Development of National Highway Traffic Monitoring Standards

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Traffic monitoring has a fundamental impact on transportation decisions. Decisions based on the results of traffic monitoring include the allocation of resources, identification of safety problems, and design of roadway alignment and pavement thickness. An overview of the development of traffic monitoring, the need for national traffic monitoring standards, and foundational principles for the development of standard practice are described. The traffic monitoring profession developed primarily as an independent activity. Agencies, offices within agencies, and individuals within offices developed independent data collection, summarization, and analysis procedures. The emphasis has been on application of professional judgment. This emphasis has proven helpful when the professional was aware of specific roadway operational characteristics. Unfortunately, this emphasis has also resulted in a lack of data consistency and comparability. There is a need to develop national traffic monitoring standards as a reference for appropriate use of professional judgment. Four foundational principles are proposed for the development of national traffic monitoring standards. They are base data integrity, measurement edits, consistent computation, and truth-in-data. With these principles, national standards could result in directly comparable, nationwide traffic statistics. Standard practice would provide transportation efficiencies through more accurate and precise assessment of traffic demand and service. Standard practice can enhance the safe transport of people and goods and the nation's transportation competitiveness.

Effective highway traffic monitoring ensures that road construction projects are appropriately designed, traffic safety problems accurately identified, and highway funds equitably allocated. Decisions concerning traffic monitoring directly influence the ability of the highway system to serve the safe and efficient movement of people and goods.

Highway traffic monitoring, the current role of individual decisions, and the need for national standards are described. Four foundational highway traffic monitoring standards are identified that can provide a reference for the current traffic monitoring practice of governmental agencies and private firms.

HIGHWAY TRAFFIC MONITORING

Highway traffic monitoring is the measurement, summarization, and reporting of vehicle characteristics. There are measurements of vehicle quantity, type, axle load, axle group load, and gross vehicle weight. Decisions concerning location, type, and period of measurement impact this aspect of traffic monitoring.

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Traffic statistics are summarized from vehicle measurements. Traffic summary statistics indicate typical vehicle volume, classification, and weight for a defined segment of roadway and period of time. Measurements at various locations may also serve as a sample of vehicle characteristics on a road network or system. This second aspect of highway traffic monitoring is affected by decisions concerning the integrity of measurements and the method of computing summary statistics.

Summary statistics are reported for use in a variety of applications. Summary statistics calculated from measurement of traffic volume are reported to evaluate operational characteristics of roadways, such as assessing accident experience compared with exposure, the impact of roadway realignment on local street travel, and the impact of new housing or commercial development on roadway congestion. Traffic volumes are also reported as one basis for highway fund allocation. Summary statistics calculated from the measurement of volume by vehicle classification are used in roadway geometric design and intersection signalization. Summary statistics calculated from vehicle axle load measurements help determine pavement thickness.

Decisions related to reporting of summary statistics characteristically concern whether and how to report the quality and quantity of measurements underlying traffic summary statistics. Alternative decisions include describing the procedures employed in measuring traffic, and estimating the accuracy and precision of traffic summary statistics.

Decisions related to each of the three aspects of highway traffic monitoring are made daily. The consequences of these decisions are found in every mile of paved roadway across the nation.

HIGHWAY TRAFFIC MONITORING PRACTICE

How are highway traffic monitoring decisions reached? The highway traffic monitoring profession in the United States developed with an emphasis on individual rather than standard practice. Indeed, there have been outstanding individuals who in the past have made positive contributions to understanding traffic data. However, the exercise of individual judgment has been preserved at the expense of common, consistent traffic monitoring practice.

To the extent that there is common traffic monitoring practice, it has been formed by federal traffic reporting requirements. Uniform samples of traffic have been recommended to help ensure that national traffic reports represent comparable data, and that construction projects using federal funding share common identified traffic characteristics.

The emphasis of federal highway traffic reporting is on system level estimates of traffic characteristics. This is reflected in the FHWA design of the Highway Performance Monitoring System and the contents of the *Traffic Monitoring Guide* (*1,2*).

The federal government has identified summary statistics to be reported that represent traffic volumes, vehicle classification, and equivalent weight by vehicle classification. This set of summary statistics for understanding traffic includes generally accepted naming conventions. Examples are the convention for naming the mean daily traffic volume as average daily traffic (ADT) and the federal typology of 13 vehicle classifications.

Beyond these positive contributions from the federal government, traffic monitoring decisions are currently based on individual agency and employee judgment. Individual decisions include the number, period, and location of measurements for site-specific traffic monitoring; the type and placement of traffic measuring devices; the computational method for deriving traffic summary statistics; and if permitted, the imputation procedure to estimate missing measurements in a traffic data set. In some traffic monitoring agencies, professional judgment is also involved in determining how to estimate the same conventionally named traffic summary statistics in the absence of any traffic measurements.

These individual decisions vary among agencies. As a result, the naming convention (e.g., ADT) for the summary statistics has developed uniformly, but the measurements or estimates underlying the summary statistics vary considerably. The measurements or estimates underlying traffic summary statistic reports vary from agency to agency, from office to office within agencies, and from year to year within offices.

The various uses of highway traffic reports are commonly made without awareness of the nature or implication of these individual decisions. At present, there is no set of national highway traffic monitoring standards or guidelines that can serve as a common reference for the appropriate exercise of individual decisions.

THE NEED FOR HIGHWAY TRAFFIC MONITORING STANDARDS

The development of highway traffic monitoring standards can provide a needed reference for individual agency decisions and individual employee professional judgment. There are advantages and limitations associated with individual decisions. However, in the absence of a standard, preferred practice limitations overshadow advantages.

An inherent advantage of decisions made by individual agencies is apparent responsiveness to user requests. Whether the individual agency is a governmental agency or a private consulting firm, location of traffic count sites and conduct of the measurements can be quickly performed. Depending on the request, an individual agency can select the traffic to be measured and allocate staff and field equipment. Emphasis on individual agency decision making has been at least time-responsive to requests for traffic summary statistics.

In the absence of standards, individual professional decisions limit the usefulness of a quickly generated traffic report. Decisions concerning period of measurement, imputation of missing measurements, and estimated values without measurement affect the equivalence and comparability of the reported summary statistics. Clients and other users of traffic reports would be justifiably concerned if they were aware of the potential for summary statistics being based on mixed data and uncounted estimates.

The reality is that comparisons are made each day using reported, inconsistent traffic summary statistics. Comparisons are most commonly made without client understanding of current traffic monitoring limitations. On this basis, each year, millions of dollars are allocated for transportation. Deterioration of the highway and bridge infrastructure, pavement failures far short of their design life, and the inability to meaningfully address safety and air quality issues are, in part, consequences of the calculation, report, and use of inconsistent traffic summary statistics. Indication of the variability of summary statistic precision and bias under current practice was documented in the 1990 ASTM H. W. Kummer Lecture (*3*).

Traffic monitoring has developed to quickly generate a traffic summary report, without ensuring the integrity of the report. Traffic monitoring has developed as time-responsive to the client, but not quality-responsive. In part, it is the growing client concern for equivalent data and comparable traffic reports that motivates the development of national traffic monitoring standards.

In addition to being time-responsive, another advantage of emphasizing professional judgment is that over a period of years some individuals gain a familiarity with general traffic characteristics on individual roads. With this knowledge, professional judgment can be used to select the best location on a given road segment to install a traffic recording device. With good judgment, the installation site is representative of the traffic characteristics sought. Moreover, mechanical errors in measuring traffic can sometimes be quickly identified by professionals who are familiar with the road.

There are limitations in individual professional judgment. As traffic and the understanding of traffic become more complex, there may be reduced effectiveness of personal professional judgment. Traffic may change more rapidly than individual awareness of change.

Without guidance, individuals may, and frequently do, make erroneous assumptions in modifying traffic measurements and summary statistics. Different individuals make conflicting modifications. The trend of traffic summary statistics across time, which is important for forecasting traffic when designing pavement or bridges, may be meaningless given the data modifications made through individual judgment.

When relying on the judgment of a specific professional, there is another common problem. In the absence of standards or guidance there is difficulty in passing along one person's insight to another. The ability to transfer consistency in professional judgment from one generation of professionals to the next is uncertain at best. Staff turnover within each generation of traffic monitoring professionals makes consistent professional judgment difficult. In part because of the problems inherent in transferring judgment, inconsistencies in traffic monitoring are found within agencies as well as between agencies.

There will always be an important role of appropriate professional judgment in traffic monitoring. Consistency of data collection, summarization, and reporting, representing

the best professional practice, would facilitate appropriate use of professional judgment. This consistency can be provided through national traffic monitoring standards.

THE DYNAMIC NATURE OF HIGHWAY TRAFFIC MONITORING STANDARDS

Traffic monitoring is a dynamic endeavor. New technologies in collecting traffic data permit increased quality and quantity of measurements. There are also new technologies in summarizing traffic data. Computer technologies permit traffic data to be quickly summarized and reported with the moments of the data distribution.

The availability of more accurate and more extensive information opens the possibility to new statistical understandings of traffic data. As traffic measurements become standardized, alternative summary statistics may be analyzed to determine if they more adequately represent the central tendency of traffic. As summary statistics are calculated and analyzed, the potential exists to produce traffic reports with estimates of summary statistic accuracy and precision. This process, in turn, would help ensure informed use of reported summary statistics.

Today, there are few standardized traffic data bases on which to base comprehensive, detailed statistical procedures for national traffic monitoring standards. Nevertheless, traffic reports are acted on daily throughout the nation as though the data were equivalent and understood. It is vital that decisions concerning the nation's highways be based on data that are, in fact, comparable. In order to do this, standard practice must be defined and professional guidance provided with the clear understanding that the practice is dynamic.

FOUNDATIONAL TRAFFIC MONITORING STANDARDS

National traffic monitoring standards should have several characteristics. They must provide a reference for individual agency and staff decisions. They must address the critical decisions in each aspect of traffic monitoring, from traffic measurement through summarization to reporting. They should support future development, given the dynamic nature of traffic technologies and statistical analyses.

A group of highway traffic monitoring standards may be considered foundational. These foundational standards are outlined in the following paragraphs.

To measure traffic for equivalent summary statistic calculation, there must be adherence to the principle of base data integrity. Missing or inaccurate raw data should not be completed, filled in, or replaced for any type of traffic measurement, at any location, under any circumstance. What is inviolable is the distinction between a measurement and an estimated value.

Not all measurements are accurate. Therefore, a set of standards must be developed to screen measurements for accuracy. If the measurements are not found to be accurate, they will be rejected for computation of summary statistics. Other measurements must be made and used.

To provide equivalent and comparable summary statistics, there must be a consistent method of computing the summary statistics. The method selected should be based on measurements that are determined as being accurate. The standards should specifically avoid computational procedures that require data imputation or estimation.

To provide useful reports, traffic monitoring standards must incorporate the principle of truth-in-data. Persons receiving traffic data reports need additional information to make traffic summary statistics meaningful. The minimum requirement for traffic monitoring standards was adopted for site-specific summary statistics by the Strategic Highway Research Program (SHRP). The SHRP requirement is that a description of the period and type of traffic measurement must be provided for each reported traffic summary statistic (*4*). Data users will preferably be provided with estimates of the precision and bias of reported traffic summary statistics.

Truth-in-data should be considered the most important principle of national traffic monitoring standards. The impact of this principle extends beyond research activities to every traffic data application.

Combined, these principles establish the foundation for standards and guidance for traffic monitoring. The principles will help ensure informed use of traffic data today, and increased understanding tomorrow.

CONCLUSION

The first highway reports in the United States were generated in the early 1900s. Systematic measurement of highway traffic was well underway in the 1930s, and was subsequently impacted by widespread automatic measurement of traffic in the 1940s. In over 50 years of automated traffic monitoring, no standards of professional practice were developed and accepted for nationwide use.

The unmet need for highway traffic monitoring standards continues to exist. Because the traffic monitoring profession has developed independently, standards will not be easy to implement. The identification of traffic monitoring standards will require virtually all public agencies and private consulting engineering firms to modify their current traffic practices.

Although defining and implementing a dynamic set of traffic monitoring standards will be difficult, the alternative is unacceptable. The use of traffic reports is too significant, both in economic and in human terms, to permit current inconsistent practice to continue.

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