Topic: N151-027

Luna Innovations Incorporated

Processes for Condition Monitoring and Prognostics at the Sensor Node

Luna Innovations Incorporated (Luna) has developed a framework to design, test and deploy condition monitoring computational processes that track the health of shipboard equipment. Signal processing and modeling techniques are robust, efficient and tailored to conserve energy when run on battery-powered sensor nodes like Luna's condition-based maintenance hardware. This allows nodes to operate as edge computing resources that diagnose faults locally, report relevant damage features or transmit entire data histories for higher fidelity models that operate on shipboard computers to verify predictions and reduce risk. Performance has been demonstrated for the Navy through relevant environment testing, using both industrial and submarine-grade equipment in partnership with the original equipment manufacturer of hydraulic systems. The ultimate goal is to inform maintenance practices and lower total ownership costs.

Technology Category Alignment:

Machine Perception, Reasoning and Intelligence
Information Collection/Management
Engineered Resilient Systems (ERS)
Maintainability/Sustainability

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SYSCOM: NAVSEA
Contract: N00024-17-C-4008

Corporate Brochure: https://navystp.com/vtm/open_file?type=brochure&id=N00024-17-C-4008

Tech Talk: https://atsi.adobeconnect.com/pr4a9ty17e3q/

Department of the Navy SBIR/STTR Transition Program

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NAVSEA #2019-0550

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Processes for Condition Monitoring and Prognostics at the Sensor Node

Luna Innovations Incorporated

WHO

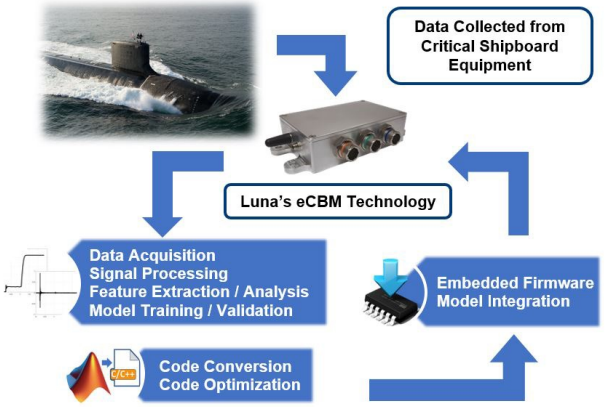
SYSCOM: NAVSEA

Sponsoring Program: PMS 450

Transition Target: PEO Submarines

TPOC:
(215)897-8358

Other transition opportunities: Unmanned underwater vehicles; life support systems for submarines; hull, mechanical & electrical (HM&E) equipment for military and commercial ships; dams and navigational locks maintained by the Army Corps of Engineers; facility scale heating, ventilation and air conditioning (HVAC) systems.



Notes: The Navy has been developing condition-based maintenance (CBM) technologies for the past decade. The integration of prognostics (CBM+) allows maintainers to estimate remaining useful life and schedule maintenance activities to avoid unnecessary overhauls, identify impending failures and ultimately minimize time spent in depot. Wireless sensing hardware can enable widespread use of CBM+, however it requires that data processing and modeling algorithms be computationally efficient, easy to train and validate and accurate in providing health assessments. Luna Innovations, Inc. (Luna) has developed an embedded CBM (eCBM) process development environment to identify the onset of damage while reliably and accurately determining equipment health and assessing the need for maintenance.

WHAT

Operational Need and Improvement: The U.S. Navy is investing in tools to monitor the health and performance of machinery onboard submarines and surface ships. These tools inform CBM+ to improve operational availability and reduce maintenance cost through condition assessments that drive overhaul and repair schedules. Widespread adoption requires robust and efficient models and software that can run on low-power sensing hardware. Luna has developed a framework to design, test and deploy eCBM algorithms that can be implemented using battery powered electronics.

Specifications Required: The Navy is seeking to develop computational processes that correlate transient and steady-state operation of equipment with health assessments related to known and predictive failure modes. Algorithms must be suitable for processors that capture data at the equipment level where sensor nodes are used to wirelessly communicate with network resources. Models need to track damage state and accumulation for core shipboard operations like, but not limited to, actuation of valves using hydraulic or electric linear and rotary actuators, pumps, motors or compressors.

Technology Developed: Luna's eCBM process development environment provides the ability to design, test and deploy data processing and classification algorithms using embedded wireless sensor nodes. The framework allows users to analyze features from a range of sensors and apply computationally efficient models that can be compiled and deployed using battery powered sensing hardware. Extensive laboratory experiments have shown these algorithms can accurately assess equipment health, damage type and damage severity. Tests have been performed on industrial and Navy grade hydraulic actuators in partnership with the original equipment manufacturer (OEM). Training workshops have been provided to DON personnel, and the methodology has been validated on three hydraulic test stands.

Warfighter Value: CBM enabled equipment will perform self-inspections, monitor for known failure modes and inform maintenance schedules to minimize time spent in depot. This will increase operational availability, reduce maintenance cost and allow warfighters to focus on mission-related objectives through automation of routine inspections.

WHEN

Contract Number: N00024-17-C-4008 **Ending on:** December 31, 2019

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Develop framework to identify data features and generate machine learning algorithms for damage classification	N/A	Provide workshop to NSWC personnel	3	April 2017
Perform failure mode analysis of industrial rotary hydraulic actuators with multiple damage states and severities	N/A	Datasets with baseline and damage states	4	June 2018
Perform relevant environment testing on Navy grade actuator in partnership with OEM	N/A	Model prediction using embedded sensor nodes	5	March 2019
Extend data collection, analysis and modeling approach to linear hydraulic actuator	Low	Accurate prediction of operating state	6	February 2020
Test performance on shipboard hydraulic components	Med	Accurate prediction of operating state	7	December 2020

HOW

Projected Business Model: Luna's goal is to deliver robust condition monitoring systems that inform maintenance activities for critical equipment and machinery. Luna's technical and commercial development team is working to market the eCBM line of technology to complement our existing products in corrosion monitoring. Luna supports low-rate production and will use the process development framework to generate software and firmware that will provide intelligent sensor nodes that can locally diagnose and predict equipment health. Luna is also working with OEMs and system integrators to discuss licensing the eCBM technology to provide a line of 'smart' equipment that can intrinsically monitor machinery health and alert operators of maintenance needs. Luna is also pursuing licensing options with the Navy to determine how the process development environment can be used to analyze and model existing data streams already being generated by shipboard equipment.

Company Objectives: Luna's creative scientists and engineers collaborate with prime contractors, government offices and federally funded R&D centers to align our applied research technologies with customer needs. Luna's Performance Systems and Analytics group focuses on advanced, high performance sensors and measurement technologies for extreme environments and long operational life to improve safety, reliability and operating cost. Luna is at the forefront of corrosion monitoring technologies, and the eCBM technology will expand our presence in equipment health monitoring. Luna has established strong relationships with prime integrators and original equipment manufacturers, and we are actively discussing how the eCBM can be integrated into new equipment designs.

Potential Commercial Applications: Luna's eCBM technologies will provide local health monitoring capabilities for a variety of equipment systems used by defense, industrial and energy customers. Direct applications would include hydraulic actuators used in dams and navigational locks, oil and gas drill rigs and off-shore platforms as well as military and commercial ships. The technology can also be used to monitor HVAC systems and equipment used in government, commercial and private facilities.

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