

DISCUSSION BRIEF

Weather routing in the Leeward and Windward Islands for Alpha Zulu: schedule-keeping and auxiliary electric energy preservation

Prepared for operational discussion of AZ1–AZ6. Draws on the September 2026 route-map climatology and on BERS (arXiv:2605.31533), a just-in-time maritime weather-routing method. Distances and winds below are as published on the route maps and are not for navigation.

Vessel class	Alpha Zulu, 40 m × 23 m sail-cargo trimaran, sub-500 GT, ~1,000 m² mechanised rig, solar on three hulls, retractable electric propulsion
Energy rule	Wind primary. Electric power when the schedule requires it. Target quiet electric endurance 200 hours; 2,000 nm electric range target. Hydrogen path is growth, not the baseline burn.
Timetable	Same route, same day, every week. Barbados interchange hub. Daylight port calls, overnight passages, staggered loops.
Climatology	Three-year lane winds, 1 Sep 2022 – 31 Aug 2025, on the AZ1–AZ6 port-to-port maps (RoPAC / Champion Maritime, September 2026).
Method reference	Precioso, Suárez, Jiménez de la Jara, Ballester-Ripoll, Gómez-Ullate. BERS: locally optimal continuous routing with just-in-time arrival. arXiv:2605.31533, 29 May 2026.

1. Purpose of the discussion

Alpha Zulu is a timetable machine that happens to be a sailing vessel, not a sailing vessel that happens to keep a timetable. The weekly slot, the daylight call, and the Barbados interchange are hard constraints. Auxiliary electric energy — battery and, later, hydrogen — is the scarce stored resource that makes those constraints survivable when the trade is on the nose, the passage is rough, or a squall line has taken the rig off. Weather routing exists to spend as little of that resource as possible while still making the gate.

This brief sets out what the published lane climatology implies for that trade-off, where a just-in-time continuous router such as BERS helps, and where the island chain breaks the open-ocean assumptions of that method. It is written to force five decisions: the interchange tolerance, the definition of the electric budget, the authority to deviate, the legs on which a longer track is allowed, and the solver architecture.

2. Operating picture

Six complementary loops, one hull class. Barbados is the hub. Calls are in daylight; passages are overnight where the distance allows. The rig is fully mechanised and load-sensing. Propulsion is retractable electric, with independent redundancy. Hotel load is not optional: eight insulated compartments can be frozen (−18 °C), chilled, cool, or ambient, and that load runs whether the vessel is reaching or beating. Solar across three hulls offsets hotel load in daylight and does almost nothing on an overnight passage. Arrival state of charge is therefore what was sailed in with, minus reefer and ship service, plus any fuel-cell contribution.

Published loop distances (approximate, not for navigation): AZ1 Mainland–Hub–Northern Link, Guyana–Barbados–Dominica–Barbados–Guyana, 1,010 nm, 4 calls; AZ2 Southern Windward, Trinidad–Grenada–SVG–Saint Lucia–Barbados–Trinidad, 525 nm, 5 calls; AZ3 Leeward Connection, Barbados–Dominica–Antigua–Dominica–Barbados, 560 nm, 4 calls; AZ4 Windward shuttle, Barbados–Saint Lucia–SVG–Grenada–SVG–Saint Lucia–Barbados, 470 nm, 6 calls; AZ5 Southern Mainland, Guyana–Trinidad–Grenada–SVG–Guyana, 900 nm, 4 calls; AZ6 breadbasket shuttle, Guyana–Trinidad–Guyana, 306 nm, 2 calls.

3. What the three-year winds actually say

The maps are climatology of the rhumb, not a forecast and not a recommended track. Mean wind on every published lane sits between 11.9 and 14.3 kt, from 085–093° — a remarkably steady easterly. December is the peak month on the island legs (means about 15–16 kt). The cross-lane component is about 11–13 kt on almost every leg. The along-lane component, defined on the maps as the wind component in the direction of travel, is usually much smaller. The design point of the island network is a beam reach in 13 kt of trade, not a run and not a beat. That is a favourable regime for a 40 m trimaran with a large rig, and it is why electric preservation is achievable on most legs if the router is forbidden from motoring early.

The exceptions are the schedule. They are few, they are stable in the mean, and they concentrate the electric budget.

Leg	nm	Wind	Along	Cross	Reading for the timetable
AZ1 Guyana → Barbados	400	11.9 kt / 087°	−6.3	11.1	Longest adverse leg. Dominates weekly electric use.
AZ1 Barbados → Dominica	—	14.3 / 090°	+10.1	10.1	Recovery reach after the mainland beat.
AZ1 Dominica → Barbados	—	14.3 / 090°	+10.1	11.8	Recovery. Do not motor a gift leg.
AZ1 Barbados → Guyana	400	11.9 / 087°	+6.3	11.1	Energy-restoration passage. Sail it.
AZ3 Barbados → Dominica	—	14.3 / 090°	+0.3	13.0	Pure beam. Rhumb is enough. Electric idle.
AZ3 Dominica → Antigua	85	13.6 / 088°	−3.8	12.7	Hardest island beat. Electric-risk leg of AZ3.
AZ3 Antigua → Dominica	85	13.6 / 088°	+3.8	12.7	Payback leg. Restore state of charge.
AZ4 Saint Lucia → SVG	49	13.7 / 091°	+11.1	12.5	Gift leg of the shuttle. Bank time here.
AZ4 SVG → Saint Lucia	49	13.7 / 091°	−2.7	13.2	Northbound adverse. Assist only if the window slips.
AZ4 Barbados → Saint Lucia	90	13.7 / 088°	−2.0	13.2	Mildly adverse. Short. Squall risk exceeds mean-wind risk.
AZ2 Trinidad → Grenada	83	12.7 / 089°	+6.4	11.7	Short AZ2 leg. Sea state, not distance, is the routing question.
AZ2 Barbados → Trinidad	175	12.7 / 089°	−2.6	12.5	Long closing leg. Needs reserve intact at the hub.
AZ6 Guyana → Trinidad	153	12.9 / 085°	+10.6	7.4	Largest along-lane gift. Simple sail-it rule.
AZ6 Trinidad → Guyana	153	12.9 / 085°	−10.6	8.5	Largest along-lane debit. The calibration leg for kWh/nm.

Table 1. Selected lanes from the AZ1–AZ6 maps. Along-lane is the published wind component in the direction of travel (kt). Highlighted rows are the electric-budget legs. “—” means the map gives the loop distance but not a separate leg length. December means on island legs run about 1–2 kt above the annual mean.

4. Where the electric budget actually goes

Three legs set the weekly auxiliary bill. Everything else is noise around a beam reach.

Guyana → Barbados (AZ1), 400 nm, −6.3 kt along-lane.

At 8–10 kt through the water this is a 40–50 hour passage, close-hauled or cracked off, with an 11 kt cross component. It is the only leg long enough for a continuous open-ocean router to earn its keep. A rhumb-line beat spends electric to hold schedule. A longer reaching track can cut propulsive energy and still make a Barbados daylight arrival, which is exactly the just-in-time formulation: fix the arrival, minimise energy, do not minimise time. The return, Barbados → Guyana, is +6.3 kt along-lane and is the restoration passage. If the northbound burned the reserve, the southbound must be sailed.

Dominica → Antigua (AZ3), 85 nm, −3.8 kt along-lane.

Short, adverse, and inside the island chain. Eighty-five nautical miles at a 7 kt VMG is about 12 hours; at 5 kt it misses a daylight call. The cross component is still 12.7 kt, so the rig is not blanketed — it is being asked to point. The correct first move is to crack off into the trimaran’s high-VMG close-reaching band and accept a longer track, not to motor the whole leg. Electric assist belongs in the last portion, and only if the Antigua daylight gate is actually threatened. Antigua → Dominica (+3.8 kt) pays the energy back if the vessel is required to arrive with reserve rather than early.

Trinidad → Guyana (AZ6), 153 nm, −10.6 kt along-lane.

The cleanest experiment in the network. The reverse leg is +10.6 kt. One direction should show near-zero propulsive kilowatt-hours; the other is the measured cost of schedule-keeping against the trade on an east–west axis. Use AZ6 to calibrate kWh per nautical mile of auxiliary assist before writing thresholds for AZ1.

A fourth debit sits on the AZ2 leg Trinidad → Grenada (83 nm). The mean wind is not the problem (+6.4 kt along-lane, 12.7 kt). On this short Alpha Zulu leg the question is sea state and departure hour inside the daylight window, not a great-circle deviation. Motoring a contrary swell to save an hour spends auxiliary energy for no slot gain. No other vessel class is in this discussion.

Hotel load sits outside these legs and inside the same battery. A longer, kinder track that saves propulsive energy can still increase reefer energy if it adds hours. The objective has to be total electric energy to the gate — propulsion plus hotel — not propulsive energy alone.

5. What BERS contributes, and what it does not

BERS (Bézier Evolve and Refine Strategy) is a two-stage weather router. A covariance-matrix evolution strategy searches globally over routes drawn as Bézier curves; a variational refinement (FMS) then enforces local optimality. Routes are scored by dense sampling along the path, so mid-segment wind, wave, and land contact count. The authors test seven operational criteria: spatial continuity, obstacle avoidance, dynamic adaptation, flexible objectives, constant engine load, just-in-time arrival, and local optimality.

The result that matters for Alpha Zulu is the just-in-time formulation. Voyage duration is fixed. Instantaneous speed comes from geometry and the remaining time. The solver minimises energy. On 366 daily departures in 2024, forced by hourly ERA5, an 88 m cargo ship with optional rigid wingsails (four × 138 m², 552 m² total) used 23–59% less propulsive energy than the great-circle of the same propulsion mode. With wind-assist, savings reached about 75% on the Pacific corridor. Local refinement cut wave-height violations from as high as 22% after the evolutionary stage to about 1%. Seasonal savings with wind-assist were much larger in winter than in summer, which is a warning: headline percentages from a North Atlantic or North Pacific winter do not transfer to a 13 kt tropical trade.

Two limits are decisive for this network. First, the validation ship is an 88 m single-skeg cargo vessel, not a 40 m trimaran; savings scale with sail area, polar, and hotel load, and the paper says so. Second, a single Bézier with few control points cannot hold a narrow fairway. The authors flag Suez and Panama. The Eastern Caribbean equivalent is the set of Alpha Zulu gates: the channels on AZ2, AZ3 and AZ4, and the reef-constrained approaches to the RoPAC calls, Bridgetown above all. A pure BERS track will cut a corner or refuse the passage. The usable architecture is hybrid: a gate graph for the chain, and a BERS-style continuous solver only inside the open corridors — above all Guyana–Barbados and the Atlantic side of the Windwards.

ERA5, which BERS uses, also does not see island acceleration, lee shadow, or channel jets. The three-year means on the route maps are the right climatological prior. The forecast used on the day has to be bias-corrected in the last 20 nm, or the electric assist will be spent correcting a model that was never going to be right under the lee of Dominica.

6. Routing doctrine proposed for discussion

The doctrine below is a proposal, not an adopted procedure. It is the smallest set of rules that keeps the railway timetable and treats auxiliary electric energy as a reserve for gates, not as a cruise mode.

- 1. Fix the gate, minimise electric energy.** Adopt the BERS just-in-time objective, not a minimum-time objective. Early arrival that then waits at anchor has burned reserve for no slot gain. Speed above the schedule on a beam reach is waste.
- 2. Electric is a schedule instrument.** Motor-sail only when predicted arrival leaves the daylight window or the Barbados interchange tolerance. The threshold is an ETA slip, not a wind-angle discomfort.
- 3. Bank time on the gift legs.** Saint Lucia → SVG (+11.1), Barbados → Dominica on AZ1 (+10.1), Guyana → Trinidad (+10.6), and Barbados → Guyana (+6.3) are sailed at or below schedule speed. They restore state of charge and they buy slip tolerance for the adverse leg that follows.
- 4. Crack off before motoring.** On Dominica → Antigua and Guyana → Barbados, a longer track inside the close-reaching band is preferred to a motored rhumb, provided the gate still holds. Track length is cheap. Stored kilowatt-hours are not.
- 5. Reserve the last of the budget for gates and squalls, not for open water.** Night arrivals and convective lines on the short Windward legs are where assist is legitimate even if the mean wind is fair. Open-water pointing is not.

6. **Count hotel load.** The objective is propulsion plus reefer plus ship service to the gate. A 90-minute longer reach that saves 40 kWh of propulsion and adds 50 kWh of frozen hold is a loss.
7. **Do not punch a cyclone to save the slot.** June–November schedule risk is the tropical cyclone, not the mean trade. Deviation authority should sit with the shore timetable controller using hub slack, not with a vessel burning reserve to hold a rhumb. South of the dangerous semicircle and a missed week is a better outcome than an empty battery on a lee shore.
8. **Hybrid solver.** Gate graph through the passages. Continuous Bézier optimisation, land-penalised and wave-constrained, only between gates. Multi-model forcing (the Ocean OS suite already assumes this). Recursive update of the polar and of the assist threshold from logged VMG and state-of-charge delta on every leg.

7. Loop-by-loop implications

AZ3 — Leeward Connection. The clean island case.

Barbados → Dominica is a beam reach (+0.3 kt along, 13 kt cross). Sail the rhumb, electric idle, arrive in daylight with the reserve untouched. Dominica → Antigua is the only decision on the loop: crack off, recompute the daylight gate, assist only the tail. Antigua → Dominica restores. Dominica → Barbados on the return is the same beam. AZ3 should be operable with near-zero propulsive electric in the mean season, and with a defined assist budget only on the 85 nm northern leg in a reinforced trade or a north-going squall line.

AZ4 — Windward shuttle. Coupling, not distance.

Six calls in 470 nm. No single leg is long enough for an open-ocean router to matter. The southbound sequence carries the positive along-lane numbers (Saint Lucia → SVG at +11.1 kt is the outlier gift). The northbound sequence is mildly adverse (−2.0 to −2.7 kt). Policy: sail southbound at schedule speed and bank the time; allow assist on the northbound sequence only if cumulative slip threatens the Barbados return. Wet-season routing on this loop is convective avoidance — a squall that forces a reef, then a motor, costs more than a 5 nm track change in the morning. December means near 15 kt are the annual wind peak and should be in the polar, not treated as a warning.

AZ2 — Southern Windward, including the rough gate.

Trinidad → Grenada is a sea-state departure decision. Delay inside the daylight window rather than motor the passage. Saint Lucia → Barbados is favourable (+7.7 kt along-lane). Barbados → Trinidad, 175 nm at −2.6 kt, is the long close of the loop and the reason the hub call must not be used to empty the battery on a short hop. A vessel that leaves Barbados for Trinidad with a depleted reserve has already failed the week.

AZ1 and AZ5 — mainland exposure.

AZ1 holds the strategic energy problem and the only corridor where BERS-style continuous optimisation should be run daily: Guyana → Barbados, fixed Barbados daylight arrival, minimise total electric energy, land and wave as hard penalties, current (Guiana / North Equatorial) in the segment model. Barbados → Dominica and the return are recovery reaches and should be excluded from assist by rule. AZ5 repeats the pattern at one remove: SVG → Guyana is favourable in the mean (+4.1 kt along-lane, 13.5 kt); the electric question is the northbound and the Trinidad–Grenada gate, not the open southern leg.

AZ6 — the measuring stick.

306 nm, two calls, ±10.6 kt along-lane. Adopt a strict sail-the-favourable, assist-only-the-adverse rule, log propulsion and hotel kilowatt-hours separately, and do not generalise any other loop's threshold until AZ6 has produced a season of actual kWh per nautical mile.

8. Decisions the discussion should take

1. What is the Barbados interchange tolerance, in minutes, before a connection is lost? Without that number the just-in-time constraint is rhetorical.
2. Is “auxiliary electric energy” battery state of charge, hydrogen kilograms, propulsion kilowatt-hours, or propulsion plus hotel? The cold chain has to be inside or explicitly outside.

3. On Dominica → Antigua and Guyana → Barbados, is a longer reaching track acceptable when it protects state of charge but consumes daylight margin?
4. Who authorises a cyclone deviation — vessel Ocean OS, or the shore timetable controller? The recommendation here is shore, using hub slack.
5. Is BERS adopted as the open-corridor solver only, with a passage-gate graph in front of it, or is a single continuous track still in contention? The paper's own narrow-waterway result argues against the single track.
6. What assist threshold is provisional until AZ6 has calibrated kWh/nm — a fixed wind angle, a predicted ETA slip, or a predicted state-of-charge floor at the next gate?

9. Sources and limits

Alpha Zulu Route Network — Port-to-Port Maps AZ1–AZ6, RoPAC / Champion Maritime Limited, September 2026. Lane winds are three-year means and monthly peaks, 1 September 2022 – 31 August 2025. Distances are approximate port-to-port estimates. The maps state they are not for navigation. Vessel particulars and the timetable principle (“sail when nature provides it; electric power when the schedule requires it”) are as published on ropac.ai.

Daniel Precioso, Francisco Suárez, Javier Jiménez de la Jara, Rafael Ballester-Ripoll, David Gómez-Ullate. BERS: Locally Optimal Continuous Algorithm for Maritime Weather Routing with Just-in-Time Arrival. arXiv:2605.31533, submitted 29 May 2026. Energy figures cited above are the authors' comparisons against great-circle baselines of the same propulsion mode on 2024 ERA5, Atlantic and Pacific corridors, 88 m cargo vessel. They are not Alpha Zulu predictions.

This brief does not compute an Alpha Zulu polar, a state-of-charge trajectory, or a recommended track. Those require the load-sensing rig polar, the hotel-load schedule, and a forecast, none of which are in the two source documents.