**Headwaters Regional Technology and Innovation Hub—At a Glance**

| |
|---|
| **Core Technology:** Smart photonic sensing systems that can be deployed in autonomous systems and applied to critical defense, resource management, and disaster prevention applications. This core technology is at the intersection of KTFAs 1 and 5. |
| **Geography:** The Headwaters Tech Hub will encompass a tightly connected geographic corridor of Western Montana that connects Kalispell (μSA), Missoula (MSA), Butte–Silver Bow (μSA) and Bozeman (MSA). Per NOFO Section A.1.d, the Hub's proposed geography meets the following selection criteria: i) significantly benefits small and rural communities; ii) is in a State or territory that is eligible to receive funding from the EPSCoR of the NSF; iii) is headquartered in a low-population State. |
| **Founding Consortium Members by Entity Type:**<br>● **Education:** Montana University System, including Montana State University in Bozeman, the University of Montana in Missoula (both R1 research institutions), Montana Technological University in Butte. Salish Kootenai College (tribal college).<br>● **Government including Tribal:** Montana State Departments of Commerce/State Tribal Economic Development Commission; Governor's Director of Indian Affairs<br>● **Private sector**: Aurora Innovations, Inc., Bridger Photonics, Hyundai America Technical Center, Inc.'s New Horizons Studio, Montana Chamber of Commerce, Montana Photonics Industry Alliance<br>● **Economic development**: Accelerate Montana, Missoula Economic Partnership, Prospera Business Network<br>● **Workforce development**: Montana State Workforce Investment Board, MT Department of Labor and Industry<br>● **Venture:** America's Frontier Fund, Homestake, Next Frontier Capital |

**Technology-based potential of the region for global competitiveness**

Montana is home to a cluster of more than 40 photonics companies with a unique strength in photonic remote sensing systems, including lidars and spectral imagers. By integrating these remote sensing systems with advances in artificial intelligence and machine learning with embedded computers, Montana is driving the emergence of smart, autonomous systems that are changing how people and things move on the ground and through the air; how economies grow food and manage risk; how communities navigate the impacts of our changing climate; and how our global community protects and sustains natural assets—all while creating a broad spectrum of new, well-paying jobs.

The **Headwaters Regional Technology and Innovation Hub's** ambition is to be the global leader in smart, autonomous, photonic remote sensing technologies. This core technology sits at the intersection of Key Technology Focus Areas 1 and 5 and addresses challenges in national defense, management of critical natural resources (agriculture, forestry, water, and minerals), disaster prevention and mitigation, and industry efficiency and safety. The Hub will leverage existing strengths with smart autonomous photonics and sensors in the region's rugged terrain, rural settings, and extreme weather.

In Montana, we invented lidar systems that detect and map gas leaks from the air; we revolutionized the use of lasers and photonic crystals for real-time radio spectrum analysis in national security; and we are currently researching and commercializing new smart spectral imager

technologies to monitor forest-floor fuel density. Existing photonic sensor products made in Montana are part of international supply chains for defense, space exploration, and manufacturing. Examples include optical materials, components and systems used in laser-guided missiles and night-vision surveillance systems; the world's most ultra-pure laser crystals, which enable unprecedented space exploration; and spectral imaging systems that maintain the security of our global food supply.

Montana-led research, commercialization, and innovation is expected to drive high growth in globally critical photonics market subsectors, including automotive lidar ($9B market by 2033; 66% CAGR), drone lidar ($2B market by 2033; 28% CAGR), and hyperspectral imaging ($30B market by 2033; 10% CAGR). These subsectors will outpace overall photonics market growth over the next 10 years ($1.5T market growing to $2.8T overall market by 2033; 6% CAGR).[1] The Headwaters Hub is poised to contribute critical technologies to power this market growth.

This growing market demand, and the opportunities it creates, exceeds current capacity, both in Montana and nationally, to commercialize and manufacture new technologies and train the skilled workforce needed to support the sector. There is an urgent need for growth in domestic photonics capabilities to offset the rapid shift toward Asia.[2,3] Our Hub can help meet this need by enabling rural regions across the U.S. to address the persistent mismatch between photonics supply and demand. By centering and engaging them in the Hub's design, the Hub will enable rural and tribal communities to co-design and produce these technologies, leading to new technology-based jobs in areas where they can have particularly transformative impact.

Montana is home to leading research universities that rank second nationally in university R&D growth over the past decade. Our region's significant high-tech sector growth in recent years has been driven heavily by the commercialization of university research. Montana State University (MSU), in particular, has been a catalyst for a globally recognized cluster of photonics businesses by establishing the Optical Technology Center (OpTeC) in 1992.[4] OpTeC has helped graduates create companies such as Scientific Materials and Bridger Photonics (a consortium member), and continues to facilitate the development and commercialization of photonics technologies, attracting investment and generating employment opportunities.[5]

Our Hub will help our broader five-state region collaborate on aligned interests, leveraging region-wide involvement in NSF Innovation Engines Type-1 Awards in autonomous systems (ND, SD, MT, ID), precision forestry and rangeland technologies (MT, ID, ND, SD, WA, WY), quantum technologies (MT, WY, ID),[6] and a NSF Engines Type-2 finalist in agricultural technology.[7,8,9] The Headwaters Hub will leverage these and other large investments like the NSF EPSCoR SMARTfireS project to create long-lasting, sustainable economic benefits for the region and the nation.[10]

Our region's naturally rugged environment, along with our unique mix of entrepreneurs, laboratories, and universities, presents unique opportunities to drive new scientific breakthroughs, identify additional real-world applications, and create sustained economic growth. With support from the EDA and ongoing commitments from our consortium partners, Montana's Headwaters Hub is well-positioned to emerge as a global leader in new applications for optics, photonics, and autonomous technologies in the coming decade.

**Role of the private sector in accelerated commercialization**
The private sector, including our region's existing cluster of over 40 photonics companies, will play a vital role in the Headwaters Hub's growth over the next decade. This growth will be anchored by three founding private-sector consortium members:

1) Aurora, a company that manufactures self-driving vehicles using sensors developed in Bozeman, recently announced plans to construct a 78,000 square foot facility near Montana State University.[11]
2) Bridger Photonics, which developed Gas Mapping LiDAR™, a groundbreaking methane detection technology, recently secured a $55 million investment round that included continued participation from consortium member Next Frontier Capital.[12]
3) Hyundai America Technical Center, Inc. (HATCI) New Horizons Studio is set to expand operations in Bozeman, including a wildfire-management project from its Progress for Humanity research lab that uses autonomous vehicles equipped with AI-enabled imaging systems that were developed at Montana State University.[13]

These consortium members are the vanguard of a portfolio of businesses, from early-stage university spinouts to global corporations, that have established or intend to establish significant operations in Montana. With their input and guidance, the Headwaters Hub will serve as a catalyst to increase private-sector involvement in research, commercialization, and the emergence of new opportunities to apply advanced photonics across a variety of industries, such as manufacturing, construction, transportation, and others.

**Regional coordination and partnerships**
The Hub will actively partner with organizations and communities, including rural and Tribal communities, across Montana to co-facilitate six provisionally identified Hub growth initiatives: a venture studio, innovation testbeds, a market growth program, an operational innovation and excellence program, a workforce development program, and a policy lab. These initiatives will require effective collaboration to succeed. The members of this consortium already have well-established relationships and have worked together for years, as documented in their commitment letters. It is also worth noting that, as Montana has a low population distributed over a large area, partnerships are commonly established and maintained over long geographic distances. Consortium members' past efforts have included these key successes:

- University research collaborations, including NSF Engines and EPSCoR grants.
- MSU imaging systems deployed by the Montana Department of Environmental Quality.
- MSU optical sensors deployed on Hyundai autonomous vehicles that measure wildfire risk.
- Statewide rapid training program funded by the Montana Department of Labor & Industry and led by Accelerate Montana in coordination with the State's two-year and tribal colleges.
- The Montana Contractors Association's "Build Montana" program partners contractors and equipment dealers with high schools to inform young people about careers in construction.
- Over $100m in business grants and loans funded by the Montana Department of Commerce (MTDOC) since 2013.[14]
- A two-year photonics technician program created by Gallatin College in partnership with the Montana Photonics Industry Alliance (MPIA).
- A high-school-to-industry rapid training program created by MPIA and Accelerate Montana.

The lead consortium member for the Headwaters Hub will be Accelerate Montana (AMT), a 501(c)3 economic and workforce development organization affiliated with the University of Montana. As outlined in its commitment letter, AMT promotes inclusive economic prosperity across Montana with a proven track record of cross-sector collaboration and statewide program delivery that includes startup coaching, acceleration, and incubation as well as innovative workforce development initiatives.

The Headwaters Hub will run a competitive recruitment process for a Regional Innovation Officer (RIO). Primary qualifications will include business, economic, or workforce development experience in Montana; established relationships with critical consortium members; experience with technology sector research commercialization and/or high-growth tech ventures; and experience executing large-scale, multi-stakeholder programs or initiatives.

**Equity and diversity**

A foundational principle of the Headwaters Hub is its ability to create economic impacts for tribal and rural communities across the State, building on existing initiatives that include:

- University of Montana's EDA University Center Grant program (AMRII).
- The Google-funded Native Women Launch program.
- Prospera and Accelerate MT's SBA-funded Women's Business Centers.
- MT DOC Indian Country Economic Development loan and assistance programs.
- Youth Entrepreneurs, a Montana Chamber Foundation-funded program developing economic and entrepreneurial traits and employment skills in the state's future workforce.
- Accelerate MT's rapid training program.
- The State Tribal Economic Development Commission, representing all eight Montana tribes.
- The EMPOWER Tribal and rural student support system at Montana State University.
- Tribal college participation in Montana's common course numbering and transfer systems.

The Headwaters Hub intends to use Strategy Development grant funds to identify opportunities to leverage and expand upon these partnerships to deliver community-driven, sustainable economic impacts in rural and tribal communities, which face multi-layered historical, cultural, and systemic challenges in achieving equitable economic outcomes. Our consortium includes and will add additional organizations that have a history of successfully working with and in tribal and rural communities to address the substantial skilled workforce and economic development needs required for technology adoption and business expansion.

**Composition and capacity of the regional workforce**

The workforce in the Headwaters Tech Hub region is highly educated, skilled, and growing. Montana ranks sixth nationally with 5.1% labor force growth in the past three years and is third in median household income growth over the past five years, ranking first among the 10 lowest-population states. Montana's 40 photonics companies employ over 1,000 workers and offer wages that are more than a third higher than Montana's overall average.[15,16,17] Given the high employment multipliers for manufacturing in general and for the photonics industry in particular, the industry is estimated to support up to 5,000 direct, indirect, and induced jobs throughout the state, contributing more than $300M in total wages to the economy.[18]

The Headwaters Hub will leverage new and existing education and training pathways, such as the rapid training and MPIA high-school-to-industry programs referenced above, to fuel a pipeline of talent that can fill a broad spectrum of jobs in high-tech manufacturing and assembly, field operations, and maintenance across the state, including rural and tribal areas. These job opportunities will cater to a wide range of skills and educational backgrounds, with many technician and field operations roles accessible to workers without degrees. This inclusive approach, supported by wraparound services to address barriers such as a lack of transportation, childcare, and broadband access, aims to bring economic prosperity and employment opportunities to the broadest possible range of regions and demographics across the state.

**Innovative "lab to market" approaches**

Two of the Hub's key projects will introduce new ways to translate lab-based research to market-ready products: A new venture studio will align emerging technologies to real-world problems and opportunities and pair experienced high-growth tech talent with specialist advisors, and new innovation testbeds will provide practical environments for developing, testing, and refining technological innovations. We anticipate testbeds in areas such as forestry, agriculture, water management, mining, defense, construction, and transportation. These approaches will leverage both our region's existing track record of commercializing sensor and photonics technology and the consortium's venture capital members and their wider relationships with additional sources of venture capital.

**Impact on economic and national security**

Advancing America's economic and national security depends on protecting and leveraging all the nation's resources and capabilities. That encompasses critical natural resources in rural communities that power much of the U.S. supply chain and urban economies—and that are frequently threatened by natural and anthropogenic disasters. It also encompasses fully utilizing the talents, wisdom, and hard work of rural and tribal community members. The Headwaters Hub will leverage those talents to drive a new wave of technological advances in smart autonomous systems that will enhance our protection and management of critical national resources, while also generating new applications in defense and other essential sectors.[19]

Establishing this rural Hub expands our nation's innovation footprint, enabling us to solve new problems, discover new ideas, and harness underutilized resources. This approach promotes national economic development, strengthens innovation infrastructure, and encourages growth in smaller communities. It also increases accessible American-held intellectual property for the government and industries of all kinds.

**Conclusion**

The Headwaters Hub is poised to create a globally competitive technology sector built around photonic remote sensing technologies and their deployment in autonomous systems to address local and global challenges in agriculture, defense, disaster prevention, and critical natural resource management. With investment from the EDA, the Headwaters Hub will leverage a powerful and growing university research base, allied to a photonics cluster of homegrown and global players, supported by strongly aligned government, workforce, and economic development capabilities, and committed to the full and equitable participation of rural and tribal communities.

**Appendix**

[1] Montana Photonics Industry Alliance Market Sizing Report: https://www.montanaphotonics.org/wp-content/uploads/Montana-Photonics-Marketing-Report.pdf.
[2] Society of Photo-Optical Instrumentation Engineers, "Optics & Photonics Industry Report 2022", July 2022 https://www.spie.org/industry-resources/information/industry-report?SSO=1
[3] "Optics and Photonics: Essential Technologies for Our Nation," The National Academies Press, https://doi.org/10.17226/13491, 2013; National Research Council.
[4] "Becoming a world leader," Mountains and Minds Magazine, April 2023. https://www.montana.edu/news/mountainsandminds/22864/becoming-a-world-leader
[5] Joseph A. Shaw, "Synergistic development of optics education and industry in a small university town," ETOP 2015 Proc. https://opg.optica.org/abstract.cfm?uri=ETOP-2015-IND09.
[6] Montana State wins $1 million grant to explore quantum economy potential. MSU News Service. https://www.montana.edu/news/22920/montana-state-wins-1-million-grant-to-explore-quantum-economy-potential
[7] UND to lead regional NSF Engines Development partnership, 16 May 2023 https://blogs.und.edu/und-today/2023/05/und-regional-universities-receive-national-science-foundation-engines-grant/
[8] UM To lead precision forestry and rangeland innovation engine. 17 MAY 2023 https://www.umt.edu/news/2023/05/051723engn.php
[9] FARMS partnership group reaches finals of NSF competition. https://www.ndsu.edu/experience/NSF-competition
[10] SMART FIRES: Sensors, Machine Learning, and Artificial Intelligence in Real Time Fire Science https://www.mtnsfepscor.org/projects/smart-fires
[11] "Self-driving vehicle tech company Aurora announces facility to be built on MSU Innovation Campus" From MSU News Service, JUNE 2, 2022. https://www.montana.edu/news/22147/self-driving-vehicle-tech-company-aurora-announces-facility-to-be-built-on-msu-innovation-campus
[12] Montana-Based Group Invests $55M in Home-Grown High-Tech Methane Detection Company, Bridger Photonics, Inc. https://www.bridgerphotonics.com/blog/montana-based-group-invests-55m-home-grown-high-tech-methane-detection-company-bridger
[13] Hyundai, "Hyundai New Horizons Studio to Design and Build Ultimate Mobility Vehicles in Bozeman, Montana", May 2022 https://www.montanachamber.com/2022/05/05/hyundai-new-horizons-studio-to-design-and-build-ultimate-mobility-vehicles-in-bozeman-montana/
[14] https://commerce.mt.gov/About/Funded-Projects
[15] Montana ranks 6th nationally in terms of labor force growth over the past 3 years: https://lmi.mt.gov/Home/Job-Tracking
[16] U.S. Census Bureau One-Year American Community Survey for 2016 and 2021, 3rd in median household income growth and 1st among low-population states. https://data.census.gov/
[17] Average annual pay of employees in Montana in the United States from 2001 to 2022", June 2023 https://www.bls.gov/bls/blswage.htm
[18] Applicant team calculations based, "2022 Montana Manufacturing Report," September 2022. https://www.montana.edu/mmec/documents/reports/2022%20Montana%20Manufacturing%20Report%20full.pdf
[19] "Battlefield lessons," SPECIAL REPORTS - JUL 8TH 2023. The Economist. https://www.economist.com/special-report/2023-07-08