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Shelter from the Storm

Optimizing Distribution of Bus Stop Shelters in Los Angeles

Philip Law and Brian D. Taylor

The functions of bus stop shelters and factors affecting their placement at stops in transit systems are analyzed. Drawing on information from a variety of sources, current shelter placement policy in Los Angeles was found to be guided principally by the revenue-generating potential of shelter advertisements, secondarily by political concerns over geographic equity, and only peripherally on the basis of bus stop use. Using data on shelter and stop locations, boardings, and headways, a methodology is developed for measuring the cumulative use of bus stops with regard to person-min of wait time. Then this measure is used to evaluate three scenarios of bus stop placement, each of which optimizes the goals of (a) private shelter providers, (b) locally elected officials, and (c) bus patrons, respectively. The conclusion is that either of the latter two scenarios would dramatically—by 2.3 person-years each day—increase the time that bus patrons in Los Angeles spend under shelter while waiting for buses at stops. This analysis both demonstrates the utility of using stop-coded boarding data in combination with headway data in the planning of bus stop shelters and shows the ineffectiveness and inequities that can arise when the sheltering of waiting passengers is not explicitly incorporated into policies guiding the placement of transit shelters.

Although buses and urban bus service have been widespread since the 1920s, bus stop shelters did not become a common part of the American landscape until the 1970s (1). New York was the first major U.S. city to provide bus stop shelters to its transit users, using designs brought from Europe (2). In recent years, bus stop shelters have come to be seen as an important part of many, if not most, urban public transit systems.

But although previous research has carefully examined the safe and efficient design of bus stop shelters (3–7), less attention has been devoted to the distribution of transit shelters in a transit system. This relative lack of attention is perhaps because of the straightforward physical constraints on shelter location; in some cities sidewalks are simply not wide enough for both a bus stop shelter and passing pedestrian traffic. But more importantly, the location of bus stop shelters is frequently not under the purview of transit operators. Because bus stop shelters are normally located on sidewalks, they are frequently controlled by private firms under contract to municipalities and other local governments that control public rights-of-way. Often, neither the private firm nor the local government is affiliated with local transit systems. As such, principal-agent problems can arise when the objectives of the private contractor with regard to bus stop shelter placement bear little relation to the goals of the transit agency or the needs of transit patrons (8).

This paper analyzes the current patterns of bus stop shelter placement in Los Angeles to explore how the different objectives of

advertising firms, local governments, and transit operators combine to affect the distribution of bus stop shelters. In light of these varying objectives, we analyze shelter and stop location, boarding, and headway data for Los Angeles to develop a methodology to optimize the location of bus stop shelters. A review of the literature on the functions of bus stop shelters is presented and a brief history of bus stop shelters in Los Angeles is offered. Current bus stop shelter policy in Los Angeles is then examined, alternative models of shelter placement are analyzed, and some suggestions are provided to optimize the location of contractor-provided bus stop shelters in Los Angeles and elsewhere.

FUNCTIONS OF BUS STOP SHELTERS

Well-designed shelters do not simply provide protection from the elements. They can also, and frequently do, attract riders, help people find their way along the transit system, and support an integrated pedestrian network (9). Suisman (7) suggests that bus stop shelters have the potential to shape and change public perception about cities and the transit system.

Bus stops advertise the transit system to the public. A stop that looks dirty or neglected, or whose waiting passengers look hot, cold, wet, confused, or vulnerable sends a devastating message: If you're lucky you don't have to ride the bus. A stop that looks clean, comfortable, safe, and informative suggests that riding the bus is a practical, attractive alternative to driving.

Bus stops also send a message about a city's public space. They are the place where bus transit and municipal identity overlap. Each stop can be thought of as having a two-way identity; it is a gateway to the transit system for pedestrians getting on and a gateway to the adjacent neighborhood for passengers getting off. Each stop should be assessed as part of a pedestrian network that permits someone to get to and from the stop.

In Los Angeles, a 1980 report by the Los Angeles Department of Transportation (LADOT) concluded that bus stop shelters enhanced passenger comfort and convenience (10). Since that time, the function of bus stop shelters has evolved to include a variety of purposes, some logical, some unanticipated. Granted, Los Angeles sees more clear, pleasant days than most American cities, but the bus stop shelters there do provide protection from the occasional rainstorm. The city also sees its fair share of hot days, with temperatures exceeding 37°C (100°F), and winds gusting at high speeds blowing dust and dirt into the air. In these cases, shelters provide much-needed protection from the elements. Shelters may also provide a place to rest while waiting for the bus—with a bench to sit on, walls to lean on. These are the typical functions of a bus stop shelter.

Shelters can also provide information, in the form of maps, schedules, and timetables. Although such amenities can also be provided

without a shelter, the structure of a shelter provides a convenient frame on which to display this information. Ideally, shelters should be located where there are the greatest number of waiting bus patrons. Providing critical information along with bus stop shelters ensures that the maximum number of people will be able to make use of it and public transit.

Shelters also provide advertising for the transit system and the communities they are located in, at least in an unofficial manner. A survey conducted by the Los Angeles County Metropolitan Transportation Authority (MTA) suggests that the presence and physical condition of a shelter can significantly affect the use of public transit (11). People may avoid using public transit when they feel there is no protection from sun or rain at the bus stop, or when they feel unsafe. Therefore, the addition of a bus stop shelter that is well maintained and well designed can significantly improve patrons' perceptions of safety and help increase transit use (12). In addition, through design elements and signage, shelters can serve to identify the neighborhood and transit system to nontransit users, including passing motorists and pedestrians.

Shelters are also revenue generators, at least when they sell commercial advertising and are located in commercially attractive locations. Collectively, the 992 bus stop shelters in Los Angeles add almost \$1 million to the city's coffers annually in the form of a franchise fee (13). More broadly, of course, the "cost" of the shelters is borne by drivers, transit patrons, pedestrians, and other users of public spaces now partially occupied by advertisements. Likewise, in addition to protection from the elements for waiting patrons and the generation of revenue for local governments, shelters also generate income for the private shelter providers, their employees, and suppliers. Unfortunately, the revenue-generating aspect of bus stop shelters—on both the part of the private shelter provider and the contracting local government—may provide no financial incentive for locating them where the bus riders are—in the poorer, more transit dependent areas of the city.

Finally, bus stop shelters can be part of vibrant residential and commercial districts. Bus stops are rarely seen as a principal driving force of economic development, since they generally do not have the scale of activity comparable to that of a rail transit station. However, in transit-dependent neighborhoods, daily bus stop boardings can easily number in the hundreds or thousands. Innovative and strategic bus stop shelter placement and design can tap into this activity to create a thriving area that can promote neighborhood vitality. For example, the Los Angeles Neighborhood Initiative (LANI) has incorporated bus stops into its projects for the revitalization of commercial corridors (9). The neighborhoods involved with LANI have used bus stops as a starting point from which to expand their local redevelopment initiatives.

BUS STOP SHELTERS IN LOS ANGELES

Establishment of the Current System

In 1980, LADOT produced a bus stop facility study as part of a program to develop a coordinated planning process for bus facilities. Using criteria such as bus passenger volume, pedestrian congestion, space availability, and amount of employment in the area, the study identified 249 locations where a bus stop shelter would substantially improve passengers' comfort and convenience (10). In part on the basis of the findings of this study, the city of Los Angeles awarded two separate contracts in 1981 and 1982 for 500 shelters each to the

same private firm. The contractor was to install and maintain bus stop shelters within the city in exchange for the right to place advertising on these shelters. In addition, the contract specified that the city would receive a percentage of the annual gross advertising revenue that would begin at 8 percent and increase over time to a maximum of 13 percent; today this 13 percent amounts to just under \$1 million annually.

Although Los Angeles today has an extensive bus stop shelter system, the placement of these shelters is not closely related to transit patronage. Using data supplied by the Los Angeles County MTA, this analysis finds that not one of the 26 bus stops in Los Angeles with the highest average daily boardings has a shelter. Over the years similar analyses have prompted researchers, the media, and elected officials to raise concerns that private contractor (and, by extension, local government) interests in advertising revenue have superseded the needs of transit users in the placement of shelters (1, 14, 15).

Clearly, the needs of the private shelter provider, the bus riders, and the transit operator need to be balanced in some way to make a contractor-provided shelter system work. Shelter companies are quite understandably concerned with selling enough advertising space to pay for capital and operating costs and to generate a profit. Quite naturally, they would prefer to locate bus stop shelters in locations that offer the greatest potential for advertising revenue. On the other hand, transit operators are concerned with maintaining or increasing ridership, and offering amenities to their passengers in the form of shelter, benches, and information. They would typically seek to locate bus stop shelters at bus stops with the highest level of use—where the riders wait. Such potentially contradictory goals between a contracting government agency and private supplier are the basis of principal-agent problems in privatization (8). But although the needs of bus riders and private shelter providers may be disparate, both should be recognized as important to the success of the shelter system. One solution to this dilemma is to allow the shelter company to install freestanding advertising kiosks oriented to passing motorists in commercially attractive areas of the city to support bus stop shelters with no advertising in areas less attractive to advertisers but with high numbers of boardings.

Current Shelter Placement Policy in Los Angeles

The current bus stop shelter contract in Los Angeles specifies that shelters will be placed at bus stops on the basis of "city request, bus service data and program revenue considerations" (Transit Shelter Contract C-66332, paragraph 7.1, March 13, 1987). These vague requirements stipulated in the contract have been manifested in a point system developed jointly by the City Bureau of Engineering and the private shelter provider that appears to be geared more toward revenue generation than bus stop use (Table 1).

Over the years some bus riders and the media have criticized the distribution of bus stop shelters in Los Angeles as being inequitable with regard to transit users. An analysis by the *Los Angeles Times* in 1987 showed that a 64.75-km² (25-mi²) area of the west San Fernando Valley, where bus ridership is relatively low and household incomes are relatively high, had more than twice the number of bus stop shelters found in a similarly sized area in higher-ridership, lower-income South Central Los Angeles (14). A report by LADOT suggests that in the early years of the contract, the city was concerned about the financial stability of the private shelter provider and, as a result, allowed a focus on advertising revenue to guide the placement of bus stop shelters (16). The report notes, however, that

TABLE 1 Criteria for Shelter Location Selection in Los Angeles

Maximum Points	City Considerations	
26	Points	Factors
	5	Senior Citizens/Hospital
	15	Council District number of shelters (points awarded on a sliding scale)
	6	Council District recommendation
25	Bus Service Considerations (Daily boardings from MTA)	
	Points	Boardings
	4	0-50
	5	50-100
	12	100-200
	16	200-300
	20	300-400
25	400-above	
49	Transit Shelter Contractor's Considerations	
	NR* = AR - (IC + MC)	
	NR = net annual advertising revenue	
	AR = gross annual advertising revenue	
	IC = installation cost (annual payment to amortize capital cost)	
	MC = maintenance cost (annual cost)	
*The value of NR is not expressed in monetary units but rather as a relative value used to determine the profitability of the shelter locations being considered.		

Source: Los Angeles City Bureau of Engineering.

this concern for the financial stability of the private shelter provider no longer appears warranted.

The point system shown in Table 1 gives the most weight (49 points) to the advertising revenue potential of bus stops and not to actual bus stop use. Under "bus service considerations," bus stops with 400 or more daily boardings are given a maximum of 25 points. This treats equally bus stops that have over 4,000 boardings per day (which exist in Los Angeles) and bus stops that have only 400 boardings. In effect, this gives proportionally less weight (with regard to points per boarding) to the people who wait at the very busiest bus stops.

An equitable method of locating bus stop shelters would give equal consideration to all bus riders and distribute shelters so that the proportion of time riders spend waiting under the protective cover of bus stop shelters is maximized relative to the total time all riders spend waiting for buses. Other factors, such as bus stop use by the elderly and handicapped and the physical constraints at the bus stop site, should be addressed as well. The remainder of this section analyzes the array of factors typically considered by the three principal stakeholder groups—the private shelter provider, the local government, and the bus riders—in determining where to place bus stop shelters and concludes by proposing a set of principles to guide an effective and equitable distribution of bus stop shelters.

Transit Shelter Contractor's Considerations: Commercial Shelters

The bulk of the points (49 percent) shown in Table 1 is allocated to the transit shelter contractor's revenue considerations. Under this point system, the locations that are deemed by the private contractor to be commercially desirable for advertising may have no relation to the significance of the bus stop in the transit network. As a result, a bus stop shelter system that is geared more to revenue generation than providing protection to transit users is likely to be both ineffective and inequitable (as a shelter), albeit remunerative.

The commercial viability of bus stop shelter locations is a function of the shelter costs and potential advertising revenue. The cost of providing shelters entails not only construction and installation costs but also ongoing maintenance expenses. A recent Los Angeles Bureau of Street Services survey of cities that oversee bus stop shelter programs found that a majority cited vandalism and graffiti as major concerns (1999 *Nationwide Transit Shelter Survey*). These costs can often frustrate efforts to provide an efficient and equitable distribution of bus stop shelters. Providing bus stop shelters where there is greatest need often involves placing them in low-income, transit-dependent neighborhoods, where they will be more likely to be vandalized. A private shelter contractor in Los Angeles, for example, claims that it spends more on maintenance for shelters in Los Angeles than in other cities because of graffiti and vandalism (15).

The involvement of advertising agencies in shelter provision further complicates the matter. Many cities, including Los Angeles, grant contracts to private companies to build and maintain the shelters in exchange for the right to sell advertising space in the public right-of-way. This arrangement potentially benefits all parties involved: the company makes money, the bus riders are provided with bus stop amenities, and the cities often receive a share of the advertising revenue from the company. The goals of these three interests, however, may not always be congruent. In 1987, for example, a private shelter provider acknowledged targeting more affluent areas of Los Angeles, such as the western San Fernando Valley, West Los Angeles, and Century City, because those areas had many shopping malls and greater advertising revenue potential (14). Some cities, such as San Francisco and San Diego, do not receive a percentage of the private contractor's revenue, but instead receive fees from advertising revenues solely to cover administrative and oversight costs, thus removing the incentive on the part of the local government to maximize advertising revenue.

Thus, from the contractor's perspective, advertising revenue considerations should be the driving factor in determining the location of bus stop shelters, even if this potential is poorly or inversely related to bus stop use.

City Considerations: Treating Geographic Areas Equally

The point system presented in Table 1 allocates some points on the basis of city council district recommendations (city considerations) and the number of existing shelters by council district. Ostensibly, this is to ensure that there is an equitable distribution of shelters by council district. The idea is that by treating districts equally, the residents within each district will also be treated equally. However, not all residents ride the bus or make use of bus stops. Although the distribution of the population of Los Angeles is roughly equal across all 15 districts, the distribution of boardings is highly unequal (Table 2).

Over half of all weekday MTA boardings (52.4 percent) occur in just four council districts: 9, 10, 13, and 14. There are more weekday boardings in District 9 than there are in Districts 2, 3, 6, 7, 12, and 15 combined. By treating council districts equally, a bus stop shelter program will treat individual transit users unequally. If the goal of the bus stop shelter program is to provide shelter to the city’s transit users, then the distribution of bus stop shelters should be determined on the basis of the distribution of transit use—and boardings represent the level of transit use.

In some instances, one might argue that not all transit users should be treated equally. A bus stop used mainly by the elderly and disabled, for example, might merit a bus stop shelter regardless of the overall number of waiting bus riders. Such concerns might be integrated into a comprehensive shelter placement policy in a number of ways: a fixed number of shelters could be set aside to be installed near hospitals or senior citizen centers, a small number of direct requests for individual bus stop shelters from members of the community might be permitted each year, or boardings by the elderly or disabled might be more heavily weighted in calculations of bus stop use.

Bus Service Considerations: Maximizing Coverage of Waiting Patrons

Although advertising revenue may be an effective means to finance the construction and maintenance of bus stop shelters, it is a means

and not the end—the main purpose of shelters is to provide bus riders with protection from the elements. For bus service considerations, the point system shown in Table 1 assigns points on the basis of daily boardings obtained from MTA. Stops with more boardings receive higher points. However, the relationship between boardings and points in the current contract between the city of Los Angeles and its private shelter provider is ambiguous.

A survey conducted for this analysis suggests that most cities do not typically assign points on the basis of boardings, but instead have an established minimum threshold of boardings. Stops that meet or exceed this threshold are identified as warranting a bus stop shelter. On the basis of prevailing practice, TRB suggests a minimum threshold of 50 to 100 daily boardings to justify the installation of a bus stop shelter (17). The actual threshold amount used by cities varies by population and transit use. Often, the threshold further varies within cities by location (central city versus suburb). For example, in Seattle, bus stops in the city must have at least 50 daily boardings before they receive a shelter, whereas stops in the suburbs require only 25 boardings (personal communication, D. Cummings, Feb. 16, 1999). In Minneapolis, the minimum threshold is 40 daily boardings in the city and 25 in the suburbs (personal communication, E. Steiner, Feb. 17, 1999); stops with 80 or more boardings are eligible for heated shelters.

Many of the cities and agencies surveyed for this study reported that three factors principally guide the location of shelters: (a) number of boardings and alightings, (b) major origins and destinations (hospitals, shopping centers, etc.), and (c) major transfer points. Arguably, however, the number of boardings actually incorporates the other two factors; major origins, destinations, and transfer points, by definition, have many boardings. Therefore, a shelter program that targets bus stops with the largest number of boardings should also capture major trip origins and destinations as well as transfer points.

Although boardings account for the number of people who wait at a bus stop, they do not accurately reflect the amount of time that people actually wait at a stop. On the one hand, it would be desirable to have a bus stop shelter at a bus stop where large numbers of people wait each day. That single structure can provide shelter to more people compared with a shelter located at a stop with a very low number of boardings. However, it would also be desirable to have a bus stop shelter at a bus stop where people tend to have longer waits for the bus. At such long-headway stops, patrons might benefit more from a bench to sit on and a roof over their heads than do other people who have to wait only a few minutes. Therefore, a more accurate measure of bus stop use would incorporate both the number boardings and the amount of time spent waiting.

The combined measure of boardings and waiting time can be calculated using a measurement called *person-minutes*. Person-min are calculated by multiplying the number of people waiting at a stop by the average amount of time, in minutes, that they spend waiting for the bus. For example, suppose five people each spend 10 min waiting for the bus at a stop. Together, they have spent 50 person-min of wait time (5 × 10 = 50). Suppose further that 25 people have each waited only 2 min for the bus at another bus stop. Together, they have also spent 50 person-min of wait time (25 × 2 = 50). In this way, a measure of bus stop use that incorporates person-min of wait time will account for both the total number of people as well as the estimated length of time they spend waiting at a bus stop.

With person-min as a measure of bus stop use, the most heavily used bus stops can be selected for the installation of shelters. The

TABLE 2 Population and Boardings by Council District

Council District	Population (October 1996) ^a		Average Weekday MTA Boardings ^b	
1	249,547	7.0 %	74,631	9.4 %
2	242,852	6.8 %	18,169	2.3 %
3	239,683	6.7 %	20,352	2.6 %
4	221,181	6.2 %	55,778	7.0 %
5	222,209	6.2 %	48,290	6.1 %
6	244,280	6.8 %	20,430	2.6 %
7	251,897	7.0 %	26,831	3.4 %
8	210,898	5.9 %	59,350	7.5 %
9	246,649	6.9 %	126,737	16.0 %
10	243,425	6.8 %	94,580	11.9 %
11	245,020	6.8 %	30,136	3.8 %
12	243,524	6.8 %	7,823	1.0 %
13	252,884	7.1 %	81,487	10.3 %
14	228,404	6.4 %	112,126	14.2 %
15	238,304	6.7 %	14,921	1.9 %
Total	3,580,755	100.0 %	791,641	100.0 %

^aSource: Los Angeles City Planning Department Population Estimate and Housing Inventory (unpublished).

^bSource: Los Angeles County MTA.

resulting distribution of shelters will be effective, in that it covers the maximum number of person-min, and equitable, because it treats equally all transit users and the amount of time they wait.

Other Considerations

Other factors that affect whether a bus stop shelter may be installed at a particular site include availability of electricity for lighting, conflicts with sight lines, and support or opposition from nearby property owners. Some of these can be addressed through visual inspection of the sites and notification of surrounding property owners. Innovative shelter design can be used in response to factors such as small sidewalk width and local ordinances prohibiting shelters. In some instances, visual inspection of a bus stop may indicate that a shelter may not be needed at all, if there is adequate cover from nearby buildings. In other cases, there may be special circumstances, such as extremely hot or windy conditions, that warrant a shelter regardless of bus stop use. As a response to these special cases, cities, transit agencies, and shelter companies usually accept direct requests from all members of the public. The idea is that although these additional factors are significant, there are ways to address them on a case-by-case basis while maintaining a standard practice of specifying bus stop shelter locations on the basis of bus stop use.

ANALYZING THE DISTRIBUTION OF SHELTERS IN LOS ANGELES

On the basis of the principles outlined above, an analysis of data provided by the Los Angeles County MTA indicates that the current bus stop shelter program falls far short of the objectives of effectiveness and equity in providing shelter to waiting passengers. The data analyzed here are drawn from Los Angeles County MTA passenger surveys conducted in 1996 and 1997 for bus stops in the city of Los Angeles served by MTA buses. The ridership data are average weekday boardings on routes operated by the MTA at over 8,000 bus stops in the city of Los Angeles. The MTA bus stop list was matched with a list of bus stop shelter locations provided by the current shelter contractor to identify 852 bus stops with bus stop shelters. There are several smaller transit operators that operate some service in the city of Los Angeles, such as the Santa Monica Big Blue Bus, Culver CityBus, Antelope Valley Transit Authority, and Foothill Transit, among others. Unfortunately, stop-specific boarding data for these systems at stops within the city of Los Angeles were not available for this analysis. Although this analysis would ideally include such data, it is unlikely that the findings below would be affected much by their inclusion; the ridership on these other systems combined is less than 20 percent that of the MTA, and most of the passengers on these other systems board and alight buses in cities other than Los Angeles.

As discussed above, bus stop use is measured with regard to person-min of wait time. Calculations based on the MTA data show that on a typical weekday there are about 791,000 boardings at MTA bus stops in Los Angeles. We analyzed these data using two different estimations of passenger queuing behavior. First, using FTA guidelines we assumed that all persons waited half of the headway reported by MTA (personal interview, A. Loui, May 8, 1999). For example, if 100 boardings occurred at a bus stop for a

bus route with an average headway of 10 min, then it was assumed that the total person-min spent waiting at that bus stop was $100 \times (10/2) = 500$. We also performed a second analysis in which we assumed that, in addition to the half-headway wait time estimated in the previous analysis, no passenger would ever wait more than 10 min for a bus; this was to account for the fact that on lines with longer headways, patrons are more likely to time their arrivals at stops by using schedules. This second analysis reduced the total estimated time patrons spend waiting for buses by 14.9 percent, but otherwise differed little from the results of the first analysis presented below. Given that (a) most MTA bus service operates on headways of 15 min or less, (b) at least some passengers are likely to wait more than 10 min for a bus on a given weekday, and (c) the 10-min cap on estimated wait times did not substantially alter our findings, only the results of the first analysis are presented.

To maximize the accuracy of the person-min wait-time measure, the weekday boardings data were disaggregated by bus stop, bus line, and time of day, and then reaggregated by bus stop to provide total boardings data by time of day at all bus stops. Headways were then estimated by time of day and for each of the more than 100 bus lines using schedule data. These headways were applied to each bus stop on the appropriate bus lines for the appropriate time of day. The results were then summed by bus stop. Systemwide, the total amount of time waiting that is spent at these bus stops is enormous: 4 million person-min, or 7.6 person-years, per weekday.

To measure what portion of those 4 million daily person-min are spent waiting at bus stops with bus stop shelters, three different scenarios are considered:

- Scenario 1 analyzes the current distribution of shelters within Los Angeles primarily on the basis of contractor considerations.
- Scenario 2 analyzes a balanced distribution of shelters by council district primarily on the basis of city considerations and secondarily on bus service considerations (i.e., shelters are distributed to the most heavily used bus stops in each district).
- Scenario 3 analyzes a distribution of shelters to the 852 most heavily used bus stops based solely on bus service considerations, regardless of council district.

Under each scenario, the data are analyzed to determine the percentage of total person-min of waiting that occur at a stop with a bus stop shelter; Table 3 summarizes the results.

Under Scenario 1, which represents the current distribution of shelters, approximately 20 percent of the total person-min of waiting occur at a stop with a shelter. In other words, of the total 4 million person-min of waiting at MTA bus stops that occur on the average weekday in Los Angeles, only 20 percent occur at bus stops that have a bus stop shelter. This means that, on average, the bus riders in Los Angeles spend roughly 3.2 million person-min, or 6.1 person-years, waiting each weekday with little or no protection from sun, wind, or rain.

Under Scenario 2, a balanced distribution by council district—but which seeks to maximize coverage within each district—increases this rate to 50 percent. It is important to note that this assumes that the bus stop shelters are placed at the most heavily used bus stops in each council district. Adjusting the distribution in this way would more than double the effective coverage of the current bus stop shelter system. Under this scenario, bus stop shelters would cover over 2 million person-min of waiting time per day. Thus, even taking the city considerations of geopolitical equity into account, Scenario 2

TABLE 3 Shelter Coverage and Three Scenarios of Bus Stop Shelter Distribution

Council District	Scenario 1 – Current		Scenario 2 – By District		Scenario 3 – By Use	
	Number of Shelters	% of Total Person-Minutes with Shelter	Number of Shelters	% of Total Person-Minutes with Shelter	Number of Shelters	% of Total Person-Minutes with Shelter
1	54	18 %	57	45 %	59	46 %
2	50	28 %	57	47 %	40	39 %
3	68	21 %	57	44 %	48	40 %
4	97	28 %	57	54 %	50	51 %
5	93	29 %	57	51 %	53	49 %
6	42	19 %	57	66 %	21	42 %
7	33	19 %	56	61 %	52	58 %
8	51	19 %	57	36 %	58	37 %
9	64	13 %	57	41 %	110	54 %
10	74	22 %	57	44 %	80	54 %
11	62	30 %	57	65 %	46	60 %
12	30	18 %	56	58 %	24	37 %
13	44	16 %	57	52 %	83	63 %
14	57	13 %	57	53 %	101	66 %
15	33	19 %	56	65 %	27	48 %
Total	852	20 %	852	50 %	852	52 %

results in an extraordinary improvement of 1.2 million person-min over Scenario 1 without adding a single bus stop shelter to the existing supply.

Finally, Scenario 3 shows that distributing the shelters to the most heavily used bus stops in the city, without regard to council district, will cover 52 percent of the total person-min of waiting time. This distribution provides the maximum amount of coverage given the current number of shelters. Even the apparently small difference in coverage between Scenarios 2 and 3 is not trivial. The 2 percent increase in shelter coverage between Scenarios 2 and 3 translates into over 34,000 boardings and 85,000 person-min of waiting time per day. Placing shelters at bus stops with the greatest levels of use, without regard to council districts, would create a system that is significantly more effective and equitable than the (current) Scenario 1 and slightly more effective than Scenario 2.

CONCLUSIONS

This analysis of Los Angeles shows how stop-coded boarding data can be combined with headway data to analyze the effectiveness and equity of bus stop shelter location. Although some may see shelters as a peripheral or supplementary part of a transit system, travel behavior data would suggest otherwise. Travel behavior studies consistently find that time spent waiting for and transferring between buses is considered by travelers to be two to three times as onerous as time spent on moving vehicles (18–20). Improving the experience of waiting for a bus can thus affect both perceptions and use of public transit.

In this case study of Los Angeles, the current shelter distribution system is explicitly defined in a contract between the city of Los Angeles and a private shelter provider. Although LADOT does contract for some transit service, neither of the two parties involved in this contract is the major transit service provider. It should not be surprising, therefore, that the location of bus stop shelters in Los Angeles has been guided primarily by advertising revenue considerations and secondarily by the distribution among city council districts. Transit boardings are only a peripheral consideration. As a result, it was found that only 20 percent of the time that bus riders spend waiting for buses is under the protection of a transit shelter.

This analysis shows further that by explicitly incorporating bus service and patronage considerations (solely or in conjunction with geographic equity considerations) into the location of bus stop shelter placement, the time that transit patrons would spend waiting under the protection of a shelter would increase dramatically—by between 2.3 and 2.4 person-years per day.

Because bus stop shelters are frequently installed and maintained by private companies under contract with cities, the revenue-generating potential of shelters is not irrelevant. As part of this analysis the bus stop shelter contracts in several other cities were examined, including those in Boston, San Francisco, Burbank, and Long Beach (in southern California). Although space does not allow a full presentation of this contract analysis, in summary it was found that the current bus stop shelter contract in Los Angeles is, in proportional terms, less lucrative (from the city's perspective) than those in any of the other cities examined (21). The experience of these other cities suggests that, in structuring future private shelter provider contracts, Los Angeles could substantially increase its control over shelter location, maintain contract revenues, and still attract an adequate number of private bidders.

In addition, there may be other ways to attract sufficient advertising revenue for private shelter providers without significantly compromising the principal purpose and function of bus stop shelters. In structuring a contract with a private shelter provider, a local government might set aside a fixed number of shelter locations per year to be chosen by the private provider, which are above and beyond those placed on the basis of patronage. Such a policy, however, can still result in the placement of shelters that are expensive to install and maintain at lightly patronized stops where they shelter few waiting passengers and serve as little more than sidewalk billboards. Alternatively, a contract could be structured to allow a private shelter company to install less-expensive, freestanding advertising kiosks oriented toward passing motorists in commercially viable areas to support the installation and maintenance of bus stop shelters in locations that have high levels of use but may not have high revenue potential. This case study of Los Angeles shows quite clearly that such a simple policy change guiding the location of shelters could provide waiting bus riders with years of additional protection from the elements every single day.

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