Decisions, Values, and Data:

Understanding Bias in Transportation Performance Measures

"Values are inescapable elements of any rational decision-making process."[1]

By Eric Dumbaugh, Ph.D., AICP, Jeffrey Tumlin, and Wesley E. Marshall, Ph.D., P.E.

Transportation practice aspires to be "rational" in its approach to decision making. That is, it relies heavily on the use of performance measures and project evaluation criteria, derived from empirical data, to examine whether specific transportation investments may advance transportation-related goals and objectives.[2]

A common misconception is that, because the transportation performance measures are derived from "objective" data, the decisions that emerge through the use of these measures are likewise "objective," or at least free from professional bias.

Yet this is not so. Knowing that a four-lane roadway carries 50,000 vehicles per day, or that a particular intersection operates at level-of-service "F" (Fail) during the peak hour, is no more a call to a specific course of action than is knowing that there is a 30 percent chance of rain. All three are simply descriptive statements. It is only when this information is filtered through our values and expectations, as reflected in our measures of transportation system performance, that they gain importance.

In this article, we use the example of level-of-service to detail how norms, values, and preferences are embedded in the data we use for transportation decision making. We proceed to detail how these values influence, in a profound way, our understanding of transportation problems and the types of solutions that are "acceptable" to resolve them. We conclude by detailing four principles of which transportation professionals should be aware when developing and applying measures of transportation system performance.

Data, Norms and Values: Considering Level-of-Service

In the United States, the most commonly used metric of transportation performance—and in many jurisdictions, the only metric—is level-of-service (LOS). This calculation strives to measure the convenience of driving a personal automobile. For urban streets, LOS is based on the number of seconds motorists are delayed at intersections, as well as reductions in free-flow speed that may occur as a result of the presence of other motorists (See Table 1). LOS is typically reported for either the most congested hour or most congested 15 minutes of the day.

Table 1. LOS for Urban Streets, Adapted from the Highway Capacity Manual[3]

Level of Service	Control Delay (s/veh)	Travel Speed at % Free-Flow Speed
A	≤10	> 85
B	> 10 and ≤ 20	> 67 and ≤ 85
C	> 20 and ≤ 35	> 50 and ≤ 67
D	> 35 and ≤ 55	> 40 and ≤ 50
E	> 55 and ≤ 80	> 30 and ≤ 40
F	> 80	< 30

While LOS is rooted in quantitative, volume-to-capacity analysis, it is reported in a qualitative, A-to-F letter scale, like a school report card. Intersection LOS is rarely reported as, for example, "84 seconds of delay," but instead as "LOS F." This terminology implies that the intersection has failed, even if it has only exceeded its capacity for 15 minutes of the day. Asserting that a roadway has failed is not a descriptive statement; it is a call to action.

To illustrate the value-laden nature of this measure, we have restated three of its implicit assumptions as explicit "guiding principles" that could be included as part of a community's long-range plan. While these principles would undoubtedly result is a great deal of public debate if presented to the public for consideration, in practice they are given little or no consideration because they are layered as implicit assumptions in the use of LOS as a performance measure.

Principle 1: Cars are more important than people.

While most transportation plans include a goal stating the importance of moving people and goods, LOS, the primary performance measure used in support of this goal, says nothing about moving either. The appropriate measure of the movement of people is the number of people that are transported through a spot or along a corridor, such as persons per hour per lane. Instead of providing us with information on people, LOS tells us only about automobile delay and vehicle speeds. Its connection to the movement of people and goods is made indirectly by the inference that: 1) Most, if not all, of the movement of people and goods will occur through the use of private automobiles; and 2) Any strategy that reduces motorist delay or increases motorist speed will also enhance the movement of people and goods.

Under this measure, the people onboard a full 50-person bus are each valued at one-fiftieth the worth of a person driving alone in a car. The needs of bicyclists and pedestrians are not measured at all. Any design changes that create delay or discomfort pedestrians, such as alteration in signal timings, are seen as entirely positive from an LOS perspective if they reduce vehicle delay or increase speed on urban streets. Transit, walking, and cycling are treated as being worthwhile only insofar as they lead to reductions to motorist delay, regardless of however efficient they may be at moving people.

Principle 2: We should provide roadway capacity greatly in excess of what is actually needed.

The rank ordering of urban streets from A to F presumes that A is an optimal solution. This encourages transportation professionals to prefer solutions that not only meet the needs of the most congested hour (or even 15 minutes) of the day, but which greatly exceed it. From an economist's perspective, LOS F is ideal, since this represents the point at which transportation supply comes into balance with demand at the peak hour. Additional capital investment in roadway expansion would be economically inefficient and wasteful. From the perspective of "main street" retailers, LOS E is preferable because it maximizes the number of passing motorists who can see their shops.

Principle 3: New development should occur in suburban and exurban locations, rather than in established urban areas.

Economically successful cities and main streets are usually congested, and few offer the opportunity to widen streets and intersections to increase capacity. Nonetheless, LOS tells us that these are "failing" locations where additional development, and the trips it may generate, is undesirable.

This is evidenced by the State of Florida's concurrency program, which requires developers to pay impact fees if the trips generated by a proposed development reduce level-of-service below acceptable levels (typically D or E). Because many urban streets are already operating below these levels, the impact fees assessed on a developer would require them to address not only the impacts of their development, but the costs of bringing the surrounding streets up to standard. Rather than pay these fees, developers opted to instead bypass urban areas altogether, shifting their projects to suburban and exurban locations that have comparative little traffic and thus excess capacity and higher LOS. The problem became so pronounced that the state allowed local governments to abandon the use of LOS through the creation of "concurrency exception areas," where LOS-based standards no longer apply.[4]

Does Level-of-Service Even Matter?

The transportation profession has become so accustomed to using LOS as its primary measure of system performance that we often fail to ask why such a measure is important. While it may be true that traffic delay is inconvenient for motorists, so what? Is this a problem that needs to be "resolved?" Is it a problem that *can* be resolved?

The current reliance on LOS is based on two philosophical assumptions. The first is the idea that a region's economic performance is linked to vehicle delay or, stated another way that traffic congestion is a drag on our economy that *should* be reduced or eliminated. The second is the assumption that we *could* resolve the problem of traffic congestion if only we made sufficient investments in transportation infrastructure and operational enhancements.

As best as can be determined, both assumptions are wrong.

Assumption 1: Economic Performance

With respect to the economic efficiency argument, popular statistics are widely used to make the case that congestion is a drag on the economy. According to the Texas A&M Transportation Institute (TTI), vehicle delay costs Americans $121 billion in wasted fuel and time each year.[5] Yet economies are measured not in terms of vehicle delay or the amount of travel that people do, but in terms of the dollar value of the goods and services that they produce. If it is true that congestion is detrimental to a region's economy, then one would expect that people living in areas with low levels of traffic congestion would be more economically productive, on a per capita basis, than those in areas with high levels of congestion.

To test this assertion, Eric Dumbaugh combined TTI's data on traffic delay per capita with estimates of regional gross domestic product (GDP) per capita, acquired from the U.S. Bureau of Economic Analysis, using 2010 data for both variables. The variables were converted into log form to make them linear and then regressed against each other (see Figure 1).

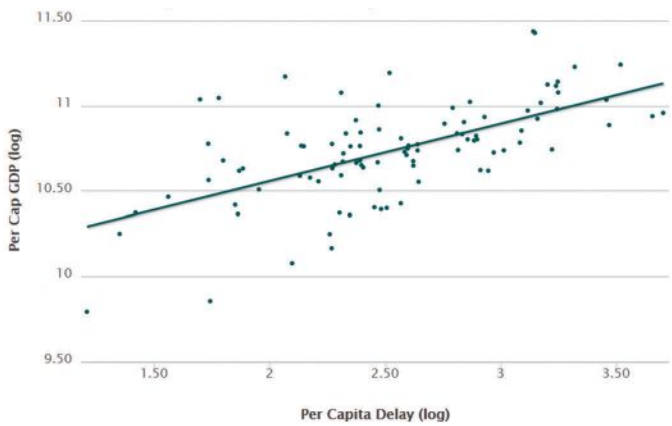


Figure 1: The Relationship between Traffic Delay and GDP in American Metros[6]

And what did this analysis find? As per capita delay went up, so did GDP per capita. Every 10 percent increase in traffic delay per person was associated with a 3.4 percent increase in per capita GDP. The relationship was significant at the 0.000 level, and the model had an R^2 of 0.375. In layman's terms, this was a statistically-meaningful relationship and is the exact inverse of the one currently assumed by transportation professionals.

Such a finding seems counterintuitive on its surface. How could being stuck in traffic lead people to be more productive? The relationship is almost certainly not causal. Instead, regional GDP and traffic congestion are tied to a common moderating variable—the presence of a vibrant, economically-productive city. And as city economies grow, so too does the demand for travel. People travel for work and meetings, for shopping and recreation. They produce and demand goods and services, which further increases travel demand.

And when the streets become congested and driving inconvenient, people move to more accessible areas, rebuild at higher densities, travel shorter distances, and shift travel modes.[7] Stated another way, people adapt to congested environments. Cities adapt as well, often by attempting to eliminate congestion but also by investing in transit or with better walking and bicycling infrastructure. Because cities provide greater access to job opportunities than do rural areas as well as wages that are more than 30 percent higher than their non-metropolitan counterparts, they have a powerful economic incentive to do so.[8]

Adaptations to congestion—such as increases in transit and population density—have been shown to ward off the detrimental economic effects that are assumed to result from congestion.[9] In a recent longitudinal study of congestion and economic growth for 88 U.S. metropolitan areas, the author concludes that "*economies do not stagnate as a consequence of traffic*" and that the best predictors of economic growth have more to do with a dense urban core and regional economic demand than the quantity of transportation infrastructure.[10]

Assumption 2: Congestion Elimination

The second assumption is that we *could* eliminate traffic congestion through investments in highway infrastructure. Such an assertion seems to have a great deal of face validity. If we expect that a roadway will carry 4,500 vehicles during the peak hour, and we design it to carry 6,000, this should, in theory, reduce delay. Unfortunately, this assertion is based on the misapplication of the principles of fluid dynamics to urban transportation systems, which presumes that travel demand is part of a fixed system that remains unchanged following modifications to a system's capacity. As detailed by Anthony Downs, traffic is not a fixed system. Changes in system capacity result in what he has described as a "triple convergence" by encouraging people to 1) re-route their driving trips to take advantage of the new capacity on the improved facility (spatial convergence); 2) shift their driving trips from off-peak periods to peak periods (temporal convergence); and 3) shift from transit to driving now that driving is more convenient (modal convergence). The net result is that new capacity is absorbed by modifications in driving behavior.[11]

Studies examining the phenomenon have found that efforts to reduce congestion are rarely successful.[12] While our models treat traffic like a fluid, it tends to behave more like a gas by filling the space it has been allocated. Thus, the extra capacity offered by road widenings is typically filled long before predicted.[13] While transit provides another mode option, the road space vacated by users switching from driving to transit is also quickly filled. As a result, transit investments tend not to result in actual travel time reductions.[14] Even policy-based solutions such as that employed by Mexico City, Mexico—where each car could not be driven on one specific day per week—have not only been ineffective with congestion relief but have inadvertently resulted in higher car ownership rates as drivers attempt to skirt the system.[15] The main successes have come in the form of congestion pricing, but such efforts are politically a non-starter in most of the world.[16]

Clarifying our Values and the Performance Measures that Reflect Them

"The values held by the planner should be made clear."[17]

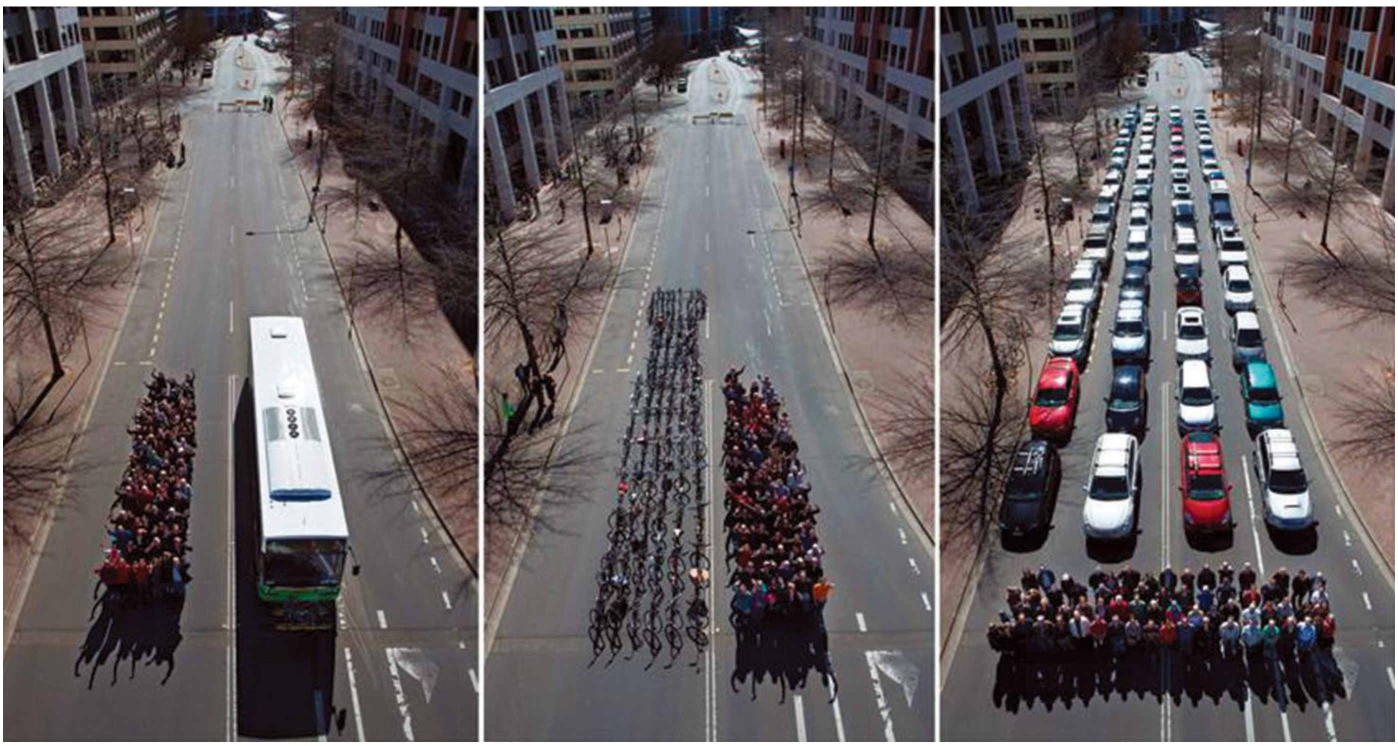
A major challenge confronting the transportation profession is that we have allowed our understanding of transportation system performance to be captured by the values and interests of the manufacturers of a specific means of conveyance—the personal automobile. As detailed in Peter Norton's fascinating historical work "Fighting Traffic," traffic engineers initially sought to manage and restrict automobile traffic in urban areas, rather than accommodate it. The saturation of automobiles on urban street networks further resulted in a tapering off automobile sales in the mid-1920s, creating a crisis for the automobile industry. The industry's response was to develop and promote the concepts of automobile efficiency, as well as the analytical methods that continue to define the profession of traffic engineering. Indeed, the first endowed chair in traffic engineering, held by Miller McClintock, was funded by Studebaker.[18]

These practices led to the allocation of right-of-way to the exclusive use of motorists, the formal allocation of right-of-way at intersections through traffic control, and the legal enforcements of the motorists' right to these formerly "public" spaces through the development of traffic laws. It further resulted in the professional entrenchment of the values that underpin our definition of transportation system performance.

To provide a contemporary analogue, the modern-day equivalent would be to develop a transportation system developed around the Segway, with street right-of-way re-allocated to the Segway's design dimensions, signalization timed to accommodate their acceleration speeds and the amount of time needed to negotiate a left turn, and a comprehensive marketing campaign focused on associating the Segway to such core American values as "freedom" and "prosperity." As superficially ridiculous as this may sound, this is precisely what the U.S. automobile industry accomplished in the mid-1920s.

What was understood by transportation professionals in the 1920s, but has since been lost, is that the objective of our profession is not to move any particular mode of transport, be it a personal automobile, a pedestrian, a streetcar, or a Segway, but to ensure the movement of people and goods. The adoption of measures such as LOS presumes that it is personal vehicles alone that matter. The decision to base transportation decisions on the operational characteristics of a particular mode of travel contains an embedded choice of values; values that may or may not be consistent with those of the community that the transportation system is intended to serve.

And for many communities, such measures are not consistent with their values. Cities throughout the country are increasingly taking right-of-way away from motorists and reallocating it to transit, bikeways, and pedestrian facilities. These facilities are not only more spatially efficient at moving people in constrained environments



Cycling Promotion Fund 2012

Figure 2: This image from Canberra, Australia shows the space required to move 69 people by bus, bicycle, and car.

(see Figure 2), they are increasingly shown to be associated with higher land values (and thus property taxes).[19] With the ongoing decline of the federal-aid gas tax as a source for funding transportation infrastructure, local governments are increasingly focused on transportation investments that generate value for their communities, both socially and fiscally.

The National Association of City Transportation Officials (NACTO), which counts most major U.S. cities among its members, has developed its own guidance on the design of urban streets. The NACTO *Urban Street Design Guide* has this to say on LOS:

> *[it] inadequately captures a project's potential benefits. As a metric, it is mono-modal, measuring streets not by their economic and social vibrancy, but by their ability to process motor vehicles.*[20]

Far from being concerned with motorists, the NACTO guide is focused principally on reallocating right-of-way and signal timings to promote the needs to pedestrians, cyclists, and transit. Unlike the American Association of State Highway Officials' A Policy on Geometric Design of Highways and Streets (the "Green Book")[2] and the Transportation Research Board's *Highway Capacity Manual*,[2] which say almost nothing about their guiding values and principles, the NACTO guide is explicit about the aims it seeks to advance, beginning with the delineation of six guiding principles, and allowing communities to determine for themselves whether these principles, and the actions they encourage, are appropriate.[21]

Conclusion: Four Considerations

"The right course of action is always a matter of choice, never of fact."[22]

We conclude this paper with four general considerations. First, while observational data may be objective "facts" about the world, the decision to define performance using one type of data, rather than another, is a value choice. As we have sought to demonstrate with the example of LOS, defining transportation system performance based on the delay experienced by motorists is not a value-neutral decision. It has profound effects on the types of transportation investments that will be valued by decision makers and thus the types of projects that will result.

Second, we should be sensitive to that fact that performance measures are "organizers of attention." They direct the attention of decision makers and the public to specific phenomenon. In so doing, they not only signify that the phenomenon is important, they are also a call to action.[23] The adoption of LOS as a performance measure does not simply indicate that we are concerned with vehicle delay; it asserts that we *ought* to prioritize projects that reduce delay.

Indeed, many project needs statements for urban streets begin with the identification that LOS has either declined, or that it is expected to decline at some point in the future. As a result, projects are initiated with the express purpose of reducing vehicle delay; once such a needs statement is issued, any solution that is to be regarded as "acceptable" must be shown to reduce vehicle delay. Adding highway lanes will always be successful by this measure (if we ignore triple convergence). Converting an existing traffic lane into a dedicated busway will always be "unacceptable" since it will almost certainly increase vehicle delay. That a dedicated busway can result in a 15-fold increase in the person-capacity of the travel lane is treated as being inconsequential.[24]

This would be no particular problem if a community preferred improvements that reduce vehicle delay over improvements to transit, but surveys of communities throughout the United States—including places as culturally disparate as Southern California and Houston, Texas—show that the majority of transportation stakeholders do *not* share these values.[25,26] Instead, there is general consensus that investments in transit are preferable to investments in additional highway capacity.

This leads to the third consideration for transportation professionals, which is that we should to be aware of how our performance measures relate to the values and desires of the public which we serve. If there is a substantive disconnect between the recommendations that emerge from our performance measures and the projects sought by our stakeholders, then we are using the wrong performance measures.

Fourth and finally, we must recognize that the adoption and use of performance measures is not simply a statement of values, it is an expression of power. Performance measures direct attention to specific phenomenon and encourage specific courses of action. The decision to highlight certain transportation phenomena, and not others, brings with it a command of public resources. And since public resources are finite, any expenditure of public funds necessarily diverts those resources from advancing other ends. The simple adoption of a performance measure creates winners and losers.

As professionals, we are stewards of the technical and factual information that informs transportation decision making. We are responsible for ensuring that the ends we seek to advance, and the measures that support them, reflect the needs and interests of the public we have been entrusted to serve. **itej**

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