OREGON DEPARTMENT OF TRANSPORTATION

Research Section
555 13th Street NE
Salem, OR 97301

ph: (503) 986-2700
fax: (503) 986-2844

SPR Quarterly Progress Report
October 1, 2016 through December 31, 2016

Date December 21, 2016

TO: Technical Advisory Committee Members:
Joel Fry, ODOT Maintenance, Pavement Marketing Committee Chair, joel.d.fry@odot.state.or.us
Eric Leaming, ODOT Traffic Devices Engineer, Eric.s.leaming@odot.state.or.us
Dennis Hackney, ODOT Assistant District Manager, D 13, Region 5, Dennis.a.Hackney@odot.state.or.us
Dan Wright, ODOT Photogrammetric Project Surveyor, Daniel.E.WRIGHT@odot.state.or.us
Nick Fortey, FHWA member, Assumed*
nick.fortey@fhwa.dot.gov
Jason Motley, ODOT sign management specialist
Jason.MOTLEY@odot.state.or.us

Project Champion:
Ron Singh, Oregon DOT, Geometronics Manager
(Interim Joseph Thomas)
Joseph.R.THOMAS@odot.state.or.us

1. Project

Title: Lidar for Maintenance of Pavement Reflective Markings and Retro-Reflective Signs
SPR # 799

2. Project Investigator

Michael J. Olsen, Associate Professor
School of Civil and Construction Engineering
Oregon State University
101 Kearney Hall
Corvallis, OR 97331
Email: olsen@oregonstate.edu Phone: (541)737-9327

Associate Investigator(s)

Christopher Parrish
School of Civil and Construction Engineering
Oregon State University
Email: christopher.parrish@oregonstate.edu Phone: (541)737-5688

3. Project Coordinator

Jon Lazarus, ODOT Research Coordinator, *TAC Chair*
Email: jon.m.lazarus@odot.state.or.us,
Phone: (503) 986-2852

4. Key Dates

Project start date: July 1, 2016
Project completion date: November 30, 2018

First Fiscal Year: [year]
Final Fiscal Year: [year]
[List revised dates and corresponding amendment numbers]

5. Project Status (Completed by project investigator)

Task 1: TAC Meeting #1
Deliverable Due Date: 8/1/2016

Percent completed reported in last quarterly report: 100%

Task 2: Draft Literature Review
Deliverable Due Date: 11/30/2016
Percent completed reported in last quarterly report: 50%
Percent completed after this quarter: 90%

Key Progress-To-Date

- Project team has compiled and reviewed over 50 journal papers, technical reports, and national standards related to retro-reflectivity measurement, mobile lidar radiometric calibration, pavement markings, signage, and condition assessment.
- Developed draft of the literature review, including summary tables of relevant methodologies for pavement striping extraction.

Specific Progress This Quarter

- Developed draft of the literature review, including summary tables of relevant methodologies. The draft contains several sections related to retroreflectivity, current procedures for retroreflectivity measurement, mobile lidar, radiometric calibration, quality control, automated feature extractions, and discussion of limitations of current literature.
- Identified the most relevant approaches to apply to our project.
- Identified limitations of current procedures and potential research gaps that can be filled in this project.

Problems

- We have fallen a little behind schedule on this task since we have been focusing more on the data analysis from the tests, but will be completing soon.

Work Planned for Next Quarter

- Perform minor revisions to complete a draft of the literature review to send to the TAC for review by mid-January.

Task 3: Draft Research Methodology
Deliverable Due Date: 1/31/2017
Percent completed reported in last quarterly report: 50%
Percent completed after this quarter: 60%

Key Progress-To-Date

- Methods for mobile lidar and retro-reflectometer acquisition and testing were developed and tested in two experiments: TestDeck 1 and TestDeck 2, both held on the ODOT TestDeck on OR 22 in Stayton on July 18 and September 13, respectively. Both procedures were distributed to the TAC prior to data acquisition.
- Methods were also developed for an intensity degradation test for wet surfaces.

Specific Progress This Quarter

- Methods were also developed for an intensity degradation test for wet surfaces.
- We have experimented with ideas and identified possible approaches for the radiometric calibration and feature extraction in the lidar data.

Problems

- No problems have been encountered

Work Planned for Next Quarter

- Begin developing plans for sign retro-reflectivity evaluation and testing.
- Refine radiometric calibration approach and select appropriate feature extraction techniques.
- Submit draft research methodology to ODOT for review.

Task 4: TAC Meeting #2
Deliverable Due Date: 2/28/2017
Percent completed reported in last quarterly report: 0%
Percent completed after this quarter:

Key Progress-To-Date

- N/A – task not started yet.

Specific Progress This Quarter

- N/A – task not started yet

Problems

- N/A – task not started yet

Work Planned for Next Quarter

- Upon submission of the literature review and research methodology, we will coordinate with ODOT to schedule TAC Meeting #2 and prepare summary materials for that meeting.

Task 5: Data Collection. (Test Sites)
Deliverable Due Date: 10/31/2017
Percent completed reported in last quarterly report: 70%
Percent completed after this quarter: 75%

Key Progress-To-Date
- Two field tests have been completed at the ODOT TestDeck site. Coordinated with various ODOT personnel for the logistics of each test.
- The first (July 2016) test focused on evaluating the data quality (resolution) with various speeds to ensure that striping is adequately covered. The intensity values from the lidar system were compared to the retro-reflectivity measurements and showed good correlation.
- The second (September 2016) varied the lane of the vehicle as well as the orientation to provide a wide range of geometric conditions to support the development of radiometric calibration equations. From the first test, the average retro-reflectivity values for each stripe showed a good correlation with the mobile lidar intensity; however, there was a lot of scatter in the data since the retro-reflectivity values themselves vary substantially across an individual line and the exact location of each retro-reflectivity measurement was not obtained. The second test was conducted to fix this problem where we used a total station to measure the location where each retro-reflectivity measurement was obtained to improve the correlation with the mobile lidar data.

Specific Progress This Quarter
- Developed a design for a third test evaluating degradation of intensity with wet surfaces.
- Reviewed results from another study evaluating reflectance degradation on various surfaces for wet conditions.

Problems
- Given the magnitude and frequency of snow and rain throughout the past few months, we have not found a suitable date to complete this testing since we need it to be warm enough to dry out and return to non-wet conditions.

Work Planned for Next Quarter
- Perform a 3rd test evaluating the degradation of intensity with the wet surface.
- Develop test procedure for evaluating retro-reflectivity of street signs.
- Coordinate with personnel with ODOT to set aside signs of various conditions for retro-reflectometry readings.

Task 6: Data Analysis
Deliverable Due Date: 6/1/2017
Percent completed reported in last quarterly report: 15%
Percent completed after this quarter: 35%

Key Progress-To-Date

- We have performed comparative analyses of the retro-reflective measurements to the mobile lidar intensity values. The preliminary results were presented at the TAC meeting #1 (Test 1) as well as in a Pavement Striping Committee meeting (Test2) with many of the TAC members present.
- Developed an extraction algorithm to extract the data from the mobile lidar point cloud in the area of each retro-reflectivity measurement.
- Developed supporting code for radiometric calibration and intensity correction.

Specific Progress This Quarter
- Presented preliminary results at an ODOT pavement striping committee meeting in October.
- Developed code to compute angle of incidence and range to each lidar point based on the scanner trajectory.
- Experimented with intensity correction equations to improve correlation.
- Improved the comparative analysis code by improving the extraction algorithm to consider both the illumination and reading footprints of the Retro-reflectometer as well as other models.

Problems
- None

Work Planned for Next Quarter
- Develop specific correction equations and write supporting open source software for the radiometric calibration process for the Pegasus 2 data.
- Evaluate correlations after radiometric calibration.
- Continue to expand capabilities and efficiency of code.

Task 7: Data Collection. (In Situ)
Deliverable Due Date: 8/1/2017
Percent completed reported in last quarterly report: 0%
Percent completed after this quarter: 0%

Key Progress-To-Date
- N/A – task not started yet

Specific Progress This Quarter
- N/A – task not started yet

Problems
- N/A – task not started yet

Work Planned for Next Quarter
- N/A – task not started yet

Task 8: Data Analysis (In-Situ)
Deliverable Due Date: 12/1/2017

Percent completed reported in last quarterly report: 0%
Percent completed after this quarter: 0%

Key Progress-To-Date
- N/A – task not started yet

Specific Progress This Quarter
- N/A – task not started yet

Problems
- N/A – task not started yet

Work Planned for Next Quarter
- N/A – task not started yet

Task 9: Draft Final Report
Deliverable Due Date: 3/31/2018
Percent completed reported in last quarterly report: 0%
Percent completed after this quarter: 0%

Key Progress-To-Date
- N/A – task not started yet

Specific Progress This Quarter
- N/A – task not started yet

Problems
- N/A – task not started yet

Work Planned for Next Quarter
- N/A – task not started yet

Task 10: Draft ODOT Research Note
Deliverable Due Date: 3/31/2018
Percent completed reported in last quarterly report: 0%
Percent completed after this quarter: 0%

Key Progress-To-Date
- N/A – task not started yet

Specific Progress This Quarter
- N/A – task not started yet

Problems
- N/A – task not started yet

Work Planned for Next Quarter

- N/A – task not started yet

Task 11: TAC Meeting #3

Percent completed reported in last quarterly report: 0%
Percent completed after this quarter: 0%

Key Progress-To-Date

- N/A – task not started yet

Specific Progress This Quarter

- N/A – task not started yet

Problems

- N/A – task not started yet

Work Planned for Next Quarter

- N/A – task not started yet

Task 12: Final Report

Percent completed reported in last quarterly report: 0%
Percent completed after this quarter: 0%

Key Progress-To-Date

- N/A – task not started yet

Specific Progress This Quarter

- N/A – task not started yet

Problems

- N/A – task not started yet

Work Planned for Next Quarter

- N/A – task not started yet

Task 13: Final Research Note

Percent completed reported in last quarterly report: 0%
Percent completed after this quarter: 0%

Key Progress-To-Date

- N/A – task not started yet

Specific Progress This Quarter

- N/A – task not started yet

Problems

- N/A – task not started yet

Work Planned for Next Quarter

- N/A – task not started yet

6. **Project Coordinator's Comments** (Completed by ODOT)

The Literature review draft needs to be complete before scheduling the next TAC meeting to give time for them to review and comment. I believe the PI is ahead of schedule on other tasks, so a minor delay in Task 2 and Task 4 should not affect the overall project.

7. **Finances** (Completed by ODOT)

SPR Project Summary

VENDOR	FY'17	FY'16	FY'19	FY'18	TOTALS
ORIGINAL BUDGET	$ 60,000	$ 87,000	$ 18,000	$ -	$ 165,000
WORK PLAN BUDGET	$ 82,656	$ 82,344	$ -	$ -	$ 165,000
REVISED BUDGET	**$ 82,656**	**$ 82,344**			$ 165,000
EXPENDITURES - VENDOR	$ -	$ -	$ -	$ -	$ -
BALANCE	$ 82,656	$ 82,344	$ 18,000	$ -	$ 183,000
ODOT	FY'17	FY'16	FY'19	FY'18	TOTALS
ORIGINAL BUDGET	$ 10,000	$ 11,000	$ 12,000	$ -	$ 33,000
REVISED BUDGET	**$ 10,000**	**$ 11,000**	**$ 12,000**	**$ -**	$ 33,000
EXPENDITURES - ODOT	$ 2,674	$ -	$ -	$ -	$ 2,674
BALANCE	$ 7,326	$ 11,000	$ 12,000	$ -	$ 30,326
PROJECT	FY'17	FY'16	FY'19	FY'18	TOTALS
ORIGINAL BUDGET	$ 70,000	$ 98,000	$ 30,000	$ -	$ 198,000
REVISED BUDGET	**$ 92,656**	**$ 93,344**	**$ 12,000**	**$ -**	$ 198,000
EXPENDITURES - PROJECT	$ 2,674	$ -	$ -	$ -	$ 2,674
BALANCE	$ 89,982	$ 93,344	$ 12,000	$ -	$ 195,326