

Prairie Grid Analytics: Low-Cost In-Field Soil Carbon Verification for Midwest Agricultural Carbon Markets

October 2026

Technology Innovation and Market Alignment

Prairie Grid Analytics, Inc., based in Lincoln, Nebraska, proposes a approach to soil organic carbon (SOC) verification through the development of low-cost, in-field optical-electrochemical sensors. Current verification protocols rely heavily on destructive core sampling and laboratory analysis, creating significant latency, high costs, and spatial sparsity that undermine farmer trust and program scalability. Our technology integrates multi-spectral optical sensing with localized electrochemical impedance spectroscopy to provide real-time, non-destructive SOC estimates at a resolution compatible with precision agriculture equipment. This innovation directly addresses the critical bottleneck in the \$2.1 billion U.S. agricultural carbon credit market (2026 projection): the lack of affordable, high-frequency data required to verify sequestration claims with statistical confidence.

Differentiation from Existing Methods. Unlike remote sensing solutions which struggle with canopy cover and surface-only readings, or traditional lab methods which are cost-prohibitive for frequent monitoring, Prairie Grid’s sensors operate at the root zone depth (0-30 cm) continuously. This allows for dynamic baseline establishment and immediate detection of management-induced changes, reducing verification costs by an estimated 60% compared to current industry standards.

The market opportunity is driven by increasing corporate demand for high-integrity nature-based carbon removals and regulatory pressures for transparent supply chain reporting. Midwest row-crop farmers represent the largest potential supply pool, yet adoption remains low due to perceived risk and complex enrollment processes. By lowering the cost of verification and providing farmers with actionable soil health data alongside carbon credits, Prairie Grid removes key adoption barriers. The proposed Phase I research will validate the sensor’s durability and accuracy across dominant Nebraska and Iowa soil series, establishing the technical foundation for scalable commercial deployment.

\$2.1 Billion	~60%	Midwest U.S.
U.S. Ag Carbon Market Size	Verification Cost Reduction	Target Region
2026 Projection	Estimated vs. Lab Methods	Nebraska, Iowa, Illinois

Prairie Grid Analytics is positioned to lead this transition with a team combining expertise in agronomy, embedded systems engineering, and environmental data science. The company s local partnerships with land-grant institutions to ensure scientific rigor and regional relevance. This Phase I proposal seeks to de-risk the core technology through rigorous field validation, paving the way for a Phase II effort focused on manufacturing scale-up and integration with major carbon registry platforms.

Phase I Technical Objectives and Success Criteria

The primary goal of this Phase I effort is to de-risk the core technology underlying Prairie Grid Analytics’ verification platform. We aim to transition from theoretical modeling to a functional, field-hardened

prototype capable of delivering the data integrity required by voluntary carbon market registries. The following three objectives are designed to be mutually reinforcing, ensuring that hardware durability, measurement accuracy, and data security are addressed in parallel.

Objective 1: Finalize Optical-Electrochemical Sensor Design for Field Durability

We will finalize the integrated sensor architecture combining near-infrared spectroscopy (NIRS) with electrochemical impedance spectroscopy (EIS). The critical challenge is moisture compensation, as soil water content significantly interferes with optical readings. The design must withstand continuous burial in corrosive soil environments for up to six months without calibration drift. Success is defined by a prototype housing that meets IP68 standards and maintains signal stability within 5% variance under fluctuating moisture conditions typical of Nebraska spring planting seasons.

Objective 2: Achieve $\pm 0.25\%$ SOC Absolute Accuracy Across Dominant Soil Series

The sensor must deliver absolute soil organic carbon (SOC) accuracy of $\pm 0.25\%$ within the 0-30 cm root zone. This metric is essential for verifying incremental carbon sequestration claims. Validation will occur across four dominant soil series in Nebraska and Iowa: Holdrege silt loam, Clarion loam, Webster clay loam, and Muscatine silt loam. These series represent the majority of row-crop acreage in the target market. We will benchmark sensor outputs against dry combustion analysis performed by an independent laboratory. Failure to meet this accuracy threshold in any two of the four soil types will trigger a redesign of the calibration algorithms.

Objective 3: Deliver Validated Firmware and Cloud Ingestion Pipeline

Hardware accuracy is insufficient without verifiable data provenance. We will develop and validate embedded firmware that performs edge-computing checks for sensor health and anomaly detection before transmission. The cloud ingestion pipeline must implement cryptographic signing of each data packet to prevent tampering, a requirement for emerging digital MRV (Measurement, Reporting, and Verification) standards. Success is defined by the successful end-to-end transmission of 10,000 simulated data points with zero loss and full audit trail generation, compatible with standard API formats used by major carbon registries.

Go/No-Go Decision Criteria. Phase II funding eligibility depends on meeting all three objectives simultaneously. Partial success in accuracy but failure in durability or data integrity will require additional Phase I-style development before scaling. Independent validation by the University of Nebraska-Lincoln Soil Physics Lab is mandatory for final sign-off.

12-Month Milestone-Driven Work Plan

The Phase I execution strategy is divided into four distinct quarters, each culminating in a critical go/no-go decision point. This phased approach ensures that technical risks associated with sensor durability and data fidelity are addressed before significant resources are committed to large-scale field trials. The timeline begins in October 2026 and concludes in September 2027, aligning with the NSF SBIR Phase I funding period.

Quarter 1: Sensor Module Integration and Prototype Fabrication

During the first three months, the engineering team will finalize the optical-electrochemical sensor architecture. Key activities include selecting moisture-resistant housing materials, integrating low-power wireless modules, and assembling ten alpha prototypes. The primary deliverable is a functional sensor module capable of transmitting raw spectral and electrochemical data. The go/no-go decision hinges on successful bench-top communication tests and initial power consumption metrics meeting the <5mW standby target.

Quarter 2: Laboratory Calibration and Algorithm Development

In Q2, the focus shifts to rigorous laboratory calibration. Alpha prototypes will be tested against NIST-traceable soil organic carbon standards across varying moisture levels and soil textures representative of Nebraska and Iowa series. Concurrently, the cloud ingestion pipeline will be developed to handle real-time data integrity checks. The milestone for this quarter is achieving a preliminary correlation coefficient of $R^2 > 0.85$ between sensor readings and lab-analyzed samples. Failure to meet this threshold triggers a redesign of the signal processing algorithm.

Calibration Rigor. Calibration must account for hysteresis effects in wet-dry cycles. Independent validation by the UNL Soil Physics Lab is scheduled for Q4 to ensure unbiased accuracy assessment.

Quarter 3: Pilot Deployment and Field Validation

Q3 involves deploying beta units across 12 on-farm plots in Nebraska, Iowa, and Illinois. These sites represent diverse management practices, including no-till and conventional tillage. Farmers will install sensors at 0-30 cm depths, and data will be collected continuously over the growing season. Simultaneous soil core samples will be taken monthly for lab verification. The key deliverable is a dataset demonstrating sensor stability under field conditions and initial accuracy metrics within $\pm 0.25\%$ SOC absolute error.

State	Soil Series	Management Practice	Number of Plots
Nebraska	Silting Loam	No-Till	4
Iowa	Clay Loam	Conventional Tillage	4
Illinois	Silt Loam	Strip-Till	4

Quarter 4: Final Validation and Phase II Readiness

The final quarter focuses on data analysis, final validation reporting, and Phase II proposal preparation. An independent agronomist reviewer will sign off on the validation report, confirming that the technology meets the technical objectives. The team will also refine the commercialization strategy based on farmer feedback from the pilot. The go/no-go decision for Phase II is based on achieving the target accuracy, demonstrating user-friendly installation, and securing letters of intent from potential commercial partners.

10 Alpha	12 Sites	±0.25%
Prototypes Built	Field Plots	Target Accuracy
Q1 Deliverable	Q3 Deployment	SOC Absolute Error

Path to Commercialization and Early Traction

Prairie Grid Analytics will protect its core optical-electrochemical sensor architecture through provisional patents filed in late 2025, with full utility patents pending during Phase I. The commercialization strategy employs a dual-track licensing model: non-exclusive hardware licenses for large-scale agricultural equipment manufacturers to integrate sensors into existing tillage and planting machinery, and exclusive software-as-a-service (SaaS) agreements for carbon credit verification platforms. This approach minimizes capital expenditure on manufacturing while maximizing recurring revenue from data validation services. Intellectual property rights will be structured to ensure that Prairie Grid retains ownership of the calibration algorithms and cloud-based verification logic, which constitute the primary competitive moat against low-cost hardware clones.

The go-to-market strategy follows a phased rollout designed to de-risk adoption barriers among Midwest row-crop farmers. Phase 1 (2027-2028) targets direct sales to regional agricultural cooperatives in Nebraska, Iowa, and Illinois, leveraging established trust networks to bypass individual farmer skepticism regarding new technology. By embedding sensors into cooperative-led soil health programs, Prairie Grid reduces the friction of initial adoption. Phase 2 (2029 onward) shifts to business-to-business integration with major voluntary carbon market platforms, where verified soil organic carbon (SOC) data from Prairie Grid sensors serves as the primary audit trail for credit issuance. This transition moves the company from a hardware vendor to a critical infrastructure provider for the carbon economy.

Industry Validation and Support. Letters of support have been secured from two leading Midwest agribusinesses, confirming intent to pilot the sensor network on 5,000 acres combined upon successful Phase I completion. These partners cite the need for lower-cost, high-frequency verification methods to replace expensive third-party soil sampling.

<\$180/unit	Q3 2029	\$256,000
Target Customer Acquisition Cost	Projected Breakeven	Phase I Budget Limit
Includes hardware subsidy and onboarding support for cooperative members	Based on 12,000 active sensor units and SaaS subscription revenue	NSF SBIR Phase I maximum award amount for FY2027

Financial projections indicate a customer acquisition cost (CAC) of less than \$180 per unit during the initial cooperative rollout. This figure accounts for hardware subsidies, field technician training, and data onboarding support. The low CAC is achievable due to the bulk purchasing power of cooperatives and the elimination of individual sales cycles. Revenue streams are diversified between one-time hardware sales and

recurring annual subscriptions for data verification and carbon credit reporting. The company projects reaching operational breakeven by the third quarter of 2029, driven by scale efficiencies in sensor manufacturing and the high margin profile of the SaaS verification platform. These estimates are indicative and should be validated against actual pilot deployment costs and current supplier prices before final submission of the Phase II business plan.

Broader Impacts on Climate Resilience and Rural Innovation

This project advances the NSF mission by democratizing access to carbon markets for small- and mid-sized Midwest farms through affordable, verifiable soil health data. By reducing the cost barrier to entry, Prairie Grid Analytics enables equitable participation in climate-smart agriculture, ensuring that economic benefits of carbon sequestration are not limited to large industrial operations.

The initiative strengthens rural STEM capacity through structured internship partnerships with the University of Nebraska-Lincoln (UNL) and Iowa State University, providing hands-on experience in sensor engineering, data science, and agronomy for undergraduate and graduate students from underrepresented backgrounds.

Open-Data Protocols for Public Good. The project establishes open-data protocols for soil health benchmarking aligned with USDA’s COMET-Farm framework, fostering transparency and trust in voluntary carbon markets while serving as a resource for regional climate resilience research.

The deployment of low-cost sensors supports local innovation ecosystems in Lincoln, Nebraska, by creating high-tech jobs and stimulating demand for precision agriculture services. By integrating rigorous scientific validation with community-engaged development, this work ensures that technological advancements directly contribute to sustainable rural economies and environmental stewardship.

Phase I Budget Summary (USD, FY2027)

The total requested funding for the Phase I project is \$256,000. This budget supports a 12-month period of technical feasibility and prototype validation. The allocation prioritizes critical hardware development, independent scientific validation, and key personnel efforts required to meet the technical objectives. These figures represent realistic estimates for the Lincoln, Nebraska region and national supply chains; confirm current supplier prices and institutional rate agreements before final submission.

Budget Category	Amount (USD)	Justification
Personnel	\$145,000	Salaries for Principal Investigator, Lead Engineer, and Part-time Data Scientist to drive sensor design and firmware development.
Equipment	\$38,500	Procurement of laboratory calibration instruments, field testing rigs, and computational resources for data modeling.
Subcontractors	\$42,000	Contract with UNL Soil Physics Lab for independent

Budget Category	Amount (USD)	Justification
		validation of sensor accuracy against standard soil carbon measurement protocols.
Travel	\$12,000	Site visits to pilot farms in Nebraska, Iowa, and Kansas for field deployment and stakeholder engagement.
Other Direct Costs	\$18,500	Purchase of FCC-certified wireless modules for IoT connectivity and cloud infrastructure setup for data ingestion.

Amount (USD)



Figure 1. Amount (USD)

Budget Note. The \$42,000 subcontract to the UNL Soil Physics Lab ensures third-party verification of data integrity, a critical requirement for carbon credit market acceptance. The \$18,500 allocation for wireless modules covers bulk procurement of FCC-certified components necessary for regulatory compliance in agricultural IoT deployments.