CHAPTER FIVE

STRENGTHS AND WEAKNESSES OF PERFORMANCE MEASURES

Table 18 summarizes commonly used evaluation criteria to assess performance measures that were adapted from other studies that assessed the strengths and weaknesses of performance measures as presented in chapter three.

Table 19 summarizes the strengths and weaknesses of the various measures identified in the research and practices for the operational effectiveness of highway segments and systems based on the criteria. This was performed as part of this synthesis and is not applicable to all situations where performance measures are applied, but is intended to document the relative strengths and weaknesses of the measures for the operational effectiveness of highway segments and systems.

The following measures received a minimum score of 15 out of 20 and were consistently reported in the synthesis of practice. The measures were also recommended based on their ability to serve as foundations for other commonly reported measures, such as congestion index.

- Outcomes (Operational) Performance Measures
  - Quantity of travel (users' perspective)
    - Person-miles traveled,
    - Truck-miles traveled,
    - VMT,
    - Persons moved,
    - Trucks moved, and
    - Vehicles moved.

  - Quality of travel (users' perspective)
    - Average speed weighted by person-miles traveled,
    - Average door-to-door travel time,
    - Travel time predictability,
    - Travel time reliability (percent of trips that arrive in acceptable time),
    - Average delay (total, recurring, and incident-based), and
    - LOS.

  - Utilization of the system (agency's perspective)
    - Percent of system heavily congested (LOS E or F),
    - Density (passenger cars per hour per lane),
    - Percentage of travel heavily congested,
    - V/C ratio,
    - Queuing (frequency and length),

TABLE 18
CRITERIA PERFORMANCE MEASURES

General Criteria	Specific Criteria
Clarity and simplicity	The measure is simple to present, analyze, and interpret
	The measure is unambiguous
	The measure's units are well defined and quantifiable
	The measure has professional credibility
	Technical and nontechnical audiences understand the measure
Descriptive and predictive ability	The measure describes existing conditions
	The measure can be used to identify problems
	The measure can be used to predict change and forecast condition
	The measure reflects changes in traffic flow conditions only
Analysis capability	The measure can be calculated easily
	The measure can be calculated with existing field data
	There are techniques available to estimate the measure
	The results are easy to analyze
	The measure achieves consistent results
Accuracy and precision	The accuracy level of the estimation techniques is acceptable
	The measure is sensitive to significant changes in assumptions
	The precision of the measure is consistent with planning applications
	The precision of the measure is consistent with an operation analysis
Flexibility	The measure applies to multiple modes
	The measure is meaningful at varying scales and settings

Adapted from Meyer (1995), Turner et al. (1996), Lomax et al. (1997), and Jackson et al. (2000).

TABLE 19
STRENGTHS AND WEAKNESSES OF VARIOUS PERFORMANCE MEASURES

Performance Measure	Overall Score	Clarity and Simplicity (out of 5)	Descriptive and Predictive Capability (out of 5)	Analysis Capability (out of 4)	Accuracy and Precision (out of 4)	Flexibility (out of 2)
Accessibility	8	0	0	3	3	2
Air quality impacts	16	5	3	3	3	2
Bridge condition	16	5	4	4	3	0
Capital costs in proportion to travel time savings	9	3	0	3	3	0
Commercial vehicle safety violations	14	5	2	4	3	0
Congestion cost per capita	13	5	1	3	3	1
Congestion cost per eligible driver	13	5	1	3	3	1
Congestion index	10	2	2	3	3	0
Cost-effectiveness (benefit/cost ratio)	11	3	0	3	3	2
Customer satisfaction—ability to bid projects	13	5	3	2	3	0
Customer satisfaction—ease of driver licensing	13	5	3	2	3	0
Customer satisfaction—ease of payment of taxes and fees	14	5	3	2	3	1
Customer satisfaction—ease through construction zones	13	5	3	2	3	0
Customer satisfaction—satisfaction with HOV lanes	14	5	3	2	3	1
Customer satisfaction—satisfaction with ramp meters	13	5	3	2	3	0
Customer satisfaction—satisfaction with service patrols	13	5	3	2	3	0
Customer satisfaction—satisfaction with traveler information	14	5	3	2	3	1
Customer satisfaction—streamlined procedures for contracting	13	5	3	2	3	0
Delay caused by incidents	17	5	2	4	4	2
Delay per capita	13	5	1	3	3	1
Delay per eligible driver	13	5	1	3	3	1
Delay, recurring	20	5	5	4	4	2
Delay, total	20	5	5	4	4	2
Density (vehicles per hour per lane)	19	5	5	4	4	1
Density (vehicles per lane-mile)	18	5	4	4	4	1
Duration of congestion	19	4	5	4	4	2
Efficacy of freight movements	8	0	2	3	3	0
Equity/environmental justice	6	0	1	2	3	0
Evacuation clearance time	15	5	3	3	3	1
Guardrail blunt ends	12	5	2	3	2	0
Incident response time	17	5	3	4	4	1
Incidents (fatal) per million vehicle-miles	17	5	3	4	4	1
Incidents (injury) per million vehicle-miles	16	5	3	3	4	1
Incidents (number of crashes or stopped vehicles)	17	5	3	4	4	1
Incidents (property damage only) per million vehicle-miles	16	5	3	3	4	1
Lane-use and development permit data	8	1	1	3	3	0
Lane occupancy	14	3	3	4	4	0
Level of service	17	5	4	3	4	1
Noise levels	14	4	3	4	3	0
Number of miles operating in desired speed range	19	5	5	4	4	1
Number of trips made per person	14	5	2	4	3	0
Pavement condition	18	5	4	4	4	1
Percent of ITS equipment operational	17	5	3	4	4	1
Percent of system congested	14	3	3	3	4	1
Percent of travel congested	15	3	3	3	4	2
Person-miles traveled	20	5	5	4	4	2
Population and employment	14	5	3	3	3	0
Project timeliness	13	5	2	3	3	0
Queuing of traffic (frequency)	18	5	5	4	4	0
Queuing of traffic (length)	18	5	5	4	4	0
Rail crossing incidents	17	5	3	4	4	1
Response time to weather-related incidents	15	4	2	4	4	1
Response times to incidents	15	4	2	4	4	1
Seat belt use	12	5	2	2	3	0
Security for highway and transit	13	4	3	3	3	0
Speed	20	5	5	4	4	2
Toll revenue	16	5	3	3	3	2
Traffic volume	19	5	5	4	4	1
Travel costs	14	4	3	3	3	1

TABLE 19 (*Continued*)

Travel rate index	10	3	1	3	3	0
Travel time	19	5	5	4	4	1
Travel time predictability	18	5	5	3	4	1
Travel time reliability	15	3	3	4	4	1
Vehicle-miles traveled	19	5	5	4	4	1
Vehicle occupancy (persons per vehicle)	18	5	3	4	4	2
Volume/capacity ratio	19	5	5	3	4	2

TABLE 20
COMMON DATA COLLECTION STANDARDS FOR PERFORMANCE MONITORING AND ADVANCED TRAVELER
INFORMATION SYSTEMS

Data Element	Attribute	Supplemental Data Elements
Vehicle travel times	5-min average for all roadways with required coverage	• Date of measurement • Start time of travel time • Anonymous vehicle identification • Link identification
Vehicle spot speeds	5-min averages by lane using actual speed observations for all roadways with required coverage	• Date of measurement • Start and end time for speed summary statistics • Detector location identification and location
Vehicle volumes	5-min totals by lane for all roadways with required coverage	• Date of measurement • Start and end time for volume summary statistics • Detector location identification and location
Roadway link and corridor identification	Links of 1–3 mi along arterials and between each interchange along limited-access roadways	• Detector location identification and location • Roadway name and direction • Link length • Number of lanes • Posted speed limit • Area type (urban, urbanized transitioning, rural) • Functional classification (freeway, arterial, collector)
Vehicle classification	Using FHWA's 13 vehicle classes as defined in the Traffic Monitoring Guide	• Date of measurement • Start and end time for volume summary statistics • Detector location identification and location

> Percent of miles operating in desired speed range,
> Vehicle occupancy (persons per vehicle), and
> Duration of congestion (lane-mile-hours at LOS E or F).

– Safety
> Incident rate by
  □ Severity (fatal, injury, or property damage), and
  □ Type (stopped vehicles, rail crossing, weather, or crashes).
– Incidents
> Incident induced delay, and
> Evacuation clearance time.

• Outputs (agency performance)
  – Incident response time by type
    > Stopped vehicle,
    > Rail crossing,
    > Weather, and
    > Crashes.
  – Toll revenue,
  – Bridge condition,
  – Pavement condition, and
  – Percent of ITS equipment operational.

In addition to identifying these performance measures, some common data collection requirements to support these measures were identified in this synthesis of practice. Table 20 summarizes these data requirements.

CHAPTER SIX

CONCLUSIONS

This synthesis of research examined the use of performance measures for the monitoring and operational management of highway segments and systems. The current state of the practice includes a wide and varied approach to performance measures, and more than 70 performance measures were identified. The relative strengths and weaknesses of the measures were reported based on professionally accepted criteria. The performance measures that were most commonly identified were conditions experienced by the traveler, such as travel time, speed, and delay. Measures that are derived from these basic units, primarily indices, were found to be less relevant to the operational environment, but very valuable for transportation planning, policy, and prioritization analysis. Based on the results of the survey of state departments of transportation and metropolitan planning organizations, the dimensions of operational performance that were the most relevant were the quantity of travel and the quality of travel.

Through this synthesis of research and practice several research needs were identified as important to enhance and expand the state of the practice.

- Because of the diversity in the use and application of performance measures nationally and their formative status (not mature and well tested), several measures such as reliability have been defined differently. A data dictionary of performance measures is needed that defines the use and application of derived measures such as reliability and the indices. Several of the seminal works identified in the literature review are approaching this status of a *de facto* standard; however, more formal policies and guidelines are needed. Inclusion of a broader range of operational performance measures and recommended practices such as the Highway Performance Monitoring System and TRB's *Highway Capacity and Quality of Service Manual* will promote this needed convergence. The FHWA's Intelligent Transportation Infrastructure Program established standards for data collection quality and reporting; however, these standards have not been widely adopted.
- Additonal information is needed in the use of performance measures in operational environments. The nation's emerging intelligent transportation systems will provide a strong operational platform for the more formal application, use, and study of the benefits of performance-based management. However,

without strong leadership, diverse and more informal practices are likely to continue that make system evaluation, aggregation of statistics, and comparisons of operational scenarios more difficult.
- Information is also needed to develop standards for data quality and coverage to support operational needs, advanced traveler information systems, and systemwide reporting. Several guidelines are currently available, such as *Closing the Data Gap: Guidelines for Quality Advanced Traveler Information System Data* published by ITS America and the Intelligent Transportation Infrastructure Program's data quality standards. These standards could be unified and developed so that deployment of data collection systems can serve multiple purposes and achieve synergistic effects.
- None of the case studies explicitly addresses accuracy or precision in the presentation of their results. This is a major challenge for the advancement of mobility performance measures programs. In addition to the data definition and quality standards identified earlier, recommended practices for reporting of performance measures are needed. These recommended practices could include reporting standard errors or confidence intervals as a common practice.
- Few agencies have addressed the need to forecast performance measures and to address the sensitivity of policy or travel behavior changes. Once national practices are established to consistently report on trends and a sufficient database has been developed over time, the next logical extension will be the forecasting of these trend data and the testing of alternate policies and scenarios. A national practice is needed that will guide policy and system planners in this technique.
- Operational performance measures that address evacuations from man-made or natural disasters are needed. During these conditions of urgency, the efficient use of transportation resources to remove people and resources from harm's way is very important. Several agencies deploy measures such as clearance time (the time it takes for an evacuee to move outside of the danger zone); however, these measures are used primarily in post-event evaluations. Use of performance measures during the operations of these events and tailoring strategies to maximize/optimize performance based on these measures could improve effectiveness.