



NavigaTE

Technical Brief



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Abstract

NavigaTE is a decision-based, bottom-up model of global shipping that predicts how policy and market developments translate into independent choices by owners, operators, and fuel producers. It respects technology readiness, supply buildout, and asset lead times, which yield insights into what is feasible in a given timeframe and where bottlenecks are expected to appear. Results connect market developments to outcomes across fleet and onboard technology development, fuel market development (costs, supply, and feedstock use), regulatory outcomes (compliance, emission trading, and subsidies), and the overall trajectory and cost of the transition. This brief explains the basics of NavigaTE by highlighting its advantages and breaking down how it works with an overview of its logic and purpose, boundary conditions, how choices are modeled, data inputs and assumptions, outputs and results, and its limitations.

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Introduction

The decarbonization of shipping is driven by everyday choices across the industry. Companies decide what fuel to bunker, which technologies to adopt, how fast to sail, and when to invest. Stakeholders make different choices due to costs, regulations, contracts, and risks, so they rarely move in lockstep. Understanding the dynamics behind these decisions is essential to understanding how shipping's decarbonization will unfold.

NavigaTE is a tool that simulates these decisions over time. It models owners, operators, and fuel producers as distinct groups and lets them respond to changing policies, costs, technologies, and fuel availability. By representing each group as a collection of individual actors, NavigaTE approximates how they behave in practice.

The model only captures the shipping sector, making assumptions about the interaction with the global economy and the wider energy system. Trade demand from the global economy is provided as an input, and the energy system is partially modeled without accounting for competition with other sectors. Within these boundaries, NavigaTE simulates how shipping adapts.

With NavigaTE, you can test the expected impact of regulatory proposals, technologies, and business models. The model results reveal how policies, technologies, and energy system constraints shape fleet development, fuel use, and costs. It approximates what is likely to happen under stated conditions and highlights where progress stalls if market developments are delayed. The goal is to give regulators honest feedback and to give industry a clear view of the operating environment — not to produce an optimal plan for a single company. Understanding why NavigaTE takes this approach is key to interpreting its results. The next section explains the principles behind the model and how it reflects real-world decision dynamics in the maritime ecosystem.



How NavigaTE delivers insights

NavigaTE is designed to simulate real-world decision dynamics across the shipping value chain, and the approach behind it stands apart for three reasons:

1 Mirrors real decisions

Owners, operators, and fuel producers are represented as independent groups that respond differently to the same market developments. Outcomes emerge from many separate choices rather than a single central plan, making the results closer to real-world industry behavior.

2 Focus on technical feasibility

NavigaTE focuses on technical realities. Adoption depends on market developments, technology readiness, asset lead times, and the ability to scale fuel production. When indications of market developments are weak or late, bottlenecks appear, costs rise, and progress slows. When indications of market developments are clear and credible, uptake advances at a pace that aligns with technical feasibility. Political ambitions are not guaranteed to be met if they are not technically feasible or the price indication is too weak. The result is a projection of what is likely to happen, not necessarily what is desirable.

3 Includes the full value chain

Fuel production is modeled alongside vessels and operations. Fuel producers expand capacity in response to market developments but face build-out constraints by pathways and regions. This makes the upstream bottlenecks visible and shows how delays in fuel supply can stall vessel adoption, even when those vessels appear viable.

NavigaTE delivers these three features by design, explained in detail in the next section.



How NavigaTE works

Having outlined how NavigaTE reflects real-world decision dynamics, focuses on technical feasibility, and includes the full value chain, this section explains how the model works — covering its inputs, simulation logic, and outputs, introducing the model's concept first and its limits.

Model concept

In technical terms, NavigaTE belongs to the family of models known as Integrated Assessment Models (IAMs).¹ More specifically, NavigaTE is a sectoral IAM as it focuses only on the shipping industry and not all sectors interconnectedly.

What NavigaTE simulates

NavigaTE simulates a global fleet that must satisfy a given trade demand while responding to policy, costs, and infrastructure constraints. Owners decide what to build or retrofit, and operators choose fuels and operations. The fuel market adjusts supply in response to demand signals from shipping.

How decisions are represented

In the real world, decisions differ across companies. Even when two owners face similar numbers, their decisions can be different because information is imperfect, strategies vary, and human factors like risk appetite come into play.

To approximate variations in decisions, NavigaTE compares the perceived business case for each available option. Options with stronger business cases attract a larger share of the market, but never the whole market. Weaker options still retain some share, reflecting that not all decisions follow the most rational or financially optimal choices.

This approach mirrors real sector dynamics: adoption grows faster when the business case is clear, but always with variation across companies.

What is an IAM?

An integrated-assessment model links economy, technology, behaviour, and emissions in a single model so that a change in one area immediately shows its impact on the others. IAMs are widely used by e.g., the Intergovernmental Panel on Climate Change (IPCC) to compare global climate scenarios. A sectoral IAM, like NavigaTE, applies that idea to just a single industry, enabling more detailed technical insights.

The result is a spread of choices that collectively shape the sector, rather than a single, uniform path.

Bottom-up feedback

Choices in one part of the wider system affect the business case elsewhere. When fuel costs fall, ships able to use that fuel become more attractive for newbuilds or fuel conversion. When regulations tighten, operators may respond by reducing speed or adopting efficiency measures. Each newbuild, conversion, or added production capacity that enters the system changes the options available in later years.

These interactions mean that results are not simply the sum of separate assumptions. They reflect how technologies, fuels, and operations interact in practice, and how one decision can ripple through to create new opportunities or bottlenecks in other parts of the value chain.

Imperfect foresight

Decisions in NavigaTE are made with imperfect information about the future. Owners, operators, and producers act on expectations of future fuel prices, technology options, or regulations, but those expectations rarely match what eventually unfolds.

As in the real world, no one can know the oil price ten years from now. Actors still commit to long-lived assets based on what they believe today. The result is that choices sometimes prove more costly than expected, progress may be delayed, and in the worst cases, bottlenecks emerge that hold back the transition.

¹iamconsortium.org/what-are-iams/W



Boundary conditions

NavigaTE focuses on decisions within shipping. Three external forces – trade demand, access to fuel supply, and technology maturation – set the playing field and are treated as inputs. The model then shows how actors respond within these three boundary conditions.

1 Trade demand

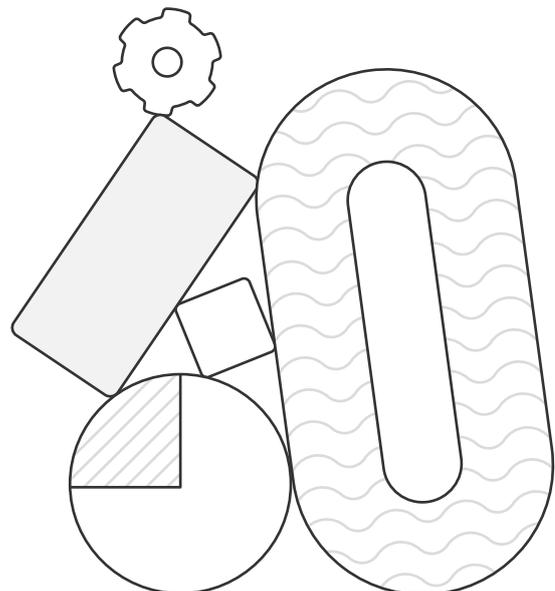
The model receives future trade demand per segment as an input, and each segment must meet that demand. We assume freight markets balance over time. Scrapping, newbuilds, and speed adjustments occur to prevent persistent over or undercapacity.

2 Access to fuel supply

Shipping competes with other sectors for feedstocks and plantbuild capacity. The share available to shipping is an input to NavigaTE, where fuel production scales only when shipping sends the necessary demand signal — if demand lags, supply does not expand.

3 Technology maturation

Costs and readiness for low-carbon fuels improve along preset global trajectories. These improvements occur over time regardless of shipping demand; and the model does not assume that the sector will be the only factor driving costs.



Decision-making

NavigaTE represents independent choices by owners, operators, and producers. Actors are exposed to the same market developments but do not act the same way or at the same time.



Owners

Newbuilds are assessed on net present cost over the vessel life, which covers capital cost and machinery-related operating cost, plus expected future fuel and compliance costs. The model looks ahead across the asset's life to infer likely fuel use, based on technology readiness, fuel availability, and infrastructure.

For energy efficiency measures, the model takes a net present value approach where future fuel savings are treated as revenue. However, real-world uptake is lower than the business case alone would suggest. To reflect this, a higher discount rate is used to put a larger emphasis on the capital cost limitations. Similarly, fuel conversions also use a net present value view with the additional limitation that conversion proceeds only when there is a surplus of the target fuel in order to avoid premature conversions.



Operators

At each time step, operators choose the fuel mix that satisfy operating requirements at the lowest cost, subject to constraints. The vessel must be compatible with the fuel, the fuel must be available at ports of call, and enough fuel must be used to satisfy the operating profile. Speed is treated as a lever to balance the expenses between fuel cost and charter rates. Lower speeds require additional vessels to meet the same trade target.



Fuel market

Plant buildout responds to a demand signal. Within shipping's allocated share of feedstocks and build resources, the model estimates future bunker demand by fuel pathway and scales capacity expansions based on that demand. New capacity is allocated across regions according to estimated production cost and investment risk.



Model inputs

With the concept, boundaries, and decision-making approach defined, a model is only as good as the quality of its input. In NavigaTE, input is not all “data” in the sense of historic measurements but includes assumptions about how the future might unfold. Data tells us what has happened, such as past emissions or the current number of ships in the fleet. Assumptions describe an expected development, such as how electricity prices may evolve or when various technologies become available in the future.

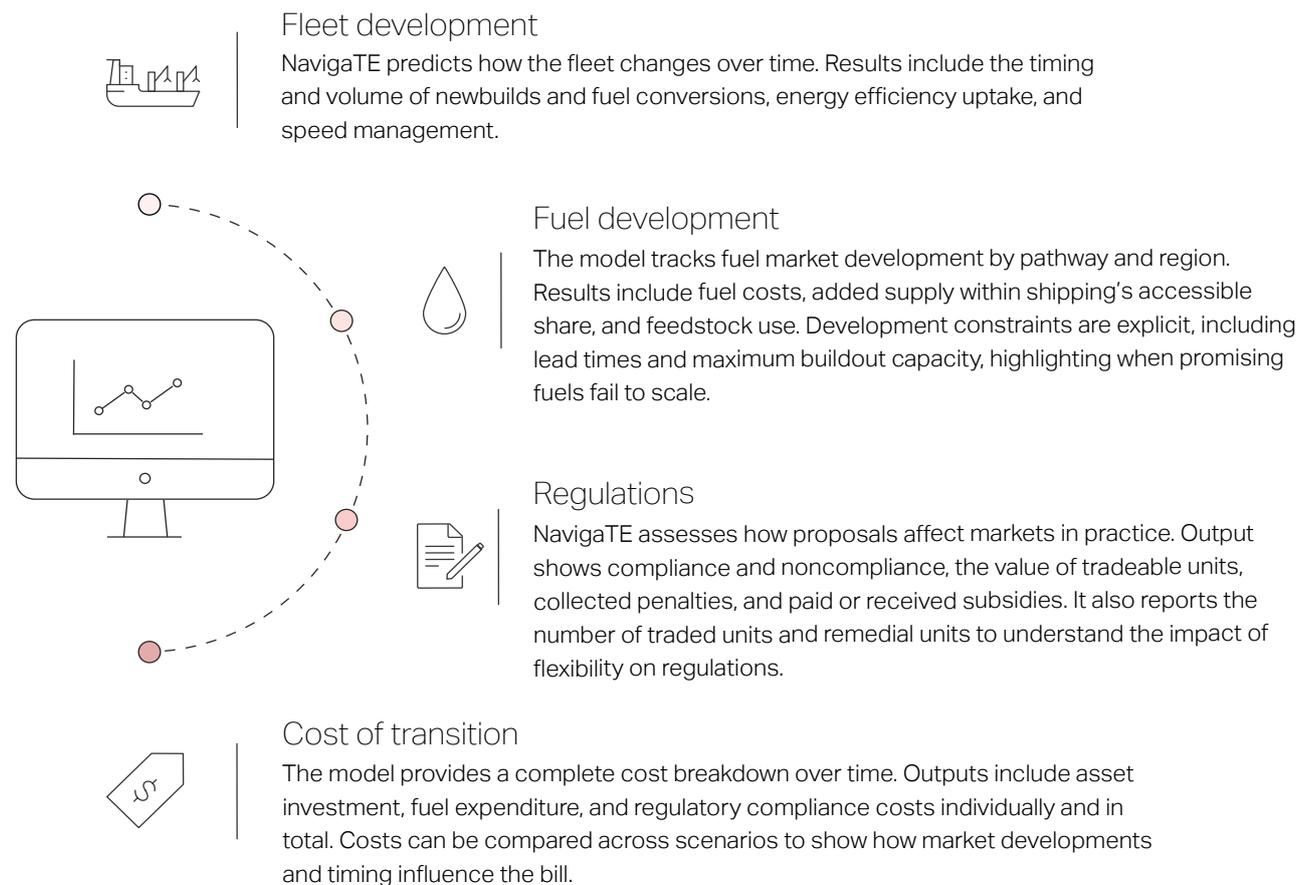
NavigaTE draws on several thousand such assumptions. Some are relatively fixed, like the physical properties of fuels or today’s fleet composition, while

others are highly uncertain, such as future feedstock prices or the cost-down of emerging technologies. Together, our assumptions span the full value chain, covering vessels, fuels, feedstocks, emissions, and regulations.

The results from NavigaTE are therefore a direct reflection of the chosen assumptions. It is not meaningful to say “NavigaTE says...” without also stating the input. NavigaTE simulates what is likely to happen, given a specific set of assumptions.

Model outputs

Drawing from the inputs, NavigaTE can simulate the following results:



Limitations

As is true for any model, NavigaTE makes simplifying assumptions about the world, particularly regarding the shipping industry's interaction with other sectors.

The wider energy market

NavigaTE only model part of the fuel market. Energy markets work in different ways. Some, like global oil or electricity in Europe, are highly liquid: prices change daily and are set by the balance of supply and demand. Others, such as ammonia or methanol, are not traded this way. New production plants are built only when someone guarantees in advance to buy the fuel. That means the risk of investment must sit on the balance sheet of a large, financially strong actor. Whether this is the shipping companies themselves, institutional investors, or states is not explicitly modeled. It is simply assumed that someone in the ecosystem carry the risk of underwriting offtake contracts so new plants can be built, and fuel can be sold at a fixed price, yielding a reasonable dividend for the investor.

NavigaTE assumes this is how the alternative fuel market will first develop: someone carries the investment risk, to catalyze the transition. The model does not place a hard limit on how much capital can be tied up, but it does assume that guarantees are in place so production can proceed.

Two further simplifications follow in our proxy of the energy markets. First, NavigaTE assumes that shipping alone will not drive cost reductions for new fuels. Instead, cost reductions are linked to the expectation that other sectors will also invest and help bring technologies and fuel pathways to scale. Second, shipping is only assumed to gain access to a share of global fuel production, since aviation, power, and other sectors will compete for the same molecules.

Together, these assumptions mean NavigaTE does not model the full dynamics of global energy markets. It represents shipping's part of the story, while treating wider market behavior as inputs.

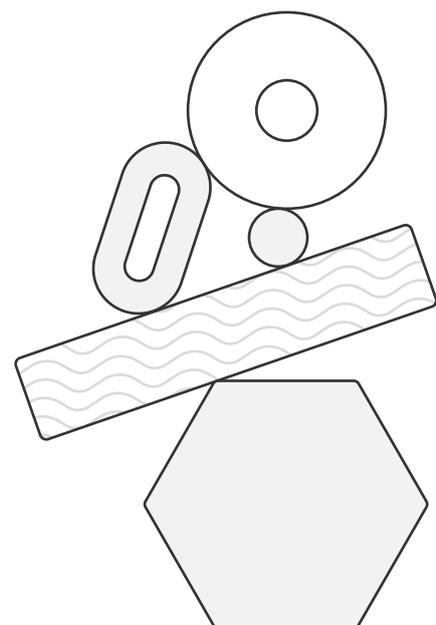
Averaged operating profiles

The operating profiles in NavigaTE are designed to capture overall energy demand and delivered cargo. Instead of simulating individual routes, the model uses distributions of speeds and cargo utilization, among others. This provides representative profiles across the fleet and ensures the global energy balance is adhered to.

The trade-off is that NavigaTE does not track where goods flow from or to. As a result, the model cannot estimate how costs will change for specific goods, trade corridors, or individual countries. Output should therefore be read at the system-wide level, not as route- or commodity-specific results.

No modeling of port infrastructure

The model includes ramp-up of fuel production and onboard technologies. Port-side bunkering infrastructure is not modeled. This is downprioritized because handling these molecules in ports is already established in cargo operations, and adapting those processes for bunkering is expected to be a solvable engineering task.



FAQ

NavigaTE comes with a set of default of assumptions and a baseline representation of the industry in terms of vessel segments, onboard technologies, fuel pathways, regulations, and more.

1. How does NavigaTE represent vessel segments and sizes?

To mirror the world fleet without modelling every ship, NavigaTE groups ships into 23 segment size classes. A segment covers vessels that carry similar cargo or do a similar job; and each segment is then split into one to four typical sizes. Every class stands in for many real ships that share costs, fuel needs, and sailing patterns.

2. What fuel technology options are included?

Each of the 23 classes can be fitted with four powertrain setups:

- a. Conventional oil/diesel (monofuel)
- b. Dual-fuel methane
- c. Dual-fuel methanol
- d. Dual-fuel ammonia

Battery electric, hydrogen, and nuclear options are not currently included in the model.

3. What onboard technologies and operational measures are modeled?

Each ship class can also adopt a range of efficiency and operational measures:

- a. Ten energy efficiency technologies
- b. Two wind-assist systems

4. Which fuel pathways and regions are considered?

NavigaTE tracks four fuel types: oil/diesel, methane, methanol, ammonia—across 12 unique fuels produced through 18 specific production pathways (fossil, bio, blue, and e-fuels). Fuel can be made in one of five world regions (Africa, the Americas, Asia-Pacific, Europe, the Middle East) and then shipped for bunkering elsewhere.

5. How are emissions calculated?

For every fuel and choice of technology, the model tracks well-to-wake emissions of the three main greenhouse gasses (GHG): carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). It does not currently track non-GHG pollutants (NO_x, SO_x), less quantifiable GHG pollutants such as black carbon or the embodied emissions from building ships and infrastructure.

6. Which regulations are modeled?

NavigaTE models both regional and global regulations. Currently four regulations are included in the model:

- a. IMO Net-Zero Framework (IMO NZF)
- b. Carbon Intensity Indicator (CII)
- c. FuelEU Maritime
- d. EU ETS

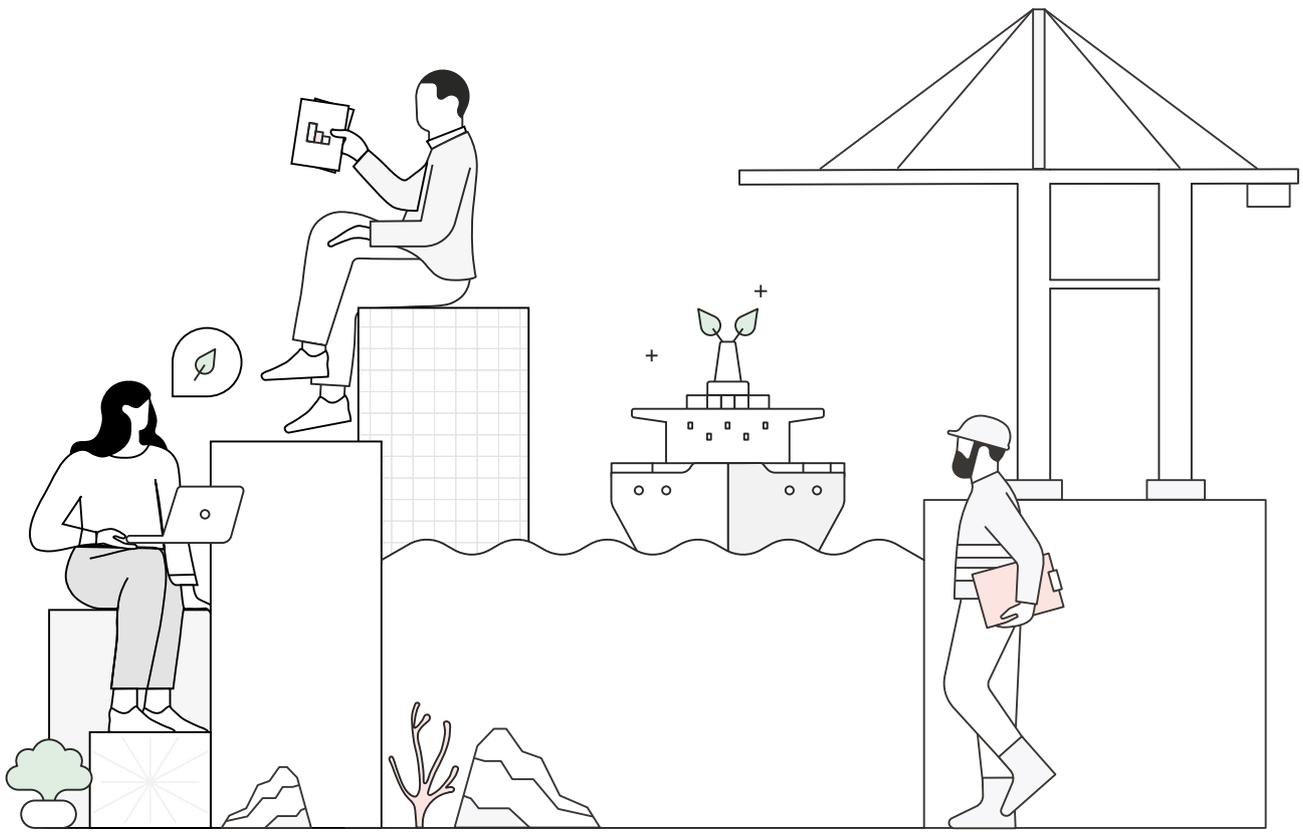
7. What is the timing and availability of new technologies?

Many options phase in gradually. Dual-fuel methanol or ammonia engines for smaller vessels, and fully sustainable bio-oils, first appear after 2030. For larger vessels, dual-fuel methanol is now available, while ammonia will be ready in 2027. These “readyby” dates ensure technology only enters the mix when it is realistically available.

8. Is the framework flexible?

NavigaTE can handle more segments, engines, fuels, regions, emissions, and regulations whenever reliable data exist. The current set of options reflects where solid assumptions currently exist; new building blocks can be added as evidence and stakeholder needs evolve.





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