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Satellite radar and AIS reveal a 97% decline in shipping traffic through the Strait of Hormuz

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Dear Editor,

The Strait of Hormuz serves as a critical choke point linking the Persian Gulf to global markets, accounting for approximately 20% of global maritime crude oil shipments.[1] On February 28, 2026, a joint US-Israeli strike against Iran prompted Iran to announce an immediate and temporary blockade of the strait.[2] This escalation increased navigation safety risks and contributed to volatility in global oil prices.

In response to this crisis, this study conducts a rapid event-driven quantitative assessment of maritime traffic dynamics by integrating Sentinel-1 radar imagery with Automatic Identification System (AIS) data over the week preceding and the week following the February 28 event (February 22–March 7, 2026). The Sentinel-1 radar satellite offers all-weather imaging capabilities at large spatial scales, enabling the detection of vessel spatial distributions regardless of cloud cover.[3] In comparison, AIS can provide real-time positions, identity details, and behavioral patterns of vessels.[4] This study contributes to maritime situational awareness by the combined use of satellite radar imagery and AIS data during the geopolitical incident.

We developed an automated method for rapidly assessing navigation dynamics, which consists of two modules. The first module is threshold-based ship detection using Sentinel-1 radar imagery. Specifically, we acquired 258 scenes of 10-m-spatial-resolution Sentinel-1 ground range detected (GRD) products in interferometric wide (IW) swath mode from the Copernicus Programme. All data were preprocessed on the Google Earth Engine (GEE) platform following standard protocols, i.e., orbit file correction, border and thermal noise removal, radiometric calibration, and terrain correction. The backscatter coefficients (σ^0) recorded in Sentinel-1 were then converted to decibels (dB). Potential ship candidates were identified by selecting pixels exceeding an empirical threshold of −15 dB and were further refined to exclude land artifacts using a high-precision ocean mask.[5] A connectivity analysis was then applied to eliminate isolated noise clusters (<3 pixels). To rule out data artifacts, we performed manual visual inspections. The ship detection method achieved an F1-score of 96.0%, with a precision of 94.2% and a recall of 97.9% (Figure 1E), on 18 test images covering congested port and open-water conditions. Finally, to mitigate temporal biases arising from uneven satellite coverage, we introduced the observed average count (OAC) metric, defined as the mean number of ships detected per satellite image within each grid ($0.25° \times 0.25°$ grid is shown in Figure 1A1).

The second module is dedicated to AIS data processing. The raw dataset was obtained from the HiFleet platform and contains 154,050,657 records, each characterized by 27 attributes. These attributes include static vessel characteristics (e.g., identity, dimension, build year, and vessel type) and dynamic navigational parameters (e.g., timestamp, status, speed, course, heading, and geospatial coordinates). Initial cleaning involved removing records with missing geospatial coordinates. Subsequently, we analyzed two parts. (1) Strait transit analysis: to estimate daily ship traffic through the Strait of Hormuz, we identified vessels whose trajectories intersected with the main shipping channel area of the strait (yellow rectangle in Figure 1A2) defined in this study. (2) Regional presence estimation: to quantify the number of vessels located inside the Persian Gulf, we retained only the last daily record for each vessel to remove duplicate signals, thereby avoiding multiple counts of the same vessel in daily statistics. In this study, the study area boundary follows the International Hydrographic Organization (IHO) delineation of the Persian Gulf. Specifically, the eastern limit is defined by a line connecting Ràs Limah (25° 57′ N, 56° 27′ E) and Ràs al Kuh (25° 48′ N, 57° 18′ E), partitioning the domain into two distinct zones: the interior of the Gulf and the adjacent waters outside.

Figure 1 illustrates the OAC of ships derived from Sentinel-1 radar imagery. The difference map (Figure 1C1), representing the change in OAC 1 week before and 1 week after the event, reveals a significant decline in vessel activity across the Strait of Hormuz (Figure 1C2). Notably, in the observation window defined in this study (yellow rectangle in Figure 1A2), the OAC plummeted from 15.25 (February 22–28, 2026, Figure 1A2) to 0.5 (March 1–7, 2026, Figure 1B2), corresponding to a reduction of approximately 97%, indicating a significant decrease in shipping activity. Conversely, an increase in OAC was observed in port areas (sites 1–4 in Figure 1C1), suggesting a pattern of spatial vessel accumulation. This redistribution is likely attributed to vessels originally scheduled to exit the Gulf being diverted or held at peripheral anchorages and ports due to security risks. Overall, satellite radar imagery showed an observable spatial shift in shipping activity, characterized by a movement from the transit corridors of the Strait of Hormuz toward port zones.

Figures 1F1 and 1F2 depict the temporal evolution of vessel transits through the Strait of Hormuz and their distribution by flag state, respectively. Following the incident on February 28, 2026, transit volumes experienced volatility before declining. On February 22, a total of 175 vessels were recorded; however, counts plummeted by 97% to just 6 vessels on March 7. The day-to-day changes derived from AIS data over the 6-day pre-event period were −13.7%, +13.2%, −4.7%, −5.5%, and +4.5%. The maximum historical fluctuation magnitude within this baseline window was bounded by ±14%, indicating that daily variations are minor under normal conditions. The observed 97% decline is approximately 7-fold the maximum historical fluctuation, clearly exceeding the bounds of random day-to-day noise. Although a transient rebound occurred on March 2, peaking at 260 vessels, traffic declined steadily thereafter. This trajectory was mirrored closely by oil and chemical tankers. After falling from a baseline of 50–60 vessels (before February 28) to 9 on March 1 (>80% decrease), oil and chemical tanker traffic briefly rose to 126 on March 2, then fell to 2 by March 7, representing an approximate 96% reduction from normal operations.

Figure 1F2 reveals that Panama, the Marshall Islands, and Liberia consistently rank as the top three flag states for oil and chemical tankers, all of which are non-Gulf states. Prior to February 28, daily transit volumes for these three major registries remained stable; however, post-event figures exhibited volatility. Illustrating this trend, the single-day rebound on March 2 saw transit counts for Panama, the Marshall Islands, and Liberia rise to 23, 18, and 14 vessels, respectively, before declining to low levels (0 vessels) by March 7.

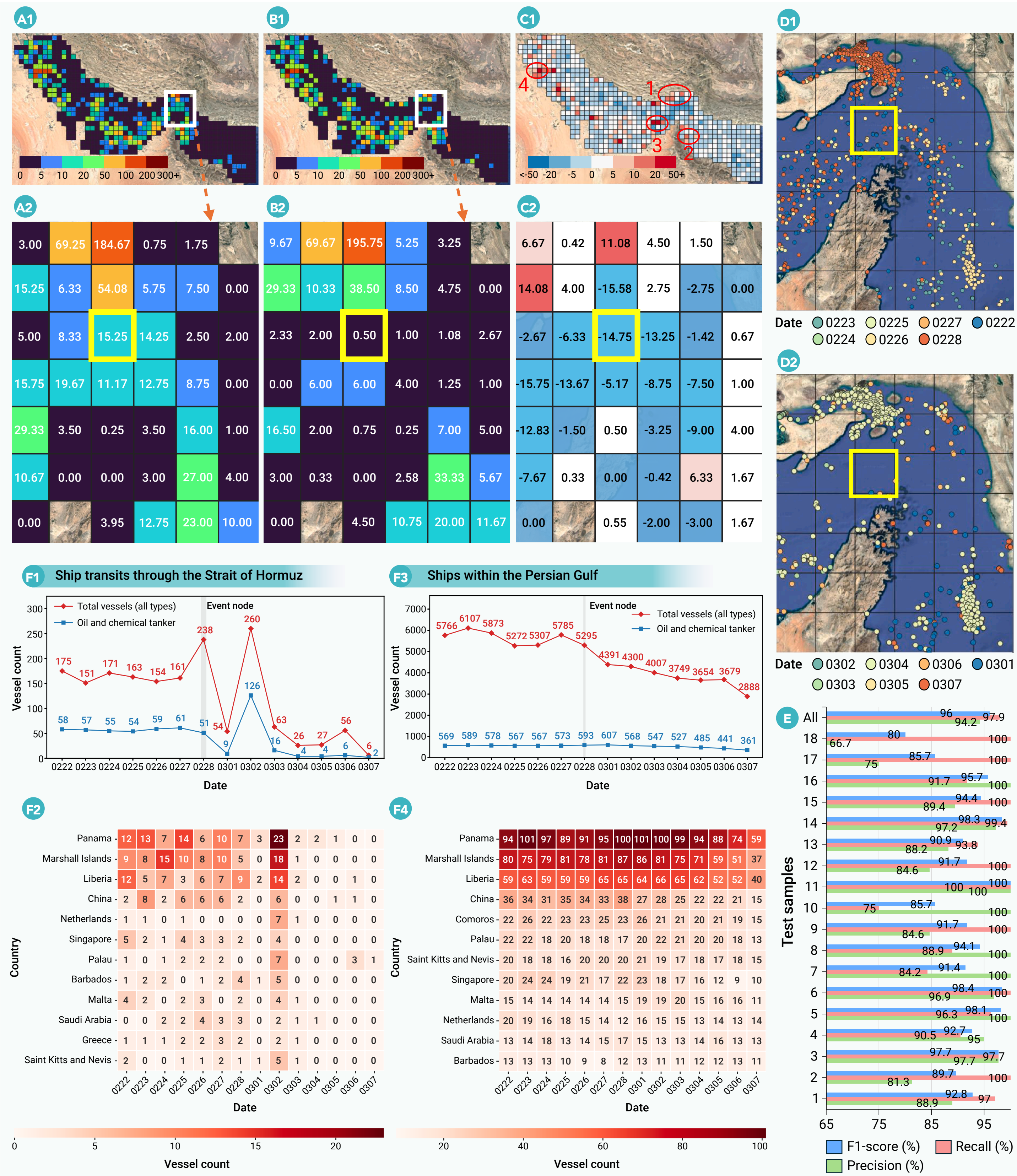

Figure 1. Shipping dynamics revealed by radar satellite and AIS data through the Strait of Hormuz (A1, B1, and C1) OAC of ships during the week preceding the event (February 22–28, 2026) (A1), the week following the event (March 1–7, 2026) (B1), and the absolute difference (after − before) (C1). (A2, B2, and C2) Zoomed-in views of the Strait of Hormuz corresponding to (A1), (B1), and (C1). (D1 and D2) Detailed spatial distribution of individual ship detections from radar satellite images corresponding to (A2) and (B2), respectively. (E) Validation performance (F1-score, precision, and recall) on 18 test images. (F1 and F3) Time series of daily vessel counts from AIS data for Strait transits (F1) and the intra-Gulf region (F3). (F2 and F4) Country-specific heatmaps depicting daily fluctuations of oil and chemical tankers from AIS data for Strait transits (F2) and the intra-Gulf region (F4).

In contrast, Saudi Arabia, a Gulf state, exhibited a daily volume of fewer than five vessels throughout the period. This result indicates that Strait transits for oil and chemical tankers involve a high proportion of non-Gulf-registered ships and that these external capacities are important targets affected by the event.

Figures 1F3 and 1F4 depict the temporal evolution of total vessel counts within the Persian Gulf and their distribution by flag state, respectively. Overall, the total number of ships exhibited a steady downward trend starting from the event date, falling from 5,766 on February 22 to 2,888 on March 7, a cumulative decrease of ~50% over the observation period. Within this aggregate, oil and chemical tanker volumes slightly increased in the immediate pre- and post-event phases (593 vessels on February 28 vs. 607 on March 1). However, this segment subsequently entered a pronounced decline, dropping to 361 by March 7, representing an approximate 39% reduction compared to February 28.

Figure 1F4 shows that Panama, the Marshall Islands, and Liberia consistently rank as the top three flag states for oil and chemical tankers within the Persian Gulf, mirroring the pattern observed in the Strait of Hormuz (Figure 1F2). Prior to the event, vessel counts for the leading three non-Gulf states remained high and stable. Post-event, however, fleets registered to these external states exhibited a uniform decline. By March 7, the Panamanian fleet had contracted from 100 vessels on February 28 to 59 (a 41% drop), while the Marshallese and Liberian fleets receded to 37 and 40 vessels, respectively, representing declines of over 57% and 38% from their February 28 baselines. In contrast, oil and chemical tankers flagged to Saudi Arabia, a Gulf state, displayed only minor fluctuations, remaining within a narrow range of 13–18 vessels throughout the week preceding and the week following the event. Collectively, these findings show that the flag state composition of tanker fleets in the Persian Gulf mirrors that of Strait transits, indicating a reliance on non-Gulf registries across the regional maritime system.

In summary, this study highlights three key findings.

(1) Strait transit decline. Vessel transits through the Strait of Hormuz plummeted ~97% between February 22 and March 7, a trend corroborated by both AIS (from 175 to 6 vessels) and satellite (OAC from 15.25 to 0.5). Non-Gulf oil and chemical tankers mirrored this trend, reducing from 50–60 daily crossings (pre-event) to ~2 vessels (March 7).

(2) Gulf-wide slowdown. Internal Persian Gulf vessel counts contracted monotonically by ~50% (from 5,766 on February 22 to 2,888 on March 7). Oil and chemical tankers, initially stable at ~570 vessels before the event, subsequently underwent a reduction to 361 on March 7, indicating a significant impact on intra-regional energy logistics.

(3) Flag state variation. Top foreign registries (Panama, Marshall Islands, and Liberia) saw a decline to 37–59 vessels by March 7, whereas Saudi Arabian (a Gulf state) tankers maintained stability (13–18 vessels). This result indicates that the region's tanker capacity is vulnerable to geopolitical shocks because of its reliance on non-Gulf registries.

These results underscore the critical value of integrating radar remote sensing with AIS for event-driven maritime traffic monitoring. Crucially, establishing such rapid detection capabilities is vital for safeguarding regional security, enabling real-time geopolitical risk assessment, and ensuring the stability of global energy trade routes during crises. However, current assessments remain constrained by Sentinel-1's fixed revisit cycles and signal confusion in congested waters. Furthermore, reported counts from AIS data remain susceptible to residual noise from signal shadowing, coverage gaps, spoofing, and transponder errors. Critically, AIS data lack sufficient security verification mechanisms, making it vulnerable to attacks such as data forgery, identity theft, and position manipulation,[4] which can easily introduce biases into statistical analysis.[6] Future research will focus on leveraging multi-source radar and optical satellite constellations to develop more advanced and efficient algorithms for complex-scene target separation and resilient trajectory fusion.[7–9]

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DECLARATION OF INTERESTS

The authors declare no competing interests.

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