Quarterly Progress Report

TPF-5(039)	Falling Weight Deflectometer (FWD) Calibration Center and Operational Improvements

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Reporting Period: **July 1, 2005 through September 30, 2005**

Project Status: (Tasks 1-5)		
	Work completed through end of period:	39.7%
	Project funds expended:	38.7%
	Expected completion date:	September 6, 2006

Status of the Project

The project is moving along well. Task 1 was completed, and substantial progress was made on Tasks 2 and 3 during the quarter. Task 4 was begun. Activity in the quarter focused mainly on converting the software to a Windows environment and evaluating the feasibility of using an accelerometer. After one year of activity, we estimate that we are somewhat behind schedule, but probably no more than two or three weeks. The schedule affords some flexibility to get caught up. We are confident that the project will be completed on schedule.

The details of the project are described in FHWA's Statement of Work which is posted at the TPF-5(039) Web site

Activity during the reporting period

Among the activities during the reporting period were the following.

- Completed the conversion of the DOS-based FWDREFCL computer program to a Windows version.
- Began modifying the Windows FWDREFCL program to work with calls to the new Keithley KUSB-3108 data acquisition (DAQ) board. This work is on going.

- Finished a series of interviews with the FWD manufacturers and Calibration Center Operators designed to draw out their suggestions for needed changes and improvements in the calibration procedures and equipment. Prepared a report on the findings.
- Selected a Silicon Designs model 2220 accelerometer for further testing as a possible replacement for the concrete block/aluminum beam/LVDT reference deflection system.
- Developed a series of experiments to evaluate the accelerometer as a deflection reference device. Results from these experiments are encouraging.
- Employed an experienced mechanical engineer on a temporary basis to assist with the experimental research.
- Developed software to use with the accelerometer and the KUSB-3108 DAQ board that allows "about triggering" using PC memory to create buffers of substantial size.
- Began populating a database with FWD calibration results to establish a baseline defining the repeatability and reliability of the current calibration methods. A statistically-based experimental design was developed to assure that sufficient replicates would be obtained. Completed the load cell calibration database with 15 replicate calibrations. Work on the deflection sensor database is on going.
- Compared new and old LVDTs from several sources and found a surprising amount of difference between them in dynamic measurements.

Problems encountered during the reporting period

Work was delayed in late July and early August when we purchased a new LVDT to use as a reference measurement device for developing our calibration database. We thought it would be wise to use a new LVDT to avoid any concerns about possible friction or wear. However, we soon found that the new LVDT was registering *smaller* dynamic displacements than the old one. Both devices had been calibrated statically using the same micrometer calibrator.

Technical assistance from the LVDT manufacturer did not provide credible answers. We borrowed two LVDTs from the PennDOT Calibration Center. We found similar variability in those LVDTs. But the two oldest LVDTs, one from Pennsylvania and the other from Cornell, yielded very similar results. Both were manufactured by Lucas-Schaevitz. The newest LVDT, from the Macro Sensors firm, gave readings about 1.2% lower.

Currently we are looking for a shake table that can be used to determine which LVDTs are the most accurate. Until the matter is settled we will continue to use the older Cornell LVDT for all measurements.

We also encountered a problem with using FWDwin on our Dynatest FWD. We began having timeout errors that resulted in the loss of data, requiring us to repeat the measurements. The problem seems to be intermittent. The Dynatest firm has been very helpful in trying to sort out the reason for the problem. At the end of the quarter they sent a revised version of the FWDwin program and loaned us a microprocessor to see if either will correct the errors.

Work completed by task

The six tasks referred to below are described in detail in the Statement of Work on the pooled-fund web site. Our strategy is to work simultaneously on Tasks 2 and 3. We feel that both the hardware upgrades and the software upgrades interact, and thus it is more efficient to work on the two tasks together. We got a modest early start on Task 4 near the end of the quarter.

Task 1. Communication, Coordination and Reference Resources

Task 1a is complete. All protocols, software, and drawings of the currently used equipment that are available are in hand. These will be included as an appendix in the Task 1 report.

Task 1b will continue throughout the project. This task provides for a dialog with the FWD manufacturers and the calibration center operators. We feel this dialog should continue for the duration of the project.

During the reporting period we concluded our interviews with the FWD manufacturers and the Calibration Center Operators. Unfortunately we were not able to interview the Center Operator at the Texas Calibration Center, nor were we able to interview a representative from Carl Bro. However, we felt that we had a good, representative selection of input from both the manufacturers and the Center Operators, so in the interest of finishing the report we decided to use the information that we had.

The Task 1 report has been completed, and it will be submitted within a few days. We will make one last attempt to interview John Ragsdale (Texas Center) and Claus Olsen (Carl Bro) during the FWD Users Group Meeting. If successful, we will integrate their replies into the report.

Task 2. Modify Calibration Process

Task 2a is continuing. A goal for streamlining the calibration procedure was established at the April meeting of the Technical Advisory Committee (TAC). The Committee asked that we expedite the procedure so it can be completed within three hours, and we believe this can be achieved. We plan to do the reference calibration on all deflection sensors simultaneously, rather than sequentially as it currently is done. We have developed two sensor holder designs to accomplish this, which we will evaluate during the coming quarter.

Another way to save considerable time is to electronically transfer the data from the FWD computer to the calibration computer. Manual data entry that is currently used takes a lot of time. From our Task 1 interviews we found that three out of four FWD manufacturers presently have the capability to create PDX file format, so we plan to take advantage of that. However, we learned in the interviews with the Center Operators that all FWD owners do not have the software needed to write PDX files. This reality is expected to be a barrier to full implementation of electronic data transfer.

During the quarter we worked on gathering a database of calibration test results. We have completed a full set of fifteen load cell calibrations, and have completed two 9-sensor geophone calibrations. This work was delayed due to the issues with the LVDT and the FWDwin computer program, as explained above.

Task 2b will not be necessary. We have been successful with developing "about triggering" for the Keithley KUSB-3108 DAQ board. This means that an event such as the falling mass striking the load plate can be used to detect the release of the falling mass. We believe this technique will work with both load and deflection sensor calibration and all types of FWDs. Thus it will not be necessary to establish an automated mechanism to trigger data acquisition at the release of the mass.

"About triggering" works in conjunction with three buffers that operate under the control of the Keithley DAQ board. More than three buffers could be used, but we have found that three are sufficient for our needs. We are collecting data at 15,000 samples per second on each of two channels (LVDT and accelerometer). Each buffer holds one second of readings. After the buffer is filled, the data are transferred to a temporary array in the computer memory, while the next buffer is filling. If the desired event is detected among the data, then a specified amount of pre-event data are saved, and sampling continues until the desired number of readings have been obtained. If not, the data in the buffer are overwritten, and the cycle continues. This allows a substantial amount of data to be collected before the event, without the need to retain an excessive amount of data.

Task 2c is continuing. Our work to date indicates that an accelerometer can be used to replace the LVDT/beam/block assembly. We will continue to assess this during the next quarter. At this moment it appears that a means of measuring beam movement may not be necessary.

Task 3. Hardware and Software Upgrades and/or Development

Task 3a is continuing. This task is being completed in three phases, using the services of a part-time computer programmer.

Phase 1. Convert the DOS-version of FWDREFCL to a Windows program. For compatibility with the Keithley KUSB-3108 DAQ board, we have elected to use Visual Basic 6 for our Windows language. This phase has been completed. We have tentatively named the new program WinFWDREFCL.

Phase 2. Replace the calls to the DAS-16G DAQ board in WinFWDREFCL with calls to the new Keithley KUSB-3108 DAQ board. This phase is currently underway and is expected to be completed during the next quarter.

Phase 3. Modify the WinFWDREFCL program to reflect the changes in the calibration protocol that are developed by the study. For instance a subroutine that double integrates the accelerometer signal will be needed. Also, the analysis software for processing the relative

calibration data will be needed after the reference and relative calibration procedures have been merged together.

No effort was made on Task 3b during this reporting period. We expect to schedule the visits of the COTR for review and acceptance of the modified calibration procedures during the coming quarter. Tentative dates for the reviews may follow soon after the TRB Meeting in January, according to the COTR. We do not expect to purchase hardware for distribution to the calibration centers until after the new procedures have been approved.

Task 4. Calibration System Testing, Installation and Operator Materials/Training

No effort was made on Task 4a or 4c during this reporting period.

Task 4b is continuing. We have begun the process of documenting the WinFWDREFCL software and developing a flow chart keyed to the software. We expect the activity to continue throughout the next quarter.

Task 5. Presentation and Reporting

There was no activity on this task during the reporting period.

Task 6. Miscellaneous Support for TPF-5(039)

This task is not included in the current contract. Effort on this task is not anticipated before fall 2006. It will require separate task orders.

Work planned during the coming quarter

Under Task 1 we will continue to maintain a dialog with the FWD manufacturers and Calibration Center operators. We may be able to obtain the two missing interviews during the FWD Users Group Meeting in early October, in which case we will merge the information into the Task 1 report.

Under Task 2 we will complete the development of a data base of calibration test results.

We will manufacture and evaluate several different designs of sensor holders to facilitate doing reference calibration of up to twelve sensors simultaneously. We plan to integrate relative calibration into the modified procedure using the new sensor holder.

Under Task 3 we will continue the software development efforts modifying WinFWDREFCL as needed. We will introduce calls to the Keithley KUSB-3108 DAQ board and then perform a series of FWD calibrations with the updated program. We will compare the results of these calibrations to the data base of results using the DOS version of FWDREFCL.

Under Task 4 we will continue to document the WinFWDREFCL software. We expect to complete the modifications to the software and hardware during the period. Testing of the modified procedures was begun in the previous quarter and the activity is expected to continue throughout the coming quarter.

We anticipate that Task 4c involving installation of new equipment and training of calibration center operators will begin late in the first quarter of 2006.

Task 5 – No activities planned.

Task 6 – Not included in the current contract.

Table 1. Work Schedule and Completed Work

WORK COMPLETED 

Year	2004			2005											
Month	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December
Task															
1 Communication and Coordination	**TASK 1**														
2 Modify Calibration Processes							**TASK 2**								
3 Hardware and Software Upgrades												**TASK 3**			
4 Testing, Installation, and Training													**TASK 4**		
5 Presentation and Reporting															
6 Miscellaneous Support															

Year	2006									2007	2008	2009	Percent of Task Completed
Month	January	February	March	April	May	June	July	August	September	FY	FY	FY	
Task													
1 Communication and Coordination													**98**
2 Modify Calibration Processes													**75**
3 Hardware and Software Upgrades													**70**
4 Testing, Installation, and Training	**TASK 4**												**5**
5 Presentation and Reporting		**TASK 5**			**Draft Report**	**TASK 5**			**Final Report**				**0**
6 Miscellaneous Support (not in this contract)										**TASK 6**			**Not in contract**