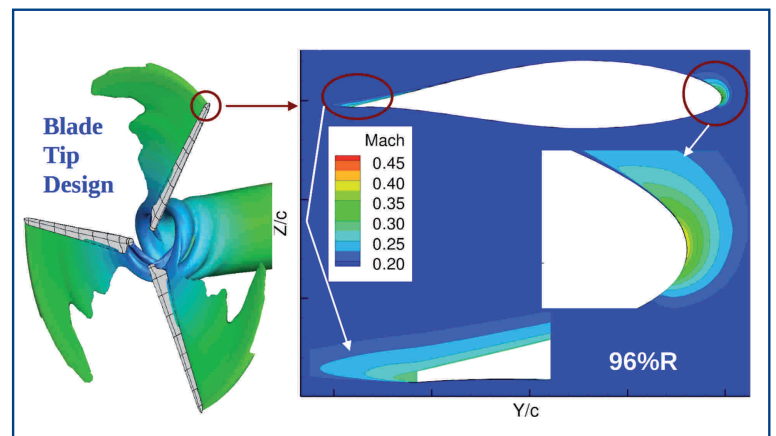




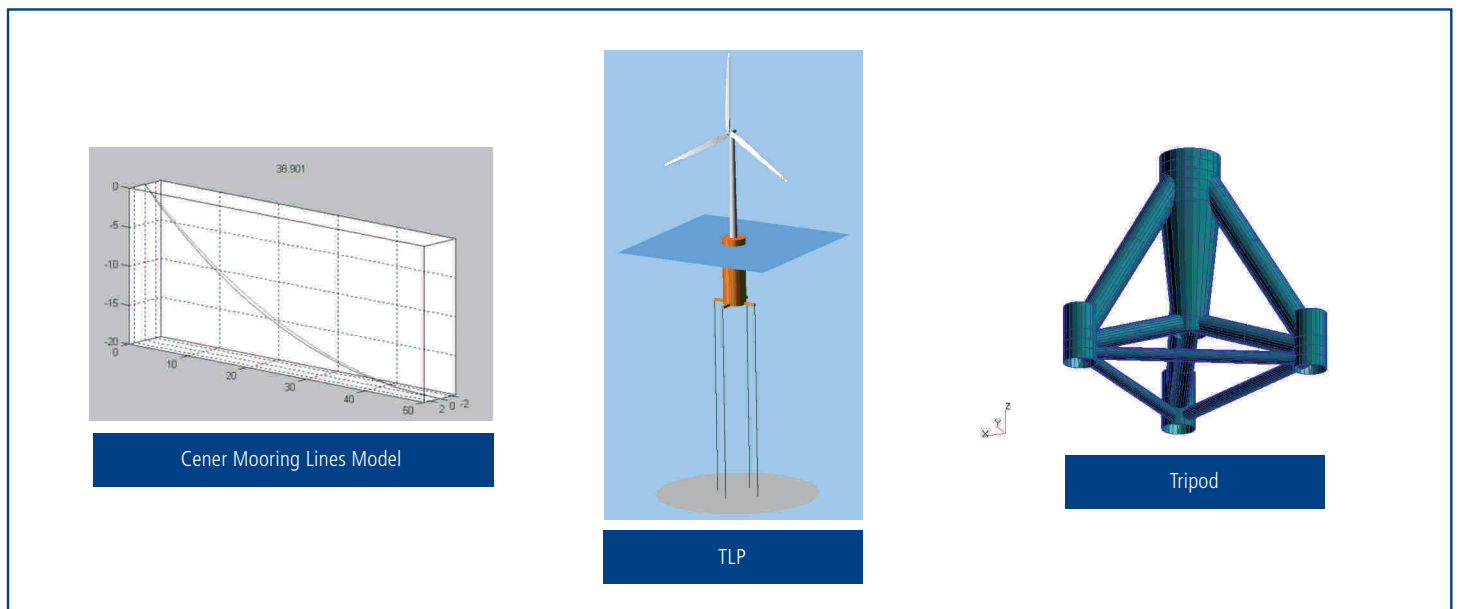
## OFFSHORE CAPABILITIES

Offshore dedicated BEM with support structures and mooring lines, and CFD compressible for high tip speeds rotor blades.

- CENER's compressible CFD method (WMB) is ready for Offshore wind turbines high tip speed influence studies (compressibility).
- CFD hydro applications – further developments of the CFD code to simulate floating structures (ongoing).



### Offshore Wind Turbine Aeroelastic Simulation for Fixed or Floating Platforms with Mooring Lines



- Simulation of dynamics for different offshore concepts, both fixed bottom and floating platforms.
- CENER is developing a code for the dynamic simulation of mooring lines – MoorDyn – This is a FEM based code coupled with FAST.

Offshore wind turbines will not have the same noise restriction than onshore ones have at the moment and in order to increase the extracted energy from wind, the rotational speed could be increased and so increasing tip speeds. Nowadays, onshore wind turbines tip speed are about 0.23Mach (~80m/s, ~280Km/h). Offshore wind turbines tip speed could be higher than 0.3Mach (~100m/s, 365Km/h), and the compressibility effects of the air should be taken into account in their simulation.

The images shown in the front page are part of the IEA Task 29: MexNext project, where CENER is involved. In that project, a small wind turbine was tested at the DNW wind tunnel (9.5 x 9.5m<sup>2</sup>) with a tip speed of 100m/s (~0.3M). It can be seen at the leading and trailing edges of the section extracted at 96%R of the rotor shown, that despite the local Mach number was of 0.3, at suction side, speeds up to 0.4Mach were observed. When the density changes of the fluid are significant (above 5%), as stands the compressibility theory, the compressibility effects should be taken into account in the rotor simulation.

For the year 2014 the issue of modelling water through WMB will be addressed. The code is being modified in order to work more efficiently with low Mach number and then a careful validation campaign will follow.

CENER has a wide experience in simulating dynamics of different offshore concepts, both fixed bottom and floating platforms as spar buoy, TLP, semisubmersible, etc. Coupled effects of aerodynamics, structural dynamics, hydrodynamics, mooring lines and control are considered.

Loads calculated with these simulations provide inputs for the design of components and for certification purposes.

CENER is also working in the development of codes. MoorDyn is a FEM based code for the dynamic simulation of mooring lines, considering contact and friction with the seabed. MoorDyn has been coupled with the FAST code. CENER has also added some new features for offshore applications to the FAST code, in particular for the simulation of semisubmersible platforms.