Intelligence-Powered Drone Command Systems for Cross-Strait Defense: Adapting Ukraine's Delta Model to Taiwan's Maritime Strategic Environment

Cobe Liu

2025-10-16

This thesis will examine the feasibility and strategic implications of developing a Taiwan-specific analogue to Ukraine's Delta situational awareness system for coordinating autonomous drone operations in a potential cross-strait conflict. The research addresses a critical gap in contemporary defense literature by systematically analyzing what specific software capabilities and architectural features would enable effective drone coordination in Taiwan Strait defense scenarios, and assessing the strategic impact such a system would have on cross-strait military balance. This investigation becomes increasingly urgent as Taiwan accelerates drone acquisition programs targeting 50,000 units by 2027 while China simultaneously enhances counter-drone capabilities, creating a dynamic technological competition with profound implications for regional security and deterrence stability.

The research problem emerges from the intersection of Ukrainian battlefield innovations and Taiwan's unique strategic challenges. Ukraine's development and deployment of the Delta situational awareness system represents a paradigm shift in modern warfare, demonstrating how accessible, AI-enabled command-and-control platforms can coordinate thousands of autonomous systems with minimal operator training. As documented by Kateryna Bondar's 2024 analysis for the Center for Strategic and International Studies, Ukraine has achieved what defense analysts describe as functional Combined Joint All-Domain Command and Control technology through Delta.[1] The system aggregates data from over 150,000 simultaneous sources, processes targeting information through artificial intelligence, and enables coordination across all military branches through interfaces accessible via standard smartphones and tablets. Bondar's research emphasizes that Delta requires no specialized hardware while processing tens of terabytes of data daily, with operators describing the interface as the "military

[1] Bondar, Kateryna. "Does Ukraine Already Have Functional CJADC2 Technology?" Center for Strategic and International Studies, December 11, 2024.

equivalent of Google Maps." Ukrainian forces have completed over 82,000 combat missions using swarm coordination integrated with Delta, establishing the first routine military employment of AI-guided autonomous drone swarms in modern warfare.

Taiwan faces fundamentally different strategic challenges than Ukraine, specifically the requirement to defend against amphibious invasion across the 110-mile Taiwan Strait. Current defense planning emphasizes asymmetric capabilities that impose prohibitive costs on potential aggressors, yet existing analysis inadequately addresses how software-enabled drone coordination systems must be adapted for maritime operational environments. The maritime setting, extended engagement ranges, limited operational windows due to weather, and the concentration of invasion forces during strait crossings create distinct requirements for command-and-control architecture that differ substantially from Ukraine's land-based operations. While Ukrainian drone warfare provides valuable lessons, direct technology transfer proves insufficient for Taiwan's defense requirements, necessitating systematic examination of what specific adaptations would enable Delta-analogue systems to function effectively in cross-strait scenarios.

Mark Cancian, Matthew Cancian, and Eric Heginbotham's comprehensive 2023 wargaming study for the Center for Strategic and International Studies provides the most authoritative analysis of Taiwan conflict scenarios.[2] Across 24 wargaming iterations, their research documents that Chinese amphibious operations face challenges "several times more difficult than the Normandy landings" due to the Taiwan Strait's geographic characteristics. The 110-mile strait width, limited viable landing beaches restricted to 14-20 locations, and operational windows constrained to April and October create natural defensive advantages that concentrate invasion forces into predictable kill zones. The CSIS wargaming concludes that even under optimistic Chinese assumptions, invasion fleets arrive "in shambles" when Taiwan employs integrated anti-ship capabilities, with modeling showing 138 Chinese ships destroyed across scenarios. However, Cancian and colleagues emphasize that successful defense requires Taiwan to resist, the United States to intervene immediately with operations utilizing Japanese bases, and adequate anti-ship missiles to be available. Their findings establish the baseline against which drone warfare contributions must be evaluated, providing quantitative metrics for assessing how Delta-analogue systems would affect conflict outcomes.

The challenge of adapting Ukrainian innovations to Taiwan's maritime environment receives detailed treatment in Stacie Pettyjohn, Hannah Dennis, and Molly Campbell's 2024 study for the Center for a New American Security on drone warfare in a future fight to defend Taiwan.[3] Their research identifies that maritime drone operations exhibit fundamentally different characteristics than land warfare, with Indo-Pacific distances requiring drones costing \$50,000-\$500,000 with ranges exceeding 100 kilometers, compared to Ukraine's \$300-\$1,000 first-person view drones with 10-40 kilometer ranges. Pettyjohn and colleagues provide quantitative modeling showing that 100-drone swarms can achieve 60-75% mission kill probability

[2] Cancian, Mark F., Matthew Cancian, and Eric Heginbotham. "The First Battle of the Next War: Wargaming a Chinese Invasion of Taiwan." Center for Strategic and International Studies, January 9, 2023.

[3] Pettyjohn, Stacie, Hannah Dennis, and Molly Campbell. "Drone Warfare in a Future Fight to Defend Taiwan." Center for a New American Security, June 20, 2024.

against destroyers by saturating point defenses designed to engage only 12 targets simultaneously. Their analysis emphasizes that the maritime environment demands longer-range, more capable systems while simultaneously creating extended kill zones during strait crossings when amphibious forces face 2.5-4 hours of exposure under continuous observation and fires. The CNAS research establishes critical parameters for evaluating what software capabilities Delta-analogue systems require to coordinate these more sophisticated maritime drone operations effectively.

Understanding the threat environment requires examining Chinese counter-drone development, which Timothy Ditter's 2025 analysis for the Center for Naval Analyses comprehensively documents.[4] Ditter's research on People's Liberation Army concepts for UAV swarms in future warfare reveals that China has systematically absorbed Ukrainian lessons, undertaking aggressive counter-drone modernization integrating detection systems, electronic warfare capabilities, kinetic interceptors, and directed energy weapons. The PLA's layered counter-drone doctrine operates across four engagement zones, with long-range detection beyond 200 kilometers employing satellites and radar networks, mid-range electronic warfare at 50-200 kilometers using sophisticated jamming capabilities including J-16D electronic warfare aircraft, and short-range hard destruction at 5-50 kilometers deploying directed energy weapons such as high-power microwave systems and laser interceptors. However, Ditter notes that recent exercises demonstrated only 40% hit rates against small drone swarms even using relatively dated systems against just 11-12 commercial drones, revealing critical vulnerabilities despite advancing capabilities. His research documents that Chinese military analyses acknowledge traditional air defenses "struggle catastrophically" against small, agile, low-flying drone swarms, creating an exploitable weakness during amphibious operations when PLAN forces must maintain formation over extended crossings while simultaneously coordinating air defense, managing electromagnetic spectrum control, tracking hundreds of incoming threats, and conducting landing operations under fire.

The primary research question guiding this thesis asks what software capabilities and architectural features a Delta-analogue command-and-control system would require to effectively coordinate autonomous drone operations in Taiwan Strait defense scenarios, and what strategic impact such a system would have on cross-strait military balance. This central inquiry generates several subsidiary questions that structure the investigation. First, what specific technical adaptations are necessary to translate Ukraine's land-based Delta system to Taiwan's maritime operational environment, particularly regarding targeting algorithms, navigation systems, and coordination protocols? Second, how do extended engagement ranges, maritime target characteristics, and weather constraints alter software requirements for effective drone operations against amphibious threats? Third, what force multiplication effects and cost-exchange ratios could Taiwan achieve through optimized drone command-and-control systems during critical conflict phases including pre-invasion reconnaissance, anti-ship operations during strait crossing, and coastal defense? Fourth, how would Chinese counter-drone capabilities and electronic

[4] Ditter, Timothy. "PRC Concepts for UAV Swarms in Future Warfare." Center for Naval Analyses, July 11, 2025.

warfare systems constrain the effectiveness of AI-enabled drone coordination in cross-strait scenarios, and what software resilience features would mitigate these threats? Fifth, what are the strategic deterrence implications—both stabilizing and destabilizing—of Taiwan fielding Delta-equivalent drone coordination capabilities, particularly regarding Chinese calculations about capability windows and preemptive action incentives?

The literature review reveals that while each of the four primary sources provides essential elements for understanding this problem, significant gaps remain in their collective coverage. Bondar's analysis of Ukraine's Delta system offers detailed technical understanding of software architecture, AI-enabled targeting, operator interfaces, and battlefield integration, establishing the baseline capabilities that any Taiwan analogue must replicate or exceed. Her documentation of Delta's ease of use—requiring minimal training while enabling smartphone-based operation—proves particularly relevant for assessing Taiwan's potential to rapidly scale operator numbers through civilian mobilization. However, Bondar's research focuses exclusively on land warfare applications without addressing maritime operational requirements or the adaptations necessary for engaging naval targets at extended ranges under different environmental conditions. The CSIS wargaming by Cancian and colleagues provides authoritative quantitative analysis of Taiwan conflict dynamics, including detailed modeling of amphibious operations, casualty projections, and the conditions necessary for successful defense. Their findings establish critical benchmarks for evaluating drone warfare contributions, particularly the conclusion that Taiwan maintains autonomy in most scenarios when employing integrated anti-ship capabilities but faces extreme costs including dozens of ships, hundreds of aircraft, and tens of thousands of casualties on all sides. Nevertheless, the wargaming study predates the maturation of autonomous swarm technologies and does not systematically incorporate Delta-equivalent command-and-control systems into its force modeling, creating an analytical gap this thesis will address.

Pettyjohn and colleagues' CNAS study directly addresses drone warfare applications to Taiwan defense, providing the most relevant existing analysis for this research. Their work identifies specific capability requirements for maritime drone operations, models effectiveness against various target types, and assesses integration challenges with existing defense systems. The study's quantitative analysis of swarm effectiveness against naval vessels, cost-exchange ratios compared to traditional munitions, and phase-by-phase evaluation of drone contributions across conflict scenarios provides essential foundation for this thesis. However, the CNAS research emphasizes hardware characteristics and operational employment rather than detailed software architecture and command-and-control requirements, leaving unexplored questions about what Delta-analogue systems must technically accomplish to achieve the effectiveness levels their modeling projects. Ditter's CNA analysis of PRC counter-drone concepts completes the threat assessment by documenting Chinese capabilities, doctrinal development, and identified vulnerabilities in counter-swarm operations. His research reveals both the sophistication of Chinese countermeasures and their critical limitations, particularly the PLA's struggle to achieve high intercept rates against distributed swarm attacks. Yet Ditter's focus on Chinese perspectives and capabilities does not extend to detailed analysis of how Taiwan could exploit identified vulnerabilities through superior command-and-control software that enhances coordination, adaptability, and resilience against electronic warfare.

Collectively, these four sources establish that Ukrainian Delta system capabilities, Taiwan Strait operational requirements, drone effectiveness modeling, and Chinese counter-drone developments each receive authoritative treatment in current literature. The critical gap lies in their integration—no existing research systematically examines what specific software capabilities a Delta-analogue system requires when translating Ukrainian land warfare success to Taiwan's maritime defense context, nor do current studies quantitatively model how such systems would alter the military balance documented in CSIS wargaming. This thesis will fill that gap by developing detailed technical specifications for Taiwan-specific command-and-control software, modeling its effectiveness against the threat environment Ditter describes, and assessing strategic implications using the conflict scenarios Cancian and colleagues established.

The methodology employs a multi-layered analytical framework integrating technology assessment, operational analysis, quantitative modeling, and strategic evaluation. The research design uses comparative case analysis to systematically examine Ukrainian Delta system capabilities documented by Bondar against Taiwan Strait operational requirements identified by Pettyjohn and colleagues, determining necessary adaptations in software architecture, targeting algorithms, coordination protocols, and operator interfaces. This comparative analysis will identify specific technical modifications required for maritime environments, including extended-range targeting systems supporting engagements at 50-150 kilometers versus Ukraine's 10-40 kilometer operations, maritime target recognition databases emphasizing ship classification and tracking rather than ground vehicles, weather-adaptive mission planning accounting for typhoons and sea state conditions affecting drone operations throughout much of the year, and multi-layered coordination protocols enabling simultaneous engagement of surface vessels across extended kill zones during strait crossings. The technical specification development will produce detailed capability requirements addressing AI-enabled targeting under electronic warfare conditions, swarm coordination algorithms enabling autonomous operations in GPS-denied environments, resilience features against jamming and cyber attacks, and operator interface design that maintains Ukraine's ease-of-use advantages while incorporating maritime-specific functionality.

Quantitative modeling will assess drone effectiveness across the conflict phases established in CSIS wargaming, incorporating variables including drone quantities and types, coordination efficiency enabled by Delta-analogue software, Chinese countermeasures documented by Ditter, weather conditions, and target concentrations during amphibious operations. This force-on-force modeling will evaluate pre-invasion reconnaissance effectiveness in providing maritime domain awareness and early warning, anti-ship operations during strait crossing when invasion fleets face extended exposure, coastal defense against forces establishing beachheads on Taiwan's limited landing zones, and urban warfare contributions should Chinese forces achieve lodgment. The modeling will calculate cost-exchange ratios comparing drone investments against both target values and defensive countermeasure costs, assessing economic sustainability of different force mixes. Sensitivity analysis will examine how variations in coordination efficiency, electronic warfare degradation, weather disruption, and countermeasure effectiveness affect overall outcomes, identifying which software capabilities prove most critical to operational success.

Strategic impact assessment will analyze deterrence implications using scenario-based evaluation of how Delta-analogue capabilities affect Chinese invasion calculations. This analysis will examine both deterrence-strengthening effects through enhanced denial capabilities that make invasion militarily unfeasible and potential crisis instability effects if Beijing perceives a narrowing capability window before Taiwan's defensive improvements raise invasion costs prohibitively. The evaluation will assess whether drone coordination capabilities primarily contribute to deterrence by denial—making successful invasion impossible—or deterrence by punishment—threatening unacceptable costs regardless of military outcome. Drawing on the CSIS wargaming findings that successful defense requires multiple conditions including Taiwanese resistance, immediate US intervention, Japanese base access, and adequate munitions, the strategic analysis will position Delta-analogue systems within this broader framework, determining whether they represent necessary-but-not-sufficient capabilities or potentially decisive force multipliers that fundamentally alter conflict calculus.

Data sources include primary technical documentation on Ukraine's Delta system from Bondar's CSIS research, operational performance data from Ukrainian combat employment, Chinese military publications on counter-drone capabilities documented by Ditter, Taiwan defense planning materials, and engineering specifications for autonomous systems. Secondary sources comprise the quantitative modeling and wargaming results from Cancian and colleagues' CSIS study, Pettyjohn and colleagues' CNAS force-on-force analysis, and additional defense literature on deterrence theory and asymmetric warfare. The analysis proceeds through four sequential stages: capability mapping identifying Delta system features and Ukrainian operational practices, requirements translation determining how Taiwan Strait environment alters software specifications, effectiveness modeling providing quantitative assessment of military impact across conflict phases, and strategic evaluation analyzing deterrence implications and generating policy recommendations.

Based on preliminary examination of these sources, several hypotheses emerge to guide the investigation. First, a Taiwan Delta-analogue system will require fundamentally different software architecture than Ukraine's land-based model, specifically demanding extended-range targeting algorithms supporting engagements at 50-150 kilometers versus 10-40 kilometers, maritime target recognition databases emphasizing ship classification rather than ground vehicles, weather-adaptive mission planning accounting for typhoons and sea states that disrupt small drone operations during much of the year, and multi-layered coordination protocols enabling simultaneous engagement of surface vessels across extended kill zones rather than sequential targeting of dispersed ground forces. Second, properly implemented Delta-analogue systems could enable Taiwan to achieve cost-exchange ratios approaching 30:1 against amphibious forces during strait crossings, making coordinated drone attacks cost-equivalent to cruise missiles while enabling rapid scaling to thousands of operators through minimal training requirements that leverage Taiwan's technological workforce. Third, the strategic impact will prove paradoxical—strengthening Taiwan's denial deterrence by increasing invasion costs while simultaneously creating crisis instability as Chinese planners perceive a narrowing capability window before defensive improvements peak, potentially triggering the preemptive action the capabilities aim to prevent.

The expected contributions span theoretical, practical, and policy domains. Theoretically, this research will advance understanding of how software-enabled coordination systems transform asymmetric defense capabilities in maritime environments, extending deterrence theory to address rapid technological change and force multiplication through accessible command-and-control platforms. The study will contribute to ongoing debates about technology's role in altering military balances between conventionally superior powers and technologically sophisticated defenders, examining whether emerging systems enable qualitatively new defensive advantages or merely provide incremental improvements within existing operational paradigms. Practically, the research will provide actionable guidance for Taiwan defense planners regarding specific software capabilities to prioritize in procurement decisions, integration requirements with existing defense systems including anti-ship missiles and coastal defense forces, realistic assessments of drone effectiveness against amphibious threats under various operational conditions, and training and mobilization strategies for rapidly scaling operator numbers through civilian sector engagement. The technical specifications developed through this research will offer concrete benchmarks against which proposed systems can be evaluated, helping avoid both over-optimistic assumptions about autonomous capabilities and overly conservative assessments that undervalue force multiplication potential.

Policy contributions will inform broader debates about technology transfer, allied support for Taiwan's asymmetric defense capabilities, and strategic stability in the Indo-Pacific region. By clarifying what Delta-analogue systems can and cannot accomplish militarily, the research will enable more informed discussions about their role in comprehensive defense architecture and their implications for deterrence dynamics. The analysis of crisis stability effects will prove particularly relevant for policymakers assessing whether accelerated drone capability development strengthens deterrence or creates destabilizing pressures for preemptive Chinese action. Understanding the capability window dynamics—the period during which Taiwan's improving defenses create incentives for urgent Chinese action before improvements peak—will inform decisions about deployment timelines, public messaging about defensive capabilities, and coordination with allied planning. The research will also address questions about sustainable force structures, examining whether Taiwan can maintain adequate industrial capacity to replace combat losses given that Ukrainian consumption rates reach 10,000 drones monthly, potentially requiring Taiwan inventories exceeding 100,000 units with continuous reconstitution capacity rather than the currently planned 50,000-drone acquisition.

The dissertation will proceed through eight chapters structured to build progressively from technical analysis to strategic assessment. The introduction will establish the research problem, significance, and methodology while positioning the study within existing defense literature. The second chapter will provide comprehensive analysis of Ukraine's Delta system based primarily on Bondar's research, documenting technical architecture, operational employment, battlefield effectiveness, and the ease-of-use factors that enable rapid scaling. This chapter establishes the baseline capabilities any Taiwan analogue must replicate while identifying Ukraine-specific features that may not translate to maritime operations. The third chapter will examine the Taiwan Strait operational environment drawing extensively on Cancian and colleagues' wargaming study and Pettyjohn and colleagues' operational analysis, characterizing geographic constraints, amphibious warfare challenges, limited operational windows, and the specific requirements for engaging naval targets during strait crossings. This chapter will identify how maritime characteristics—extended ranges, weather sensitivity, target mobility, and concentrated kill zones—create distinct software requirements.

The fourth chapter represents the core technical contribution, developing detailed specifications for Delta-analogue software requirements including targeting systems adapted for maritime environments, swarm coordination algorithms enabling distributed attacks against moving naval formations, electronic warfare resilience features addressing the jamming capabilities Ditter documents in his analysis of Chinese counter-drone systems, and operator interfaces that maintain ease-of-use while incorporating maritime-specific functionality. This chapter will address how AI-enabled targeting must adapt to ship classification rather than ground vehicle recognition, how navigation systems must function in GPS-denied maritime environments, how mission planning must account for weather windows and sea state conditions, and how coordination protocols must enable massed attacks against naval formations rather than sequential engagement of dispersed ground targets. The fifth chapter will provide force-on-force modeling and effectiveness assessment, using quantitative analysis to evaluate drone contributions across the conflict phases established in CSIS wargaming. This modeling will assess pre-invasion reconnaissance value in providing maritime domain awareness, anti-ship operations effectiveness during strait crossings when amphibious forces face extended exposure, coastal defense contributions against landing operations, and urban warfare applications should Chinese forces establish lodgment. The analysis will calculate cost-exchange ratios, force multiplication effects, and sensitivity to various degradation factors including electronic warfare, weather disruption, and countermeasure effectiveness.

The sixth chapter will examine Chinese countermeasures and system vulnerabilities based primarily on Ditter's CNA research on PLA counter-drone concepts. This analysis will assess how China's layered defense doctrine including long-range detection, mid-range electronic warfare, and short-range hard-kill systems would constrain Delta-analogue effectiveness, while also examining the vulnerabilities Chinese exercises revealed—particularly the 40% hit rates against small swarms that suggest critical weaknesses during amphibious operations when defensive coordination proves most challenging. The chapter will evaluate which software features most effectively mitigate countermeasures, including adaptive swarming algorithms that maintain effectiveness despite partial attrition, electronic warfare resilience through frequency-hopping and visual navigation, and coordination protocols that degrade gracefully rather than failing catastrophically when portions of the network suffer disruption. The seventh chapter will assess strategic implications and deterrence dynamics, examining how Delta-analogue capabilities affect the military balance documented in CSIS wargaming while analyzing both stabilizing effects through enhanced denial deterrence and destabilizing pressures from capability window dynamics. This analysis will position drone coordination capabilities within the broader framework Cancian and colleagues established, determining whether these systems represent decisive advantages or force multipliers requiring integration with conventional capabilities including missiles, naval forces, and air defense.

The concluding chapter will synthesize findings, emphasizing contributions to theory, practice, and policy while identifying limitations and future research directions. The conclusion will address the fundamental question of whether Delta-analogue systems enable Taiwan to achieve decisive defensive advantages against amphibious invasion or whether they provide important but ultimately incremental improvements within broader defense architecture. The research will clarify under what conditions drone coordination capabilities most strongly contribute to deterrence stability versus potentially creating crisis instability through capability window effects. Recommendations will address procurement priorities, integration strategies, training approaches, and policy considerations for managing the technological competition with Chinese counter-drone development.

The research timeline spans fifteen months divided into five phases. Months one through three focus on literature review completion, data collection from the four primary sources and supporting materials, and preliminary analysis establishing baseline understanding of Delta capabilities, Taiwan operational requirements, Chinese countermeasures, and existing effectiveness modeling. Months four through six emphasize technical specification development and comparative case analysis, translating Ukrainian land warfare systems to maritime requirements and generating detailed software capability specifications. Months seven through nine concentrate on quantitative modeling and force-on-force assessment, evaluating drone effectiveness across conflict phases and calculating cost-exchange ratios under various operational conditions. Months ten through twelve focus on strategic analysis, deterrence evaluation, and initial writing, assessing implications for military balance and crisis stability. Months thirteen through fifteen complete the dissertation through revision, incorporating advisor feedback, defense preparation, and final submission.

This research addresses an urgent defense planning need as Taiwan accelerates drone acquisition while China enhances counter-drone capabilities, creating a dynamic technological competition with profound implications for regional security. By systematically examining what software capabilities Delta-analogue systems require for effective maritime operations and assessing their strategic impact on cross-strait military balance, this thesis will provide both theoretical contributions to understanding technology's role in asymmetric defense and practical guidance for Taiwan defense planners making critical procurement and integration decisions. The investigation fills a significant gap in existing literature by bridging technical analysis of command-and-control systems with strategic assessment of deterrence dynamics, offering insights essential for informed policy decisions about Taiwan's defensive capabilities and their implications for Indo-Pacific stability.