How Energy Observer Set Sail with a Toyota Fuel Cell

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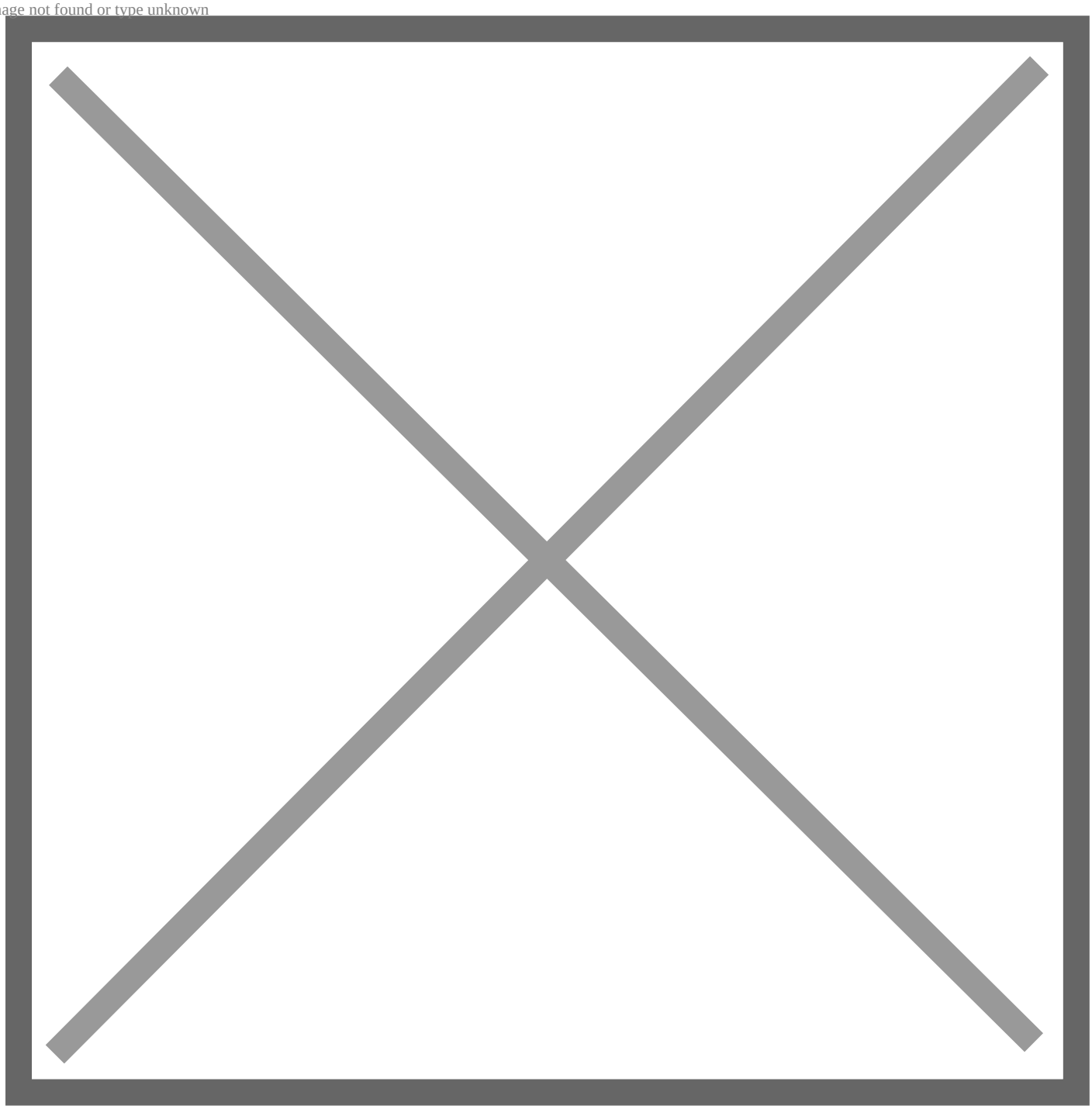

What an Around-the-World Experimental Ocean Voyage Taught the World About Hydrogen

Five years ago, Toyota answered a call inquiring about its hydrogen-powered fuel cell technology from Energy Observer, an experimental ocean-going catamaran with a mission to circle the globe using only renewable energy. Thoughtfully built as the first hydrogen-powered, zero-emission vessel to be self-sufficient in energy, Energy Observer's mission was to advocate and serve as a laboratory to raise awareness of renewable energy technologies available now for society's ecological transition.

Though Energy Observer had used a hydrogen fuel cell stack from the onset, the captain, Victorien Erussard, was interested in technology upgrades as they became available. He learned that Toyota was offering a commercially available hydrogen-powered fuel-cell stack. Erussard thought that Toyota, with its reputation for making reliable and affordable cars, might have a product that could withstand the roughest conditions of the ocean. He placed a call and soon found an audience with Toyota Motor Europe (TME), kicking off discussions.

Toyota has long been exploring carbon-reducing and carbon-neutrality mobility solutions, and hydrogen-powered fuel cells are a part of its multi-pathway strategy. Toyota introduced the world to its first mass-produced hydrogen-powered fuel cell electric vehicle, the Mirai, in 2014, and the company had been discussing applications of the technology beyond cars. For Toyota, Energy Observer was an exciting opportunity to demonstrate the scalability of the fuel-cell stacks Toyota developed for the Mirai, said Luc Vercauteren, a powertrain project leader at Toyota Motor Europe.

"I was immediately struck by the adventure of it," Vercauteren said. "Toyota has ambitions to get to zero emissions. The fact that this ship was going to tour the world was a great way to get that point across."

Already, the versatile technology had been scaled and used globally in commercial vehicles, such as trucks and buses, and even in non-automotive applications, such as stationary power units – and now, with the help of Energy Observer, Toyota went to sea.

Not that there weren't challenges.

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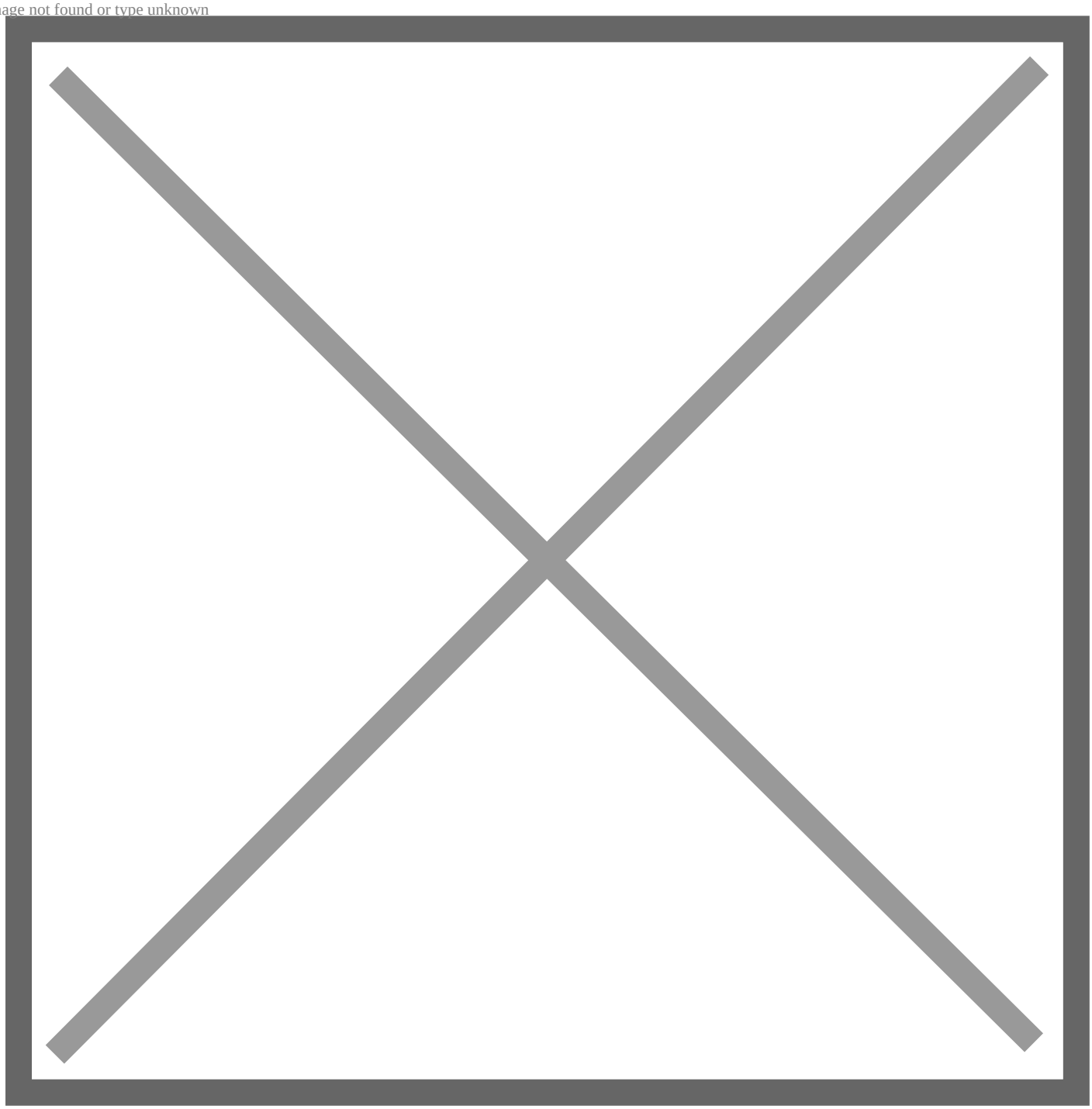


As a literal floating test bed of different technologies that includes solar and wind energy capture, hydroelectric generation, and hydrogen fuel cell technology, space is at a premium on Energy Observer.

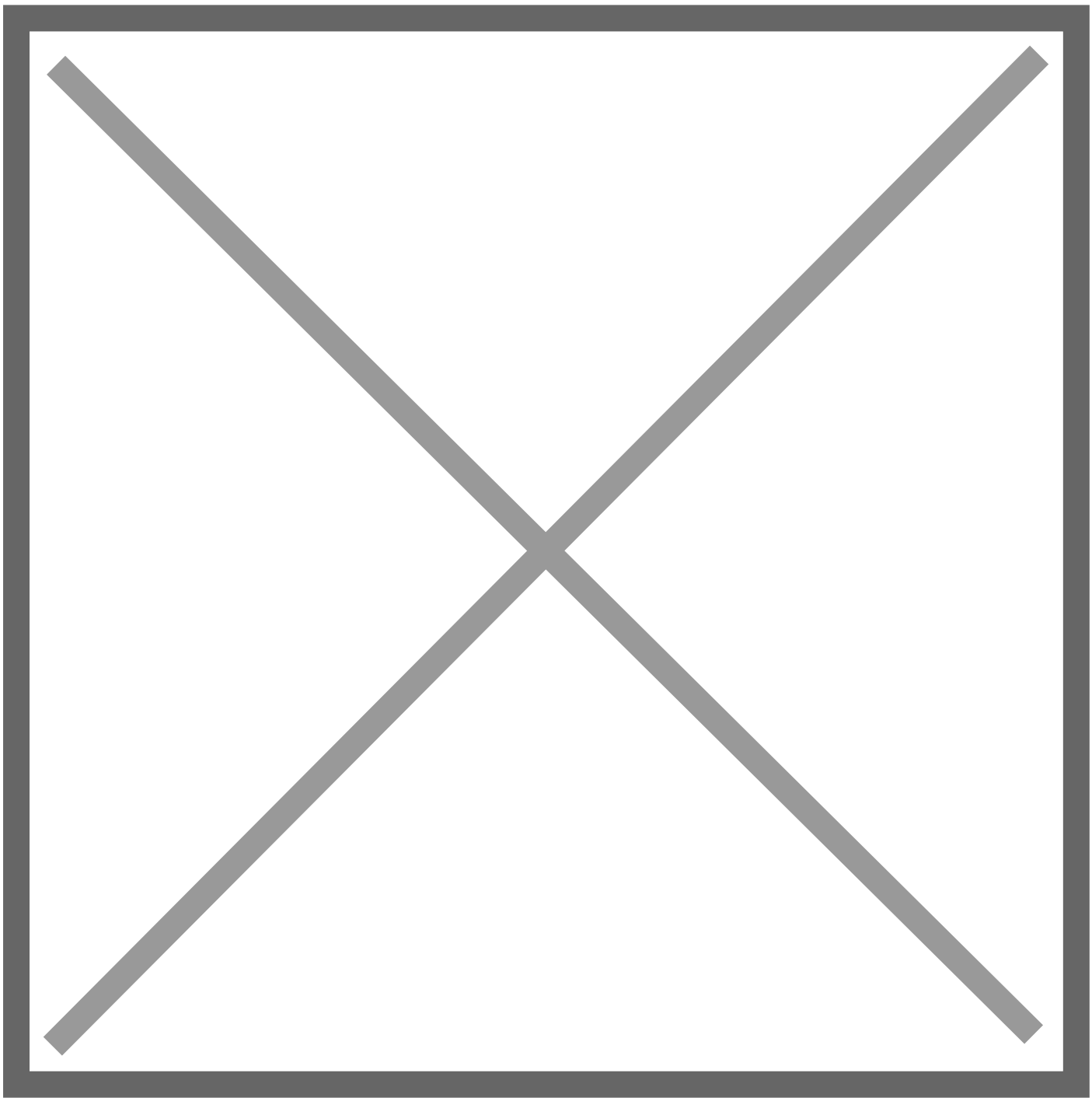
OVERCOMING OBSTACLES

The Energy Observer vessel began life as a sail-powered racing catamaran. It has a cabin suspended between two large pontoon-like hulls. Different parts of the boat are connected by netting that the crew walks on to get around. It’s an extremely lightweight and efficient design ideal to use a minimum amount of energy. But it

doesn’t leave a lot of extra space for equipment.

When the Toyota team went to see the space for the fuel-cell stack, they found a tiny compartment inside one of the ship’s racing hulls that was housing a washing machine. The hull wasn’t strong enough to hold a stack weighing more than 500 pounds. Systems that were originally designed to be spread around the Mirai passenger vehicle’s frame had to be repackaged into a cube-like shape fit to the exact specifications of the space. Even after that, there was no way to squeeze the stack through a tiny cargo door.

Soon, the fuel-cell stack was retrofitted by TME’s Technical Center Europe team and repackaged to withstand the challenges of an ocean environment — protected from the ravages of salty air and seawater. To install it, the boat crew had to cut a hole into the hull and would later have to patch it back together after the system was installed and working.

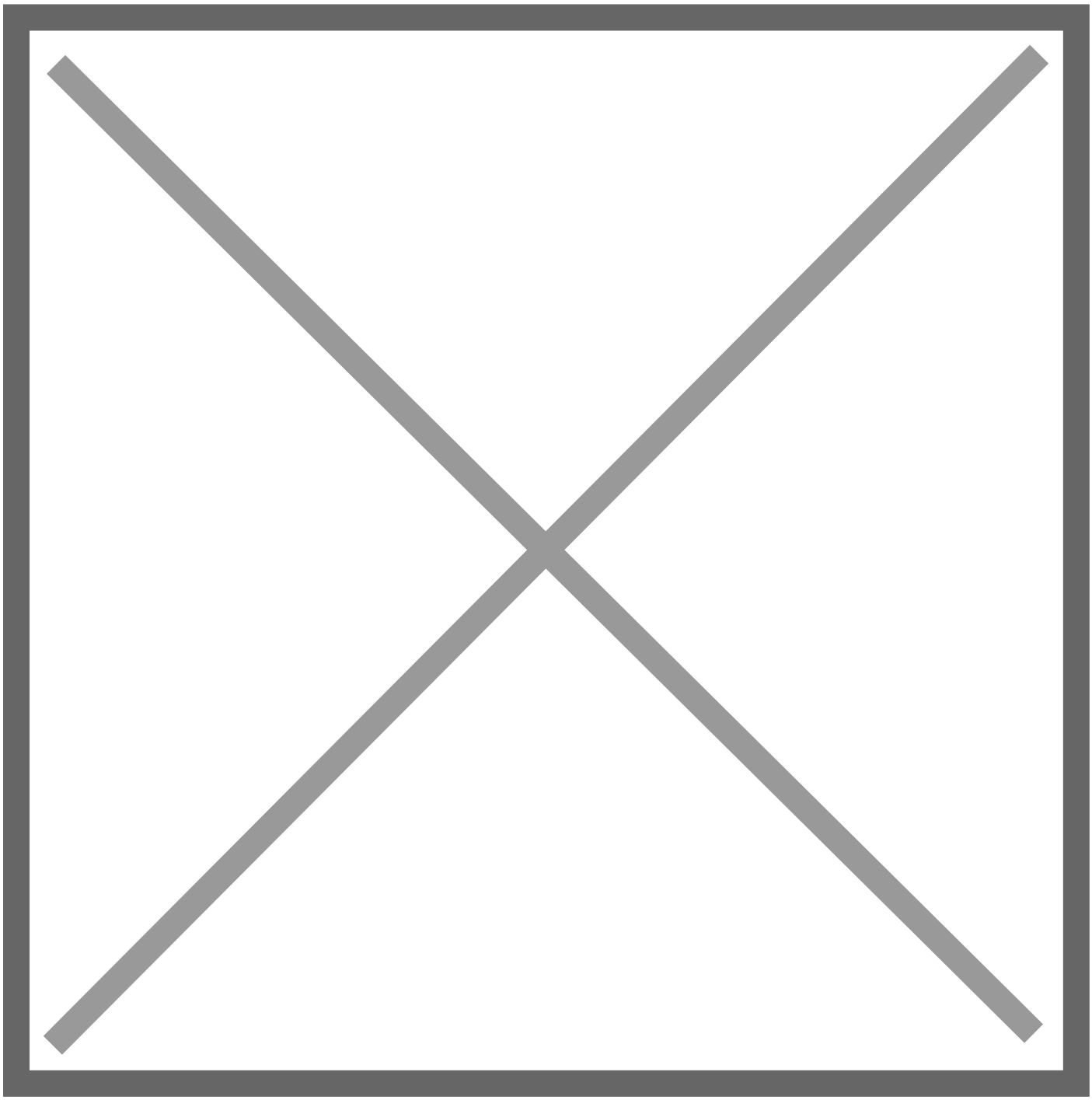


It’s a tight fit for the Toyota fuel cell system underneath the deck of Energy Observer. Toyota Motor Europe engineers needed to reconfigure the fuel cell system to fit in the small space allotted.

To get fresh water and air needed for the fuel cells to generate electricity, Energy Observer used other key onboard components. Fresh water was provided through a reverse-osmosis desalination system. An electrolyzer produced pure hydrogen from the fresh water using electrolysis, based on electricity provided by the other renewable energy sources, including solar and wind. For the pure air needed to power the fuel cell, they needed a

filter as well.

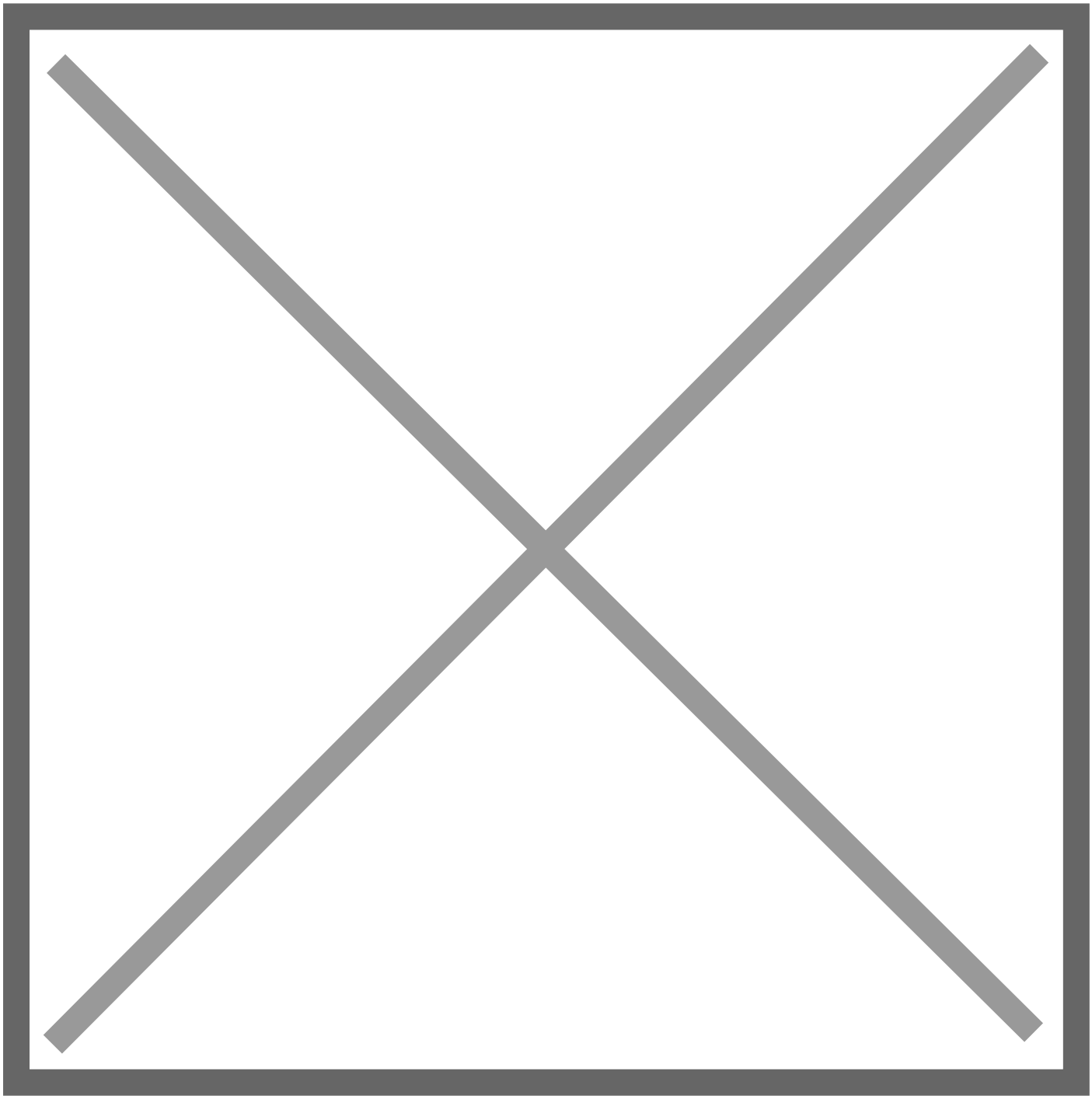
“They made sure the space was pressurized,” Vercauteren said. “The unit needs air to operate. Air comes through a desalination filter. The salt is separated from the air and filtered after that. Then the module can breathe.”



All energy sources collectively worked together to make all of the Energy Observer's systems operate at any given time. Aside from the solar energy provided by the panels (top), the battery and hydrogen storage (bottom) could be used at any given time, especially in instances such as nighttime when solar power isn't available.

Toyota's fuel cells worked in tandem with the Energy Observer's other energy sources. The produced hydrogen is stored in pressurized tanks during the daytime when there is excess electricity from solar and wind. According to Energy Observer's website, the double storage of batteries and hydrogen complement each other. The batteries provide short term immediate power, while the hydrogen provides long-term autonomy. At night or in poor weather conditions, the hydrogen could feed the fuel cells to provide the electricity needed to operate the vessel.

Once the system installation and testing were complete, Energy Observer, equipped with the Toyota fuel cell stack, set off again in February 2020 to continue its mission and circle the globe – more than once!



After 7 years and 68,000 nautical miles of adventure, Energy Observer made it back to its home port in Saint-Malo, France.

MISSION ACCOMPLISHED

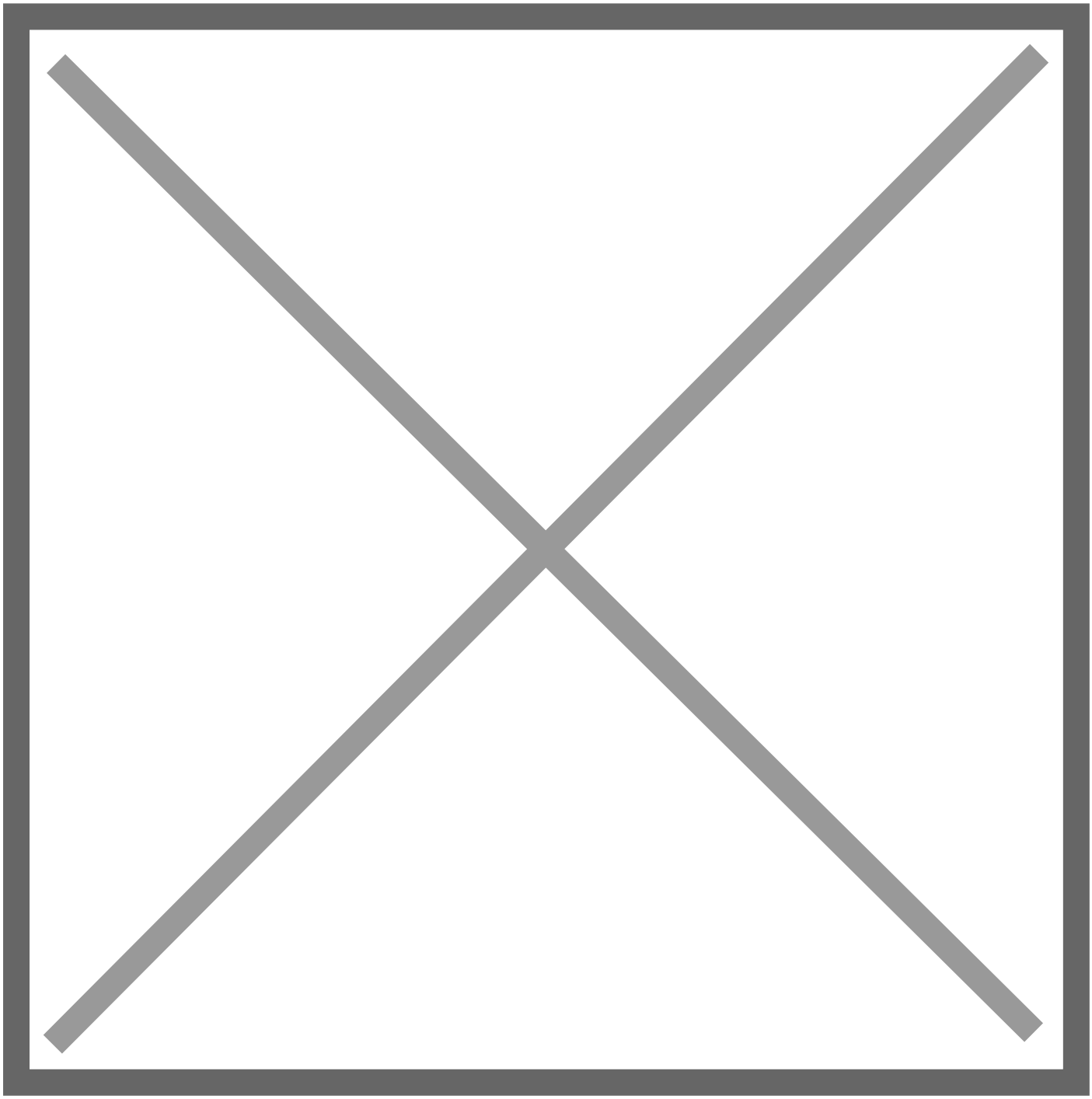
Energy Observer recently made it back to its home port in Saint-Malo, France, after sailing for seven years, and a total of 68,000 nautical miles. The floating energy lab is anchored in Paris for the summer. The Energy Observer team will continue its work there, providing opportunities to share their experiences by talking about

the lessons they learned from circumnavigating the world with hydrogen, solar and wind power with the expected crowds.

Through its voyages, Energy Observer demonstrated the immense advantage that hydrogen can have over batteries, especially in applications where weight is a factor. The on-board lithium-ion battery set weights 1,400-kg (approx. 3,085 lbs.) for 112-kWh of electricity, while the hydrogen storage and fuel cell together weigh a total of 1,700-kg (approx. 3,745 lbs.) for 1,000-kWh. Translated, this means that 1-kWh weighs 12.5-kg when stored in batteries vs only 1.7-kg when stored as hydrogen. In other words, for equal weight, the hydrogen storage contains 7.35 times more power than the on-board lithium-ion batteries, a considerable advantage for mobility, especially in a maritime application.

Based on their experience with this and other applications, both Toyota and Energy Observer agree that fuel cell technology should be applied to help make environmental progress in places that makes sense across society, since it is a proven way to help reduce carbon dioxide emissions that contribute to climate change.

“When I joined Energy Observer, I was curious to know how those high technologies would age at sea,” said Beatrice Cordiano, a scientist and crew member. “I was surprised to see after seven years of the project how well those technologies worked as they faced challenges across the seas all around the world.”



Fuel cells weren't the only technology being tested in the harsh ocean-going conditions. Solar panels cover almost the entire top deck of Energy Observer.

Energy Observer had set out on a mission to prove that solar, wind and hydrogen could power an ocean-going vessel in a harsh environment – and it worked. The boat, covered in solar panels, was also a testing platform for unique high-tech sail, called Oceanwings, which are now being adopted by numerous long-distance ships.

Now that Energy Observer has proven the technologies can stand up to the rigors of open-ocean travel, the team is setting its sights on larger ambitions. They recently announced plans for Energy Observer 2, what they claim as the world's first cargo ship powered by liquid hydrogen set to launch in 2029. The plans call for a vessel 160 meters long weighing 1,100 metric tons. Its goal is to operate for 25 years, hauling containers along the Atlantic on 14-day, 1,600-mile cycles. It would demonstrate a solution for the U.N. International Maritime Organization's goal of halving greenhouse-gas emissions from ocean-faring cargo ships by 2050. These ships currently consume an estimated 250 million to 300 million tons of diesel-based fuel a year, with an annual 1.1 billion tons of CO2 emissions.

Toyota remains in discussions with Energy Observer on future projects, but the collaboration thus far has proven that fuel cell technology has untapped potential in maritime applications. Toyota continues to have discussions with other maritime operators about hydrogen ocean vessels and will continue to explore ways in which fuel cell technology can support carbon emission reduction in various industries.

"Toyota is about much more than cars now," Vercauteren said. "Hydrogen fits very well into our mobility mission. It allows us to diversify into many different low-carbon applications."

– Story by Jeff Plungis