# 2008 Summary of Research Reports

Associate Professor Joel Esposito
Weapons and Systems Department
esposito@usna.edu

**Project:** A Framework for Distributed Manipulation by Swarms of Autonomous Vehicles
**Sponsor:** ONR

**Statement of Work:**

Imagine a team of autonomous tugboats that could have transported the USS Cole out of hostile waters and to a friendly port for repair. Picture teams of small ground robots that could work together to drag injured occupants from building rubble in search-and-rescue applications. Someday a team of autonomous tugboats might be able to transport the massive pilings needed to construct an offshore drilling platform or floating base. In the future, such tugboat swarms could even be useful as a non- destructive approach to prevent unauthorized ships from entering a harbor. Large-scale cooperative manipulation tasks such as these are performed by natural systems, from army ants to human beings, with a kind of "robust intelligence". They require no supervisory agents, little information about their environment and limited communication capacity. Yet the team somehow self-organizes, negotiates conflicts and produces the desired motion. They robustly adapt to the loss or addition of team members and environmental disturbances. In contrast, few man-made systems exhibit these qualities. Yet, there is a very real and growing need to develop systematic methodologies to control swarms of robots when performing tasks, such as manipulation, requiring dynamic coordination. Distributed, or decentralized, decision making is critical to achieving robust, scalable solutions. However, to date most distributed approaches to swarm control have focused on tasks that do not require controlling forces and torques. On the other hand, much of the work in robotics that focuses on more tightly coupled dynamic behavior, like manipulation, is not yet suitable for truly distributed implementation. The proposed work uses techniques from optimization and nonlinear control to address the uncertain aspects of cooperative manipulation by swarms of unmanned tugboats. The intellectual merit of this activity is to significantly advance the state of the art by introducing distributed and scalable versions of three traditional concepts in robotics: (1) coordinated motion control, (2) grasp planning, and (3) force control of prehensile manipulation. Fundamental questions on the role of communication will be addressed. Each of these sub- problems will be validated using a series of scale-ships in the Academy's premier hydrodynamic testing facility, as well as in open water creeks. The work builds on the results from prior ONR funding