GPR Equipment and Service Providers

Geophysical Survey Systems, Inc.
13 Klein Drive
North Salem, NH 03073
Phone: 603-893-1109
Fax: 603-889-3984
http://www.geophysical.com/
Equipment vendor

Infrasense, Inc.
14 Kensington Road
Arlington, MA 02476
Phone: 781-648-0440
Fax: 781-648-1778
http://www.infrasense.com/
Service provider

Penetradar Corporation
2509 Niagara Falls Blvd.
Niagara Falls, NY 14304
Phone: 716-731-4369
Fax: 716-731-5040
Service provider

Pulse Radar, Inc.
3535 Briar Park Drive
Houston, TX 77042
Phone: 713-977-0557
Fax: 713-977-2159
Email: roadar4@aol.com
Equipment vendor and service provider

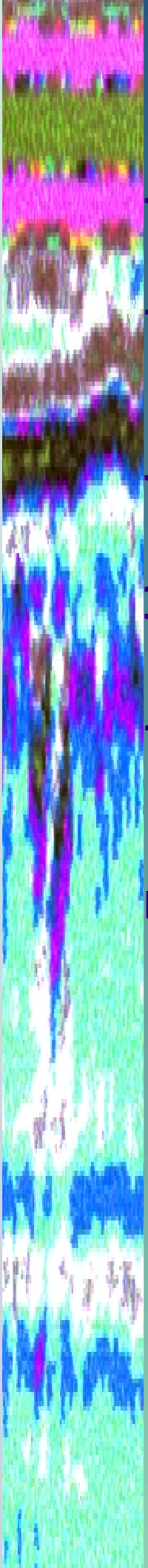
Road Radar, LTD
14535-118 Avenue
Edmonton, Alberta
CANADA T5L 2M7
Phone: 403-453-5873
Fax: 403-454-5688
http://www.rrl.com/
Service provider

Sub-Surface Informational Surveys, Inc.
145 Shaker Road
East Otis, MA 01029
Phone: 413-525-4666
Fax: 413-525-2887
http://home1.gte.net/bacan/
Service provider

Notice *– The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of the article.*

Prepared by the Office of Asset Management. For more information, call 202-366-0392.

Publication Number: FHWA-HIF-00-015



Ground Penetrating Radar for Measuring Pavement Layer Thickness

U.S. Department of Transportation
Federal Highway Administration

Highway agencies and contractors now have a new tool for estimating the remaining service life of pavements and selecting the appropriate maintenance and rehabilitation activities—ground-penetrating radar (GPR). GPR systems collect pavement layer thickness data quickly, unobtrusively, and inexpensively. Using GPR, pavement management engineers can survey subsurface conditions at a small fraction of the cost of conventional core sampling and gather data for network-level pavement management.

What is ground - penetrating radar?

***GPR** is a pulse-echo method for measuring pavement layer thickness and other properties. It works like ultrasound, but uses radio waves rather than sound waves to penetrate the pavement.*

Antennas mounted on a moving vehicle transmit short pulses of radio wave energy into the pavement (see figure 1). As this energy travels down through the pavement structure, echoes are created at boundaries of dissimilar materials (such as the asphalt–base interface). The arrival time and strength of these echoes can be used to calculate pavement layer thickness and other properties, such as moisture content.

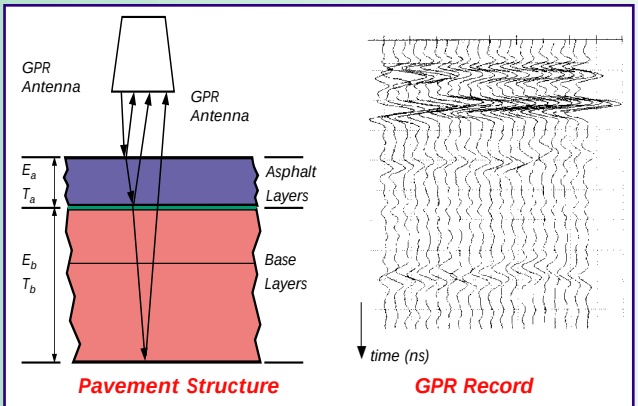


FIGURE 1:
Principles Used for Measuring Pavement Thickness

Why use GPR?

GPR systems yield accurate data in a form ready for management consideration. They survey pavements quickly, cost-effectively, and with minimal traffic disruption and safety risks. The Strategic Highway Research Program (SHRP), the Federal Highway Administration (FHWA), and several States and other agencies have carried out studies of GPR (see "Further Information" Section) that demonstrate the advantages of this automated surveying system.

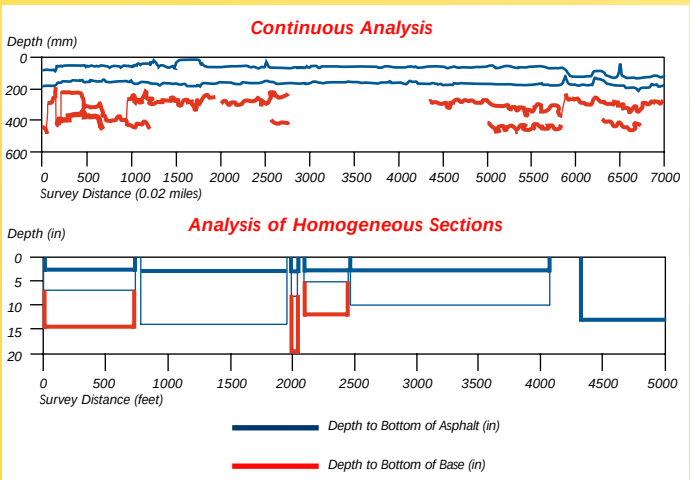
FIGURE 7:
Output of GPR Surveys

Continuous Analysis

Distance (miles)	Thickness Asphalt (mm)	Thickness Base (mm)
.001	171.338	266.816
.011	172.064	275.062
.021	172.004	261.257
.031	178.452	278.780
.041	169.455	287.135
.051	172.131	295.694
.057	172.730	310.635
.059	181.170	121.075
.069	172.251	110.218

Homogeneous Section Analysis

Station (ft.) Begin	Station (ft.) End	Mean Layer Thickness ASPH	Mean Layer Thickness Base
5	739	7.05	8.25
779	1953	13.96	0.00
1993	2038	8.12	11.50
2087	2448	5.08	7.07
2460	4066	9.74	0.00
4321	6408	12.92	0.00
6421	6489	15.05	0.00
6491	6567	19.68	0.00
6567	6697	15.39	0.00
6701	8773	11.06	0.00



The advanced GPR technology is not only available, but it has also been tried and tested. Denmark, Finland, and the United Kingdom are already using GPR in their pavement evaluation programs, as are several States, including Florida, Louisiana, Michigan, North Carolina, and Texas. Some States operate their own GPR equipment and perform their own analyses, and some contract the survey work. Other States, including Wyoming, Idaho, Minnesota, and Kansas, are evaluating GPR options.

Field tests and evaluative reviews conducted over the past decade have examined the accuracy and efficiency of GPR performance as a network pavement management tool for measuring pavement layer thickness. The studies have established the following benefits and limitations:

- **Lower Surveying Costs**— *GPR provides 100 percent pavement coverage at a small fraction of the cost of taking conventional core samples.*

- **Management Utility**— *GPR thickness data can be imported directly into a pavement management system to provide accurate data for calculating the remaining life of pavement sections, selecting the appropriate maintenance and rehabilitation actions, and developing specific rehabilitation designs. Software converts the radar readings into ASCII file output or graphical representations. Survey data can be displayed in continuous form or for discrete homogeneous sections.*

GPR can reveal other conditions that are not visible at the surface (like moisture content). When used on concrete, GPR reveals steel reinforcing bars, full-depth asphalt patches, and joint spacing, as shown in these GPR records.

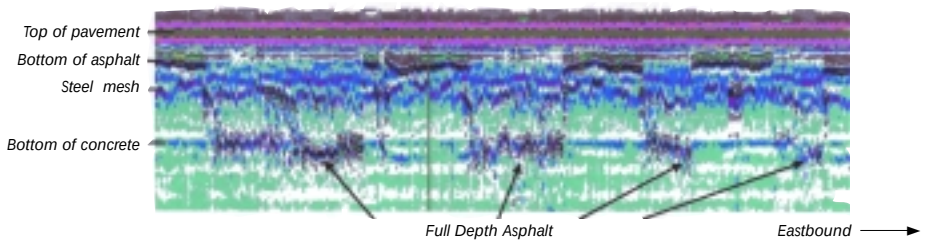


FIGURE 2:
GPR Record of Asphalt-Overlaid Concrete, Showing Evidence of Full-Depth Patching in Concrete

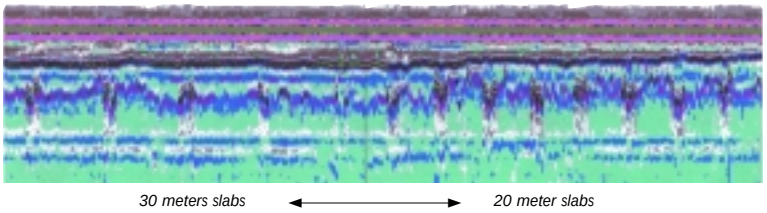


FIGURE 3:
GPR Record Showing Transition in Slab Length from 30 to 20 Meters

◆ **Greater Efficiency—** *GPR systems are fast and efficient. Radar-equipped vehicles—like those shown here—typically cover as many as 322 km per day (200 miles per day), moving at normal highway speeds. Automated data collection reduces survey time dramatically and makes the process nearly invisible to the traveling public.*

◆ **Increased Safety—** *GPR minimizes the exposure of highway workers to dangerous situations. It requires no road crews, lane closures, congestion, traffic backups, or core patching. Workers are not exposed to high-speed traffic, weather, noise, or pollution, and the traveling public escapes the frustrations, delays, and attendant safety risks of lane closures.*

◆ **Adequate Accuracy—** *GPR pavement thickness data are accurate to within 3–15 percent of data obtained through conventional core samples (Maser, 1996), levels appropriate for network-level pavement management. Accuracy varies slightly with paving material, and research has established typical GPR accuracy levels for GPR surveys of four types of pavement layers:*

FIGURE 4:
European GPR Van

FIGURE 5:
FHWA Radar Unit

FIGURE 6:
Portable GPR Equipment Mounted on Rented Vehicle

Ground-Penetrating Radar:
*Range of Accuracy for Pavement Layer Thickness Measurements**

Layer Type	*Accuracy (vs. Cores)*
New asphalt	*3–5%*
Existing asphalt	*5–10%*
Concrete	*5–10%***
Granular base	*8–15%***

**Maser, 1996*

***Requires adequate contrast between layer materials*

- Limitations— *GPR may not always be able to detect the thickness of concrete pavement or the thickness of the base layer if there is insufficient contrast between the concrete and the base below. Agencies should be aware of the capabilities of GPR and stay within those boundaries, which produce reliable results.*

Getting Started

Agencies can opt to purchase equipment and software or to contract for GPR survey services. Costs vary with the number of antennas and the vehicle and system options. Operation requires a minimum of two trained operators.

Purchase Option
(estimated costs)

- *$150,000–$250,000*
- *Radar equipment*
- *Vehicle and support equipment*
- *Software*
- *Training*

Contracted Services Option
(estimated costs)

- *$18.50–$37.00/lane-km ($30–$60/lane-mile) at the network level*
- *Equipment, operator, and driver—$1,500/day*
- *Mobilization—$500/day*
- *Data analysis (16–40 km/day [10–25 miles/day])—$500/day*

Specific costs can be obtained from the equipment vendors and survey service providers listed in this brochure. In addition, a Federal Communications Commission permit is needed each time radar is used by a State or radar vendor.

Further Information

Fernando, E. 1992. Highway Speed Pavement Thickness Surveys Using Radar. Final Report prepared for the Federal Highway Administration. Texas Transportation Institute.
- *Pavement layer thickness*

Fernando, E., and K.R. Maser. 1996. Development of a Procedure for the Automated Collection of Flexible Pavement Layer Thicknesses and Materials: Phase IIB—Final Report. Florida DOT State Project 99700-7550.
- *Network pavement evaluation*

Maser, K. 1994. Ground Penetrating Radar Surveys to Characterize Pavement Layer Thickness Variations at GPS Sites. Strategic Highway Research Program, SHRP–P-397.
- *Pavement layer thickness for long-term pavement performance*

Maser, K. R. 1996. Evaluation of Pavements and Bridge Decks at Highway Speed Using Ground Penetrating Radar. Proceedings, ASCE Structures Congress XIV. Chicago, IL. 15–18 Apr.
- *ITD—Bridge decks and pavement thickness (1995)*
- *MnROADS—QA of pavement thickness (1995)*
- *TRL (UK)—Network pavement evaluation (1993)*
- *WTD—Bridge decks and pavement thickness (1994)*

Mesher, D., C. Dawley, and B. Pulles. 1997. Application of Ground Penetrating Radar Technology for Evaluating and Monitoring Asphalt Thickness Concrete Pavement Structures. Edmonton, Alberta, Canada: EBA Engineering Consultants Ltd.

National Cooperative Highway Research Program Synthesis 255. 1998. Ground Penetrating Radar for Evaluating Subsurface Conditions for Transportation Facilities. Transportation Research Board, National Research Council. March.

Scullion, T., C. L. Lau, and Y. Chen. 1992. Implementation of the Texas Ground Penetrating Radar System. Research Report 1233-1. Texas Transportation Institute.
- *Layer thickness accuracy*