NEW ENGLAND TRANSPORTATION CONSORTIUM

2019 RESEARCH PROBLEM STATEMENT SOLICITATON

Submit Research Problem Statements to MassDOT Research Section
[Nicholas Zavolas, Nicholas.Zavolas@state.ma.us] by January 18,2019

I. PROBLEM TITLE

Development of A LiDAR-Based Pavement Marking Inventory and Condition Assessment Method for Enabling Connected and Autonomous Vehicles

II. RESEARCH PROBLEM STATEMENT

Pavement marking is a vital transportation asset and traffic control device to facilitate safe and uninterrupted travels. In the era of connected and autonomous vehicles (CAV), pavement marking is playing an even more crucial role in enabling vehicles' autonomous and seamless navigation. Traditionally, manual field survey and visual inspection have been used for pavement marking by state departments of transportation (DOTs) although it usually takes excessive amounts of time and consumes significant amounts of!abor. There is an urgent need for state DOTs to develop and implement an effective and efficient inventory method for pavement marking not only to meet the requirements detailed by the Manual on Uniform Traffic Control Devices (MUTCD) but also to enable and facilitate CAYs, while continuously supporting human-operated vehicles and other road users.

III. RESEARCH OBJECTIVES

This study is aimed to utilize the emerging mobile light detection and ranging (LiDAR) point cloud data and develop an automated method for the extraction, classification, localization and condition assessment for pavement markings in the state highway network. The outcome of this study will not only generate a complete pavement marking inventory but will also establish an essential data layer to support state DOTs' decisions on CAV testing, implementation, and operation.

IV. COST ESTIMATE

$200,000

V. RESEARCH PERIOD

24 Month

VI. URGENCY AND PAYOFF POTENTIAL

Urgency: With the fast-paced advancements in mobile data acquisition and machine learning in recent years, automated roadway assets detection and recognition algorithms using mobile LiDAR have become a feasible option for inventorying critical traffic control devices. As many state DOTs, such as Massachusetts DOT (MassDOT), have been actively collecting mobile LiDAR data, the accumulated point cloud data have become an excellent data repository to support the development of these algorithms (which, unfortunately, also yields an intensive management burden). Therefore, there bears the urgency for state DOTs to leverage the existing LiDAR point cloud data and develop an effective pavement marking inventory and condition assessment method.

Payoff Potential: The payoff potential of utilizing mobile LiDAR data for inventorying pavement markings is threefold:

I) The automated method will significantly improve the efficacy and productivity in implementing the urgently needed pavement marking inventory by developing LiDAR processing algorithms;
2) The automated method will significantly relieve state DOTs' burden in managing the large-volume, unstructured LiDAR point cloud data;
3) The automated method will lay a knowledge foundation and a fundamental geospatial data layer to support state DOTs' subsequent critical investigation, such as condition deterioration modeling, etc.

VII. PRELIMINARY LITERATURE SEARCH

To avoid duplicating research already published or in progress, the submitter of the Problem Statement will perform a brief literature search prior to submitting the Problem Statement. This literature search can be conducted using the Transportation Research Board's TRID database, available at https://trid.trb.org/. *The TRID database contains information on completed research as well as research in progress.*

I. Olsen, M. J., Parrish, C. E., Che, E., Jung, J., and Greenwood, J. (2018a). "Lidar for Maintenance of Pavement Reflective Markings and Retroreflective Signs: Vol. I Reflective Pavement Markings." *Oregon Department of Transportation Research Report SPR-799.*
2. Olsen, M. J., Parrish, C. E., Che, E., Jung, J., and Greenwood, J. (2018b). "LIDAR for Maintenance of Pavement Reflective Markings and Retroreflective Signs Vol. II: Retroflective Signs." *Oregon Department of Transportation Research Report SPR-799.*
3. Ai, C. and Tsai, Y. (2016). "Automated Traffic Sign Retroreflectivity Condition Assessment Using Mobile LIDAR and Computer Vision." *Transportation Research Part C: Emerging Technologies,* 63, 96-113.
4. Ai, C., and Tsai, Y. (2016). "Automated Sidewalk Assessment Method for Americans with Disabilities Act Compliance Using Three-Dimensional Mobile Lidar." *Transportation Research Record: Journal of the Transportation Research Board,* Vol. 2542, 25-32.
5. He, Y., Song, Z., Liu, Z., and Lindsey, R. (2016). "Implementation of Aerial LiDAR Technology to Update Highway Feature Inventory." *Utah Department of Transportation UT-17.06.*
6. Johnson, S., Bethel, J., Supunyachotsakul, C., and Peterson, S. (2016). "Laser Mobile Mapping Standards and Applications in Transportation." *JTRP Technical Reports.*
7. Ai, C. and Tsai, Y. (2015). "Critical Assessment of an Enhanced Traffic Sign Detection Method Using Mobile LiDAR and INS Technologies." *ASCE Journal of Transportation Engineering,* 141(5), 04014096.
8. Guan, H., Li, J., Yu, Y., Ji, Z., and Wang, C. (2015). "Using Mobile LiDAR Data for Rapidly Updating Road Markings." *IEEE Transactions on Intelligent Transpprtation Systems,* 16(5), 2457-2466.
9. Lane, T., and Cudmore, P. (2014). "Mobile Lidar: The Benefits to Airports from an Operations and Safety Perspective." *FAA Worldwide Airport Technology Transfer Conference,* Galloway, New Jersey, USA.

Attach a brief summary (1-3 paragraphs) of the results of this literature search to the Problem Statement. The summary should describe how the subject of this Problem Statement would differ from or add to existing studies.

Two limitations have been identified in the preliminary literature review:

1) There were very limited attempts on automated pavement marking inventory or condition assessment in previous studies. The only a few identified studies on pavement parking have focused on exploring the feasibility of the mobile LiDAR and using small datasets.
2) Existing studies have focused on the implication of mobile LiDAR point cloud data on general transportation asset management or MUTCD mandates. None of the studies have emphasized the critical role and the unique inventory needs of pavement markings for CAV-enabling traffic control devices.

This study will develop an automated mobile LiDAR-based methodology for efficiently processing large-scale point cloud data and effectively identifying pavement marking. The critical conditions of pavement marking will also be assessed automatically using mobile LiDAR. The proposed methodology in this study will be general to support other critical traffic control device and roadway asset inventory, such as signages, guardrails, sign supports, cables and fences, rumble stripes, etc.

VIII. RESEARCH KEYWORDS

Provide a list of keywords that can be used to conduct an additional search of the TRID database for related research. To the maximum extent possible, keywords should be selected from the Transportation Research Thesaurus (http://trt.trb.org/).

LiDAR, Traffic Control Devices, CAV, MUTCD, Asset Management, Automation, Pavement Marking

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TWO DOT ENDORSEMENTS ARE REQUIRED (To be signed by separate individuals.)

IX. ENDORSEMENT BY THE SPONSORING DOT (To be signed by the DOT representative to the NETC Advisory Committee through whom the Problem Statement is submitted.)

By signing the endorsement, the DOT representative is certifying that:

1. *The Problem Statement follows the required format.*
2. *The required literature search has been conducted.*
3. *The Problem Statement addresses a transportation issue of relevance to NETC and does not duplicate another Problem Statement being submitted at this time.*

Name: Nicholas Zavolas MassDOT

nicholas.zavolas@state.ma.us Email

857 360 9056 Tel.

Signature | Date: 1/25/19

X. ENDORSEMENT BY A SECOND EMPLOYEE OF THE SPONSORING DOT who agrees to chair the project's technical advisory committee (TAC) if the Problem Statement is selected for funding. (To be signed by a DOT staff person who has technical knowledge of the project topic and is committed to the research outcome.)

DOT Technical Endorsement: *I agree to chair tlze project's Teclznical Advisory Committee if this Problem Statement is selected for funding by NETC.*

John M. Moran	MassDOT
Name	DOT
john.m.moran@state.rna.us	781.844.1774
Email	Tel.

Signature | Dater 11/7/19