Abridgment

Evaluation of Public Transit Services: The Level-of-Service Concept

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In recent years privately owned urban mass transportation has almost disappeared and been replaced by public operations. While there are many reasons for this change, the key factor appears to have been the rapidly increased costs of operation. Inflation has affected all labor-intensive industries but has been particularly severe on transit, which has required ever-increasing subsidies.

These increased subsidies have made the need for evaluation of transit increasingly evident. New evaluative methods for measures of both efficiency and effectiveness are required.

EVALUATION FRAMEWORK

There are four primary elements of service to be evaluated: cost, amount, impacts, and quality. The cost of service applies to the user and to the governments that supply subsidy funds. In terms of public administration theory, its evaluation is a management or efficiency evaluation. The amount of service can be readily quantified and the impacts of service can be construed to be part of a substantive evaluation. However, the quality of service is difficult to describe meaningfully since there are no generally accepted sets of standards or criteria by which quality can be measured.

Thus, there is the problem of qualitative evaluation and its integration with quantitative review. A possible model for the evaluation of transportation that could provide such an integration is shown in Figure 1.

The quality measures of urban transit can be placed in two categories, transportation hygiene factors and level-of-service (LOS) indicators. If the hygiene factors theory of job motivation is extended to a transit operation, there would be certain attributes that would create satisfaction, but the absence of such attributes, although it might discourage and displease riders, would not dissatisfy to the point of causing people to change modes.

The theory of transportation hygiene has value in that such a categorization may explain why operations with clean safe equipment may have very few riders: All hygiene factors may be met (no dissatisfaction), but the level of service be very poor (no satisfaction either). In these terms, only the LOS indicators motivate behaviorial change by those who have an option; hygiene factors are subjective qualities that are necessary but are never permanently satisfied, need continual improvement, and seem, in this context, most related to maintenance and equipment costs. While there is tremendous need to investigate and develop meaningful measures for transportation hygiene factors, this paper further addresses only LOS.

LEVEL OF SERVICE

The familiarity of local officials and technicians with the LOS concept in pedestrian planning (2) and traffic engineering appears to be the source of the term in public transit evaluation. (If transit LOS standards can be defined in terms already comprehended by policy makers and technicians, so much the better.) As the Institute of Transportation Engineers has noted (3), "Levels of service are tools equally useful to the traffic engineer and the administrator, yet also apparent to the average driver."

The following parameters are used to define transit LOS: a composite of basic accessibility, travel time, reliability, directness of service, frequency of service, and passenger density. The operationalism of the concept must be evaluated according to whether it is (a) user oriented rather than operator oriented, (b) operations oriented rather than facility or equipment oriented, (c) trip (or link) specific rather than area related, (d) quantifiable by an independent observer, (e) independent of an evaluation of efficiency measures and effects or impacts, and (f) exclusive of any transportation hygiene factors.

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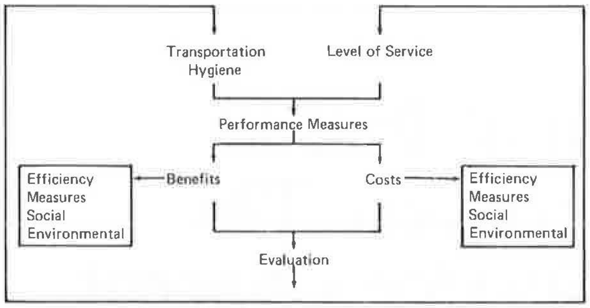
Figure 1. Transportation evaluation model.



CONCEPTUAL INDICATORS AND OPERATIONAL DEFINITIONS

At present, there is no consensus as to what indicators should be used, their relative importance or meaning, or how to measure some of them (4, 5, 6, 7). Public and private researchers and administrators have proposed numerous factors (4, 8, 9, 10, 11, 12, 13, 14), but few have quantified these measures. Work completed more than 15 years ago by the National Committee on Urban Transportation (NCUT) (15) is almost the only source of criteria and standards that are close to being the equivalent of commonly accepted principles. The first problem then is to develop operational definitions.

It is first necessary to determine basic accessibility. If there is no transit reasonably available, then there can be no LOS, but if we assume basic accessibility (indicator 1) then the relative accessibility can be used to determine the transit access time (indicator 1A), which is defined as the time necessary to get to transit from the trip origin and then from transit to the trip destination. A basic requirement for this indicator is that the trip be accessible to pedestrians at least at one end. While this indicator is defined in terms of time, it may also be defined in terms of distance, but this requires several subdivisions into modes of access (Table 1). Level C represents the commonly accepted distance for pedestrians to travel to transit. Under this standard time remains constant and distance changes in relation to mode.

Indicator 2, travel time, measures the ability of transit to compete with the private automobile. The index for this is simply the travel time by transit divided by the travel time by automobile (15), shown below. In this case, transit access time is not included in the calculation of total travel time.

Level of Service	Index	Comment
A	<1.00	Best service; transit is faster than automobile
B	1.00 to 1.10	Transit is 10 percent slower than automobile
C	1.11 to 1.34	Transit is up to 33 percent slower than automobile
D	1.34 to 1.50	Transit is 50 percent slower than automobile
E	1.51 to 2.00	Transit is no more than twice as slow as automobile
F	>2.00	Transit is more than twice as slow as automobile; service available only for transit-dependent people

Indicator 3, the reliability of transit, is related to frequency: the more frequent the service, the lower the importance of early or late service (Table 2). Similarly, the less frequent the service, the more important the reliability. LOS C with a service frequency of 9 to 12 min is the same as that recommended by NCUT for peak-hour operations (15).

Some may say that transit should not be expected to adhere to strict on-time performance since traffic congestion, accidents, or weather may severely hamper operations. In most places poor weather is always a problem during certain seasons and can be calculated into time tables. Accidents can also sabotage adherence to schedules but, in truth, they either rarely hurt schedules or are so common as to always prevent adherence. Traffic congestion is a continuing fact in most cities during peak travel hours; the extra time needed for travel should be included in the assigned schedule times. Finally, some argue that reliability is less important than a tight schedule that encourages drivers to provide the fastest service possible (6). However, properly developed trip tables accomplish the same result while providing accurate information to the public. There is no reason that schedules for employees and those for the public cannot be identical.

The fourth indicator is the directness of service. People generally do not like to transfer to complete a trip and the time necessary to transfer is as important to riders as the actual need to make a transfer and the number of transfers to be made, as shown below.

Level of Service	Number of Transfers	Wait Time (min)	Level of Service	Number of Transfers	Wait Time (min)
A	0	—	D	2	<5
B	1	<5	E	2	>5
C	1	5 to 10	F	3 or more	—
D	1	>10			

Indicator 5, the frequency of service, should be a function of demand, which is related to the population densities at each trip end. However, frequency of service is a chicken-and-the-egg situation: There must be some initial (policy) frequency. Policy headways based on varying population densities are suggested in Table 3.

The final indicator is the passenger density, indicator 6. From the perspective of the user, any density greater than 1 person/seat is undesirable and, where standing would be required for considerable periods of time or at high speeds, the undesirable becomes the unacceptable (see below).

Level of Service	Passenger Density
A	Individual separated seat or high-back row seat per passenger
B	1 seat/passenger; parallel rows of upholstered seats with minimum of 0.46 m^2/person
C	1 seat/passenger; parallel rows of molded seats with minimum of 0.46 m^2/person
D	Perimeter seating; 0.28 to 0.46 m^2/person, or 100 to 110 percent of seated load
E	0.19 to 0.28 m^2/person, or 111 to 125 percent of seated load
F	0.19 m^2/person or less, or more than 125 percent of seated load

At the other end of the scale, individual seating has greater psychological appeal than the traditional parallel rows of double transverse seating. Molded fiberglass seats and perimeter seating are also less desirable. The NCUT (15), like many transit operators and consultants (16, 17), considers a standing load evident of good planning and policy during peak periods, but this is an obvious effort to increase operator productivity. There are many similarities between this density indicator and others that are considered to be transportation hygiene factors, rather than indicators of LOS. The critical difference is that passenger density is crucial in creating rider satisfaction; low density pleases riders, while high density displeases but rarely totally dissatisfies them.

ALTERNATIVE CONCEPTUAL INDICATORS

Several measures have been deliberately excluded from the proposed LOS indicators.

1. Ridership is a response to an offered LOS. As such, it is an important performance indicator, but it in no way directly measures LOS.
2. Public cost (subsidy required) is created by the LOS offered. The individual cost, or fare, depends on the willingness of the rider to pay for the LOS offered. That willingness may be constrained by the ability to pay or by the availability of alternative means of travel. There is ample evidence that people are willing to pay (if they are able) higher prices for higher quality service.
3. Personal security, frequently a problem of psychological perception, is a transportation hygiene factor. From the perspective of a rider, there is a dichotomy: The system is either safe or dangerous. In reality, it is a continuum—a relative degree of safety—and, as studies by the American Public Transit Association (11, 12) and the Metropolitan Washington Council of Governments (18) discovered, personal security is generally a minor concern of passengers.
4. Marketing, planning, and public information services are all vital components in the provision of transit services and are therefore considered part of the transit organization. However, they do not affect the operating service at a given time and are, instead, a means to generate changes in travel behavior. Moreover, if the rider with a mode choice is displeased with the LOS provided, any change in his travel behavior created by marketing is temporary. Certain basic components (bus stop signs, timetables, and such) of public information and marketing are also transportation hygiene factors. There are many operations that do not have such basics, but riders prefer to have them, if their need is perceived.
5. Passenger comfort, whether in the form of shelters, air conditioning, nonglare glass, or other amenities, is a standard improvement to a transit operation. These particular examples reflect facilities, not operations. While they are important considerations, they do not indicate the quality of the service provided. (In this specific set of examples, service is defined strictly: It is the provision of transportation between two points.) Therefore, these examples are hygiene factors. However, there are aspects of passenger comfort that should be considered for future inclusion in the LOS measure, since comfort is of concern to the rider. [One measure already included is passenger density and the type of seat provided (indicator 6).] Any potential comfort indicator should also include the smoothness of the ride.
6. Interior and exterior vehicle cleanliness is viewed as highly important in many rider surveys, but, while there may be degrees of cleanliness that could be developed into a standard, it is still a hygiene factor.

AGGREGATION OF THE INDICATORS

To reiterate, it is hypothesized that there are six LOS indicators: basic and relative accessibility (including transit access time), travel time, reliability, directness of service, frequency of service, and passenger density. To use these indicators properly in an evaluation, an aggregation of factors is required. A five-point grading scale, in which each of the indicators is also weighted, is proposed below. Each community could develop its own ranking for the indicators, based on the numerous research survey techniques explored elsewhere, but it is also possible to arbitrarily develop a ranking system.

Level of Service	Points	Level of Service	Points
A	5	D	2
B	4	E	1
C	3	F	0

Indicator	Weighting Credit	Indicator	Weighting Credit
1A	2	4	2
2	3	5	1
3	2	6	1

Table 1. Transit access for one end of trip.

Level of Service	Time (min)	Distance: Walking (m)	Distance: All Automobile (km)	Distance: Park-and-Ride (km)
A	<2.0	0 to 100	<0.8	—
B	2.0 to 4.0	100 to 200	0.8 to 1.6	0.4 to 1.2
C	4.0 to 7.5	201 to 400	1.6 to 3.2	1.2 to 3.2
D	7.5 to 12.0	401 to 600	3.2 to 4.8	3.2 to 4.8
E	12.0 to 20.0	601 to 1000	4.8 to 8.0	4.8 to 8.0
F	>20.0	>1000	>8.0	>8.0

Note: 1 m = 3.3 ft; 1 km = 0.6 mi.

Table 2. Indicators of reliability (percentage of transit not more than 1 min early or 3 min late).

Level of Service	8 Min or Less[a]	9 to 12 Min	13 to 20 Min	>21 Min
A	85 to 100	90 to 100	95 to 100	98 to 100
B	75 to 84	80 to 89	90 to 94	95 to 98
C	66 to 74	70 to 79	80 to 89	90 to 94
D	55 to 65	60 to 69	65 to 79	75 to 89
E	50 to 54	50 to 59	50 to 64	50 to 74
F	<50	<50	<50	<50

[a]Double the definition of "on time"; average wait is half the headway.

Table 3. Frequency of service at varying population densities.

Level of Service	4000 People/km² Peak Headway (min)	4000 People/km² Off-Peak Headway (min)	3000 to 4000 People/km² Peak Headway (min)	3000 to 4000 People/km² Off-Peak Headway (min)	2000 to 3000 People/km² Peak Headway (min)	2000 to 3000 People/km² Off-Peak Headway (min)	750 to 2000 People/km² Peak Headway (min)	750 to 2000 People/km² Off-Peak Headway (min)	Waiting Time for Demand-Responsive Service (min)
A	<2	≤5	≤4	≤9	≤9	≤14	≤9	≤14	9
B	2 to 4	5 to 9	5 to 9	10 to 14	10 to 14	15 to 19	10 to 14	15 to 29	10 to 14
C	5 to 9	10 to 14	10 to 14	15 to 19	15 to 24	20 to 30	15 to 24	30 to 44	15 to 25
D	10 to 14	15 to 20	15 to 19	20 to 29	25 to 39	31 to 45	25 to 39	45 to 59	26 to 60
E	15 to 20	21 to 30	20 to 30	30 to 60	40 to 60	46 to 60	40 to 60	60 to 90	>60
F	>20	>30	>30	>60	>60	>60	>60	>90	Day or more

Note: 1 km² = 0.4 mi²

To determine the overall LOS, multiply the number of points for the LOS for each indicator by the weighting credits; the total number of points accumulated is divided by the total number of weighting credits (11) which then equals the aggregate LOS.

CONCLUSION

There are two key independent combinations of factors that can be directly controlled by transit policy makers: transportation hygiene factors and indicators of the level of service. Of these two, only the LOS indicators can motivate potential riders; transportation hygiene factors can only discourage. The evaluation model discussed here contains subjective values; it is a starting point for further discussion and refinement. It should be remembered, however, that any method of evaluation developed will contain some subjective concepts. Furthermore, most commonly accepted standards began as subjective concepts.

This modal evaluation methodology, then, appears to provide a useful framework for transit professionals and decision makers to evaluate public transit.

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