

How safe are slender carbon structures?

A new safety-assessment technique, pioneered in the aerospace industry, will make it easier to assess the structural health of slender carbon fibre spars.

The need

Yacht racers' title hopes can evaporate immediately once a mast or rigging breaks. Similarly, wind turbine blades, which can be more than 60m long, are high-risk structures due to their loading and environmental conditions. Removal for testing, analysis and reinstatement is undesirable and can cost tens of thousands of pounds for each element.

Researchers needed to develop a way to assess the damage threats that carbon fibre marine and wind turbine spars are likely to experience from manufacturing, installation and in service. This would enable the designs to continue to function, even with damage present, through their life – saving time and money.

The results

In this Technology Strategy Board co-funded R&D project, Materials Engineering Research Laboratory (MERL) led a consortium known as Maintaining Structural Integrity in Yacht and Wind Turbine Spars (project MSI-SPAR).

NDT Solutions brought to the project its portable RapidScan inspection system, which produces ultrasonic images of carbon fibre spars. The technology is similar to medical ultrasound scans, and the RapidScan system can locate and assess the extent of internal damage.

Insensys provided fibre-optic strain measurement systems that, when embedded in a composite structure, can monitor the 'structural health' and record progressive damage via microsensors distributed over the length of a glass fibre optic cable.

These tools can tell the operator that damage exists. But is it safe to carry on?

The answer comes from 'damage tolerance' techniques that assess selected locations within a spar, under typical loading conditions, to predict whether defects will get worse. Developing these ideas, the project tested various slender spars that have 'worst case' damage. MERL then modelled various scenarios to see under what conditions a spar has enough in reserve to keep going. In other words, they could tell how much damage a yacht or turbine spar could tolerate before it became unsafe.

The Maritime and Coastguard Agency has adopted damage tolerance methods from this project in its new Large Yacht Code. Using this advice, yacht operators will have increased confidence in the integrity of masts and spars.

For offshore wind farm operators, these damage tolerance methods – together with structural health monitoring of turbine blades – may reduce inspection costs by about 20%.

Bringing small businesses together

The benefits of collaboration, although difficult to measure, are particularly evident in this project.

There are few big, long-established players in the marine industry. The MSI-SPAR project succeeded because it brought together several small firms, each with niche expertise. Many had never worked together before and several entered sectors in which they

had no previous experience, such as the wind and wave turbine markets.

Collaborations for MSI-SPAR have carried over to spin-off projects in the defence, marine and rail sector, and continue in the aerospace industry.

Markets ripe for exploitation

The UK is a world leader in yacht design, building and racing. In 2008, the UK leisure and small commercial marine market was worth over £3bn, with 35,000 employees in 4,300 businesses.

In contrast, the wind turbine industry is relatively new but has significant commercial potential. The Government's ambitious plan to

generate 15% of the UK's energy needs from renewable sources by 2020 would require more than 7,000 wind turbines.

The techniques developed by the MSI-SPAR project should roll out to operators of yacht and wind turbine spars within three years.

'Confidence in carbon fibre yacht and wind turbine spars will increase as users adopt this damage tolerance approach that is already used in the aerospace industry.'

MERL



Technology Strategy Board

Driving Innovation

Collaborative research and development projects are one of the tools that the Technology Strategy Board uses to drive innovation in the UK. The Technology Strategy Board is a business-led executive non-departmental public body, established by the

Government. Its role is to promote and support research into, and development and exploitation of, technology and innovation for the benefit of UK business, in order to increase economic growth and improve the quality of life. It is sponsored by the Department for Business, Innovation and Skills (BIS).

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Project partners

MERL, EMCL, Formula Yacht Spars, High Modulus, Insensys, MCA, NDT Solutions, Gurit, Testsure Technologies

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£617,000

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