January 4, 2006

Solicitation Proposal

Title: The Digital Highway Measurement Project's Instrumented Van: System Completion and In-State Demonstrations for Evaluation and End-User Recommendations on a Final System Specification.

Lead Agency: Federal Highway Administration, Turner Fairbank Highway Research Center, 6300 Georgetown Pike, McLean VA 22101-2296.

Lead Agency Contacts: Pete Mills (pete.mills@fhwa.dot.gov) 202-493-3338; Mort Oskard (mort.oskard@fhwa.dot.gov) 202-493-3339

FHWA Technical Liaison: Pete Mills (pete.mills@fhwa.dot.gov) 202-493-3338; Mort Oskard (mort.oskard@fhwa.dot.gov) 202-493-3339

Study Partners:
Potential Partners Having Expressed Interest:
- FHWA Office of Federal Lands
- Office of Safety R&D
- Office of Pavement Technology
- Office of Asset Management
- Federal Railroad Administration (FRA)
- Federal Aviation Administration (FAA)
- States -VA, NC, and PA

Contract Amount: $150,000 per partner (minimum over 3 years)

Commitments Received: $300,000, FHWA

Background: Over the last decade, the States, Federal and local agencies, and others involved in highway transportation have placed significant additional emphasis on improving highway safety and infrastructure performance. The American Association of State Highway and Transportation Officials (AASHTO), Governors Highway Safety Association, and the USDOT have set the goal of a 20 percent improvement in safety as measured by reductions in fatalities and injuries. A central focus of FHWA's infrastructure research has always been to maximize performance and significantly reduce the associated long-term costs. In 1998, AASHTO developed its Strategic Highway Safety Plan that identified 22 areas needing improvement. A number of these focus areas dealt with the roadway or roadside elements of highway design, operation, and maintenance. The Plan also identified data, especially roadway and roadside data, as needing significant improvements.

The need for improved roadway and roadside data has also been echoed in numerous other initiatives before and after the AASHTO Plan. There was a call for "safety management systems" in earlier Federal legislation; a complete inventory of the roadway and all its features and condition was determined as prerequisite for effective monitoring, research, and decision-making to improve safety and to track infrastructure performance status. The more recent initiatives that depend upon or called for improved roadway and roadside data include:

- National Research & Technology Partnership Agenda
- National Cooperative Highway Research Program Project 17-18 to Implement the AASHTO Strategic Highway Safety Plan
- The Strategic Highway Research Program (SHRP) II
- The requirement in SAFETEA-LU for States to establish Strategic Highway Safety Plans, identify roads and intersections that have the worse safety record in the State, and spend the new Core Highway Safety Improvement Program funds
- Highway Safety Research, especially the special studies conducted with data from the States involved in the Highway Safety Information System (HSIS).

Certain types of roadway data have been especially noted for improvement: roadway and roadside geometrics (horizontal and vertical alignments, cross slopes, etc.), identification and location of all hardware (e.g., signs, guardrails, etc.), and road aspects (e.g., pavement markings), as well as obtaining precise performance data (i.e., condition) of the devices. For the most part, States and localities do not have an accurate inventory of these data for most, if any, roads in the State. This is especially true for two lane rural roads that are often off the "State highway system," but where a disproportionate number of crashes, fatalities, and injuries occur. In January 2000, a survey by AASHTO of the State Departments of Transportation revealed that none had precise information for the seven asset categories queried in the survey (signs, signals, lighting, supports/structures; guardrails/barriers/cushions, pavement markings, and detector devices. This type and level of information is also needed for the State DOTs to meet the financial reporting standards established by the Government Accounting Standards Board (GASB) in their Statement 34.

A review of the collection and analysis methods regarding roadways and roadside data and its correlation with crash records revealed a significant gap between the needs and the state-of-the-practice capabilities. While a few States were beginning to collect and store data in an electronic manner, the geometry accuracy was frequently inadequate and the collection processes often required significant manual interpretation that made data collection and use too costly. In response to these gaps, the FHWA embarked on an effort to develop an instrument (i.e., van) that could be operated on the road at highway speeds and collect the desired information at extremely high levels of accuracy without interruption of traffic and not requiring extensive manual interpretation. It was modeled after pavement management system vehicles, but more accurate and considered the full spectrum of measurement needs simultaneously and synchronized, all within a single vehicle. Also envisioned by FHWA were rapid analysis of the data and an ability to import the information into other design tools, such as the Interactive Highway Safety Design Model (IHSDM) and Highway Driver Simulators.

Over the last two years, the FHWA's Office of Safety R&D Advanced Research Team at the Turner-Fairbank Highway Research Center developed the instrumented prototype vehicle capable of accurately measuring various highway infrastructure conditions and engineering parameters. The vehicle, called the Digital Highway Measurement (DHM) van, is able to capture all measurements while operating at normal highway speeds therefore avoiding a disturbance to traffic as data is collected. The van uses very accurate sensors to record roadway features, fuses the signals from the sensors with ultra-precise location sensors, to get highway infrastructure condition and location information previously unattainable from existing moving platforms.

At present the system collects the following data at normal highway speeds and maintains cross-reference location information:

1. Horizontal and vertical alignments of the roadway (precision derived from an accurate gyroscope and applicable for use with computer aided design software).
2. Detailed cross-sections including ditch sections and safety hardware location and identification (within two-foot intervals or less in the direction of travel).
3. Roadway and roadside video from two stereoscopic digital cameras for eventual automated identification, location and status inventories of most highway features.
4. Three continuous longitudinal texture and roughness measurements in each vehicle wheel path and at the vehicle's center.
5. Continuous road surface temperature measurements for warp and curl analysis.

Other sensors or analytical methods are currently under development:

6. Automatic image processing of the stereoscopic digital cameras data to provide accurate identification and analysis of signs and other features.
7. Continuous tire-pavement noise generation information.
8. High-resolution three-dimensional picture of underground conditions, including subsurface utilities down to approximately thirty feet (by a 3D Ground Penetrating Radar (GPR) that can also be utilized on bridge deck and pavement studies. This work is contingent on FCC and FAA approval that is presently being processed).
9. Automatic production of an accurate set of "as-built" plans.

The initial DHM van assembled at FHWA's TFHRC already has a sufficient number of measurement sensors completed and working at this time to demonstrate its potential. A second phase is needed to collect feedback on a wider range of roads and road conditions, make improvements in response to user feedback, and produce system specification so others may construct DHM vans for production use. A more detailed overview of the van's present technical capabilities is posted on the FHWA FTP Server (web site FTP://FHWAFTP.fhwa.dot.gov) in folders labeled HRDS\DHM_POOLEDFUNDS. (The user ID is hrdsguest and the password is hrdsguest. Click on the file labeled Draft-ExecSum-DHMFinalRpt-PhaseI.pdf. It is a draft of the Executive Summary for the Phase I Final Report of the Project. The Final Report for the Phase I work is in preparation and will be placed on the same FTP server folder when available along with other various published papers and presentation material that has been produced over the years.

Objectives: The goals of this Pooled Funds Project are to finalize development of the existing "mid project" vehicle; explore the incorporation of new sensors and algorithms that expand the number of items measured and/or the accuracy of the data collected; develop a second van; test and evaluate both vans; receive comments and reflect recommendations of State DOT and Federal users into a final set of system specifications.

Possible enhancement could include:

1. An automated, accurate infrastructure inventory capability, measuring from fence line to fence line.
2. An automated, accurate safety hardware, tree and pole locations inventory and a corresponding safety assessment of these and other rigid roadside objects. (This data would thus be available to roadway design tools, such as the Interactive Highway Safety Design Model (IHSDM)).
3. An automated signage content and retroreflectivity inventory.
4. An automated location and assessment of severe edge drop-off and side slopes or ditch conditions.
5. An automated condition evaluation of roadside vegetation.
6. The ability to link roadway and roadside assets to high hazard or crash location data to support safety decision-making or to conduct research, such as the SHRP-II.
7. Detailed safety evaluation of existing hardware and proposed countermeasures before they are deployed. (This future work will be performed in coordination with the IHSDM Project and the crash simulation capability presently available in the Office of Safety Design.)

The long-range objective for the DHM van is to improve the quality, cost-effectiveness, and quantity of roadway and roadside engineering data for both design and analysis processes within a state or local highway department or for Federal agencies. The enhanced analytical and computational capabilities developed to process data collected by the van will ultimately be capable of producing more analysis power for any data collection efforts within DOTs that monitors conditions and projects remaining life of their highway infrastructures.

While the detailed tasks will be finalized by the involved parties, specific tasks could include: 1) the 3-D Ground Penetrating Radar (GPR) capability already tested on a regular van needs to be added to and integrated with the DHM van; 2) the stereoscopic digital camera system would be finalized; and 3) consideration given to general system and algorithm upgrades. Then, a second van with the new upgraded state-of-the-art equipment and algorithms could be built. Following completion of the second van, a series of significantly large partner in-state demonstrations on a variety of road types will be completed, and evaluations and recommendations from partners will be solicited. The partners would provide feedback on such matters as the type of data to collect, the data format used and the style of information display, all of which will be considered for inclusion in the final published specifications for the mid-project vehicle. Suggestions for innovative types of measurements or computations and display formats will also be solicited from all the partners.

The output from this study will be the functional specifications for the total system (van); this will be beneficial for the states as they then can commercially arrange for construction of their own measurement vehicles. The initial two resulting instrumented vehicles will also be used for further research and development of the system.

Scope of Work: The scope of the work for this project will include refinements and completion of the development of the existing Digital Highway Measurement Van; release of an initial set of system specifications; assembly of a second van; the van's collection and evaluation of new data from roads within participating States and agencies; obtaining recommendations from the partner States and agencies on additional vehicle/sensor and measurement enhancements; and completion of a system specification.

Miscellaneous Technical Comments: The first van is near completion ("mid-project level") at this time. The instrumented van's specific measurement capabilities are listed on its web site; the corresponding listed improvements are much greater than the current state-of-the-practice accuracies. The presence of even the current van's capability in a state DOT office would represent a significant increase and improvement in roadway and roadside data for highway design, operation, and maintenance, and ultimately in the improvement of highway safety and infrastructure performance.

Participation Comments: This project is open to any number of participating states or other Government Offices, with a minimum of ten (10) needed for this study. The approximate amount of funding requested per partner is $50,000 per year for three years for a total commitment of $150,000.

Funding commitments will continue to be accepted through March 31, 2006.

Reference Papers and Presentations Related to the DHM Project:

The following references are listed as background reading and represent some of the work that has been reported during the early development of the instrumented van. The next update of the DHM Project material on the FHWAFTP web site will add copies of some of these references for your review.

1. Measurement and Analysis of Slab Curvature in JPC Pavements using Profiling Technology. - D. Sixbey, M. Swanlund, N. Gagarin, J. R. Mekemson. IIF-IIR – Commission B1, B2, E1, and E2 – Purdue University, USA – 2001. (Best Conf. Paper)
2. Variability of Road Profile Measurements on Portland Cement Concrete Due to Diurnal Temperature Change. - N. Gagarin, J. R. Mekemson, M. Swanlund, D. Sixbey, M. Mills. IJVD RP-17. (submitted)

3. Effects of Accelerometer Sensitivity on Inertial Road Profile Measurements of Accuracy and Precision. – N. Gagarin, J. R. Mekemson, L. Lineman, D. Sixbey, M. Mills. IJVD RP-16. (submitted)
4. Introduction of Non-Linear Non-Stationary Analysis into the Post-Process of Pavement Surface Profiles. – N. Gagarin, J. R. Mekemson. M. S. Oskard. Surf 2004, Toronto, Canada.
5. Utilization of the Hilbert-Huang Transform in Highway Engineering. – N. Gagarin, M. S. Oskard. HHT Conference at the University of Delaware, 2003.
6. The Application of the Hilbert-Huang Transform to the Analysis of Inertial Profiles of Pavements. N. Gagarine, N. E. Huang, M. S. Oskard, J. R. Mekemson, D. G. Sixbey. IJVD RP-22, July 2003. (accepted)
7. Performance of Inertial Profilers Subjected to Certification Procedures. – J. R. Mekemson, N. Gagarine, L. Lineman, Surf 2004, June 6, 2004, Toronto, Canada.
8. Misc. Presentations – F-Sharp, V-DOT, EDMaps, PA-DOT, Federal Lands/FHWA, TFHRC IHSDM Project staff, FHWA Office of Pavement Technology Staff.