Research Project Work Plan

for

INERTIAL AND INCLINOMETER BASED PROFILER REPEATABILITY AND ACCURACY USING THE IRI MODEL

SPR-744

Submitted by

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for

Oregon Department of Transportation
Research Unit
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June 2011
Research Project Work Plan

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1.0 Identification

1.1 Organizations Sponsoring Research

Oregon Department of Transportation (ODOT)
Research Section
200 Hawthorne Ave. SE, Suite B-240
Salem, OR 97301-5192 Phone: (503) 986-2700

Federal Highway Administration (FHWA)
Washington, D.C. 20590

1.2 Principal Investigator(s)

Michael J. Olsen, Assistant Professor
School of Civil and Construction Engineering
Oregon State University
220 Owen Hall
Corvallis, OR 97331 Phone: (541) 737-9327

1.1 Technical Advisory Committee (TAC) Members

Dean Chess, ODOT
Anthony Bosen, FHWA
Larry Ilg, ODOT
Jim Hudleston, Oregon Asphalt Paving Association

1.2 Project Coordinator

Norris Shippen, ODOT Research

1.3 Project Champion

Larry Ilg, ODOT pavement services

2.0 Problem Statement
ODOT will be implementing an International Roughness Index (IRI) based smoothness incentive/disincentive program with an inertial profiler certification and a Quality Assurance program. The development of the program has been based on AASHTO provisional standards. ODOT has a “certification site” and an inclinometer based reference profiler. The question arises: Are the AASHTO provisional standards applicable when comparing an inertial profiler and an inclinometer profiler?

2.1 Background and Significance of Work

ODOT has attempted a field calibration process during the last construction season with mixed success. The inertial profiler was successfully certified. The process of establishing a reference site within a paving project proved to be difficult for both time and safety. A second approach of establishing a site for inertial profilers for calibration has shown some promise. The ability to establish reference site off of a project site allows adequate time to establish the reference profile and ensure better quality control. The site itself has reduced safety concerns, as it is not located on a busy interstate highway with a high volume of fast moving vehicles. The inertial profiler that was certified at this site was able to show good repeatability, but could not meet the AASHTO accuracy criteria. Once testing guidelines are developed from this research, all contractors would be required to certify their systems at this site prior to performing work in Oregon.

A rod and level process will be used to measure the “true profile” of the calibration site. The “true profile” will also be complimented with a 3D laser scanning survey, which enables more measurements covering the entire road width rather than just a single profile. The repeatability and accuracy of the reference profiler needs to be verified against the “true” profile of the certification site. A variety of inertial profilers will measure the profile established at the site and compared to the “true profile” and the profile measured with the reference profiler. The data will then be compared with established repeatability and accuracy requirements established by AASHTO procedures.

The parameters and observations from this research will provide the baseline standards for all inertial profilers used to evaluate pavement smoothness throughout Oregon. These standards will allow ODOT to ensure all inertial profilers, when operated properly, are able to provide accurate and repeatable smoothness assessments. The parameters will also help establish quality assurance tolerances to ensure an inertial profile is continuing to report acceptable smoothness measurements on project sites.

The value of this project has been estimated on a ten year period based increased pavement life, accuracy of incentive and disincentive payments and defending inaccuracies in incentive payments. Also value has been found to the public from smooth pavements in the form of reduced wear on vehicles and fuel savings.

3.0 Objectives of the Study
The overarching objective of this study is to provide ODOT with a site and methodology necessary to certify contractors performing smoothness measurements using inertial and inclinometer based profilers. Further, this research seeks to:

- Establish an appropriate test site for certification
- Determine the repeatability and accuracy of the reference profiler, and
- Develop the procedures/guidelines for an inclinometer based profiler certification

4.0 Implementation

The research findings will allow ODOT to establish a certification procedure and QA/QC guidelines for the smoothness program. This will provide the needed components for a incentive/disincentive process recommended by the Federal Highway Administration for their participation.

ODOT will share the results with the industry through meetings and conferences. ODOT will then use the guidelines to establish an annual certification program for inertial profilers used to measure smoothness in Oregon.

The QA program would be improved based upon the research to ensure data used for payment is repeatable and accurate. These improvements will revolve around the method of comparing the data from two certified profilers.

5.0 Research Tasks

The project duration is estimated to be 12 months in duration and cost approximately $105,000 ($90,000 for OSU and $15,000 for ODOT research oversight). The project will consist of the following tasks:

**Task #1:** Literature Review and evaluation of existing certifications

To commence, we will study and compile relevant literature to inertial profile and inclinometer profile systems. We will particularly focus on certification and calibration procedures used to validate data from inertial and inclinometer profilers in determining smoothness.

A critical component of the literature review will be to evaluate the applicability of existing certification programs established by Texas and AASHTO for consideration. The emphasis of this review will be to determine if those guidelines and certification procedures are relevant to ODOT’s operations and needs. We will also review ASTM E950 as part of this effort.

**Time Frame:** September to November 2011

**Responsible Party:** Michael J. Olsen, OSU Geomatics Lab

**Cost:** $ 8k
**Deliverable:** Summary of existing literature and certification procedures.  (Written documents or Oral Presentation )

**TAC Decision/Action:** The TAC will review the certification procedure summary to provide comments on relevance to ODOT. The TAC will also provide feedback on ODOT’s needs and requirements.

**Task #2:** Calibration and parameter testing of ODOT’s reference profiler.

a) Determine reference profiler site. We will establish control point markers for the start and end of the reference profiler segment and measure these points using a survey grade EDM to determine the distance and elevation differences between the points.

b) Perform repeat measurements of two test sections, each 528 ft (0.1 miles) in length. This section will be surveyed with both high-precision, survey grade, digital levels at 1’ intervals, and 3D laser scanning to establish a baseline profile to evaluate ODOT’s reference profiler. This will be done in accordance with ASTM e950 and ASTM E1364 procedures.

c) Several passes will be done using ODOT’s reference profiler to assess accuracy and repeatability.

d) The data from Tasks 2a, 2b, and 2c will also be analyzed to determine important certification parameters such as the number of passes necessary for certification, the sampling ratio (typically 1”), etc. By evaluating varying scenarios, we can analyze the repeatability of the measurements. ProVAL software will be used to perform comparisons and determine the IRI. We will also request data and assistance from FHWA and the Road Profiler’s User Group (RPUG) to obtain data and observations for analysis.

**Time Frame:** a) September 2011, b) & c) October 2011 d) Nov 2011-Feb 2012.

**Responsible Party:** Michael J. Olsen, OSU Geomatics Lab

**Cost:** $30k

**Deliverable:** Laser scan, level data to define profile.

**TAC Decision/Action:** Assist with site selection and access for data collection,

**Task #3:** Contractor Inertial Profiler Tests at Certification Site

For this task, we will conduct Inertial and inclinometer profiler tests at the certification site. We will invite manufacturers and contractors to run their profilers and perform a preliminary analysis of variances in common systems to the reference profiler (2c) and the prior survey data (2b).

**Time Frame:** November 2011

**Responsible Party:** Michael J. Olsen, OSU Geomatics Lab

**Cost:** $7k

**Deliverable:** Data from manufacturer runs.

**TAC Decision/Action:** Assist with contacting vendors.
**Task #4**: Develop Certification Procedure and QA/QC guidelines.

The analyzed data will be used to develop guidelines for the certification procedures, which will discuss what ODOT needs to do prior to start of profiler certification each year. Because of seasonal changes in pavement and wear, ODOT will most likely need to re-establish the baseline profile at the certification site. The guidelines will outline best practices and procedures to perform this work. This document will also discuss the procedure and acceptance criteria for manufacturer profiler testing when performing certification.

**Time Frame**: December 2011 – May 2012

**Responsible Party**: Michael J. Olsen, OSU Geomatics Lab

**Cost**: $25k

**Deliverable**: Certification Procedure and QA/QC guidelines

**TAC Decision/Action**: Review the procedure and guidelines

**Task #5**: Preliminary Pavement Texture Analysis.

Because aggregate size can influence surface roughness, we will use fine-scale laser scanning (sub mm accuracy and resolution) on several small pavement sections (~2’ by 2’) to evaluate pavement texture and roughness. Each section will have a different aggregate size and be of similar age. Using this data, we can link pavement roughness (e.g. rugosity) to aggregate size. This will be helpful in evaluation of inertial profiler readings on different pavement textures. Particularly, this will be useful in comparing line lasers to point laser systems.

**Time Frame**: May – July 2012

**Responsible Party**: Michael J. Olsen, OSU Geomatics Lab

**Cost**: $7k

**Deliverable**: Texture data.

**TAC Decision/Action**: Assist with determining pavement sites with different aggregate sizes.

**Task #6**: Additional Literature Review for inertial profilers on concrete.

Tasks 1-4 will focus on asphalt pavements only, a second literature review will be performed to evaluate the use of inertial/inclinometer profilers on concrete. We will also seek out research related to the orientation of tinning in concrete pavements and how that influences smoothness and noise.

**Time Frame**: June – July 2012

**Responsible Party**: Michael J. Olsen, OSU Geomatics Lab

**Cost**: $5k
Deliverable: Summary of existing literature. (Written documents or Oral Presentation)

TAC Decision/Action: Review the summary.

Task #7: Prepare final report, publications, and conference presentations and implementation

The final report for the project will be continually developed and refined throughout the entire project duration. The final report will be completed by the end of the funding cycle (June 30, 2012) and delivered to ODOT along with supporting data files. This project will fund two graduate students (Abby Chin, Shawn Butcher), who will develop these guidelines and findings for publication as in their theses and in peer-reviewed journal and conference papers. However, it is anticipated that the publications may require additional time beyond the project cycle to complete. We will also give presentations/training to ODOT personnel on the guidelines, as directed by the TAC.

Time Frame: June to August 2012.

Responsible Party: Michael J. Olsen, OSU Geomatics Lab

Cost: $8k

Deliverable: Final Report to ODOT, presentation to relevant ODOT personnel.

TAC Decision/Action: The TAC will assist in setting up the presentations and review the report.
### 6.0 Time Schedule

<table>
<thead>
<tr>
<th>Project Tasks</th>
<th>FY2012</th>
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<tbody>
<tr>
<td></td>
<td>Qtr 1</td>
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<tr>
<td></td>
<td>Sept. - Nov</td>
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<tr>
<td>Task 1: <em>Literature Review</em></td>
<td>a</td>
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<tr>
<td>Deliverable: Summary</td>
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<tr>
<td>Task 2: <em>Calibration and parameter testing of ODOT’s reference profiler</em></td>
<td>b, c</td>
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<tr>
<td>Deliverable: data and testing results</td>
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<tr>
<td>Task 3: <em>Inertial Profiler Tests at Certification Site</em></td>
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<tr>
<td>Deliverable: data and testing results</td>
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<td>Task 4: <em>Develop Certification Procedure and QA/QC guidelines</em></td>
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<tr>
<td>Deliverable: Certification Procedure and Guidelines</td>
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<tr>
<td>Task 5: <em>Preliminary Pavement Texture Analysis.</em></td>
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<tr>
<td>Deliverable: Texture data</td>
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<td>Task 6: <em>Additional Literature Review for inertial profilers on concrete.</em></td>
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<tr>
<td>Deliverable: Summary document</td>
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<tr>
<td>Task 7: <em>Prepare final report, publications, and conference presentations and implementation</em></td>
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<tr>
<td>Deliverable: Final report and presentations</td>
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### Budget Estimate

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<th>FY2012</th>
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<tr>
<td><strong>Personnel</strong></td>
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<tr>
<td>Michael Olsen, OSU</td>
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<td>Abby Chin, OSU</td>
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<td>Shawn Butcher, OSU</td>
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<td><strong>Total Salaries</strong></td>
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<td>Travel to conference to present findings</td>
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<td><strong>Services and Supplies</strong></td>
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<td>Traffic Control/flagging</td>
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<td>Paint, nails, etc. for testing</td>
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<td>Survey equipment</td>
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<td>batteries\cables\field supplies</td>
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<td>Micron resolution scanner (for pavement texture analysis)</td>
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<td><strong>Total Indirect Costs (26%)</strong></td>
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<td><strong>Total Project Costs</strong></td>
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