Master Event 2020
Aerodynamics & Wind Energy
09-03-20
Track and profile coordinators

Sander van Zuijlen
Track coordinator
Aerodynamics & Wind Energy

Sander van Zuijlen
Profile coordinator Aerodynamics

Wim Bierbooms
Profile coordinator Wind Energy
Outline

- Track overview
- MSc program structure
- Aerodynamics profile
- Wind Energy profile
Track overview

**Goals:**
- To advance your knowledge of aerodynamics and wind energy
- To strengthen your fundamental analysis skills
- To increase your industrial experience
- To develop your ability to carry out independent research

**Means:**
1) Specialist courses
2) Internship
3) Literature study and final thesis project
MSc program structure

- General courses
- Core courses
- Profile courses
- Electives
- Literature Study
- Thesis

Time:
- 0
- 60 EC
- 1
- 60 EC
- 2
MSc program structure

- General courses
- Core courses
- Profile courses
- Electives
- Literature Study
- Thesis

Time: 0 - 60 EC - 1 - 60 EC - 2
MSc program

Composition

- General courses
- Core courses
- Profile courses
- Electives
- Projects

Same for both profiles

Depends on chosen profile

Your choice!

Internship, literature study, thesis
For both Aero and WE profiles – 15 EC
Includes two courses mandatory for all tracks

Course list:
• *Viscous flows*
• *CFD for aerospace engineers*
• *Rotor/wake aerodynamics*
• *Ethics and engineering for aerospace engineering*
• *Research methodologies*
Profile courses

Aerodynamics profile (17 EC):
• Experimental simulations
• Aircraft aerodynamics
• Partial differential equations A
• Gas dynamics
• Flow measurement techniques
• CFD2: discretization techniques

Wind Energy profile (16 EC):
• Site conditions for wind turbine design
• Airborne wind energy
• Wind turbine design
• Aeroelasticity
• Wind turbine aeroelasticity
These courses start in Q1; so use the coming months to determine which profile you would like to choose.

Aerodynamics profile (17 EC):
- Experimental simulations
- Aircraft aerodynamics
- Partial differential equations A
- Gas dynamics
- Flow measurement techniques
- CFD2: discretization techniques

Wind Energy profile (16 EC):
- Site conditions for wind turbine design
- Airborne wind energy
- Wind turbine design
- Aeroelasticity
- Wind turbine aeroelasticity
Must be approved by profile coordinator*

How to choose electives?
• consider the topics you like most from your BSc
• consider possible thesis topics
• discuss with teachers / fellow students
• look at information on study guide (studyguide.tudelft.nl)
increase your industrial experience
Same topic/supervisor as final thesis
It is convenient in case you do research methodologies in parallel
• Pursues a scientific research question
• The student is responsible for the planning and execution of the project; so you are in charge!
• Should be suitable for conference/journal publication
• Result to be defended in public, and in front of expert committee
• All practical issues: Student Portal!
• All practical issues: Student Portal!
• You are free to choose which group you will graduate from
• Some projects, however, will have a preference for students with a certain course profile
Choosing a topic and supervisor

- Consult each group's web site for a description of research areas
- Consult the group's MSc project descriptions (Brightspace/web)
- Consider the topics you like most from courses
- Discuss with fellow students (also from previous year)
- Make appointments with the supervisors associated with the areas of interest to you (any time in the year)
- Projects are also available in industry. In this case you still need to find a TU Delft supervisor to monitor the work
Some differences between BSc and MSc

From the study guide: “On completing the Graduation Project, the student should be able to:

- Demonstrate that they are capable to independently apply relevant theory and/or knowledge to research and/or design”

In order to prepare you also during the MSc courses you will have more responsibility:

- you will have more freedom / have to do the planning yourself
- for BSc courses it is precisely defined what you should read and what kind of exercises you should be able to do in order to pass the exam; for MSc courses this relation becomes less strict.
Aerodynamics & Wind Energy

Profile 1: Aerodynamics

Sander van Zuijlen

09-03-20
Aerodynamics Research Group – Mission

To understand, model, predict and control aerodynamic flows

Products:

- New experimental techniques
- New computational techniques
- New analytic techniques
- New actuation systems
Aerodynamics Profile – Courses

A deeper understanding of physics and tools

- PDE A – a basis for analysis
- Gas Dynamics – waves, characteristics, nonlinearities
- Aircraft Aerodynamics – transition, turbulence, separation
- CFD 1, 2 – discretization methods, turbulence
- Flow Measurement Techniques – laser, refractive, infrared, PIV
- Experimental Simulation – design of effective campaigns
Aerodynamics Profile – Research

- 12 scientific staff + 25 PhD/postdoc
- 10 Wind tunnels, from low speed to Mach 11
- 3000 core computer cluster
- Innovation in measurement and computation

⇒ Will show (only some) of the research areas an MSc can work in
Pushing the limits of measurement

- PIV: Multiple high-rate images
- Optimal path reconstruction given experimental uncertainties
- Navier-Stokes equations + statistical modelling tools
Computing with minimum effort

• **Mimetic Methods**: Preserve topological relations *exactly*
• **Fluid-Structure Interaction**: Efficient treatment of deforming domains, strong coupling
Computing with detail

- Adaptive large-scale simulations: compressible and two-phase turbulent flows
- Multiscale Methods: Goal-oriented optimal representations of what we cannot compute
Combining experiment and computation

- **Data Assimilation**: Optimal predictions for given experimental and computational uncertainties
- **Model development**: What is most informed by a dataset?
Plasma flow control

- DBD: 10 kV, ≈ 100 Hz or 3ns rise, 12 ns length
- Plasma/ionic wind, localized heating, shocks
- Transition control or forcing
- Non-intrusive and low energy use
Micro ramp separation control

- Shock and reflection induce separation
- Control obtained using microramps within boundary layer
- Mechanisms unknown: high-speed PIV + LES
Space related research topics

Launcher aerodynamics

Investigation of the external flow
- Baseflow nozzle plume interaction
- Flow separation downstream of hammerhead launcher fairing

Internal flows
- effect of nozzle wall roughness on heat transfer
- investigation of fluid structure interaction on flexible thin walled nozzles

PIV on Ariane 5 baseflow

Rough nozzle wall heat transfer

Baseflow – plume interaction
Space related research topics

Re-entry aerodynamics

Attitude control
- Compression ramp flows
- Jet in cross flow

Aerodynamic heating
- Roughness induced boundary layer transition

Capsule aerodynamics
Space related research topics

High speed propulsion systems

Intake flows
- Flow control of shock wave boundary layer interactions,
- Dynamics of shock – shock interactions
- Submerged scramjet intakes

Combustion chamber flow
- Jet in cross flow

Shockwave boundary layer interaction flow control

Submerged SCRAMjet intake

Jet in cross flow
Aerodynamics: Closing Note

- More research areas than mentioned to be found on Brightspace “MSc AE Profile Aerodynamics”
- MSc projects within industrial partners also available
- Diverse job prospectives
Aerodynamics & Wind Energy

Profile 2: Wind energy

Wim Bierbooms

09-03-20
MSc Aerospace Engineering
Track: Aerodynamics and Wind Energy
Profile: Wind Energy

1. Wind Energy Research Group
2. Main R&D topics
3. Profile courses
4. Graduation projects
5. Career prospects
1. Wind Energy Research Group
Wind Energy Research Group - People

Dr. ir. W.A.A.M Bierbooms (Wim)
Profile coordinator

S.M. Willems (Sylvia)
Executive secretary
Wind Energy Research Group - People

Other staff members
2. Main R&D topics
Why wind energy…

- Sustainable source of energy
- Large share in electricity production is feasible
- …

- Mean challenge: reduce costs from 0.16 €/kWh to 0.12 €/kWh (offshore)
  0.05 €/kWh
- Innovative designs needed
Main R&D topics

Wind Energy Research Group

- Rotor aerodynamics
  - Open Jet Facility (OJF).
  - Design and analysis tools

- Wind turbine design
  - Design methodologies (offshore)
  - Reduction of loads
  - Increase availability (reduce O&M)

- Wind conditions

- Kite power

- Aeroacoustics

- Floating wind energy
Main R&D: Open Jet Facility (OJF)
Main R&D: Smart rotor
Main R&D: Wind conditions
Main R&D: Kite power systems

- Reel-out (traction) phase: energy generation
- Reel-in (retraction) phase: energy consumption

Wind
Main R&D: Aeroacoustics
Main R&D: Floating wind energy
3. Profile courses
Please note that none of these courses have the reputation to be (very) difficult.

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4. Graduation projects
Thesis project

Wind Energy Research Group

Track / profile:

• Wind Energy profile
• Aerodynamics profile
• Flight Performance and Propulsion (FPP) track

Supervisors not yet overloaded
When should you choose the wind energy profile?

In case you are good in:
- aerodynamics
- mathematics
- structural analysis
- design
- programming
- reporting
- …

In case you like to combine:
- a challenging thesis topic
  and
- contribution to one of the basic needs of society
Recent thesis topics I

*The turning of kites*
Recent thesis topics II

Vortex Generators

Momentum Equation:
\[
\frac{C_f}{2} = \frac{\partial \theta}{\partial x} + (2 + H) \frac{\theta}{u_e} \frac{\partial u_e}{\partial x}
\]

Energy Equation:
\[
2C_D = \frac{\partial \theta^*}{\partial x} + \left( 3 + \frac{2H^*_x}{H^*} \right) \frac{\theta^*}{u_e} \frac{\partial u_e}{\partial x}
\]

Reference Data

Xfoil Data
Recent thesis topics III

Wind Farm Layout Optimization
Recent thesis topics IV

Floating LiDAR
Thesis project proposals (+finished)

Have a look at our websites

• http://www.lr.tudelft.nl/windenergy (tab Education)

• http://www.kitepower.eu

Contact

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w.a.a.m.bierbooms@tudelft.nl
Room 5.21
Thesis projects at a company

- ECN
- Ecofys
- Vestas
- Siemens
- Actiflow
- Ampyx Power
- Enevate
- TwingTec
- EnerKíte
- Google / Makani Power
- …
5. Career prospects
Career possibilities

• PhD position
  In the framework of EU or national projects

• Research institutes/consultancies
  TNO, Ecofys …

• Industry
  Vestas, Siemens, Vattenfall, Ampyx Power, Kitepower, Google, …
WindEurope
European Wind Energy Association

Macro economic benefits of wind energy under WindEurope’s 2030 scenarios

- Jobs in 2030: 716,000
- Investments to 2030: 351,000 M€
- Avoided CO₂ emissions in 2030: 485 Mt
- Avoided fossil fuel imports in 2030: 16,600 M€
- Share of wind in EU’s electricity demand in 2030:
  - Low scenario: 21.6%
  - Central scenario: 29.6%
  - High scenario: 37.6%
In case of further questions

• drop by at my office: room 5.21 Aerospace Eng.

• or send an e-mail

• be part of it

Europe’s largest green hydrogen project starts in Groningen
Thursday 19 March: Master Drink

You need to register for the Master Drink!


Event:
Date: Thursday 19th of March
Time: 17:45 – 19:30