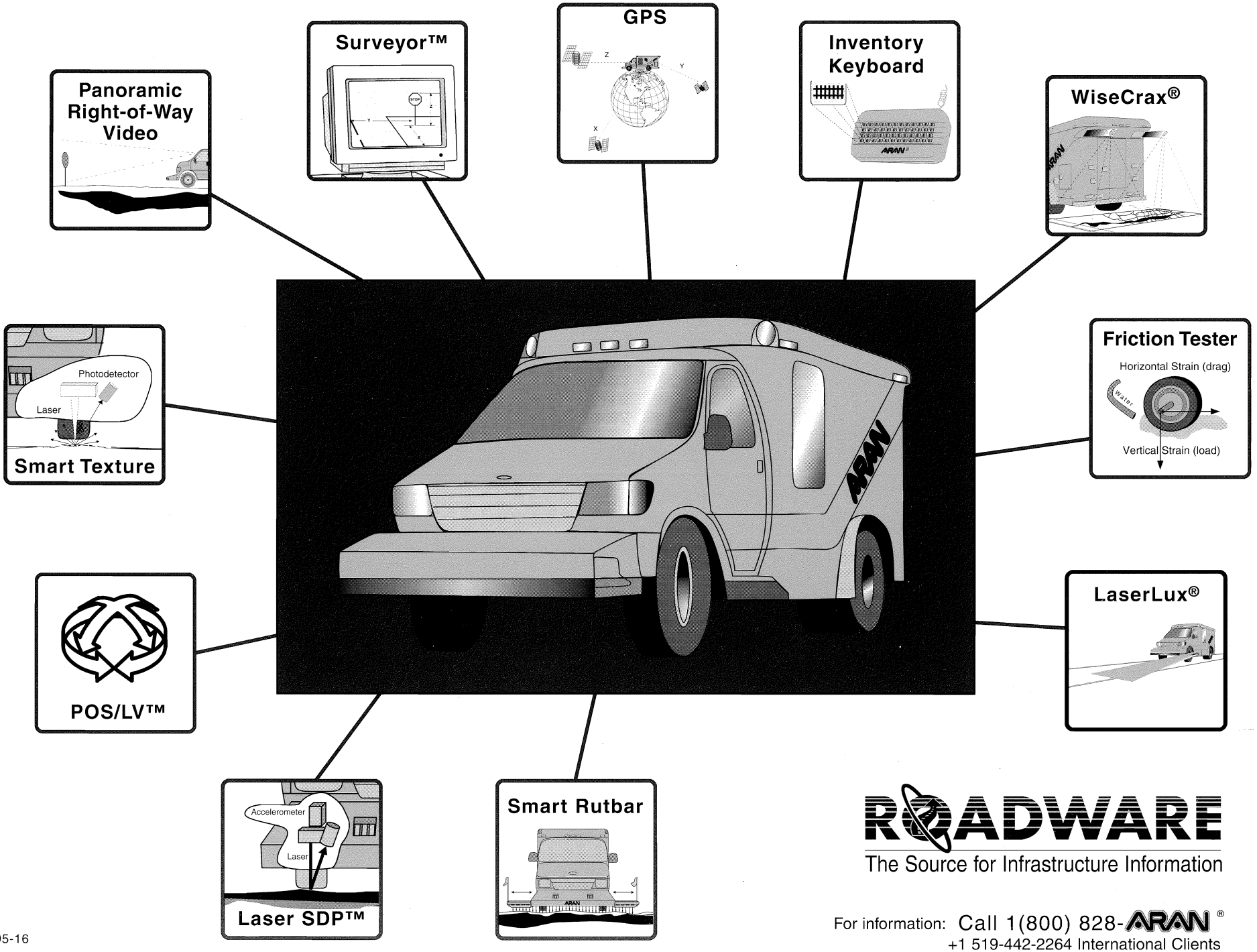

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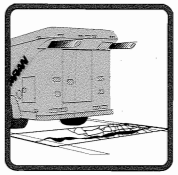
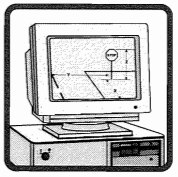
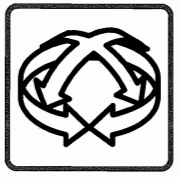
I895-16



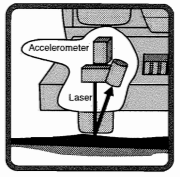
WiseCrax® is a fully automated crack detection system for pavement condition rating. WiseCrax helps to remove the subjectivity from pavement evaluation.



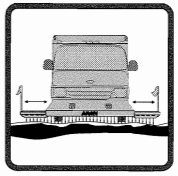
Surveyor™ Computer Scaled Video makes measurements from images recorded on videotape or other video recording media. Operators point and click to measure the location or size of signs and other road features.



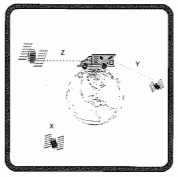
POS/LV™ (Position Orientation System/Land Vehicle) is a high precision geometrics system used to measure road crossfall, the radius and super-elevation of curves, and the grade of the road. Capable of "rod & level" survey accuracy.



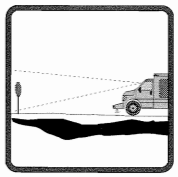
Longitudinal Profile - The Laser SDP™, produces a longitudinal profile of the road surface and determines the roughness of the road. International Roughness Index (IRI) and other indices are calculated in real-time.



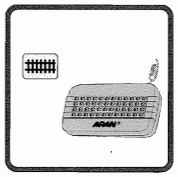
Smart Rutbar is used to calculate the transverse road profile to determine the amount and severity of rutting. Special software calculates the mill and shim quantities of asphalt to restore proper crossfall.



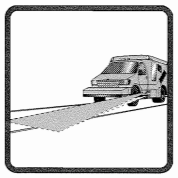
GPS (Global Positioning System) is used to determine the three dimensional coordinates in geographic space. GPS also provides latitude/longitude coordinates of roadway features to create maps using CAD and GIS.



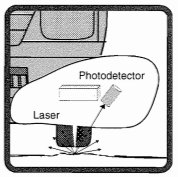
Panoramic Right-of-Way (ROW) Video produces videologs of the road right-of-way. Up to six cameras can record different perspectives (side view, rear view, etc.) simultaneously and synchronously.



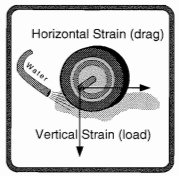
Inventory Keyboard allows technicians to record pavement condition and roadside features such as signs, bridges, culverts, guardrails, grade crossings, etc. LCD keycaps are programmable to display symbols.



LaserLux® uses a scanning laser to measure the retro-reflectivity of pavement markings. Special ARAN software enables analysis of data as well as integration into Safety Management System data bases.



Smart Texture measures the mega and macro texture of the pavement using a high speed laser mounted in the rutbar enclosure. These measurements provide an indication of surface friction.



Friction Tester uses a limited-slip wheel and a metered quantity of water to measure surface friction of pavements. Strain gauges measure the load and drag forces and an integrated microprocessor calculates the coefficient of friction.

ROADWARE

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U.S. Corporate Office
P.O. Box 209
Kylertown, PA 16847
Ph: 800-828-2726

Canadian Corporate Office
P.O. Box 520
147 East River Road
Paris, Ontario N3L 3T6
Ph: (519) 442-2264
Fax: (519) 442-3680

Roadware Digital Video FAQ's

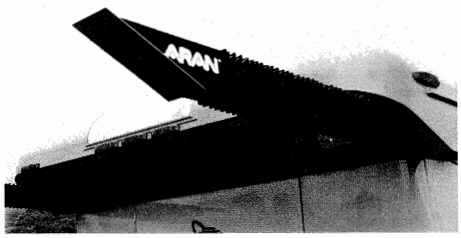
Here are a few frequently asked questions about Roadware's ARAN digital video capabilities.

**** What is the camera location?***

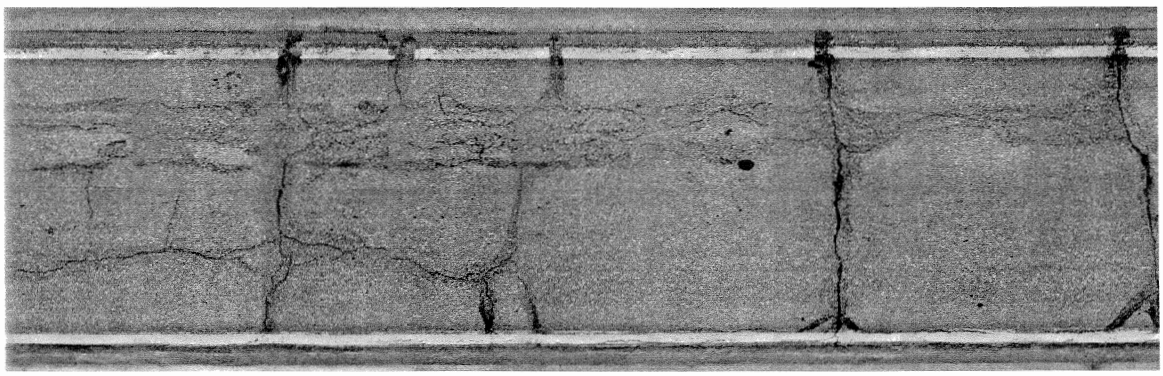
We have two types of vehicles, a type we call a 4300 and a 4900. The 4300 is a 12 passenger window van with the cameras mounted inside between the driver and passenger. Recently Tucson purchased such a system with two digital cameras.

The 4900 is a van chassis with a cube similar to that of an ambulance. In this configuration we have an enclosure on the roof that houses three cameras. It is accessible from inside the cab so that they can be easily adjusted and serviced. The state of Maine recently purchased this model and a photo of their truck is at the right.

For Pavement Video we use two high resolution cameras extending from the back of the vehicle. They point straight down at the pavement and each takes an image of one half the lane. The picture to the right shows the camera booms. High intensity strobe lights are contained in the slanted windows you see at the back. The lights are synchronized with the camera to reduce shadows from trees, powerlines and overpasses.

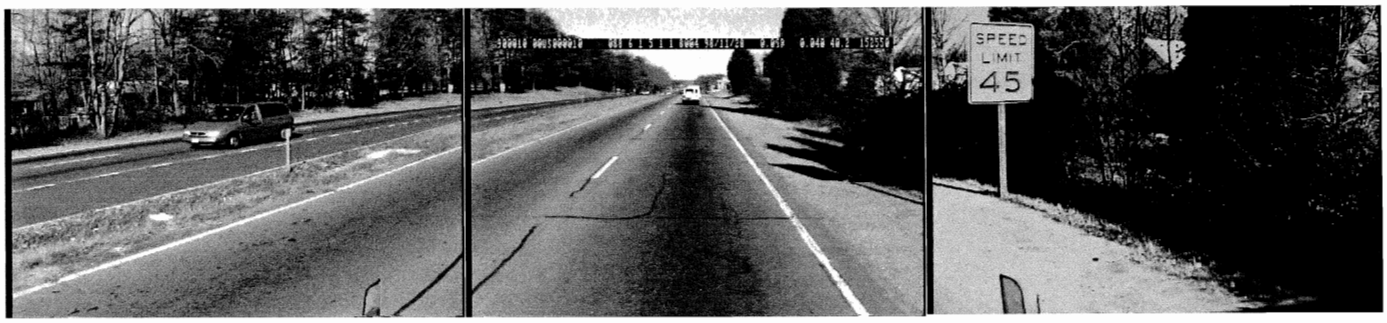


The images are recorded on one videotape and displayed seamlessly side by side when they are displayed on the office workstation. The figure below is an example of the digital image of an ACP road covering one lane wide by about 50 feet long.



**** What is the camera housing?***

As explained above, we house 5 of the cameras inside the vehicle which gives us easy access and climate control to eliminate fogging or other problems. On some of our own trucks we have mounted two side facing cameras to give a right angle perspective for guardrail inventory and condition assessment.



Sample of 3 camera panoramic video

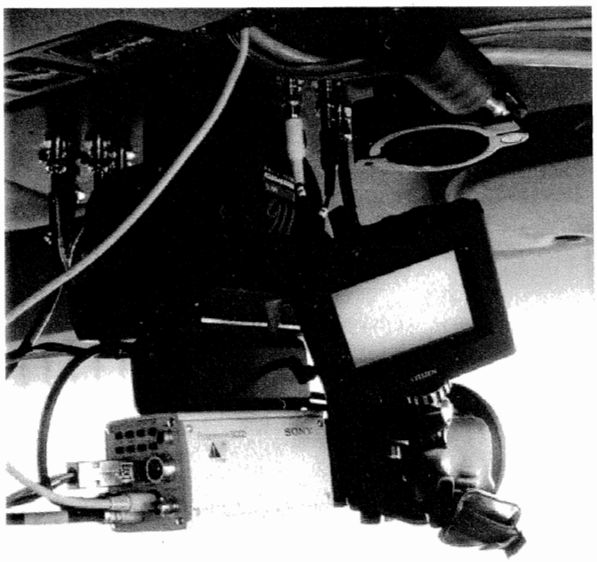
The ARANs that Connecticut DOT uses have a single side facing (right side) in addition to the forward Right-of-Way digital camera. The pavement video cameras are the only cameras mounted outside the vehicle. They are mounted in power actuated booms in a weatherproof enclosure.

**** Are the lenses fixed or wide-angle?***

We use high end commercial cameras with a wide choice of lenses (usually Nikon or another top quality brand). On some camera systems such as that used by Union Pacific, we used a wide angle lens that is specially constructed to eliminate aspherical distortion. This prevents the "fish eye" lens problems that make straight lines appear curved. Depending on the needs of the customer we configure the lens to suit their requirements using commercial-off-the-shelf components to increase reliability and reduce repair, replacement and upgrade issues.

**** Are the cameras adjustable?***

Yes, the cameras are infinitely adjustable. The camera optics and mounting are set to customer specifications for field of view and center axis. The right-of-way camera mounting is a professional grade Manfrotto head providing the user with infinite adjustment of pan and tilt. The Manfrotto mount provides a very secure lock down of camera position once adjusted for proper orientation by the operator. The figure to the right shows one of these systems mounted in a recent videologging vehicle.



** How many frames are recorded per second?*

There are two types of digital cameras we use currently. One is a digital camera with NTSC output (Sony DXC9000); the other is completely digital from start to end (DVC1300).

Camera option 1

The **Sony DXC9000** camera can record 30 frames per second either to a computer hard disk or to S-VHS videotape. The camera contains 3 CCDs and electronic shutter with auto iris controls.

Camera Option 2

The **DVC 1300** is the ultra high resolution digital camera. It has a frame rate of up to 12 frames per second. This is completely satisfactory for taking images at 26.4 foot intervals at 60 mph. At 60 mph (88 feet/second) the frame rate needs to be only 3 or 4 frames per second to capture an image at 26.4 foot intervals.

Since this digital camera records over 1.3 million pixels per image the limitation in frame rate is actually in the disk storage capacity and the bandwidth of the computer recording the images. While JPEG compression can reduce the size of the images, we avoid too much compression lest we defeat the purpose of using an ultra high resolution camera in the first place. Our experience has shown that a compression rate of 12:1 produces images so close to the original that it is nearly impossible to see any difference.

Using a 54 Gigabyte hard drive on-board the vehicle we can store roughly 1000 miles before filling the disk. Of course, we recommend downloading the images long before you fill up the disk, but the capacity is there if needed. We could even double that to 100 Gigabytes on-board the vehicle at very little added cost due to the rapid decline in prices for hard disk storage. We have recommendations on how to manage this amount of information that we would be glad to share if you wish more details.

We can, and do, use both cameras simultaneously for different purposes. The State of Vermont, for example, wants continuous 30 frame/sec video of a right hand view of the road so they can clearly see the difference between a public side road and a private driveway for right-of-way management. They also want an ultra-high resolution forward view to see as much detail of the pavement and roadside as possible. Therefore they specified both cameras in their new videologging vehicle.

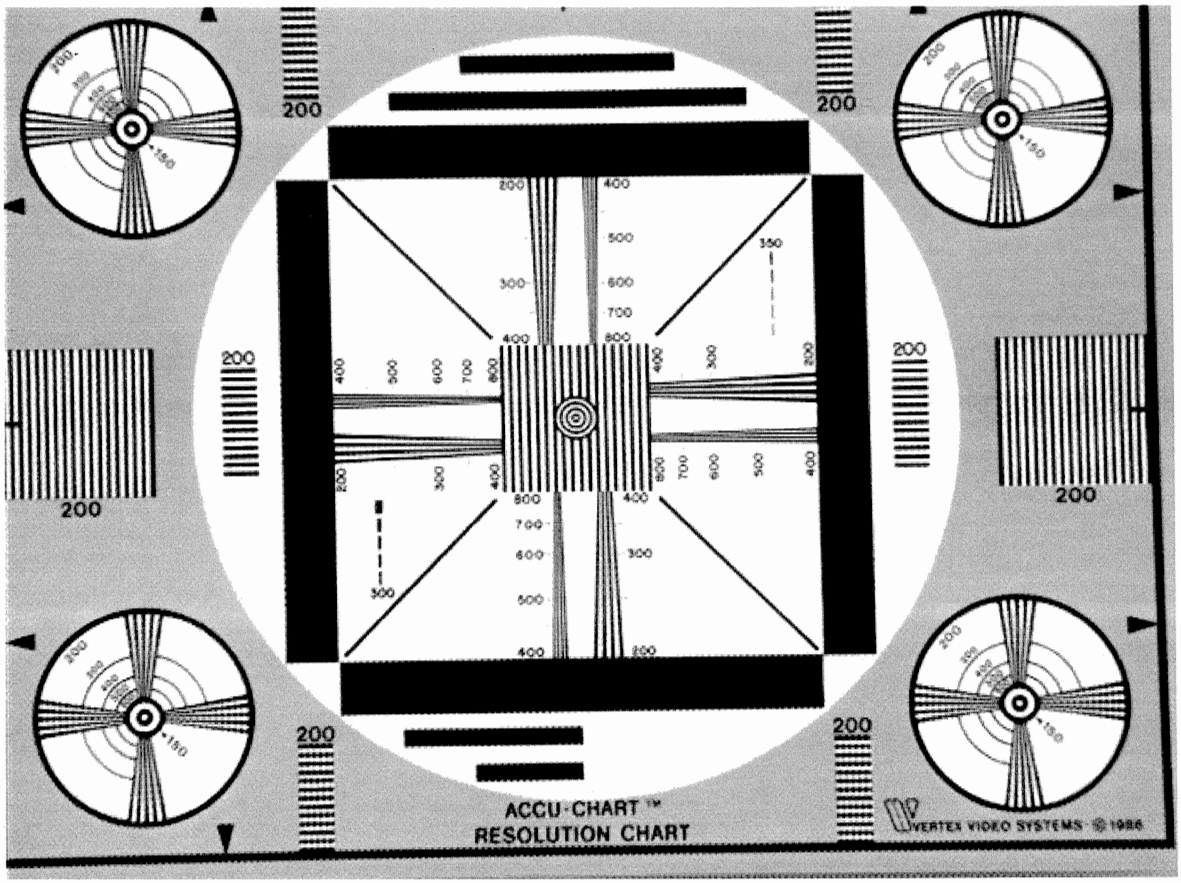
Using off the shelf components we will configure a system that best meets the needs of the end user.

** How clear are the images on the monitor?*

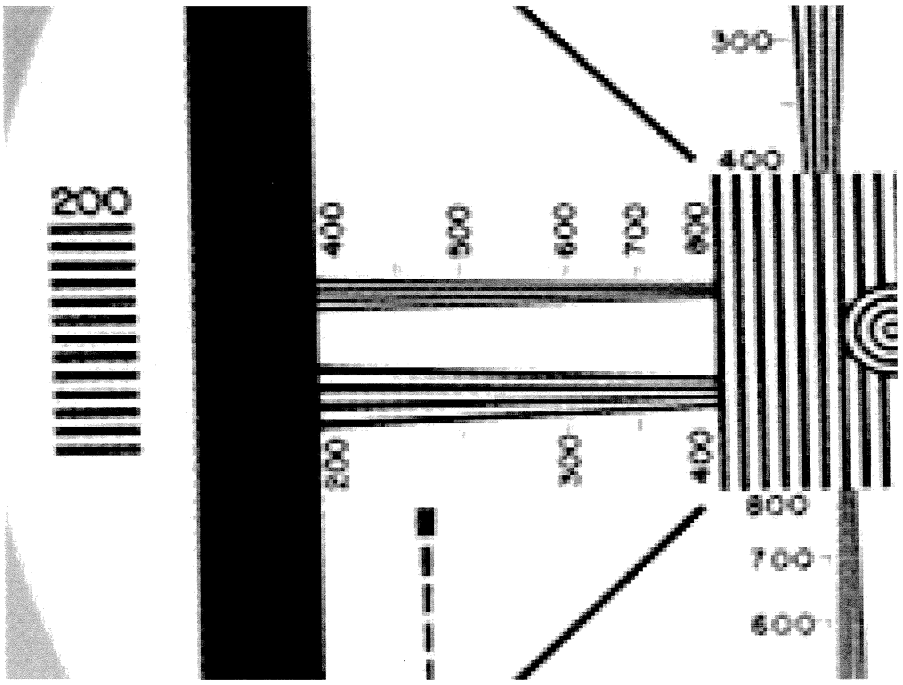
The images from both the DXC 9000 and DVC 1300 both show excellent quality. As expected, however, the DVC 1300 provides greater resolution, but the DXC 9000 is certainly acceptable quality for many applications.

The **Sony DXC 9000** records at roughly 700 x 500 pixel resolution because it uses NTSC compatible recording format. By definition, NTSC supports only 500 scan lines which is standard on North American television receivers. This is not to say that the Sony DXC is not high resolution because it truly is. It is just that digital video technology has advanced so quickly in the past 12 months that ultra high resolution video is much more affordable and feasible. As noted above, the Sony DXC still has the advantage of recording continuously to videotape at 30 frames/second.

The figure below is a standard chart used to evaluate the number of lines of resolution of a video picture.



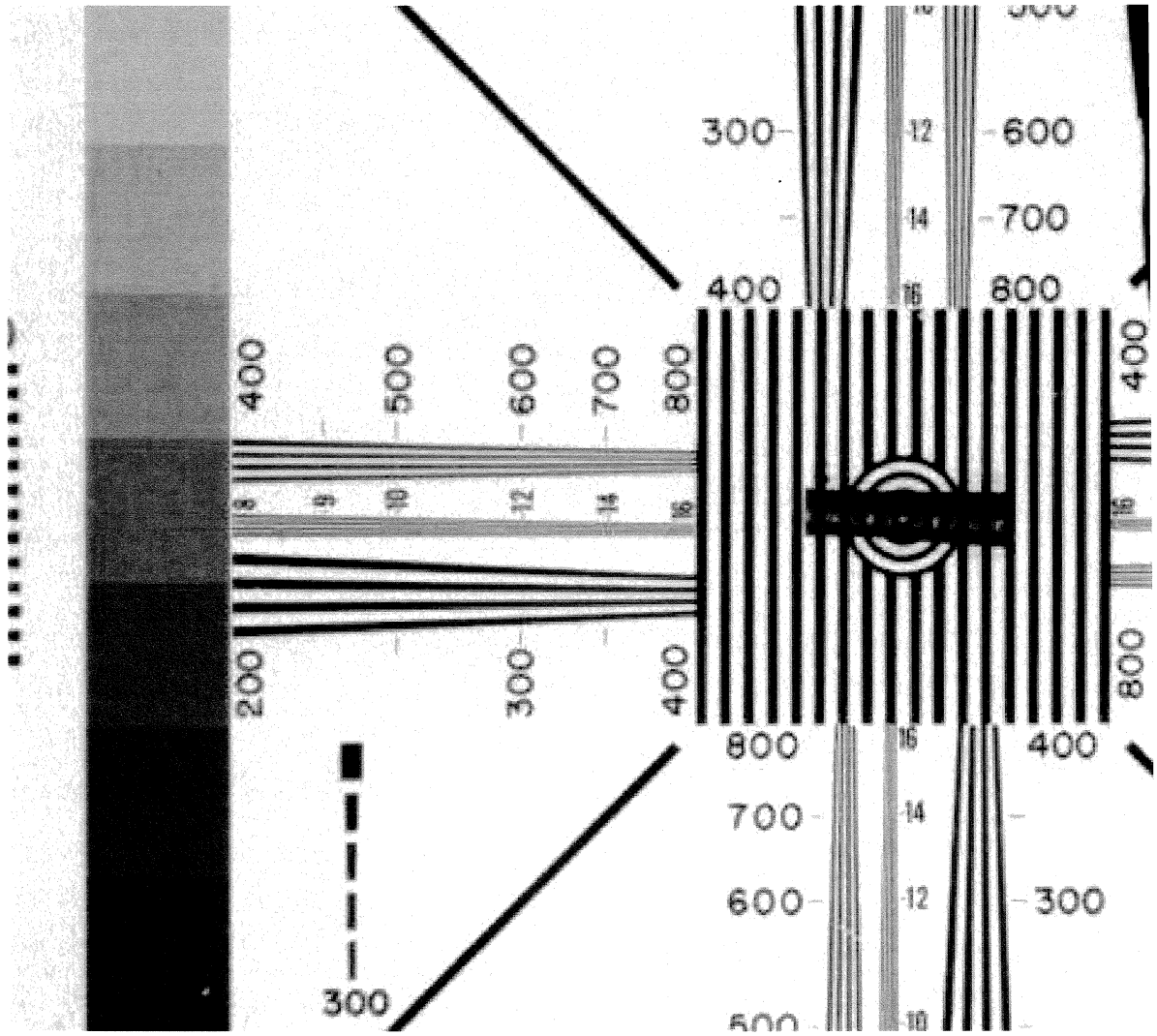
Here is an enlargement of a portion of that chart recorded using the DXC 9000 camera.



The number of lines of resolution is determined by observing the point at which you can still see four distinct lines. In this example, the resolution is between 400 and 500 lines. The picture below is an example of the output of this camera taken by the Vermont DOT using the Sony DXC 9000 and compressed to 100 KBytes in JPEG format.

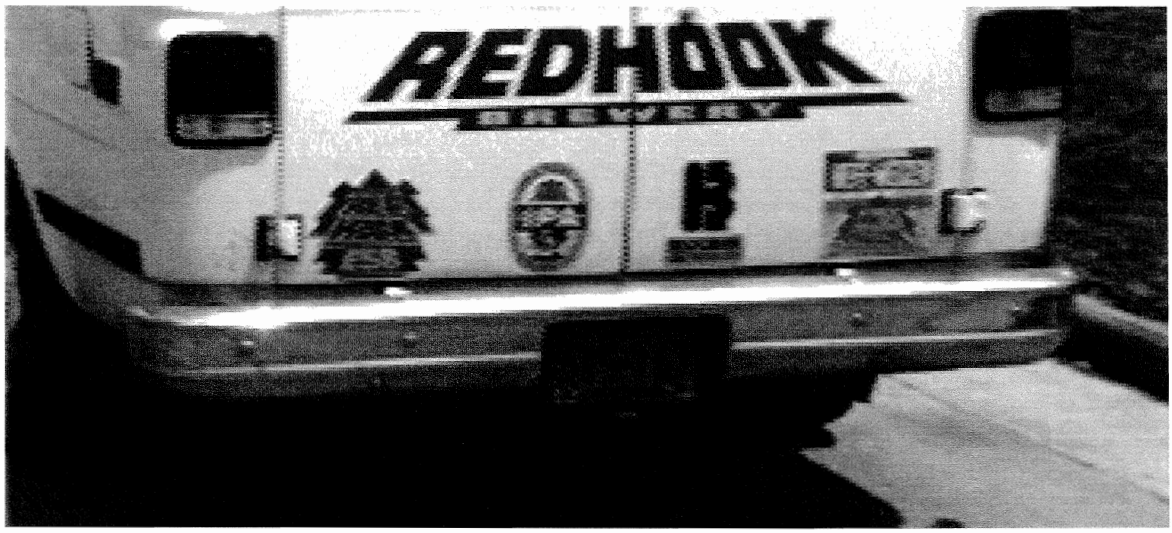
The **DVC 1300** images from the ultra high resolution digital camera are exceptionally sharp. The camera produces 1300 x1030 pixel resolution which means you can view them best using an Ultra XGA (1600 x 1200) monitor.

Below is a resolution chart showing the exceptional clarity of the image. The resolution is well in excess of 800 lines of resolution.



The image on the following page was recorded using the DVC 1300 camera. The image was recorded directly to digital disk in the ARAN vehicle and compressed to 300 KBytes using JPEG format. Higher compression rates are also feasible depending on the quality of the final image desired.

A major advantage of the ultra-high resolution video is the ability to zoom in on details. As the example below shows, you can actually read the license plate on the vehicle by zooming in on it.



Which camera to use? If you want continuous video at 30 frames per second, or want to record to videotape, the DXC 9000 produces very acceptable video for most applications. If you need the very highest resolution and can accept an image at 10 foot intervals, then the DVC 1300 is the best choice.

**** What type of computer and operating system are used?***

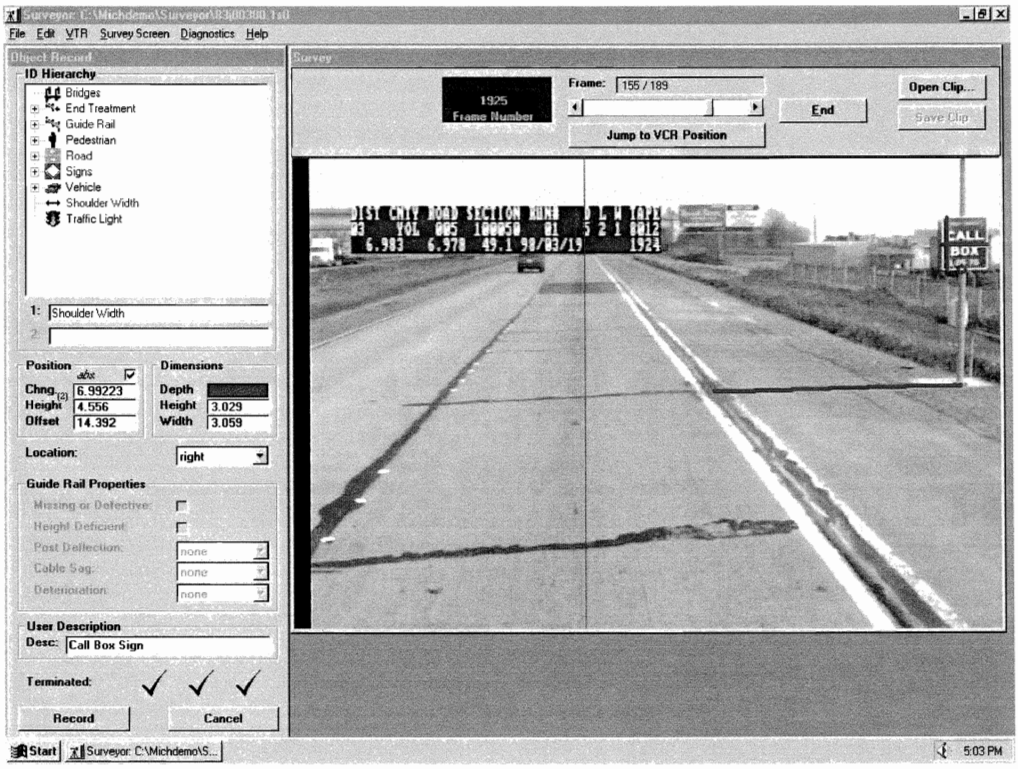
We use Pentium II and III computers operating under Windows NT

**** What software is included?***

The *standard* software for ARAN pavement data analysis is VIEW software. This provides the capability to reduce, summarize and manipulate sensor data from the roughness, rutting, crossfall, texture, etc. data.

Other *optional* software includes the following major software systems: Surveyor™, VisiData™ and WiseCrax®

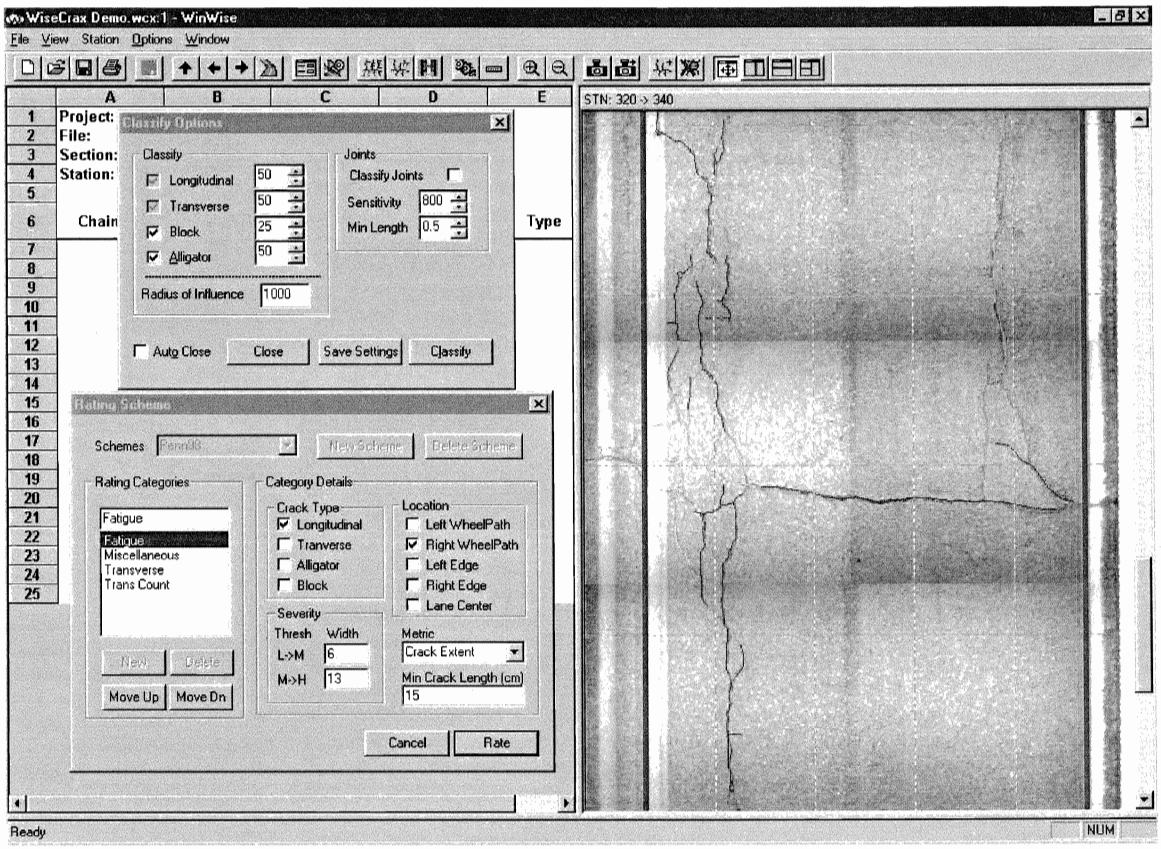
Surveyor™ is an office workstation program that allows operators to measure the location and dimensions of assets such as signs for entry into an inventory database. The images are tagged with GPS and linear reference data (milepost and offset) and can be mapped into GIS or AutoCAD type programs. Operators can add condition rating or other comments to be stored with the images.



Sample Surveyor screen measuring offset and dimensions of a sign

VisiData™ is a data visualization tool that provides the ability to display data in tabular form and in charts or graphs synchronized with digital video images. While VisiData is not intended to be a full functioned GIS, it allows the ability to associate data with maps in a simple easy to use graphical user interface. The program allows operators to search databases of pavement data using an SQL command to show data, graphs and images of roads that meet or exceed certain criteria. This is a powerful tool for quality assurance and data analysis.

WiseCrax® is an automated distress analysis program that uses image and pattern recognition techniques to analyze pavement video images objectively. By removing the subjectivity of manual distress rating, engineers have a more reliable method to determine pavement performance. Distress classification can be tailored to each agency's specific requirement whether it is SHRP, AASHTO protocol, or a combination of other classification schemes.



**** What equipment is supplied with the vehicle and/or workstation?***

Typically we provide a Pentium computer that is specially ruggedized for the vibration and conditions in a moving vehicle. We include a CD ROM writer for sensor data, flat screen monitors for viewing images and data, a printer and UPS.

For digital video systems we also include a separate Pentium computer on-board with a large (54 GB or greater) hard disk, plus whatever digital capture/recording cards are appropriate. We include a 35 GB Digital Linear Tape (DLT 7000 typically) for downloading images at high speed, and a network connection card 10/100 ethernet for downloading direct from the vehicle computer to the in house computer via ethernet networks (we also support token ring if desired)

The in-house computer is a Pentium III 500 MHz or the fastest speed available at time of delivery with AGP, a fast SCSI interface, USB and appropriate number of serial/parallel ports. The usual accessories such as keyboard, mouse, and Ultra XGA monitor are included. It would also contain the appropriate hardware to accommodate the subsystems chosen on the ARAN vehicle. Typically this would include a CD-R/CD-RW, 54 GB hard

disk, DLT tape drive, S-VHS tape player if chosen, a digital capture card, laser printer and a network connection card.

We normally provide Windows NT, SP4, and MS Office Professional as standard software on both the mobile and office computers.

**** How user-friendly is the vehicle/equipment/software?***

All of the on-board software is menu driven and designed to be user friendly for efficient operation. Calibration and real time data monitoring are available to ensure good quality control. Other features include an electronic field sheet that allows the operator to pre-load road segments and header information from the department's database. This helps eliminate missed segments and provides routing information automatically. The operator can override this at any time if schedules change during the mission due to a lane closure or other unforeseen circumstances.

Other software such as VisiData and Surveyor are designed with simple yet powerful features to help operators become as efficient as possible. Roadware uses this same software in performing data collection service contracts and is constantly improving the software to make our own operations as efficient and productive as possible.

**** Please provide additional information regarding technical support, warranties, maintenance, and lease/purchase/contract options.***

Roadware provides a one year parts and labor warranty on all equipment and software. We have a dedicated staff of 5 engineers/technicians on call 7/24 to respond to customer service requests. This staff is augmented by our production and engineering staff on an as needed basis. Telephone, fax and email support is utilized where appropriate. Software fixes and workarounds are sent out as needed. Standard operating procedures call for a service rep to visit the customer's site if a problem remains unresolved after 5 days. This can be accelerated under critical conditions if requested by the customer. A preventative maintenance call is scheduled annually as part of the service contract to perform factory calibrations. The service rep will also upgrade minor component changes and install the latest software modifications.

Roadware does not have a leasing option but has worked closely with third party companies such as General Electric Leasing who handled the Maine DOT ARAN purchase financing.

More Information

If you have additional questions or would like more information, please contact us at:

Roadware Corporation
147 East River Road
Paris, Ontario N3L 3T6
Tel: 800-828-2726, or 519-442-2264
Fax: 519-442-3680
Email: info@roadware.com
Web site: www.roadware.com

A PENNWELL PUBLICATION

NOVEMBER 1997

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Imaging systems survey roadways

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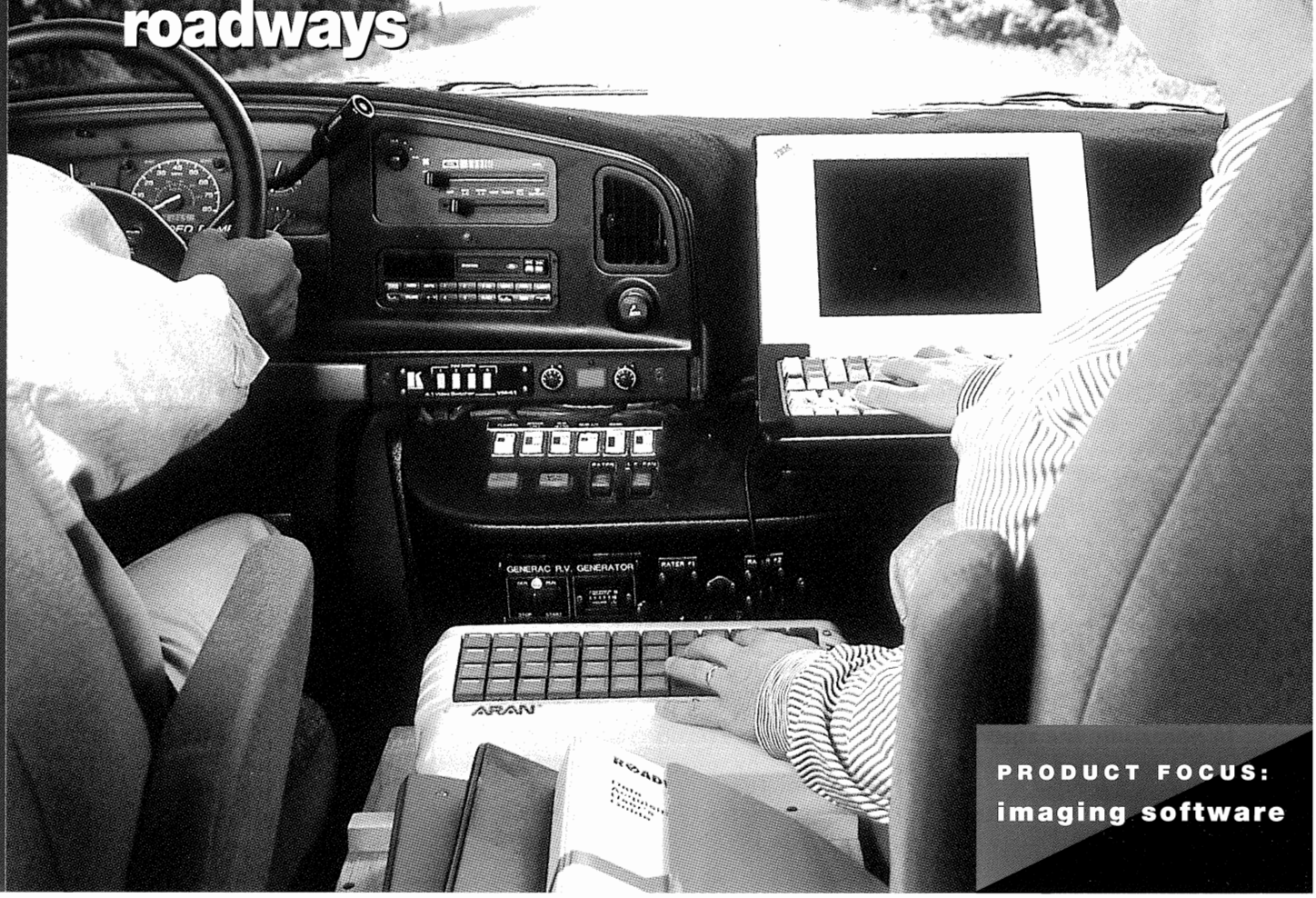


PRODUCT FOCUS: imaging software

SMART VANS WITH imaging equipment INSPECT STATE ROADWAYS

By Lawrence H. Brown, Contributing Editor

Checking, maintaining, and repairing roadways requires accurate data collection. In the past, collecting such roadway data required expensive, labor-intensive, time-consuming visual inspections. These inspections tended to be involved and prone to human errors, making them inconsistent. To solve this problem, the Connecticut Department of Transportation (DoT; Rocky Hill, CT) started photologging its roadways to create an integrated system of video images and data for storage and retrieval (see "Integrated office retrieval saves time and resources," p. 4.)

"We began experimenting in 1971 by photographing selected roadways with a video camera," explains John Hudson, DoT photolog supervisor. Unfortunately, changing technologies and strict state budgets forced the Connecticut DoT to keep changing its roadway imaging systems. Then, two years ago, the state contracted with Roadware (Paris, Ont., Canada) to design a modular Automatic Road Analyzer (ARAN) system. Today, Connecticut's DoT uses two ARAN systems to assess the condition of 12,550 km of roads and 1280 km of access and exit ramps throughout the state each year.

Integrated systems

In operation, the automated visual inspection system measures a road's slope, roughness, and pavement characteristics while simultaneously providing a video log of the roadway. Installed in a converted Ford van, the system is outfitted with front- and side-view digital video cameras, laser, and ultrasound subsystems, all controlled by five onboard computers (see Fig. 1). The collected data are used to qualify and quantify pavement, roadside, and bridge conditions.

Because the system uses multiple sensors, the collected visual, ultrasound, and laser-based data must be correlated using both local and global reference positioning systems. To tag data by mileage, the ARAN system incorporates a distance-measurement instrument from Encoder Products of Canada (Toronto, Ont., Canada). The instrument consists of a plate fitted on the hub of the van's left rear wheel. Spaced circularly around the edge of the plate are 1800 tiny windows. Located on either side of the plate, a light-emitting diode (LED) sends light pulses to an accompanying photodetector, which counts the pulses as the van travels along the roadways. The light data are then digitized and delivered to a central data-acquisition computer, located in the back of the van. Here, software is used to determine the distance traveled by the van.

All the data and images collected

Reprinted from the November 1997 edition of **VISION SYSTEMS DESIGN**

Equipping a van with imaging equipment enables the Connecticut Department of Transportation to measure and catalog roadway conditions.

by the ARAN system are referenced to longitude, latitude, and elevation parameters. This is accomplished by integrating data information from a global positioning system (GPS) into the central data-acquisition computer.

Using off-the-shelf antennae and receivers from Leica (Torrance, CA), as many as 12 GPS satellites can be referenced to provide accurate positioning information. These local and global references tag the position of the van to the visual, ultrasound, and laser-based data collected by the inspection system. Such references also provide a rapid means of finding images and data during replays.

Data inputs

To capture images of the roadways and surrounding area, two Sony DXC-9000 cameras are positioned at the front and side of the van (see Fig. 2). In operation, red-green-blue (RGB) images from the cameras are delivered continuously at 30 frames/s to a JVC digital recorder. Controlled via an RS232 interface to the central data-acquisition computer, the front-view camera is triggered to capture a frame and read it to a 9-Gbyte disk every 0.01 km. In this manner, the road-analysis system minimizes the number of captured frames (100 frames per km)and related storage requirements.

The side-view camera records at 30 frames/s. Stored on video-tape recorders, the camera data are converted from RGB to YUV format by a transcoder board from Nova Systems (Canton, CT) installed in the smart video controller.

To detect ruts in the road, the front of the van is equipped with a horizontal bar, known as a rutbar, that holds 19 ultrasonic transducers. By measuring the reflected ultrasound profile of the roadway from these transducers, the inspection system can detect ruts as small as 1 mm. An additional 18 sensors mounted on two telescoping wings of the rutbar enable 12-foot-wide coverage of the roadway. All the sensor data are then processed by a single-board computer from Ampro (Sunnyvale, CA), located in the rutbar housing. As well as digitizing the signals, this computer system also determines rut depths, which are then transmitted and displayed in real time on a van monitor (see Fig. 3).

To determine the amount of cracking of the road, the ARAN system uses a machine-vision system located at the back of the van. To image cracks, the road is illuminated with strobe lighting devices from EG&G Optoelectronics (Salem, MA) to ensure that the shadows from other objects are eliminated. Programmed by the video controller computer, the strobe lights are synchro-

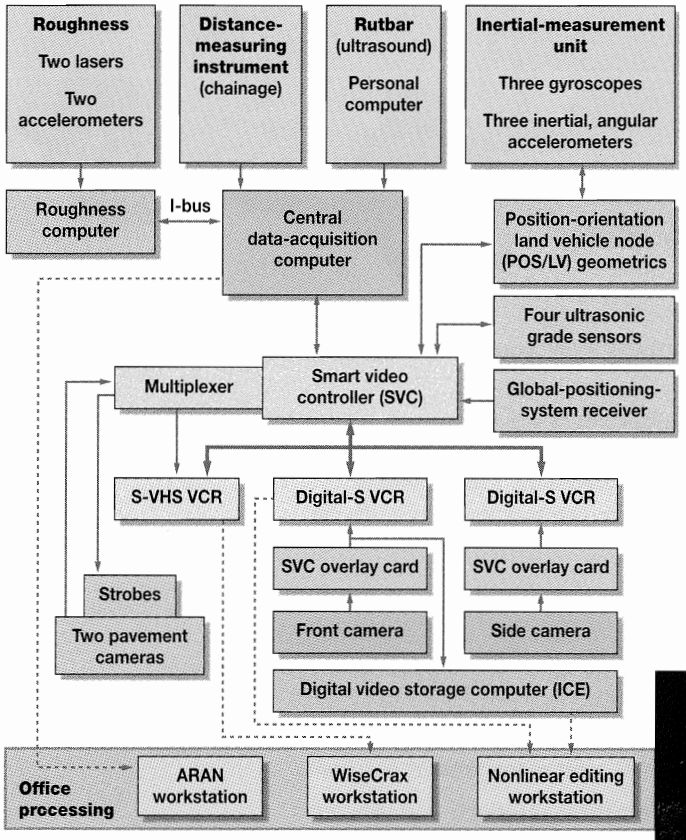
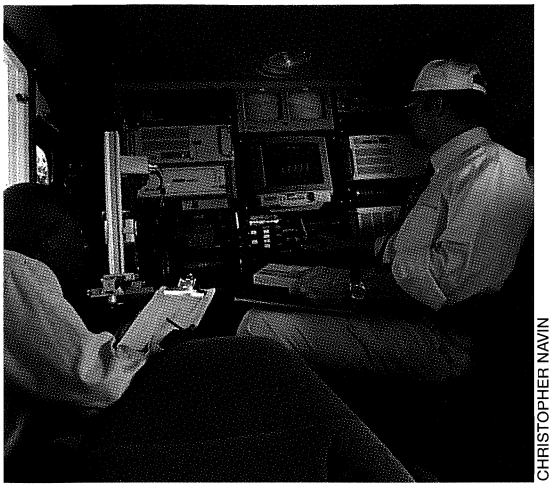


FIGURE 1. *The Automatic Road Analyzer (ARAN) field-image/data-acquisition inspection system is used by the Connecticut Department of Transportation to assess the physical condition of state roads. The integrated system, which is installed in van-type vehicles (below), is equipped with lasers, accelerometers, gyroscopes, computers and computer boards, sensors, cameras, controllers, video-cassette recorders, and graphics cards. As the van is driven on the state roadways, the inspection system automatically maps and photologs imaging, positioning, and video data for workstation processing and analysis.*



CHRISTOPHER NAVIN

FIGURE 2. *The ARAN roadway inspection system occupies the entire rear panel of a van-type vehicle. The two small monitors (center, top) display road roughness images, right and left side, respectively, for a full lane-width view. The large, multifunctional monitor (center, middle) shows front and side camera images, histograms for rutbar measurements, and menu and input screens.*

nized with two progressive-scan digital cameras from Pulnix (Sunnyvale, CA).

After capture, the road images are analyzed by a PC-based package called WiseCrax from Roadware. "Because WiseCrax uses a gray-scale-based analysis, consistent illumination is necessary to offset any stray effects," explains Steve McKenna, Roadware vice president.

Integrated office retrieval saves time and resources

The Connecticut Department of Transportation (DoT) has deployed 44 retrieval stations throughout the state for use by state engineers, technicians, and managers in planning, constructing, and maintaining roadways. Most of the stations contain a single laser-disk player, but state departments such as the Division of Traffic, where roadway monitoring is frequent, are equipped with a Pioneer IC-V330 jukebox that holds 72 laser disks.

Images and data are stored at the stations for three-year cycles. Each log-on to a station is recorded, and all inquiries are computed to show field trips either saved or reduced in time to analyze overall fleet vehicle use and fuel consumed. The DoT estimates that the state saves $1 million every year in such costs. The stations are also used by public and private legal departments to analyze traffic accidents and to help resolve conflicting or incomplete traffic information.

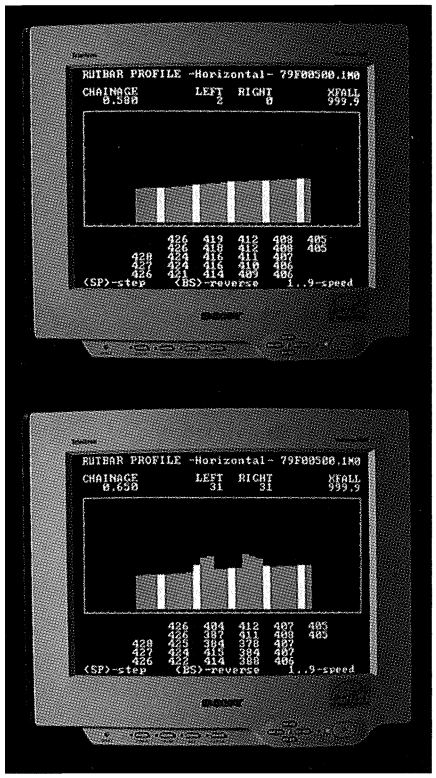
Microsoft Windows NT software is used for the operating system. It is interfaced with an application written in C to display and control the video contents window, a tool control language/tool kit (TCL/TK), and a graphical-user-interface software package to monitor the image frame numbers and process all the data associated with each image. "We chose the TCL/TK because it's a multitasking system in the public domain," explains David Burns, DoT software-development engineer. "It has the same component-building capability as Visual Basic Active X software without the added burden of its costs."

All the retrieval stations are also equipped with a Gateway 2000 PC using a 166-MHz Pentium processor, 128-Mbyte RAM, 3 Gbytes of memory, and a color printer. Because the images are in an NTSC analog format on disk, a Spectrum video board from Imagraph (Chelmsford, MA) with an on-board A/D converter processes images and supports real-time graphic overlays.

"Integration of images and graphics causes bleeding and dithering of the image," says Burns. "The video board gives the system sharp images and true colors. We have, for example, the ability to discern legends on signage as far away as 30 feet from the van."

Images are referenced by frame, route number, and route direction. The global-positioning-system data, gyro inertial reference, cross slope, roughness and rutting information, and area checkpoints, such as intersections, bridges, and underpasses, can all be accessed for any given area for an image.

L. H. B.



CHRISTOPHER NAVIN

FIGURE 3. *To detect ruts in the roadways, the front of a Ford van is equipped with a horizontal bar called a rutbar. This bar contains ultrasonic transducers, a single-board computer, and special software that produces a reflected ultrasound profile of the roadways that is displayed on a monitor inside the van. Sonograms are used to detect and measure the roadway ruts. The top sonogram shows a smooth roadway; the bottom sonogram indicates two ruts.*

The WiseCrax software helps measure the type (such as edge, transverse, or faulting), severity, and extent of pavement cracks. Left and right images, each 6 feet wide and 4.5 feet long, are seamlessly joined to provide a lane-width view of the road. According to McKenna, cracks as small as 0.10 inch wide (3 mm) can be detected by the inspection system (see Fig. 4).

Integrated replay

Final editing of the video tapes from the JVC digital recorder is performed on a nonlinear editor, PC-based workstation. This workstation contains a digital-signal processing (DSP) board from Digital Processing Systems (Markham, Ont., Canada) for nonlinear editing, SpeedRazor editing software from In-Sync (Bethesda, MD), and special software developed by Roadware. After conversion and

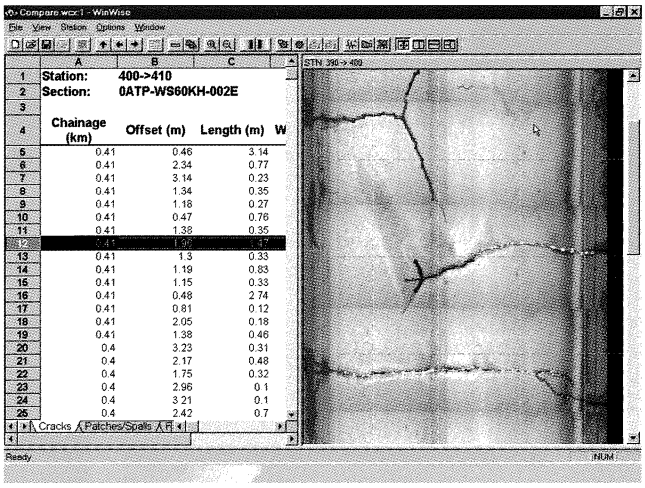


FIGURE 4. *WiseCrax gray-scale analysis software is implemented to measure the type, severity, and extent of pavement cracks in the roadways. It includes algorithms to detect particles such as oil spots that can be mistaken for road wear and to determine the length, width, orientation, and location of cracks in each video frame for every linear foot of surface. Graphic overlays are used to display the cracks on a monitor along with tabular data and header information.*

editing, the frames are written in NTSC format to a laser-disk jukebox storage system. In the jukebox, double-sided, 12-in. laser disks are used to store 108,000 images.

Front- and side-view images total about 1.875 million bytes each. The access and ramp images number approximately 100,000. All the images fill some 18 laser disks a year. These images can be accessed by laser-disk players at retrieval stations located throughout the state.

Expanding uses

US Federal Highway Administration and other states such as Massachusetts and South Dakota are using a version of the ARAN system, none has been as aggressive in adapting, deploying, and marketing roadway imaging capabilities as Connecticut. During the past year, the number of retrieval stations available throughout the state has been doubled. The DoT plans to continue that expansion as the demand for use of its photologging system continues to grow.

By combining the capabilities of both the federal and state photologging systems, a nationwide monitoring system could provide valuable roadway information for planning, maintaining, and repairing highways.

ARAN®

Automatic Road Analyzer

Automated collection of roadway data for

- **Infrastructure Asset Management**
- **Pavement Management Systems**

The Automatic Road Analyzer (ARAN®), along with its associated applications, captures a wide variety of information in a single pass of the roadway:

- WiseCrax® – Automated Crack Detection – featuring multi-camera video sources with consistent illumination
- Surveyor™ – Video-Based Roadway Inventory
- Videolog – High resolution, full-frame digital right-of-way video with 1 to 3 cameras
- Laser SDP™ – Non-contact Longitudinal Roughness Profile for computing IRI, HRI, RN etc.
- POS/LV™ – High Accuracy Inertial Reference System
- Rut Depth – using up to 37 sensors
- Roadway Geometrics – grade, cross-slope, superelevation, radius of curvature
- Surface Texture – high speed laser-based measurements
- XYZ co-ordinates – all data items tagged using Global Positioning Systems/Inertial Referencing Systems
- VisiData™ – roadway information and video at your fingertips.

The ARAN is the recognized leader in single pass roadway data collection technology. Over 100 agencies throughout the world use ARAN on a regular basis in conjunction with their asset management programs.

Along with ARAN, Roadware also offers the following complementary products and services:

- Norsemeter® – continuous and variable slip friction measurements
- LaserLux® – mobile laser retroreflectometer for measuring lane line retroreflectivity.

Roadware Corporation has been in the infrastructure data collection business since 1969. Give us a call today to learn more about ARAN, Roadware and how we can tailor a data collection program or vehicle to your specific needs.

ROADWARE *Corporation*

The Source for Infrastructure Information

1-800-828-ARAN®

International Headquarters: P.O. Box 520, 147 East River Road, Paris, Ontario N3L 3T6 Canada 1-519-442-2264 Fax: 1-519-442-3680
U.S. Corporate Office, P.O. Box 209, 1 Larson Drive, Kylertown, PA, 16847 U.S.A. 1-800-828-2726
Website: www.roadware.com e-mail: info@roadware.com

Newsletter

Summer 1999
The Source for Infrastructure Information

Data Services Contracts

Roadware expects 1999 to be another record breaking year since virtually all of our contracts utilize Wisecrax, and we have added 33% more capacity to our fleet. The following are some of our active projects:

Alabama - Roadware recently signed a two year contract with the Alabama DOT to collect PMS data and right-of-way video on 36,000 miles of Interstate and NHS roadway. This is Roadware's second multi-year contract with ALDOT. An ARAN 4900C will be used for data collection and Wisecrax/NT will perform the distress analysis. The data and images will be delivered on CD-ROM for use in conjunction with Roadware's VisiData software.

Iowa - Roadware will collect over 16,000 kilometers of PMS data for the Iowa DOT. The project includes a wide variety of pavement ranging from county roads to Interstate highways. This will be the fourth consecutive year that Wisecrax is used for distress analysis on the Iowa project. The Iowa PMS does not employ a traditional linear referencing system; rather, GPS is used exclusively for referencing the data on this project.

Pennsylvania - Two full-featured ARAN 4900Cs are hard at work in the Keystone State and are scheduled to collect 30,000 miles of PMS data and right-of-way video this year. This is our third year in Pennsylvania. For 1999, the state has opted to collect panoramic

Cont'd on page 4

Roadware's latest ARAN builds (from left to right): Belgium [Flemish Road Administration], South Africa [BKS (Pty) Ltd.], Taiwan [National Central University], North America [ARAN #9, the newest Roadware fleet vehicle].

ARANs Around the World

The photo above speaks volumes to the production marathon that has occurred at Roadware in recent months. All of this ARAN activity was in response to a flurry of contracts won over the past year.

The Flemish Road Administration contracted Roadware to build an ARAN 4900C early in 1998 but delivery had been delayed by the GM strike over the summer. The vehicle left Roadware's production facility early in 1999, certified to exacting CE standards. The Flemish ARAN is fully configured for roughness, rutting, video logging and Wisecrax automated distress.

BKS (Pty) Ltd., a major South African based engineering firm, has purchased an ARAN 4300LC. This will be the first, but not the last, ARAN on the African continent! (See Roadware Africa, page 2.)

The National Central University of Taiwan has taken delivery of an ARAN 4300. The University and their consultant partners will use the ARAN to inventory expressways for the Taiwan Freeway Bureau, major highways for the National Highway Bureau, and provincial roads on the main island of Taiwan. This is the 7th ARAN delivered to the Asia Pacific Rim.

In response to the increasing demand for Roadware Data Services, we have added another ARAN 4900C to our existing fleet. Roadware now has four fully configured ARANs capable of collecting all levels of distress data. The increase in fleet size allows us to handle the ramp up in customer contracts as well as respond flexibly to capacity demands when contract and weather delays threaten to impact completion dates.

ROADWARE Africa
Infrastructure Inventory Services for a Continent

Roadware Corporation is pleased to announce the creation of Roadware Africa (Pty) Ltd. This is a new joint venture with BKS Group (Pty) Ltd. of South Africa.

The BKS Group is a multi-disciplinary engineering firm with business in all parts of the world.

Using ARAN technology supplied by Roadware Corporation, this exciting joint venture combines the extensive expertise of the two partnering organizations to provide the most accurate and appropriate data for effective asset management in the provision, operation and maintenance of transportation infrastructure throughout the entire continent.

The South African National Roads Agency is the first customer of Roadware Africa and more contracts are being bid.

BKS representatives and Roadware staff in Paris, Ontario check out Roadware Africa's new ARAN 4300LC

Precision Scan buys Three ARAN Laserlux Vehicles

Precision Scan, a service company based in Thomasville, NC, has taken delivery of three Laserlux vehicles. The company offers its services to State and Local governments as well as private contractors to measure the quality of pavement stripes. Precision Scan is experienced in the collection, evaluation and computer analysis of retroreflectivity, color, and visibility data for signs and pavement markings.

Precision Scan has made the Laserlux 30-meter mobile laser retroreflectometer the centerpiece of its pavement marking retroreflectivity data collection activities. According to Precision Scan spokesman, Hans Jensen, "The Laserlux provides safe, high speed data collection which allows Precision Scan to provide state, local and private entities with an efficient and economical means to quantitatively evaluate the performance of pavement marking materials."

"The Laserlux has numerous unique and important features including the ability of the Laser Scanner to distinguish individual lane markings as well as plot the quality of the retroreflectivity within each lane marking," Hans Jensen continued.

West Virginia DOT is among the first states to contract with Precision Scan to use the Laserlux to measure the retroreflectivity of its line miles. The trend toward performance/warranty based evaluation of pavement markings was one of the central reasons that Precision Scan invested in a mobile retroreflectometer.

Hans Jensen has been monitoring the changes affecting traffic safety for years through another one of his companies, Flint Trading, Inc. Flint Trading, Inc. sells traffic safety products including PREMARK, pre-formed thermoplastic pavement markings and the LTL 2000 hand-held 30 meter geometry pavement marking retroreflectometer. The LTL 2000 is used for static measurements and for verification purposes.

For more information on the Laserlux pavement marking measurement services or on other products/services offered by Precision Scan, contact Hans Jensen at 336-475-7550.

Graham-Migletz Enterprises Evaluates Paint Stripes Using Laserlux

Graham-Migletz Enterprises (GME) of Independence, Missouri is a consulting engineering firm working with Federal, State and Local officials to build efficient pavement marking management programs. GME is using ARAN Laserlux as a major tool in their evaluation process.

Highway agencies spend millions of dollars each year painting traffic lines to ensure the safety of motorists at night and in bad weather. GME helps them to develop performance standards and procedures to maximize the return from their investment.

New mobile devices are becoming available for retroreflectivity measurement, and highway agencies need specialized expertise in deploying such devices effectively in an overall pavement marking management program. With more than 15 years of highway safety and traffic engineering experience, GME has the expertise necessary to aid highway agencies with this important task.

As part of its association with the Federal Highway Administration (FHWA), GME has been involved with all phases of the development of the mobile Laserlux retroreflectometer equipment including initial testing, development of equipment and marking acceptance criteria and in-service evaluations of a wide variety of pavement marking types.

Working with the FHWA and highway agencies such as the Michigan DOT, GME has experience building all portions of a transportation department's pavement marking monitoring program, from the short-term assessment of contractors' performance to overall service life evaluations for entire pavement marking systems. For additional information, contact James Migletz or Jerry L. Graham at 816-254-1788 or at jmigletz@aol.com.

Tucson Right-of-Way Video Log ARAN - Workstation within a data collection vehicle

Historically, data collection and data processing have been two separate processes performed by different resources in different environments. After the data is collected on the road and preliminary quality checks performed, it is sent to the office for processing. The detailed study of data is done at the office workstation where the capability of the computer system is designed for processing, editing and reporting, with in-depth quality checks throughout all procedures. If these capabilities were available in the collection vehicle, the overall cost of producing results from the data could be reduced.

Roadware has now delivered an ARAN to Tucson, AZ that can collect, process, and report information about the road from its on-board instruments. Two integrated computer workstations, each running Windows NT, allow two users to simultaneously review and report data, steps that would otherwise take place in an office environment. New developments with the Surveyor software have allowed measurements to be taken directly from images stored on a hard disk. To round out the features of the ARAN, computer equipment such as network hubs, CD-writers, Jazz drives, and a laser printer were also installed.

This ARAN also has two Surveyor cameras that record directly to a computer hard drive. The resolution of the full-frame cameras are maximized by digitizing the camera signals in real-time and recording the digital data to a hard drive. The ARAN is also fitted with a POS/LV fiber optic inertial navigational system and an Ashtech GPS system capable of real-time differential corrections which records position to sub-meter accuracy.

City of Tucson's ARAN incorporates two on-board computer workstations

POS/LV Enhancements

In 1995, Roadware Corporation introduced a highly advanced position and orientation measuring system (POS/LV™) as an upgrade to its standard GYRO package. With enhanced measurement of vehicle roll, pitch and heading, other on-board systems and office applications relying on this data reflect an increase in accuracy and repeatability.

This year, POS/LV has been completely re-engineered to provide a broader range of capabilities with improved reliability and performance. Hardware improvements include:

- A new Inertial Measurement Unit (IMU) incorporating Fiber Optic Gyros (FOG) with solid-state accelerometers for superior reliability.
- An integrated GPS receiver facilitating real-time position fill-in.
- Support for a second receiver for real-time, differential corrections.
- An enhanced navigation 'engine' blends inertial measurements with GPS and DMI measurements for position, attitude, dynamics and velocity updates at up to 50Hz (3x that of the original POS/LV).
- The improved initialization algorithm no longer requires vehicle to be at rest.

Software and control improvements include:

- Support for simultaneous distance-based and time-based data streams.
- Time-based data includes geographic position and velocity, vehicle attitude (roll, pitch and heading), vehicle dynamics (accelerations and rates-of-change of attitude) and vehicle (x, y, z) velocities.
- Superior fault detection and recovery from hardware failures (the software automatically recovers from a hardware reset without necessitating a complete system reboot).
- On-the-fly configuration changes are dynamically integrated into the POS/LV hardware (in virtually any mode of operation).
- Roll, pitch calibration algorithm to zero-out subtle offsets between the measured attitude and the 'known' attitude.
- POS/LV automatically 'remembers' the vehicle's previous geographic position and can use this data to speed-up system initialization in the event that a GPS fix is unavailable.

The new POS/LV has been incorporated into an ARAN delivered to the City of Tucson in the fall of 1998.

Cont'd from page 1

ROW video that will be deployed at the district level using VisiData.

City of Brampton - Roadware has been working with Brampton since 1987. This year we'll collect another 350 kilometers of data and video. Whoever said 13 was not a lucky number?

Region of Peel - Recently Roadware was awarded a contract to collect almost 900 kilometers of PMS data and video for the Region. Peel has opted for the state-of-the art Wisecrax distress analysis system and will also receive pavement and ROW JPEG images for use with VisiData.

RPUG '99

Roadware will once again exhibit at the Road Profiler Users Group Meeting to be held in the fall in Phoenix, AZ.

1999 North East Pavement Management Conference

The North East Pavement Management Conference will be held this year in Sherburne, VT, November 3-4. Roadware will be there.

 Published by: Roadware Corporation, 147 East River Road, Paris, Ontario N3L 3T6 Canada Phone: 519-442-2264, Fax: 519-442-3680
Website: www.roadware.com e-mail: info@roadware.com

For more Information Call 1-800-828-ARAN

ROADWARE Corporation
P.O. Box 209
Kylertown, Pennsylvania 16847
U.S.A.

global positioning systems

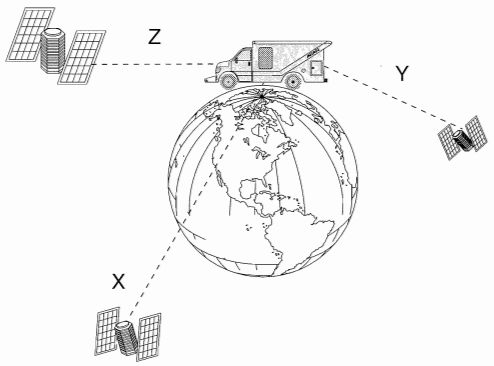
GPS is used to provide location coordinates of roadway features and to create maps using CAD or Geographic Information Systems.

The ARAN® GPS is integrated with other subsystems so that if the receiver cannot lock onto enough satellites to determine its position, and satellite lock is lost, the ARAN Distance Measuring Instrument (DMI) and the ARAN Inertial Reference System (Smart Geometrics or POS/LV) will fill in the gaps.

The accuracy of the system depends upon the mode of operation:

- stand-alone mode: with one ARAN mounted receiver the system is accurate to 50 - 100 meters (± 164 - 328 feet).
- differential mode: an auxiliary base station is employed. The data from the base station and the mobile survey vehicle are merged during post processing to achieve sub meter accuracies.
- real-time differential mode: a real-time GPS mode where differential corrections are received from satellite or FM transmitters. Accuracy is ± 2 to 5 meters.

Roadware uses a twelve channel mobile receiver and OmniStar Real-time Differential GPS . OmniStar is a satellite differential correction service used to eliminate the need for fixed base stations.



Features and Applications

Use to build an inventory of roadside features (bridges, guard rails, rail crossings, etc.)

The data is commonly formatted in UTM coordinates.

The data can also be output in plain ASCII and in DXF formats for importing into CAD and GIS systems.

Real-time differential correction available with satellite or FM services.

All ARAN data including video can be tagged with GPS coordinates.

wisecrax

WiseCrax® is a new crack detection system developed by Roadware. Cracks as small as one millimeter are detected and analyzed automatically.

High speed cameras on retractable booms record sharp, clear pictures at variable highway speeds up to 80 km/h (50 mph). Video is recorded as a continuous series of non-overlapping, high contrast images 1.5 m by 4 m (4.9 ft by 13 ft).

Synchronized strobe lights eliminate shadows from trees, bridges, tunnels, and other overhead objects even in bright sunlight.

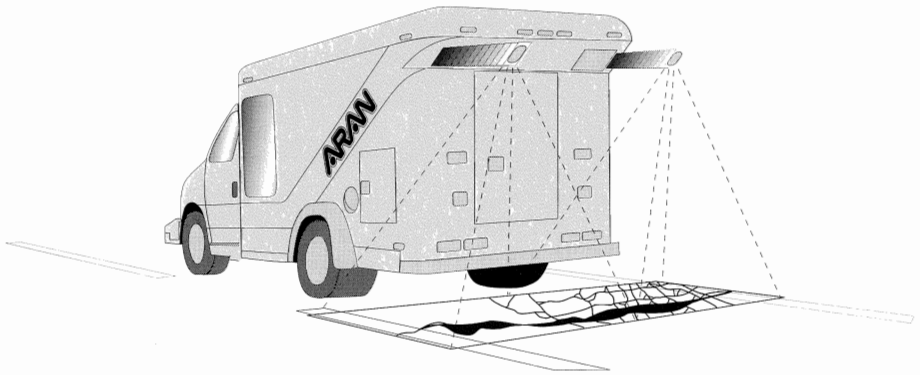
A day's worth of video images is processed off-line overnight at the office workstation by a unique open architecture process using advanced image recognition software.

Reports are produced describing crack length, width, orientation, and location. Crack maps are easily produced and printed on a laser printer for hard copy output.

A unique symbiotic design enables the pavement engineer to interact with the computerized analysis process, to apply sound engineering judgement and experience to the automated outputs.

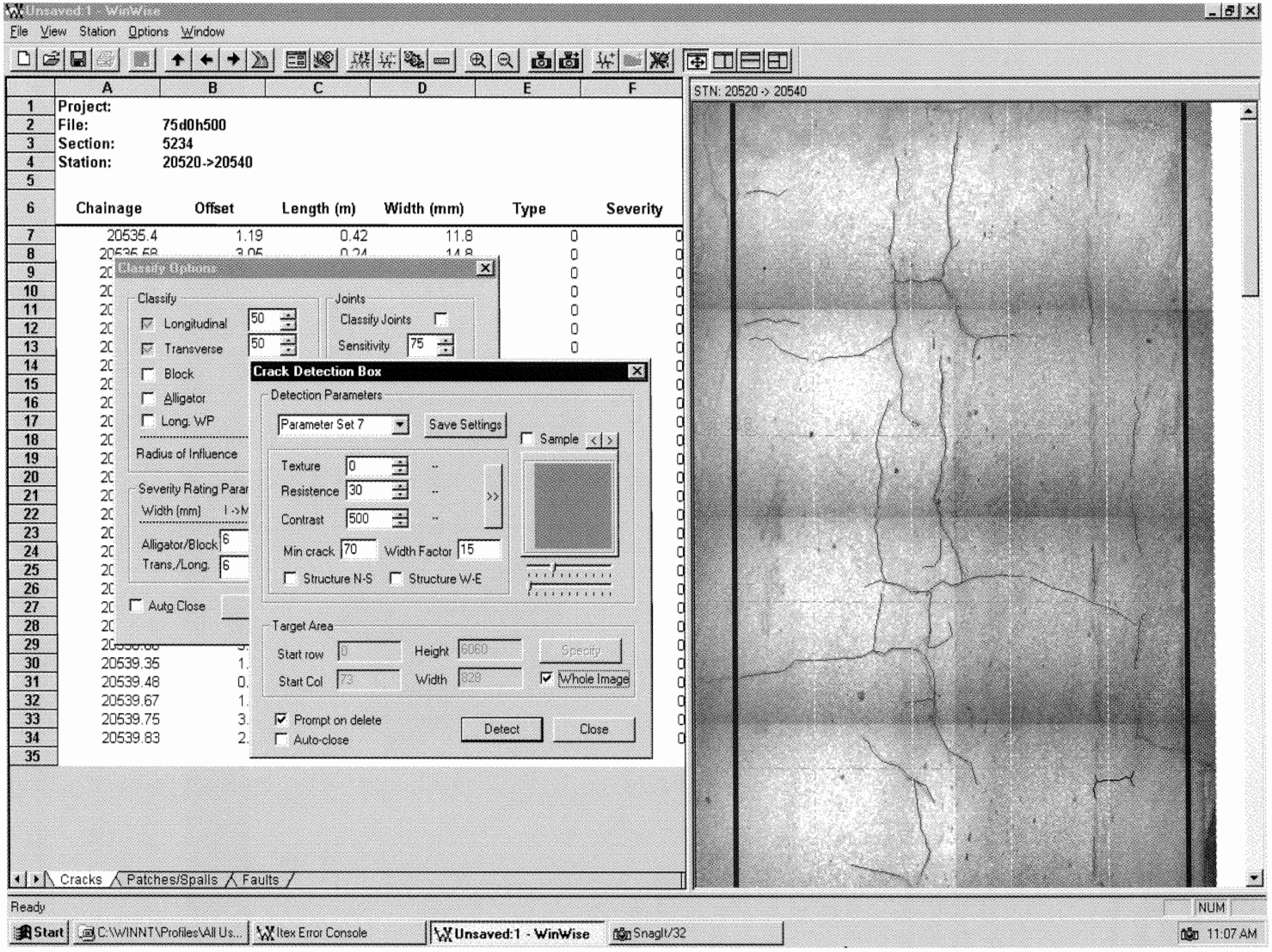
WiseCrax helps to remove the subjectivity and drudgery from pavement evaluation and ensures more accurate, repeatable comparisons of road deterioration from year to year.

The open-architecture software design makes it possible to adjust WiseCrax to suit local conditions and distress criteria.



Features and Applications

- Prepares crack maps automatically
- Totally Automated
- Reports crack length, width, orientation, and location
- Detects and analyzes cracks as small as 1 mm (0.04 in)
- Dual video cameras record 1.5 m by 4 m sections of pavement
- High intensity strobe lights produce shadow free images even in bright daylight
- Compatible with GIS for automatic mapping of pavement distress
- Eliminates hazardous and expensive walking of pavements
- Crack mapping can be done without disrupting traffic flow
- Helps agencies meet ISTEA mandates for PMS data collection
- Interactive, symbiotic and open architecture design



WiseCrax Screen showing automatically detected cracks overlayed on pavement image.

surveyor

Surveyor™ is a unique patented computer scaled video measurement system. Surveyor compatible video from the ARAN® visually captures and accurately locates roadside features, while moving at highway speeds.

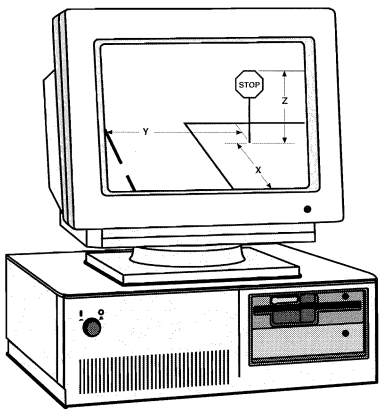
The Surveyor system establishes the location of features through the use of the Distance Measuring Instrument (DMI), and optionally with inertial gyro systems and GPS. Each video frame is tagged with a computer readable reference and recorded to tape, CD-ROM or other digital disc.

At the ARAN Office Workstation, each video frame is automatically digitized. An operator interactively selects roadway and roadside features to be located by pointing and clicking with a computer mouse.

Object dimensions are measured to an accuracy of better than six inches. Object location with respect to the camera position is measured to an accuracy of six inches in the lateral (horizontal) and vertical planes, and better than 30 inches in the longitudinal (depth) plane.

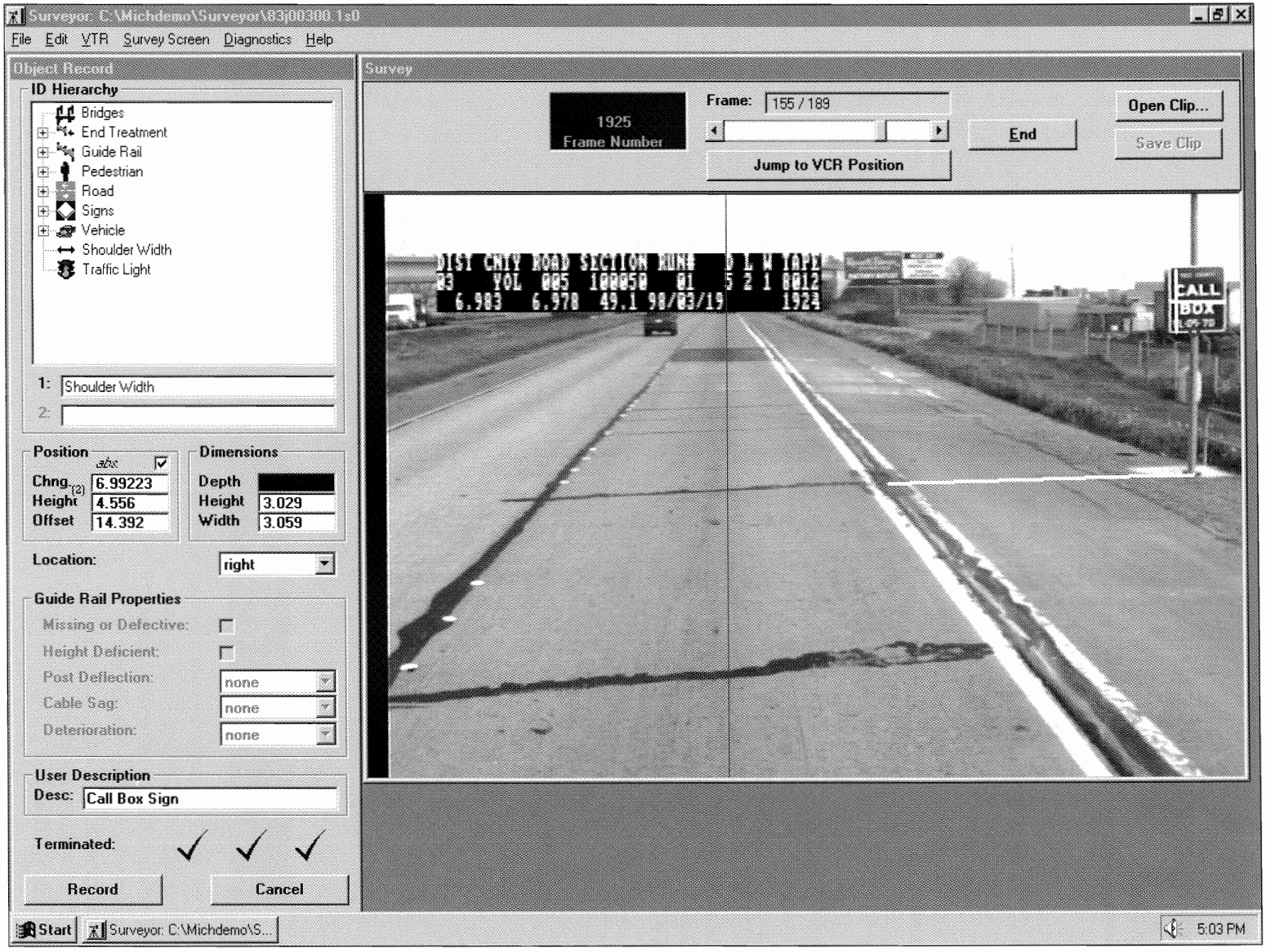
The Surveyor subsystem, like all other ARAN subsystems, is totally modular and can be integrated with other ARAN modules such as Global Positioning (GPS), that will allow it to become an integral part of a Geographic Information System (GIS).

The located features are inventoried into a GIS coordinate or Chainage & Offset database format. A plan view map can be generated using Intergraph, ARC/INFO, or AutoCAD.



Features and Applications

- Perform efficient and accurate roadway surveys
- Create sign and feature inventories
- Safe data collection at highway speeds
- Computerized video reference
- Determine offset measurements
- XYZ Coordinate referencing
- GIS compatible data
- Interfaces with Intergraph, ARC/INFO, and AutoCad software
- Integrated with:
  - Global Positioning System (GPS)
  - ROW video
  - POS/LV Gyroscopes
  - Chainage DMI
  - Digital Video Workstation



Surveyor™ running on Windows NT, locates sign with offset measurements and sign dimensions.

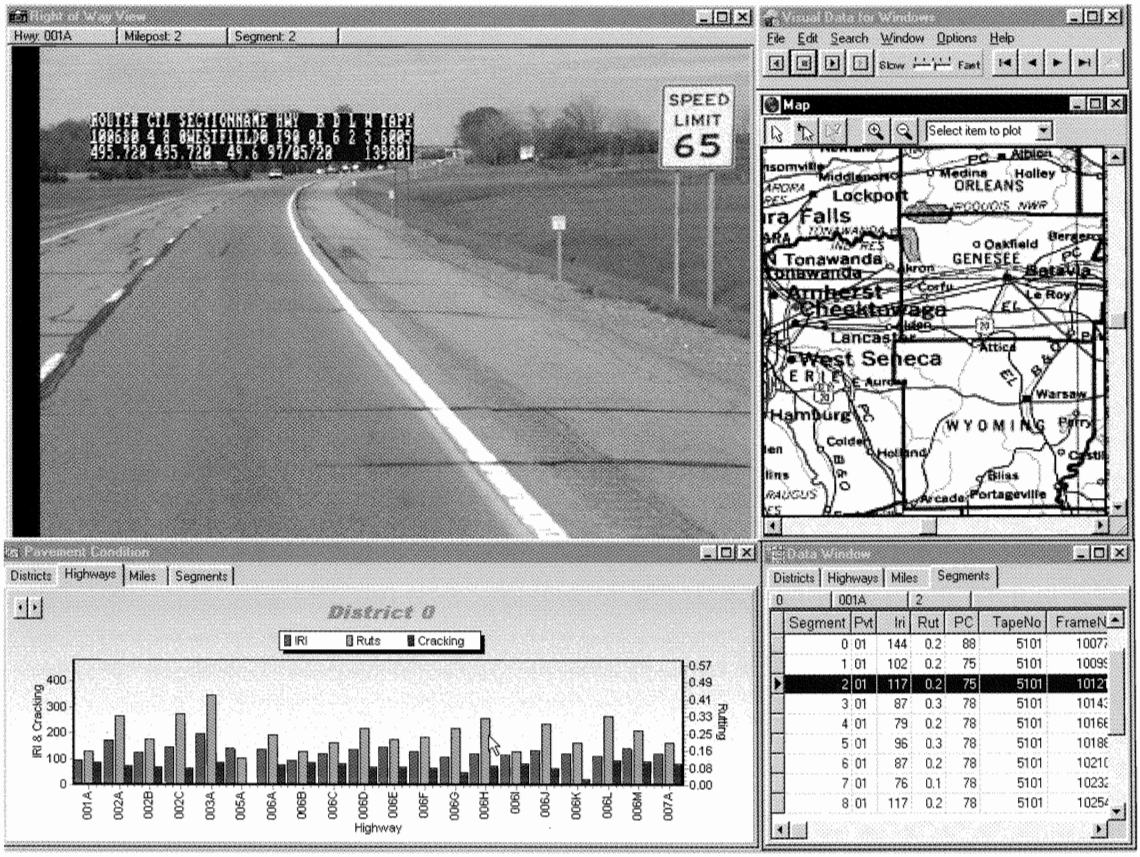
visual data presentation

COMPUTER VIDEO WORKSTATIONS

Roadware has extensive experience in the development of custom software for video workstations and equal experience in configuring hardware for such operations. Roadware currently offers several video based workstation software products including Surveyor™ for Windows NT and WiseCrax® for Windows NT.

Videotape and CD ROM ROW Viewing

A visual data presentation program, VisiData, provides the ability to review ARAN processed data. This program, which was developed by Roadware, allows the operator to display multiple windows, each containing different combinations of data in graphical as well as tabular form.



Data such as roughness, rutting, cross slope, etc., at various points, can be displayed at detail or summary level along with digital images by specifying reference locations. The data can be presented at various summary levels starting at the highest level which might be the entire road network or District. The user can point and click on an element such as Route number to drill down to see the data at the individual section level.

Location based video playback: The operator will be able to select section to view video from the starting location by entering LRS locations and offset. If non-primary (rear-pointing) video is selected as an option, the ability to chose camera view will also be included.

Video tape will start playback at the location selected. The operator will be able to control the speed of video playback as necessary. If a CD-ROM has been made of the section of interest, this may also be used for playback with similar functions to the video tape.

In addition to the video data, other data collected as part of the contract will be viewable. This data will be reported by section or by smaller increment as defined by the operator.

Video CD-ROM Capability: As an option, Roadware offers the ability to create CD ROMs which contain both pictures as well as road data. Operation of the Roadware Video CD-ROM creation software consists of three parts.

1) Edit List Generation: The software will let the user generate an edit list based on data including County, Route, segment, and a user defined interval (e.g. 10 meters). Multiple segments can be entered. The software will keep a running check of the number of frames entered and memory requirements and report back remaining space on a CD-ROM. The system will allow edit list creation for up to 4 CD-ROMs at a time. It should be noted that a minimum of 3.0 gigabytes of hard drive space must be left free for 4 CD-ROMs to be made at a time. The software will also allow further editing of the edit lists to remove specific sections or to add selected locations as desired.
2) Image Capture and Compression: Once the edit list is complete, Image Capture and Compression will occur. The software will prompt the user to load in the tapes as required. The control of the VCR is automatic through software. The tapes will be forwarded to the proper location, the images will be captured by the frame grabber, and then compressed and stored to disk. If a new tape is required, the software will prompt the user to load a new tape. Roadware recommends using a JPEG compression algorithm for compatibility.
3) CD-ROM Writing: The software will next prompt the user to enter a CD-ROM. The software will then write the video images and any other required information to the CD. If multiple CDs are to be made, the user will be prompted to load in another CD.

Inventory Capability: Road inventory is in large part a linear process well suited to using video-tape as the input media. During videotape playback, the operator will have the ability at any point to select an image for digitization. Once selected, the software will prompt the user to identify the "type" of object to be inventoried. This type will be one of several "types" previously defined by the operator or system administrator. Once the type is selected, a data entry box will pop up and prompt the user to enter attributes associated with the type. These attributes will have been previously defined by the user or system administrator. Once this operation is finished the data will be stored in a general purpose database format including:

- Compressed video image
- Tape identifier, frame number
- Location, latitude and longitude
- Operator defined type and entered attributes
- Other roadway data

This information can then be recorded to a CD ROM, exported to a GIS system, etc. as required by the customer. It should be noted that in addition to the Video it will also be possible to record the database information on CD-ROM as desired.

Verification of all operator input will be requested by the software, and where the possibility to overwrite data occurs, the operator will be further prompted for verification. A multi-level password system will allow controlled access so that only certain users can manipulate data, while others can only read data.

laser sdp

The Laser SDP™, developed by Roadware, overcomes problems associated with conventional ultrasonic technology based profilers. Ultrasonic sensors operate at relatively slow sonic velocity and consequently do not identify short wavelength irregularities such as a speed bump.

This is a serious shortcoming since corrugations and short bumps under two feet contribute significantly to road roughness, vibration and discomfort.

The high speed Laser SDP samples more frequently at 50 mm (2 in) intervals. Consequently, the Laser SDP measures bumps as short as 100 mm (4 in) and can measure at variable speeds up to 100 km/h (60 mph) without loss of accuracy.

Two lasers, one over each wheel path, measure the vehicle's height above the road. Accelerometers monitor the vertical forces caused by surface deformities.

This profile data is used to calculate the roughness (riding comfort) of the road surface.

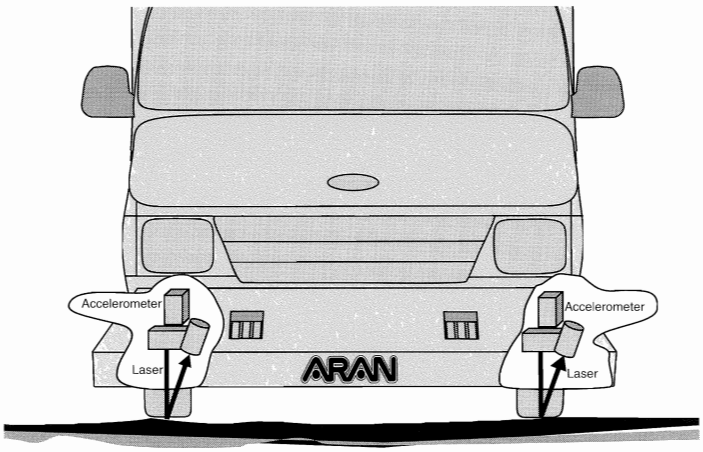
The International Roughness Index (IRI) and other indices are calculated in real-time, a feature which saves significant office data processing time and effort. Data is also recorded on computer disks for further processing if desired.

Faulting of concrete pavements is also measured and reported using special fault detection software.

The Laser SDP meets US FHWA specifications for a Class II HPMS profiler which is the highest level for automated data collection.

The Laser SDP also meets or exceeds specifications for the ASTM Class I profiler which again is the highest performance level possible.

The excellent accuracy and repeatability of measurements made by the Laser SDP makes this subsystem an excellent choice for project level applications such as monitoring project acceptance, enforcement of "end-result" specifications, etc.



Features and Applications

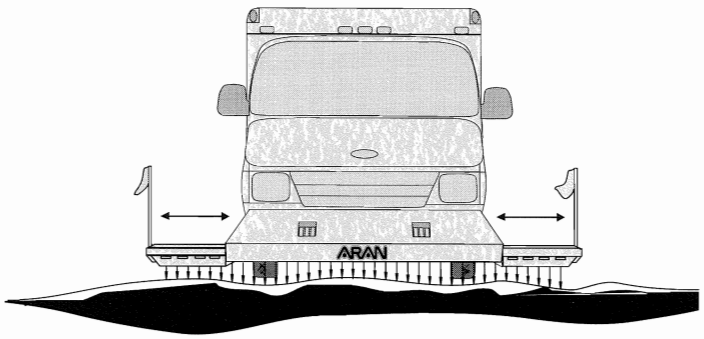
- Lasers and accelerometers measure roughness in each wheel path
- Integrated with Distance Measuring Instrument (DMI) for precise location information
- Develops a complete longitudinal profile
- Measures concrete joint faulting accurately
- Not affected by surface texture as are some ultrasonic sensors
- Samples surface at 50 mm (2 in) intervals and reports bumps as short as 100 mm (4 in) or as long as 100 m (328 ft)
- Measures at variable highway speeds up to 100 km/h (60 mph) without loss of accuracy
- Calculates IRI or other specified indices in real-time
- Calculates other ride and comfort indices
- Reports roughness for each wheel path or combined as required.
- Generates graphs charts and tabular reports
- Meets Class II FHWA profiler specifications
- Meets or exceeds ASTM (E950) Class I profiler specifications

smart rutbar

The ARAN® Smart Rutbar is a vehicle mounted subsystem that uses ultrasonic transducers to accurately measure the transverse cross section of a roadway. The Smart Rutbar has its own microprocessor that insures measurements are made accurately and collected quickly. This insures the best possible profiles of the road surface.

All sensors are spaced at 100 mm centers (4") over whatever measurement width is selected. Up to 37 sensors are used to cover a full lane width of 3.6 meters (12 feet); 19 in the main enclosure and 9 sensors in each of two telescoping wings.

The greater number of sensors provides more accurate measurements of ruts than systems with fewer sensors. Each sensor measures to an accuracy of 1.0 mm. The overall accuracy of the rut depth measurement for the lane is 1.5 mm.

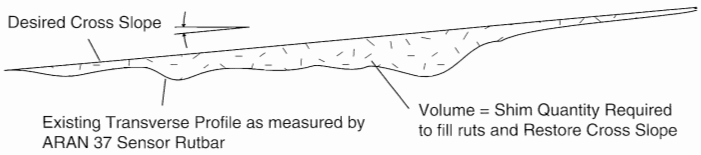


Deformities such as double ruts are clearly defined. Accurate measurements are recorded regardless of the vehicle's path caused by the driver wandering across the lane.

Special software produces useful graphic displays, plots, and calculations such as mill and shim quantity of asphalt needed to restore crossfall. Rut quantities, water ponding depths and cross section analysis reports are also produced.

Cross Slope can be calculated from geometric and rutbar transverse profile data.

When used with the Position and Orientation System for Land Vehicles (POS/LV), measurement accuracy approaches or exceeds Rod and Level surveys in a fraction of the time and in a much safer work environment.



Features and Applications

- 19 ultrasonic sensors in main bar
- Two telescoping extensions with 9 sensors each for a total of 37 sensors
- Individual sensor accuracy of 1.0 mm. Overall rut depth measurement to an accuracy of 1.5 mm
- Real-time rut depth calculation and graphic display
- Measures at variable traffic speeds
- Graphical reporting software
- Compatible with all ARAN subsystems such as POS/LV, WiseCrax™, and GPS
- When the Smart Rutbar is combined with POS/LV, ARAN software calculates multi-lane mill/shim quantity, water ponding depth, and performs cross section analysis with "rod and level" survey precision

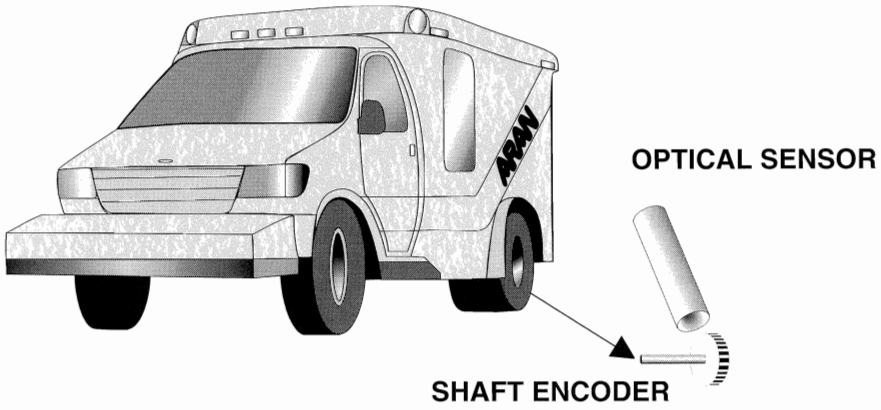
dmi

The Distance Measuring Instrument (DMI) measures chainage or distance. It is the most basic and yet one of the most important measurements made by every ARAN® vehicle. All data must be accurately referenced to its location on the road.

ARAN sub-systems use distance as their base for measurement, and are not speed dependent as are many competitive time based measurement systems. This feature allows the vehicle to move at variable speeds in traffic and collect data safely without data corruption due to speed changes.

The DMI uses a shaft encoder driven from the rear wheel to produce a stream of 1800 pulses per wheel revolution. These pulses are sent to the Central Data Acquisition Computer (CDAC) for use by all other ARAN sub-systems.

The DMI also measures velocity changes which are used with the gyro subsystems and GPS subsystem to precisely determine the vehicle's position in geographic space. This provides the geographic coordinates for CAD and GIS mapping applications.



Features and Applications

- Provides essential chainage measurements
- Divides each wheel revolution into 1800 pulses
- Measures linear distance within 0.02%
- Links all data to linear location references
- Interfaces with Central Data Acquisition Computer
- Easy calibration to compensate for tire wear
- Provides distance trigger pulses to all ARAN subsystems
- Integrates with GPS and Inertial Reference System for geographic positioning
- Operator selectable Metric or Imperial units
- Simple, reliable operation
- Adaptable to any vehicle

inventory keyboard

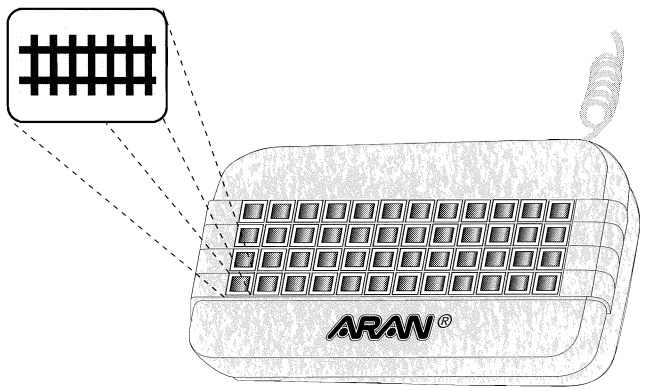
This special keyboard allows technicians to record the location of roadside features as well as pavement condition while traveling in the ARAN® vehicle.

The keyboard can also be used with special V-RATE software at an office workstation. With V-RATE, the operator can evaluate pavement condition or record the location of roadside features while viewing the video at an office workstation. This is a safe and efficient method of performing visual distress rating for pavements recorded with ARAN Pavement Video.

The fully programmable keyboard enables the technician to perform such functions as evaluating the condition of pavement distress by type, severity, and extent. For example, the operator can rate ten distresses with three degrees of severity and their extent quickly and efficiently.

In addition, special event keys can be used to record the exact location of special features such as signs, bridges, guiderails, rail crossings, etc. These data can then be entered into an inventory data base Because the keys are programmable they can be configured to meet specific needs of the agency.

The unique ARAN keyboards feature special Liquid Crystal Display (LCD) key caps which are customized through user friendly software programs. The 24 by 24 array of pixels can be programmed to design special key caps that display symbols, words, characters, or icons, to aid the operator and improve efficiency.



Features and Applications

- Use to build an inventory of roadside features (bridges, guiderails, rail crossings, etc.)
- Use to rate multiple pavement distresses— eg. ten types of defects with three severity levels and five extent levels
- User definable keys
- Back lit LCD key caps
- Keycaps display icons, letters symbols, etc., using simple software utilities
- Rugged cast aluminum case for long service life

pos/lv

Position and Orientation System for Land Vehicles (POS/LV™) is Roadware's latest and most advanced geometric system for the ARAN® mobile data collection system. It provides ARAN users with an even more precise alternative to the standard gyro geometrics package.

POS/LV is a state-of-the-art Inertial Reference System which provides precise roll, pitch, heading, velocity, and position information to other ARAN measurement subsystems.

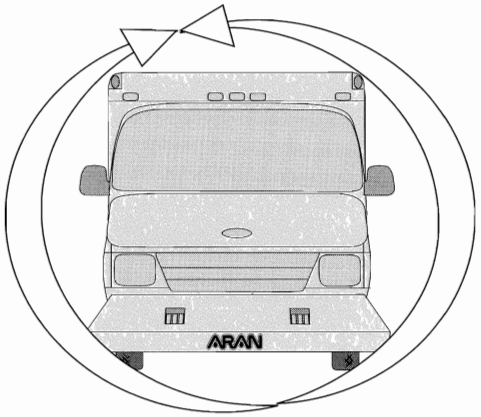
Originally developed for use in high performance military aircraft, POS/LV is a combination of sensitive gyros and accelerometers.

Data is integrated from other ARAN measurement subsystems such as the Distance Measuring Instrument (DMI) and Global Positioning Systems (GPS) to produce highly accurate information on the attitude of the ARAN vehicle in relation to the road surface as well as in geographic space.

POS/LV inputs help determine longitudinal and transverse profiles of multi-lane roads as well as other geometric data such as curve radius, grade, and elevation measurements with survey level accuracy.

A primary component of the system is mounted in the Front Instrument Enclosure (bumper) for precise "roll" information without the error introduced by the twist of the vehicle frame. These data are used to determine the transverse profile of the road surface.

ARAN software determines crossfall and calculates precise mill and shim quantities of asphalt needed to restore the road to acceptable standards.



POS/LV makes it possible to construct or update existing maps when it is used with Geographic Information Systems (GIS) and GPS. This Inertial Reference System fills in the gaps of GPS when satellite lock is lost.

Features and Applications

• Rod and Level Accuracy •

Field tests demonstrate millimeter accuracy for measurements taken at highway traffic speeds

- **Military Spec Gyroscopes**

Highly accurate, military quality instruments with proven reliability and performance

- **Strap-Down Inertial Measurement Unit**

Provides higher reliability than gimbaled gyro systems at an affordable cost

- **Sophisticated Filtering Algorithm**

Data is analyzed in real-time using a Kalman Filtering Algorithm which blends the best characteristics of the DMI and GPS and at the same time filters out anomalies and errors

- **Rugged Design**

Designed for use in high performance aircraft to withstand high G forces, vibration, and shock without degrading accuracy or reliability

smart geometrics

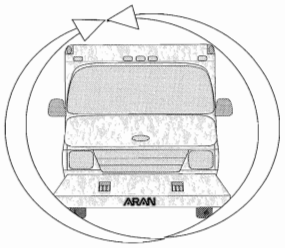
Smart Geometrics is a vehicle-mounted subsystem that utilizes a patented combination of gyroscopes and software to measure the crossfall, transverse profile, vertical alignment (grade), and horizontal alignment (curve radius) of the roadway.

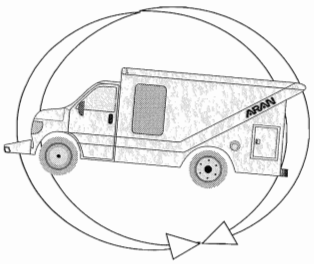
The Smart Geometrics subsystem is comprised of vertical gyroscopes measuring the roll, pitch, and heading of the vehicle.

The outputs of these gyroscopes are fed into an on-board computer along with other ARAN data to calculate information such as curve location, radius, grade location and percent grade required by highway departments and HPMS.

Smart Geometrics sends data to the ARAN® Smart Rutbar and GPS systems to enhance their functionality.

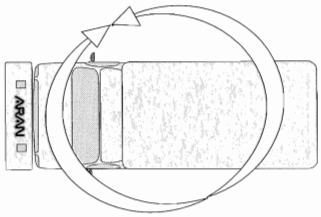
The roll data, when combined with Smart Rutbar data, provides detailed cross sections of the road on a lane by lane basis. Special software and the Auto Start feature produce multilane cross-sectional profiles. Mill/shim quantities can be calculated as well as water-ponding depth and hydroplaning potential.





The pitch data is used to determine highway elevations and grade. Used in combination with bench marks or survey monument references, it provides vertical alignment (grade) details in absolute elevation terms.

The heading gyro yields directional data describing horizontal alignment (curves) of the roadway. Curve entry and exit points are calculated from these data.



Features and Applications

- Roll data is integrated with Smart Rutbar data for precise crossfall measurement and transverse profiles of multi lane roads
- Vertical and horizontal geometrics collected at 500 samples per gyro per mile
- Self correcting for centripetal forces
- Provides the geometric data needed to determine safe passing zones, detailed transverse profile, ponding depth (hydroplaning potential), mill/shim quantities, grade and crossfall
- Moves at variable traffic speed
- Compatible with all ARAN systems such as Smart Rutbar, WiseCrax™, and Global Positioning System (GPS)
- Smart Geometrics combined with GIS and GPS provides automated mapping capability
- Supplements GPS by filling in the gaps when satellite lock is lost
- Satisfies FHWA requirements for horizontal and vertical road alignment data.

smart texture

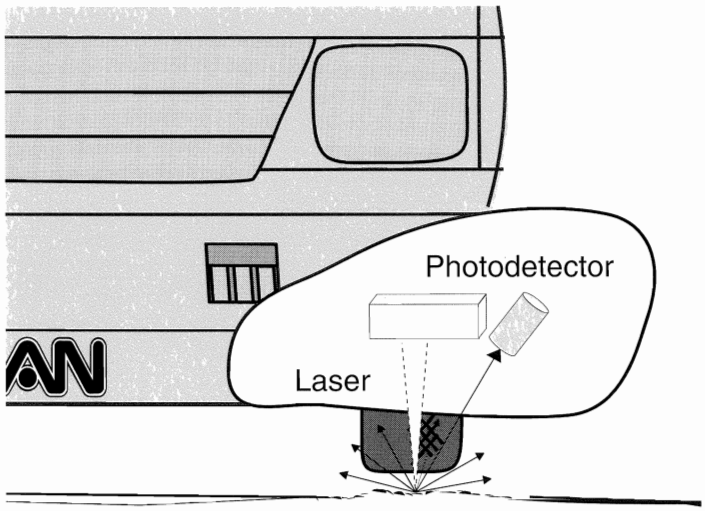
The Smart Texture subsystem is a vehicle mounted module that utilizes high frequency lasers to measure the mean texture depth and macrotexture of the roadway. Texture data is an important measure of the rain water drainage and skid resistance potential of a pavement's surface.

During data collection, the operator can review real-time texture data. Workstation processing enables detailed review of texture profiles or statistical summaries for pavement management applications.

The Smart Texture module consists of one or two 64 kHz pinpoint lasers, signal conditioning electronics, and a computer. The system can acquire wide bandwidth macrotexture at speeds up to 100 km/h (60 mph).

Summary RMS data is stored for macrotexture at operator selected intervals. Additionally, raw texture "bursts" can also be stored.

Rigorous correlation studies have produced an R^2 of 96% correlation with ASTM standard tests such as the sand patch method for texture measurement.



Features and Applications

- Full bandwidth macrotexture
- One or two lasers (optional)
- Data collection at variable traffic speeds
- Referenced to precise chainage or to Global Positioning System (GPS) coordinates
- Graphical reporting software
- Can be installed on any vehicle
- Compatible with all ARAN® subsystems such as Smart Rutbar, Position and Orientation System/Land Vehicle (POS/LV™), Smart Geometrics, WiseCrax™ and GPS
- Compatible with all commonly used Management and Geographic Information Systems

laserlux

LASERLUX® is an ARAN® subsystem that utilizes a scanning laser to accurately measure the retroreflectivity of pavement markings. As with all ARAN subsystems, the LASERLUX unit is intelligent and contains its own microprocessor that insures measurements are made accurately and collected quickly, synchronous with all other measurements.

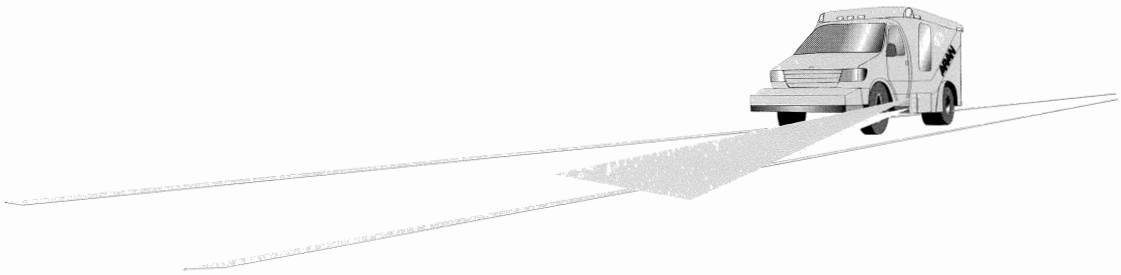
The laser beam is projected forward from the truck and sweeps left to right across the pavement markings. The beam reflects off the pavement marking and is sensed by a photo array. The geometry of the laser and photo array matches the standard geometry of the headlight and driver's eye perspective.

The amount of laser light returned to the array determines the marking retroreflectance. Low retroreflectivity represents poor marking visibility under night time and inclement driving conditions.

The unit can be attached quickly to either side of the ARAN or two units can be used to measure retroreflectivity of both sides of the lane simultaneously.

All ARAN subsystems are computer controlled and operate under menu driven software. The LASERLUX subsystem includes processing software to produce useful graphic displays and plots as well as database compatible output.

LASERLUX was developed in cooperation with the FHWA and numerous units are currently being used by this agency.



Features and Applications

- Measures retroreflectivity of pavement markings objectively
- Tests at variable traffic speed; a clear safety benefit
- Day or night operation, which improves productivity
- Matches driver/headlight geometry; extremely important especially with an aging driver population
- Graphical reporting software
- Can be used to:
  - Monitor striping contractor performance
  - Prioritize striping needs
  - Track performance of striping materials
  - Establish efficient re-marking strategies
- Eliminates unnecessary striping
- LASERLUX data leads to safer visibility conditions on your highways

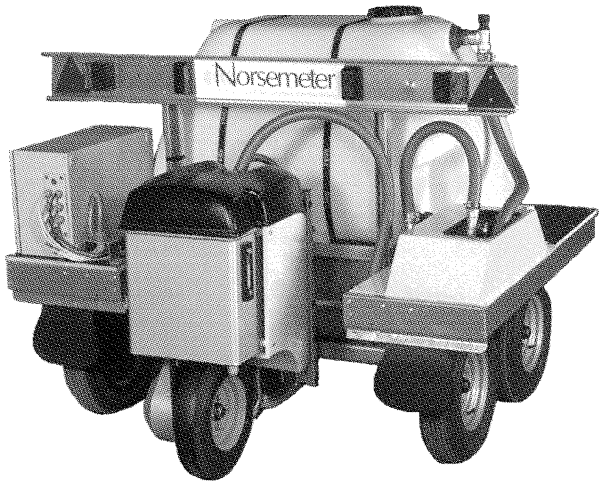
LASERLUX is a trademark of Potters Industries

norsemeter

The Norsemeter is a continuous friction measuring instrument for roads, bridges, and airport runways using a new variable slip technique. Measurements can also be made in a Locked Wheel and Fixed Slip mode to provide correlations with previous friction data.

The new International Friction Index (IFI) is measured directly in one pass. The Norsemeter has the unique ability to determine both Macro as well as Micro texture of the pavement surface in real-time.

This rugged and compact device is more economical to own and operate than conventional locked wheel trailers. It uses less expensive ASTM test tires, which last longer under wet or dry operation. In the continuous wet operating mode, it uses far less water (35 liters per km) so scheduling does not rely on routing for water replenishment. It is easily operated by a single person and does not require a dedicated vehicle. The unit can be easily moved between vehicles for maximum flexibility. Maintenance and servicing are simple and easy to perform.



The unit can be mounted either on the back of a truck or towed on a trailer with its own water supply (500 liters) and water dispensing mechanism (0.5 or 1.0 mm metering). An on-board IBM compatible computer measures and displays friction in real-time on a user friendly LCD panel. Output can be stored and sent to common spreadsheet and database programs.

For winter operations, the Norsemeter can be mounted on an inspector's pickup truck or directly on a plow or sander. It has been tested extensively in Norway, Canada and by the Minnesota Department of Transportation under harsh winter conditions to measure winter pavements with ice, loose or compacted snow, slush, or water.

Norsemeter has been certified for airport runway friction testing by NASA, FAA, Transport Canada, and International Civil Aviation Organization (ICAO).

Features and Applications

Measures Peak Friction and Texture in one pass
Directly Measures International Friction Index (IFI)
Suited for Roads, Bridges and Airport Runway testing
Wet or Dry measurement
Winter or Summer operation
Variable Speed - 20 km/h to 130 km/h
Operates in new Variable Slip mode as well as older Locked Wheel mode, and Fixed Slip mode

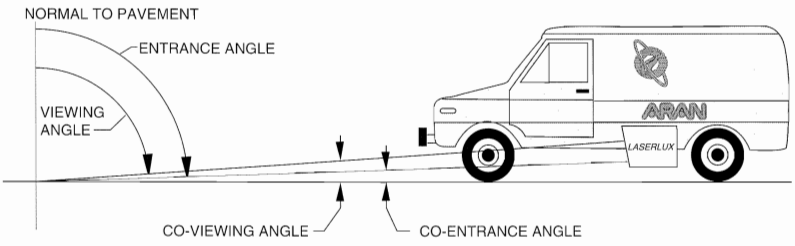
Meets new ASTM Variable Slip test standard
Certified by NASA, FAA, Transport Canada, ICAO

Applications:

- Accident Investigation
- Pavement Materials Research
- Network Pavement Management
- Quality Assurance of Paving Contracts
- Winter Maintenance - plowing, sanding, salting

ROADWARE Corporation 147 East River Road, Paris, Ontario, N3L 3T6 Canada Tel: 519-442-2264, Fax: 519-442-3680

LASERLUX® MOBILE RETROREFLECTOMETER



LASERLUX employs a scanning laser to measure pavement marking retroreflectivity with the new 30 meter geometry specified by the U.S. Federal Highway Administration (FHWA). The laser and photoreceptor are mounted at an angle that duplicates the effect of the vehicle's headlights reflecting back to the driver's eye. The geometry is scaled by 1/3, so the measurements are performed at a distance of 10 meters in front of the laser. The co-entrance angle (angle between the light beam and the pavement) can be set at the standard North American geometry of 1.5°, or to the *European Committee for Normalization* geometry of 1.24°.

The laser beam scans an area one meter wide to allow for driver steering wander. The retroreflected laser light is collected by a sensitive photo array. Narrow band interference filters reduce the effect of ambient light to allow operation in full sunlight as well as night time conditions. An on-board computer calculates and displays retroreflectance values in real time which allows the operator to monitor validity of scanned data. Off line workstation software summarizes values at user defined intervals and produces tabular and graphical reports.

An integral video camera displays the area being measured on a cab mounted monitor for easy setup and driver guidance. An optional video overlay feature superimposes the real-time reflectance values on the video display. The video and data display overlay can be recorded to a VCR for later review. An optional Right-of-Way video camera can be added for sign inventory.

LASERLUX measures single or double lines, yellow or white lines, continuous or skip lines, or any combination of these lines. It can be employed for paint, epoxy, tape, or any other reflective medium, with or without glass beads.

The ARAN vehicle is equipped with a Distance Measuring Instrument to tag the data and video with mile point and offset location information. An optional GPS receiver can be added to tag the retroreflectance data with latitude and longitude location coordinates. Data can be imported easily into most GIS and database systems.

Features

- Real-time pavement retroreflectivity measurement
- Driver/headlight geometry 1/3 scaled distance, at North American or European standard geometry
- Statistical correction algorithm for skip lines based on the geometric probabilities
- Standard real-time display of retroreflectivity profile of measured markings
- Standard forward looking video camera and cab mounted monitor for driver guidance
- Standard high precision Distance Measuring Instrument to tag data to chainage
- Standard events keyboard to identify types of lines and road features
- Real-time event codes, with programmable header labels
- Graphic reporting software
- Controlled by an on-board industrial 80486 computer
- Internal temperature control
- Minimal calibration required
- Standard 3/4 ton vehicle with mounting brackets for left hand or right hand pavement stripes
- Optionally the customer can provide a comparable vehicle
- Optional ROW video camera for sign inventory
- Optional video overlay with real-time display of data overlaid on the video image
- Optional GPS geographic coordinate tagging of data

Specifications

- 10 milliwatt Helium/Neon laser
- Maximum retroreflectivity: 800 millicandella/(m^2 lux). Optional maximum reflectivity to 1500 millicandella/(m^2 lux)
- Minimum retroreflectivity: 20-30 mcd/(m^2 lux), depending on reflectivity, variability, and contrast between pavement and stripe retroreflectivity
- Accuracy: ±15%
- Measures contrast of pavement and stripe retroreflectivity
- On-board 80486 computer and display
- Real-time display of measurements
- Thirty meter geometry scaled down to 1/3
- Co-entrance angle 1.5° (North America), or 1.24° (Europe)
- Measures single/double lines, right/left lines, continuous/skip lines, yellow/white lines
- Minimum stripe width 65 mm (2.5 in.). System modification can allow measurement of strips as narrow as 25 mm (1 in.)
- Laser scanning path: 1 meter (40 in.) wide
- 30,000 readings per hour
- Measurement at all speeds up to 90 km/h (55 mph)
- Measurement at night or day, including full sunlight
- Operating temperature 0 to 50° C (32° F to 120° F)
- Electronics: 12 VDC; 12 bit A/D; RS232C interface

ROADWARE Corporation

International Headquarters: P.O. Box 520, Paris, Ontario N3L 3T6, Canada Tel: 519-442-2264
U.S. Headquarters: P.O. Box 209, Kylertown, PA 16847, U.S.A. Tel: 800-828-ARAN (2726)

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ARAN® USERS
(Data Collection Services Sample List)

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City of **Brampton,** ON (A)
Province of **British Columbia**
Province of **Manitoba**
Ministry of Transportation of **Ontario**

USA

State of **Alabama**
Boulder County, CO
State of **California**
State of **Colorado**
State of **Delaware**
City and County of **Denver**, CO
State of **Florida**
City of **Fort Collins**, CO
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ARAN®