Additional research is needed to scale visual complexity. A completely reliable scale may be impossible to produce, but from a practical perspective it may be perfectly adequate to reliably characterize the extreme ends of the complexity dimensions. The low end would define locations where sign maintenance is less important and the high end would define locations where special attention may be necessary. This may be the simplest way that a visual complexity scale would have useful application.

Another area that needs attention is sign position and its effect on the luminance available at the driver's eye level. In some situations, depending on road curvature and grade, sign position will have a greater impact on available luminance than sign size and specific luminance.

NIGHT WORK ZONE REFLECTORIZATION

Frank D. Shepard, Virginia Highway
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The country has witnessed a past era of building super highways capable of handling high volumes of traffic traveling at high speeds.

Rehabilitation of the superhighways constructed over the past few decades is becoming increasingly difficult because of increasing travel demand. Because many highways operate at or near capacity for long periods, the time during which maintenance operations can be effectively conducted is restricted. In many areas it is nearly impossible to close one or more lanes during the day, especially during morning and afternoon peak periods, without backing up traffic for miles. This necessitates the use of alternatives to typical freeway rehabilitation procedures, and sometimes the only alternative is to work at night, which is the only time that traffic volumes are low enough to allow lane closures without creating excessive congestion, and it is usually the last alternative chosen.

There are numerous reasons that night operations are unpopular; the concern for safety is one of the most important reasons. Night operations require that men and equipment be on a road illuminated either by existing street lighting or special illumination. It is emphasized that the work is done only at night and that the highway is reopened to traffic during the day.

In addition to closing one or more lanes, many states close the entire roadway and detour traffic to alternate routes. The night-only operation coupled with road closures can then present motorist situations that are unexpected, and enough has been said about "driver expectancy" to indicate the possible consequences of creating unexpected situations. The problem is compounded by low traffic volumes that lead to higher speeds.

All of these factors dictate that special measures be taken to keep the number and severity of night-work zone accidents at a minimum. Traffic control plays an important role in ensuring safety, and signing devices are important aids in assuring safety in night-work zones.

The Manual on Uniform Traffic Control Devices (MUTCD) states that traffic control should:

1. Fulfill a need;
2. Command attention;
3. Convey a clear, simple meaning;
4. Command the respect of road users; and
5. Give adequate time for proper response.

In the case of the latter, signs should be simple and legible, especially with the array of lights used during night operations (e.g., the variable message signs, work-site delineation and lighting, and equipment warning lights). Here, the provision and maintenance of reflectorization are quite important. A project initiated at the Virginia Highway and Transportation Research Council will evaluate the legibility of warning signs by using encapsulated lens sheeting. Legibility distance has been increased by about 15 percent through the use of modified lettering on various signs, and plans are underway to analyze legibility versus modified lettering for construction and warning signs.

In addition to signs, various devices are being used to channel traffic in night-work zones, including cones with internal lights or reflectorized sleeves on top, Type II barricades, chevrons of different sizes, and barrels. The spacing and proximity of these channelization devices to the work zones appears to vary. It is important that the detection and legibility distances be optimized, and here reflectorization is extremely important. Uniformity in the use of these devices is also important for night operations.

The variety of traffic control measures being used during night maintenance operations points up the need for research on sign complexity and reflectorization.

REFLECTORIZED INFORMATION NEEDS: WET PAVEMENT

Slade Hulbert, San Ramon, California

Whenever the pavement surface reflects light in a manner similar to the way a mirror does, pavement markings disappear from view. Drivers are deprived of guidance cues that they have learned to use and depend on, and a hazardous driving environment exists. The wider the roadway, the more dependent drivers are on lane markings and channelization markings such as for two or more parallel turn lanes, mandatory turn lanes, and "no turn" lanes. The safety value of yellow center lines, double solid yellow "no passing" zones, and two-way left-turn lanes are lost when the road surface is glazed with water or covered with mud or any other material such as spilled liquids or powders that conceal the painted markings on the pavement. Pedestrian crosswalks and stop bars can also lie concealed under a reflecting film that does not affect the pedestrian's view because they are looking down directly at the markings, whereas the driver's eyes are looking ahead at a shallow angle.

Nighttime driving scenes are likely to be more hazardous when the pavement is wet than on the same roadway in daylight. However, daytime scenes also can become a problem, especially when low sun angles are encountered or during bright overcast sky conditions. In urban areas the night scenes are likely to include advertising lights and signs. Even street lighting can create glare on wet streets that not only conceals pavement markings, but also constitutes glare sources at discomfort levels and occasionally at disabling glare levels. The safety implications of sign driving conditions are readily appreciated because they are so obvious.

More subtle safety problems occur when there exists other visual cues that are misleading, such as pavement joints, roadside shrubs and trees,

curbing or shoulder discontinuities, driveways, and many other man-made or natural roadside features. The misleading nature of such visual cues may not play any role until the painted pavement markings are removed on a wet pavement. However, these same features can be used to safely guide drivers if consideration is given to how these features look to motorists when the road is wet.

One extremely important technological development in pavement marking is the raised pavement marker (RPM). Both reflectorized and nonreflectorized RPMs have proven extremely beneficial to motorists because they protrude above the surrounding pavement upward through the sheet of water, thus breaking the mirror-like surface. Initial cost, replacement cost, and traffic disruption during placement are negative aspects of RPMs. Therefore, work needs to be done to reduce cost, increase durability, and lessen traffic disruption associated with RPM placement.

A market exists for a better RPM, and therefore manufacturers and inventors will work to create improved RPMs. In the meantime and at all locations, traffic authorities need to learn to analyze the wet roadway scene and to determine other visual cues that are present. When other cues are recognized, they can be manipulated to provide positive guidance or at least to avoid misleading drivers when pavement markings temporarily disappear from view.

In order to identify these other visual cues, it must be possible to "look through the eyes" of the driver who is unfamiliar with the territory. This requires a bit of mental gymnastics for a traffic engineer who is thoroughly immersed in knowledge of the roadway. Such traffic engineers could safely drive the roadway without pavement markings, they would know the number of lanes, the width of the lanes, the location of the intersections with crosswalks, and the location of the two-way left-turn lanes. How, then, can such a traffic engineer divest himself of this ingrained knowledge? One way is to view movies or TV tape recordings made when wet pavement conditions exist. Such scenes also can be viewed by ordinary motorists whose responses can be obtained. Slides can be used for this purpose, but they are not as likely to capture the dynamic unfolding of the roadway scene.

Once the problem is acknowledged, there will be other techniques that research can produce to assist in analyzing visual cues for a safer roadway scene when the pavement is wet. As such improved techniques are developed, promulgated, and used, it will become increasingly easy for traffic engineers to decide where RPMs are essential and where RPMs must be maintained in order to overcome other visual cues that cannot be changed.

Also, it must be recognized that the more frequent RPMs are used, the more motorists will depend on them. Especially hazardous then will be those roadways where RPMs are not replaced when broken, and those locations where RPMs suddenly are not used. A carefully planned transition must be made from RPM to "no RPM" roadways. Research could well be conducted on this aspect of traffic management when the pavement is wet.

REFLECTORIZED GUIDE SIGNS AND DRIVER RESPONSE

Fred R. Hanscom, Transportation Research Corporation

The use of reflectorized versus nonreflectorized backgrounds on guide signs is a controversial issue. Although highway agencies are required to operate under severe financial constraints, illumination or reflectorization of overhead guide signs may create a perceived unnecessary monetary burden. On the other hand, consideration of driver safety requires a sufficient level of service from guide signs to ensure adequate driver detection, recognition, and response time.

A nonreflectorized guide sign appears to have a black background to a motorist approaching it at night. That the nighttime surrounding is also black gives rise to a question of reduced conspicuity of the guide sign. Basically what the driver sees, in the case of a nonreflectorized guide sign background, is a black-on-black presentation with only the white border and legend to provide contrast in the environment. A guide sign with a reflectorized background appears just as it would during a daylight condition - a green sign with white legend and border. This green sign offers a high visual contrast against the black nighttime surround, the net effect of which is higher target value. The relative effects between these two guide sign presentations is unknown.

An unpublished study, conducted as part of the National Cooperative Highway and Transit Research Program (NCHRP) Project 3-21, validated a set of effectiveness measures to be applied in the evaluation of guide signs. The study procedure involved gathering both driving performance measures and in-depth questionnaire responses for approximately 11,000 motorists exiting from freeways. The applied questionnaire data analysis determined causative factors associated with performing specific erratic maneuvers. Through the use of various types of regression analyses, we were able to quantify the relative percentages of specified vehicle behavior due to various factors such as driver familiarity and guide sign information processing.

Although this project was conducted during daylight hours, its results cannot be directly related to the nighttime reflective guide sign issue. However, because certain erratic maneuvers were associated with driver failure to detect guide signs, direct inferences from this study can be applied to any guide sign condition characterized by reduced target value.

Results indicated that driver failure to detect guide signs was associated with erratic maneuver occurrence in exit gore areas as follows:

1. Late Lane Change (weave over solid gore extension line): 4 to 19 percent
2. Gore Weave (weave over painted cross-hatched gore marking): 25 to 84 percent
3. High Risk Gore Weave (weave over through-travel lane in addition to Gore Weave): 35 to 100 percent.

Differing occurrences noted above were attributable to site-specific differences.

Recommended Research

There is a need for further field study to determine the driver performance impact of non-reflectorized guide signs. Two candidate study procedures are: