META AIS · MARITIME AI & VOYAGE ECONOMICS BRIEFING

AI Maritime AIS Anomaly Detection & Voyage P&L Digital Twin Guide

600K+ AIS Trajectory Preprocessing · Hybrid Isolation Forest / LSTM-AE Architecture · Executive Walkthrough of the 3 Live Showcase Twins

TRAINING CORPUS	DETECTION PRECISION	HYBRID WEIGHTING	COMMERCIAL LINK
600,000+ AIS	97.4% Verified	Rule 0.55 : AI 0.45	Working C/B & PDA

01. Purpose & Strategic Value — Beyond Conventional AIS Position Plotting

Traditional AIS trackers merely plot vessel coordinates on a map, failing to distinguish **open-sea engine blackout drifting**, **hull-fouling fuel leakage**, or **anchor dragging** from benign operational maneuvers—generating severe alert fatigue. **META AIS** fuses vessel kinematics, deep time-series anomaly models, charterparty **Sailing Instructions**, and **live Working CharterBase (C/B) voyage economics** into a unified decision-support platform.

Operational State	Engine & Order	Kinematic & Trajectory Signature	AI Detection & Commercial Cross-Check
1. Drifting (NUC) [Open Ocean]	Main Engine Off Uncommanded	Sudden SOG drop in open sea (e.g., 13.4→1.2 kn) with sharp divergence between Heading (HDG) and Course (COG)	Current/wind dead-reckoning vector correlation + PoL corridor kinematic anomaly trigger
2. Under-Performance [Open Ocean]	Engine Running No Slow Order	Sustained speed drop below warranted curve (e.g., -2.5 kn) under normal RPM/weather conditions	LSTM-AE / Speed-Power curve residual + absence of slow-steaming order → Hull cleaning & claim evidence
3. Slow Steaming [Open Ocean]	Eco-Load Running Order Active	Reduced speed with stable heading-course alignment and planned eco-fuel burn profile	Cross-checked against active **Sailing Instructions** to prevent false under-performance alarms
4. Route Deviation [PoL Corridor]	Engine Running Detour Check	Cross-track excursion beyond historical Pattern-of-Life safety band (XTE > ±5.0 nm)	Validates weather routing approval; flags unauthorized shallow-water or corridor exits
5–6. Berth / Anchor / Wait [Port Waters]	Moored / Swinging Port Geofence	Quay-parallel mooring (Berthing), ~100m swing arc (Anchoring), or 10 NM outer loitering (Waiting)	Port polygon Geofencing + ST-DBSCAN clustering; triggers **Anchor Dragging** if swing radius breaks

02. Four-Stage Time-Series AIS Data Engineering Pipeline

Raw VHF AIS streams suffer from packet dropouts, inland coordinate jumps, and variable reporting intervals (2s to 3m). META AIS preserves immutable raw files (SHA-256) and executes a rigorous four-stage mathematical conditioning pipeline:

STEP 1 · Quality & Map Match

Removes invalid MMSI, sentinel noise, duplicate timestamps, and inland coordinate jumps via coastline map matching.

STEP 2 · Resampling & Gaps

5/10-min regularization; short gaps reconstructed via local **Lagrange Interpolation**; long blackouts split cleanly without artificial bridging.

STEP 3 · 2D Kalman Smoothing

Kinematic state-space **2D Kalman Filter** suppresses SOG/acceleration spikes while preserving true physical vessel motion.

STEP 4 · RDP Compression

Meter-based **Douglas-Peucker** retains critical turning points and derives acceleration, ROT, and HDG-COG delta vectors.

03. Hybrid AI Scoring Formula & Priority Triage Funnel

To ensure explainability and maritime rigor, META AIS blends domain naval-architecture physics rules with unsupervised machine learning (`Isolation Forest, n_estimators=200` & `LSTM-Autoencoder`):

Hybrid Anomaly Scoring Equation:

`Hybrid Score = (0.55 × Rule_Physics_Score) + (0.45 × AI_Model_Score)` [Scaled 0–100; **Alert Threshold > 75 pts**]

* Field-Proven Triage Funnel: Compresses **3,260** candidate events → **655** high-score candidates (75 ships) → **187** recent events → **61** context-verified reviews → **10 Priority-1 (P1) actionable investigations**, eliminating over 99% of operator alert fatigue.

04. Executive Walkthrough of the Three Interactive Showcase Screens

The three live modules on the `ailogi.ai` portal demonstrate a complete closed loop: **(1) Real-time Navigational Safety → (2) Hull/Engine Fuel Diagnostics → (3) Fleet-wide Voyage TCE & Port PDA Accounting**.

Screen 01 · AI AIS ANOMALY DETECTION & POL CORRIDOR RADAR

01 / AIS ANOMALY RADAR

- **Standard Pattern-of-Life (PoL) Corridor (Cyan Band):** Visualizes historical safe shipping lanes across Korea–China–Japan corridors (Qingdao/Shanghai ↔ Gwangyang/Busan/Ulsan ↔ Kobe) for 8 bulk/tramp vessels at `142 msg/s`, tracking live cross-track error (`1.4 nm` vs. ±5 nm limit).
- **Interactive What-If Fault Injection Lab:** Enables live client testing via four instant scenario triggers—`Inject Engine Drift`, `Under-Performance`, `Force Route Deviation`, and `Anchor Dragging`—proving real-time AI scoring and red target-ring alerting on demand.

Screen 02 · VESSEL SPEED-POWER & CORRIDOR DIAGNOSTICS

02 / SPEED-POWER & VECTOR

- **Heading (HDG, Green) vs. Course Over Ground (COG, Amber) Physics:** Under normal propulsion (e.g., `HANJIN STAR` at 13.4 kn), HDG and COG align within 2°. During an open-sea engine blackout, SOG collapses (~1.2 kn) while ocean currents push the hull sideways—widening the **HDG-COG gap** and triggering an immediate drift alert.
- **Context-Aware False-Alarm Suppression:** `BLUE HORIZON` off Gwangyang shows `SOG 0.2 kn` and a 14° `HDG-COG` gap due to tidal swing, yet the AI recognizes anchorage geofence context and classifies it cleanly as `ANCHORED (25 pts)` without false alarms.
- **Quantified Daily Fuel Loss ($/day):** Detects `KOREA TRADER` (Supramax) running at `10.3 kn` (`-2.5 kn` below warranted speed curve, score 82/100), translating hull fouling degradation directly into **$2,180/day excess fuel burn**.

Screen 03 · WORKING C/B, VOYAGE TCE & PORT AGENCY PDA DIGITAL TWIN

03 / WORKING C/B & PDA

- **From Post-Voyage Accounting to Live P&L Control:** Synchronizes 180-day continuous ERP rotations (38 voyages across 8 bulkers, 582K DWT—Ballast, Loading, Laden, Bunkering, Discharging) to benchmark pre-fixture `CharterBase Target TCE` against live `Working C/B TCE`.
- **Granular Voyage Variance Tracking (e.g., `YOUNG SHIN` · 52,000 MT Soybeans):** Compares Target TCE ($15,800/d) vs. Live TCE (**$16,280/d, +$480/d upside**), integrating Singapore VLSFO burn ($563,241), load/discharge Port PDA (`EPDA/FDA: $107,800`), net despatch (+$6,500), and Net Voyage P&L ($99,840).
- **Market Stress-Testing & ESG Compliance:** One-click simulation of `Bunker Spike (+18%)`, `Asia Port Congestion (+3.5d)`, and `Weather Detour` instantly updates fleet Net P&L ($2.60M), Average TCE ($17,345/d), AI ETA reliability (96.8%), and EU MRV / IMO CII rating (`Grade B, 4.18 g`).

05. Executive Briefing Takeaways & Operational Governance

Key Value Proposition for Shipowners, Charterers & Port Authorities:
1) **Decision Prioritization, Not Blind Automation:** Hybrid AI scores prioritize the top 0.3% high-risk anomalies for human fleet superintendents, backed by full auditability (raw packet checksums, model versions, and kinematic evidence).
2) **Closing the Loop Between Navigation & Chartering P&L:** Every knot of speed loss, nautical mile of deviation, or port waiting hour is immediately reflected in daily fuel cost, ETA reliability, demurrage/despatch, and live Working C/B TCE.