a question of standards

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Nathaniel Pulling has correctly stated that "quality of service versus societal cost is the overriding issue of greatest criticality in all forms of transportation." Quality of service is related to the efficient allocation of resources, whether it is in the area of allocation of energy to mass transit versus the private automobile, the smoothness of a guideway surface versus a more expensive vehicle suspension system, or, in terms of this article, the standards that must be met by government entities for maintenance of highways, roads, and streets.

On August 9, 1979, a notice of proposed rule making for Interstate maintenance guidelines by the U.S. Department of Transportation was published in the ***Federal Register.*** The action was required by Section 116(d) of the Surface Transportation Assistance Act of 1978. Adopted without much discussion in the closing days of the first session of the 95th Congress, it reflects a desire to gain a better understanding to and establish more control of highway maintenance—a vital, decentralized, and amorphous transportation function that many authorities feel has been neglected in the drive to build our national highway system.

It is difficult to establish standards for maintenance that have any uniformity of application in all of the variability of local conditions. There is, in fact, a dichotomy between engineering standards intended for a uniformity of application, with which I deal in this article, and a fully economic approach in which what is done should depend ideally on cost/benefit relationships.

Obviously, maintenance authorities cannot have a completely free rein to perfectly maintain roads—such an unbalanced distribution of resources would soon become intolerable. On the other hand, the presence of potholes or other evidence of deterioration does not necessarily represent a dereliction of professional duty; instead it repre-

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sents the allocation of resources that legislative bodies deem appropriate after consideration of other demands on the public purse.

We know relatively little, in economic terms, about the benefits of maintenance, e.g., reduction in speed with road conditions, rates of vehicle deterioration, accident rates, and the cost to society of road blockages caused by a winter storm. Consequently, we are not able to create the best balance between maintenance expenditures and quality of transportation service or to judge precisely what the effect of an incremental increase or decrease in maintenance expenditures will be on the cost/benefit relationship.

In the absence of authoritative cost/benefit analysis, we must resort to using engineering standards for maintenance operations. Standard measures of actual road conditions have to be identified and agreed on. Help is available. We can measure such characteristics as roughness, slipperiness, and deflection even though we are woefully weak when it comes to relating such data to performance.

With this background in mind, the Maintenance Section of TRB Group 3, Operations and Maintenance of Transportation Facilities, decided to sponsor a workshop on Maintenance Quality Standards on July 10, 1979, in conjunction with the American Association of State Highway and Transportation Officials' Operating Subcommittee meeting in Flagstaff, Arizona. The introduction for the meeting consisted of four presentations:

1. Sample size needed to make a realistic assessment of the current condition of a roadway network, R. L. Lytton, Texas A&M University;
2. Use of a trained-observer system to develop performance indicators for the highway maintenance program of the Pennsylvania Department of Transportation, Theodore H. Poister, Pennsylvania State University;
3. Maintenance levels-of-service guidelines, Fred N. Finn, Woodward-Clyde Consultants; and
4. Photologging: a tool for measuring maintenance quality levels, Adrian G. Clary, TRB.

R. L. Lytton stated that the method of sampling and the size of the sample to use must depend on the cost of the survey and the expected precision of the results. By using utility theory, it was shown in Texas that, under normal conditions, where the cost of the survey is more important than the precision, a 1-3 percent sample will be the optimum; where precision is more important, a 5-10 percent sample will be the optimum. The National Road Maintenance Condition Survey, now in its third year in England, identifies specific road defects and measures

them on a large number of sample sites. The Ohio method involves a 20 percent sample of the entire system of defects in a somewhat similar method. Shahin, developer of a pavement management system for the U.S. Army, is attempting to combine a number of separate measurements to give a simple, overall indicator of conditions. The English system is currently addressing the same problem.

The purpose of performance indicators, according to T. H. Poister, "is to assist in programming maintenance funds as well as to monitor performance over time. The indicators for maintenance activities are being developed within a framework of the overall highway program, including safety and construction as well as maintenance. The indicators relate to effectiveness as well as efficiency. The approach is to monitor the outputs of maintenance activities, such as tons of patching material or miles of shoulder cutting; incorporate a quality rating of how well the work is done; and compare unit costs for given activities across counties and districts. The quantity and quality of work performed will then be related to changes in the overall adequacy of the highway network, including standard sufficiency rating measures."

The primary objective of NCHRP Project 14-5, Maintenance Levels-of-Service Guidelines, is to develop a systematic and structural procedure for establishing maintenance levels of service to be used for planning, programming, and scheduling of roadway maintenance. F. N. Finn's summary of the procedures used in establishing maintenance levels of service by the proposed method includes (a) specifying alternate levels of service; (b) identifying considerations (e.g., safety, user comfort, preservation of investment) for each element, i.e., pavement, shoulder, roadside; (c) estimating the effect of alternate maintenance levels of service to user benefits; and (d) establishing trade-offs between various levels of service.

A. G. Clary suggested that photologging is a tool that offers unique advantages for measuring maintenance quality. Two sequential photographs from a strip of photolog photography can be used to measure in objective fashion such things as sign legibility, cracking, roughness, downed guardrail, striping, shoulder drop-offs, cross slopes, pavement pumping, backslope failures, roadside hazards, roadside flora, rutting, brush control, snow fencing, and the presence (or absence) of litter. Use of terrestrial photography in this fashion provides a capability to obtain heights, widths, lengths, areas, and differences in elevation. Clary acknowledged the difficulty of taking large numbers of measurements from photographs, although the feasibility was established long ago by the Federal Highway Administration (FHWA), but he suggested that a relatively modest research program would resolve that problem.

Photologging is not the only tool available for measuring maintenance quality. Most work has concentrated on developing equipment for pavement evaluation, and a whole family of pavement-roughness-measuring equipment has evolved—from the Chloe profilometer to the British prototype contactless texture meter. Similar attention has been devoted to devices for measuring road slipperiness and pavement deflection. Less well known to highway authorities is the work proceeding along parallel lines to measure quality of service from the viewpoint of a vehicle occupant. For example, Richards and Jacobson used the University of Virginia Portable Environment measuring system (PEMS) to measure automobile ride quality as transferred from the road through the automobile's suspension and seat to the occupant (1). It would be interesting to see a comparison of the two systems as they relate to setting maintenance quality standards.

With these introductory remarks in mind and operating on the tacit assumptions that FHWA Interstate maintenance guidelines, when set, must be complied with and that monitoring maintenance quality is an important management function regardless of federal involvement, participants were divided into four groups and asked to answer the question, Is sampling a technique that can be used to measure road conditions and/or the level of quality of maintenance to established standards? Further, what is the use of data collection? What are alternate strategies? The advantages and disadvantages of maintenance quality standards are listed below.

Advantages

1. Standards provide a legal basis for defense or proof of a good job.
2. They are evidence that public funds are being expended wisely.
3. They enhance the ability of management to communicate objectives to subordinates.
4. Standards, of some type, are essential to management control.

5. Standards make it possible to allocate resources on the basis of need.
6. Sampling reduces the cost of measuring maintenance quality.
7. Quality measurements make possible timely feedback of information on road-system condition.

Disadvantages

1. Uniform maintenance standards would cause serious problems. They can be uniform only for certain factors, and many exceptions occur; hence, flexibility is needed.
2. An agency is liable in lawsuits if established standards have not been met.
3. Standards cannot substitute for competent supervisors and workers.
4. Training is a problem. Who will test? Variability of individuals (trained-observer approach) may be great, even after training.
5. Weather and terrain introduce variations. The units being measured may not be homogeneous. Construction standards affect the level of maintenance.
6. It is difficult to replicate results by different people even though the same method is used.
7. Data acquisition costs may be low at the beginning but will undoubtedly continue to increase. The bureaucratic tendency is to continually ask for greater refinement of procedures and more data.

Additional conclusions were reached by specific groups. Group A, led by Michael Darter, University of Illinois, concluded that (a) uniformity is impossible unless it is tempered with environmental consideration; (b) the system can be used to allocate resources to central and district crews, but careful training is required to calibrate the observing teams, and timing of inspections is important; and (c) there is a question of how far we go in cost advantages. Further questions were, How will the reports be used? Who will use them? Where will the use be advantageous? Development of reports will be an exercise in futility unless people are trained to use the reports for adjustments to programs and procedures.

Group B, led by Donald Anderson, Washington State Department of Transportation, concluded that (a) federal standards will increase costs without benefits for those states that now have few road maintenance problems, (b) NCHRP Project 14-5 findings could be used as a planning tool and the other systems (statistical sampling, trained observers, and photologging) could result in adequate measurements of program results; and (c) a definition of "level of service" (for maintenance) must be developed and agreed on. It was suggested that the term should relate to the traveling public. The term "quality standards" should apply to specific elements of a maintenance program.

Group C, led by Charles Miller, Florida Department of Transportation, included several persons who have extensive experience in sampling to measure quality. Ronald Zook, Ohio Department of Transportation, described the Ohio method, which involves a 20 percent sample of the entire system. The system is broken down into two-mile sections, and the sample sections are selected from random tables with a requirement that every county must be included. Two crews sample continuously. Fay Bloomfield, Iowa Department of Transportation, described Iowa's three-person teams, which consist of two "outside" observers and the local superintendent; final ratings are the average of the team's ratings. The superintendents tended to be more critical of their areas than were the outside observers. The group concluded that sampling is an effective means of determining the overall condition of a system but that care must be exercised to select by some random means a representative sample, the sampling technique must eliminate or consider the bias of the observer, and equipment should be used wherever feasible to provide objective ratings. The group also concluded that sampling is a useful tool to determine the overall condition of a system but not for project planning.

Group D, led by David Mahone, Virginia Highway and Transportation Research Council, concluded that there is no viable alternative to sampling and that a state might use sampling to prove compliance with FHWA guidelines. The data may be helpful in lawsuits, but court decisions sometimes seem to be made capriciously.

It is clear, after considering the results of the deliberations of these groups, that defining and using maintenance quality standards, or levels of service, is a subject that deserves greater exposure. It is on the program for the Fourth Maintenance Management Workshop, to be held in July 1980 in Hilton Head, South Carolina. And it will inevitably be an issue in the upcoming FHWA-sponsored pavement management workshops.

Legislative bodies have become much more aware that the capital investment in the U.S. road plant is at risk, and they are increasingly willing to provide resources to rehabilitate and maintain the system, but they also want to be assured that the resources are efficiently used.

Our highway maintenance organizations, using current procedures, lack the data and knowledge to demonstrate that fact objectively. In the absence of such data and knowledge we must assume that much needs to be done before we can assure that the appropriations we seek are neither too high nor too low. The collection and use of data by sampling and defining objectives in terms of the road users may provide the reassurance legislators are beginning to demand.

Acknowledgment

I wish to acknowledge the influence on the thoughts expressed here of the Economic and Finance Committee report of the 16th World Road Congress, Vienna, Austria, September 16-21, 1979.

Reference

1. L. G. Richards and I. D. Jacobson. Ride Quality Models for Diverse Transportation Systems. Prepared for the 59th Annual Meeting of TRB, 1980.