

# Research Record

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## Measuring Pavement Rutting with Lasers: Getting Down to the Nitty-Gritty

**rut** (*rʹut*) n. 1. A sunken track or groove made by the passage of vehicles. 2. A fixed, usually boring, routine.

**R**uts seem pretty straight forward; it's easy to tell when you're in a rut. But it's not as easy to determine when a groove in pavement is a rut—a precise definition is elusive. Generally, to be considered a rut, a depression must be continuous, but exactly how deep and how long the depression must be before it is technically or legally defined as a rut has not been satisfactorily determined, because no one has been able to accurately measure pavement surfaces.

Ruts occur when traffic loading displaces the bituminous material that makes up part of the pavement structure. How the material is displaced depends on the composition of the pavement. It's either displaced laterally from the wheel tracks toward the shoulder and centerline and between the wheel tracks, or vertically.

Rutting is a problem because water collects in the ruts and subjects the pavement to ponding and freezing, eventually causing the pavement to deteriorate. Ponding in ruts also creates possible hazards for drivers, but the wheel tracks themselves can also pose problems. If the depression is deep enough, the vehicle rides in a trough. As long as the vehicle stays in the trough, the rut poses no problem. However, when a vehicle goes to moves out of the trough it could become unstable.

Different vehicles respond in different ways to the same rut, depending on the size of the vehicle, its wheel base, and the design and condition of its tires. Current knowledge of how these variables interact is insufficient to predict how different vehicles will respond to the same road condition. In other words, it is unclear at what point a rut becomes a problem.

Improvements in measuring pavement surface is expected to provide a better understanding of the role pavement rutting plays in vehicle response.

### From an Antiquated System. . .

Until recently, pavement rutting was measured the old fashioned way—with a ruler and either a straight edge or a wire. These methods do not lead to accurate results. The depth of a rut can vary depending upon the length of the straight edge used. Using a wire in place of a straight edge compensates for the curvature of the road surface, but is still a slow tedious process: two people secure the ends of the wire stretching from the centerline to the shoulder by stepping on it while a third person measures the depression, if any, from the wire to the bottom of a rut. In either case, crews typically record two or three such samplings per mile, so the compiled rut profile is sketchy at best. To make matters worse, traffic must be routed around the lane being measured.

### . . . To Laser Technology

MDOT, using laser technology, has developed an improved method for measuring ruts. With its newly-equipped van, MDOT can now travel at highway speeds while collecting measurements every two lineal feet. They can also collect transverse measurements at six-inch (15 cm) intervals over a five-foot (1.5 m) width. Thanks to the accuracy of the laser sensors, these measurements are precise to .002 inches (.0027 cm).

Eleven laser sensors are mounted on a bar which is attached to the front bumper of a van. When the bar is hydraulically lowered and shifted to the side, the laser sensors ride eight inches (20 cm) above the pavement (see figures 1 and 2). As the lasers

measure the rut depth, the computer collects and stores the data, producing a road profile that is infinitely more accurate than the old method.

Because it is impossible to keep the sensors from moving up and down as they travel along the road, MDOT developed data-processing software that compensates for the fluctuation. The two sensors at the ends of the bar provide a baseline from which the other sensors' measurements can be compared. When the software processes the data, it interprets only the differences in elevation from the baseline, giving much more accurate results.

### Safety Is the Bottom Line

More accurate measurements of pavement surface ruts will lead to earlier detection of potential trouble spots and earlier correction of the problem. By taking a proactive stance toward pavement rutting, MDOT can prevent minor depressions from becoming possible hazards.

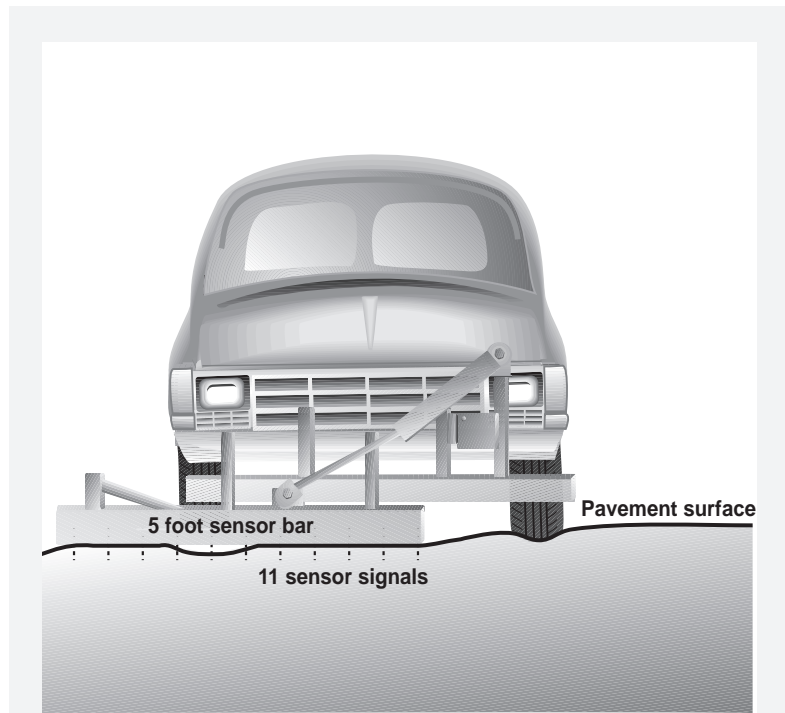


Figure 1: Optical Distance Sensor bar attached to front of van

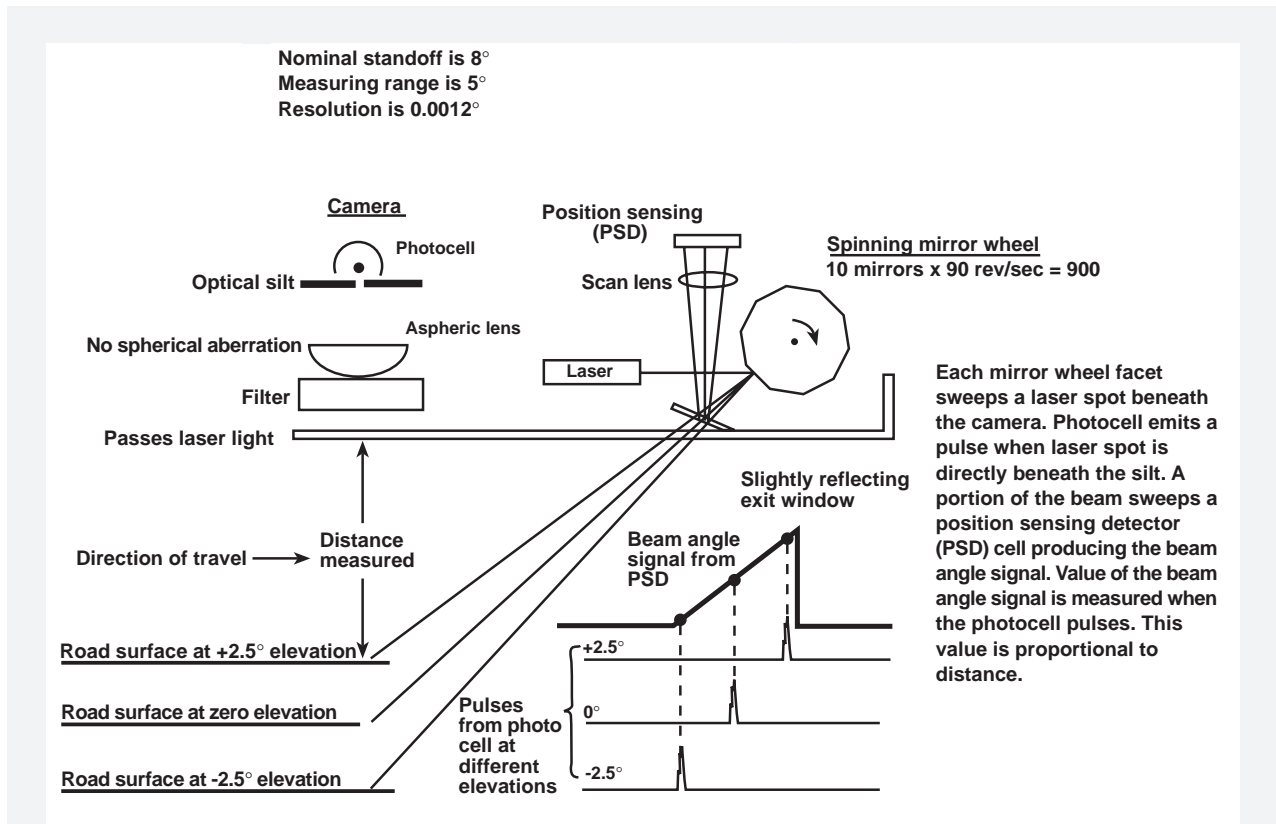


Figure 2: MDOT's Optical Distance Sensor (ODS) Unit

# Sign Quality Is a Reflection on MDOT: A New Method to Measure Reflectivity

**H**ighway signs mark our way—day and night. Much time and research has gone into making these signs as readable as possible: colors were chosen for most contrast for the human eye, size and style of text were designed for best readability at highway speeds as were placement of and distance between signs. Now, the use of reflective material will increase the readability of signs at night.

Just how reflective this material should be is still up in the air. Although there are federal standards mandating a specific level of reflectivity for the reflective sign sheeting, there are no current standards for the signs themselves once they are in place—in part because there is no simple and consistent way to measure the actual signs' reflectivity. But MDOT, in conjunction with the FHWA, is developing a technology that will accurately measure a sign's reflectivity and make it possible for additional standards to be established.

## The Way It Was

Up until now, MDOT had two methods for evaluating reflectivity; they could visually rate signs at night, or they could measure the reflectivity of the signs with a retroreflector.

The first option was highly subjective and didn't provide consistent ratings. The second option, although it

provided more objective information, was undesirable because the process was time-consuming. The retroreflector, a 2-foot (0.6 m) long tube with a 4-inch (10 cm) diameter, had to be placed against the sign. A beam of light was emitted from the far end of the tube, and the amount of light reflected back from the sign was measured. As many as 60 of these samples were sometimes needed in order to evaluate the whole sign. Depending on the location of the sign, this method frequently made it necessary to route traffic around the workers or temporarily close the road to traffic.

To address these problems, MDOT designed the METS (Mobile Evaluation of Traffic Signs), a van equipped with two video cameras, a flash tube and laser mounted on the roof, and a computer and two video monitors inside. None of the equipment itself represents new technology, but the way the METS puts it all together makes it the only van of its kind.

## Cruisin' Down the Highway

Using this METS system, a two-person team—driver and video operator—can evaluate 300 to 400 signs per day. Because the METS system takes its measurements while traveling at highway speeds, the flow of traffic is never disrupted. Here's how it works:

As the van travels down the highway, the video opera-

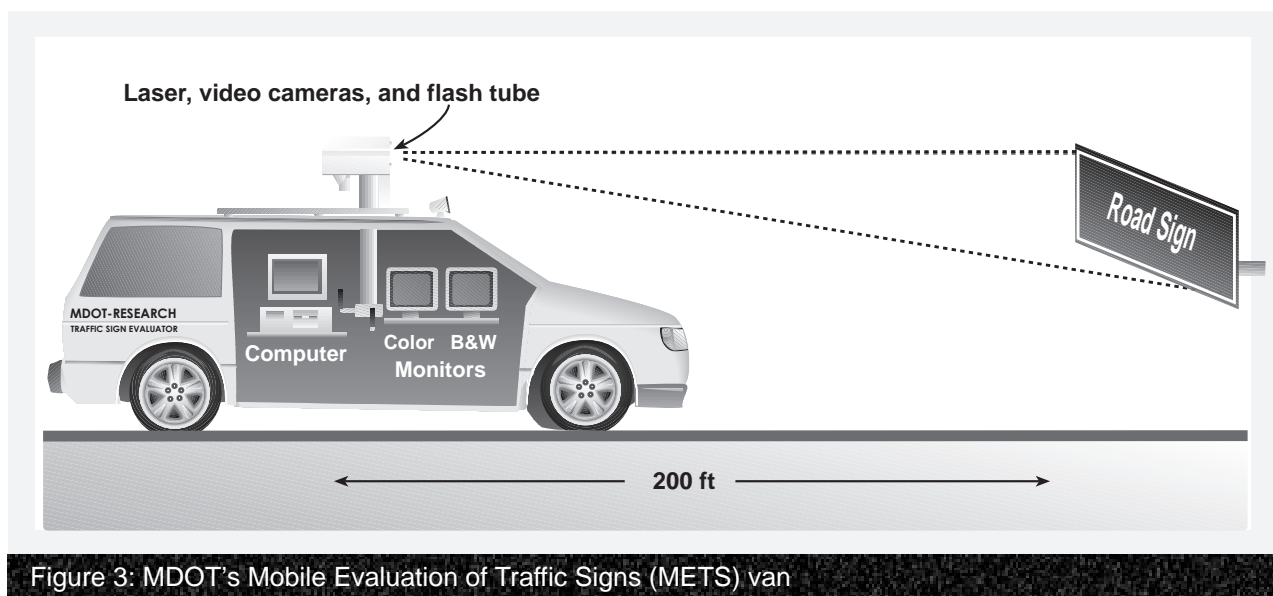
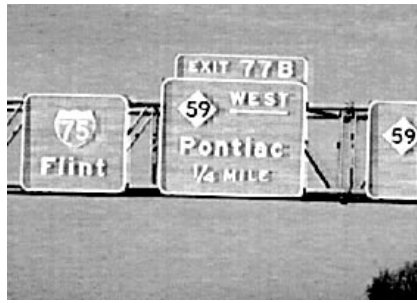


Figure 3: MDOT's Mobile Evaluation of Traffic Signs (METS) van



EXIT 77B  
M-59 WEST  
PONTIAC  
1/4 MILE

SIGN #: I75 /N/ 77:30.00:1 Section: 63174 Mileage: 77.430  
Location: Mali:     .000  
WHITE III Legend on GREEN III Background  
Installed: Sign Facing:



Date	Calib	Grey	Raw Bkgrd	BACKGRD	LEGEND	Raw Legend	Standard	METS #
95-10-25	3.40	30	21	58	256	94	5	12362

Figure 4: Output from the METS system. The color photo is the top photo.

tor keeps the roof-mounted video camera and laser focused on the sign with the help of the two video monitors and the control arm for the camera (see figure 3).

The laser measures the distance between the van and the traffic sign being evaluated. When that distance measures 204 feet (62 m), the flash tube illuminates the sign. A slight delay before activating the cameras allows it to capture the whole sign at 200 feet (61 m), the optimal distance for the camera lenses.

After the image is captured, the video information is digitized and stored in the computer in a one-megabyte file.

With this process, METS quickly and objectively documents the condition of a sign and its reflectivity. If the procedure sounds simple, it is. But simplicity doesn't mean the system lacks sophistication.

### 170,000 Pixels Is Worth a 1000 Words

Software commonly called a "frame grabber" digitizes the captured black-and-white video image. The resulting image is 500 pixels wide and 340 pixels high. Using a software program developed by MDOT, the reflectivity of the

sign is calculated from the digital image (see figure 4).

A black-and-white image alone is insufficient to calculate reflectivity because the human eye sees some colors better than others. Hunter orange, for example, is easier to see than mauve. The color video provides this information. Knowing the legend and background colors of each sign, the digital image can be properly calibrated to account for the differences in our ability to see color. The image is matched against known reflectants of the appropriate color to determine the sign's reflectivity. Reflectivity, or the specific intensity of light per unit area, is measured in candelas per square foot.

The color image also encompasses a wider view of the sign than the black-and-white image and is used to identify large guide signs and the specific locations of smaller, common signs.

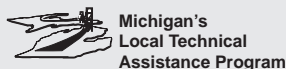
Storing the data on computer provides MDOT several advantages. As these digital images of signs are collected over a period of time, their visual history is recorded, and a sign's performance can be evaluated. METS not only provides more consistent and reliable information than before, but also provides a more complete inventory of the state's signs. The digital format also makes this information more readily available to more personnel.

The METS van is a valuable tool that makes evaluating traffic signs simpler and faster. But more than convenience or efficiency, METS provides MDOT and the FHWA with valuable information. When the FHWA eventually mandates reflectivity levels for all signs, MDOT will already be ahead of the game.

*For more information on either of these vehicles, contact Leo DeFrain, Supervising Engineer of Instrumentation and Data Systems Unit, Michigan Department of Transportation; 517-322-5715.*

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