Task Force on Statistical Methods Advocates Quality Assurance Techniques

The organizers of the first session at the Transportation Research Board's 1986 Annual Meeting on Misuses of Statistics did not know quite what to expect. With a Monday evening time slot, the likelihood of a large turnout seemed slim. As the time for the session drew near, however, they realized that they were going to be faced with a different problem from the one they had anticipated: would they have enough handouts for the standing-room-only crowd that was assembling?

Five years later, at TRB's 1991 Annual meeting, this scenario was repeated on a grander scale. Another session on Misuses had been scheduled in one of the regular meeting rooms. With minutes remaining before the start of the session, the room was filled and a large crowd jammed the hallway outside. Fortunately it was possible to move the meeting to the ballroom across the hall to accommodate the 300 to 400 people who arrived.

Task Force on Statistical Methods in Transportation

The group responsible for generating all this interest and activity was originally created as a subcommittee of the TRB Committee on Traffic Records and Analysis (A3B11) in response to a growing concern about the appropriate application of statistical methods in the treatment of various transportation issues. It has since been reorganized as the Task Force on Statistical Methods in Transportation (A3T51), chaired by Olga Pendleton, a Research Statistician with the Texas Transportation Institute.

The 1986 session began to focus attention on the frequency with which questionable statistical procedures and applications have slipped through the review process and appeared in papers in the Transportation Research Record series. This is believed to be the result of a general lack of awareness of the need for a thorough technical review when statistical procedures are involved. One of the major activities of the new Task Force is to provide assistance to other committees in the paper review process.

Throughout the approximately three years that the Task Force has been in existence, it has continued to sponsor a wide variety of sessions and tutorials on statistical methods and has assisted in numerous paper reviews. Because its members have experience in a wide variety of fields, its advice has been sought on a number of issues. A recent request concerned the analysis of the effectiveness of the statistical acceptance procedures that are frequently used with highway construction specifications.

Statistical Specifications

Construction specifications based on statistical principles began to be developed shortly after the then American Association of State Highway Officials' Road Test produced a wealth of data relating quality to performance. It was found that various statistical measures effectively described the desired characteristics and, by performing tests on random samples taken at the job site, it was possible to determine the extent to which the required results had been achieved. Depending on the degree of compliance, adjusted pay schedules were used to award an appropriate level of payment.

Although most of the theory underlying sound acceptance procedures had been developed, it was not generally familiar to the highway community. In addition, the computers and software to facilitate implementation were not available at that time. Consequently, the early development of statistical specifications consisted largely of a trial-and-error process usually resulting in several unsuccessful field trials before a workable specification was finally obtained. Even today, there is still a tendency to produce statistical construction specifications by the old trial-and-error approach. According to the Task Force, the transportation profession needs to become aware that statistical specification writing is now a thoroughly scientific activity.

"All the necessary knowledge and techniques are readily available, it's just a matter of putting them to use," says Task Force member Richard Weed, a Supervising Statistical Engineer with the Division of Research, New Jersey Department of Transportation. "And one of the most important steps is the construction of the operating characteristic (OC) curve. This is an absolutely vital step in the development of a statistical specification—analogous to performing a structural analysis when designing a bridge—because this is the only way to know in advance whether the acceptance procedure will have the desired dis-

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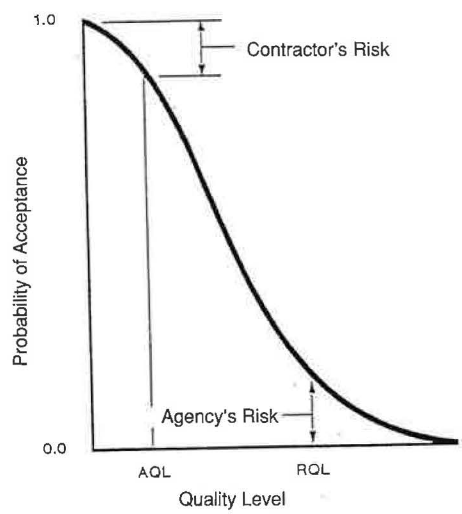

FIGURE 1 Conventional operating characteristic curve.

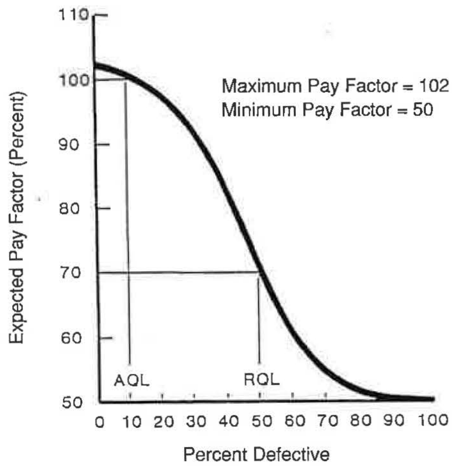

FIGURE 2 Typical operating characteristic curve for statistical acceptance procedure with an adjusted pay schedule.

criminating power. It is through the study of such curves that the risks to both the contractor and the state agency can be recognized and controlled at suitably low levels. This enables the transportation agency to develop fair and effective specifications and may aid the contractor in determining the appropriate bidding and production strategies," he explains.

Operating Characteristic Curves

A conventional OC curve is shown in Figure 1. Probability of acceptance is indicated on the *Y* axis for the range of quality levels (indicated schematically in this example) on the *X* axis. The contractor's risk of having good AQL (acceptable quality level) material rejected and the agency's risk of accepting poor RQL (rejectable quality level) material are both illustrated in this figure.

An OC curve constructed for a statistical specification with an adjusted pay schedule is shown in Figure 2. Quality levels are indicated on the *X* axis in the usual way but, instead of probability of acceptance, the *Y* axis gives the expected pay factor.

Although the risks have a slightly different interpretation when associated with the expected payment curve in Figure 2, essentially the same type of information is provided. In this particular example, AQL work receives an expected pay factor of 100 percent, as desired. At the other extreme, RQL work corresponds to an expected pay factor of 70 percent. Presumably the highway agency has determined that this will cause sufficient money to be withheld to cover the anticipated cost of future repairs. For still lower levels of quality, the curve levels off at the minimum pay factor of 50 percent.

In the case of pass/fail acceptance procedures, OC curves of the type shown in Figure 1 can be computed directly or constructed with the aid of tables designed specifically for that purpose. For acceptance procedures with adjusted pay schedules, OC curves of the type shown in Figure 2 can be obtained by using special software or by developing relatively simple computer simulation programs. The Task Force can also provide guidance in the development of OC curves.

Value of OC Curves

The important thing now, according to Task Force Chairman Olga Pendleton, is to publicize the usefulness of OC curves—both to specification writers who are developing construction specifications and to authors who are writing about them. It is also important, notes Weed, to check the many existing specifications for which OC curves have never been developed. Richard Pain, TRB's Transportation Safety Coordinator, adds that he hopes this will soon become part of the research culture, a feature that authors of quality assurance papers will automatically include and that reviewers and readers will come to expect.

Future Plans

The Task Force is continuing to plan additional paper sessions and tutorials on a variety of topics and remains available to all committees seeking assistance with the review of statistical papers or advice on statistical methods. Those interested in taking advantage of its services or becoming involved in activities are encouraged to contact Olga Pendleton, Texas A&M University System, Texas Transportation Institute, Materials and Construction Division, College Station, Texas 77843-2473; or Richard Pain, Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.