Navy’s NEPTUNE Program Energizes Innovation from Lab to Fleet



Bridging University Research and Naval Needs

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The Office of Naval Research’s Naval Enterprise Partnership Teaming with Universities for National Excellence (NEPTUNE)

program is aligning academic innovation with naval energy needs. Launched as a pilot in 2015, NEPTUNE connects top universities with Navy and Marine Corps problem sponsors to tackle energy challenges ranging from power management to next generation fuels.

“The NEPTUNE program exemplifies the kind of innovative partnerships we need to accelerate defense technology development,” commented Dr. Scott Higgins, ONR program officer, and NEPTUNE lead.

By funding university research teams that include military or veteran students, and focusing on energy-related domains like energy storage, power generation and micro-grids. NEPTUNE rapidly transitions lab concepts toward operational naval solutions. The program has established strategic partnerships with institutions including Stanford, MIT, Purdue University, UC Davis, and others. The results of such partnerships align with the Secretary of the Navy’s priorities of people, capabilities, and processes.

NEPTUNE’s approach emphasizes moving research along the technology readiness scale by advancing basic science (TRL 2-4) to prototype demonstrations in real-world environments (TRL 7). This is done by fostering connections between the Department of the Navy, colleges and universities, and industry.

“These collaborations are proving instrumental in rapidly transitioning innovative technologies from laboratory concepts to operational naval assets” said Dr. Jeff Decker, managing director of Stanford’s Tech Transfer for Defense and a Hacking for Defense program director.

Programs like NEPTUNE are accelerating the time between the lab and real-world impact,” said Justin Fanelli, chief technology officer for the Department of the Navy. “By embedding operational needs directly into university projects,

we’re not just moving new technologies forward, we’re ensuring it’s deployable where it matters most – at sea and in the field.”

From Purdue Lab to Startup: EnergyMind Takes Flight

A prime example of NEPTUNE’s impact is the technology transition from Professor Vikas Tomar’s lab at Purdue University into a new startup called Primordis, Inc. Supported by NEPTUNE-funded research at Purdue, Dr. Tomar’s team developed a suite of artificial intelligence algorithms for energy management of autonomous systems, mobile robots, and data centers. His work has resulted in three related patents and now forms the core of Primordis’ EnergyMind platform. Founded in late 2024, Primordis.ai is bringing Purdue University technology to market, targeting applications in both defense and industry.

“This is about bridging the gap between what we demonstrate in the lab and what the warfighter needs on the field,” explains Dr. Tomar, a professor of aeronautics and astronautics and Primordis co-founder.

Primordis describes EnergyMind as a new form of Autonomous Energy Intelligence (AEI) – essentially, a real-time AI decision agent for operators and platforms. Unlike conventional monitoring systems that merely track usage or give static forecasts, EnergyMind proactively guides decision-making on energy use in dynamic environments. It integrates mission timeline goals, operational range priorities, and immediate power consumption into a single predictive gauge. Backed by machine learning, the system continuously learns from context and predicts energy bottlenecks before they occur, suggesting or automatically executing adjustments in real time.

At the individual asset level (say, an unmanned vehicle or a server), EnergyMind can reschedule tasks or rebalance loads to

extend runtime without sacrificing performance. At the fleet or enterprise level, it manages charging cycles, route planning, and load distribution across multiple assets to optimize overall energy availability and resilience. Crucially, the platform is hardware-agnostic as it is compatible with any battery chemistry and neutral to OEM, and works in standalone devices or networked across an entire operation. By blending predictive energy "survivability" analytics with the commander's intent, EnergyMind aims to extend operational reach, reduce downtime, cut sustainment costs, and enhance the endurance of systems ranging from autonomous drones to data centers.

Transitioning this technology out of academia was enabled by NEPTUNE's support, noted Dr. Tomar. "NEPTUNE allowed us to de-risk the early research and focus on a solution for real naval problems."

The NEPTUNE framework connected his team with Navy stakeholders who provided feedback during development, ensuring the resulting technology addresses operational pain points like limited battery life and unpredictable power demands in the field. With ONR's backing, what began as a basic research project on AI-driven battery health monitoring quickly evolved into a deployable capability. In November 2024, Dr. Tomar and colleagues launched Primordis to commercialize EnergyMind and related innovations. The startup is already securing pilot contracts, including with Navy and Marine Corps end-users to integrate EnergyMind into next-generation platforms. This trajectory from lab to spin-off exemplifies how NEPTUNE accelerates the naval "innovation pipeline," turning university research into products for Sailors and Marines.

AI Power Management for the Fleet

Primordis's technology is arriving at a pivotal moment, as the Navy and Department of Defense push to electrify platforms and

improve energy efficiency across the board. The EnergyMind platform provides a critical piece: AI-powered energy management that can dramatically extend the endurance and reliability of electrically propelled systems. Military and commercial stakeholders are taking note of its potential.

Jeff Wright is CEO of SplashOne Robotics, and the former CTO of Special Operations Command Pacific (SOCPAC), where he led the development of INDOPACOM's un-manned systems strategy. "We believe this integration [EnergyMind on drones] will create a decisive edge in contested environments where energy autonomy is just as critical as speed, agility, and firepower" he stated. "Single digits of improvement in system life can be decisive: 20% increases are quantum leaps and a 'no brainer' to include in our designs."

Kevin Murray, senior director of Strategic Growth at Anduril Industries shared, "As the former director of S&T and CTO for the U.S. Marine Corps, I see application of this technology across numerous DoD robotic and autonomous system programs at all levels, all the way down to soldier borne mission command and FPV drone operations. I'm unaware of anything similar that could be as impactful."

Front-line requirements are driving interest as well. A Program Executive Officer at NAVWAR, the Navy's warfare systems command, underscored the need for greater endurance in unmanned systems. "I need on-station time doubled or tripled for certain USVs. EnergyMind is the type of solution we are looking for," the PEO remarked. Even industry partners echo this enthusiasm – the CEO of one UAV manufacturer noted that a mere 2% range increase in their drones would be game-changing, so "a 20% increase using Primordis' technology will be phenomenal." Such testimonials highlight how advanced energy-management AI could fundamentally improve combat effectiveness: longer loiter times for uncrewed vessels, more patrol hours per battery, and reduced logistics for fuel or battery resupply.

Primordis is positioning EnergyMind to support a wide array of defense systems. In the near term, the company is working with original equipment manufacturers (OEMs) of battery-powered unmanned aerial, surface, and underwater vehicles to embed AI energy controllers in their platforms. The technology is equally relevant to operational energy at the enterprise level — for example, managing the micro-grids powering expeditionary bases, command-and-control hubs, or even directing energy usage for high-power systems like radar and directed-energy weapons. By extending battery life and optimizing power use, tools like EnergyMind can bolster concepts such as Expeditionary Advanced Base Operations (EABO) by reducing the logistics burden and increasing platform uptime. Navy and Marine Corps initiatives that depend on swarms of autonomous systems or long-endurance sensors could see immediate benefits. As one Air Force special operations architect observed, an AI energy management layer can dramatically extend the performance of emerging technologies like high-density batteries and wireless power beaming — multiplying the impact of those innovations in the field. In short, the EnergyMind solution born from NEPTUNE research is poised to give U.S. forces a tactical advantage: the ability to outlast and outmaneuver by intelligently managing every watt.

A Broader NEPTUNE Impact

The Purdue-Primordis story is just one illustration of NEPTUNE's broader impact on naval technology. Across the country, NEPTUNE-sponsored projects are yielding tangible results in surprisingly short timeframes. A standout example comes from the Massachusetts Institute of Technology, where Professor Steven Leeb's team, also part of NEPTUNE, developed a groundbreaking Combat Power Monitor (CPM) for shipboard use. Leveraging advances in energy sensing and analytics, Leeb's group created a system to continuously monitor a ship's electrical consumption and power quality, enabling real-time insights for condition-based maintenance and fuel

economization. With NEPTUNE backing, the MIT researchers moved this concept from the lab to a prototype installed on active Navy and Coast Guard vessels in only 24 months.

“With Professor Leeb’s work, the ability to monitor and manage energy usage on ships ensures that our vessels can operate longer, with greater endurance, and with reduced logistical footprints,” noted Fanelli. “Put simply, Leeb’s work improves naval readiness by keeping ships afloat and out of drydock, which is a focal point for the chief of Naval Operations.”

Such enhancements are crucial in scenarios where at-sea resupply is challenging or when minimizing energy signatures is vital for stealth[19]. The CPM’s rapid transition to ship trials, made possible by NEPTUNE’s university partnerships, underscores how this program speeds up innovation.

As the NEPTUNE initiative continues, it represents a strategic investment in future naval capabilities. By funding promising ideas in academia and teaming scientists with warfighters early, ONR is compressing the timeline from discovery to deployment. Dr. Scott Higgins emphasizes that its mission is not just to invent new technologies but to ensure those innovations make a difference for sailors and marines. The program’s success stories – from smart battery AI at Primordis to MIT’s combat power sensors – are proving the model.

“We stand at an inflection point – an era marked by great power competition, proliferating threats, rapid technological convergence and an increasingly contested maritime domain. To prevail, we must build and sustain a Navy that is ready to fight and win – today, tomorrow and well into the future.” said Admiral Daryl L. Caudle, United States Navy, 34th chief of Naval Operations. “NEPTUNE’s university partnerships are answering that call, delivering energy-smart solutions to the Fleet and fueling a culture of innovation that will help the Navy sail stronger into the future.”

“The unique construct of the NEPTUNE program allows Navy and DoD stakeholders to share capability gaps and technology needs with academic researchers and engages veteran, active duty, reserve and ROTC students in mission-focused research,” noted Corey Love, senior science and technology manager for Power and Energy at the U.S. Naval Research Laboratory and former NEPTUNE program officer. “The positive impact on workforce development hits on two levels: first it provides opportunities to support advanced degrees in science and engineering for veterans, with many who will go on to military civilian or defense industry research positions; and second, it exposes our future military leaders with an appreciation of energy challenges and the importance of making energy-informed decisions on the battlefield. Combined with the focus on advancing technology to promote entrepreneurship to develop the industry required for the future Navy, the tenants of NEPTUNE address Navy priorities outlined by senior leadership.”

To learn more about the ONR NEPTUNE program, visit onr.navy.mil; for more information on the Technology Transfer for Defense program at Stanford University, visit techtransferfordefense.stanford.edu or on the Hacking for Defense Program, visit h4d.stanford.edu.