



Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-583

Proposal Title: DIY Amphibious Robots: Aquatic Ecology Education for Minnesota

Project Manager Information

Name: Nikolaos Papanikolopoulos

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: We propose to create robotics-based educational activities for middle- and high-school youth on aquatic ecology in Minnesota. Youth will learn to measure lake health and communicate results through hands-on projects.

ENRTF Funds Requested: \$450,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Education and Outdoor Recreation (C)

Project Location

What is the best scale for describing where your work will take place?

Statewide

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

While water quality is central to the health of both Minnesota's watersheds and the general population, the capacity to monitor the state's vast lake systems remains severely limited. Lake shorelines are primary factors that regulate lake health, but Municipal surveying efforts alone struggle to understand the health of Minnesota's shorelines in detail. Systematic shoreline monitoring at the local level remains largely absent. Finally, though the general public recognizes that environmental stewardship is important, effective education in environmental awareness and stewardship is insufficient.

The overlapping gaps in water quality, shoreline data, and education deficiencies represent a significant opportunity. Inexpensive robotic sensing platforms and carefully-crafted aquatic ecology learning experiences, coupled with K-12 youth enthusiastic about both robotics and conservation, present a compelling path forward. Engaging middle-school students across Minnesota Counties from Big Stone to Pine and From Beltrami to Le Sueur, our ENRTF-funded project (project ID 2024-250) demonstrated that hands-on robotics activities help youth learn about and engage with Minnesota's water quality issues. This next phase aims to leverage that base and expand on the scope of citizen-collected data by equipping student teams with an amphibious sensing platform capable of addressing water quality, fish habitat, and shoreline monitoring across Minnesota's lakes.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

Building upon the project's first phase, we propose continuing our youth water quality education initiative by developing an amphibious robotic vessel for surveying lake shoreline health. The first phase engaged students in collecting water quality data from Minnesota watersheds, using sensor systems that only went underwater and were tethered to the operator. In this new phase, we'll introduce an untethered robotic amphibious vessel which can move on land as well as on and in the water. The enthusiastic participation of around 30 teams statewide, together with strong interest in the project's continuation, justifies the increase in scope this phase requires.

The amphibious platform will enable high-quality shoreline surveying: GPS positioning for precisely targeting specific zones and returning to the same locations over time, enabling meaningful long-term trend monitoring; a more capable onboard computer to enable AI-assisted detection and classification of the most common and health-determining plants along underwater shoreline environments; and untethered remote piloting capability. These enhancements will leverage the learning communities and partner networks established during the first phase, ensuring this next phase grows from a proven, statewide foundation. In the hands of Minnesota's youth, this robotic platform will enable hands-on environmental education and high-quality lake health data collection.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

By engaging youth in hands-on lake monitoring, we aim to equip students statewide as citizen-scientists with the skills for building and operating innovative, low-cost robotic platforms; measuring water quality, fish habitat, and shoreline conditions across Minnesota lake systems, and contributing environmental data to statewide monitoring efforts. This work will prepare the next generation to protect, conserve, and steward Minnesota's natural resources. It will also produce a field-tested, low-cost amphibious platform that individuals and organizations alike can independently build and deploy, lowering entry barriers and enabling citizen participation in the protection and preservation of Minnesota's lakes and watersheds.

Activities and Milestones

Activity 1: Develop Amphibious Robots and Learning Experience

Activity Budget: \$204,000

Activity Description:

The objectives of this activity are to design and develop an amphibious robotic vessel that integrates with a low-cost underwater robotic environmental sensor kit, and to create comprehensive learning materials that guide student teams through the engineering intuition behind this new platform. Working with our established partners, we will develop a bank of ready-made kits with accompanying assembly manuals and structured learning materials. Rather than designing the platform from scratch, student teams will assemble the kit while engaging with a curriculum that explains the reasoning behind key design choices, including platform integration, sensing hardware selection, and onboard AI computing. This approach ensures that students develop a meaningful understanding of engineering principles and systems thinking without being overburdened by design complexity. Feedback gathered from the first phase will be incorporated to ensure that learning materials are effective and appropriate for the student demographic. The primary output of this activity will be a validated, field-ready amphibious robotic platform accompanied by comprehensive assembly documentation and structured learning materials. Youth educators will be trained on platform fundamentals and curriculum delivery through a series of workshops and online sessions in coordination with our partners, ensuring consistent implementation across all participating teams statewide.

Activity Milestones:

Description	Approximate Completion Date
Build partnerships and promote design meetings with established student communities and youth educator partners.	December 31, 2027
Design and validate amphibious platform architecture; identify requirements for integration with existing robotic sensing kits.	January 31, 2028
Develop structured learning materials explaining engineering design choices and systems thinking principles for student teams.	April 30, 2028
Promote and perform training sessions for youth educators on platform fundamentals and curriculum delivery.	May 31, 2028

Activity 2: Aquatic Ecology Education with Robotic Vision and Machine Learning

Activity Budget: \$142,000

Activity Description:

This activity will deploy a student-led network of amphibious robots to monitor the “living filters” of Minnesota’s lakes. The shallow water near the shore, known as the littoral zone, is the engine of lake health, where native plants and mussels naturally clean millions of gallons of water. Monitoring and protecting these species is vital for lake health. Using high-definition cameras integrated into the amphibious robots, students will capture images of shore and shallow water habitats often unreachable by traditional means. Our custom-built curriculum will guide students in teaching the amphibious robot to recognize healthy lake patterns — identifying, for instance, rare mussels or thriving wild rice beds. This approach will transform “screen time” into “science time,” allowing students to build modern technical skills while collecting scientific data that can contribute to a statewide Benthic Health Map, which will in turn provide Minnesota natural resource experts with real-time data to improve the management of local water resources. By training local educators to lead these missions, we can ensure that Minnesota students gain the digital literacy required for future careers, resulting in a more resilient environment and a generation of young Minnesotans prepared to protect our 10,000 lakes for years to come.

Activity Milestones:

Description	Approximate Completion Date
Amphibian robotic vision system deployment; curriculum development and educator training	April 30, 2028
Student field education missions; establishment of littoral zone monitoring dataset	August 31, 2028
Education program consolidation and expanded data collection	June 30, 2029

Activity 3: Deploy and Evaluate Learning Experience**Activity Budget:** \$104,000**Activity Description:**

We will carry out free summer water quality education programs for the target participation of 150 students, conducting sampling experiments at the 30+ lakes chosen in the previous project. We will send education materials and robot kits to local experience coordinators. Robotics and sensing experts from the Minnesota Robotics Institute (MnRI) at UMN will provide coaching on system design and assembly via a flexible combination of face-to-face and virtual communication. Before field testing, we will provide training on all Minnesota DNR compliance safety procedures and on standardized data collection methods.

MnRI will host the top 3 teams of students at UMN to experience a research laboratory environment and underwater robot.

Data collected throughout the program will be aggregated, processed, and made available for documenting water quality. Our educational partners will monitor our educational methods, evaluate them, and work with MnRI to make improvements. We will conduct online surveys of students and other stakeholders, gathering feedback on the concepts or sensors that have excited the students and on the ones that did not. A revised set of activities and sensors will be created and shared with the broader community as a final output of the program.

Activity Milestones:

Description	Approximate Completion Date
Supply robots to all participants and local coordinators	June 30, 2028
Host on-campus immersion session for the top 3 teams, research vehicle interaction, and on-site data	August 31, 2028
Aggregate and process measurement data; re-publish to teachers and stakeholders for environmental education	September 30, 2028
Collect post-experience feedback from students and local coordinators	February 28, 2029
Analyze the post-experience feedback and publish the results	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Nikolaos Papanikolopoulos	University of Minnesota	PI	Yes
Theodore Morris	University of Minnesota	Senior Personnel	Yes
Junaed Sattar	University of Minnesota	Co-PI	Yes
Ce Yang	University of Minnesota	Co-PI	Yes
Travis Henderson	University of Minnesota	Senior Personnel	Yes
Brian McNeill	University of Minnesota	Senior Personnel	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.

The proposal collaborators have several parallel plans for dissemination of data and results. First, data collected by students will be reviewed, aggregated, and published to a publicly accessible website maintained by UMN. Second, the learning experience will culminate in an opportunity for the students to publicly share their findings and experiences at the Minnesota State Fair. Finally, any engineering innovations that may arise as a byproduct of the amphibious robot design will be documented and submitted for publishing through the peer review process to the relevant robotics conference or journal.

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?

The University of Minnesota currently maintains a web-based portal presenting results from the first phase. It contains training materials for building the initial robotic platform, the source code required to operate the sensing module, and a map with the collected data preserved for the general scientific audience. The second phase of the project will expand the project's "open-source" nature by including materials generated in this iteration. These results, an extension of the current resources, will be preserved and accessible for both the general scientific audience and the Department of Natural Resources (DNR).

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Water Quality and Robots: Experientially Educating Minnesotan Youth	M.L. 2024, , Chp. 83, Art. , Sec. 2, Subd. 05s	\$353,000

Project Manager and Organization Qualifications

Project Manager Name: Nikolaos Papanikolopoulos

Job Title: Minnesota Robotics Institute Director, McKnight Presidential Endowed Prof. of CS

Provide description of the project manager’s qualifications to manage the proposed project.

Nikolaos P. Papanikolopoulos, an IEEE Fellow, received a Diploma degree in electrical and computer engineering from the National Technical University of Athens, in Greece, in 1987, an M.S.E.E. in electrical engineering from Carnegie Mellon University, in 1988, and a Ph.D. in electrical and computer engineering from Carnegie Mellon University, in 1992. Currently, Papanikolopoulos is the McKnight Presidential Endowed Professor in Computer Science, a Distinguished McKnight University Professor in the Department of Computer Science at the University of Minnesota, and Director of the Minnesota Robotics Institute (MnRI). His research interests include robotics, computer vision, sensors for transportation applications, and control. He has authored or co-authored more than 400 journal and conference papers in the above areas, including more than 90 refereed journal papers. His work has been funded by NSF, NIH, DHS, DARPA, MnDOT, Wisc DOT, Kansas DOT, FHWA, Honeywell, Minnesota Corn Growers, 3M, Johnson Controls, and Sentera. He has advised more than 30 Ph.D. students and holds eight patents. He has been General and Program Chair for the two largest international robotics conferences (IEEE International Conference on Robotics and Automation and IEEE/RSJ International Conference on Intelligent Robots and Systems). He has received the IEEE Robotics and Automation Distinguished Service and George Saridis awards. He founded along with his students ReconRobotics Inc. which has deployed more than 6,000 robots worldwide. His service to the University of Minnesota ranges from working with a donor to secure a \$10M donation for the robotics effort to chairing the MnDRIVE Robotics, Sensors, and Advanced Manufacturing planning committee for organizing MnRI and the MS in Robotics program. He has also organized and supported robotics summer camps for middle schoolers from various groups for the last 16 years. More than 1,000 students have participated in these events.

Organization: U of MN - College of Science and Engineering

Organization Description:

The project will be managed by the Minnesota Robotics Institute (a unit of the College of CSE, UMN). The Minnesota Robotics Institute (MnRI) is an outcome of the University of Minnesota’s Discovery, Research, and InnoVation Economy initiative that brings together interdisciplinary researchers to solve grand challenges and increase Minnesota’s position as a worldwide leader in robotics research and education. MnRI is housed in the world-class Gemini-Huntley Research Laboratory, made possible by a generous gift from Jim & Sharon Weinel and Fred & Siri Oss. The laboratory has a 20,000-square-foot, state-of-the-art robotics research space and includes nine flexible robotics labs and various workspaces for faculty and graduate students—including a two-story drone lab and labs that provide research space for research on underwater robots. MnRI is offering several outreach programs that range from robotics summer camps to support of high school robotics teams throughout the state. MnRI has also started an MS program in Robotics. The project will be done in collaboration with CFANS. An Advisory Panel, consisting among others of Michelle J. Snider (Executive Director, Minnesota Recreation and Park Association), Renee Mattson (Executive Director, Greater Minnesota Regional Parks and Trails Commission), and a DNR representative, will help us execute the plan.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Nikolaos Papanikolopoulos		PI-Responsible for overall project oversight, coordination of project activities, management of partnerships, and ensuring the successful execution of all technical, educational, and reporting components. Note the correct % is 36.6, but due to rounding in the system, it is listed as 36%.			36%	0.08		\$40,684
Junaed Sattar		Co-PI-Responsible for providing domain expertise in underwater robotics, contributing to the design, integration, and technical development of the amphibious robotic platform and sensing systems. Note the correct % is 36.6, but due to rounding in the system, it is listed as 36%.			36%	0.16		\$45,414
Ce Yang		Co-PI-Responsible for supporting the design, development, and testing of the amphibious robotic platform, including integration of sensing systems and assisting with technical implementation of project components. Note the correct % is 36.6, but due to rounding in the system, it is listed as 36%.			36%	0.08		\$16,993
Travis Henderson		Senior Personnel-Responsible for leading education and outreach efforts focused on engaging student teams in robotics-based learning, supporting curriculum implementation, coordinating team participation, and facilitating technical learning experiences related to robotic system use. Note the correct % is 32.3, but due to rounding in the system, it is listed as 32%.			32.3%	0.3		\$30,645
Ted Morris		Senior Personnel-Responsible for supporting the development, testing, and refinement of the amphibious robotic platform, including assisting with system integration, troubleshooting, and validation of sensing and robotic components. Note the correct % is 36.6, but due to rounding in the system, it is listed as 36%.			36%	0.16		\$22,259

Brian McNeill		Senior Personnel-Responsible for leading outreach and engagement efforts focused on natural resources education, supporting connections between student teams and environmental topics such as lake ecology, shoreline monitoring, and conservation, and assisting with the coordination of community and educational partners. Note the correct % is 36.6, but due to rounding in the system, it is listed as 36%.			36%	0.02		\$3,271
Graduate Research Assistant (CFANS)		Responsible for supporting the implementation of the project through hands-on development, testing, and deployment of robotic sensing systems, assisting with data collection and analysis, and supporting student teams and educational activities related to aquatic ecology and robotics. Note the correct % is 24.2, but due to rounding in the system, it is listed as 24%.			24%	0.5		\$99,721
Graduate Research Assistant (CS&E)		Responsible for supporting the technical development of the amphibious robotic platform, including software development, sensor integration, data processing, and implementation of machine learning or AI-based components for environmental monitoring. Note the correct % is 24.2, but due to rounding in the system, it is listed as 24%.			24%	0.5		\$104,013
							Sub Total	\$363,000
Contracts and Services								
High Tech Kids	Subaward	High Tech Kids will support statewide program implementation by recruiting and coordinating student teams, assisting educators, and facilitating the delivery of robotics-based aquatic ecology activities. Funds will primarily support personnel for outreach, coordination, and training, with minor administrative support costs. No equipment or generally ineligible expenses are included.				0.2		\$15,295
							Sub Total	\$15,295

Equipment, Tools, and Supplies								
	Equipment	Robotic Platform Components Description: Amphibious robot components (motors, waterproof housings, propulsion systems, microcontrollers, structural materials) for ~30 student kits	To design and build amphibious robotic platforms used by student teams for aquatic ecology monitoring and data collection					\$25,000
	Tools and Supplies	Environmental Sensors and Imaging Equipment Description: Water quality sensors, cameras, GPS modules, and sensing instrumentation for robotic platforms (multiple units across kits)	To enable collection of environmental data including water quality, shoreline conditions, and ecological indicators across Minnesota lakes					\$18,000
	Tools and Supplies	Assembly and Integration Supplies Description: Wiring, connectors, batteries, mounting hardware, waterproofing materials, and general assembly supplies (bulk)	To support assembly, integration, maintenance, and field deployment of robotic systems by student teams					\$8,500
	Equipment	Educational Robotics Kits and Materials Description: Standardized kit materials and instructional components distributed to ~30 student teams	To support hands-on learning, enabling students to build and operate robotic systems as part of aquatic ecology education activities					\$5,925
	Tools and Supplies	Freight Description: Shipping and distribution for robotic kits, components, and supplies to participating teams statewide	To ensure equitable access to project materials for teams unable to collect kits in person					\$2,405
							Sub Total	\$59,830
Capital Equipment								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	Travel support for approximately 30 student teams (non-employees) attending required one-day, in-person training sessions. Includes mileage reimbursement (estimated ~\$120 per team) and	An exception is requested for participant travel expenses because these costs are directly necessary for project implementation. The required training sessions provide essential					\$4,800

		limited lodging support for teams traveling long distances.	instruction in robot assembly, safety procedures, and curriculum delivery. Without travel support, teams from rural and under-resourced areas would be unable to attend, limiting statewide participation and reducing the project's effectiveness. These expenses are not general travel costs but are directly tied to enabling participation in mandatory project activities.					
	Miles/ Meals/ Lodging	Travel support for approximately 30 student teams (non-employees) to attend a statewide final dissemination event. Includes mileage reimbursement (estimated ~\$120 per team) and limited lodging support for teams traveling long distances.	An exception is requested for participant travel expenses because the final dissemination event is essential for achieving the project's statewide impact and knowledge-sharing objectives. Unlike training sessions, this event focuses on public presentation of project outcomes, cross-team learning, and dissemination of results to broader audiences, including educators and stakeholders. Based on prior implementation (27 teams × 8 students ≈ 216 participants), this event is expected to generate over 30 team presentations and engage more than 200 students statewide. Travel support ensures full geographic representation and equitable participation, which is critical to maximizing the project's visibility and impact. Without this support, participation from rural and under-resourced schools would be significantly limited.					\$4,800
	Miles/ Meals/ Lodging	Research team travels for project-related activities, including approximately 10–12 in-state site visits and partner meetings. Costs include mileage reimbursement (estimated average ~\$0.65/mile) and limited lodging for multi-day field support as needed.	Travel is necessary for project personnel to conduct on-site field support during program implementation, coordinate with school and community partners, and ensure fidelity to project protocols.					\$2,275

			In-person engagement is critical for troubleshooting, training reinforcement, and monitoring progress across participating sites. Travel may also support presentation of project findings at relevant in-state meetings to facilitate knowledge sharing and broader impact.					
							Sub Total	\$11,875
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$450,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
			Non State Sub Total	-
			Funds Total	-

Total Project Cost: \$450,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: [be172163-cec.pdf](#)

Alternate Text for Visual Component

This visual component describes an educational program for young Minnesotans which seeks to encourage environmental stewardship of Minnesota surface waters....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
UMN Special Projects Administration Project Endorsement	89961fb4-cb2.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

No

Does the organization have a fiscal agent for this project?

No

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing \$10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

Yes

Do you certify that background checks are performed for background check crimes, as defined in Minnesota Statutes, section 299C.61, Subd. 2, on all employees, contractors, and volunteers who have or may have access to a child to whom children's services are provided by your organization?

Yes

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Nikos Papanikolopoulos, University of Minnesota

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A