WHITE PAPER

Why Resolution Wins in Weather Routing

A routing grid that is finest where your vessels navigate close to land, so every route follows the real coastline, the zones you set and the weather on the way.

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SUMMARY

01

Introduction

A route can only be as accurate as the map of the ocean it is calculated on.

Most modern routing engines divide the ocean into a grid of points and search it for the best path. If the grid is too coarse, the route misses changes in the weather and cuts corners near the coast. If it is fine everywhere, it becomes too large to search quickly.

VesselFront uses a variable-resolution hexagonal grid: fine along coastlines, in port approaches and through straits, coarser in open water. Routes follow the real coastline and the real boundaries of the zones you set, and are calculated in seconds.

24M+
Nodes in the routing grid

3
Resolution zones, from the coast to open water

CERTIFICATION

VesselFront's routing is SMART EnE3-Em-W certified by Bureau Veritas (2026). Each recommendation is presented with the limits and forecast it was generated under.

THE BASICS

02

Grids, graphs and search

Underneath, grid-based weather-routing engines all work the same way: they turn the ocean into a graph and search that graph for the best route.

Grid and graph

The **grid** divides the ocean into cells; the centre of each cell is a point the route can pass through. The **graph** is those points plus the connections between neighbouring cells. A route is a chain of connections from departure to destination.

VesselFront's cells are **hexagons**. Within each resolution zone, every hexagon has six neighbours, all at the same distance from its centre, so each step of the route is measured the same way in every direction.

Node

The centre of a hexagonal cell at sea: a point the route can pass through.

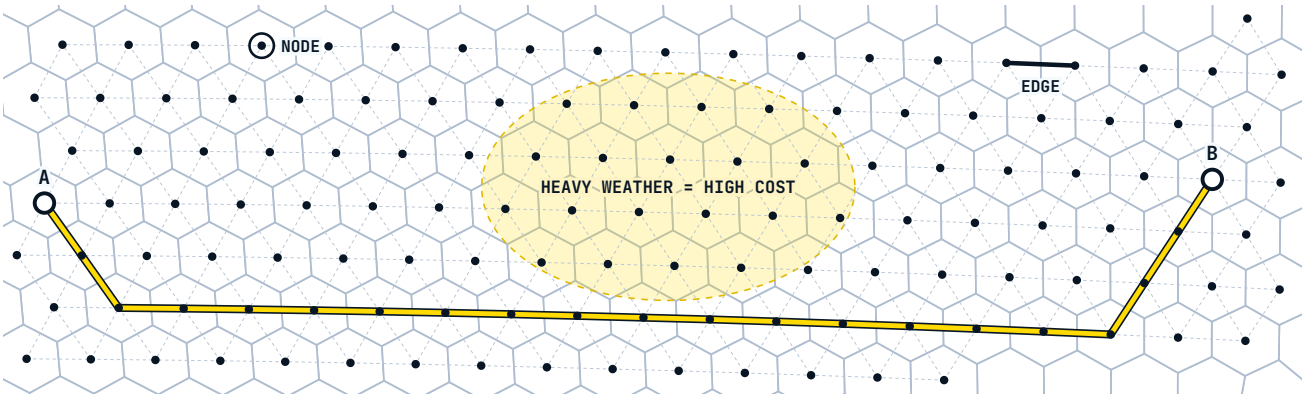
Edge

A connection between two neighbouring nodes: one possible leg of the voyage.

Cost

What it takes to sail an edge (time, fuel or weather exposure), worked out from the forecast for when the vessel would be there.

Figure 1. From graph to route: the lowest-cost chain of edges from A to B



Illustrative. The route passes around the high-cost area because that chain of edges costs less in total. VesselFront

Search algorithms

A search algorithm explores the graph to find the chain of edges with the lowest total cost. With millions of nodes, checking every possible route one by one is not practical, so the algorithm needs a way to decide which nodes to explore first.

Informed search and admissibility

VesselFront's route search is an **informed search**. At each step it adds the cost already sailed to an **estimate** of the cost still to go, and explores the most promising nodes first. This estimate is called the **heuristic**.

A heuristic is **admissible** when it never overestimates the real cost still to go. With an admissible heuristic, this kind of search returns the **lowest-cost route** on the graph: no other route through the graph, under the same constraints and forecast, costs less.

On a variable-resolution grid, the heuristic has to stay admissible where coarse and fine cells meet. VesselFront's heuristic is designed to do so across the whole grid, from berth to berth.

WHY IT MATTERS

The lowest-cost route is found on the graph the search runs on. The finer and more accurate that graph is where it counts, the closer the optimal route on the graph is to the best route at sea.

THE CHALLENGE

03

Why resolution matters

A routing grid has to meet three demands that pull in opposite directions.

Weather detail

Edges must be short enough to capture how wind and waves change along the way, so a weather system is not averaged out.

Coastal accuracy

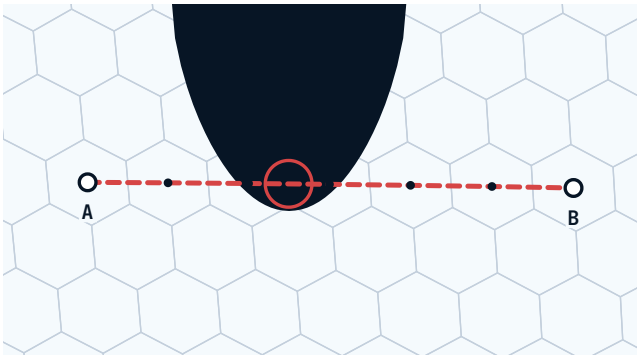
Near coasts, islands, ports and shallow water, edges must be short enough that the route cannot cut across land or a depth contour.

Speed

The graph must stay small enough to search quickly. Halving the spacing everywhere roughly quadruples the number of nodes.

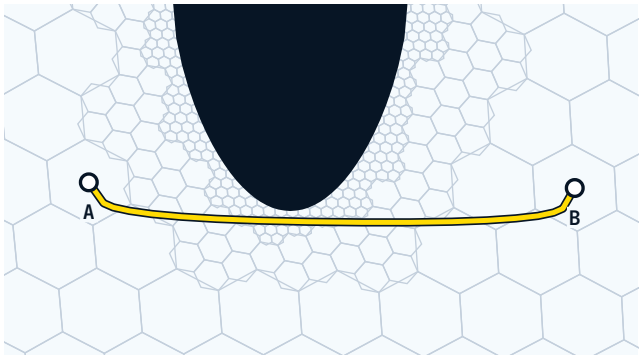
A grid with the same spacing everywhere meets at most two of the three. Figure 2 shows what happens near the coast when the grid is too coarse.

Figure 2. Rounding a headland on two grids



Coarse grid

The nearest nodes sit on either side of the headland. The edge between them crosses land.



Variable-resolution grid

The grid refines around the headland. The route passes it at sea.

Illustrative. Not to scale.

VesselFront

HOW IT WORKS

04

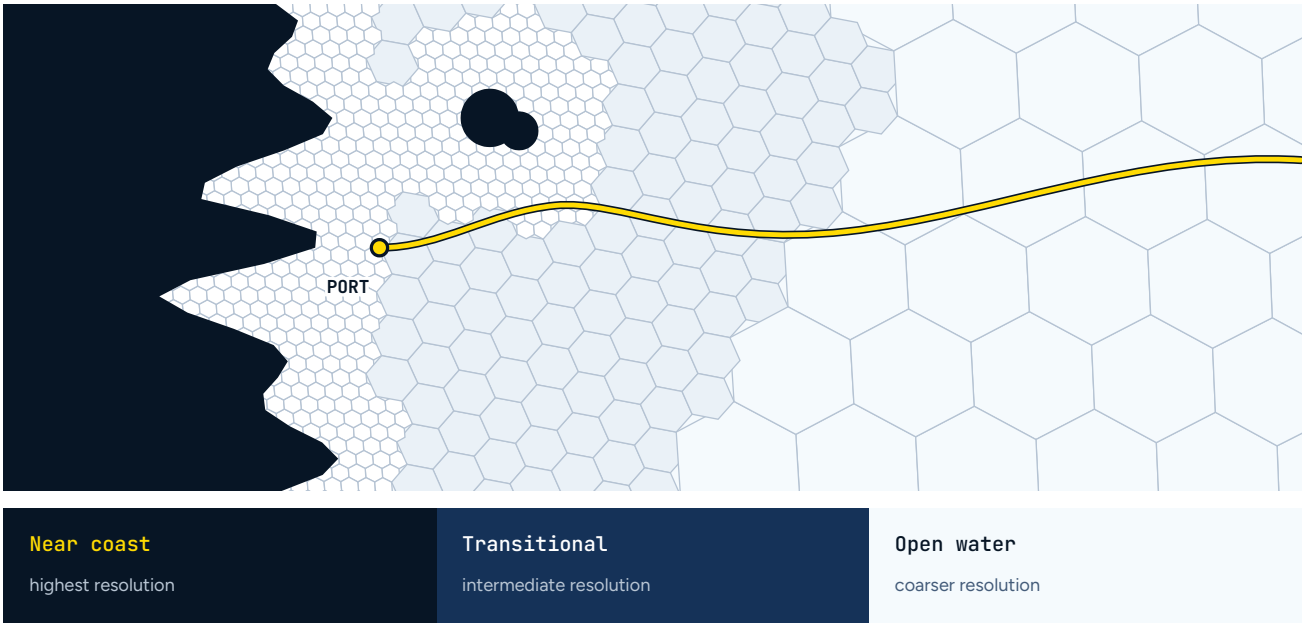
The variable-resolution grid

Fine where it matters, coarser where it does not.

The VesselFront grid has more than 24 million nodes, at the centres of hexagonal cells arranged in three resolution zones. Cells are smallest near the coast and largest in open water. It is densest along coastlines, in port approaches, through straits and traffic separation schemes, and becomes coarser in the open ocean, where the weather, not the geography, sets the detail needed.

Zone	Where it applies	Resolution	What it gives you
Near coast	Coastlines, port approaches, straits, traffic separation schemes, shallow water	HIGHEST	No corner-cutting across land or depth contours; avoid-zone, ECA and draft limits followed closely
Transitional	Between the coastal zone and open water	INTERMEDIATE	A gradual change in spacing, so the route moves on and off the coast without a break
Open water	Open ocean	COARSER	Enough detail to follow the weather, with fewer nodes to search, so results come back in seconds

Figure 3. The routing grid adapts its resolution to the operating area



Illustrative. Exact settings depend on the deployment.

One connected grid

The three zones form a single connected grid. A route passes from open water into a port approach without a break or a jump at the boundary, and the same constraints (weather limits, latitude bounds, avoid zones and ECA minimisation) apply across the whole grid.

ON THE PLATFORM

05

What the grid gives you on the platform

The grid is what makes the limits, zones and ECA figures on each route accurate.

1

Avoid zones are followed as defined.

War-risk, sanctions, piracy high-risk and customer-defined zones are applied at the grid's local resolution. Where a zone boundary runs close to a coast or through a strait, the grid is at its finest, so the route keeps out of the zone itself, not out of a rough approximation of it.

2

ECA miles are calculated on the real boundary.

Emission Control Areas follow the coastline. A coarse grid either cuts their corners or rounds them outward, and misstates the miles inside. The variable-resolution grid follows the boundary, so ECA minimisation works on accurate distances. Since 1 May 2025 the Mediterranean Sea is an ECA, so this applies to every Mediterranean voyage.

3

Shallow water is excluded while the route is built.

Because the grid is dense over coastal and shelf areas, water shallower than the vessel's draft plus a 10% screening margin is excluded during the search, not filtered out afterwards.

4

Re-routes continue the original plan.

When a new forecast arrives, the remaining voyage is re-optimised from the vessel's current position on the same grid. The new route continues the original optimisation rather than being recalculated on a different map.

5

Results in seconds.

Because open water needs fewer nodes, the search stays fast. Alternatives such as a different departure time or a different avoid zone can be compared before a decision is made.

FOR YOUR TEAM

06

What it means for your team

Commercial and operations managers

Routes come back in seconds, so departure times and avoid-zone choices can be compared before a voyage is fixed. Re-routes follow as forecasts update.

Technical managers and superintendents

Draft screening and distance from the coast are applied at the grid's finest resolution, inside the route search rather than as a later check.

Charterers and claims teams

ECA miles and avoid-zone compliance are calculated on the actual boundaries and stated in the voyage report, giving a documented basis for charter-party and claims discussions.

Masters

Re-routes continue the same plan on the same grid. Every output is a recommendation; the decision stays with the master and operator.

SCOPE

07

Scope

- **Supports passage planning; does not replace it.** Charts, tides, under-keel clearance and the passage plan remain with the bridge.
- **Optimal within the inputs.** The route is optimal on the grid, under the constraints set and the forecast available. Routes are re-evaluated as forecasts update.
- **Figures are illustrative.** Figures 1 to 3 show the principle; cell sizes are not to scale.
- **Advises; the master and operator decide.** Every output is a recommendation.

IN SUMMARY

→

Key takeaways

Fine where it matters

Highest resolution at coasts, ports, straits and traffic lanes; coarser in open water, where the weather sets the detail.

Boundaries as they are

Avoid zones, ECAs and shallow water are applied at the grid's local resolution, not at a coarse approximation.

Optimal by design

Informed search with an admissible heuristic returns the lowest-cost route on the grid, under the constraints and forecast used.

One grid, start to finish

More than 24 million nodes in one connected hexagonal grid. The original route and every re-route run on the same grid.

See it on one of your own voyages

VesselFront is in closed beta with rolling admissions, working with Greek-owned fleets. Request a demonstration on a route you know.

vesselfront.com

SMART EnE3-Em-W BV 2026

VesselFront is a routing-intelligence layer for commercial fleets. Its neurosymbolic route optimisation (USPTO patent-pending) combines learned routing patterns with the hard limits of physics, regulation and vessel capability, weighing weather, fuel, compliance and risk on every voyage. Routing certified to SMART EnE3-Em-W by Bureau Veritas (2026); weather models validated against hindcast data under an ESA research contract.

Mediterranean Sea ECA: IMO Resolution MEPC.361(79), sulphur limit applicable from 1 May 2025. Figures 1 to 3 are illustrative. Platform behaviour as of October 2026; settings may vary by deployment. VesselFront reserves the right to make technical changes to the contents of this document without prior notice. Reproduction or disclosure to third parties without prior written consent of VesselFront I.K.E. is not permitted.