

Research Stage 1 Problem Statement

PROPOSED TITLE: MODERNIZING TUNNEL INSPECTION LEVERAGING REALITY CAPTURE DATA

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

Oregon determines overall tunnel conditions qualitatively (good, fair or poor) by aggregating element condition information as a workaround as currently there is no established standard. A routine inspection procedure typically requires lane closure for hours, sometimes taking several nights for a thorough and detailed inspection. And yet, the assessment and reporting procedures can still be inconsistent due to subjective judgement, large workload, and hand drawing. The lack of consistent and precise reference also makes it difficult to conduct any comparative assessment between different epochs. While leveraging lidar, photogrammetry, and other reality capture techniques can potentially improve the consistency, accuracy, and efficiency in tunnel inspection, new methodologies need to be developed to overcome challenges for georeferencing in GNSS-denied areas (e.g., tunnels), as well as make the reality capture data (e.g., georeferenced images and 3D point clouds) workable for tunnel inspectors. Such modernized tunnel inspection will also help ODOT become more effective and efficient in maintaining tunnels managed across the state.

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

To improve the consistency of ODOT's current practice in tunnel inspection, the following key objectives need to be achieved:

- Establish a detailed baseline database for the tunnels that ODOT maintains. This baseline database will serve as a reference for future data processing and analysis. The data will include not only the interior of a tunnel, but also the surrounding areas such that the final data package is able to support more comprehensive analysis, which is especially valuable for tunnels that are subject to landslide, coastal erosion, and other geohazards.
- Develop a workflow to constrain ODOT's mobile lidar data collection in GNSS-denied areas. ODOT collects mobile lidar data on regular basis, which provides great recurring detailed 3D coverage of the tunnels to be inspected. However, because a mobile lidar system is heavily reliant on accurate GNSS positioning, the GNSS-denied areas such as tunnels can be challenging to capture with the desired precision and accuracy. Thus, a new workflow needs to be developed to further constrain the mobile lidar data to align with the baseline database.
- Develop an automated methodology along with prototype tools for reality capture-based tunnel inspection. While 3D point clouds from reality capture technologies are powerful and can provide rich information, extensive training on both fundamental knowledge of geomatics and specialized software is often required. To break down this barrier for tunnel inspectors, a methodology needs to be developed to convert 3D reality capture data into a format that is easier for tunnel inspectors to utilize. Automated feature extraction will also help highlight certain features or damages to

further improve the efficiency of tunnel inspection. The prototype tools implementing the proposed methodology will aid ODOT's current practice in tunnel inspection.

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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Brian McNamara	Engineering Geologist	Brian.MCNAMARA@odot.oregon.gov	503-871-6733
Michael Goff	Senior Bridge & Tunnel Inspector	Michael.GOFF@odot.oregon.gov	503-930-7808
Rhonda Dodge	Senior Remote Sensing Surveyor	Rhonda.K.DODGE@odot.oregon.gov	503-507-1809
Michael Dyra	Bridge Inspection Team Lead	Michael.J.DYRA@odot.oregon.gov	503-969-1091

4. Other comments:

The proposed research will potentially include the following primary tasks:

Task 1. Literature review: This task will result in a comprehensive literature review on topics such as current practice of tunnel inspection, examples of using remote sensing techniques to acquire data from tunnels, methodologies for feature extraction and modeling from reality capture data. This literature review can be conducted starting with the literature review published by the OSU Geomatics research team (Che, E., Jung, J., & Olsen, M. J. (2019). Object recognition, segmentation, and classification of mobile laser scanning point clouds: A state-of-the-art review. *Sensors*, 19(4), 810.) where it summarized the state of the art in using mobile lidar data for tunnel maintenance and monitoring.

Task 2. Research baseline tunnel database: The research team will work with ODOT personnel to gather existing datasets and collect detailed reality capture data at selected locations. Non-invasive targets or markers will be considered to help establish survey control to ensure more rigorous georeferencing process and QA/QC.

Task 3. Methodology to aid tunnel inspection: The research team will develop the methodology to convert the reality capture data (e.g., point cloud or mesh) into better format to aid tunnel inspection procedures. During this process, certain feature extraction and visualization enhancement will be considered to improve the workability of the data.

Task 4. Workflow for improving mobile lidar data quality: A new workflow will be developed and tested to demonstrate the feasibility of improving mobile lidar data quality in GNSS-denied areas such as tunnels.

Task 5. Case study for modernized tunnel inspection: The research team will work with ODOT tunnel inspectors to analyze selected tunnels using the proposed methodology and test its effectiveness to pave the way for future implementation.

Task 6. Workshop for tunnel inspectors: A workshop will be hosted for ODOT tunnel inspectors to cover the key findings of this research as well as fundamentals of reality capture to stay informed on the latest technological development.

Task 7. Reporting: A final report will be compiled to document the project in detail.

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:

- *5d: Tunnels themselves are designed and built to provide a more direct and faster route that will reduce mileage and emission. Additionally, one potential outcome of this proposed research is to reduce the time that inspectors need to spend in the field while closing lanes or shutting down the entire tunnel, which will reduce detour or idling when tunnel inspections take place.*
- *5e: Some of the tunnels that this proposed research will focus on are subject to frequent climate events and ongoing natural hazards. For example, the tunnel at Arch Cape is impacted by both coastal erosion and landslide, as well as other climate events such as sea-level change.*
- *5f: The methodology developed in this work can be extended to monitoring the conditions of underpass wildlife tunnels.*

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:

- *Although equity is not the primary focus of this proposed research, keeping tunnels safe and sound while minimizing the disruption of traffic due to inspection work can maximize their functionality in the transportation systems to advance equity for all.*

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**?

☒ Yes☐ No☐ Unsure

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

- *5m: Leveraging remote sensing techniques can potentially reduce the time that tunnel inspectors have to spend in the work zone, which in turn can improve the safety for transportation workers.*
- *5o: The mobile lidar system that ODOT operates is a state-of-the-art remote sensing system. Leveraging such systems can significantly reduce the need for traffic control and work on the roadside and hence improve safety for transportation workers and users.*
- *5q: More consistent tunnel inspection procedures and reporting can result in more informed decision making when it comes to keeping the tunnels functional and safe while reducing the cost.*

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.