

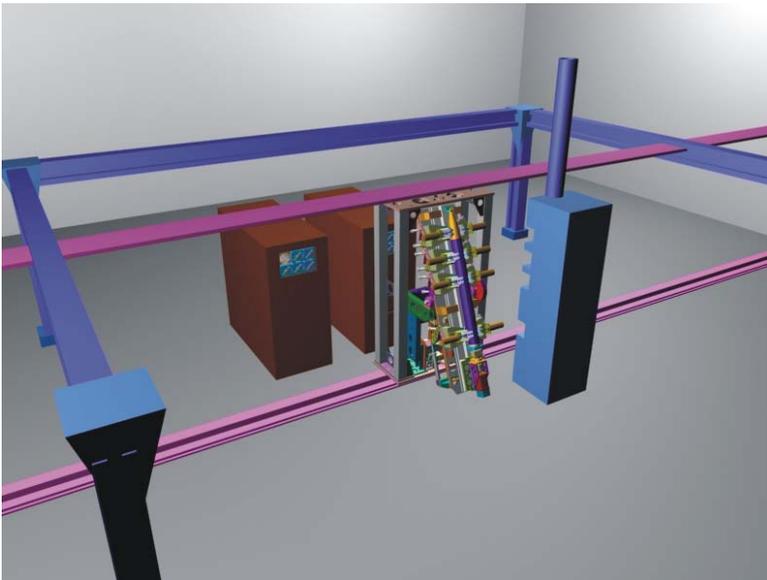
MODULAR AND FLEXIBLE HEAVY ORDNANCE HANDLING SYSTEM

Orbital Research's ship automation mission is to develop and commercialize innovative modular and flexible hardware and software technologies and services to meet manpower reduction needs of ships at sea while enhancing crewmembers' quality of life. The modular components will facilitate automation of vessels under dynamic sea-states and will significantly expedite the stowage or breakout of stores and weapons. We are dedicated to implementing and supporting our state-of-the-art technologies working closely with the Navy or ship manufacturer to produce a cost affordable and robust automation system.

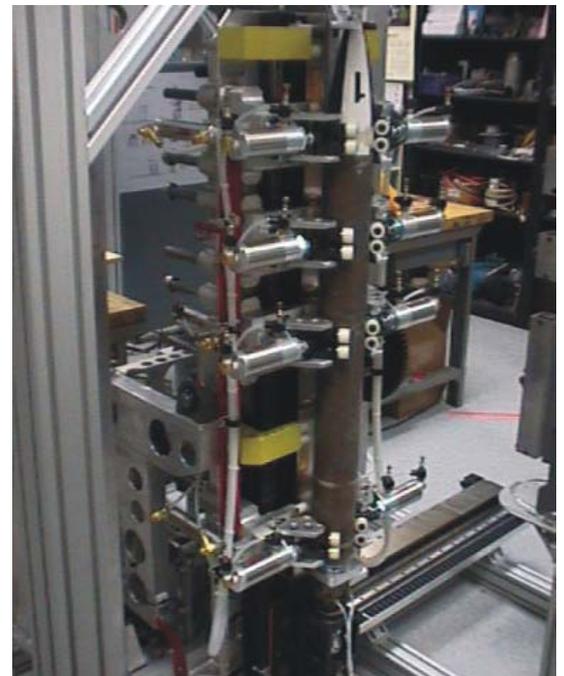
Phase II Program goal was to demonstrate an innovative control and hardware system utilized for ordnance stowage and handling. This modular system was designed to fulfill the Navy's needs for reduction of manpower in all manners of labor intensive environments and to accommodate ammunition too heavy for manual handling. The system also had to be affordable, robust and survivable while facilitating strike-down and also maintaining fire during high sea states. To avoid conflicting with Blue and Gold team DD-21 ship

designs, Orbital Research set out to automate the DDG-51 (Arleigh Burke Class) 5-inch gun magazine to demonstrate our technologies. The weapons magazine of the 5-inch gun is currently not automated. Further, it will need to handle the Extended Range Guided Munitions (ERGM) as well as the conventional 5-inch projectiles.

ERGM and 5 inch Projectile Hardware Demonstration – To demonstrate our modular hardware and software concepts, Orbital Research produced a 65% scale handling system for loading the ERGM, conventional projectiles, propellant and containers. Linear electric motors power the demonstrator. The motor's electromagnetic flux is completely contained which means that there are no EMI concerns within the magazine. The system included a "tilt and elevate" projectile handling tray and components to prevent loose weapons in the magazine. The hardware demonstrated the capability to sustain a firing rate of 6-10 ERGMS as well as conventional rounds per minute with a common loading mechanism.



Conceptual Drawing of Orbital Research's munition handling hardware demonstration (above) and a photograph of the handling system loading an ERGM into a lower hoist mock-up



Unified Control System Solution Simulation - a simulation of the control solution algorithm was demonstrated that represents ORI's core technology. The simulation introduced increased damping forces into the system. These damping forces represented either an unexpected increase in payload weight, friction in the system, actuator performance degradation, or a near-miss shock event. The simulation demonstrated how the control solution senses these significant changes in the system and adapts to maximize system performance. If for instance a component's performance is beginning to degrade, the control system recognizes the change in performance in real time, creates a new model of the system and continues to perform with essentially no degradation in performance or at least maximizes the performance given the nature of the degradation. In a global sense, the system is capable of recognizing a degraded condition and alerting an operator that system maintenance or component replacement is needed. Perhaps the most intriguing capability is its ability to recognize a near-miss shock condition and to enable a shock

algorithm that would result in a safer mode of operation. Allowing the system to continue to operate.

In summary, Orbital Research Inc successfully demonstrated a Modular Heavy Ordnance Handling System in fulfillment of a Phase II Small Business Innovative Research program supported by the DD-21 program office. This technology has a significant potential to benefit aircraft carriers as well as other surface combatants. More importantly, the concepts can be forward or backfit for Navy material and cargo handling needs. The potential benefits include.

- Tremendous cost savings
- Allows for a leaner and robust design
- Self tunes for actuator degradation
- Self tunes for sensor degradation
- Recoverability after near-miss shock
- Fault tolerance/isolation
- Enables precision placement of object in dynamic fluctuating environment

FEATURES	ADVANTAGES	BENEFITS
Automated System	Minimal personnel required Utilize entire weapon magazine	Reduced manning Increased stowage density Increased material throughput Reduce total ownership cost Reduce fatigue induced accidents Reduce ship underway replenishment time
Unified Control Solution Software	Multiple ship applications Less software programming for hardware applications	Custom configured to particular applications Cost saving Less training
Adaptive and Predictive Software Control	Updates its own model Accommodates degradation	Leaner, lower cost hardware
Crash avoidance algorithms	Reflexive collision avoidance	Works with personnel in environment
Emergent behavior algorithms	Coordinate activities among autonomous vehicles	Less human intervention required to accomplish tasks
Optimal trajectory control algorithms	Plan a path to maneuver from start to finish	Expedites material handling by avoiding bottlenecks
Modular Hardware	Use on other ship applications	Cost savings Less training Sailor familiarity

This work supported by the NAVSEA DD-21 SBIR program. Contract # N00024-98-C-4802

Orbital Research Inc., established in Cleveland Ohio (1991), is a high technology company. Our corporate mission is to develop and commercialize innovative solutions for the medical, controls and transportation industries through leveraging our expertise in MEMS devices and advanced control software. Orbital Research applies these core technologies to solve technical challenges using low cost and commercially viable solutions.