Charles River Analytics Advancing Predictive Maintenance Capabilities for Naval Systems

Advanced predictive maintenance and logistics technologies will enable the Navy to transition from reactive to proactive maintenance strategies.

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Charles River Analytics is developing advanced predictive maintenance and logistics technologies for the United States Navy's ship systems. The technology helps ensure reliability across the entire lifecycle of complex assets, including ships, fleets, and equipment. The work is sponsored by the Naval Sea Systems Command (NAVSEA) and supported through a series of contracts totaling $6.6 million over 8.5 years. The multidisciplinary team is using system modeling, hybrid AI reasoning, and cognitive systems engineering to create software services that predict system performance and

proactive maintenance needs.

Traditional prescriptive maintenance relies on fixing or replacing degraded parts on rigid schedules. This reactive approach can lead to wasted resources, late or premature maintenance, and operational delays. Logistics and timely availability of parts are especially critical for long-duration or hard-to-reach assets, such as ships at sea, where system failures can have severe consequences and teams have small windows of opportunity to complete any necessary repairs.

“By predicting when failures occur, you can optimize resource and labor allocation by prioritizing the failures or degradations that are most pressing or most impactful for the mission,” says Kenny Lu, Machine Learning Scientist at Charles River Analytics.

The Navy is shifting toward a more proactive approach that uses data to forecast maintenance needs before catastrophic failure. The Charles River team is supporting this effort by developing software that provides on-platform, real-time prognostics and real-time diagnostics, including actionable insights for operators and maintainers. The solution features a back-end analytics engine that uses a statistical modeling technique called probabilistic programming to forecast failures and assess risk. It is based on a hybrid AI approach that combines domain expertise with available sensor and log data. The system translates complex technical data into clear recommendations through a front-end decision support interface, delivering user-friendly guidance to maintenance personnel in an intuitive format.

“We’re not framing the information from a system engineering perspective, but from a perspective where maintenance staff can interpret the maintenance picture,” says Mandy Warren, UX Senior Scientist at Charles River Analytics. She adds, “Our end users greatly appreciate that they don’t need the same

understanding as the engineer who architected the system; they only need to know what's relevant and what they need to do in that moment."

These predictive analytics technologies enable junior technicians to quickly identify potential problem areas and prioritize maintenance tasks, ultimately allowing the Navy to deploy technical specialists strategically when advanced knowledge is required.

The team is addressing a fundamental challenge with predictive systems and AI by helping users understand how the system arrives at its conclusions.

"We're building the system with the idea of being able to collect performance data over time, to make sure that the output is explainable, and that the provenance of the forecasting is constantly updating, so that the operator knows that they can trust the predictions of our system," said Samuel Mahoney, Vice President and Chief Product Officer at Charles River Analytics.

After more than eight years of development and testing, the system is now transitioning from research to operational use, and a prototype will soon be deployed on a Naval ship. By reducing unnecessary maintenance, the technology frees up the Navy's resources for mission-critical needs while increasing operational readiness through early failure prediction and prevention.

Charles River Analytics is also exploring opportunities for its predictive maintenance and logistics technology beyond the Navy to other military and commercial domains, including ground and air autonomy, oil and gas, power grids, and industrial maintenance. The focus is on making complex analytics accessible to non-engineers through improved trust and a user-friendly interface.

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maintenance and logistics and our other human-machine teamingand probabilistic programming capabilities.

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