Enhancing Naval ISTAR using Secure COTS Drone Swarms

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Royal Navy

Outline

Introduction

Disclaimer

I am presenting this as Open Source research independently from any Royal Navy projects in this area. My views do not necessarily reflect the Royal Navy's views on these topics.

Motivation

Figure 1: Type 45 Destroyer

[BAE Systems, 2025]

Figure 2: Conventional Fast Inshore Attack Craft (FIAC) Swarm

[GlobalSecurity.org, 2022]

Motivation

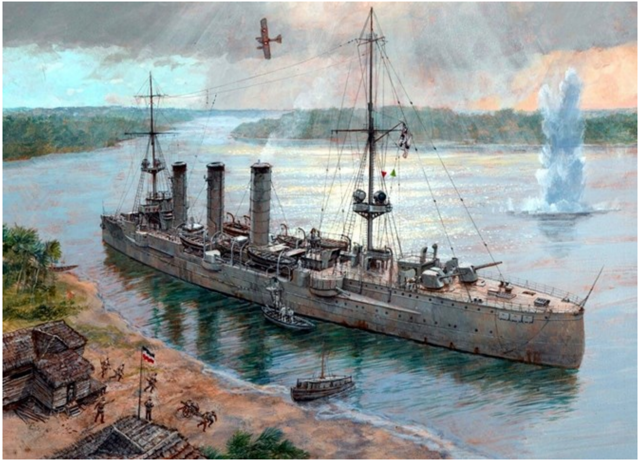


Figure 3: Rufiji Delta (1915) by Paul Wright

[The Western Front Association, 2025]

Motivation

Figure 4: Wildcat with Martlet equipped

[Navy Lookout, 2020]

Motivation

- Maritime domain: asymmetric threats (FIACs, small-boat swarms, drone swarms) demand low-cost Intelligence, Surveillance, Targeting, and Reconnaissance (ISTAR) solutions.
- Rapid evolution of Commercial Off The Shelf (COTS) drones reshaping modern warfare; demonstrated impact in Ukraine.
- Central question: How can COTS drones be used in maritime warfare without compromising security or real-time data flow for operations?

Network Centric Warfare

Network Centric Warfare

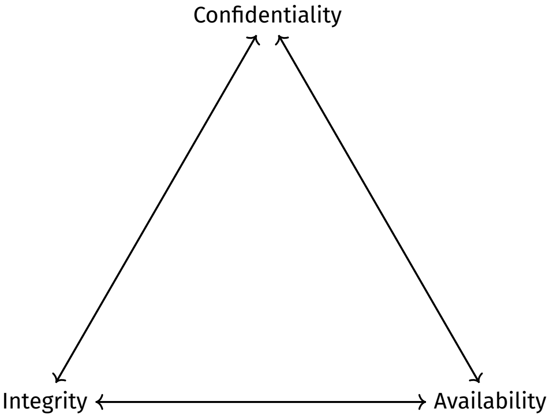
- Information dominance is and has always been a force multiplier.
- Modern Network Centric Warfare is provided by sensors, communications, command & control (C2), and precision weapons.
- Tactical Data Links (TDLs) provide backbone.
- Direct integration into the TDLs increases the cyber attack surface and potentially derails the way we fight.
- Use of non-military assets requires pragmatic security and interoperability measures.

Balancing the Confidentiality, Integrity, Availability Triad

Balancing Confidentiality, Integrity, Availability (CIA)

- **Confidentiality:** prevent adversary interception of sensitive data.
- **Integrity:** ensure targeting and C2 data are untampered.
- **Availability:** maintain timely data flow, even under attack.

The Trade Off



The Trade Off

If you prioritise...	You constrain...	Why
Confidentiality	Availability & Integrity	Strong access control and encryption can make systems harder to access or verify.
Integrity	Availability & Confidentiality	Verification layers (hashing, audits, validation) introduce overhead and delay.
Availability	Confidentiality & Integrity	Fewer access barriers and reduced checks maintain uptime but weaken protections.

Drones in the Maritime Domain

Drone use for ISTAR

- Command will have a higher risk appetite with uncrewed drones allowing higher risk operations to be carried out.
- High quantities of drones provide mass and persistence.
- Use-case: feeding targeting data to naval guns (e.g. 5” guided projectiles).
- Multiple cheap drones reduce cumulative error (GPS-like error correction).

Error Correction

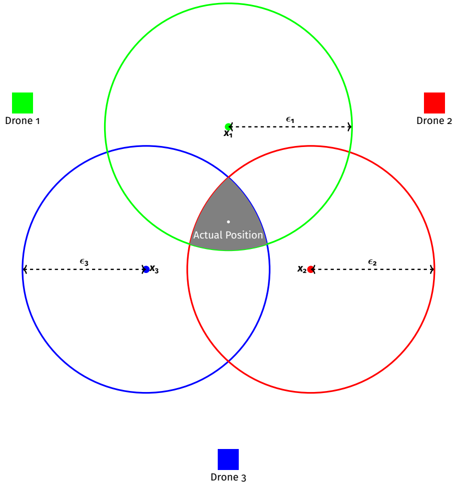


Figure 5: Multiple data sources reduce overall error

Resilience in Contested Spectrum

Resilience: RF DEWs, Jamming, and Hardening

- Radio Frequency (RF) Directed Energy Weapons (DEWs) and Global Navigation Satellite System (GNSS) jamming threaten COTS survivability.
- Options: Electromagnetic shielding against RF DEWS; Inertial Navigation Systems (INS) for GNSS-denied ops.
- Increases in resilience corresponds to an increase in cost.
- Tiered fleet: mass-produced “disposable” drones vs hardened persistent drones.
- Options to Command, allowing a threat appropriate drone to be used in each scenario.

Authentication and Trust Models

Authentication and Trust Models

- **Public Key Infrastructure:** strong integrity and confidentiality, familiar civilian tooling (Transport Layer Security, TLS; Secure Socket Layer, SSL; Secure Shell Hashing, SSH).
- **Centralised:** central authorities, no local authentication, less flexible, provides excellent top down security.
- **Decentralised:** no central authority, flexible for ad-hoc coalition partners; suitable for local vouched trust.
- **Hybrid:** central authorities with local verification permitted for operational flexibility.

Centralised Certificate Authority

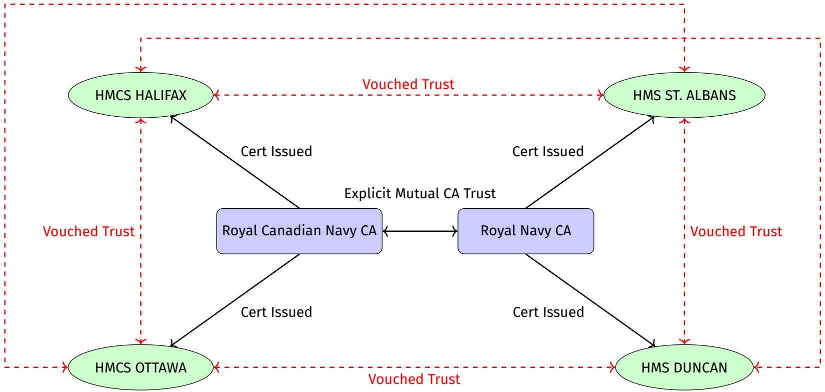


Figure 6: Web of trust with only centralised authorities permitted to authenticate.

Decentralised Certificate Authority

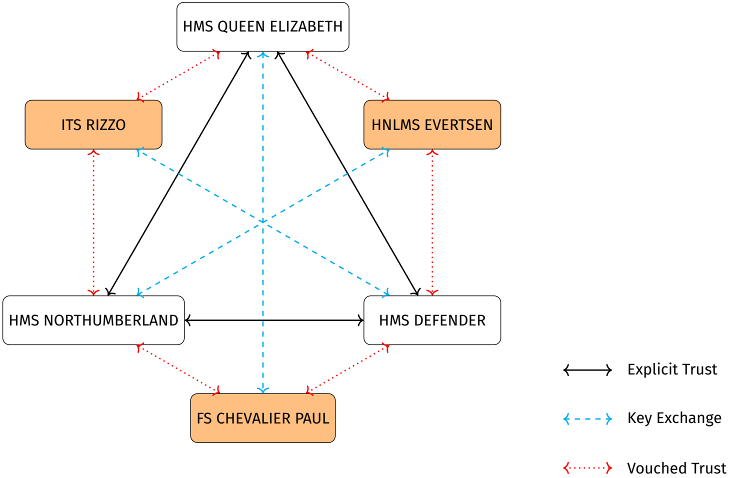


Figure 7: Web of trust with anyone permitted to authenticate. Though vouched trust exists between all parties the additional vouched trust lines have been omitted for clarity.

Secure Network Topology

Proposed Topology: Vouched Trust

- A full zero trust model cannot be used due to requirement for interoperability.
- Zero-trust principles applied pragmatically with a vouched-trust model for coalition ops.
- Sandbox picture compiler aggregates, filters, rate-limits COTS inputs.
- Hardware unidirectional data diode moves curated picture into the combat system.

Proposed Network Topology

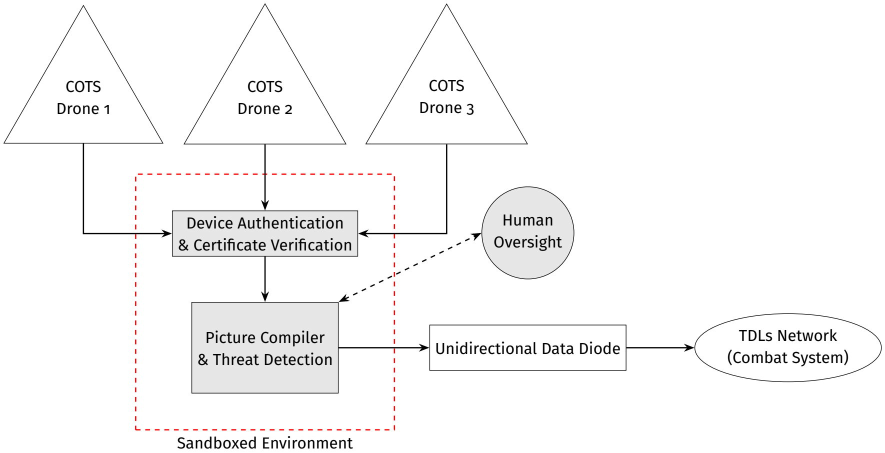


Figure 8: Proposed network topology with three drones as an example

Operational Trade-offs

Costs, Survivability, and Force Design

- Command can consider the mission threat profile.
- Evaluate cost-per-mission vs survivability (e.g. 3 cheap drones vs 1 hardened drone).
- Heterogeneous fleet design enables appropriate asset selection per mission profile.
- Net effect: restore cost-parity against asymmetric threats and reduce personnel risk.

Responding to the Quantum Threat

Quantum Threats and Post-Quantum Cryptography

- Quantum computing will eventually break today's asymmetric algorithms (e.g., RSA) on strategic timescales.
- To prepare, we adopt a hybrid cryptographic model combining conventional and post-quantum algorithms.
- NIST (2024) standardised CRYSTALS family (Kyber/Dilithium) enables a quantum-resistant Web of Trust.
- The tactical risk today is low so COTS drones are unlikely to incorporate quantum-relevant attacks.
- For resource-constrained drones, computationally heavy PQC operations should be kept off-device to preserve performance.

Conclusion

Conclusion and Next Steps

- Secure use of COTS drone swarms yields significant operational advantage at low cost.
- Enables our people to be kept out of harm's way.
- Implement hybrid trust architectures, sandboxing, and data diodes for safe integration.
- Opportunity to exploit COTS drones in the maritime domain through Royal Navy Task Groups in lieu of crewed air assets.

Questions

Thank You.

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