Research Stage 1 Problem Statement

PROPOSED TITLE:
Rapid Vulnerability Assessment and Mitigation for Waterway Bridges Against Vessel Collision

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

In the wake of the Francis Scott Key Bridge collapse, the National Transportation Safety Board (NTSB) conducted a thorough investigation into the accident and further identified 68 bridges with unknown collision risk due to the lack of vulnerability assessment, including two bridges owned by ODOT (Astoria-Megler Bridge and St. Johns Bridge). Since the NTSB investigation only considered large ocean-going vessels similar to the containership *Dali* causing Key Bridge collapse, the actual number of bridges with unknown collision risks is likely to be much higher. Based on the FHWA InfoBridge database, there are in total 91 waterway bridges in Oregon with navigation control (thus can potentially be damaged by vessels), 64 of which were built/rebuilt prior to 1991 when the AASHTO Specifications for vessel collision analysis were first introduced, and thus have unknown risks of collapse due to vessel collision. Given the number of assets at risk, it is challenging to conduct detailed engineering analysis for all of them. In addition, many older bridges may have unknown foundation conditions, missing as-built plans, and long-term scour damage to foundations. **Therefore, the goal of this research is to establish rapid analysis procedures for vulnerability assessment and mitigation decision-making for these waterway bridges.**

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

The proposed procedures will comply with the general methodology laid out in AASHTO's Method II for Vessel Collision Vulnerability Assessment, with **(a) updated navigation statistics and vessel maneuver data in Oregon waterways, (b) common substructure/protection characteristics of Oregon bridges, and (c) refined structural reliability assessment for collapse vulnerability estimation**. The procedures will be developed and piloted for the 19 waterway bridges with navigation control in and near the City of Portland. The city is an excellent testbed because: (a) both the Columbia and Willamette Rivers are major maritime corridors with a good mix of critical/essential bridges and typical bridges; (b) the waterway includes bends, intersections, and closely spaced bridge crossings that are known to increase the likelihood of accidents; and (c) focusing on smaller ocean-going and riverine vessels that were left out in the NTSB investigation.

In particular, the research will lead to the following specific deliverables useful to ODOT:

- Databases for waterway characteristics and maritime traffic for PDX waterway bridges, along with an automated tool to expand to all Oregon bridges;
- Spreadsheet or Jupyter notebook to conduct vulnerability assessment with the established rapid procedures based on common substructure/foundation classes defined in this study;
- Development of a tier list for vessel collision risk of PDX bridges that can be further expanded to state-level implementation;

- An interactive dashboard showing the estimated effects of various operational, protection, and retrofitting measures for vulnerable bridges.

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
Arash Khosravifar	Associate Professor, Portland State University	akhosravifar@pdx.edu	503-725-4280
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4. Other comments:

The AASHTO's Method II for Vessel Collision Vulnerability Assessment expresses the annual frequency (AF) of bridge collapse caused by vessel collisions as follows:

$$AF = (N)(PA)(PG)(PC)(PF)$$

where N = annual number of vessels; PA = probability of aberrancy; PG = probability of collision given waterway geometry; PC = conditional probability of collapse given collision; PF = correction factor to account for protection systems. Bridges over navigable waterways should have an AF less than 0.0001 for essential/critical bridges and 0.001 for typical bridges.

The rapid procedures will be established by completing the following key tasks, focusing on each term in the assessment equation above to reflect the unique situation in Oregon:

- **Task 1: Creating a centralized data clearinghouse for maritime traffic and waterway characteristics**: Statistics to derive N, PA, and PG are scattered among various agencies, e.g., NOAA and USCG for N and PA, and USACE and USGS for PG. For public online data (e.g., AccessAIS by NOAA), a web scraping tool will be developed to automatically and consistently extract data. Other data sources will be clearly documented for Oregon bridges, and a database will be prepared for PDX bridges using the developed tool and from the identified sources.
- **Task 2: Categorizing typical substructure and foundation conditions and their load-bearing capacities**: Similar to the NBI superstructure classification, substructure and foundation will be categorized based on easily attainable, widely available properties that can also meaningfully indicate the lateral load-bearing capacity of these components. This classification will simplify the process of estimating PC, especially for bridges without detailed substructure/foundation information.
- **Task 3: Verifying the proposed rapid procedures with detailed engineering analysis**: The established procedure, especially the classification of substructure/foundation for capacity estimation, will be verified with the detailed engineering analysis results from the two Oregon bridges identified by the NTSB, as well as the PDX bridges whose substructure/foundation details are available.

- **Task 4: Developing risk tier list and recommending mitigation measures to meet AF thresholds**: The established procedures will be used to assess and rank the collision risk of PDX bridges. For bridges with AF greater than the thresholds, an interactive dashboard will be developed to show the effects of different mitigation measures, such as regulating vessel types and speed (operational measures targeting PG and impact force), adding/strengthening dolphins or fences (protection measures targeting PF), and strengthening piers (retrofitting measures targeting PC and potentially integrated with seismic considerations).

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:

N/A

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:

N/A

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:

- 5o: To improve navigation safety (reduce collision risk), we will utilize the latest waterway and maritime traffic data collected from the best available technologies such as the **Automatic Identification System (AIS)**. We will also conduct **engineering-based reliability analysis** to replace empirical/subjective estimations on structural vulnerability.
- 5p: We plan to engage and collaborate with local stakeholders and agencies within **US Army Corps of Engineers (USACE) and US Coast Guard (USCG)**. We will gather inputs from these agencies and seek feedback for any potential mitigation measures suggested by this research.
- 5q: Quantifying collision risk enabled by this research can supports **risk-based benefit-cost analysis** for different mitigation measures, allowing more strategic investment.

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.