Gray-Zone Maritime Rights-Protection Strategy: Asymmetric Costs and Sustainable Presence, A Case Study of the China–Philippines Dispute over Scarborough Shoal

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Abstract

Gray-zone maritime rights-protection operations increasingly hinge on sustained presence rather than episodic tactical encounters, particularly under conditions of geographic asymmetry between near-shore and far-shore actors. This paper introduces a Cost–Distance–Frequency (CDF) analytical framework that models cost per effective hour of presence, integrates risk expectation and policy-defined sustainability thresholds, and derives closed-form conditions for manned–unmanned substitution in long-duration deployments. Applying the framework to the China–Philippines dispute over Scarborough Shoal, the analysis demonstrates how near-shore advantages rooted in proximity and sortie frequency can be structurally offset over time through far-shore cost compression, prepositioning, and unmanned force integration. The study highlights the dynamic interaction among cost accumulation, operational tempo, and incident risk in shaping strategic symmetry under gray-zone conditions. By linking operational design to long-term fiscal and institutional endurance, the CDF framework offers a potentially generalizable analytical tool and informing force-posture decisions in contested maritime environments.

1. Introduction

Amid disparities in comprehensive national power and a geostrategic asymmetry between "near-shore" and "far-shore" actors, the essence of gray-zone maritime confrontation is not a one-off tactical duel but a systemic war of attrition centered on resource endurance and operational sustainability (Mazarr, 2015; Freier, Cunningham, & Goldgeier, 2018). The near-shore side leverages geographic proximity to apply sustained tactical pressure through high-frequency, low-cost deployments, eroding the far-shore side's resilience in maintenance, fuel, manpower, and political tolerance (Brands, 2016; Mazarr et al., 2019). The far-shore side, in turn, relies on force structure scale, system-level control, and stronger resource mobilization to build and sustain long-term dominance in rights-protection operations.

Drawing on a dual analytical framework—the Asymmetric Cost–Effective Presence model (Cost–Distance–Frequency, CDF) and an Operational Sustainability Threshold—this paper uses the China–Philippines dispute over Scarborough Shoal as a representative case. It systematically analyzes each side's relative advantages and constraints across geography/distance, sortie frequency, platform mix, and legal–discursive narratives, and offers analytically grounded strategic implications consistent with current international rules.

2. Analytical Framework: The Cost–Distance–Frequency (CDF) Model

In gray-zone maritime rights-protection and sustained-presence missions, the central challenge is to handle—within a unified decision framework—transit time and energy consumption induced by distance, turnaround and maintenance pressure induced by

frequency, and the cumulative effects of cost and risk over time.

Existing methods struggle to evaluate, on a consistent basis, the presence effectiveness of manned/unmanned mixed deployments and to endogenize both risk expectation and policy sustainability thresholds (Biddle, 2004; Watts, 2004).

The CDF model adopts "Cost per Effective Hour of Presence" as the core yardstick (Sullivan, 2012; Posen, 2014), integrating "Effective Presence", "Risk Expectation", and the "Sustainability Threshold" into a single framework. It supports evaluation of manned–unmanned mixed deployment strategies (Horowitz, 2010; Scharre, 2018), provides a closed-form threshold solution for substitution ratios, and helps design more cost- effective and resilient force-posture options—facilitating platform integration and real-time scenario simulation.

A. Manned-Only Scenario

Cost per sortie:

$$C_{sortie} = C_{fixed} + (C_{var,eff} + r_{maint}) \times (T_{transit} + T_{on}) + E_{risk} \quad \textbf{(2.1)}$$

As shown in Equation (2.1), distance-driven transit time enters costs through $T_{transit}$.

Effective presence hours:

$$H_{eff} = w_m \times T_{on}$$

Cost per effective hour of presence:

$$C_{per,eff} = \frac{C_{sortie}}{H_{eff}} \quad \textbf{(2.2)}$$

Equation (2.2) defines the core metric—cost per effective hour of presence—used throughout the CDF evaluation.

B. Manned–Unmanned Mix Scenario

On-station time decomposition:

$$T_{on,m} = T_{on} \times (1 - u), \qquad T_{on,u} = T_{on} \times u$$

Cost calculations:

$$C_{ops,m} = C_{fixed} + (C_{var,eff} + r_{maint}) \times (T_{transit} + T_{on,m}) + E_{risk}$$

$$C_{ops,u} = C_{u,fixed} + C_{u,var} \times T_{on,u}$$

$$C_{sortie,mix} = C_{ops,m} + C_{ops,u}$$

Effective presence hours (with weights):

$$H_{eff,mix} = T_{on} \times [w_m \times (1 - u) + w_u \times u]$$

Cost per effective hour (mixed):

$$C_{per,eff,mix} = \frac{C_{sortie,mix}}{H_{eff,mix}}$$

C. Risk, Presence, and Sustainability Threshold

Risk expectation:

$$E_{risk} = p_{loss} \times C_{replace}$$

Presence weight:

$$H_{eff} = T_{on} \times w, \qquad w \in \{w_m, w_u\}$$

D. Sustainability threshold:

Let superscripts A and B denote the two competing actors (or deployment strategies) under comparison. Use the ratio of "cost per effective hour" as the sole benchmark:

$$R_{eff} = \frac{C^A_{per,eff}}{C^B_{per,eff}} \tag{2.3}$$

As defined in Equation (2.3), R_{eff} compares relative sustainability burdens between competing actors/strategies.

If $R_{eff} > \lambda$, the deploying party B exceeds the policy-defined sustainability threshold λ, implying that its long-term presence will face systemic fiscal, reputational, or institutional constraints. λ is a policy-defined tolerance parameter rather than a universal constant (Posen, 2014; Sullivan, 2012), reflecting fiscal, political, and institutional endurance constraints. Typical aggregate settings may use values such as λ=3 for illustrative purposes.

E. Critical Substitution Ratio in the Mixed Case

If the goal is cost parity between the mixed deployment and the manned-only baseline,

$$C_{per,eff,mix} = C_{per,eff}$$

the closed-form solution for the unmanned share u is:

$$u^* = w_m \times \frac{C_{u,fixed}}{(A+B) \times (w_u - w_m) - w_m \times \left(C_{u,var} \times T_{on} - B\right)} \tag{2.4}$$

where A and B denote aggregated baseline cost constants (e.g., fixed and variable components inherited from the manned-only benchmark)..

Equation (2.4) provides a closed-form break-even condition for the unmanned substitution share under cost parity (Horowitz et al., 2018).

When $w_u = w_m$ (i.e., identical presence weights), this simplifies to:

$$u^* = \frac{C_{u,fixed}}{B - C_{u,var} \times T_{on}}$$

If $C_{per,eff}$ is dominated by B and significantly exceeds the unmanned component $C_{u,var} \times T_{on}$, a cost advantage emerges once the unmanned share u surpasses the threshold needed to amortize the fixed unmanned cost $C_{u,fixed}$. Conversely, if $w_u < w_m$, the discount in unmanned presence weight means a higher u is required to break even.

3. Key Points of the China–Philippines Dispute over Scarborough Shoal

Scarborough Shoal lies roughly 120 nautical miles west of Luzon in the northeastern South China Sea and is among the most contested maritime areas between China and the Philippines (Fravel, 2011; Hayton, 2014). Since 2012, China has maintained a continuous presence of the China Coast Guard and sustained fishing activities in the area, amounting to a de facto and normalized maritime presence (Erickson & Kennedy, 2016; Fravel, 2011).

In 2016, the Permanent Court of Arbitration, ruling on a case unilaterally initiated by the Philippines, held that China's claims to "historic rights" over parts of the relevant waters, including those around Scarborough Shoal, had no legal effect (Permanent Court of Arbitration, 2016; Beckman, 2013). The Philippines accepted and has cited the award in its diplomatic and legal positions, while China stated it does not accept or recognize the ruling and emphasizes resolving disputes through negotiation.

Geographically and in terms of deployment, the Shoal's proximity to the Philippine mainland gives Manila notable cost advantages in resupply, crew rotation, and sortie frequency. By contrast, China must dispatch coast guard, fisheries enforcement, and at times naval assets from more distant bases, making each sortie more costly in fuel, time at sea, and manpower.

In recent years, both sides have engaged frequently in law-enforcement patrols, fisheries control, and at-sea resupply activities in the area, with recurrent friction, including water- cannon use, vessel interceptions, resupply obstruction, and boarding/inspection encounters, exhibiting typical "gray-zone" characteristics. Taken together, these dynamics constitute a paradigmatic asymmetric contest: **near-shore, low-cost, high-frequency presence** versus **far- shore, higher-cost, higher-control posturing**.

A. Geographical Distance and Sustainment Characteristics

a) Structural Advantages of the Near-Shore State: The Philippines

In rights-protection practice around Scarborough Shoal and other disputed waters, the Philippines—as the geographically "near-shore" actor—possesses several structural advantages:

- **Geographic proximity and low sortie cost.** Scarborough Shoal lies roughly 120 nautical miles from the Philippine mainland, yielding short transit times, quick resupply cycles, and significantly lower per-sortie costs than those of a far-shore actor.

This geographic edge enables high-frequency, low-cost presence operations—relying on agile small coast-guard craft, fishing vessels, and civil maritime assets—to exert steady tactical pressure as a matter of routine.

- **Legal ruling and moral capital in the public discourse.** In 2016, the Permanent Court of Arbitration rendered an award favorable to the Philippines in the South China Sea arbitration. Although China rejects the award, it provides Manila with a measure of "legal backing" under international law. By persistently citing the ruling, the Philippine government and media reinforce a narrative of "defending the international order," enhancing discursive leverage and perceived legitimacy in multilateral venues.
- **Civilian "space-occupation" mechanism.** The Philippines organizes fishermen, small fishing boats, and non-military maritime groups to maintain a factual presence in disputed waters. This low-intensity, semi-informal posture reduces escalation risk while strengthening the impression of routine use and, potentially, supporting claims of *effective occupation* in legal argument (Erickson & Kennedy, 2016; Hayton, 2014). The deliberate policy ambiguity of such deployments also affords maneuvering room in diplomacy and helps limit formal governmental liability.

b) Strategic Advantages of the Far-Shore State: China

Despite greater distance, higher sortie costs, and heightened international scrutiny, China—as the "far-shore" actor—retains several key advantages in the South China Sea rights- protection, particularly in force structure, institutional integration, and strategic control:

- S**trategic control enabled by resource scale and platform systems.** China fields a composite enforcement and control architecture spanning the coast guard, fisheries administration, and the navy, with large-displacement, long-endurance government vessels and auxiliary platforms. Coupled with island-reef infrastructure and forward logistics nodes, this supports a relatively stable long-range presence system capable of persistent patrols, rapid contingency response, and sustained rights-protection operations—providing enduring tactical pressure and area control, including layered patrol cycles and rotational tasking of enforcement units.
- **State-level integration and a legitimacy-building narrative.** China can mobilize cross-ministerial resources—coast guard, diplomacy, scientific research, environmental protection, and state media—to construct a rights-protection narrative framed as "non-military" and "non-coercive" (Fravel, 2011; Mazarr et al., 2019). By institutionalizing activities such as ocean monitoring, ecological protection, and scientific surveys—and by invoking themes like "resource protection," "international navigation order," and "non- militarization of the South China Sea"—Beijing seeks to downplay the confrontational nature of its actions, bolster legal and institutional legitimacy, and shape rule interpretation in a direction favorable to its interests.

B. Game Mechanisms and CDF Mapping for Near- and Far-Shore Rights-Protection Operations

Within the CDF framework, the near-shore advantage is endogenized through shorter $T_{transit}$ and lower marginal frequency costs, rather than treated as an exogenous assumption, while far-shore disadvantages are correspondingly reflected in higher transit-related variable costs and steeper frequency–maintenance tradeoffs (Biddle, 2004; Watts, 2004; Sullivan, 2012). As illustrated in Figure 1, relative strategic symmetry is shown to evolve over time as cost, frequency, effective presence, and risk parameters interact under different deployment architectures.

In gray-zone practice in the South China Sea, near-shore and far-shore actors exhibit a pronounced three-dimensional asymmetry in cost–frequency–risk. The divergence is not only about the distribution of resources and response capacity, but also about fundamentally different strategic logics. The analysis below proceeds from the evolution of the competitive game and its mapping to the CDF model.

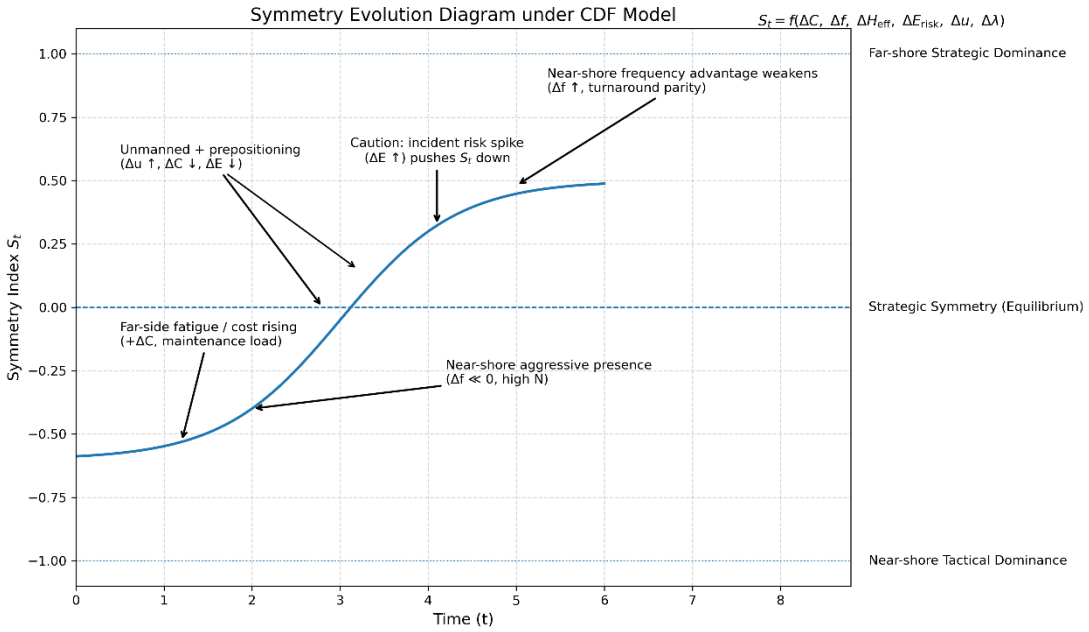

Figure 1. Symmetry evolution under the CDF framework (conceptual illustration). The figure illustrates the qualitative evolution of strategic symmetry St as relative cost, frequency, effective presence, and risk parameters change over time. The curve is schematic rather than empirically calibrated, and is intended to visualize the directional effects implied by the CDF model rather than to represent a quantitative simulation.

b) Near-shore high-frequency, low-cost pathway

Leveraging geographic proximity, near-shore states commonly employ high-frequency, small-scale, low-cost operations. By organizing fishermen, small craft, and light law- enforcement vessels (often non-military or low-visibility platforms) to enter disputed waters frequently, they establish factual presence and generate cumulative media/discourse effects. Although tactically limited in intensity, this approach sustains pressure and compels far-shore actors to respond repeatedly.

If a far-shore actor persists with large manned vessels as its primary toolset, sortie frequency is constrained by fuel and maintenance costs, transit time, and political exposure. Over time, this produces systemic burdens—rising fuel consumption, accelerated wear and tear, crew fatigue, and diplomatic costs—undermining fiscal and strategic sustainability.

c) Far-shore transformation: cost compression and presence re-architecture

To offset those disadvantages, the far-shore actor should pursue a three-part transformation:

- **Unmanned.** Deploy USVs/UAVs to substitute part of manned force structure, reducing personnel and maintenance costs per hour.

- **Prepositioned.** Build island-reef facilities, floating platforms, or temporary nodes to shorten transit and improve sortie responsiveness.
- **Legitimized Presence.** Strengthen evidence collection like law-enforcement records, comms tracks and video, and strategic messaging to elevate legal defensibility and international acceptability.

Together, these measures lower **per-sortie cost (C_{sortie})**, raise **effective presence (H_{eff})**, and progressively erode the near-shore advantage rooted in geography and frequency—rebalancing the structural game (Horowitz et al., 2018; Scharre, 2018).

C. CDF-model parameter mapping and strategic takeaways

The CDF framework offers a structured way to understand how the game evolves and how key parameters interact.

- **Distance (D) amplifies cost and maintenance pressure.** Owing to longer deployment ranges, far-shore actors incur greater transit time ($T_{transit}$), which elevates the variable-cost term $(C_{var,eff} + r_{maint}) \times T_{transit}$. As frequency rises, the distance penalty accelerates maintenance and depreciation, becoming a principal constraint on sustained presence.
- **Frequency (f) and turnaround (T_{turn}) determine sustainability.** Frequency and turnaround efficiency directly shape **effective presence per unit time (H_{eff})**. With short sortie–return cycles (low T_{turn}) and stronger port support, near-shore actors more easily sustain high-frequency deployments and rapid backfilling, achieving continuous on-scene presence.
- **Risk expectation (E_{risk}) captures asymmetric incident risk.** In interceptions, boardings, and dispersal actions typical of the gray zone, accident rates, media exposure, and detention risk are asymmetric. The E_{risk} term affects **cost per effective hour ($C_{per,eff}$)** non-linearly. Civilian craft on the near-shore side may trigger diplomatic friction; far-shore law-enforcement failures or escalation can carry higher international reputational and diplomatic costs.
- **Presence weights (w_m, w_u) and substitution rate (u) in a mixed force.** In manned–unmanned mixes, the model applies presence weights. Because unmanned platforms typically deliver less sensing/ deterrence value ($w_u < w_m$), achieving equivalent H_{eff} requires a higher unmanned share **u**, with potential trade-offs in identification fidelity and evidentiary robustness—hence the need to optimize cost versus effectiveness. In practice, w_m and w_u can be proxied by composite indicators combining sensing fidelity, deterrence credibility, and evidentiary robustness, calibrated ex ante for scenario simulation. Such proxies are scenario-dependent and intended for comparative simulation rather than precise empirical measurement.
- **Sustainability threshold (λ) and stability boundary.** High-intensity, long-duration deployments can yield tactical gains but risk structural fatigue if a side's R_{eff} persistently exceeds its policy tolerance λ (e.g., personnel limits, maintenance cycles, budget ceilings). The CDF model supports constructing a strategy sustainability function to forecast how long a given presence level can be maintained and where the critical breakpoints lie.

4. Future Strategies for Both Sides

A. Near-Shore Actor (Philippines): Amplify Proximity Advantages and Institutionalize High-Frequency Presence

Within the South China Sea's asymmetric competition, the Philippines, as the geographically near-shore actor, should concentrate on its relative strengths in distance, sortie frequency, and narrative framing. By leveraging low-cost, high-frequency, and institutionalized methods, Manila can build a resilient, scalable rights-protection posture. Specifically:

- **Advance a lightweight, routine forward-presence mechanism.** Procure or lease large numbers of low-maintenance, low-cost maritime platforms (e.g., small patrol craft, USVs) to reduce dependence on a few large vessels and create a **high-quantity / high-frequency** coverage network. This improves responsiveness, on-scene accessibility, and routine area occupation.
- **Institutionalize a fisheries–civil vessel linkage.** Normalize a dual track of "**government oversight + civil participation**.**"** Using fisheries escort mechanisms as the backbone, integrate fishermen's organizations, small fishing boats, and local maritime networks. Establish escort protocols, liability waivers, and commercial insurance to form a **semi-official** presence structure that achieves low-cost factual control.
- **Build a triad of evidence collection, media dissemination, and diplomatic leverage.** Create a front-end evidence pipeline (video, AIS tracks, VHF recordings), synchronized media release, and rapid diplomatic engagement to convert each maritime friction into actionable **legal–narrative capital**. Amplify through U.S. military–affiliated or third-party think-tank media channels (e.g., USNI News) to reinforce a "law-abiding party" image and cultivate international support.
- **Strengthen logistics chains and multilateral support**. Establish **joint replenishment agreements** or **shared repair/monitoring hubs** at regional or allied ports to enable multi-node logistics for high-frequency sorties. Combine intelligence-sharing and ocean-state warning networks to distribute platform risk and fiscal burden, extending the sustainability window of operations.
- **Promulgate ROE and training for low-intensity operations.** Under a "non-military non-conflict" framework, codify SOPs that define at-sea behavioral boundaries, communications norms, and de-escalation responses. Provide basic training for civil/self-organized platforms to avoid inadvertent escalation or casualties. Emphasize a **restrained, professional, and lawful** posture to reduce international backlash and legal exposure.

B. Far-Shore Actor (China): Converting Scale into a Low-Cost, Sustainable Presence

Facing the triple constraints of long distance, higher costs, and intense international scrutiny, China, as the far-shore actor, should convert existing scale and system advantages into a low-intensity, low-cost, high-resilience, and durable rights-protection posture. The core shift is from a traditional "large manned-vessel–centric" model to a structure of platform diversification, forward deployment, and institutionalized operations. Recommended lines of effort:

- **Build a forward logistics network and normalize unmanned on-scene presence.** Using controlled or claimed features (reefs, shoals) and floating platforms, deploy floating resupply nodes, unmanned buoys, and low-signature USVs to form a three-segment presence chain: **far-shore → forward node → objective area**. Maintain radar-detectable and comms-identifiable presence during non-friction periods to avoid frequent tasking of large government vessels, thereby reducing sortie costs and external sensitivity.
- **Construct a legitimacy narrative and a closed evidentiary chain.** Embed presence in lower-salience, non-confrontational missions—scientific surveys, ocean monitoring,

ecological protection—to institutionalize legal justifications. Pair with law-enforcement recorders, AIS track management, and audio-video evidence collection to form a legitimacy-and-evidence loop suitable for international scrutiny, supporting dispute management and external messaging.

- **Use multi-point inducement to disperse near-shore resources.** Create multiple "legal gray-edge" task lines—cross-sector fisheries patrols, oceanographic transects, buoy placement—to lengthen the opponent's response radius and resource chain. Forcing dispersion of limited near-shore assets lowers their concentration and sortie frequency in key zones, helping reshape perceptual dominance and the information narrative.
- **Optimize platform mix and deployment tempo to reduce cost per presence hour.** Prioritize adaptable, low-marginal-cost unmanned systems and pursue mission fusion (e.g., monitoring–communications–patrol on shared platforms) to improve task coupling. Use the CDF model's "cost per effective hour of presence" metric to dynamically tune platform types, rotation cycles, and payloads—achieving a coordinated optimum of cost, effectiveness, and sustainability.
- **Keep diplomatic channels open and crisis-management mechanisms usable.** After incidents, employ hotlines, bilateral engagements, and third-party mechanisms to maintain communication, clarify positions, and convey red lines, reducing miscalculation and misperception. This helps bound actions within limited confrontation or controlled escalation, slowing external intervention and broader multilateral pressure.

The analysis does not prescribe policy choices but examines strategic feasibility under cost–sustainability constraints.

5. Conclusion

This study argues that outcomes in gray-zone maritime rights-protection are determined less by episodic displays of force than by the capacity to sustain cost-effective presence over time. Under conditions of geographic asymmetry, tactical advantages derived from proximity and sortie frequency do not automatically translate into long-term strategic dominance. Instead, endurance—shaped by cumulative cost, operational tempo, and risk exposure—emerges as the central determinant of stability and control in contested maritime environments (Mazarr, 2015; Posen, 2014).

By introducing the Cost–Distance–Frequency (CDF) framework, this paper integrates transit distance, deployment frequency, effective presence, and incident risk into a unified analytical structure centered on cost per effective hour of presence. The framework demonstrates that near-shore advantages are structurally contingent rather than permanent, and that far-shore disadvantages are not immutable. Through cost compression, prepositioned logistics, and manned–unmanned force integration, far-shore actors can progressively offset proximity-based frequency advantages and re-balance strategic symmetry without resorting to overt escalation.

Applied to the China–Philippines dispute over Scarborough Shoal, the analysis illustrates how gray-zone competition unfolds as a dynamic process of presence re-architecture rather than a static contest of strength or legality alone. The interaction between operational design and sustainability thresholds highlights why persistent presence strategies must be evaluated not only in tactical or legal terms, but also through their long-term fiscal, institutional, and reputational viability.

The CDF framework is not intended to predict specific tactical outcomes or to prescribe policy choices. Rather, it provides an analytical lens for assessing the sustainability of maritime presence under prolonged cost and risk constraints. Future research may extend the framework through empirical calibration, simulation-based stress testing, or application to

other maritime theaters characterized by asymmetric geography and persistent gray-zone interaction. In doing so, the framework offers a foundation for more systematic evaluation of endurance-based competition in contemporary maritime security.

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