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Subject: Emerging Threat of Unmanned Surface Vehicles (USVs) to Naval Warships and Maritime Infrastructure

1. Executive Summary. The evolving threat of unmanned surface vessels (USVs) to naval assets and critical infrastructure demands a strategic reassessment of maritime defense capabilities. Operational examples, including Ukrainian (UKR) attacks on the Russian Navy (RFN) Black Sea Fleet and Houthi USV strikes against merchant vessels, highlight the sophistication, range, and lethality of these systems. The accessibility of sea drone technology enables both state and non-state actors to challenge naval dominance and threaten global maritime traffic. This necessitates a comprehensive approach to counter these threats.

2. Purpose. To discuss the growing threat posed by USVs to naval warships and maritime infrastructure and to propose a multi-layered, cost-effective tactical solution utilizing both existing and emerging technologies to enhance naval unit defense capabilities.

3. Lessons from Recent USV Operations:

- **Effectiveness of Asymmetric Tactics:** UKR's use of inexpensive, agile sea drones has disrupted operations of superior naval forces, forcing the RFN Black Sea Fleet to adapt by repositioning assets, adjusting patrol strategies, and increasing defensive postures. This exemplifies how even a well-established naval force can be challenged by unmanned, cost-effective systems.
- **Operational Impact on Naval Strategy:** Sea drones have demonstrated the ability to restrict the operating range and freedom of maneuver for traditional naval forces. The need for increased defensive measures, as seen with the RFN Black Sea Fleet, indicates the potential for USVs to limit maritime operations in critical zones.
- **Wake Signature Vulnerability:** Although USVs are designed for stealth, their wake patterns make them detectable from above. Observations show that RFN used helicopters to identify these signatures when radar systems were inadequate. This underscores the value of investing in an Intelligence, Surveillance, and Reconnaissance (ISR) platforms capable of detecting and tracking such wake patterns.
- **Defensive Measures and Countermeasures:** Open-source videos indicate that RFN sailors used small arms and crew-served weapons to engage USVs on approach, with mixed success. The effectiveness of 7.62mm and .50 caliber rounds in disabling or detonating USVs remains unclear. However, it's reasonable to assume that a .50 caliber round impact, with kinetic energy around 19,248 joules, can neutralize a USV payload. This insight highlights the need for naval defensive systems that can deliver a similar level of kinetic or explosive energy for effective neutralization.

4. Anticipation of Similar Tactics Against U.S. and Allied Forces.

- **Adapting Defense Postures:** U.S. and allied forces must be prepared for adversaries employing sea drones in contested regions like the South China Sea and Persian Gulf. This requires updated defensive strategies to address the unique capabilities of unmanned surface threats.
- **Enhancing Detection Capabilities:** Given the low radar cross-section of USVs, traditional systems may prove insufficient. Investments in advanced sensor technology, such as high-resolution EO/IR systems, synthetic aperture radar (SAR), and UAV-based platforms like RQ-21A and INSITU ScanEagle with VTOL capability, are essential for early detection and tracking.
- **Developing a Layered Defense System:** A layered approach, including UAVs for early detection, precision-guided munitions such as APKWS for moderate-range engagement, and CIWS for close-in defense, will maximize the probability of intercepting threats before they reach their targets.
- **Training and Preparedness:** Regular training exercises should simulate sea drone attacks, allowing naval crews to test the effectiveness of kinetic and electronic countermeasures. Familiarity with counter-USV tactics will enhance response readiness and ensure effective threat neutralization.
- **Electronic Warfare (EW) Considerations:** Many USVs depend on remote control or pre-programmed guidance. Leveraging EW to jam or disrupt control signals offers a non-kinetic option to neutralize threats. However, recent evidence of Russian forces reliance on fiber-optic-guided drones in UKR suggests that EW effectiveness may be limited if adversaries adopt similar communication methods in some cases.

5. ISR Role. ISR capabilities are critical for proactive identification and neutralization of USV threats:

- **Persistent Surveillance:** ISR platforms like the ScanEagle UAV and maritime patrol aircraft should provide continuous coverage in high-risk maritime areas. This will enable early detection by identifying USV wake signatures or other unique patterns, addressing radar limitations.
- **Anomaly Detection and Real-Time Data Sharing:** Advanced analytics and AI-equipped ISR systems are essential for distinguishing between normal pattern of life and potential threats. This proactive approach enhances situational awareness, enabling effective identification and classification of suspicious vessels.

6. Proposed Tactical Countermeasures. As was pointed earlier to ensure effective neutralization of USV, defensive measures should ideally deliver at least 19,248 joules or more of energy, whether through kinetic impact or explosive payloads.

- Existing Onboard Weapons Systems:

- Phalanx CIWS: Effective for close defense but variable against small, fast targets with the estimated kinetic energy of a CIWS 20mm round at impact is approximately 53,561 joules. The CIWS utilizes 20mm rounds, specifically the Mk 244 Mod 0 Enhanced Lethality Cartridge (ELC). As of the U.S. Navy's 2025 Fiscal Year budget request, each Mk 244 round is priced at approximately \$45.84. The Phalanx CIWS has a firing rate of up to 4,500 rounds per minute, equating to 75 rounds per second. Therefore, a one-second burst would discharge 75 rounds, costing about \$3,438. A two-second burst would fire 150 rounds, totaling approximately \$6,876.
 - SeaRAM: High-speed precision, but costly (\$1 million per missile). It is intended and used primarily as a point-defense weapon against anti-ship missiles.
 - .50 Caliber and 7.62mm Small Arms: Low-cost but less effective against agile, high-speed USVs.
- Advanced Precision Kill Weapon System (APKWS)
 - APKWS is a moderately priced at \$30,000 per round, the precision weapon designed for mid-range engagements. While it is the program of record for the USMC, it has yet to be integrated into the USN surface fleet as a point-defense system.
 - Loitering Munition Options
 - Switchblade 300: With a range of up to 10 km, the Switchblade 300 can engage targets at a safe distance, making it useful for intercepting USVs before they come within striking range of a ship. While the Switchblade 300 can inflict significant damage through its explosive warhead, it may not be as effective against armored or hardened USVs. Preliminary analysis indicated that the Switchblade 300 delivers around 1,681 joules of kinetic energy at impact, far less than the 19,248 joules needed to reliably detonate a USV payload. Thus, it is not ideal for kinetic neutralization. While not ideal for kinetic impact, the Switchblade 300 can provide standoff engagement with an explosive warhead, useful for disrupting USVs at a distance. The unit cost is approximately \$6,000.
 - Switchblade 600: Capable of delivering 19,800 joules of kinetic energy, the Switchblade 600 can effectively neutralize USVs with both direct impact and a more substantial warhead. It has a range of over 40 km, allowing it to engage USVs at a significantly safer distance compared to small arms fire. The unit cost is approximately \$10,000.

7. Cost-Effectiveness and Recommendations.

- SeaRAM is highly effective but expensive, and it would require additional modifications to be used as a point defense weapon against USVs. It is best utilized for high-priority threats as an anti-ship missile, as originally designed.
- Phalanx CIWS: Cost-effective, extensive ammo expenditure required for small targets.

- APKWS: Economical, effective for mid-range engagements, easy integrable onboard.
- Switchblade Systems: 600 variant is ideal for early interception, easy integrable onboard.
- Small Arms: Inexpensive, effective as a last-resort defense.

8. Conclusion. A multi-layered approach is essential to counter the USV threat effectively. Early detection via ISR assets, UAV systems like RQ21A and ScanEagle VTOL, and countermeasures such as Switchblade 600, APKWS and CIWS ensure comprehensive defense. Balancing investments between traditional and emerging technologies will enhance the Navy's capability to detect, track, and neutralize USVs, ensuring naval and maritime security.