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The PAVECHECK data integration and analysis system was developed to merge Falling Weight Deflectometer (FWD) and Ground Penetrating Radar (GPR) data together with digital video images of surface conditions. In this study Global Positioning System (GPS) was added to the system, and both the existing data collection and data processing programs were modified. One goal of this study was to evaluate the potential of using the upgraded PAVECHECK system to collect network level pavement condition data to assist in pavement rehabilitation planning. GPR data were collected on the entire roadway network for Williamson County in the Austin District. Collecting the entire 400 center lane miles took less than 10 days. Maps showing the limits of the data collection activities were developed. The upgraded system and the outputs from Williamson county are described in this report. The collected data and upgraded software has been delivered to district personnel.

This system has tremendous potential to assist Texas Department of Transportation (TxDOT) engineers with future forensic and pavement rehabilitation studies. The PAVECHECK framework can also assist in future pavement layer database efforts and in documenting and evaluating the performance of research test sections.</td></tr>
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PAVECHECK: INTEGRATING DEFLECTION AND GPR FOR NETWORK CONDITION SURVEYS

by

Wenting Liu, P.E.
Associate Research Engineer
Texas Transportation Institute

and

Tom Scullion, P.E.
Research Engineer
Texas Transportation Institute

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College Station, Texas 77843-3135

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Texas Department of Transportation or the Federal Highway Administration. The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report. This report does not constitute a standard, specification, or regulation. The engineer in charge was Tom Scullion, P.E. (Texas, # 62683).

ACKNOWLEDGMENTS

This project was made possible by the Texas Department of Transportation (TxDOT) and the Federal Highway Administration. Elias Rmeili, P.E., from the Brownwood District served as project director and his support for the implementation of PAVECHECK is greatly appreciated. Dr. German Claros, P.E., and Mike Arellano, P.E., deserve thanks for recognizing the potential of this software package to play a major role in future pavement management efforts within TxDOT.

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CHAPTER 1
INTRODUCTION

PAVECHECK is a software package used to integrate nondestructive test data from various testing systems to provide the pavement engineer with a comprehensive evaluation of both surface and subsurface conditions. Figure 1 shows the basic data that can be integrated.

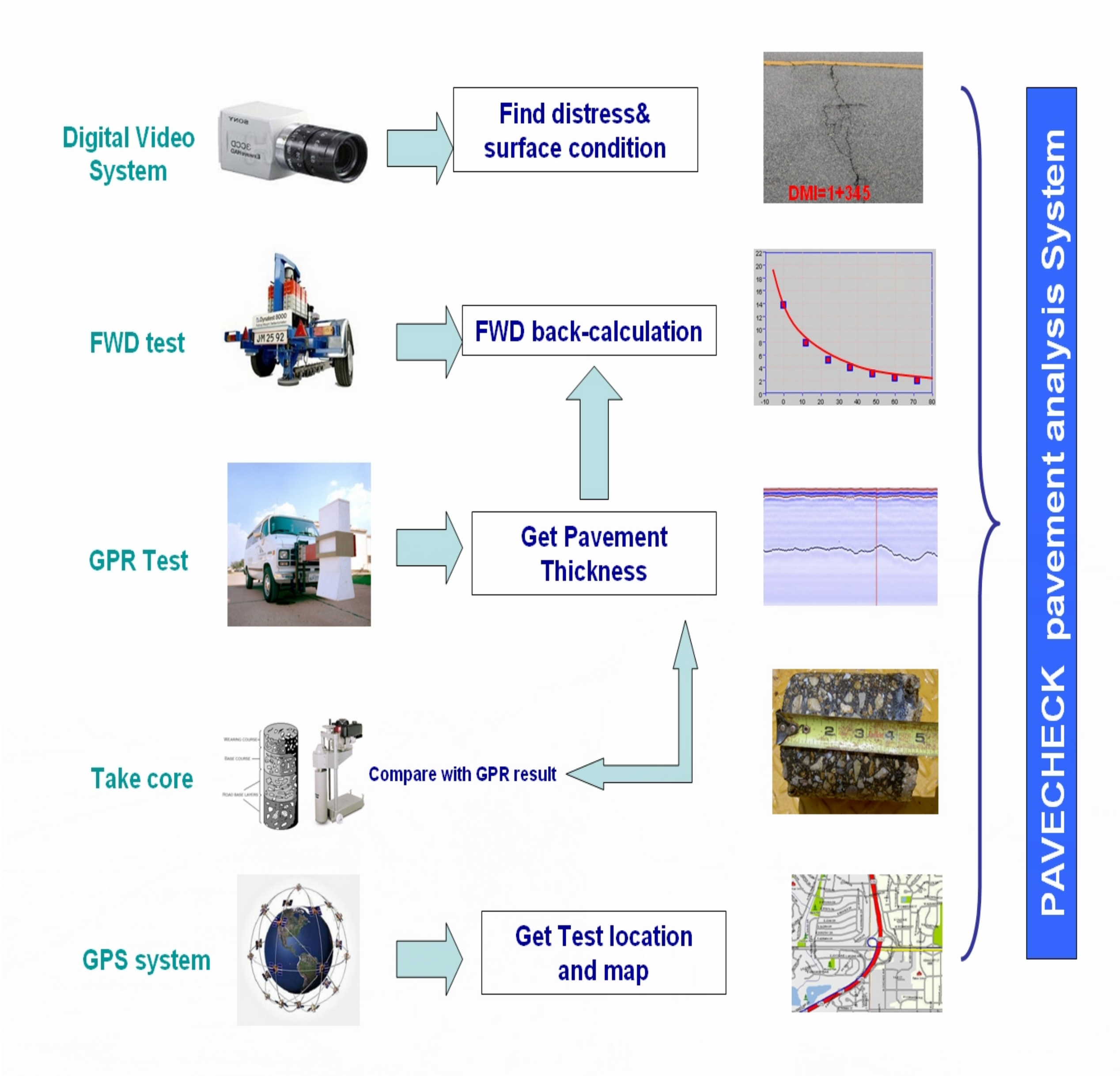


Figure 1. Elements of the PAVECHECK System.

PAVECHECK permits the user to:

- Display Ground Penetrating Radar (GPR) and synchronized video images. The video shows the existing surface condition, and the GPR identifies the subsurface condition, which permits the user to potentially identify the possible cause of surface distress.
- Integrate other photographs of pavement cores or other relevant data, which can be useful in the pavement evaluation.
- Integrate deflection data collected independently with Falling Weight Deflectometers.
- PAVECHECK also includes the MODULUS 6 backcalculation algorithms (Liu, 2001). The PAVECHECK system uses the layer thickness determined from the GPR data within the backcalculation analysis.
- This version of PAVECHECK automatically collects GPS data and displays the route tested on a map.

The detailed user manual and sample data sets for the upgraded PAVECHECK system can be found elsewhere (Liu and Scullion, 2008). The user manual is provided on a CD that contains data sets, which the user can open and learn to use the many functions within the analysis package.

This report provides update of the changes recently made to both the data collection and processing software within PAVECHECK. These changes primarily involve the addition of the GPS data referencing system. One objective of project 4495 was to determine if PAVECHECK can be used for network level data collection. As part of that evaluation, data were collected in Williamson County in the Austin District. This data collection effort is described in Chapter 5 of this report.

CHAPTER 2
UPGRADES TO DATA COLLECTION SYSTEM

As part of this study TTI's GPR vehicle was upgraded to include a GPS system. The modified vehicle is shown in Figure 2.

Figure 2. TTI's Latest GPR Vehicle with GPS.

The vehicle has two data collection computers and two monitors. One computer collects video images, and the second records both the GPR traces and GPS coordinates. The vehicle also has a distance measuring system. All of the data items are stored in separate files and integrated within the PAVECHECK data processing package.

The icons to activate both the video and GPR collection systems are 

and  . During data collection the screen shots shown in Figures 3 and 4 are observed by the operator. In Figure 3 the control panels at the bottom left are used to adjust camera settings. The video collection interval is user-selected and distance-based; in normal operation one video image is collected for every 10 – 20 feet of travel. Within PAVECHECK these image are integrated with the data shown in Figure 4.

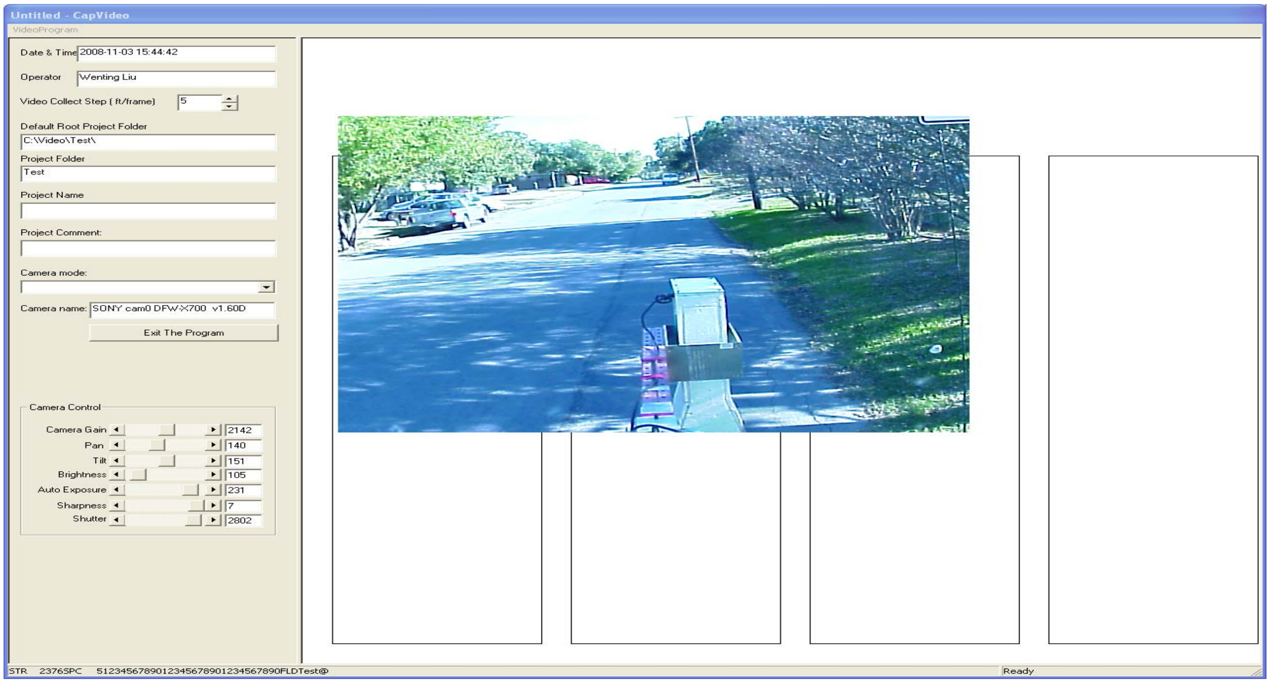


Figure 3. Video Data Collection Screen Shot.

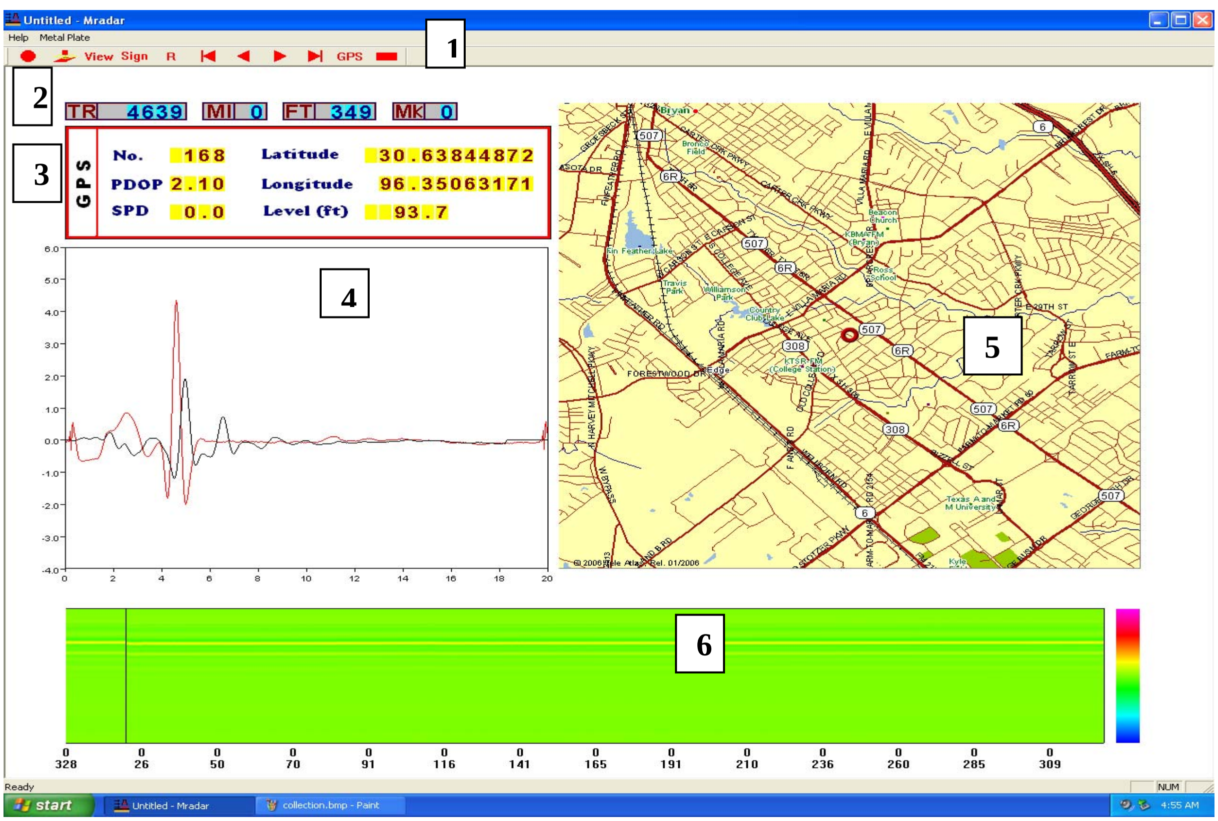


Figure 4. GPR Data Collection Screen Shot.

Figure 4 shows a screen shot of the GPR and GPR data collection system. The various parts of the figure are described below:

1. This is the main control panel for data collection set up; including naming files, establishing data collection intervals and for the checking that the system is operating correctly.
2. Trace number, distance in miles and feet from the start of the run and the number of user supplied marks placed in the data.
3. GPS coordinates for the current location (location of video photo in Figure 3)
4. GPR real time trace. The black line is the real time GPR reflections from the pavement layers. This is the trace that is stored as the vehicle moves along the highway. GPR traces are typically stored at user defined intervals typically 1 to 10 feet. The red line in this plot is the 100 percent GPR reflection from a metal plate, and this is used during system set up to ensure that the GPR unit is working correctly.
5. Map of the current location. The current location is the red circle in the middle of the map. This moves as the vehicle moves along the highway. The computer function keys provide zoom in and zoom out features to this map.
6. The color-coded display shows the GPR data as it is being collected. The current location is marked as the vertical line. The distance in miles and feet is at the bottom of this plot.

CHAPTER 3

UPDATES TO DATA PROCESSING SYSTEM

The user manual for the PAVECHECK system, including incorporating the GPS data, was recently updated and supplied as deliverable P1 to this study (Liu and Scullion Oct 2008). Reference should be made to that manual for a description of all of the functions available in PAVECHECK. All of the data items described in Chapter 2 are integrated using the project description screen shown in Figure 5.

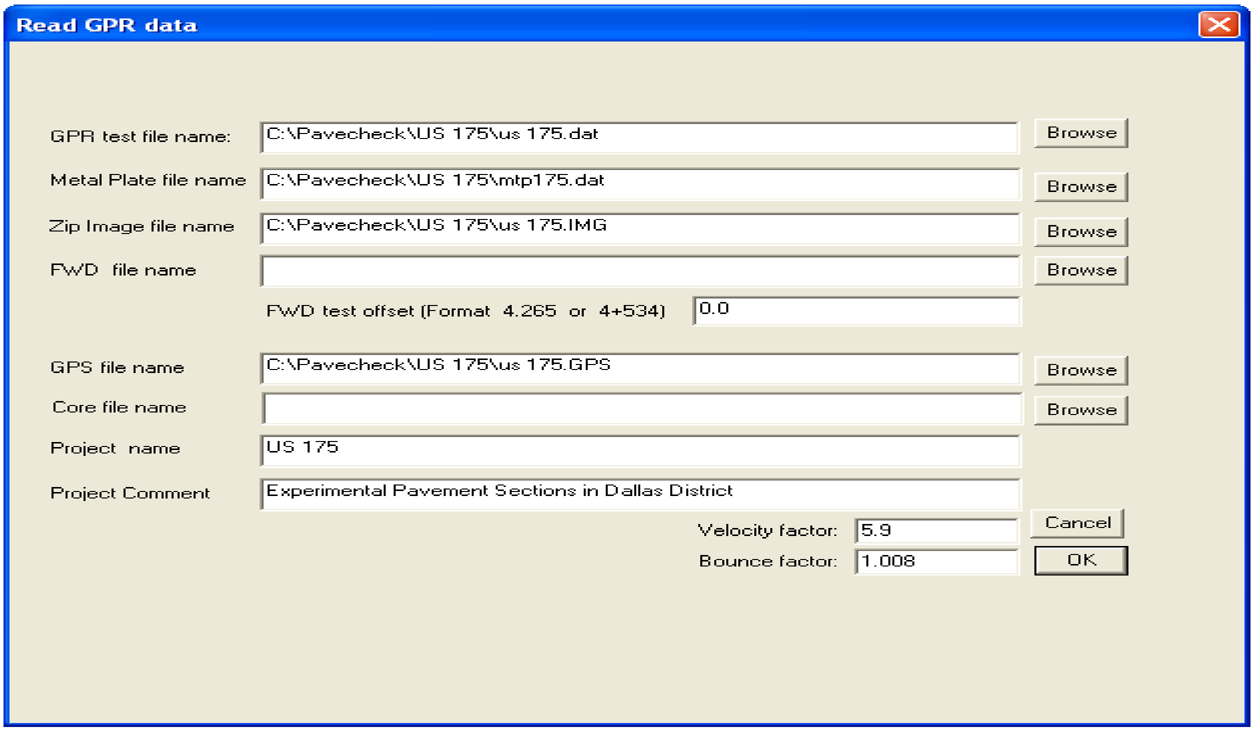
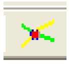


Figure 5. Example of Loading Typical Data into the Project File.

Upon hitting the "Ok" button, the integrated GPR data shown in Figure 6 will be displayed. The lower left shows a typical video image. The top shows a segment of color-coded GPR data. The basics of the GPR signal processing and the color-coding system are given elsewhere (Scullion, 1995). In the GPR display, the depth in inches is given on the vertical axis (y axis) at the right of the display, and the distance in miles and feet is given in the horizontal axis (x axis). The solid blue line at the bottom of this display is the surface dielectric plot for the highway and is useful to identify both low density and wet locations in the top layer of the pavement. The video image was taken at the location of the vertical red line in the color display. The quadrant at the bottom right has the GPR trace for the test location. PAVECHECK permits the user to play the video images, the vertical red line then scrolls across the color display. The user can then compare surface condition from the video with subsurface info from the GPR.

Figure 6. Typical GPR Data Display.

To display the stored map of the section tested click the  map display button on the main menu and the map shown below in Figure 7 will be displayed. The test section is shown as the blue line. The map shown in Figure 7 is the first generation of digital maps to display the location of the collected GPR and video data. This mapping and display system will continue to be improved with time.

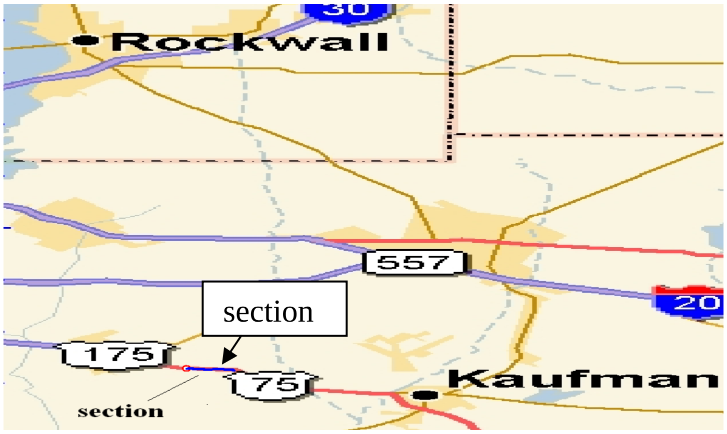


Figure 7. Location of Test Section on US 175.

CHAPTER 4
CASE STUDY FROM WILLIAMSON COUNTY

Traditionally in Texas GPR data are collected for discrete project level evaluation and as a design tool to assist in identifying subsurface damage, which is important when developing rehabilitation options. However, because of the high speed nature of GPR testing, the potential exists for collecting network level data. The GPR data are already integrated with the FWD deflection data, GPS coordinates, and digital video. There is also the capability of including additional images into the system; these could be photos of pavement cores, plan sheets or typical cross-sections. The eventual goal is to merge the PAVECHECK data with the information currently stored within TxDOT's Pavement Management Information System. The merged system would provide project designers with state-of-the-art information on structural strength, visual and subsurface pavement conditions. It is this integrated data that will be very useful in conducting pavement rehabilitation need assessments.

To evaluate the potential for collecting GPR data at the network level, all of the roadways in Williamson County were tested. This is about 400 center lane mile of roadways. For four-lane divided highways, GPR data were collected in both the northbound and southbound directions. For all other highways data were collected in one direction only. Data collection was completed in two weeks in August 2008. No major problems were encountered with data collection. The total size of the data files collected was 16 GB with video images collected at intervals of 15 to 20 feet of travel. All of the data collected together with the latest version of PAVECHECK has been supplied to Mike Arellano the Austin District's Pavement Design and Lab Engineer.

As a first step to using the GPS data for assisting with data management and reporting, several automated map functions were developed. Examples of these are shown in Figures 8 and 9. For each roadway tested, the GPR, GPS video images, FWD data, etc. are stored in individual highway folders under the main Williamson County folder. When the mapping program is activated, the GPR file in each highway's folder is read, and the map shown in Figure 8 is drawn. The highlighted roadways show those for which GPR data has been collected. From the main map shown in Figure 8, each of the individual highways can be selected and the details of each displayed, as shown in Figure 9.

Figure 9 displays the map of each individual highway sections. To the right of the map are close-up maps showing the start and end of each section. At the bottom of the figure is an elevation plot for the section from the z component of the GPS data. The lower table has details of the file names available within the highway project folder.

An example of data from one of the main highways in Williamson County is shown in Figure 10. This is from the southbound mainlanes of IH 35. The entire section was 28 miles long. One GPR trace was collected every 5 feet of travel and one video image every 15 feet. The PAVECHECK system allows the user to scroll through the entire section to identify pavement changes, layer thicknesses, and potential subsurface defects. In the data shown in Figure 10, one major performance issue is the highly variable surface dielectric for this section. This is displayed as the blue line under the color display. Large drops in surface dielectric have been associated with highly variable densities in the surface mat. This information is useful when planning rehabilitation options, as shown in the video image. The wheel paths of this major highway are exhibiting cracks.

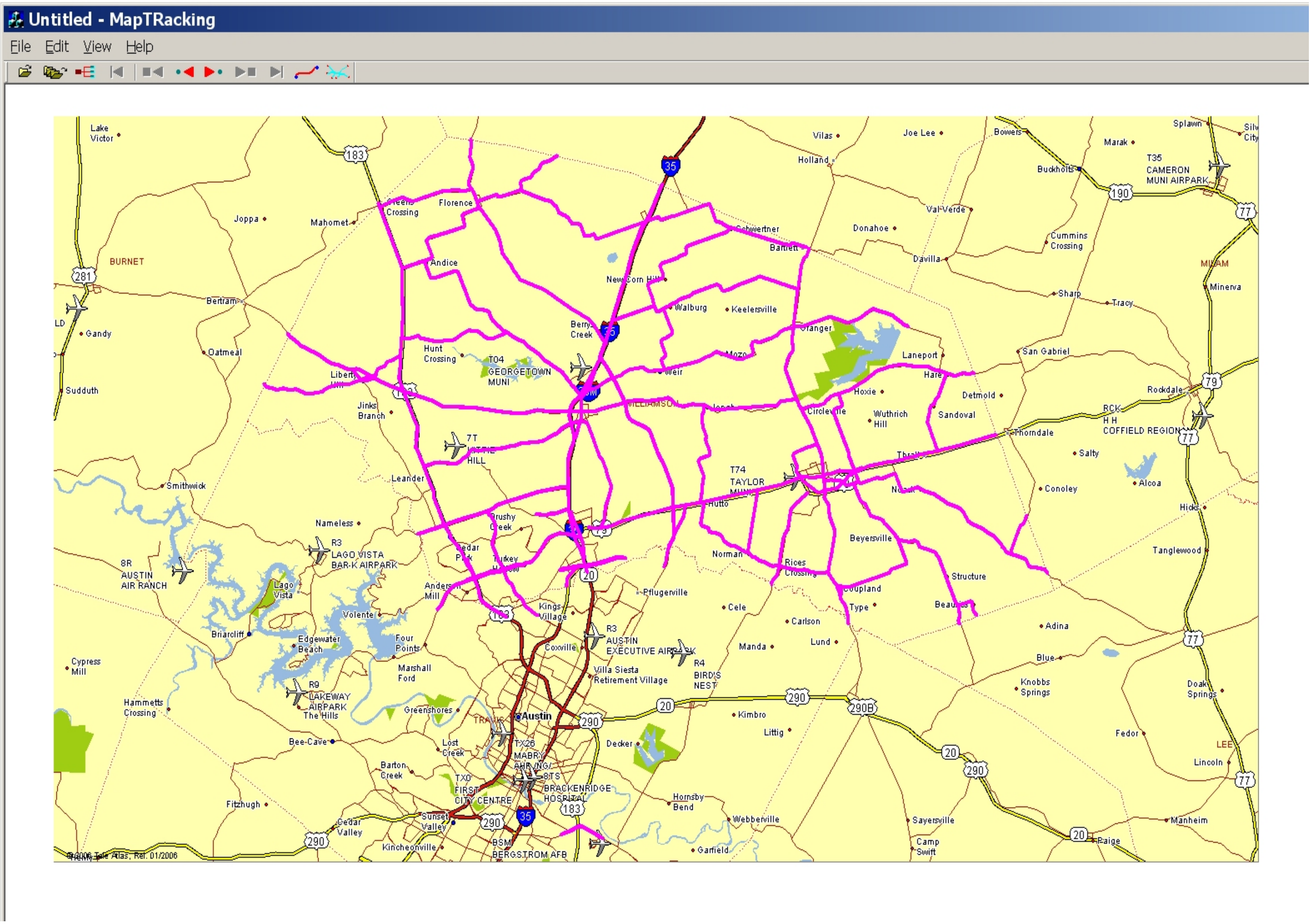


Figure 8. Map Showing the Locations of All the Highways Tested in Williamson County.

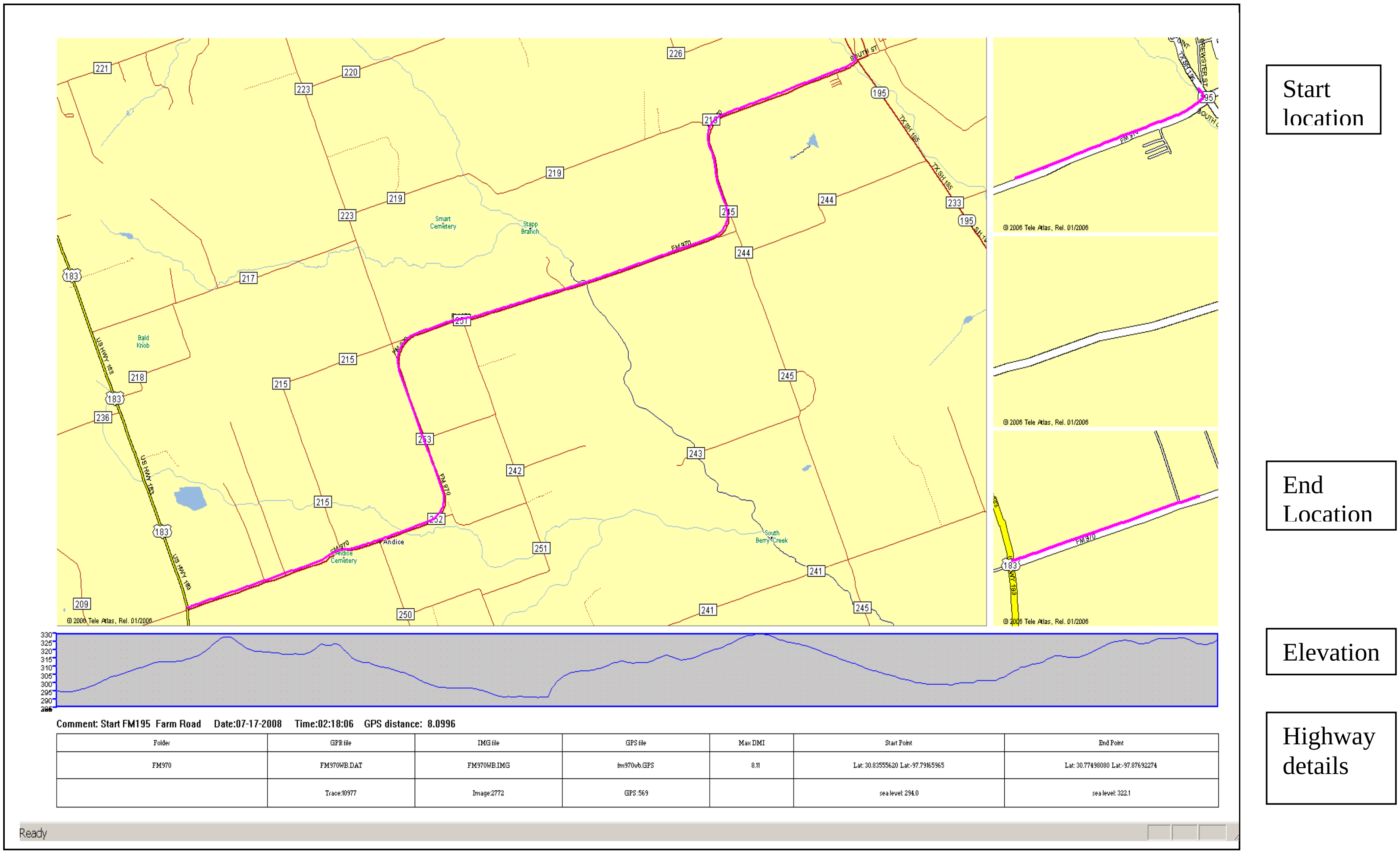


Figure 9. Graphical Display of One of the Williamson County Highways.

A close up of the beginning and end locations is provided in the small maps at the right of the figure. Elevation and project details provided at the bottom.

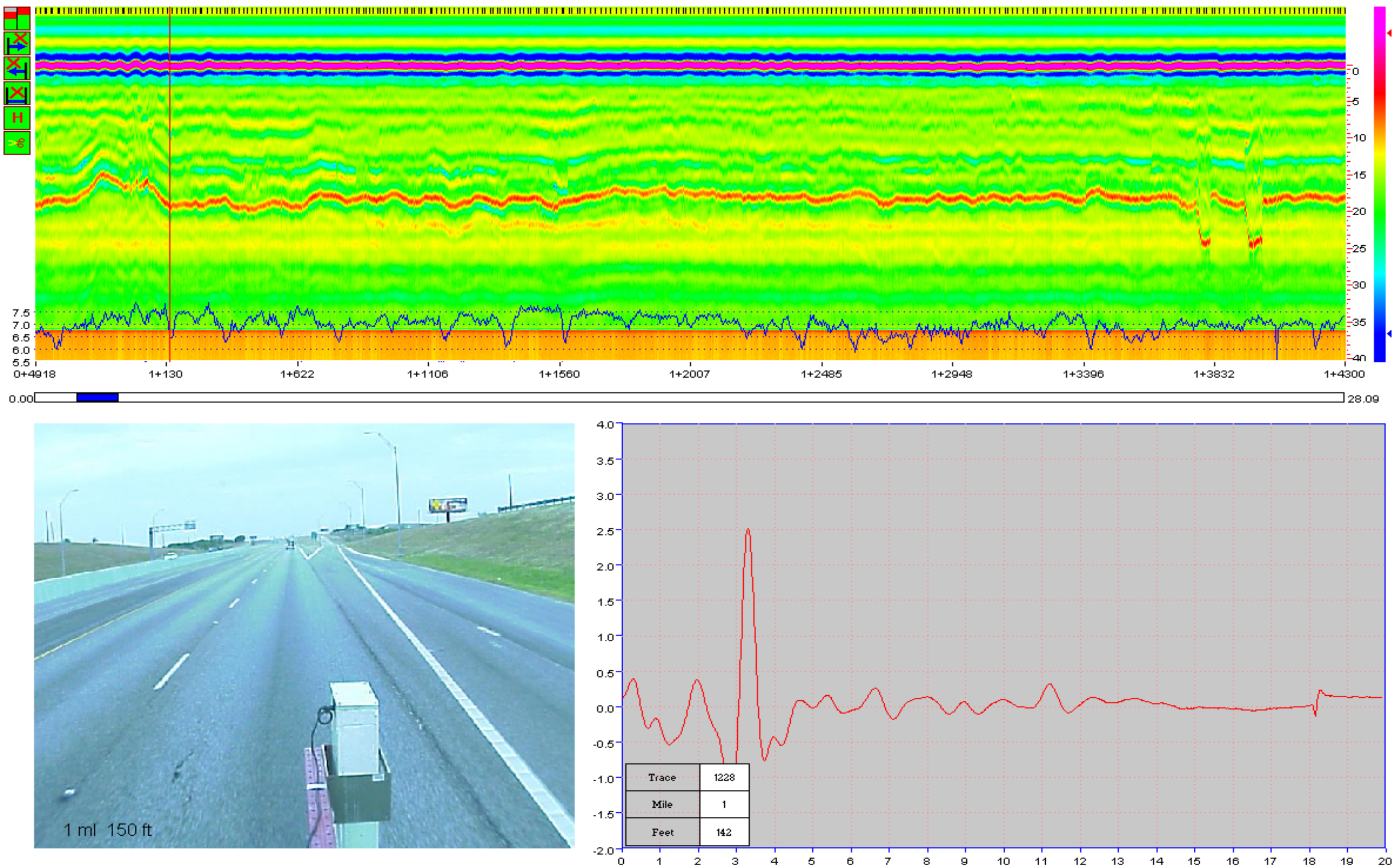


Figure 10. PAVECHECK Display from IH 35 Southbound Main Lanes in Williamson County.

The entire run was 28 miles.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

The data collection and processing packages developed in this project and described in this report have been installed in TTI's GPR vehicle. Over the past year we have collected over 800 miles of data with this system. It appears to be robust and the GPS offers great potential for future development efforts. The following recommendations are proposed based on the work completed in this study.

- TxDOT's GPR vehicles should be modified to include the new data acquisition and processing software.
- Future efforts should be made to collect GPS data with other critical items such as FWD data. Attempts to match distance information from different data collection vehicles with different distance measuring instruments has not provided the accuracy needed for merging the FWD and GPR for long sections.
- The maps shown in Figures 8 and 9 should be further developed. They should be further integrated within PAVECHECK. The goal would be provide a function to point to a location on the map and then load the data from that location and open the PAVECHECK software. The database provided to the Austin District should be expanded. Mike Arellano is very interested to use the PAVECHECK system as a base for future efforts where other materials-related information can also be stored for each section. Items could include date of last surface, surface material type, base material type, etc.
- The availability of other mapping packages should be investigated. Future efforts should be focused on software that can be distributed without a license. The current mapping package costs $120 per installation. In the future it would be ideal to transfer the software to a package where TTI can buy a site license and distribute it free with the PAVECHECK package.

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