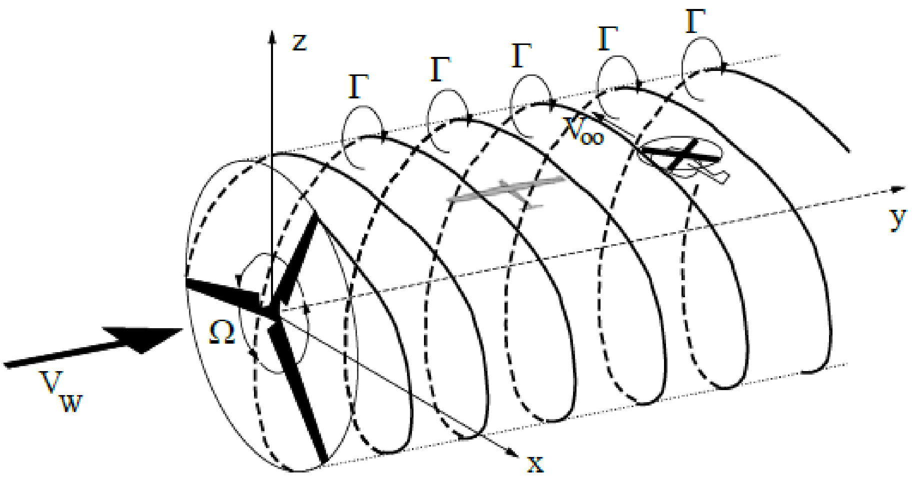
- To provide a set of guidelines/rules
- To provide recommendations for legislation
- To disseminate the findings to the appropriate authorities and parties concerned

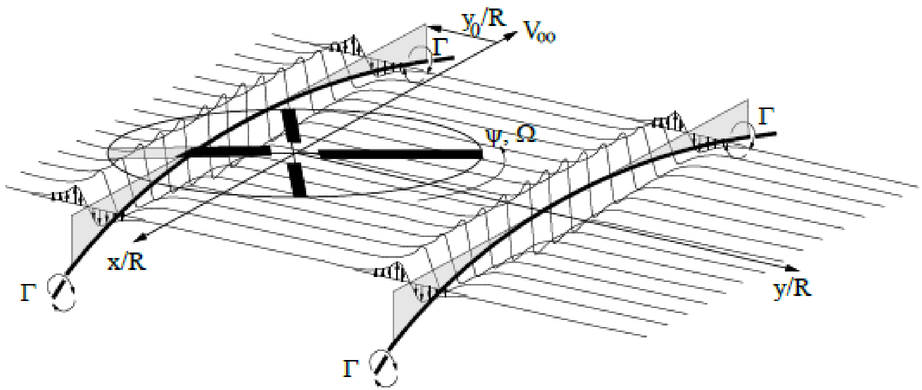
Preliminary results a wind turbine wake - helicopter encounter

Impact of Wind Energy Rotor Wakes on Fixed-Wing Aircraft and Helicopters

Berend G. van der Wall, Dietrich Fischenberg, Paul H. Lehmann, Lennert B. van der Wall, DLR, Germany

Presented at the European Rotorcraft Forum (ERF) 2016.





Main results of the investigation

- At 100m distance to a 3MW turbine a sailplane flying at 17m/s, crossing the upper layer of the wind turbine wake, would become uncontrollable due to the vortex induced roll moments that cannot be compensated by the controls
- A BO105 size helicopter near hover speed, only needed 20 / 15% (theoretical / simulation method) of max control power to counteract the vortex induced roll moment
- Further investigations should focus on all helicopter components (not only rotor) and to flight dynamics response when entering or leaving the wind turbine wake spiral, at different speeds

Conclusion and Outlook

- Wind energy production facilities and aviation ‘share the sky’ with, in some cases, conflicting interests

- The awareness, the concern and importance of wind turbine wake – helicopter encounters, is increasing with governmental agencies, the regulators, energy companies and operators

- Dedicated research programs to investigate aerodynamic wake interference for fixed-wing and rotorcraft, have been initiated in the past and have recently started to address the safety issues of wind turbine wake – helicopter interaction

- Outcomes of the research programs will contribute to the efficiency of operation and maintenance of (wind) energy production facilities while at the same time preserve and improve relevant safety issues for helicopter operations

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Fully engaged

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