TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Oregon Department of Transportation

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # TPF 5(259)	**Transportation Pooled Fund Program - Report Period:** ☐ Quarter 1 (January 1 – March 31) X Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 1 – December 31)
Project Title: **Imaging Tools for Evaluation of Gusset Plate Connections in Steel Truss Bridges**	

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Lead Agency Project ID: **TPF5259**	**Other Project ID (i.e., contract #):** **Agreement 17384** **Work Order 12-05**	**Project Start Date:** April 2012
Original Project End Date: **9/30/2014**	**Current Project End Date:** **9/30/2014**	**Number of Extensions:** 0

Project schedule status:

X On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$440,000	$218,006.33	82%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$31,770.47	90%

Project Description:

The collapse of the I-35W Bridge in Minnesota has resulted in considerable interest in steel truss and gusset plate connection performance. The load paths in many truss bridges are non-redundant and thus failure of a truss member or connection may cause collapse of the structure. Periodic inspections and structural evaluations are crucial for these types of bridges.

The most common method of evaluation that has been used to assess the safety of highway bridges is load rating, an approach used to estimate the available strength and allowable load on a bridge. Although sophisticated bridge load rating computer programs are available, these programs do not explicitly consider the gusset plates connecting the truss members. Hence, after the initial design calculations are completed and checked, it is unlikely that recalculations for load rating purposes have been made for gusset plates. As an outcome of the investigation into the collapse of the I-35W Bridge, steel truss bridge connections are required to undergo review. This additional scrutiny requires development of new tools to efficiently and effectively evaluate the large numbers of steel truss bridge connections in the inventory.

Digital imaging techniques have been developed to enable rapid collection of field geometric data from in-service gusset plates. These tools are implemented in software that allows extraction of gusset plate dimensional information to facilitate ratings. The present tools provide a basic set of functionality such as image rectification and scaling and allow geometric data extraction such as length, perimeter, and angles. However, these basic functions need enhancement to take full advantage of the advancements available to bridge inspection and management with digital imaging. Enhancements such as automation of rectification tasks and identification of features within the images are proposed that will enable transportation agencies to efficiently and effectively collect geometric and condition data and use this data to evaluate and rate gusset plate connections.

There are four main objectives of this research:

1. Develop methods to collect dimensional gusset plate connection information including surface geometry and out-of-plane deformations on in-service gusset plates. The information to be collected includes the geometry of the connectors, members, and overall plate dimensions. It also includes out-of-plane distortions of the gusset plate.

2. Develop methods to automate identification and optimization of reference target points, and to automate identification and extraction of the gusset plate edges, fastener locations and their corresponding member affiliations, as well as member orientations. These dimensional data feed directly into the connection rating tasks.

3. Develop finite element modeling and analysis techniques to directly rate gusset plates using extracted digital image data as the input source.

4. Develop software tools to manage and organize images and image data to enhance bridge management and allow identification of condition changes over time.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Task 1: Literature Review
Schedule status: *On schedule*
Percent complete: 90%

Task status: *Literature being collected and synthesized as research progresses.*

Task 2: Software Development and Data Collection
Schedule status: *On schedule*
Percent complete: 90%

Task status: *Continued to revise and refine the software to make it easier and faster to use as well as to remove bugs.*

A beta version of the software was developed to allow the TAC to work through the process.

New image targets were sent out for fabrication to enable automatic target detection in the software. The new targets also eliminate the need for standoff correction.

Task 3: Gusset Plate Analysis
Schedule status: *On schedule*
Percent complete: 90%

Task status: *Manual calculations of gusset plate components are fully implemented into the image processing module. Reporting features are all presently text and revisions are underway to report the images with the overlayed dimensional information.*

Recent revisions to the MBE (June SCOBS meeting) will need to be added to the software.

Task 4: Implementation Example
Schedule status: *On schedule*
Percent complete: 100%

Task status: *A gusset plate sample that has an image target has been developed. The gusset plate analyses according to AASHTO-MBE and finite element, have been performed.*

Task 5: Imaging Data Informatics for Bridge Management
Schedule status: *On schedule*
Percent complete: 50%

Task status: TAC member consensus was to use the ArcGIS platform to conduct this task. Following the TAC recommendation, a framework for managing gusset plate image data as well as other relevant data (drawings, reports, analysis results, etc.) within the ArcGIS platform was continued and remains under development. *The implementation will be web based to allow universal access to the data.*

The Bridge of the Gods is being used in the framework.

Task 6: Analysis Software
Schedule status: *On schedule*
Percent complete: 95%

Task status: *The gusset FEA software was modified to allow users to define thresholds for setting strength limits based on changes in stiffness. Options were added to allow users to add brace member stiffness properties and gusset plate separation to the analysis. Options were provided to allow users to develop alternative methods of establis initial imperfections in the gusset plate for compression members. The reporting features and graphical user interface continued to be enhanced.*

Anticipated work next quarter:

Task 1: Literature Review- *Near complete, continue to collect any new information.*

Task 2: Software Development and Data Collection – *Beta version of software is released and a revision has already been released. Solicit feedback from TAC. Provide another on-line demonstration for TAC members. Provide set of targets to TAC members for use.*

Task 3: Gusset Plate Analysis – *Get feedback from TAC members and use to assess uncertainties in results. Conduct sensitivity studies to user/software detection errors. Work through known test results and calibrate the initial imperfections and thresholds for establishing capacity.*
Include the newest MBE provisions in the analysis features of the software.

Task 4: Implementation Example - *None*

Task 5: Imaging Data Informatics for Bridge Management – *Finalize the framework for the GIS-based management system for image data. Demonstrate for TAC.*

Task 6: Analysis Software – *Solicit user feedback and incorporate changes into software. Refine outputs so that results can be more easily synthesized. Implement LRFR/LFR approach when given user data for live and dead loads.*

Significant Results:

While results are preliminary, the following results are significant:

A revised set of image targets shows good rectification with significantly reduced cost and eliminates the need for standoff correction in the scaling.

The software application can now automate image processing of a general gusset plate. It requires refinement and further development by the research team.

The analysis tools can effectively rate the connection strength using either AASHTO-MBE or nonlinear FEA.

A beta version of the image processing and FEA analysis software have been released.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

No significant problems.

Final internal testing and revisions took additional time. The software was released to the TAC just after June 30. A conference call was held with the TAC to walk through the beta version.

We developed a way to allow the TAC members to run the software via the internet, which took more time than anticipated.

Potential Implementation:

A newly revised version of the software is released and hopefully will be used by the TAC members.
New image targets are being fabricated and will be distributed to TAC members for field use.
The PI will demonstrate the software via internet workshops and will plan on-site visits to help in deployment after receiveing feedback from the TAC members.