Research Project Statement

Fiscal Year: 2004 **Project Statement Date:** 10/21/03

Project Number: 8-8171 **Modification?** ☐ Yes ☒ No

Title: Evaluate Fiber-Optic Sensor System for Weigh-in-Motion

RMC Number: 2

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Duration (# of years): 2

	Total Budget:	$ 320,000 (see the note under "Additional Information.")
First Year	**FY 04**	$ $150,000
Second Year	**FY 05**	$ $170,000
Additional FYs	**FY**	$

Project Description:

This project will be a national pooled fund study managed by the Texas Department of Transportation (TxDOT). Commitments of funding to the study from other states are currently being solicited using FHWA's pooled study web site. This study is posted as project #816 on the pooled fund study website at:

http://www.pooledfund.org/browse.asp?action=study_number

Problem

There is an increasing demand at both the state and federal levels for accurate and cost-effective weigh-in-motion (WIM) systems. These systems are important to monitor traffic flow and for predicting degradation of roadways due to heavy trucks. Currently available WIM equipment falls primarily into two categories: 1) high accuracy bending plates and load cells, which are expensive and require significant road closure time for installation, and 2) lower accuracy piezoelectric sensor-based WIM systems. Piezoelectric systems are significantly lower in cost and require much less road closure and installation time than the first category. However, piezoelectric sensors have an unpredictable and relatively short service life, along with other shortcomings. The success of recent and on-going evaluations of fiber-optic axle sensors by the Tennessee, Alabama, Idaho, Oregon DOTs and toll authorities in Illinois, New York and California suggests that, with some modifications, fiber-optic sensors could be successful for WIM applications. Accuracies are anticipated to be better than piezoelectric systems, but costs should be similar.

Objectives

To investigate the accuracy and reliability of a fiber-optic sensor system for weigh-in-motion. The objectives will be met by conducting a literature search, contacting state partners to coordinate efforts, developing a test plan, conducting laboratory and field tests of proposed system and components, determining signal properties of the sensors, evaluating cost implications of a fiber-optic WIM system, and reporting findings to the participating agencies.

Major Research Tasks

The proposed work plan should include the following tasks:

Task 1: Conduct a Literature Search.

This task involves a thorough evaluation of previous research pertaining to the use of fiber-optic sensors for either

classification or WIM. Also, industry and university contacts of knowledgeable personnel should be established to better understand their experiences relating to fiber optic applications with traffic data collection.

In addition, the researchers should review and consider the following studies, one completed, and one ongoing relating to fiber optic sensors.

The completed study is by the Oregon DOT titled: "*Evaluate Fiber-Optic Sensor System for Weigh-in-Motion*," which is available at:

http://www.odot.state.or.us/tddresearch/reports/fiber_optics.pdf

The other relevant research is an ongoing TXDOT study titled: "*Evaluate Innovative Sensors and Techniques for Measuring Traffic Loads*." The scope of this study includes an evaluation of several types of WIM sensors, which are: (1) piezo-electric pressure sensors, (2) bending plate, and (3) ***fiber optic*** pressure/load sensors. The evaluation will include lab testing of sensor types and development of a prototype WIM system using one or more of these sensor types. The evaluation criteria include cost, ease of installation and calibration,, accuracy, remote accessible, and maintenance requirements.

The researchers on this pooled fund study, as a minimum, will coordinate with the researchers on the two studies listed above to ensure there will be no duplication of effort, and also to use the results of the previous and ongoing research in developing a viable experimental design.

In addition to the two listed above, the researchers should also be aware that in September 2004, TxDOT will be starting a research project relating to the pavement requirements to support WIM sensors. If this project kicks off as planned, coordination should also occur with this TxDOT study.

Task 2: Determine the Need to Modify Sensors Based on Findings.
Based on the results of Task 1, the researchers should consult with the sensor manufacturer(s) to determine the requirements (if any) to modify existing sensors to specifically address WIM needs.

Task 3: Determine the Most Appropriate Presence Detectors.
Identifying viable presence detection that is reliable and less expensive than inductive loops is an important goal of this research. In addition to considering inductive loops, the researchers should evaluate newer devices that have the potential to be less intrusive without compromising accuracy or significantly increasing the cost of the overall system. Variations in the available inductive loops or magnetic detectors appear to be promising alternatives.

Task 4: Develop Sensor Test Plan.
In this task, the researchers should develop a test plan, first by determining appropriate test sites for sensor installation. Site selection should consider participating states interests, and locations of varying climate, highway classification, pavement type and depth, traffic volume, etc. The installation plan should also consider availability of ground truth data, cost, and availability of sensors and other hardware needed for multiple field tests.

Please note:

(1) The researchers will solicit vendors to provide sensors (*gratis*) for test sites. If vendors cannot donate sensors for the research effort, the researchers will be responsible for the procurement of the sensors.
(2) The states that will be hosting test sites will be responsible for test site construction, traffic control, and their associated costs. The host states' pooled fund contribution will not be used to pay for these costs.

Task 5: Install and Evaluate Fiber-Optic Sensors.
The research team should work with host states during sensor installation to provide technical support and oversight. After the sensors are installed, the researchers need to ensure the testing plan is followed at the specified locations. Where installed, the researchers will assist DOT representatives in monitoring and closely scrutinizing the signals generated by fiber-optic sensors over a period of several weeks to determine signal consistency and degradation over time.

Task 6: Evaluate One or More Electronic Interface Units.
In this task, the researchers should use the results from Task 1 to guide the selection of the interface units. Once selected, the appropriate hardware or other details needed to interface with the sensors will be determined.

Task 7: Investigate the Feasibility of Alternative Energy Sources.
Because some sites may be in remote areas of a participating state, there is a need to investigate the feasibility of alternative sources of energy such as solar and wind power. The researchers should provide support to the interested states as needed, if alternative power sources are utilized.

Task 8: Meetings and Deliverables.
It is anticipated there will be at least one to two meetings per year involving the participating states. The research team will arrange the meeting location, meeting agendas, presentation materials, and follow-up proceedings that will be sent to the states. Further, the researchers will earmark part of the project budget to directly reimburse participating states' travel to research kickoff and progress meetings.

Deliverable Products And Reports:

1. Research report fully documenting the research performed, findings, and recommendations.
2. Project summary report outlining the research, findings, and recommendations.
3. **P1**: Guidelines for the installation and use of fiber optic sensors for weigh-in-motion..
4. **P2**: Power Point presentation (with speaker notes) that highlights the guidelines and identifies potential strategies for implementing fiber optic sensors for classification and WIM. This product will be used by state DOTs as an educational tool for their traffic operations, planning, and design staffs.

Implementation:

The results of this study will provide guidance to state DOTs on the utility of various types of approaches for addressing this national issue. It is expected that the guidelines will be used by participating states to make informed decisions regarding sensor selection for their WIM and classification systems.

Pre-proposal Meeting: ☐ **Yes** ☒ **No**

Sole Source Justification, if applicable:

Additional Information:

PLEASE NOTE: For the potential researchers who wish to propose:

1. Funding. TxDOT's contribution as the lead state is $40,000 per year, for two years. Level of commitment from the other states is being solicited for $30,000 per year, for two years. To date, there has been $170,000 in commitments from three states (KY, OH, and TX). Other commitments are expected from interested states later in FY 04. If other states do not commit to make up the $150,000 difference in the current overall two-year budget, the project scope will be reduced to the amount that is commensurate with available funding.

2. Proposal Review. All participating states will review and evaluate each research proposal. Final proposal selection will be based on a weighted decision matrix established by the consensus of the participating states in conjunction with their individual review ratings.

Deadlines (for RTI use only)**:**