1. **Objective of Proposed Work**

The objective of this Statement of Need (SON) is to build a fundamental knowledge base concerning the occurrence and behaviors of shipboard oil/water emulsions. A better understanding of how oil/water emulsions are created, stabilized, or worsened in this environment will assist the development of methodologies or technologies that can mitigate the formation and undesired consequences of shipboard emulsions.

Knowledge gaps in Armed Forces bilgewater applications regarding formation and stabilization of emulsions should be addressed. Proposers ultimately must identify the factors that drive the formation and breaking of complex oil/water emulsions chemically bound by surfactants. Factors warranting further investigation include but are not limited to pH, types of surfactant, zeta potential, redox potential, temperature, shear/mixing, salinity (e.g., electrolytes, ion strength), water/oil/surfactant ratios, interfacial tension, morphological changes, size distribution, hydrophobicity/hydrophilicity, affinity to potential coagulants (e.g., Fe), and feasibility of microbial biodegradation. Ideally, new ideas or approaches will be proposed to gain further understanding and control of shipboard emulsions. Proposals that only address alternative emulsion removal methods will not be considered responsive to this SON.

2. **Expected Benefits of Proposed Work**

Understanding the underlying principles of emulsion formation and breaking will lead to the reduction of oil/water emulsions which in-turn will greatly improve wastewater treatment effectiveness, waste oil-holding capacities, and fuel-holding capacities aboard ships. More effective treatment will decrease the need to re-process oily wastewater before discharging and will result in decreased operational time required for wastewater treatment. This capability will reduce the maintenance burden, increase oil water separator (OWS) treatment system availability, and lower resultant offloading costs for oily wastewater. These savings of time and money will benefit all Defense branches that use ships or service crafts as part of their mission requirements.

This work will help to advance emulsion prevention and separation by providing fundamental information needed to formulate strategies for minimizing the emulsion formation while maximizing emulsion breaking. In addition, this information will support the informed
development of emulsion treatment technologies, bilge management practices, and recommended chemicals for shipboard use.

3. Background

Oils, fuels, and lubricants are critical components of every ship and watercraft used in every branch of the Armed Forces. These include Navy ships, Army transports, Coast Guard cutters, and Air Force recovery vessels. Oily water is generated on all of these vessels in bilgewater, compensated ballast tanks, or oily waste holding tanks. While emulsion formation and stability has been widely studied in other adjacent industries (e.g., food and medical industries), these specific properties have not been thoroughly investigated for Armed Forces bilgewater. Emulsions can be formed mechanically via shearing or turbulent forces and chemically via contamination by surfactants. Mechanically formed emulsions tend to settle out into separate distinct oil and water phases over time; however, chemically formed emulsions are extremely stable and will not settle out into the different phases.

Properties that determine the stability of a chemical emulsion include surface charge, steric stabilization, and pH. Components that affect these properties include particle size, particle isoelectric point, surfactant type and concentration, solution properties, and other contributing factors such as temperature and potential physical conditions or chemical reactions.

Preliminary studies have investigated idealized emulsion conditions and determined that chemical emulsions formed with surfactants available for shipboard use are stable over a wide range of pH and salt concentrations. Micelles range in size between 0.1 to 1.5 μm. It is well accepted that particles below 1 μm follow Brownian hard sphere properties, meaning they react like solid particles due to their small size despite being composed of liquid. Under these conditions, the micelles begin to collect surface charges which further enable emulsion stability from electrostatic repulsion. However, dependent upon the type of surfactant used, zeta potential, which is related to surface charge, can be neutral, but the emulsion is still stable. Under these conditions, the micelles are stabilized with steric forces, meaning the surfactant chains are looped in such a way which prevents micelle interaction.

Current OWS systems rely on specific gravity differences when separating oil and water. This can be very successful for bulk oil separation, but not in situations with chemically or mechanically formed emulsions. Because emulsions are combinations of oil, surfactant, and water, no specific gravity can be targeted for system design to distinguish the difference between oil and water. This results in long operational durations, leading to increased maintenance from continued processing and reprocessing of emulsions. Commonly available secondary treatment systems include absorbing technologies to capture and remove oil from the waste stream. Although the oil will be removed, the loading onto the absorbing technologies is high and requires frequent media replacement. Operational costs from media procurement and associated logistics from onboard storage of spares and spent media are increased. Other secondary treatment systems capable of removing the emulsions from the discharge stream (e.g., membrane technologies) do not destabilize emulsions and increase the burden to the finite storage capacity of the waste oil tank (WOT) by delivering the stable emulsions bonded with water that are not separated.
Issues caused by emulsions have led the Navy to field secondary membrane systems aboard new vessels. Additionally, the Navy is planning to back-fit 37 destroyers with secondary membrane systems at approximately $400K each for procurement plus the associated installation costs. If proper emulsion prevention and breaking technologies are designed and implemented based on better understanding of bilgewater emulsion, the oil fraction of bilgewater can be simply removed by the conventional OWSs, possibly without the need for secondary treatment systems, reducing the burden to the WOT and resulting costs.

Despite the problems associated with emulsions, little is known about the physiochemical processes involved with the formation, further generation and breaking of shipboard emulsions. In order to adequately address the issue of emulsions, comprehensive basic research efforts to understand and treat ship relevant emulsions at a variety of stabilization conditions are needed.

4. Cost and Duration of Proposed Work

The cost and time to meet the requirements of this SON are at the discretion of the proposer. Two options are available:

Standard Proposals: These proposals describe a complete research effort. The proposer should incorporate the appropriate time, schedule and cost requirements to accomplish the scope of work proposed. SERDP projects normally run from two to five years in length and vary considerably in cost consistent with the scope of the effort. It is expected that most proposals will fall into this category.

Limited Scope Proposals: Proposers with innovative approaches to the SON that entail high technical risk or have minimal supporting data may submit a Limited Scope Proposal for funding up to $200,000 and approximately one year in duration. Such proposals may be eligible for follow-on funding if they result in a successful initial project. The objective of these proposals should be to acquire the data necessary to demonstrate proof-of-concept or reduction of risk that will lead to development of a future Standard Proposal. Proposers should submit Limited Scope Proposals in accordance with the SERDP Core Solicitation instructions and deadlines.

5. Point of Contact:

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For Core Proposal submission due dates, instructions, and addition solicitation information, visit the SERDP website.

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