Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-407

Proposal Title: High-Altitude Imaging for Wildfire Detection and Monitoring

Project Manager Information

Name: Ognjen Ilic

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: This project seeks to develop a low-cost, high-altitude imaging platform to detect wildfires and monitor smoke over Minnesota's landscapes, supporting earlier response and protection of the state's natural resources.

ENRTF Funds Requested: $298,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Small Projects (G)
Secondary Category: Resiliency (A)

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.

Wildfire and smoke pose growing risks to Minnesota's forests, habitats, air quality, and communities. Emerging fires, residual hotspots, and smoke can be difficult to detect and track in remote or inaccessible landscapes. Current monitoring approaches leave important gaps: satellites provide broad coverage but not always the timing or resolution needed for evolving events; ground-based observation is limited by terrain and line of sight; and while drones and aircraft can provide detail, they are constrained by limited altitude and endurance (drones) and logistics and high cost (aircraft). High-altitude balloon platforms have the potential to fill this gap by providing a practical new layer of fire and smoke monitoring, e.g., by improving early detection of small fires, quantifying burn intensity and smoke-generating activity, and supporting better understanding of smoke transport. Additionally, such platforms could be fielded at a comparatively low cost and may be especially valuable when operated autonomously or in networks that expand spatial coverage and revisit. Thus, a clear opportunity exists to determine whether such systems can provide practical, cost-effective monitoring while supplying actionable information that improves fire management decisions and protection of Minnesota's landscapes and communities.

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.

We propose to develop and flight-test a high-altitude balloon platform capable of multi-band imaging using visible and thermal-infrared cameras for early wildfire detection and to evaluate its performance over Minnesota landscapes. The project has two components. First, we will build an imaging payload that combines visible-light and thermal-infrared imaging with compact onboard computing. Visible imagery provides scene context, landscape features, and smoke-plume identification, while thermal-infrared imaging is well-suited to detecting hotspots and smoke-producing fire activity that may be difficult to identify with visible imagery alone. The payload design will also allow exploration of multi-sensor configurations to better understand how coordinated sensing may improve spatial coverage and detection performance. Second, we will collect baseline imagery under non-fire conditions and use these data to develop image-analysis methods, including machine learning where appropriate, to distinguish fire-like signatures from normal background while examining how multi-sensor fusion and multi-view imaging approaches can improve spatial coverage and reliability. Detection capability will then be evaluated using controlled thermal targets and, where feasible, prescribed burns already scheduled by the Minnesota DNR. This work will determine the practical potential of low-cost high-altitude imaging for fire monitoring in Minnesota.

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?

This project will advance the understanding of how high-altitude observation can reliably detect hotspots, monitor burns, and provide useful fire and smoke information for land managers. Specific outcomes include: (1) a flight-tested balloon platform demonstrated over Minnesota terrain; (2) validated imaging and algorithm performance, including proof-of-concept detection and monitoring of fire/smoke signatures; (3) a curated field dataset; and (4) evaluation of the practical potential of low-cost high-altitude balloon platforms for supporting fire management in Minnesota. These outcomes have the potential to improve fire detection and monitoring, helping protect air quality and strengthen the resiliency of fire-prone landscapes.

Activities and Milestones

Activity 1: Design, build, and field-test a multi-band, high-altitude imaging payload

Activity Budget: $169,000

Activity Description:
Imaging in multiple spectral bands is directly beneficial for fire and smoke detection. Thermal-infrared cameras, operating in bands sensitive to different temperature ranges, can detect high-temperature flames and lower-temperature smoldering that are invisible to visible imagery. By combining thermal and visible imagery of the same scene, thermal anomalies can be correlated with visible smoke signatures, reducing false alarms from benign warm surfaces.
In this activity, we will design and build a payload integrating these cameras with synchronized acquisition, GPS/IMU-based position and attitude logging, and compact onboard computing. The onboard processing pipeline will include image analysis to align multi-band frames to a common coordinate system, thermal thresholding to flag candidate hotspots, and change detection against baseline imagery to identify anomalies. We will evaluate convolutional neural network classifiers to distinguish real fire-plus-smoke signatures from false positives, with detection performance improving over time as flight data accumulate. The system will continuously acquire imagery throughout the flight, producing a time series that can reveal developing fire/smoke activity. Camera selection will prioritize dynamic range sufficient to capture both fire and ambient signals. The payload will be engineered for high-altitude conditions (low temperature, vibration, power constraints) and validated through ground testing and initial flights.

Activity Milestones:

Description	Approximate Completion Date
Payload design, component selection, and bench integration completed.	December 31, 2027
Ground testing completed, including imaging, thermal, and onboard data system validation.	March 31, 2028
Initial balloon field-test flights completed to verify payload performance under flight conditions.	September 30, 2028

Activity 2: Collect baseline imagery, develop algorithms, and validate fire detection capability

Activity Budget: $129,000

Activity Description:
Reliable detection depends on distinguishing thermal anomalies from the natural variability of the landscape below. To characterize this background, we will collect thermal and visible imagery over representative Minnesota terrain under normal conditions across varied viewing and terrain conditions. These data will serve as a reference library for new observations. Using this library, we will develop and evaluate a detection pipeline, including (1) multi-band change detection to flag thermal anomalies relative to baseline, (2) spatial filtering to reject point artifacts and sensor noise, and (3) classification of candidate detections using combined visible and thermal features. We will train and test neural network classifiers on this dataset, with model performance expected to improve as the library grows over successive flights. To validate detection capability, we will image controlled thermal targets (e.g., contained fire pits of known size and temperature) from lower altitude to quantify detection limits, localization accuracy, and false-positive rates. We will also seek opportunities to fly over prescribed burns scheduled by the Minnesota DNR. These flights will provide real-world tests against active fire/smoke in Minnesota conditions. Results from both approaches will be combined into an assessment of system performance, limitations, and practical next steps toward operational use.

Activity Milestones:

Description	Approximate Completion Date

Baseline balloon flights completed and reference thermal/visible imagery library assembled.	October 31, 2028
Detection and monitoring algorithms developed and demonstrated onboard.	January 31, 2029
Validation completed using controlled thermal targets and prescribed burns, with final performance assessment.	June 30, 2029

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 target audience for results from this work includes several communities, including those working in remote sensing and monitoring, wildland fire management personnel at agencies such as the Minnesota DNR and U.S. Forest Service, and related state and federal agencies and interested parties. We will publish findings in peer-reviewed journals, with budget allocated for open-access publication to ensure rapid dissemination and broad availability. To ensure longevity, the datasets collected during this project, along with the hardware designs and software tools and algorithms we develop, will be archived in a publicly accessible Data Repository for University of Minnesota (DRUM), which provides a digital object identifier (DOI) to enable persistent access and formal citation and curates submissions to ensure data and files are maximally Findable, Accessible, Interoperable, and Reusable (FAIR). We plan to present results at relevant conferences, including state venues such as the Minnesota GIS/LIS Consortium Annual Conference, the Minnesota Space Grant Consortium Conference, and Minnesota Robotics Institute seminars. All project data products and publications will acknowledge the Minnesota Environment and Natural Resources Trust Fund (ENRTF) through use of the trust fund logo or attribution language in accordance with ENRTF Acknowledgement Guidelines.

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?
After completion, the results will be shared with federal and state agencies and other interested parties through publications and conference presentations. The success of this effort will lead us to pursue follow-on funding from USDA or NASA's Flight Opportunities program, providing a credible pathway for continued development beyond this grant. Ilic has led NASA-supported projects at UMN, providing relevant experience working with the agency. This project builds on our existing high-altitude ballooning and thermal-infrared optics research at UMN. The low per-flight cost of balloon operations makes it realistic that routine monitoring could eventually be sustained by state or federal agencies.

Project Manager and Organization Qualifications

Project Manager Name: Ognjen Ilic

Job Title: Benjamin Mayhugh Assistant Professor of Mechanical Engineering

Provide description of the project manager's qualifications to manage the proposed project.
Ilic is a Benjamin Mayhugh Assistant Professor of Mechanical Engineering at the University of Minnesota Twin Cities, with (graduate) faculty appointments in the School of Physics and Astronomy and the Department of Electrical and Computer Engineering. He received his PhD in physics from MIT and was a postdoctoral scholar in applied physics at Caltech.

Ilic brings experience in core areas of imaging and high-altitude ballooning required by this project. His research focuses on light and thermal radiation interactions, with publications spanning thermal sensing, infrared spectral control, and mid-infrared photonics. He organized the special symposium "Mid-Infrared and Thermal Photonics" at the 2021 Conference on Lasers and Electro-Optics (CLEO), a leading international conference in optics and photonics, and serves as Associate Editor of Optics Express, the most cited journal in optics. This background provides the engineering foundation needed to carry out this project.

Ilic and his students have a track record of conducting high-altitude balloon launches in Minnesota and developing balloon-borne payloads for space and near-space applications, including the development and testing of materials and coatings for radiation management in space. He has co-instructed a stratospheric ballooning course at UMN. This hands-on launch experience, from payload design and integration through flight operations and recovery, is central for executing the proposed technology demonstrations.

Ilic has successfully managed research grants as the Principal Investigator funded by agencies including NASA, NSF, DARPA, and the Air Force Office of Scientific Research. His research has been recognized by the NASA Early Career Faculty Award, the DARPA Young Faculty Award, the AFOSR Young Investigator Award, the 3M Non-Tenured Faculty Award, and the McKnight Land-Grant Professorship, University of Minnesota's leading award for junior faculty.

Organization: U of MN - College of Science and Engineering

Organization Description:
The College of Science and Engineering (CSE) at the University of Minnesota Twin Cities is one of the university's largest and most research-intensive academic units. It brings together engineering and sciences across 12 academic departments. CSE supports thousands of undergraduate and graduate students and hosts numerous interdisciplinary research centers while maintaining strong partnerships with regional industry and national research agencies.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Principal Investigator		PI will lead the proposed work and be responsible for project management, effort coordination, payload design, data acquisition and analysis, advising of personnel on this project, dissemination of results, and oversight of the whole project.			27.8%	0.16		$43,048
Undergrad student		Two undergraduate research assistants (UA) will assist with payload development, balloon flight operations, and experimental data collection. They are budgeted for $16/hour, for approximately 5 hours/week/student on average per year.			0%	1		$16,000
Research Assistants		Two graduate research assistants (RAs) will be supported by this project. The first RA will work at full-time GRA appointment (50% effort) on payload development, high-altitude balloon flight operations, baseline imagery collection, and validation testing. The second RA will work at 50% GRA appointment (25% effort), assisting with image analysis and algorithm development. Both RAs will work on and participate in field tests.			45.59%	1.5		$199,417
							Sub Total	**$258,465**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Tools and Supplies are split into two categories: Payload Development and Fabrication Materials and Consumables. Payload Development: parts and components include cameras (thermal-infrared cameras, visible cameras), lenses, interface hardware, GPS, IMU, radios, satellite modems, tracking electronics, structural hardware, onboard storage and processing, calibration and test	Payload Development: This category supports the imaging, computing, tracking, and ground-support hardware needed to build and operate the balloon-based wildfire monitoring payload for the duration of the project. Fabrication Materials and Consumables: This category					$26,535

		equipment for analyses and experiments. Fabrication Materials and Consumables: this category includes fabrication materials, balloons, lifting gas, power supplies, enclosure hardware, insulation, and other consumables needed for payload assembly, launch, recovery, and field operations. All materials expenses will relate directly to the proposed project and be used solely to benefit the project. To enable fair and reasonable purchases, the University of Minnesota "UMarket" system will be used as a first option for finding materials and supplies, as this system searches and compares products from over 40 suppliers and reduces internal processing costs on transactions Parts and supplies will be acquired from University of Minnesota-approved vendors, some of which can offer favorable pricing.	covers the expendable and fabrication items required to assemble, launch, recover, and repeatedly field the payload system over the course of the project.					
							Sub Total	**$26,535**
Capital Equipment								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Other	Travel support is requested for in-state travel and logistics to conduct high-altitude balloon launch campaigns, field validation, and payload recovery activities. Costs include transportation (vehicle rental x2, transport of field equipment), supplies and meals for 5-6 people per trip. We plan for 8 field launches over the course of the project estimated at $1,000/launch.	Travel support is requested for in-state travel and logistics to conduct high-altitude balloon launch campaigns, field validation, and payload recovery activities.					$8,000
							Sub Total	**$8,000**
Travel Outside Minnesota								

							Sub Total	**-**
Printing and Publication								
	Publication	Support is requested to cover open-access charges to make published journal articles immediately available, thereby maximizing data availability and dissemination. Estimate is based on open-access costs of $2,500/article for two articles.	Support is requested to cover open-access charges to make published journal articles immediately available, thereby maximizing data availability and dissemination.					$5,000
							Sub Total	**$5,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$298,000**

Classified Staff or Generally Ineligible Expenses

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

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	Unrecovered F&A calculated at 54% MTDC	Support of ME facilities where research will be conducted.	Secured	$128,754
			Non State Sub Total	**$128,754**
			Funds Total	**$128,754**

Total Project Cost: $426,754

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: b1f8d177-6ce.pdf

Alternate Text for Visual Component

Three-panel schematic showing: (1) a high-altitude balloon collecting large-area thermal and visible imagery; (2) onboard image processing for hotspot detection, fire identification, and smoke monitoring; and (3) validation using thermal target tests and prescribed burns, with assessment of accuracy, false alarms, and operational readiness....

Supplemental Attachments

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

Title	File
UMN Institutional Support Letter	211141f6-08d.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")?

No

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

Alex Sullivan, Dept. of Mechanical Engineering, University of Minnesota Twin Cities

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