Oregon Department of Transportation

Research Stage 1 Problem Statement

Number 26-28 – "Usage of Artificial Intelligence (AI) Tools to Automate Pavement Degradation Monitoring System and Associated Decision-Making Processes"

1. Concisely describe the **transportation issue** (including problems, improvements, or untested solutions) that Oregon needs to research.

The aging and deterioration of roadways are accelerating due to rising traffic volumes, heavier truck loads, and insufficient funding for regular maintenance and rehabilitation (Coplantz 2022). Enhancing current asset management practices by developing new tools and strategies offers a promising avenue for improving network-level pavement performance and achieving substantial economic savings. Implementing more efficient maintenance and rehabilitation strategies can also mitigate the environmental impacts associated with different pavement life cycle stages.

Effective pavement asset management relies on collecting, storing, and analyzing diverse datasets, including pavement layer types, thicknesses, stiffness, asphalt mix production and construction details, moisture damage assessments, layer density, and other critical properties. These data help identify mechanisms of pavement distress initiation and propagation. ODOT has a private contractor collecting Automated Pavement Condition Survey (APCS) data every two years. This collected data and all other construction, materials production, and design information should be stored in a centralized database for processing and decision-making. Stored data should also include the Environmental Product Declarations (EPDs) that are started to be collected from various pavement material production plants as a result of ODOT's efforts to address House Bill 4139. Establishing an integrated, online geographic information system (GIS) database to replace the current process and centralize all pavement-related data is also essential for creating a more efficient pavement management system (PMS) in Oregon.

In the current ODOT process, by following different criteria, pavement construction and maintenance decisions are made based on the collected data and the availability of funding. With the development of artificial intelligence (AI) tools and methods, this decision-making process should be automated and streamlined. The AI tool that will be developed in this study will directly take the data from the GIS database and update itself (its internal models) continuously to "learn" (through an embedded machine learning algorithm) from the impact of several factors/inputs listed in the previous paragraph on long-term pavement performance. The AI tool will be structured as an online tool that will directly take the data from the GIS database to update the internal models and processes with the new information. The AI tool will also have an integrated decision-making process that will provide recommendations for ODOT for pavement maintenance based on a ***decision tree analysis process where random forest analysis will be employed through a machine learning technique***. Those decisions will be structured so that ODOT can select several different priorities, *such as road conditions, traffic levels, regions, funding levels, greenhouse gas (GHG) emissions, etc.,* to direct the tool for decision-making in a way that ODOT Engineers think is more appropriate for the current situation. For this reason, a supervised machine learning model would be adapted to create a decision-making process guided by the ODOT PMS experts.

The developed online GIS database with the integrated AI-based decision-making process will be the foundation for a network-level application that consolidates all pavement-related data for the ODOT roadway network. This comprehensive database will also store critical information, including mix design,

material production, PMS records, ground-penetrating radar (GPR) data, falling weight deflectometer (FWD) results, core samples, dynamic cone penetrometer (DCP) data, and additional laboratory and field test results. By utilizing this centralized pavement information, the total value of pavement assets and their economic contributions can also be accurately quantified and assessed.

2. What **final product or information** needs to be produced to enable this research to be implemented?

This research study will produce an online GIS database that integrates all pavement-related data—including mix design, material production, GHG, cost, available funding, PMS data, GPR, FWD, core samples, DCP results, laboratory test data, and more—into a unified platform. Users will be able to input post-miles, traffic direction, and other highway details (or use GPS coordinates) to access all data collected for a specific roadway section since its initial construction.

The system will feature embedded data visualization tools, enabling users to evaluate the information before downloading. An integrated AI-based data processing and decision-making tool will also be developed and integrated to highlight the key factors influencing pavement performance for selected locations. An embedded cost and GHG calculation tool will also be available in the developed AI-based decision-making tool. ODOT personnel will receive training on using the database for data visualization, processing, and entry, ensuring effective and ongoing utilization of the system. Several example decision-making scenarios will also be developed using the outputs of the developed AI-based tool to clearly present the working principles of the tool for training ODOT engineers and achieving a seamless technology transfer process.

3. (Optional) Are there any individuals in Oregon who will be instrumental to the success of implementing any solution that is identified by this research? If so, please list them below.

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4. Decision making lenses

Please complete the following three sections. Your answers to these questions will be applied on a programmatic basis to support agency decisions. Answering yes to the questions below is not required. Resolving a narrowly focused technical research problem may meet agency needs without answering yes to any of the following questions. The ODOT Research Section will seek a balanced portfolio some projects will answer yes to one of the three categories below (e.g. climate, equity, and/ or safety) and other projects in a different category.

We are looking for an overall program balance and no one project is expected to balance all categories. Generally, a research problem statement is expected to be able to answer yes with clear and verifiable information in only one of the three categories below, some projects may be able to answer yes in two or even three categories. Some projects (i.e. needs focused on specific elements of infrastructure design), may have no yes answers but may still be high value research need.

Climate

Oregon recognizes the climate crisis and makes systemic changes to reduce emissions caused by travel. Every mile driven in Oregon is powered by a clean source of fuel. We seek research that supports construction and maintenance operations are carbon neutral and investments in mobility that support travel by low and no emission modes. While every research project may not result in a reduction in emissions, transportation investments overall support emission reductions to achieve state goals.

Oregon envisions a transportation system that is resilient in the face of seismic and climate events and impacts to the degradation of the natural environment are reduced. Our vision includes a transportation infrastructure is built in a way that avoids impacts on key habitat and results in better environmental conditions for wildlife and native vegetation. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan and Oregon Transportation Plan.

4f. Will addressing the **transportation issue** identified as a need in Question 1 develop, or validate methods for the estimation, measurement, or monitoring of transportation generated greenhouse gasses (GHG)?

☐Yes ☒No ☐Unsure

4g. If climate or GHG is not the focus of this **transportation issue** identified in this problem statement, will the research apply a GHG analysis to transportation infrastructure, planning, operations, maintenance, or materials?

☒Yes ☐No ☐Unsure

4h. Will the addressing the **transportation issue** include development or testing of construction practices, methods, or materials to establish potential reductions in greenhouse gas emissions?

☒Yes ☐No ☐Unsure

4i. Will the solving the **transportation issue** in question 1 study or support the reduction of vehicle miles traveled and single occupancy vehicle travel or support transition to electric vehicles (or other types of zero emission vehicles) or low-carbon alternative fuels?

☐Yes ☒No ☐Unsure

4j. Will the solving the **transportation issue** in question 1 lead to work that will support, measure, monitor, transportation system resilience in response to expected climate events, effects, or natural disasters in general?

☐Yes ☒No ☐Unsure

4k. Will the solving the **transportation issue** in question 1 lead to work that may result in better environmental conditions for wildlife and native vegetation ?

☐Yes ☒No ☐Unsure

4l. If you answered yes to any of the climate questions above or can provide alternative details related to climate, please provide additional information:

This developed AI-based decision-making tool with the GIS database will allow ODOT to make more informed decisions to improve the network-level service life of roadways. In addition, the tool will allow ODOT to determine the most critical factors that control pavement performance, cost, and the associated GHG. Based on the outputs of the tool, maintenance, and construction decisions to reduce GHG emissions can be made more accurately.

According to an ODOT/FHWA research study (FHWA Climate Challenge) recently completed by the OSU-Asphalt Materials and Pavements (AMaP) research group, the cost of fuel and tire wear that can be saved by reducing current pavement roughness levels by 20% is around $73 million/year for the road users. The associated annual emissions savings are around 193,000 MT CO2/year, while ODOT's total annual

emissions from all operations were calculated to be 182,592 MT CO2/year (Proudfoot and Toneys 2022). This important result shows that lowering the cost of paving materials and improving the performance of roadways, which are the major objectives of this proposed research study, is crucial in this low paving budget environment to keep the roadway roughness and rolling resistance low to reduce GHG emissions and road user costs.

Equity

Equity can have many dimensions and impacts relating to communities, and transportation. It is important that problem statement proposals clearly explain in what capacities are equity dimensions or impacts being examined within problem statements. It is a goal of the OTP to "Improve access to safe and affordable transportation for all, recognizing the unmet mobility needs of people who have been systemically excluded and underserved. Create an equitable and transparent engagement and communications decision-making structure that builds public trust". Proposed research may have the intent of studying elements of this goal or apply analysis to specific transportation topics to ensure the resulting research recommendations is consistent with our equity goals. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan and Oregon Transportation Plan.

4a Is the **transportation issue** identified as a need in Question 1 specifically focused on transportation equity?

☐Yes ☒No ☐Unsure

4b If the **transportation issue** is not focused on transportation equity, will the primary topic be assessed for equity benefits or impacts within the research project?

☐Yes ☒No ☐Unsure

4c Is the implementation of potential findings from this research likely to directly involve participation from an identified group that would benefit from an equitable process or outcome?

☐Yes ☒No ☐Unsure

4d Is the intended final product or information expected to support ODOT's equity efforts (Including but not limited to supporting one of the equity related objectives of the ODOT's Strategic Action Plan or Oregon Transportation Plan) ?

☐Yes ☒No ☐Unsure

4e If you answered yes to any of the equity questions above or can provide alternative details related to equity, please provide additional information:

Safety

Research outcomes may include interventions and countermeasures to prevent or reduce the frequency of crashes or other causes of transportation-related injury or death; or may include measures to reduce severity of injury (including prevention of death) after a crash or other injurious event. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan, Oregon Transportation Safety Action Plan and Oregon Transportation Plan.

4m. Will solving the **transportation issue** in question 1 support improving **safety culture** for either transportation workers or the traveling public?

☐Yes ☒No ☐Unsure

4n. Will the solving the **transportation issue** support improving safety through **healthy and livable communities**?

☐Yes ☒No ☐Unsure

4o. Will solving the **transportation issue** support improving safety through using **best available technologies**?

☐Yes ☒No ☐Unsure

4p. Will solving the **transportation issue** support improving safety through **communication and collaboration**?

☐Yes ☒No ☐Unsure

4q. Will the solving the **transportation issue** support improving safety through **investing strategically**?

☐Yes ☒No ☐Unsure

4r. If you answered yes to any of the safety questions above or can provide alternative details related to safety, please provide additional information:

5. Other comments:

REFERENCES:

1) John Coplantz. (2022). Pavement Condition Report. Oregon Department of Transportation, Pavement Services Unit.

6. Corresponding Submitter's Contact Information:

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