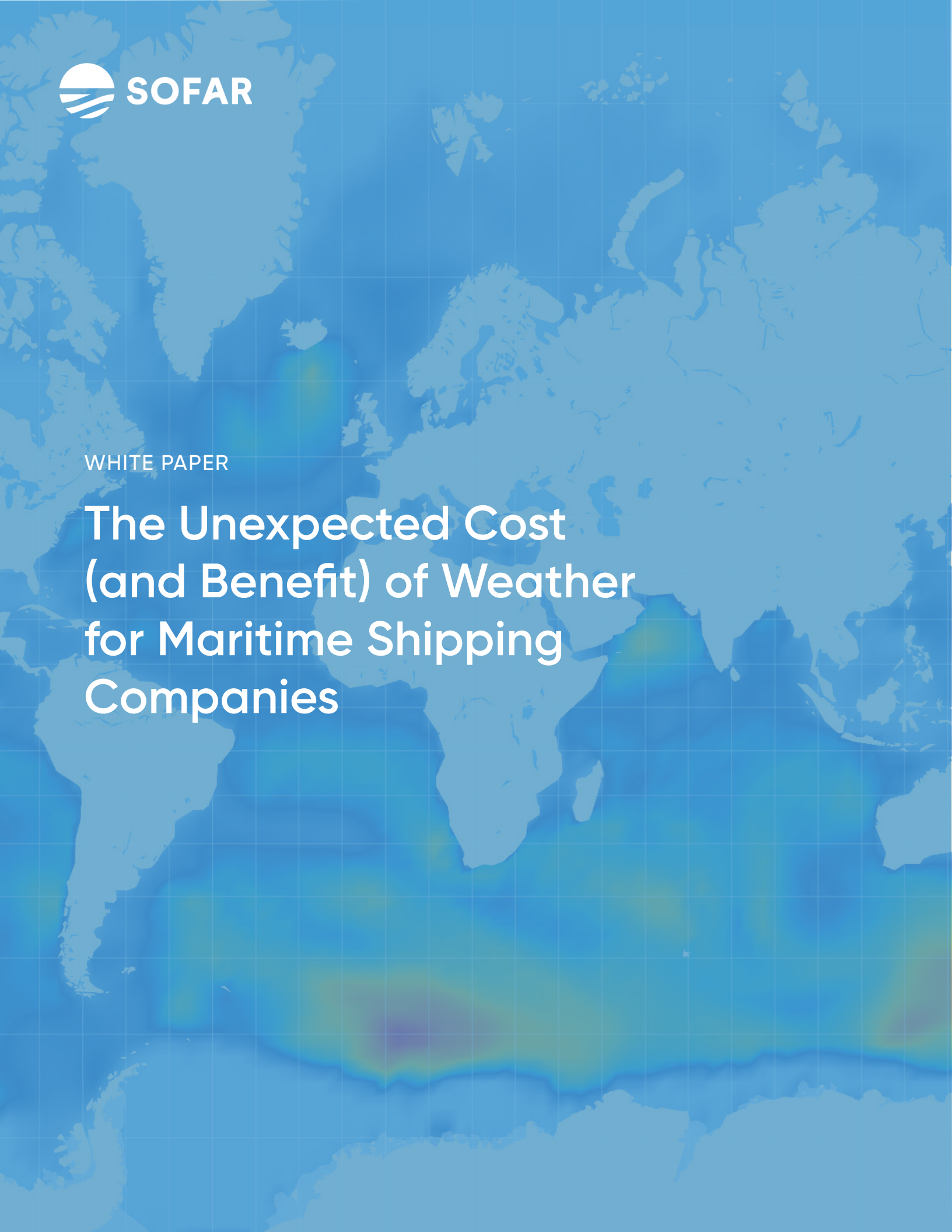
SOFAR

WHITE PAPER

The Unexpected Cost (and Benefit) of Weather for Maritime Shipping Companies



The outsized impact of weather resistance on vessels

How efficiently a vessel sails depends on the type of ocean weather it encounters during a voyage. Waves, wind, and currents apply resistance that a ship overcomes by burning more fuel. This decreases efficiency and increases costs.

Waves contribute the most added weather resistance and cause unwanted vessel motion, such as pitching and rolling. In **Figure 1**, we show how a Capesize bulk carrier's fuel consumption rapidly increases as the size of the waves it encounters increases. When sailing at 12 kts in fair weather, fuel costs are just over $70/NM. As wave height increases past 2m, the fuel cost rapidly approaches $90/NM. Over the course of a typical voyage, which can cover more than 5,000 NM, this added wave resistance has a massive effect on a vessel's total fuel cost.

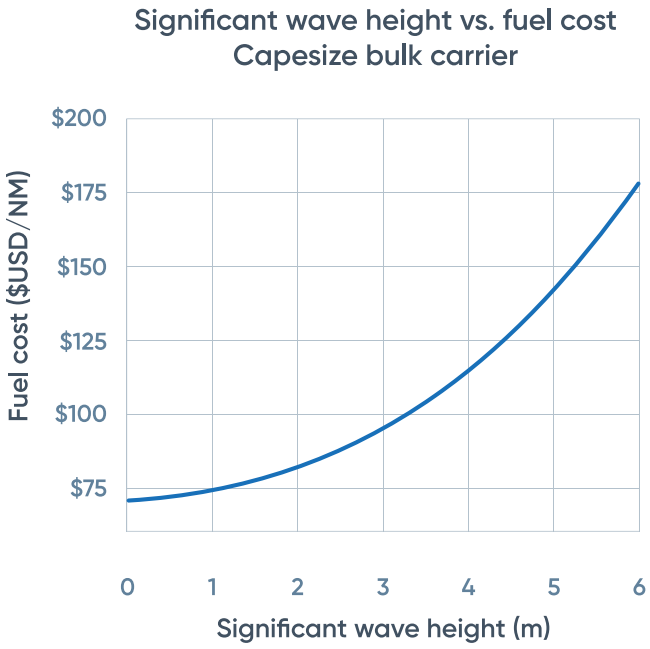


Figure 1. A Capesize bulk carrier's fuel cost rapidly increases as the size of the waves it encounters increases.

Sofar's Spotter buoys collect and transmit wave, wind, sea surface temperature, and barometric pressure data.

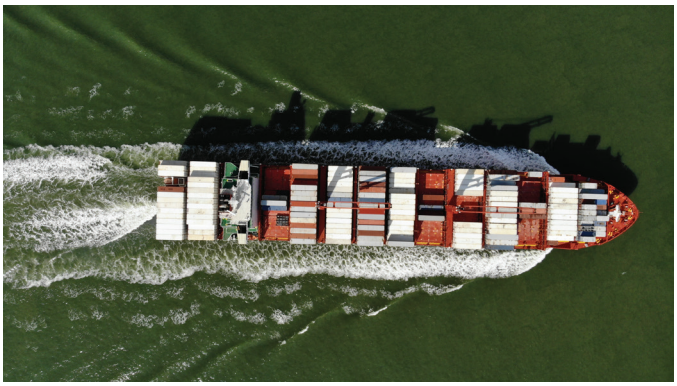
Analysis: Bulk carriers and container ships generate high annual fuel costs and emissions to overcome weather resistance

We analyzed historical weather data and noon reports to quantify the cost of weather for a typical Capesize bulk carrier and New Panamax container ship.

18% of a bulk carrier's main engine fuel consumption is due to adverse weather. This translates to ~$920,000/year[1] in fuel costs and ~5,730 MT CO2/year in emissions. However, favorable weather propels a vessel forward and offsets some of a bulk carrier's adverse weather-related fuel consumption. This lowers main engine fuel consumption due to weather to 12.4%.

14.9% of a container ship's main engine fuel consumption is due to adverse weather. This translates to $1.36 million/year[2] in fuel costs and ~8,465 MT CO2/year in emissions. The time a container ship spends sailing in favorable conditions that propel it forward lowers its overall main engine fuel consumption due to weather to 10.9%.

[1] Assumes a 70% utilization rate per year with an average main engine consumption of 40 MT/day, and an estimated bunker price of $500/MT. Emissions factor used is 3.114.
[2] Assumes a 50% utilization rate per year with an average main engine consumption of 100 MT/day, and an estimated bunker price of $500/MT. Emissions factor used is 3.114.



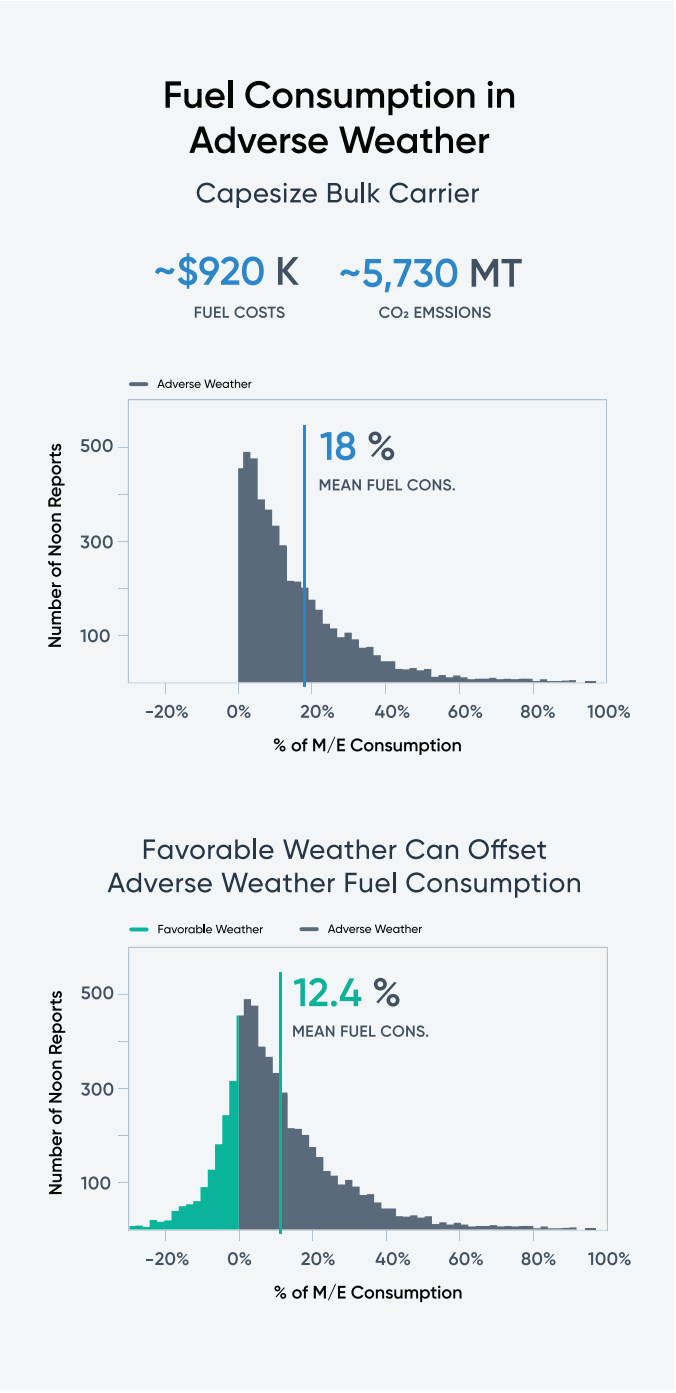


Figure 2. An analysis of historical weather data and noon reports shows that 18% of a typical Capesize bulk carrier's main engine fuel consumption is due to adverse weather. Over 5% of that fuel consumption can be offset by favorable weather that propels a vessel forward.

Highly accurate weather forecasts improve vessel performance models and drive superior voyage guidance

To reduce the effects of weather on a vessel's fuel consumption and emissions output, maritime shipping companies are increasingly turning to voyage optimization platforms.

A typical platform uses widely-available forecasts to choose a safe and efficient route prior to a voyage. Sofar's Wayfinder platform uses our highly accurate forecasts to deliver daily voyage guidance that minimizes weather resistance and maximizes time spent in favorable weather.

Sofar's marine weather forecasts are up to 40-50% more accurate than the models used by traditional platforms. The key differentiator between Sofar's forecasts and other models is the **assimilation of real-time ocean data at scale**.

Sofar's forecasts assimilate the hundreds of thousands of daily ground truth observations made by our global network of marine weather sensors, known as Spotter buoys. Spotter observations provide spatial and temporal coverage of sea state conditions not captured by satellites, which are the primary data source for widely-available forecasts.

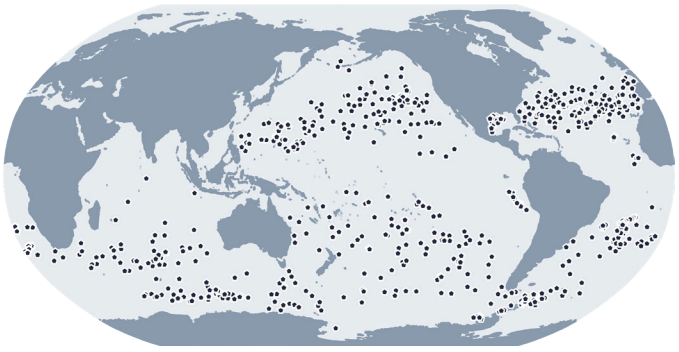


Figure 3. Locations of Spotter buoys in Sofar's global buoy network, as of January 1, 2023.

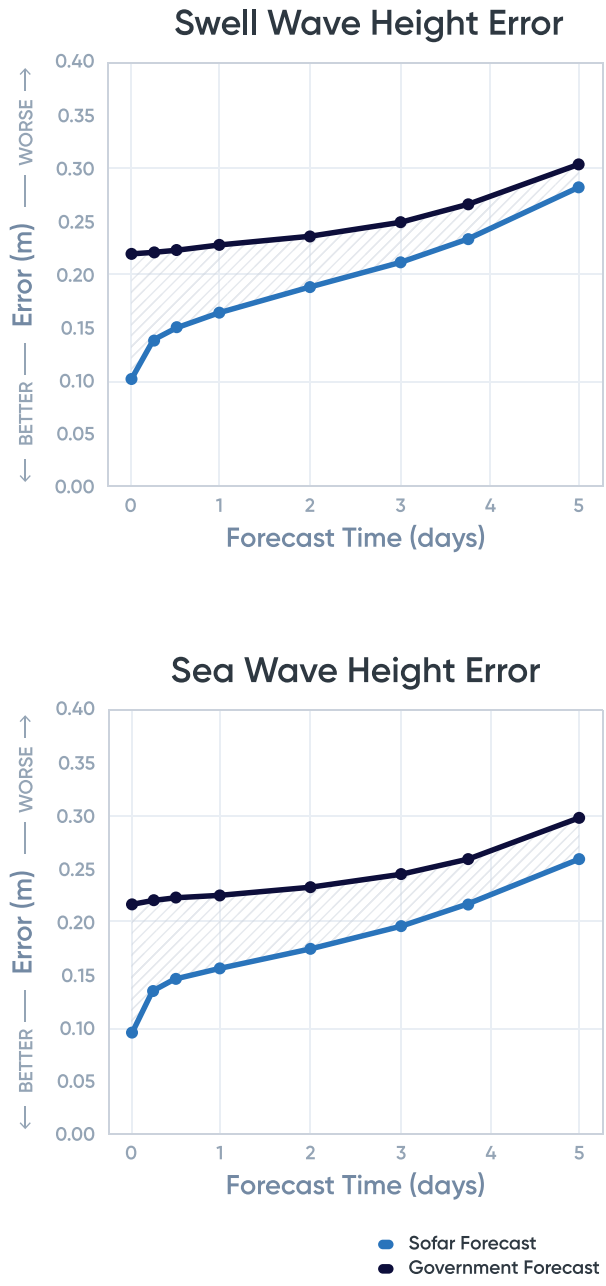


Figure 4. Comparisons of global swell wave height error and sea wave height error at different forecast lead times for Sofar Ocean's wave model and a leading government wave model. Sofar's forecast of (swell and sea) wave height has up to 50% less error than the government forecast at short lead times when compared to wave height measurements made by the global Spotter buoy network.

Spotter observations of wave spectra are particularly valuable, given that waves generate the most weather resistance for ships at sea. Assimilating these observations increases Sofar's forecast accuracy of significant wave height by 38% and of wave period and direction by up to 45%.

By combining Spotter observations with available satellite and in situ data, Sofar's forecasts are more accurate along a vessel's entire route. This increases the accuracy of Wayfinder's vessel performance model (VPM) and the reliability of its daily optimized guidance.

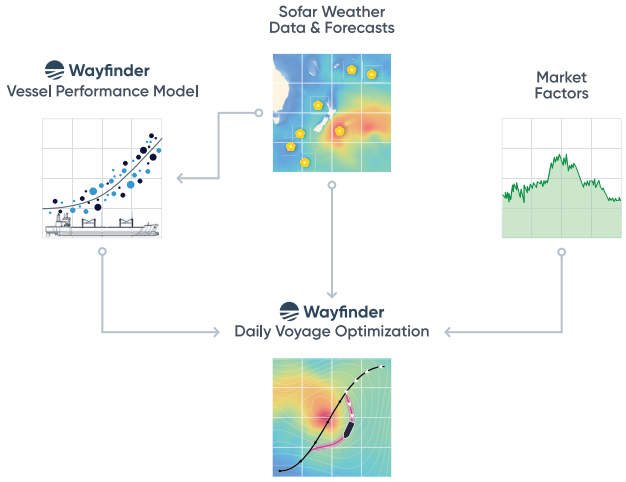


Figure 5. Sofar's superior weather data and forecasts improve the reliability of Wayfinder's daily optimized voyage guidance, as well as the accuracy of the speed and fuel predictions made by its vessel performance model.

We calibrate Wayfinder's VPM using fundamental naval architecture principles, information about a ship's past performance, and Sofar's highly accurate weather data. The VPM makes precise vessel speed and fuel consumption predictions, which shoreside teams use to forecast the effects of individual routing decisions across all sea states.

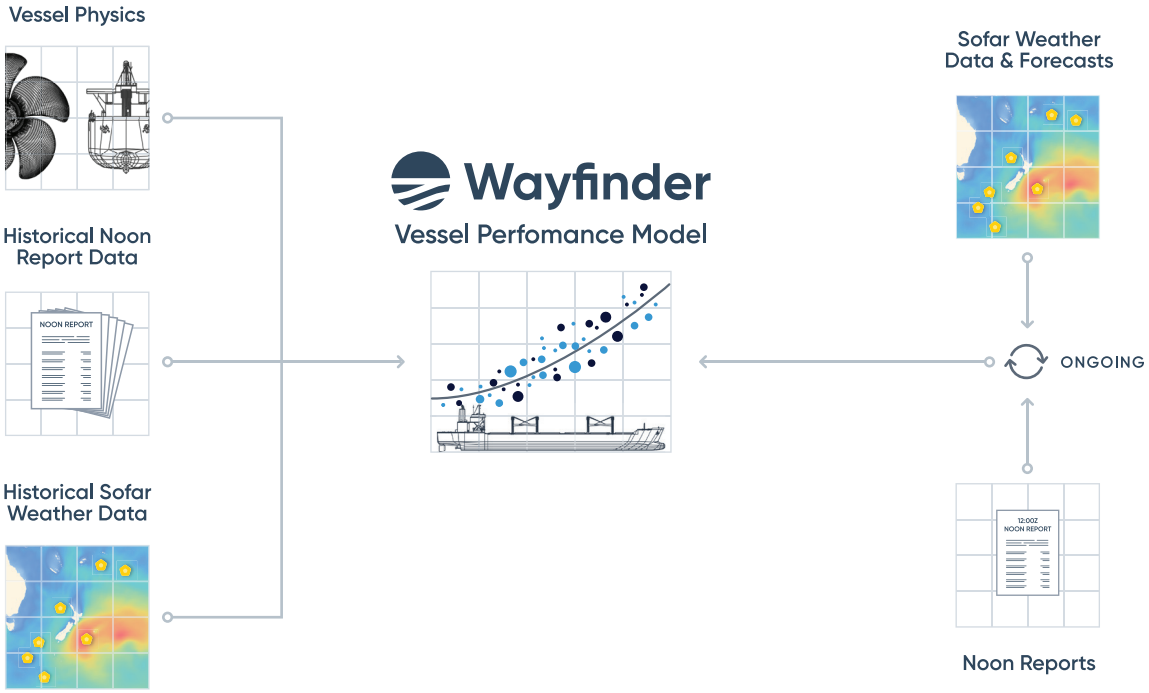


Figure 6. A schematic of Wayfinder's vessel performance model (VPM), which is calibrated using naval architecture principles, information about a ship's past performance, and Sofar's highly accurate weather data. The VPM is continuously monitored and periodically recalibrated using the latest weather and vessel data.

Wayfinder uses its VPM's predictions and Sofar's superior forecasts to generate continuously optimized guidance for Captains and Navigational Officers. The platform issues an RPM recommendation daily and new waypoints when a significant route advantage is identified from amongst hundreds of millions of options. Wayfinder's guidance unlocks significant savings opportunities over the course of a voyage, while always accounting for a vessel's business and safety constraints.

By keeping vessels on the most efficient path to port, Wayfinder helps fleets reduce fuel consumption, emissions output, and cost. Highly accurate weather forecasts are central to the platform's success and are a prerequisite for an effective voyage optimization solution.

To learn more about Wayfinder, schedule a demo with our team.

Wayfinder by SOFAR

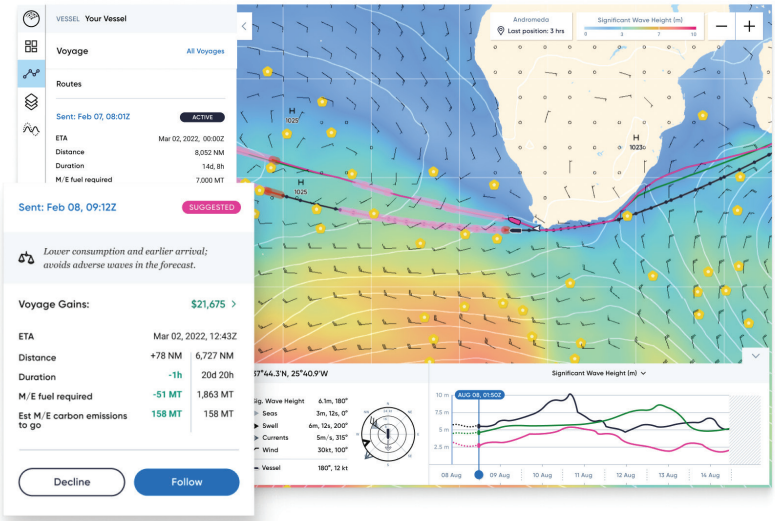


Figure 7. Wayfinder's modern and easy-to-use dashboard.

Connecting the world's oceans to power a more sustainable future

Sofar has designed, built, and deployed the largest privately owned network of ocean sensors, which it uses to produce the world's best marine weather forecasts. Sofar's Wayfinder platform couples these forecasts with robust vessel performance models to provide continuously optimized voyage guidance to fleets. This guidance helps maritime shipping companies reduce emissions, prioritize safety, increase operational efficiency, and maximize profitability.

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