Research Stage 1 Problem Statement

PROPOSED TITLE: Post-Installed Resin-Bonded Anchors for MASH TL-4 Side-Mounted Bridge Rail Retrofit.

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

ODOT and other state transportation agencies need a practical, MASH-compliant retrofit option for existing bridges using a steel side-mounted beam-and-post rail attached with post-installed resin-bonded anchors. Existing MASH TL-4 side-mounted bridge rail systems were tested with cast-in-place anchors, and current AASHTO LRFD and ACI anchor design provisions for post-installed adhesive anchors are intentionally conservative and do not support the use of post-installed connections for this application. As a result, ODOT cannot currently use this MASH TL-4 side-mounted rail system to upgrade a large population of substandard side-mounted bridge rails. This project will perform targeted component (bogie) testing of post-installed resin-bonded anchor connections to develop validated design resistances and equations, enabling a consistent, crashworthy retrofit detail for Oregon bridges.

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

This project needs to produce a practical, implementable design methodology for using post-installed resin-bonded anchors to attach a MASH TL-4 side-mounted beam-and-post bridge rail to existing bridge decks or box-beam sections. The primary final products should include:

- A peer-reviewed research report documenting:
  - Test matrix, instrumentation, and procedures for component (bogie) and static tests of posts attached with post-installed resin-bonded anchors.
  - Measured load–deformation behavior and failure modes of the anchored posts, including concrete breakout, bond, and combined cone-and-bond behavior.
  - Validated design equations and resistance factors for post-installed adhesive anchors in this side-mounted rail configuration, calibrated against the modified equations in report TRP-03-264-12 and compared to ACI/AASHTO LRFD baseline provisions.
  - Recommended minimum embedment depths, edge distances, bar diameters, and adhesive products appropriate for ODOT bridge rail retrofit projects.
- Design implementation tools for ODOT staff:
  - Draft revisions or additions to ODOT Bridge Design Manual / Bridge Design Drafting Manual details to incorporate a standard side-mounted TL-4 rail retrofit detail using post-installed resin-bonded anchors.
  - Draft changes or supplemental guidance for ODOT standard drawings and/or specifications (e.g., Section 00587 – Bridge Railings, adhesive anchor installation specifications) to capture installation and quality-control requirements.
  - A concise design example (or spreadsheet template) showing how to compute required anchor capacities and embedment using the validated equations for typical ODOT deck geometries.

With these products, ODOT bridge design staff can adopt a single, tested retrofit detail and avoid one-off analytical exceptions, while providing a clear, defensible basis for design exceptions where full MASH crash testing is not feasible.

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. Other comments:

ODOT has a large inventory of substandard side-mounted bridge rails that do not meet current MASH crashworthiness criteria. Many of these rails are located on facilities with heavy truck traffic and significant vertical drops, where penetration or rollover failures can result in severe or fatal crashes. At present, ODOT often has no cost-effective, constructible retrofit option: replacing the entire deck or using long, cast-in-place anchor rods is highly disruptive and expensive, while relying on conservative ACI/AASHTO LRFD adhesive anchor equations frequently results in "no-solution" designs or requires repeated project-specific design exceptions.

The proposed post-installed resin-bonded anchor retrofit for a MASH TL-4 side-mounted steel beam-and-post rail directly addresses this gap. Prior work TRP-03-264-12 has shown that post-installed resin-bonded anchors can achieve capacities significantly higher than those predicted by basic ACI provisions, particularly when combined cone-and-bond behavior is considered. However, that work was focused primarily on vertically installed anchors with limited test configurations. ODOT's need is specifically for side-mounted rail posts, where embedment is limited (~10–14 in.) and edge distance, moment eccentricity, and dynamic impact behavior may control.

This project will:

- Construct one or more short sections of bridge deck edge representative of typical ODOT bridge decks used for side-mounted rails.
- Install rigid or representative posts with post-installed resin-bonded anchors (e.g., a commonly used adhesive such as HIT-RE 500 V3 or equivalent) at selected embedment depths and edge distances.
- Conduct static and surrogate vehicle (bogie) impact tests (anticipated 3–5 days of testing) to determine the actual demand on the anchor groups and validate the combined cone-and-bond equations proposed in TRP-03-264-12.
- Compare measured capacities to analytical demands from the side-mounted TL-4 rail design, including realistic post plastic moment behavior and load distribution along the rail, to determine an adequate, economical anchor configuration.
- Evaluate whether full-scale crash testing is necessary, or if robust component-level testing provides sufficient basis for design and potential FHWA acceptance as a retrofit detail.

Estimated project cost and benefit (order-of-magnitude):

- Component bogie test cost per configuration has been rough-estimated at approximately $30,000 (per correspondence with Prof. Joshua Steelman, MwRSF/UNL), including construction of a short deck section, installation, testing, demolition, and reporting.
- A program involving on the order of 5–8 different configurations (varying embedment depth and edge distance) leads to an expected direct research cost of approximately $150,000 to $240,000, plus ODOT staff time. A more comprehensive program with additional permutations and analysis may approach $250,000 total, consistent with the prior draft problem statement.

By contrast, if ODOT is unable to develop a standard post-installed anchor retrofit detail, programmatic costs and risks will remain high:

- Assume that 20 bridges in Oregon will require side-mounted rail upgrades over the next 10–20 years.
- If each project must pursue a project-specific design exception and bespoke analysis, and each exception consumes even 20–40 hours of combined ODOT and consultant engineering and review time at an average loaded cost of $150/hour, the agency spends roughly $3,000–$6,000 per bridge just in design/approval effort. Across 20 bridges, this equates to approximately $60,000–$120,000 of staff and consultant cost.
- If a lack of a feasible retrofit detail forces more intrusive construction (deck modification, special details, or full deck replacement) on even 5–10 of those bridges, and if those more intrusive alternatives cost $100,000 more per bridge than a post-installed anchor retrofit, that alone represents $500,000–$1,000,000 in additional construction cost.

Taken together, developing a single, tested retrofit detail has a realistic potential to avoid about $560,000–$1.12 million in combined design and construction costs over the program life, against an approximate research investment in the $200k–250k range. This suggests a benefit–cost ratio on the order of 2:1 to 5:1, not counting safety benefits.

Safety benefits are even more significant but harder to quantify exactly. Preventing even one serious truck penetration or vaulting crash over the life of the upgraded inventory would likely justify the research from a societal cost perspective. Typical crash cost estimates for a single fatal crash range from $10–15 million; a handful of serious injury crashes avoided through improved rail performance would easily overwhelm the research cost. Given Oregon's mix of freight routes and aging bridge inventory, the likelihood that better rail retrofits prevent at least one severe event over multiple decades is reasonable.

In summary, this project offers:

- A realistic, implementable path to a MASH-consistent retrofit for side-mounted rails using post-installed adhesive anchors.
- A strong economic justification at the program level, with expected savings far exceeding the research cost.
- A clear link to ODOT's safety and resilience goals and a straightforward implementation path through standard drawings and design manuals.

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:

While not a primary climate-focused project, the research has indirect climate and resilience benefits through construction methods and asset durability:

- By enabling a post-installed retrofit rather than full deck replacement or reconstruction, the research can reduce the amount of concrete and reinforcing steel that must be demolished and replaced. This reduction in material production, hauling, and demolition directly decreases GHG emissions associated with construction compared to more intrusive alternatives.
- A standard, tested retrofit detail promotes consistent, durable performance of upgraded bridge rails under heavy truck traffic and extreme events (e.g., icy conditions, higher intensity storms) that may increase crash frequency. Better-performing rails contribute to system resilience**,** helping infrastructure withstand more frequent or severe events without catastrophic failure and extended closure.
- The research will also support more efficient maintenance and rehabilitation strategies (e.g., avoiding repeated interim repairs or temporary barriers), reducing repeated construction mobilizations and associated emissions over the life of the asset.

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:

This project is primarily a technical safety and design effort. However, implementing a cost-effective retrofit detail can help ODOT upgrade older structures on lower-volume, lower-resource corridors—including rural, coastal, and historically underinvested communities—where full deck replacement would be difficult to fund. In that sense, a lower-cost, high-performance retrofit may make it more feasible to deliver safety improvements across a broader range of communities, rather than concentrating improvements only on a small subset of high-volume urban structures.

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:

Safety is the primary driver for this research:

- The MASH TL-4 side-mounted steel beam-and-post rail system is designed to prevent heavy truck penetration, rollover, and passenger-car vaulting at bridge edges—failure modes with severe consequences. Developing a tested, post-installed anchor retrofit detail allows ODOT to deploy this performance level on existing structures where full reconstruction is not feasible.
- By grounding the retrofit detail in measured test data and validated equations (rather than relying solely on conservative code provisions or engineering judgment), ODOT can strengthen its internal safety culture—staff can rely on evidence-based details rather than one-off exceptions.
- The project will employ best available technology in adhesive anchor design and test methods, including modern bonded anchor products and advanced component-level impact testing.
- Communication and collaboration will be integral: ODOT will work with external experts (e.g., MwRSF/University of Nebraska or similar research institutions) and internal Bridge Section, Region Bridge, and Maintenance staff to ensure the research questions match field needs and the final retrofit detail is constructible and maintainable.
- From a strategic investment perspective, the research allows ODOT to target limited capital dollars toward a standard, high-impact upgrade that can be replicated across many structures, rather than one-off, expensive solutions. Avoiding even a single severe crash at a retrofitted bridge rail (with typical societal crash costs in the $10–15 million range for a fatal crash) would more than justify the $200k–250k research investment.

6. Corresponding Submitter's Contact Information:

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

Name:	
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Crew Number:	
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Email:	

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.