

SPR RESEARCH PROGRAM

SECOND-STAGE PROPOSAL SUMMARY

PROBLEM NUMBER AND TITLE

27-05: Risk Reduction, Optimized Hydraulic Design, & Efficient Site Characterization using Integrated UAS Topographic-Bathymetric Lidar Data

PROBLEM SUMMARY

Storm events present significant hydraulic loads on highway infrastructure through flooding, overtopping, scour, channel migration, bank erosion, coastal cliff erosion, culvert failure, and embankment damage. Accurate hydraulic models reduce risk by optimizing infrastructure design to withstand extreme events. Similarly, repeat monitoring of vulnerable sites enables accurate risk assessment to inform maintenance priorities. Currently ODOT uses traditional survey methods to build hydraulic models for design and site assessment, which includes collection and integration of manual topographic and single-beam bathymetry data into a Digital Terrain Model (DTM). These manual methods are slow, labor-intensive, and often constrained by steep terrain, restricted land access, or dangerous conditions. Resulting terrain models may then present critical data gaps with missing channel bathymetry near structures, introducing uncertainty into scour, erosion, and floodplain analyses. Aging infrastructure, coupled with projected increases in hydraulic loads from extreme events present increasing risks to the traveling public. **A safer, easily deployable, and efficient survey method that delivers comprehensive DTMs as needed is critical for optimized hydraulic design, reliable risk assessment, and site prioritization for risk-based decision making.**

ODOT OBJECTIVES

Uncrewed Aircraft System (UAS) Topographic Bathymetric (topo-bathy) Lidar can rapidly capture continuous, model-ready input for hydraulic design or site assessment post-event in one mobilization. Both the USGS and NOAA have now adopted topographic bathymetric lidar to build comprehensive river and coastal DTMs where conditions allow. However, this survey methodology is limited by depth and turbidity and has yet to be fully evaluated for transportation infrastructure needs, especially for use in Oregon's unique riverine and coastal conditions. ***Specific Aim:*** to produce a validated framework for the operational use of UAS topo-bathy Lidar in support of ODOT's project design, hydraulic, and structural monitoring programs.

BENEFITS

When applied appropriately, UAS topobathymetric lidar reduces hydraulic risk by improving the most consequential input for analysis: the DTM. Current workflow for manual topographic collection is internally recognized as slow, labor intensive, and constrained by terrain and access, leading to potential issues with repeatability and reliable data capture. Transitioning UAS topo-bathymetric lidar from state-of-art to state-of-practice will improve safety for personnel and the traveling public, provide defensible risk-based management decisions, and potentially improve cost efficiencies for the state.

SCHEDULE, BUDGET AND AGENCY SUPPORT

Estimated Project Length: 30 months.

Estimated Project Budget: \$290,000

ODOT Support: Alvin Shoblom (State Hydraulic Engineer), Mike Nichols (State Surveyor)

FOR MORE INFORMATION

For additional detail, please see the complete STAGE 2 RESEARCH PROBLEM STATEMENT online at:
<https://www.oregon.gov/odot/Programs/ResearchDocuments/27-05.pdf>

SPR RESEARCH PROGRAM

SECOND-STAGE PROBLEM STATEMENT

FY 2027

27-05: Risk Reduction, Optimized Hydraulic Design, & Efficient Site Characterization using Integrated UAS Topographic-Bathymetric Lidar Data

RESEARCH PROBLEM STATEMENT

Storm events present significant hydraulic loads on highway infrastructure through flooding, overtopping, scour, channel migration, bank erosion, coastal cliff erosion, culvert failure, and embankment damage. Accurate hydraulic models reduce risk by optimizing infrastructure design to withstand extreme events. Similarly, repeat monitoring of vulnerable sites enables accurate risk assessment to inform maintenance priorities. Currently ODOT uses traditional survey methods to build hydraulic models for design and site assessment, which includes collection and integration of manual topographic and single-beam bathymetry data into a Digital Terrain Model (DTM). These manual methods are slow, labor-intensive, and often constrained by steep terrain, restricted land access, or dangerous conditions. Resulting terrain models may then present critical data gaps with missing channel bathymetry near structures, introducing uncertainty into scour, erosion, and floodplain analyses. Aging infrastructure, coupled with projected increases in hydraulic loads from extreme events present increasing risks to the traveling public. **A safer, easily deployable, and efficient survey method that delivers comprehensive DTMs as needed is critical for optimized hydraulic design, reliable risk assessment, and prioritization of critical locations for risk-based decision making.**

RESEARCH OBJECTIVES

Uncrewed Aircraft System (UAS) Topographic Bathymetric (topo-bathy) Lidar can rapidly capture continuous, model-ready input for hydraulic design or site assessment post-event in one mobilization. Both the USGS and NOAA have now adopted topographic bathymetric lidar to build comprehensive river and coastal digital elevation models where conditions allow (Figure 1). However, this survey methodology is limited by depth and turbidity and has yet to be fully evaluated for transportation infrastructure needs, especially for use in Oregon's unique riverine and coastal conditions. ***Specific Aim:*** to produce a validated framework for the operational use of UAS topo-bathy Lidar in support of ODOT's project design, hydraulic, and structural monitoring programs.

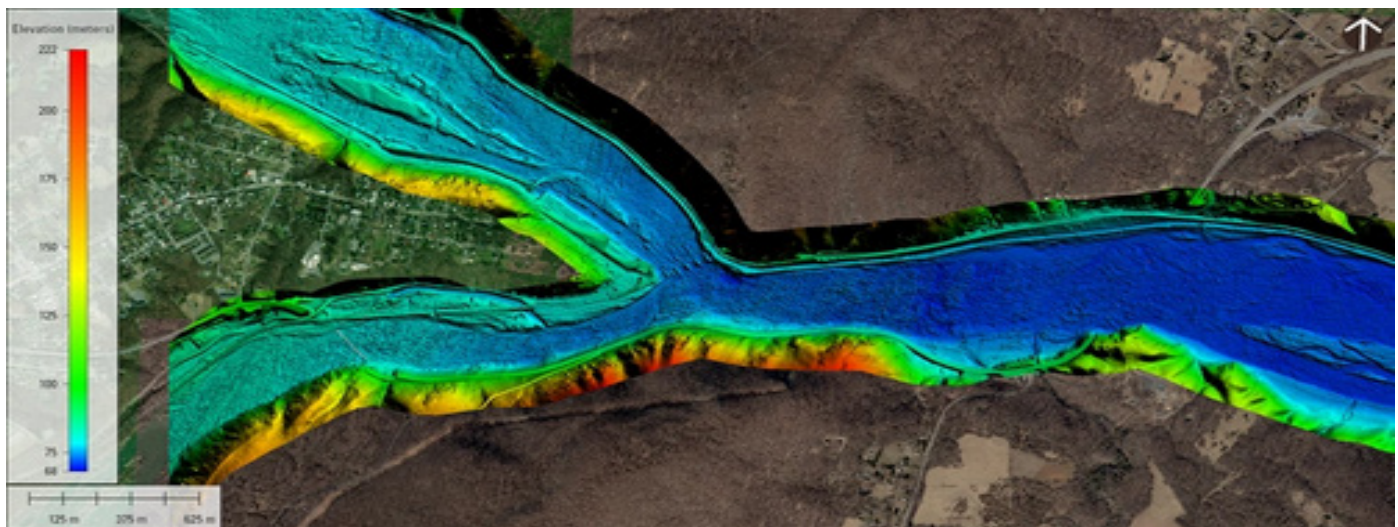


Figure 1: Example of topobathymetric digital elevation model. Notice the continuity of land terrain together with the underwater terrain (USGS).

WORK TASKS, COST ESTIMATE, AND DURATION

Task 1: Deliver Technical Review. Deliver focused literature review with the goal of identifying appropriate methods and best practices that include criteria for performance assessment as for UAS topo-bathymetric lidar. This Task should prepare the groundwork for Pilot Testing in *Task 3*. This review will cover current means and methods of bathymetric Lidar, summarizing best practices, performance characteristics, and technology limitations across different environmental and operational conditions.

Task 2: Develop pilot protocols and assessment method. Leverage published methods and protocols identified in *Task 1* together with input from the Technical Advisory Committee to assess performance of UAS topo-bathymetry for 3 pilot test locations/conditions that are anticipated to be high-performance, high-return investments. As a part of this Task preliminary technical guidelines and specifications will be developed including recommended acquisition parameters, processing workflows, and quality-control standards for UAS topo-bathy data collection applicable to ODOT Survey and Hydraulics teams.

Task 3: Pilot testing and performance assessment. Identify, execute, and document pilot testing for 3 sites of interest using protocols and criteria identified in *Tasks 1* and *2*.

Task 4: Develop Oregon Application and Suitability Map. Deliver a decision-support tool identifying areas across Oregon where UAS Topo-Bathymetric LiDAR is most effective. This flow-chart will serve as a practical aid for scoping and prioritizing projects that require bathymetric data acquisition.

Task 5: Refine protocols and assessment method. Finalize protocols, pilot results, and analyses from *Task 3*. Ensure topo-bathy deliverables are compatible with existing ODOT processes.

Task 6: Deliver Implementation Recommendations. Guidance for integrating UAS Topo-Bathymetric products into existing ODOT processes, such as bridge-scour monitoring, culvert assessment, and asset-management systems.

Task 7: Deliver Technical Report, Workshop, and Outreach. Deliver short technical report and training session for use of this new method. A roadshow for ODOT Regions will also be included.

Key Deliverables: *Accuracy and Cost Validation Analysis, Technical Guidelines and Specifications, Pilot at three varied locations, Best Practices and Performance Assessment, Oregon Application and Suitability Map, Implementation Recommendations.*

Estimated Project Length: 30 months

Estimated Project Budget: \$290,000

EXPECTED ODOT IMPLEMENTATION ACTIONS

If the research confirms the approach is viable, Geometronics will obtain quotes for applicable topo-bathy hardware, evaluate funding options, and procure the necessary equipment. If funding is not available, Geometronics will establish a price agreement with a qualified consultant to support data acquisition and rapid project turnaround. Geometronics will provide QA/QC oversight for any consultant surveys, serve as the technical authority for data review and approval, and coordinate processing and deliverables to ensure outputs are compatible with each division's required formats and workflows. Following successful pilot testing and validation, the Hydraulic Engineering Section will coordinate with Geometronics to establish a process for engineering staff to request UAS topo-bathymetric data. Implementation will include 1) training on the tool's abilities and advantages related to bridge scour, culvert analysis, and stream stabilization projects 2) integrating data with 2D hydraulic modeling software, and 3) selection of projects utilizing the Oregon Application and Suitability Map.

POTENTIAL BENEFITS

When applied appropriately, UAS topobathymetric lidar reduces hydraulic and scour risk by improving the most consequential input for analysis: the Digital Terrain Model (DTM). ODOT's current baseline workflow of

manual topographic collection that is individually integrated with single beam bathymetry is internally recognized as slow, labor intensive, and constrained by terrain and access, leading to potential issues with repeatability and reliable data capture. Note that the final DTM will also assist with geotechnical design as well as assessment of slope stability. Transitioning UAS topo-bathymetric lidar from state-of-art to state-of-practice will improve safety for personnel and the traveling public, provide defensible risk-based management decisions, and potentially improve cost efficiencies for the state.

PEOPLE

ODOT champion(s): Alvin Shoblom (State Hydraulic Engineer), Mike Nichols (State Surveyor)

Problem Statement Contributors: David Moehl (Project Surveyor), Ronda Dodge (Senior Remote Sensing Surveyor), Rob Trevis (Senior Culvert Hydraulic Engineer), Kira Glover-Cutter (Principal Research Analyst)

STAFF REVIEW PAGE

LITERATURE CHECK

TRID&RIP

A review of TRID & RIP databases found no existing research that answers the research question

ODOT DECISION LENSES

Climate: UAS Topobathymetry monitoring of high-risk locations directly supports ODOT's transportation resilience efforts.

Equity: This research is not focused on equity and will not include analysis of equity.

Safety: UAS Topobathymetry is a remote sensing method that reduces time on site for our surveyors, increasing safety and reducing or eliminating in-water safety concerns.

TECHNOLOGY & DATA ASSESSMENT

No Identified T&D output

At the end of this project, the implementing unit(s) within ODOT will need to coordinate the adoption of new technology or data in order to realize the full potential of this research.

CROSS-AGENCY IMPACTS

- List ODOT partners or impacted units. Hydraulics Section, Engineering Automation Section, and Geotechnical Engineering, Engineering Geology, Hazmat Section
- Identify any issues of concern raised by an ODOT partners. Note expected mitigation that addresses these concerns. No.