Maximising potential of shallow ports for floating wind deployment

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Research motivation

The rapid growth of offshore wind technologies presents a unique opportunity for the UK to lead the global transition to renewable energy. With high wind energy potential near its coasts, the UK aims to develop innovative and cost-effective methods to deploy floating offshore wind farms. This project focuses on optimising existing shallow Scottish ports to assemble, store, and deploy novel Floating Offshore Wind turbine (FOWT) technologies, such as the C-Dart mooring system and T-Omega Wind FOWT. By addressing the limitations of current port infrastructure and creating digital models of selected ports and technologies, the research aims to reduce operational costs, increase profitability, and create exportable, cost-efficient solutions for other coastal nations, strengthening the UK's position in the offshore wind market.

Aim

Develop digital engineering models of port infrastructure for Floating Offshore Wind Turbine (FOWT) projects and perform simulation studies to evaluate innovative approaches to towing, mooring, in-port assembly, and maintenance. The objective is to identify cost-effective strategies that minimize operational risks and reduce the offshore renewables LCOE and initial project CAPEX.

Methodology

Port models and FOWT devices are design with CAD and imported to the multiphysiscs state-of-the-art Marine Simulator (Fig.1) to perform simulation trials under variable locations and environmental conditions to evaluate, visualise and collect data from structure-environment dynamic interactions in real time of offshore assets [1] .

Fig. 1. Marine Simulator dome.

This project modelled the ports of Nigg, Talbot and Peterhead including their bathymetry and realistic environmental conditions (Fig.2). Further hydrodynamic analysis was performed with ANSYS to verify quick mooring connections hydrodynamic responses under regular and irregular sea states.

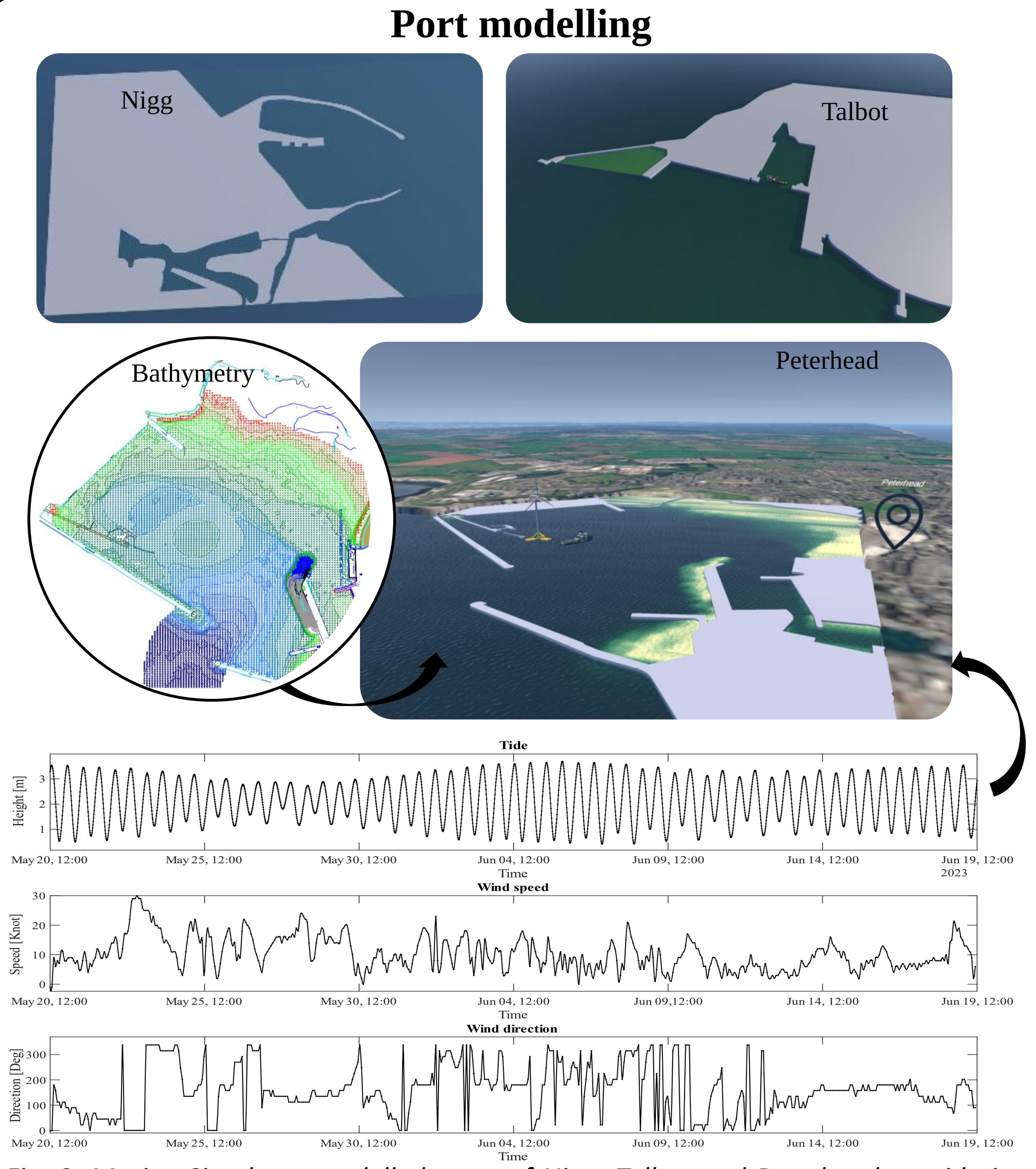

Fig. 2. Marine Simulator modelled ports of Nigg, Talbot and Peterhead considering the bathymetry and realistic environmental parameters of tide height and wind speed and direction.

Results

Simulation trials to moor different models of FOWT (i.e. T-Omega Wind turbine and VoltumUS) are performed with the novel C-Dart mooring system developed by Blackfish Engineering Ltd. Simulations are performed under realistic weather conditions for their connection and disconnection phases, when the turbines are located at the port, nearshore and offshore. Fig 3. shows an example of a connection procedure. An assistance tug connects/disconnects the C-Dart into the system buoy for the temporary mooring. The number of C-Dart mooring systems depend on the turbine's configuration.

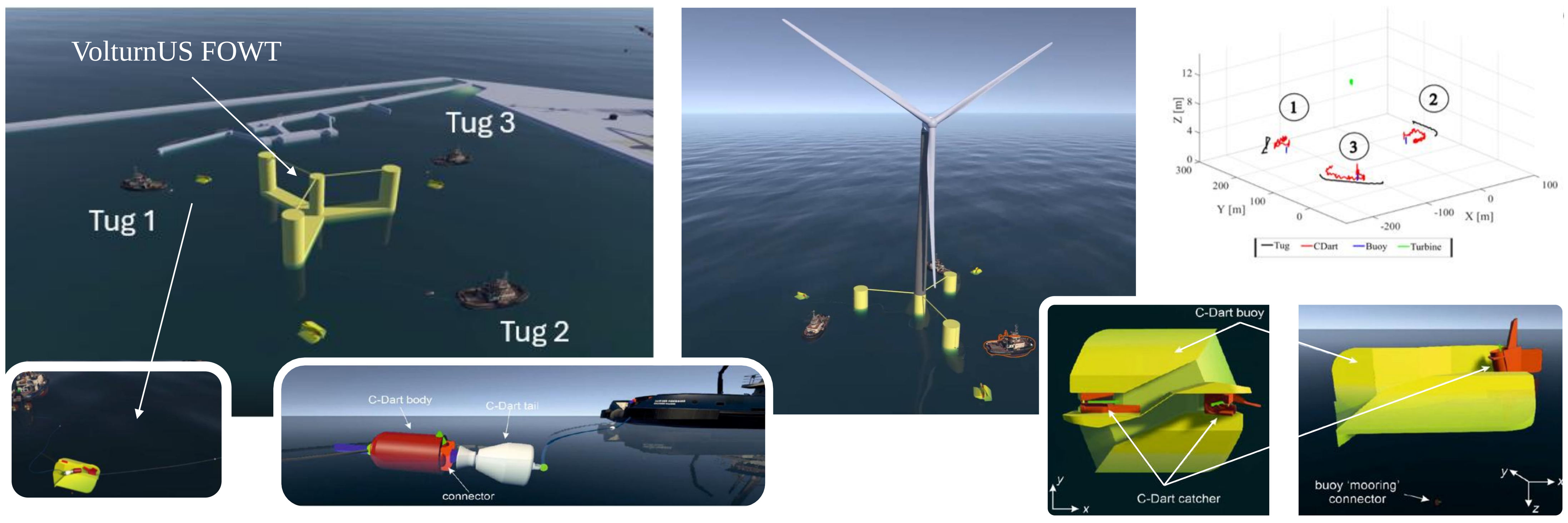

Fig.3. Temporary mooring connection in Peterhead Port and offshore environment of the VolturnUS turbine with 3 C-Dart systems. Each C-Dart system comprises a C-Dart buoy, a C-Dart device and an assistance tug; an exemplary 3D operation model trajectories for in port cases. 3D representation of bodies trajectories during mooring connection in port-conditions.

Time histories of C-Dart connection and disconnection procedures are recorded and analysed to identify potential risks or failures under various environmental conditions and locations. Further C-Dart hydrodynamic studies are modelled and simulation trials performed in ANSYS AQWA to validate the Marine Simulator models and. C-Dart system is evaluated under regular waves under different wave incident angles and response RAOs are evaluated and presented in Fig.5 depicting relatively small displacements for seas of $T > 7$ [s].

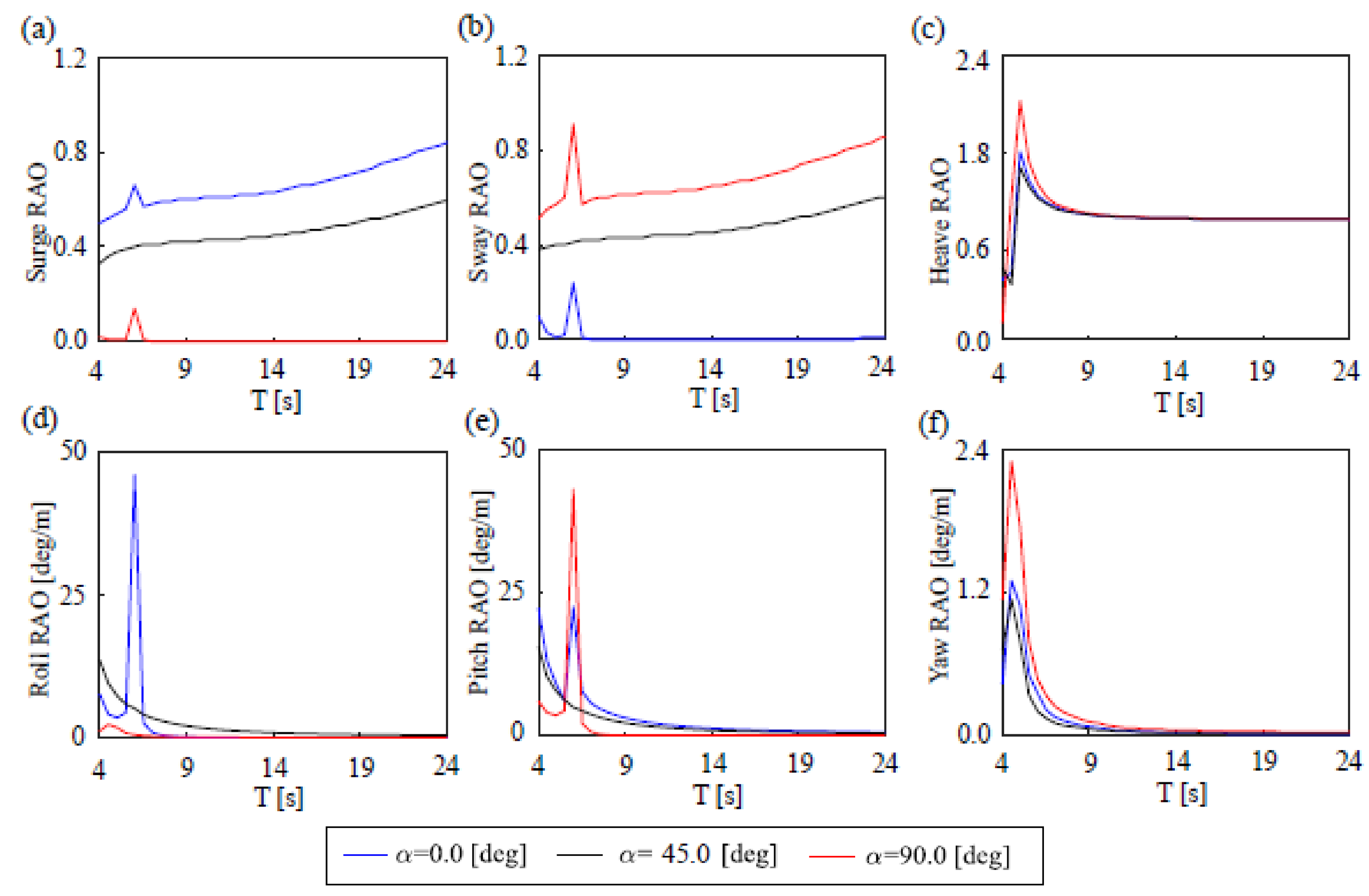

Fig.4. C-Dart RAOs computed with ANSYS AQWA for different wave heading angles α.

To obtain realistic C-Dart hydrodynamic reactions simulated trials are performed for different sea state scenarios of irregular waves modelled with JONSWAP spectrum for North Sea parameters. An example is depicted in Fig. 5 for the case of in-port conditions depicting minimum angular displacements for greater wave periods

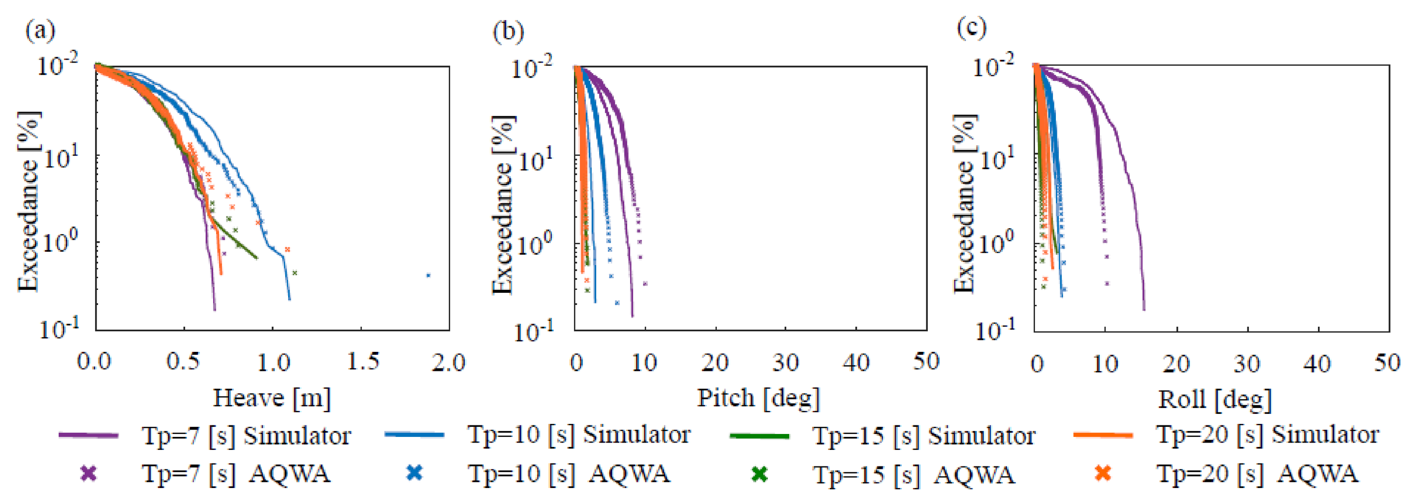

Fig.5. C-Dart response exceedance under irregular waves for heave, pitch and roll DOF for in –port ``Low'' sea states of $H_s = 0.5$ [m].

Simulations of the in-port assembly of the T-Omega Wind [2] turbine are conducted, with time histories of displacements and tension forces in the winches evaluated. The process involves two winches that tilt the turbine at different stages (Fig. 6), where the velocity of the turbine driving the motion must remain constant to avoid peak tension in the lines.

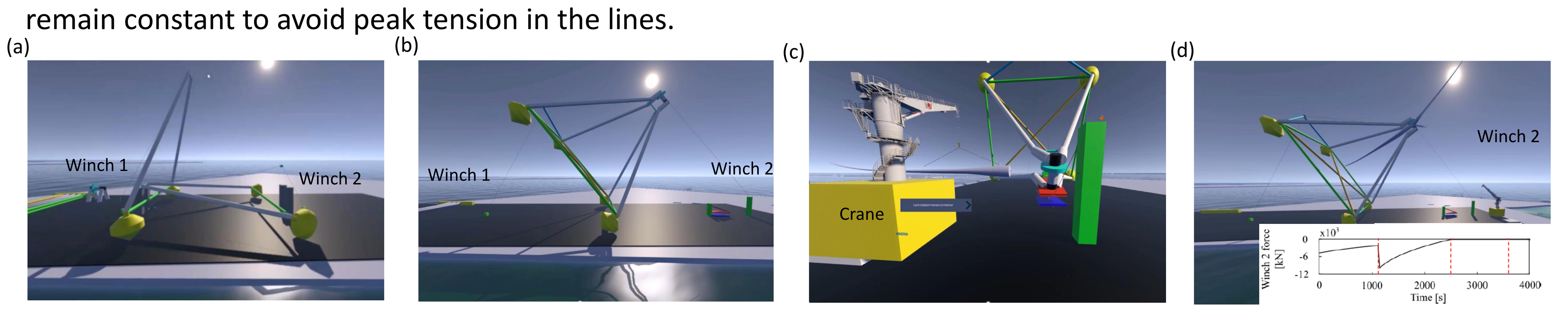

Fig 6. Full scale T-Omega Wind turbine in-port assembly stages at Peterhead Port model. (a) Left and right arm lifted for connection. (b) Turbine lowered for blades assembly. (c) Blades assembly with small crane. (d) Final assembly up-tilted and ready for deployment.

Concluding remarks

- RAOs and exceedance curves show that C-Dart quick mooring connection is save for wave periods of T and $T_p > 7$ [s]
- Simulations on the proposed in-port assembly operation for a novel FOWT concept show reliable procedure solutions.

References

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[3] Terrero Gonzalez, A., Hastie, J., Neilson, R., Kapitaniak, M., Virtual Prototyping of Deployment of C-Dart Quick Mooring Connection System: Floating Offshore Wind Case Study, Proceedings of Offshore Mechanics and Arctic Engineering–OMAE, OMAE2026-181410, 2026

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