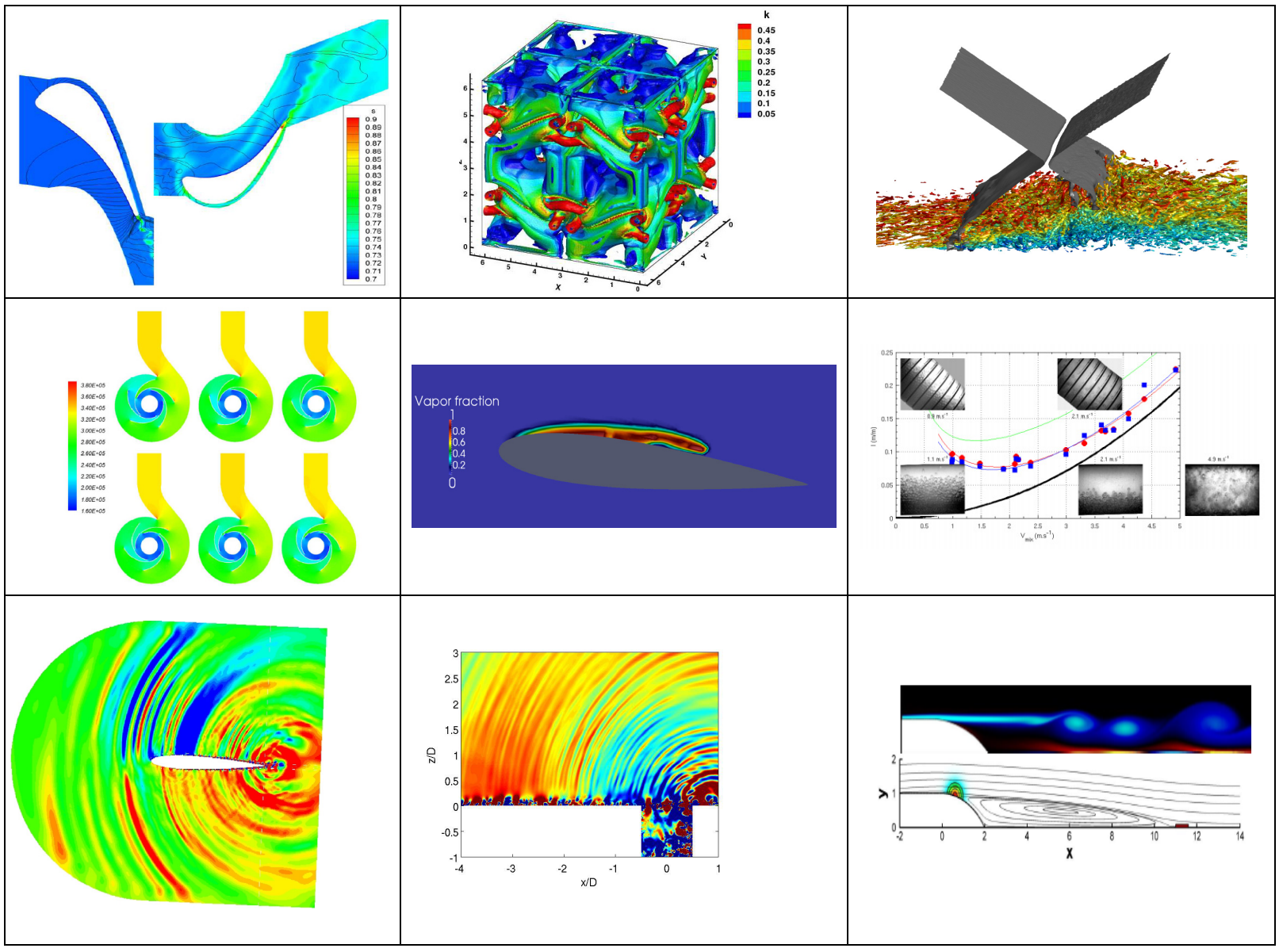

Figure: Applications of CFD to internal and external flows, DynFluid Laboratory, Arts et Métiers-ParisTech

Recent progress in high-fidelity Computational Fluid Dynamics

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In the last two decades, Computational Fluid Dynamics (CFD) has become widely accepted as one of the main methods for evaluating the performance of new designs. Applications of CFD tools range from external and internal Aerodynamics, to multidisciplinary fields like aero-elasticity, aero-acoustics and aero-optics, to the numerical simulation of complex flows like multiphase and/or reacting flows. CFD tools are even more frequently being used in place of experimental tests, namely in the early phases of design, because of their lower cost and greater flexibility. Moreover, they can be coupled to automatic optimization algorithms, with improvement over "trial and error" approaches.

Nevertheless, broadening the applicability limits of CFD requires further research effort for advanced flow modeling, reduction of numerical errors introduced by approximate solution methods and, a brand new aspect in numerical simulation (especially in fluid mechanics), quantification of the confidence intervals that can be associated to the simulation results or, in other words, uncertainty quantification.

It has come into use to refer to simulation tools assembling advanced modeling, high-accurate numerical methods, and uncertainty quantification techniques as "high-fidelity CFD" (HiFi-CFD). The use of HiFi-CFD is expected to ultimately lead to certified fluid flow simulations.

The purpose of the seminar is to present the basic principles of HiFi-CFD and the main scientific hurdles that are making the object of recent investigations in the CFD community, including two European projects. Emphasis will be put on applications of HiFi-CFD in Aerodynamics and energy-conversion systems. Some perspectives on modern joint experimental/numerical design approaches using data assimilation techniques will also be provided.

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