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# Making walking irresistible: enabling level-of-service measures to achieve their potential

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**Abstract**

Despite walking's exceptional benefits, it continues to receive surprisingly little attention. In response, the potential of "level of service" (LOS) measures to show accessibly the true, relative status of walking is investigated. A survey of the literature on various LOS measures reveals their distinct evolutionary paths and, in particular, that true commensurability across modes has not so far been achieved. A modelling exercise using leading micro-simulation suggests that pedestrians do fare less well than drivers even where efforts have been made to promote walking, and confirms anomalies in the measurement of experience across modes. The availability of a set of "ideal speeds" is identified as crucial to the issue of commensurability; a critical assessment of "free-flow" speeds for motorised vehicles leads to a proposal that the equivalent for pedestrians should be sprinting speed, for the purpose of gauging performance.



*Keywords:* Walking; Level of service; Justice; Accessibility; Smooth and active modes; Social inclusion and societal issues in mobility

## 1. Introduction

"Despite widespread use of walking as a transportation mode, walking has received far less attention than the motor vehicle in terms of [US] national guidance and methods to support planning, designing, and operating safe, functional, and comfortable facilities" (McCusker, 2022).

The case in favour of walking† in terms of public health and environment is so overwhelmingly strong and well documented that we feel no need to repeat it here. We also note the increasing body of evidence demonstrating the potential of walking to benefit local economies. Cycling has been described as a "miracle pill" (Walker, 2017), and

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† Throughout this paper, we shall use "walking" as shorthand for "walking and wheeling", by which we mean the range of ways in which people travel through the "pedestrian" environment, on foot, in wheelchairs and mobility scooters, etc.

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the same could be said of walking. And walking remains fundamental to transport systems across the world: many journeys are made wholly by walking; practically all journeys by any other form of transport involve at least some element of walking, whilst walking is a critical part of journeys by collective transport, which very rarely provides a door-to-door service. These facts support our claim that walking is the most important mode of transport.

It is therefore strange that walking is not a much more prominent part of transport research and policy. To provide an illustration, we conducted a very simple search of the TRID database[‡]. The two queries used were KEYWORD= "walking" or "pedestrian"; KEYWORD= "driving" or "automobile" or "car". There were 1,182 items from the last year returned to the first query, compared with 5,333 items for the second. We concede that this is at best an approximate test, but the difference between the numbers is nonetheless striking. With respect to policy, a look at the organisational structure of the UK's Department for Transport is revealing: within the "Roads, Places and Environment Group" (other groups having as their modal focus rail, aviation and maritime), there are four teams whose titles are explicitly about vehicles or motoring. In contrast, within one team ("Local Transport"), there is one official (out of a total of nine) associated with the theme of "Active Travel", which covers both walking and cycling.

The modern history of walking in high-income countries is inextricably linked with the modern history of the car. As car ownership and use have grown, walking has become more hazardous and less pleasant both because cars pose a danger to the pedestrian and, in a more structural sense, because environments have been reconfigured to cater for driving (Jacobsen et al., 2009; Norton, 2008). This is coupled with changes in land use that have led to fewer essential trips being readily walkable than used to be the case (Frank et al., 2010). These trends are borne out by behaviour: in Great Britain, the mode share of walking decreased from approximately 35 per cent in 1975/6 to 27 per cent in 2018. Its mode share for the journey to work in the late 19$^{th}$ Century is estimated to have been 59.4 per cent as compared with 7.9 per cent a century later (Pooley, 2021). And it seems reasonable to suggest that the phenomena witnessed in wealthier countries will be replicated in low-income countries as they become more prosperous, unless concerted action is taken to prevent a rise in car use from creating conditions less conducive to walking. Amongst high-income countries, there are some walking "beacons" (e.g. Switzerland[§]) but, here, concerted pro-walking policies have been accompanied by major investment. In contrast, the mode share of walking in the US was 10.5 per cent in 2009 (Buehler et al., 2011). Such numbers are dramatically out of line with the levels of walking that are thought necessary if we are to decarbonise the transport system sufficiently to avoid catastrophic harm resulting from climate change. For example, the UK government has set a target for half of all journeys in towns and cities in England being cycled or walked by 2030 (Department for Transport, 2020). As the then Acting Commissioner of Active Travel England observed, cycling can make a major contribution to its achievement but massive growth in walking is required (All-Party Parliamentary Group on Cycling and Walking, 2022).

We suggest that the lack of attention to walking in transport policy (and research) and conditions for walking are not unconnected. Whilst there are many explanations for both, it is plausible that the lack of attention to walking has helped it to become an "invisible" mode. Moreover, as conditions for walking in many jurisdictions have deteriorated, insufficient notice has been taken of this in the policy sphere, partially because not enough evidence concerning the trend has been made available to policy makers. And this contributes to a vicious circle, in which that lack of attention allows conditions to deteriorate further. And so on.

In this paper, we invoke the well-worn adage that what is measured is managed (Ridgway, 1956) in exploring possible ways of enabling walking to become more "visible". That is, we take as our hypothesis the proposition that, if good evidence concerning the status of walking were made available to policy makers, more might be done to support this most important of modes. But what would constitute good evidence? Our response is to investigate the potential of level-of-service measures to provide it. The rationale for this is that "level of service" as a term is both accessible and (in principle) modally neutral. The first of these is important because policy makers are, we argue, likelier to respond to a performance measure that is clear and, therefore, does not require additional explanation. In contrast, a measure such as *volume over capacity* is meaningful to traffic engineers but will not be immediately intelligible to laypeople. Modal neutrality, meanwhile, is important because the impetus for action in transport very

[‡] https://trid.trb.org/

[§] In 2013, the estimated mode shares for walking in five Swiss cities ranged from 30 to 37 per cent (Ravalet et al., 2014).

frequently arises from the *relative* gravity of a situation – policy makers argue for or initiate change because circumstances in a given location are bad relative to comparable locations, say. In the case of our inquiry, the implicit tension that we have identified between car use and walking necessitates a measure that applies equally to both modes. Applying this observation about relative performance, a score of D (on a scale from A to F) for one mode may be a cause for concern in itself, but seems likelier to be considered grounds for action if another mode scores A.

Our approach to this work had two "prongs": we searched the literature in order to obtain an informed view of the history and state of the art of level-of-service measures; and we used industry-leaving software for traffic modelling to test whether the respective qualities of the walking and driving experience a) are discernible in such software and b) are consistent with our hypotheses concerning declining walking.

## 2. Method

Our method had two elements.

For our literature review, we searched two databases (Scopus and TRID) for all items whose titles featured "level of service" or "quality of service" and "multimodal" or "pedestrian". We then filtered the resulting documents for those that incorporated some discussion of the concepts, reviewed examples and/or proposed new developments. These items were read and are cited in our survey of the topic, as appropriate. We additionally sought out certain documents cited in those found in our literature search and refer to these, again as appropriate.

For our simulation of walking and driving trips, working from an existing model of an area of central London, we developed a network for testing the comparative delay experienced by walkers and drivers. We describe this more fully in Section 4 below.

## 3. Level of service as a meaningful and useful measure

It is by no means axiomatic that level of service will prove the right tool for the task of informing policy makers about the status of walking (relative to driving). In order to test its appropriateness, our inquiry proceeds in stages: we briefly survey the history of level-of-service measures for motorised vehicles; we then discuss the measurement of level of service for pedestrians in particular; we finally consider the merits of so-called multimodal level-of-service measures.

### *3.1. Level of service and motorised vehicles*

Level of service (LOS) is seen as having been a ground-breaking development when it was first incorporated into the US Highway Capacity Manual (HCM) in 1965 (Flannery et al., 2006). Though it only addressed motorised vehicles at the time, what impressed was its ambition to "include all factors important to travelers" (Flannery et al., 2006, p. 17) and thereby provide a comprehensive performance measure for the first time. But its ambition was also its weakness, as data were not then available to support the development of models that could capture all the factors. This gap between aspiration and reality has persisted in some form ever since, though data are now much more plentiful.

At its core, LOS for motorised vehicles is based on the relationship between actual and free-flow speed, with the proviso that the level automatically becomes F (the worst grade) if volume exceeds capacity. Other than that, grade is derived from a table of threshold values. For example, if the free-flow speed on an "urban street segment" is 55mph and actual speed exceeds 44mph, the level of service is graded A (the best rating) (National Academies of Sciences and Transportation Research Board, 2016, p. 16.8). We note, in passing, that free-flow speed is generally calculated on the basis of actual vehicle speeds in conditions of very low traffic. It is therefore not guaranteed that this value will be lower than the posted limit (Deardoff et al., 2011) and will likely reflect a proportion of vehicles exceeding that limit. We shall return to this point later. The volume/capacity threshold is visibly arbitrary but speed-based thresholds have been derived and honed over time through user survey (National Academies of Sciences and Transportation Research Board, 2016, p. 5.8). In addition to "percent of free-flow speed", LOS can be derived from "percent time-spent-following" and average travel speed. Their respective roles depend on the type of road in question. For example, a major two-lane highway's LOS is derived from proportion of time spent following and average speed. This contrasts with two-lane highways in "developed rural areas", where LOS is based only on the ratio of actual to free-flow speed (National Academies of Sciences and Transportation Research Board, 2016, p. 5.11). The fact that LOS continues to evolve is demonstrated by the comparatively recent addition (in 2010) to HCM of a measurement approach for freeways (Roess et al., 2010).

Despite its gradual sophistication, LOS in general and the variant for motorised vehicles in particular do receive criticism. Choocharukul et al. (2004), for example, carried out field tests to establish whether road users' understanding of the verbal definitions of the six levels accorded with ratings derived from operational data. They found some significant differences. Roess et al. (2010), meanwhile, found good evidence that survey respondents struggled to distinguish more than three levels of service, placing the six-level version in doubt. And Flannery et al. (2005) concluded that the metrics on which LOS is based are too narrow and, in particular, that interventions such as planting trees may be sufficient to lift a road segment into a higher category, when this would have no impact on the traffic-flow metrics on which LOS is based. In policy terms, LOS has been blamed for urban sprawl, because it discourages the building of new housing in locations where this could be expected to lead to a deterioration in driving conditions. For this reason, California is amongst states giving more weight to vehicle miles travelled as a metric better matched to their strategic goals (Planetizen, 2022).

### *3.2. Level of service and pedestrians*

The measurement of the level of service experienced by pedestrians grew out of its original formulation for motorised vehicles (Raad and Burke, 2018). That said, the work of Fruin (1971) introduced the concept of pedestrian density, which does not have a direct analogy in motorised traffic, and this has tended to feature in measures of pedestrian level of service (PLOS) since. This helps to demonstrate how fundamental differences between modes have been reflected in distinct approaches to the measurement of performance. In the HCM, another way in which PLOS differs from the version for motorised vehicles is that the former involves both "performance measures" (e.g. speed) and "basic descriptors of the urban street character (e.g., sidewalk width)", whilst the latter is based only on performance measures.

PLOS measures in general are considered to do at best a partial job of measuring the quantity of concern (Karatas and Tuydes-Yaman, 2018), whilst Kadali and Vedagiri (2016) find them both overly geared towards conditions in high-income countries and weak in their treatment of the needs of people with disabilities. Nag et al. (2020), meanwhile, argue that PLOS measures need to take account of three components — flow characteristics, built environment, and users' perception. But, in their survey of 47 measures, they found none that included all three. They were generally unimpressed with the quality of the measures they reviewed and were in particular disappointed that only one incorporated *directness* as an element.

PLOS first featured in the Highway Capacity Manual in its 1985 edition and it has continued to evolve since then. In particular, the work of Landis et al. (2001) is described by Ryus et al. (2022a) as seminal in using the views of pedestrians to inform quantified models of level of service, which have since become the standard. The version featuring in recent versions of the HCM draws on a large number of variables to produce a grade, reflecting what Raad and Burke (2018) describe as a contest between "geometricians" and "experientialists". The former prefer objective, engineering-based measures whilst the latter favour measures designed to capture the subjective experience of the pedestrian. The tension between these two stances is so far unresolved and explains the often highly complex formulations of PLOS, something for which PLOS receives criticism, particularly in terms of the effort required for its estimation (Asadi-Shekari et al., 2013). The HCM version is considered to contain some anomalies (Ryus et al., 2022a) and other measures, such as Oregon's pedestrian level of traffic stress, are considered to do a better job (Ryus et al., 2022b), but it remains the reference measure because of the dominance of the Highway Capacity Manual. And it continues to evolve, with the 2022 incorporating revisions to the measurement of LOS at signalised and uncontrolled junctions (McCusker, 2022). For our purposes, it is important to note that the HCM version of PLOS is based on reference walking speeds: "in general, a travel speed of 4.0 ft/s or more is considered desirable, and a speed of 2.0 ft/s or less is considered undesirable" (National Academies of Sciences and Transportation Research Board, 2016, p. 16.20).

### *3.3. Development of the "multimodal" form of LOS*

The Florida Department of Transportation is generally credited with leading the development of multimodal level-of-service (MMLOS) measures (Zuniga-Garcia et al., 2018). But, lest MMLOS appear to be limited to the USA, we note that a European research project (FLOW) also sought a multimodal measure of network performance (Rudolph, 2017).

The motivation for creating MMLOS measures is aptly articulated by FLOW, though in its case from the perspective of improving the lot of pedestrians and cyclists: "decision makers will be provided with facts to argue for walking and cycling to be put on equal footing with other modes of transport" (Rudolph, 2017, p. 7). This term, "equal footing" neatly encapsulates the goal of MMLOS. And work led by Florida and since taken up by others in the USA (Flannery et al., 2006) has made it increasingly possible to say that a grade of A has the same meaning across modes. Indeed, the HCM now stipulates standard threshold values in a continuous quality-of-service variable: for example, a "segment-based LOS" measure has the same boundary between grades A and B (a value of 2.00) for each of pedestrians, bicycle and transit. This consistency turns out to be only superficial, however: the pedestrian grading system can be "trumped" by high density, something that does not happen for either of the other modes. And "link-based" scores for pedestrian and bicycle are given a different set of thresholds. LOS calculations for motorised vehicles, meanwhile, have not been converted to this common scale. Moreover, whilst a grade of A might be thought to have the same *meaning* across modes, prevailing policy is structured differently: D is the target peak-time level when designing for motorised vehicles (to avoid infrastructure being severely underused outside the peak) but is considered inadequate by pedestrians and cyclists (State of Florida Department of Transportation, 2020).

As in our discussion of other forms of LOS, MMLOS measures vary greatly and some are considered better than others (Zuniga-Garcia et al., 2018). The HCM method in particular is criticised because it may not represent satisfactorily the perceptions of transport professionals (Carter et al., 2013). Of particular relevance to our inquiry, we note that MMLOS measures invariably use different *reference speeds* for the various modes included, a point to which we return below.

### *3.4. Discussion*

The concept of level of service is self-explanatory and the potential value of such measures is considerable. But, as the brief survey above shows, creating satisfactory measures of LOS is easier said than done. For a single mode, there is considerable debate concerning which aspects of user experience to include, how to capture these, and which criteria to use in deriving an assessment of quality (i.e. which level to assign). When attempts are made to assess level of service across modes, these debates inevitably become more complex. As we have seen, the *status quo* constitutes an uneasy compromise between the desires for construct validity, ease of measurement, consistency with historic practice, and comparability across modes. In particular, the first two of these are in obvious tension, but the desire for construct validity appears to be in the ascendency, such that prevailing formulations of level of service tend to be quite onerous to apply. Given these challenges, it is no surprise that the authors of the HCM expect "to continue to include new LOS methodologies in future editions" (National Academies of Sciences and Transportation Research Board, 2016, p. 5.8-5.9).

With respect to MMLOS specifically, the real and significant differences between modes present a major barrier to progress. Modes are not only substantively different (to give a simple example, travel by private car does not involve interchange, unlike collective transport), but the way they are experienced by travellers differs as well. As was concluded in the FLOW project, delay is experienced differently depending on the mode (Rudolph, 2017). This helps to explain what is effectively an admission of defeat from the Florida team that pioneered the field: "FDOT and its research team evaluated and considered various methods to make the LOS thresholds more consistent across modes, but found no scientific basis to adjust the scales" (State of Florida Department of Transportation, 2020, p. 8).

Nevertheless, the potential value of an effective MMLOS remains considerable. Perhaps, if a scientific basis for adjusting scales for consistency is lacking, a more conceptual approach may be in order, even if it is empirically weaker.

## 4. Using simulation software to understand relative experience of walkers and drivers

Is the experience of walking objectively poorer than that of driving, as implied in the introduction? Whilst it is beyond the scope of this paper to address this question fully, it is appropriate to conduct at least a modest investigation. In so doing, we have been able also to ask whether the standard tools of the traffic engineer allow questions of relative experience to be answered satisfactorily.

We were given access to a model of a small network created in VISSIM[**], often described as the industry leader in micro-simulation software. It covered an area within the City of London and included 18 junctions at which vehicles and pedestrians could interact, five of them signalised. The City of London is recognised for its progressive approach to deterring motorised traffic on its road network and to catering for pedestrians. We therefore would expect the operation of junctions in the area modelled to be rather more benign towards walkers than might be typical.

There were 13 entry/exit points around the edges of this network and we had been given an origin-destination (O-D) matrix for vehicles based on these points. Having made some modifications to the network to allow this matrix to apply also to pedestrian journeys, we simulated the peak hour for the two categories of user. Thus, for each O-D pair, similar numbers of drivers and walkers made the journey, with the software assigning each to the optimal available path in each case.

Our headline finding is that the mean delay experienced by car users was 31.73 seconds per person, and that experienced by pedestrians 65.79 seconds per person. That is, according to this simulation, pedestrians were delayed more than twice as much as drivers. It is important not to read too much into this single result but the difference is nonetheless stark, particularly in light of the pro-walking policies of the authority within which these roads are located.

Beneath the headline are some important details concerning the calculation of delay. Pedestrian delay is calculated as the aggregate time an "individual" has to stop (because of congestion or to wait for a crossing signal, say). For drivers, it is the difference between actual and a "free-flow" journey time based on conditions of very low traffic. As we discuss in the following section, this superficially reasonable approach conceals interesting and important assumptions. And, in practical terms, these distinct approaches to walking and driving militate against the even-handed comparison we seek.

## 5. Towards true commensurability between modes

We have identified that the pursuit of multimodal LOS measures involves a tension between construct validity (where a measure accurately captures the quantity it is intended to) and intermodal comparability. Existing measures tend to prioritise the former at the cost of the latter. But, for our purposes, fair comparison between modes is crucial. This being so, we may have to accept compromises in construct validity in order to make defensible statements about the relative experience of different modes. In other words, we may have to ignore various important characteristics of the walking experience, such as air quality or noise level, in order to be able to make intermodal comparisons.

The essential component of LOS is an understanding of how a mode performs relative to some hypothetical ideal. MMLOS measures of the sort featuring in the HCM are, with the exception of motorised vehicles, based on user assessment, such that the top grade (commonly "A") is as good as a user could expect the experience to be. The grade for motorised vehicles is largely based on a comparison of actual and free-flow speeds, which we note is also the basis for calculating delay in VISSIM. This is problematic for the following reasons: user grades reflect experience and thereby reinforce it. If the quality of a given mode is objectively poor but this is all that the user has known, their Grade A will represent a worse experience than the same grade for an objectively superior mode. And, in the case of motorised vehicles, the use of free-flow speed as a reference assumes that it is reasonable to hope to travel at that speed, despite its dubious derivation (as discussed earlier).

Nonetheless, speed is the obvious quantity that readily offers itself for intermodal comparison (though we acknowledge a case could be made for generalised cost). And, given our assertion that LOS depends on comparing actual performance to an ideal, the adoption of speed as a metric means we require an ideal speed for each mode. We

[**] VISSIM is proprietary software developed by PTV ─ https://www.ptvgroup.com/en/solutions/products/ptv-vissim/

must first consider the possibility that this speed might be fixed across modes: if people who enjoy the use of a vehicle could travel at 50km/h at times of low traffic in a given location, say, would not those travelling by other means like to be able to travel as quickly if their mode permitted? In practical terms, this would make the ideal speed irrelevant for comparing across modes and we would need only actual speed. The implication of this approach would be for walking's level of service to be almost invariably very low compared with that of other modes because all other modes enjoy higher mean speeds in the vast majority of settings. But we do not doubt that this approach would be swiftly rejected on the basis that 50km/h is not a feasible speed for walking (or cycling, in most cases). Thus it would fail for being unrealistic. Its other prominent weakness is its inflexibility: road environments vary and, if we set a number of concerns aside, it is possible to drive "safely" at higher speeds on some sections of roads than others.

If not a uniform ideal speed, then, a figure must be chosen for each mode, or perhaps a range, reflecting the context-dependent nature of "ideal" conditions mentioned above. For good or ill, "free-flow" speed is the established ideal speed for motorised vehicles. That is, the ideal speed is a product of the capacity of vehicles to travel quickly and the capacity of the environment to accommodate this. This has the advantage that the value matches (to an extent) the physical conditions. In contrast, as noted above, the actual speed of walking tends to be assessed against a mean walking speed. Why this inconsistency? Humans can travel at a range of speeds, reflecting their personal characteristics and the length and urgency of the journey, as well as physical conditions. If free-flow speed for motorised vehicles is, in effect, the fastest a typical vehicle can go given the environment, should not the equivalent for walking be the sprinting speed of an average person? At first blush, this may seem laughable: walking is not running so the experience of walking should not be gauged using running speed, it might be argued. But, we contend, people walk instead of running mainly because it is tiring to run long distances whilst the popularity of e-scooters suggests people embrace the opportunity to speed up walking journeys. So, if resources (fuel) were not an issue, would not most walkers run, other things equal? We note in passing that, in the case of motorised vehicles, "ideal" speeds are calculated without any thought concerning the implications in terms of fuel consumption or journey length. For these reasons, we suggest that sprinting speed deserves to be at least considered as the ideal speed where walking is concerned.

Given pedestrian LOS measures have to date compared actual speed to a representative *walking* speed, the adoption of sprinting speed would instantly downgrade all quality scores for pedestrian facilities. And, if multimodal LOS measures served their purpose of enabling policy makers to prioritise areas for action, this might imply that more attention and resource would be devoted to those facilities.

## 6. Conclusion

The idea of using sprinting speed as the reference when assessing pedestrian facilities is as much a provocation as it is a serious proposal but we maintain that it deserves at least sincere consideration. Further, even a cursory examination of the case we have presented here may prompt some deeper thought about the relative quality of facilities for walking. And, we suggest, this thought may lead to the conclusion that, on average, the quality experienced by pedestrians is significantly less good than that experienced by drivers. If this were seen as a cause for action, work could readily be done to improve conditions for walking, in terms of designing routes that followed desire lines more closely and reducing waiting times, to give just two examples.

Whether policy makers will act to "level up" pedestrian levels of service is a matter for speculation, as is the question of whether doing so would make walking irresistible. But making walking considerably more attractive might be a sufficient achievement.

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