Research Stage 1 Problem Statement

PROPOSED TITLE: LEVERAGING SURFACE MONITORING TECHNOLOGIES TO GUIDE EMERGENCY RESPONSE AND LONG-TERM STRATEGIC PLANNING ALONG LANDSLIDE-PRONE ODOT CORRIDORS

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

Slope failures impede transportation in Oregon, costing the state tens of millions of dollars annually through maintenance and repair, while diminishing system reliability due to closures. Frequently, these landslides affect right-of-way through slow movements that affect driver safety, result in road closures, or in some cases, accelerate towards collapse. Conventional monitoring, site investigation and assessment of landslides for mitigation often requires drilling along with installation of piezometers and inclinometers, but are not always feasible due to the significant expense of drilling, safety concerns about working on an active landslide, and difficult access. Unfortunately, even using remote sensing data to monitor near-real time movements at larger scales is not always feasible owing to vegetation, temporal resolution, lack of ground-truthing, and the short lifespan of subsurface instruments. These restrictions result in only a small proportion of landslide-prone terrain having any level of characterization or monitoring. Consequently, there is a need to expand the capabilities of near-real-time monitoring of ground movements not just at the scales of a specific site but also at the scale of critical highway segments. Such data is key towards evaluating highway safety, need for repairs, approaches towards mitigation, and strategies for reopening after failure. The absence of this information places critical infrastructure and ultimately ODOT customers at risk.

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

Key advances in *in situ* GNSS surface monitoring technologies currently supported by ODOT have enabled near-real-time observation of ground movements, providing critical information regarding highway access, mitigation efficacy, and long-term landslide behavior at critical locations along ODOT lifelines. Along with an online interface for viewing near-real-time landslide movements (LandslideLink: landslidelink.github.io), ODOT professionals and planners have used this technology to strategize reopening at the Arizona Inn Landslide along US101, monitor movements and mitigation efficacy at US26 MP13 where ground movements have resulted in accidents and delays, and provide information on the relative activity (or lack thereof) of eleven other landslides traversing lifelines across the state. Further, data from this monitoring investment is being used for discussion in Goal 18 exceptions along erosion-prone, unstable right-of-way at several landslide locations along US101. However, this strategic monitoring is (1) not yet at the scale to provide relevant data on many other problematic slopes traversing US101 and other key lifelines, (2) does not have sufficient time series to consider long-term changes in behavior, (3) has not been deployed along extended stretches of highway as a means of examining early warning at the scale of vulnerable highway segments (e.g. all of Beverly Beach) and (4) has not been incorporated into a simplified, but effective public-facing mechanism that can provide necessary data to planners inside and outside of ODOT to justify mitigation strategies.

We propose expanded monitoring of critical ODOT lifelines, not only at specific landslide locations, but along corridors prone to instability and in dire need of public-facing mitigation justification and strategies. This approach would leverage ODOT's investment in surface monitoring technology, which has thus far been directly and indirectly used by planners inside and outside of ODOT to make decisions regarding highway closures, reopening, and observe the efficacy of mitigation. Considering the success and utility of this monitoring approach thus far in SPR878 and SPR807, we envision deployment of surface monitoring technology, including both in situ GNSS arrays and laser extensometers along other critical State highway locations. This expansion would be implemented for (1) existing, unmonitored slope failures, (2) along metastable but actively eroding corridors that lack quantifiable justification for mitigation and have a tendency to fail rapidly (thus lacking a means of scoring in the Unstable Slopes database), and (3) a suite of "go kits" for rapid, temporary emergency monitoring of slope failures that could guide reopening strategies and mitigation efficacy. For example, there are numerous active landslides on the South Coast that resulted in travel delays and partial closures in Curry County but remain unmonitored; ODOT would benefit from added surface monitoring to triage which landslides are highest priority for repaving or repair, especially following heavy precipitation that results in movements of many landslides along this corridor. Some stretches of ODOT right-of-way, such as Beverly Beach, remain prone to localized failures from coastal erosion, but there is limited monitoring of how retreat results in loss of ocean-facing right-of-way. Segments of erosion- and landslide-prone highway would benefit from uniformly-spaced arrays of surface monitoring that would inform ODOT planners as to the distributed loss of right-of-way along key corridors. Finally, maintaining a series of modular surface monitoring kits would help inform reopening strategies and observational data regarding mitigation efficacy on an *ad hoc* basis, improving mitigation implementation and worker safety at critical sites. These data would be processed through the cloud and immediately usable through development of an augmented version of LandslideLink, which would be modified to provide relevant surface monitoring data and early warning of movement. This multi-faceted approach would leverage and expand on ODOT investments in near-real-time surface monitoring and enhance prioritization of ODOT resources, both for emergency management and long-term planning strategies.

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.

Name	Title	Email	Phone
Curran Mohney	Senior Engineering Geologist	Curran.E.MOHNEY@odot.state.or.us	(503) 986-3490

4. Other comments:

The following tasks are envisioned for this research, which will leverage existing monitoring of slope failures and erosion such as SPR807, SPR808, SPR843 and SPR878:

1. Review current approaches for monitoring landslide movements using GNSS systems and *in situ* laser displacement systems. Provide guidance to ODOT on the appropriate application of this technology for monitoring existing landslides and new failures, along with applications of technology for emergency monitoring.

2. Install GNSS units to additional problematic landslides. Connect instruments with ODOT Geometronics GNSS network. With ODOT site guidance, install GNSS units and laser displacement systems along corridors prone to coastal retreat and localized failure as a linear array for monitoring loss of right-of-way. Create sets of rapidly deployable systems for emergency deployment on an *ad hoc* basis based on demand from ODOT projects and needs.

3. Advance LandslideLink webviewer to update with added, relevant GNSS and laser displacement transducer data from new landslide sites, linear arrays of monitoring, and *ad hoc* emergency monitoring to provide near-real-time information to relevant planners. Tailor web tool for multiple audiences, whether ODOT engineering staff or public-facing systems guiding policy planning.

5. Provide documentation for field application of supplementary surface monitoring techniques.

6. Host hands-on training course for ODOT professionals in the tools including sensor installation, monitoring, and data analysis.

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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:

This problem statement directly supports measurement and monitoring of natural hazards (landslides and coastal erosion) that are very sensitive to climate variability, and are highly disruptive to ODOT infrastructure. These data have already demonstrated benefits for resilience, e.g. guiding reopening of Highway 101 after a landslide surge event, providing information on a problematic slope failure (and its mitigation) that has resulted in delays and accidents on HWY26 (a lifeline). It has also provided information to planners focusing on mitigation of erosion-prone parts of HWY101. Climate is inherently the driver of these ground movements, and this technology has thus far empowered ODOT and other relevant personnel to monitor numerous, hazardous sites with less personnel time.

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:

This research would expand and empower existing monitoring networks, the best available technology for precise and accurate near-real-time monitoring of ground movements, which have enabled planners to make decisions about road closures, speed limits, and delays. This benefits healthy and livable communities – particularly those dependent on singular lifelines, like coastal communities - by providing data behind reopening roads that when closed can turn a 30 minute trip to the doctor into a five-hour journey. The webviewer of this data has enabled communication to planners considering erosion mitigation options at vulnerable segments of Highway 101, which is critical for safe highway use and connectivity between coastal communities. These data, if public-facing, could provide opportunities for collaboration and communication between ODOT, other agencies, and the public, providing a means for justifying mitigation in strategic locations based on quantitative, real data. This work would leverage previous ODOT investments to expand on these results.

6. Corresponding Submitter's Contact Information:

Name:	Ben Leshchinsky, Ph.D., P.E.
Title:	Professor
Affiliation:	Oregon State University
Telephone:	541-737-8873
Email:	Ben.leshchinsky@oregonstate.edu

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

Name:	Curran Mohney
Title:	Engineering Geology Program Lead
Crew Number:	7163
Telephone:	(503) 508-3628
Email:	curran.e.mohney@odot.oregon.gov

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.