

## **Understanding Aero- and Hydrodynamics of Sailing**

### **The Key to improve Performance**

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### **ABSTRACT**

The Americas Cup is arguably the pinnacle event in competitive sailing. It was first held in 1851 and it is today the oldest international sports trophy. Teams, engaged in the Americas Cup have always been at the forefront of sailing related research. A deep understanding of aero- and hydrodynamics of sailing, simulation, and automatic optimisation have been key ingredients to successfully compete in the America Cup. The amount of research invested into an Americas Cup yacht is one to two orders of magnitude larger than for any other top level sailing yacht.

In this lecture the basics of the underlying physics of sailing are presented. The physics and evolution of sailing against the wind is described and it is shown how a sailing vessel can move faster than the wind. The importance of raw sail power versus improving the aero- and hydrodynamic gliding angles is discussed. It is demonstrated how the transition from intuition to applied mathematics in the design process has led to yachts, that are able to sail four times the wind speed.

In the second part of the lecture hydrofoils on sailing vessels are discussed. The introduction of hydrofoils over the past two decades has boosted the performance of sailing vessels. Stability and control issues are presented and discussed. On traditional displacement yachts the hydrodynamics have been the limiting factor for performance. Through the introduction of hydrofoils this has changed and it is now the aerodynamics where the biggest gains can be made.

The lecture finishes with a short excursion into static and dynamic performance simulations of sailing vessels and how they can be used in an automated design and optimisation loop.

**Keywords:** Americas Cup, hydrofoils, hydrodynamics, sail aerodynamics, performance prediction, cavitation, ventilation