Maths could help search and rescue ships sail more safely in heavy seas

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A unique new computer model built on highly complex mathematics could make it possible to design safer versions of the 'fast ships' widely used in search & rescue, anti-drugs, anti-piracy and many other vital offshore operations.

Travelling at up to 23-30 knots, fast ships are especially vulnerable to waves that amplify suddenly due to local weather and sea conditions – extreme funnelling effects, for example, may turn waves a few metres high into dangerous waves tens of metres tall that can destabilise ships, resulting in damage, causing injuries and threatening lives.

Developed with Engineering and Physical Sciences Research Council (EPSRC) support at the University of Leeds by Dr Anna Kalogirou and Dr Vijaya Ambati with Professor Onno Bokhove, the new model produces unprecedentedly accurate animations and simulations that can show exactly how sea waves can affect fast ships. It highlights the importance of having accurate predictions of the pressure forces that these craft are subjected to, and could aid the design of fast ships better able to withstand the effects of rough seas.

The researchers can already simulate the complex interactions of sea waves that can lead to an anomalously high freak wave, but adding the motion of ships into the equation complicates matters significantly.

Dr Kalogirou said: "We have managed to develop a simulation tool that uses sophisticated mathematical methods and produces fast and accurate simulations of linear wave-ship interactions. Our tool can also provide measurements in terms of wave amplitudes around ships, as well as pressures on ships' surfaces."

The aim is to extend the model over the next three years to produce a tool that can be used extensively by ship designers and maritime engineers.

The model has been validated through laboratory experiments on a man-made freak or rogue wave (the so-called 'soliton splash') using test tanks. A comparison with wave and ship motion, for a ship moored on two anchors, has been set up in a small test tank, which is also used for public demonstrations.

Results from the project are being disseminated to a range of organisations including the Maritime Research Institute Netherlands (MARIN). A related European Industry Doctorate project with MARIN on rogue and breaking waves against offshore structures has strengthened Professor Bokhove's EPSRC-funded research on wave impact against ships, as well as his EU-funded work on fixed offshore structures.

Fast ships deliver all kinds of services in fields such as disaster response, the fight against crime, the provision of supplies for oil and gas platforms and the transportation of wind farm maintenance personnel. Each year, however, around 100 such ships worldwide are lost or damaged in heavy seas, with around 2,500 casualties in 2013.

Professor Bokhove says: "Describing mathematically the complex behaviour of waves and their interaction with fast ships and then incorporating all of this into a robust computer model has been very challenging. We're delighted to have provided further proof of how advanced mathematics can have real-world applications that help save money and safeguard lives."

More information: Anna Kalogirou et al. Variational finite element methods for waves in a Hele–Shaw tank, *Applied Mathematical Modelling* (2016). DOI: 10.1016/j.apm.2016.02.036

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