



## Using a Cosmic Ray Neutron Rover to Measure Unpaved Road Moisture for Improved Maintenance and Safety

*CTIPS-022 – UTC Project Information*

|                                    |   |
|------------------------------------|---|
| <b>Recipient/Grant Number:</b>     | North Dakota State University, Colorado State University<br>Grant No. 69A3552348308                                     |
| <b>Center Name:</b>                | Center for Transformative Infrastructure Preservation and Sustainability  |
| <b>Research Priority:</b>          | Preserving the Existing Transportation System   |
| <b>Principal Investigator(s):</b>  | Jeffrey D. Niemann, Ph.D., P.E.<br>Joseph Scalia IV, Ph.D.  |
| <b>Project Partners:</b>           | USDOT, Office of the Assistant Secretary for Research and Technology – \$45,000<br>Colorado State University – \$45,000 |
| <b>Total Project Cost:</b>         | \$90,000  |
| <b>Project Start and End Date:</b> | 7/16/2024 to 7/15/2026  |

### Project Description

Unpaved roads represent an important component of the nation’s transportation portfolio. The moisture of unpaved roads affects their preservation, safety, and health impacts. However, monitoring road moisture has been difficult because rapid, non-invasive measurement methods have not been readily available. In recent years, cosmic ray neutron (CRN) rovers have been developed, which can rapidly sense nearby water. Because most of the CRN signal originates near sensor, CRN rovers can potentially observe road moisture when driven on unpaved roads. The objective of this project is to evaluate the accuracy of a CRN rover for monitoring the moisture of unpaved roads. The project will focus on a lightly traveled section of an unpaved road in Colorado. The road moisture will be estimated by combining the rover measurements with landscape soil moisture estimates obtained by downscaling SMAP remote sensing data. The resulting road moisture estimates will be evaluated by comparing to gravimetric moisture measurements from road material samples.

### USDOT Priorities

This project will advance the USDOT strategic goal of Safety. Most public roads in Region 8 are unpaved, and high moisture of unpaved roads increases road damage. By developing a rapid and non-destructive method to measure road moisture, interventions to protect unpaved roads can be evaluated at larger scales (longer road sections), thereby producing more informative results. Furthermore, the linkage

between the protective intervention and the road damage can be better understood if the road moisture is known. Reduced visibility from dust lofting is a major safety hazard on unpaved roads, and dust lofting also reduces air quality and increases the risk of disease. Dust lofting is strongly linked to the road moisture. Current mitigation strategies are applied after dust lofting occurs because dust lofting cannot be readily predicted. If rapid measurements of road moisture are available, then the onset of dust lofting can be predicted, and these strategies can be implemented before the health and safety hazards occur.

## **Outputs**

Technology transfer to researchers and practitioners will be accomplished by presenting the key findings at one or more conferences. The conferences will be selected to maximize the visibility of the work for the target audience (transportation professionals who focus on hydrologic aspects of roads). We also anticipate that the results will be published as a peer-reviewed journal article in a widely viewed and cited journal. We will also contact the Tribal Technical Assistance Program at NDSU to collaborate on a larger subsequent proposal effort that specifically focuses on application of the rover technology for unpaved tribal roads.

## **Outcomes/Impacts**

The key outcomes from this project will be: (1) a method to estimate road moisture using a CRN rover and downscaled SMAP soil moisture, (2) an evaluation of the errors in the road moisture estimates, and (3) a comparison of road and landscape moisture values. Together these outcomes are expected to determine the feasibility of using CRN rovers for measuring road moisture. These results are expected to help guide future research studies that explore this topic in more diverse conditions. They could also be used to gain a better understanding of the conditions where surface distress and dust lofting occur and to develop more proactive strategies for preserving unpaved roads and improving health and safety. The outcomes will be documented in at least one presentation at a professional conference and at least one peer-reviewed journal article.

## **Final Report**

Upon completion, the final report link will be added to the [project page on the CTIPS website](#).