

Research Stage 1 Problem Statement

PROPOSED TITLE: Multimodal Mitigation to Landslides by Integrating Cross-Domain Data

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

The Landslide Information Database for Oregon published by Oregon Department of Geology and Mineral Industries (DOGAMI) indicates that about 43% of the events are Flow, 35% are Slide and 17% are Rock Fall over the last three decades. In the meantime, soil type, drainage system, vegetation, weather elements and other geological dimensions are reported as contributing factors. Compositions of these causal factors trigger different types of landslides that are costly to ODOT, e.g. repair cost estimated to be \$21 million in 2022 and \$11 million in 2024. Long-term solutions likely will cost billions. Leverage existing measurement data in the forms of imagery, text and models that aim to improve understanding of landslides, we will develop hybrid and multimodal mitigation methods by detecting time-varying causes and consequences from these cross-domain data. Our project is to refine current ODOT measurements at specific sites in terms of types and ranges of causal factors over even more granular temporal and spatial resolutions to improve decision-making over combined mitigation methods.

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

Landslides affect nearby communities and the road networks. To fully describe the terrains, we need to include geographical information, geo-mechanical information and tree-coverage, and similarly for the road networks, we need to include geographical, geo-mechanical, usage, and jurisdiction information. Combining the measured data and tested physical models, we will construct a decision matrix to organize mitigation methods such as stability control focused, erosion control focused, or reinforcement focused to protect the road networks while managing the terrains.

Specifically, to decide over ditches next to the roads or meshes on the side of the slope, analysis of the slope, the soil, the tree coverage and the drainage along with seismic information is needed. Hybrid solutions or multimodal solutions such as initial reinforcement focused and final erosion control methods will be developed. When and where to stabilize will be simulated using the parameters that have been investigated. In the above-mentioned decision matrix, evaluations of the strengths and limitations of the methods reported in the literature will be included. This matrix with measurements for location-specific risks and documented practices over time can lead to assessment of the implementation of derived mitigation methods.

Furthermore, at each location, parametric models for the geometric dimensions of the mitigation methods such as the meshes and the ditches will be created. These dimensions will be corroborated with simulations over ranges of values of the causal factors for the different types of landslides. This approach can help ODOT fix the problem right the first time to further achieve protection of nearby communities and working crew members.

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.

ODOT Research is looking for individuals that have expert knowledge of the problem, key approval authority, will otherwise help oversee the study, or will implement the results of this work. Please don't list ODOT research staff.

Name	Title	Email	Phone

4. Other comments:

Cross-linking information from the different databases on geology, geomechanics, weather, vegetation and road networks is the first step to furthering and extending their use to develop resilient mitigation solutions. This requires defining levels of details for each parameter or variable evaluated and extracting high level indicators that determine the physical movement of the land. One effective method is to use weights to combine various contributing factors, e.g., combining clay content, rainfall, slope and elevation to create a risk indicator through giving a unique weight to each factor. Furthermore, once movement is started according to some threshold values of susceptibility, simulations of how initial change could lead to disastrous consequences will be the second step. The results from these two steps will be fused with transportation related information on the road networks to enable estimation of damage control and evacuation planning.

As the landscape is constantly changing, the temporal and spatial resolutions of the slopes, the elevations, and the soil content need to be robust enough to accommodate the updates from climate induced variations. This requires spatial models for terrain description, drainage consideration and tree coverage. Computation over these models and data can be costly, and fast-computing hardware support will be included. This can enable timely interaction with the data to select regions that are suitable for using ditches or meshes on the slopes. By contrasting the movement type and the size of shifted land for these two methods over time and physical space of the terrains, some long-term solutions will be developed. On top of these methods, biological methods such as those related to trees/shrubs/groundcover and geotextile methods such as those related to biodegradable mats/blankets/walls will be incorporated to create a combined or multimodal approach that is workable over time for various terrain conditions.

Lastly, benchmarking the proposed multimodal mitigation methods over higher resolutions of the land and time to existing metrics at ODOT such as those for debris flows and slope heights will be performed. During our project, communications with ODOT experts will be ensured on a monthly or quarterly basis along with data owners at DOGAMI and USFS.

5. State of Oregon Decision Making Lenses

State decision making lenses are a part of the state of Oregon's policy structure. State policy and federal policy are not always aligned. The state will prioritize research according to state policy, however ODOT may be required to skip prioritized proposals based on constraints placed on the use of federal funds. If

state funds are available ODOT will attempt to fund prioritized research that is deemed ineligible for federal funding.

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 a high value research need.

Climate

Oregon recognizes the climate crisis and makes systemic changes to reduce emissions caused by travel. To that end, we seek research that reduces carbon emissions from construction activities and materials, and from maintenance equipment and operations. Oregon envisions a transportation system that is resilient, this means a system that is durable in the face of seismic events and extreme weather to avoid negative impacts, withstand them or bounce back quickly to resume system function. We seek research that improves the ability of the transportation system to adapt or cope with more frequent and extreme weather events. This may include innovations in data and data sharing, construction materials and project design, communication, emergency planning and response, and more. Similarly, we seek research that avoids negative impacts on key habitats and ecosystems that can buffer or reduce damage to infrastructure and improve 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](#).

5a. 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 gases (GHG)?

☐ Yes

☐ No

☒ Unsure

5b. 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

5c. Will 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

5d. Will 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

5e. Will the solving the **transportation issue** in question 1 lead to work that will support, measure, or monitor, transportation system resilience in response to expected climate events, effects, or natural disasters in general?

☐ Yes

☐ No

☒ Unsure

5f. Will 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

5g. If you answered yes to any of the climate questions above or can provide alternative details related to climate, please provide additional information:

Equity

Equity can have many dimensions and impacts relating to communities and transportation. It is important that problem statement proposals clearly explain the equity dimensions or impacts being examined. Oregon commits to social equity in the OTP, specifically 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.* We seek research that studies elements of this goal or applies analysis to specific transportation topics to ensure the resulting research recommendation is consistent with agency equity goals. For definitions and details please review the equity vision, goals, and objectives of the [ODOT Strategic Action Plan](#) and [Oregon Transportation Plan](#).

5h. Is the **transportation issue** identified as a need in Question 1 specifically focused on transportation equity?

☐ Yes

☐ No

☒ Unsure

5i. 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

5j. 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

5k. 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

5l. 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](#).

5m. Will solving the **transportation issue** in question 1 support improving **safety culture** for either transportation workers or the traveling public?

☐ Yes ☐ No ☒ Unsure

5n. Will the solving the **transportation issue** support improving safety through **healthy and livable communities**?

☐ Yes ☐ No ☒ Unsure

5o. Will solving the **transportation issue** support improving safety through using **best available technologies**?

☐ Yes ☐ No ☒ Unsure

5p. Will solving the **transportation issue** support improving safety through **communication and collaboration**?

☐ Yes ☐ No ☒ Unsure

5q. Will solving the **transportation issue** support improving safety through **investing strategically**? 5r. If you answered yes to any of the safety questions above or can provide alternative details related to safety, please provide additional information:

6. Corresponding Submitter's Contact Information:

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7. ODOT Sponsor Contact Information (Required if Submitter is not an ODOT employee)

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This form is not a grant application or contract document. Please do not include proprietary information on this form. Once this form is received ODOT may revise and publish the problem statement. If selected, ODOT will assign investigator(s) of the department's choosing to conduct research.