

## APPLICATIONS OF ADVANCED COMPUTATIONAL FLUID SIMULATION: HIGH-FIDELITY, MULTIPHYSICS, AND DATA- DRIVEN APPROACHES

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### ABSTRACT

Recent advances in computational fluid simulation have significantly expanded its role in addressing complex challenges across a wide range of industrial applications. Modern fluid systems—spanning energy, aerospace, ocean, environmental, and process engineering—are characterized by intricate geometries, turbulent flows, and strong coupling with thermal, chemical, and structural phenomena. In response, advanced simulation approaches integrating high-fidelity modeling, multiphysics coupling, and data-driven techniques are increasingly being adopted to deliver more accurate, efficient, and actionable insights.

This minisymposium focuses on the diverse applications of advanced computational fluid simulation, highlighting how state-of-the-art methodologies are being translated into practical industrial value. In particular, it aims to showcase how high-fidelity numerical methods, multiphysics frameworks, and data-driven approaches are utilized to improve system performance, enhance safety, and support design and operational decision-making.

Contributions are invited that demonstrate the use of high-resolution simulations enabled by advanced numerical schemes and high-performance computing (HPC), including GPU acceleration and large-scale parallelization. The role of multiphysics modeling—such as fluid–structure interaction, heat transfer, reactive flows, and particulate systems—will be emphasized as a critical component for accurately capturing real-world industrial processes. Both conventional mesh-based approaches and particle-based simulation methods are within the scope of this minisymposium, recognizing the complementary strengths of these frameworks in handling complex interfaces, large deformations, and multiphase phenomena.

The minisymposium will also explore the growing impact of data-driven methodologies, including machine learning-assisted modeling, surrogate models, and reduced-order approaches. These techniques are increasingly enabling faster simulations, real-time or near real-time predictions, and improved integration with digital technologies such as digital twins and data assimilation frameworks.

Applications of interest include, but are not limited to, energy systems (including nuclear and renewable energy), ocean engineering, industrial processes, environmental and urban flows, and advanced manufacturing. Contributions that clearly demonstrate both methodological innovation and tangible industrial impact are particularly encouraged.

By bringing together researchers and practitioners from academia and industry, this minisymposium aims to provide a comprehensive perspective on how advanced computational fluid simulation is being applied in practice. It will highlight current capabilities, identify remaining challenges, and outline future directions toward more robust, scalable, and application-driven simulation frameworks.