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WHATEVER FLOATS YOUR BOAT

Shipping is one of the most fuel-efficient ways to move freight, but the industry still produces significant greenhouse-gas emissions, including more than a quarter of the world's nitrogen oxides emissions. And it also produces more sulphur dioxide emissions than all land transportation combined. In the latest of our Future Transport series, **Duncan Graham-Rowe** looks at the new wave in shipping.

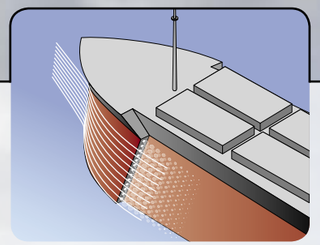
DRAG RACING

Reducing drag is likely to be the most effective way of mitigating environmental impact. Ships that slip faster and more easily through the water use less energy and produce fewer emissions.

MICROBUBBLES

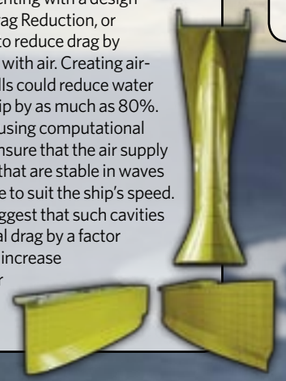
One effort, being explored by Yoshiaki Kodama at Japan's National Maritime Research Institute in Tokyo, is to inject a blanket of tiny bubbles beneath a ship's hull. The idea is to reduce contact between the ship and the water. The bubbles, which are as small as 2 millimetres across, are designed to reduce drag by displacing water at the boundary layer, the centimetre or so closest to the hull where the interaction between ship and water is strongest. As air is 100 times less viscous than water, the bubbles should reduce drag considerably. They are blown out of holes at the bow, and forced along the hull by their own buoyancy; ribs running along the ship's length prevent the bubbles from slipping sideways.

"We carried out a full-scale experiment earlier this year," says Kodama. A 120-metre-long ship was tested off the coast of Japan and found to achieve a 10% energy saving over a similar journey without the bubbles. However, energy has to be put into creating the bubbles, says Kodama, so the net saving was closer to about 5%.

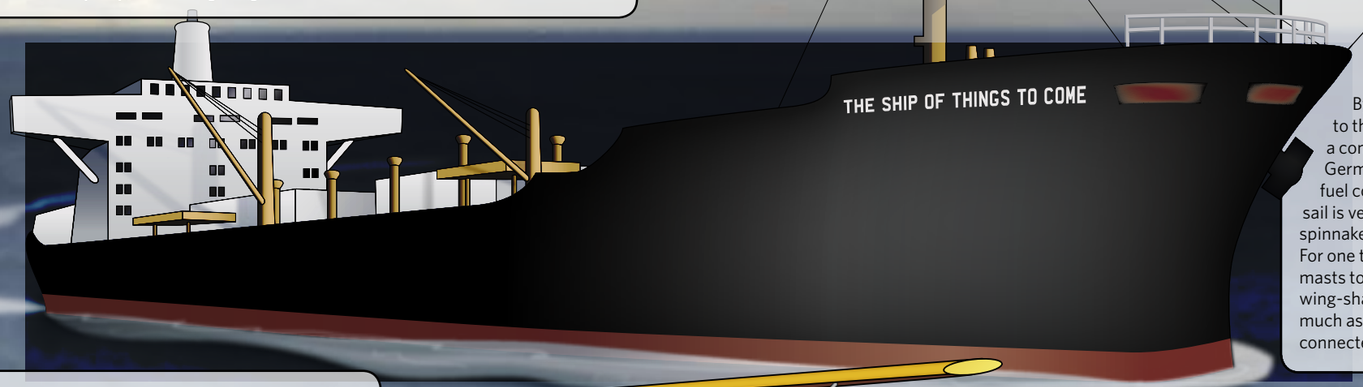


CAVITY CUSHIONS

The US Defense Advanced Research Projects Agency is experimenting with a design called Air Cavity Drag Reduction, or AIRCAT, that aims to reduce drag by lubricating the ship with air. Creating air-filled cavities on hulls could reduce water contact with the ship by as much as 80%. Hulls are designed using computational fluid dynamics to ensure that the air supply creates air cavities that are stable in waves and vary their shape to suit the ship's speed. Tests on models suggest that such cavities can reduce frictional drag by a factor of five and possibly increase ships' speed by four times.

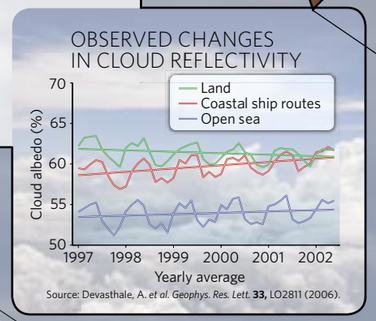


DARPA



CLOUD COVER

Not all emissions warm Earth. According to work by remote-sensing specialist Abhay Devasthale and his colleagues at the University of Hamburg, Germany, ships' exhaust fumes are making clouds colder and bigger. The researchers studied six years' worth of satellite data to see how ships in coastal European waters affected cloud formation. Where shipping increased, the reflectivity of clouds increased by 1.5% (see chart). This is due to sulphur dioxide emissions, which form nuclei upon which cloud droplets can form. Devasthale says he is now analysing 20 years of shipping data covering the busier Atlantic, to see the effects there.



Source: Devasthale, A. *et al. Geophys. Res. Lett.* **33,** L02811 (2006).

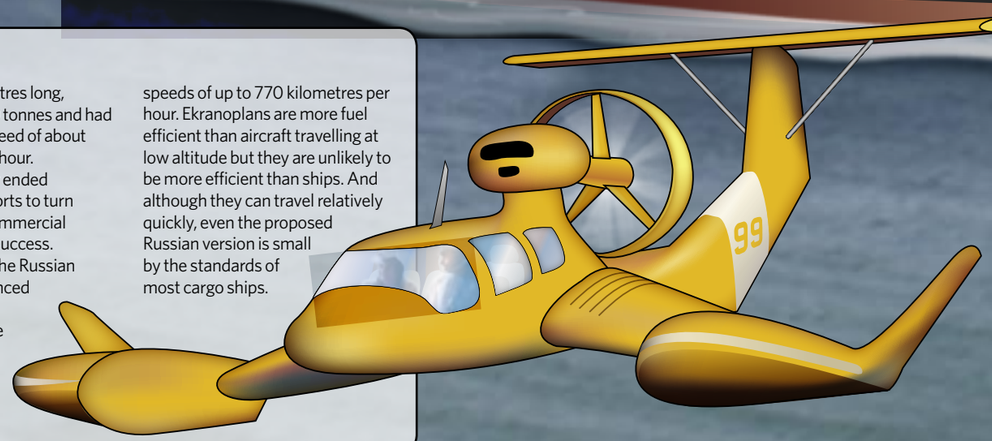
KITES

The idea of sticking a sail on a ship may not sound particularly high-tech, but it could be just what the shipping industry needs. By fixing huge kite-like sails to the bows of ships, SkySails, a company based in Hamburg, Germany, says it can reduce annual fuel costs by up to 35%. The kite-sail is very different from the average spinnaker, and much more effective. For one thing, there are no bothersome masts to deal with. Instead , the wing-shaped sail is designed to fly as much as 300 metres above the ship, connected only by a tether. At such heights the wind is much stronger and more stable. The sails are self-deploying and computer-controlled, so no sailing knowledge is required of the crew. Since December, SkySails has been testing the technology on two medium-sized cargo ships and found that its 160-square-metre sails can generate 8 tonnes of tractive force, the equivalent of the power produced by an Airbus A318 turbine engine. According to SkySails, under optimum wind conditions the sail has been able to reduce fuel consumption by as much as 50%. Currently there are more than 100,000 cargo ships and cruisers that could be fitted with this technology.

FLOATING ON AIR

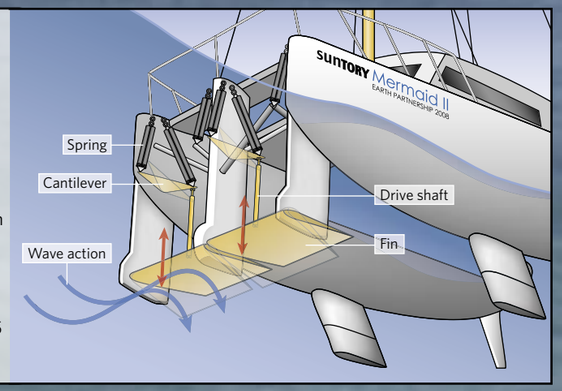
Not touching the water at all would considerably reduce drag. This is the principle of the ekranoplan, an unusual vehicle that can travel on a cushion of air just above the water. Ekranoplans often resemble aircraft, but they do not fly. Instead they use truncated wings to create the cushion of high-pressure air on which the craft moves. Developed in the Soviet Union, the most famous example was the Ekranoplan KM, a huge, fast-moving craft dubbed the Caspian Sea Monster by the US Central Intelligence Agency. Designed for military transportation, the KM was 100 metres long, weighed nearly 500 tonnes and had a fully loaded top speed of about 400 kilometres per hour.

Since the cold war ended there have been efforts to turn ekranoplans into commercial vehicles, with little success. However, last year the Russian government announced plans to develop a fleet of 2,300-tonne ekranoplans for its navy that could carry 900-tonne payloads and reach speeds of up to 770 kilometres per hour. Ekranoplans are more fuel efficient than aircraft travelling at low altitude but they are unlikely to be more efficient than ships. And although they can travel relatively quickly, even the proposed Russian version is small by the standards of most cargo ships.



WAVE POWER

An unusual way to reduce ships' fuel consumption is to make them wave-powered. In July this year, Japanese sailor Ken-Ichi Horie completed a 7,000-kilometre, 110-day voyage from Japan to Hawaii in a wave-powered catamaran. Propulsion was generated by two horizontal fins mounted beneath the bow, at the front of the ship. Incoming waves cause these fins to move up and down, producing dolphin-like kicks of thrust and driving the ship forward at speeds of up to 5 knots (9.25 kilometres per hour).



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