CoSeC Grand Challenges

The Collaborative Computational Project in Wave Structure Interaction (CCP-WSI / HEC-WSI)

Over the next decade, CCP-WSI will establish itself as the leading UK and international hub for advanced simulation tools in wave-structure interaction towards Net Zero by 2030

The Community

CCP-WSI a Collaborative Computational Project in Wave Structure Interaction

HEC-WSI a High End Computing Consortium for Wave Structure Interaction

www.ccp-wsi.ac.uk

www.hec-wsi.ac.uk

The Collaborative Computational Project in Wave-Structure Interaction (WSI), brings together two computational communities – fluid dynamics and structural mechanics. This will enable the community to co-design the next generation of Fully Coupled Wave-Structure Interaction (FCWSI) tools with realism both in the flow physics and the structural response, and in this way, unlock new complex applications in ocean and coastal engineering. WSI is primarily focussed on engineering (both computational and experimental) but crosses into other areas such as chemistry, physics and natural (Earth) sciences. Key topics revolve around scientific code coupling, high-performance computing, fluid dynamics, solid mechanics and solid body kinematics, with a focus on community dissemination of methods, software and results with repeatability in mind. Application areas of particular interest include understanding of offshore renewable energy devices (offer wind, wave energy and tidal stream), flood defences and fundamental understanding of the physics of WSI. Increasingly there is also interest in the application of data science topics like AI in the context of surrogate modelling. Their support is split into three key work-packages: WP1: Code Coupling; WP2: Code Performance; WP3: Impact and Sustainability. The work undertaken by CoSeC is intended to be generally applicable to scientific areas of importance to CCP-WSI, as such focus on floating offshore wind turbine design is key, alongside other wave-structure problems, such as violent sloshing of a fluid in a tank.

The Challenge

Lack of data necessary for validating computational models, integrating fluid-structure interaction simulations and supporting multiple software platforms

The UK is a world leader in offshore renewable energy and has committed to delivering up to 60 GW of offshore wind by 2030 as part of its Clean Power, Net Zero and energy security strategies. Achieving these ambitions requires a step change in their ability to model and predict wave–structure interaction (WSI) processes that govern the performance, safety, and sustainability of floating offshore wind turbines, coastal defences, and maritime infrastructure.

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Despite progress made by the CCP-WSI community in supporting this goal, their ability to numerical modelling of WSI process faces three critical barriers:

Data Availability for Validation: One of the key challenges is the lack of experimental and field data necessary for validating and calibrating computational models, such as granular/structure models and floating offshore wind turbine coupled models. While CCP-WSI continues to develop advanced models, their capabilities can only be validated through rigorous validation against real-world datasets. Collaborating with industry is essential to access high-quality field data from real projects, such as floating offshore wind farms. Engaging with experiment labs and leveraging cyber-physical model development will help bridge this gap.

Computational Advancements and Industry Integration: With the rapid evolution of HPC, we are continually optimising our codes to take advantage of parallelisation and partitioned coupling frameworks. However, the computational demands of fully coupled fluid-structure interaction simulations remain high, making them difficult to integrate into industry design workflows. There is a need to develop AI-based surrogate models and reduced-order methods that allow industries to conduct early-stage design assessments before resorting to high-fidelity simulations.

Community Engagement and Cross-Disciplinary Collaboration: CCP-WSI differs from other CCPs in that we support multiple software platforms rather than a single solver. While OpenFOAM is widely used within our community, we recognise the need to collaborate more extensively with other CFD groups and communities, such as the UK Fluids Network and SPH specialists. Expanding collaborations with the AI and computing communities can also provide new opportunities for innovation in model optimisation and data-driven methods.

The Solution

Rigorous validation against real-world datasets, develop AI-based surrogate models and expanding collaborations with the AI and computing communities

Over the next decade, CCP-WSI will establish itself as the leading UK and international hub for advanced simulation tools in wave–structure interaction, underpinned by innovation in numerical modelling, AI, and emerging computer architectures. To achieve this, the community will work closely with industry and experimental facilities to generate high-quality validation datasets from both offshore projects and laboratory studies, supported by cyber-physical approaches and AI-based methods that supplement traditional methods. These efforts will ensure scalable, efficient, and robust validation pipelines, while optimised HPC workflows and AI-based models will accelerate industrial design and reduce computational cost. A central focus will be the development of Grand Challenges and benchmark cases that address both fundamental scientific questions and real-world engineering priorities in offshore renewables, coastal infrastructure, and maritime structures. By aligning these challenges with industry needs, CCP-WSI community will drive targeted research, attract new collaborations, and deliver measurable impact. CAT-WSI will be further

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developed as a platform for open datasets, benchmarks, codes, and training resources, ensuring transparent and FAIR digital research practices. This platform will also be leveraged to train researchers and RSEs in high-fidelity modelling, AI/ML, and HPC workflows in collaboration with CoSeC and the wider CCP network. To broaden impact, CCP-WSI will strengthen cross-disciplinary and international partnerships, extending collaborations with the AI, quantum computing and data-centric computational mechanics communities. Internationally, they will build on the strong profile of CCP-WSI blind tests to establish joint facilities, common standards, and shared datasets, including through European partnerships and global consortia. Finally, the community will foster a vibrant and diverse skills base, supporting RSE career development through pooled training, networking, and exchange opportunities. This integrated roadmap will ensure CCP-WSI community continues to advance world-class digital infrastructure, strengthen sovereign capability in offshore engineering, and accelerate the deployment of clean, resilient, and sustainable marine and offshore energy technologies.

The Outcome

Accelerating floating offshore wind deployment to achieve Net Zero by 2030

Addressing these challenges directly supports national strategic priorities. The work aligns with UK Government goals by accelerating floating offshore wind deployment to achieve Clean Power 2030 and Net Zero 2050 targets, strengthening the capability in offshore engineering for the Energy Security Strategy, and enabling sustainable coastal infrastructure in line with Maritime 2050. It also advances UKRI DRI priorities by delivering interconnected DRI through federated workflows linking OpenFOAM, SPH, and AI-based surrogate models; training RSEs and researchers in high-fidelity modelling, AI/ML, and HPC workflows; promoting FAIR via open datasets and benchmarks released through CAT-WSI as a digital asset; and fostering sustainability by implementing efficient algorithms and surrogate modelling to reduce HPC costs, energy use, and carbon footprint.

More Information

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