<u>Abstract: Optimal flight trajectories and Nonlinear control of a tethered kite for ship propulsion under variable wind conditions</u>

PhD student: Monika Pasquali
Supervisors: Patrick Lanusse, Christophe Farges, Tudor-Bogdan Airimitoaie

Laboratory: IMS Laboratory, Talence

Airborne Wind Energy systems (AWEs) are a promising renewable wind power technology. Among these, tethered kites flying lemniscate trajectories, allow to generate auxiliary traction force for ship propulsion, enabling a reduction in fuel consumption.
The path that the kite follows within the flight window directly determines the generated traction. Hence, maximising the average traction force, translates in finding the optimal flight trajectory. In this research, the paths are parametrised through Bernoulli lemniscates and a genetic algorithm optimizer is used to find the optimal one under varying wind conditions, specifically when the angle between the wind and the boat's direction changes. Additionally, the nonlinear system's property of differential flatness has been proved and exploited for the design of a feedforward control. Crucially, the identified flat-output has been designed to take into account real-time variations of the kite's velocity along a periodic trajectory, making it robust to varying wind conditions. This approach led to a reduced tracking error for different sized, oriented and positioned lemniscate trajectories in the flight window, compared to an only-feedback architecture (ranging from a simple Proportional controller to a more complex CRONE - a robust controller which uses fractional order operators).