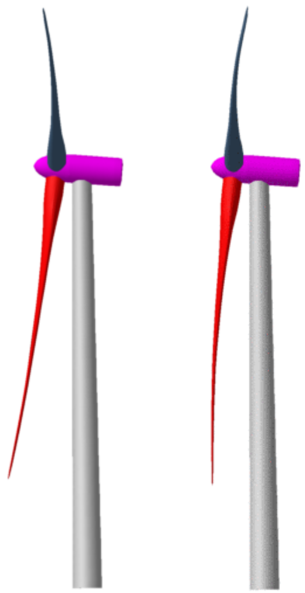
CFD Methodology for Wind Turbines
Fluid-Structure Interaction

- PhD thesis of Dr.-Ing. Sergio González Horcas
- Supervised by Prof. Grégory Coussement

Motivations

- Large **Horizontal Axis Wind Turbines** (HAWTs) rotors significantly **deform** due to **aerodynamic loading**
- Requires **computational methods** coupling air and blade physics: **Fluid-Structure Interaction** (FSI)
- To handle :
  - 3D **complex unsteady flow** structures driven by the Navier-Stokes equations
  - **Strong periodic interactions** between the flexible elastic **structure and the flow**
  - An **accurate analysis** of the risk of modification in the **power performance**
  - With a **reasonable computing cost**



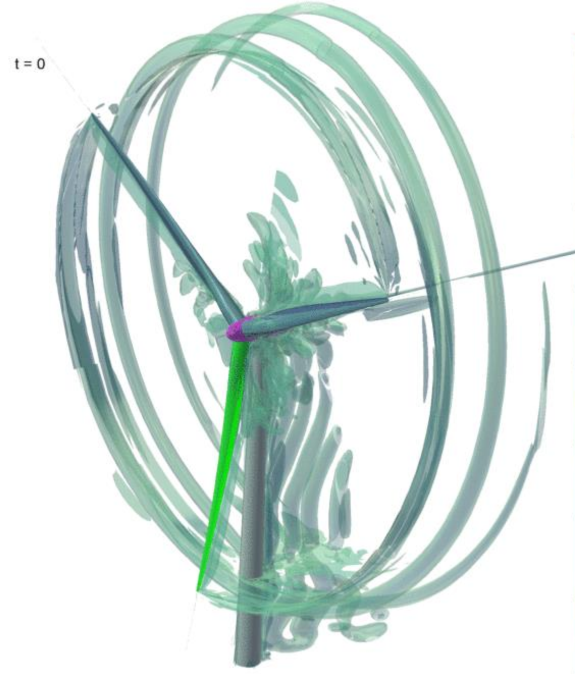
Typical HAWT rotor geometry (PhD results)

Objective and methods

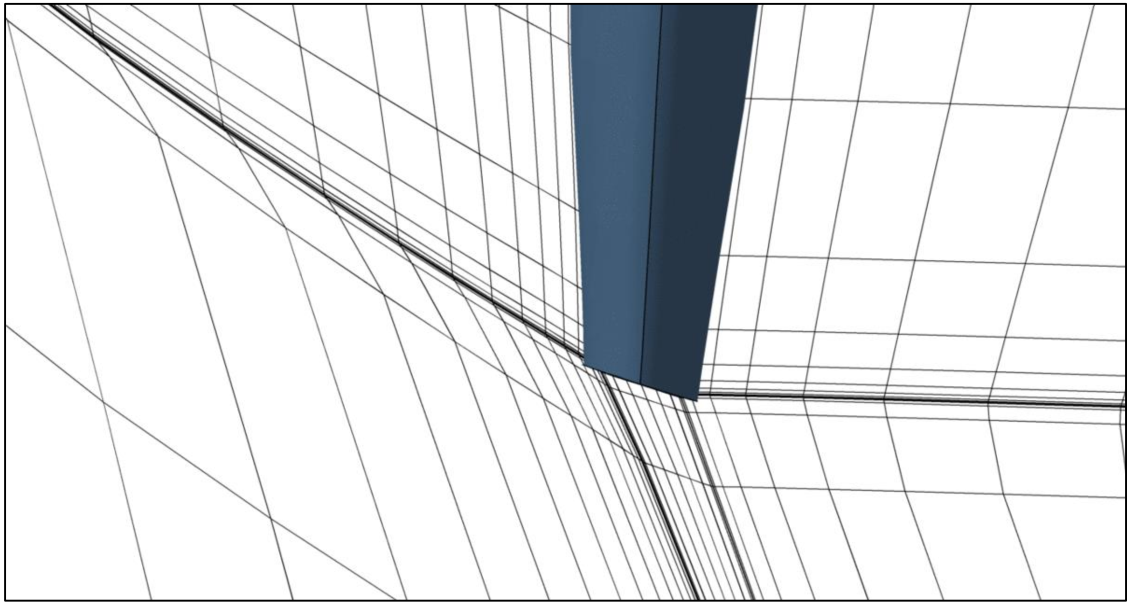
- **Objective**: Development of a **FSI** solution based on **Computational Fluid Dynamics** (CFD) tools
  - ✓ Optimization of the **accuracy and computational cost trade off**
  - ✓ **Unsteady flow** and **structure** solved in the **frequency** domain
  - ✓ **Innovative harmonic FSI coupling** and **mesh deformation** algorithms

Results

- Dynamic aeroelasticity of **whole 10MW HAWT** computed in less than **5 days with 128 Procs**
- **One order of magnitude faster** than traditional **time-marching** CFD (**52 days expected**)



Vorticity of a 10MW HAWT



Detail of harmonic mesh deformation at blade tip