# Transit Platform Analysis Using the Time-Space Concept 

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#### Abstract

The time-space concept is a new approach to the planning and design of pedestrian facilities. Conceptually, it considers pedestrian facilities as time-space zones in which moving and standing pedestrians require different amounts of space and occupy that space for different periods of time. The subject of this paper is the application of the time-space approach to a transit station platform. The time-space approach can address many issues that cannot be considered by using traditional analytical procedures. These issues include the (a) duration of peak loadings, (b) amount of time spent waiting, (c) amount of walking on the platform, (d) location of access points, (e) spatial distribution of passengers on the platforms, and (f) the way in which passengers actually use the platform. This paper shows how the time-space concept can be used to analyze platforms at a relatively simple, aggregate level, and then goes on to develop more detailed, disaggregated analyses, exploring how the level of detail at which the problem is analyzed affects the results. The location of the platform access stairs is changed in a final example to demonstrate the ability of the time-space method to reflect various platform conditions and configurations. Examined in this application study is a platform of a downtown bus tunnel station in which buses will operate in platoons of four vehicles at close headways. However, the tlme-space concept presented here has wide application to many types of facilities that must handle large volumes of pedestrians involved in many types of activitles.


From the standpoint of passenger level of service, platforms have been difficult spaces to analyze. Platform shape anó configuration are usually dictated by various systemwide factors or site constraints. Train or vehicle length establishes platform length. Structural considerations, vertical circulation requirements to meet emergency evacuation standards, and operational parameters affect platform width; type (high or low, side or center); space available for passengers; and entry/exit locations.

The traditional analytical procedure does not take into account several significant variables. The maximum accumulation of people waiting on the platform during the peak period, typically estimated during the ridership forecasting step, is multiplied by a waiting, or queue, area per person to determine the platform area required to accommodate the passenger load. The space requirement is compared with the space available on the platform. Elements not considered during the usual study of platform space include the (a) duration of peak loadings, (b) amount of time spent waiting, (c) amount of walking on the platform, (d) location of platform access points, (e) spatial distribution of passengers on the platforms, and (f) the way in which passengers actually use the platform.

[^0]The pedestrian time-space concept can analyze platforms and address the issues previously listed, however, because it considers the time passengers spend walking and waiting on the platform and the space they require while involved in these activities. The manner in which the time-space concept can be used to analyze platform activity and performance is demonstrated in this paper. Initially the platform is modeled at a relatively simple, aggregate level and then more detailed, disaggregated analyses are developed, with an exploration of how the level of detail at which the problem is analyzed affects the results.

## TIME-SPACE CONCEPT

Conceptually, the time-space method considers pedestrian facilities as time-space zones with moving and standing pedestrians requiring different amounts of space and occupying the zones for different periods of time (1). Time-space is the product of an area (or space) and a time period (2). For example, a pedestrian walking through a waiting room may require up to $24 \mathrm{ft}^{2}$ of space for movement, but will occupy that space for a relatively short period of time (e.g., 10 sec ). This would be $240 \mathrm{ft}^{2}-\mathrm{sec}$ or $4 \mathrm{ft}^{2}-\mathrm{min}$. A pedestrian waiting on a platform requires 5 to $10 \mathrm{ft}^{2}$ for a longer period of time, such as up to 5 min . This would be equivalent to 25 to $50 \mathrm{ft}^{2}-\mathrm{min}$. The time-space concept considers the type of activities occurring in a space within a given time period and the number of people involved in each activity. The amounts of time-space required for each activity are summed and compared with the timespace available or proposed within the facility.

Mathematically, the time-space concept can be described as

$$
\begin{equation*}
T-S_{\text {req. }}=\sum P_{i} M_{i} T_{i} \tag{1}
\end{equation*}
$$

where

$$
\begin{aligned}
T-S_{\text {req. }} & =\text { time-space required, } \\
P_{i} & =\text { number of people involved in activity } i, \\
M_{i} & =\text { space (area) module required per person } \\
& \text { for activity } i, \text { and } \\
T_{i} & =\text { time required for activity } i .
\end{aligned}
$$

$T-S_{\text {req. }}$ is then compared with the time-space available ( $T-S_{\text {avail. }}$ ) to determine the adequacy of the space for the expected activities. $T-S_{\text {avail. }}$ is the product of the area available ( $A_{\text {avail. }}$ ) and the time it is available ( $T_{\text {avail. }}$ ), or
$T-S_{\text {avail. }}=A_{\text {avail. }} \times T_{\text {avail. }}$

The first application of the time-space concept was to sidewalks, comers, and crosswalks, as presented in the 1985 Highway Capacity Manual (2). Application of the time-space concept to a commuter terminal corridor and waiting area was demonstrated by Benz (3). Furthermore, Grigoriadou and Braaksma described the application of the time-space concept to a station platform (4). Their approach treats the portion of the platform analyzed as one zone and examines the level-ofservice conditions during passenger alighting periods and the gap between the arrival and departure of trains. The approach described in this paper demonstrates the merits of subdividing the platform into a set of subareas or zones and comparing the time-space required in each zone to what is available.

One of the most important elements in understanding and using the time-space concept is the pedestrian level-of-service standards, as developed by Fruin in Pedestrian Planning and Design (5). These criteria and other essential principles are described in Fruin's book, and also in the 1985 Highway Capacif, Manual (2) and Urban Spaces for Padestrians (0). These sources should be consulted for further information on the fundamentals of pedestrian level of service.

## APPLICATION STUDY DESCRIPTION

An underground transit station platform served by buses is described. The station is part of a downtown bus tunnel project. The buses-60-ft, 3-door, articulated vehicles-operate through the tunnel in platoons of four. The stations are side platform arrangements with stair connections from the ends of the platforms to the fare control mezzanine above. Each platform is 380 ft long by $16^{1 / 2} \mathrm{ft}$ wide (see Figure 1).

The bus routes operating through the tunnel are clustered into four groups. Routes having similar service areas are grouped together so that riders who have the choice of several routes for their trips will find their route options within one group. Each of the four groups, labeled A through D, has a designated loading location on the platform. Each four-bus platoon will typically have one bus from each group ordered in the A-B-C-D sequence. Riders will go to the A location to board a bus from the A group and so on. The platforms are paid areas so fares are not collected onboard the vehicle. Therefore, all three sets of bus doors can be used by entering passengers.

The afternoon peak 15 min -period has the heaviest passenger loads on the platforms because downtown commuters heading home are waiting for their buses. During the peak $15 \mathrm{~min}, 910$ people will arrive on this platform (one of two side platforms) by the stairs at each end to board the buses. Of the 910 passengers, 474 will use the south stairs and 436 will use the north stairs. Another 40 people will arrive by bus on the platform, and whon ckiting thoy will to covily split tuinuen the two sets of stairs. Passengers from each stair are evenly distributed among the four bus loading locations. (Conceivably, passengers would tend to use the stair closest to their respective loading location. Thus, the passengers from each stair would not necessarily be evenly distributed among the loading locations.)

Many types of platforms are subject to short-duration, peakload conditions created by train arrivals or departures-relatively discrete events. This analysis examines a repetitive series of events that constitute a type of steady-state condition within a design period. Platoons of buses arrive at the platform with relatively short intervals between arrivals and departures throughout the analysis or design period.


Plan of Station


Detailed Plan of Platform
FIGURE 1 Downtown bus terminal station platform.

## TIME-SPACE APPROACH TO PROBLEM

The platform is analyzed here using the time-space technique at three levels of detail. The first level treats the platform as one space and uses average values for the walk and queue times for all the passengers. The second level of detail treats walk and queue times separately for each of the four loading locations while still treating the platform as one space. The third level of detail divides the platform into time-space zones representing various areas used for walking or queueing and areas that generally are not used by passengers.

## Level of Detall 1

The platform and the passenger activities on it are treated in an aggregated manner. The platform is treated as one large timespace zone, and average walk distances and wait times are used to model passenger activities.

## Time-Space Available

The platform is 380 ft long and has an effective width of 15 ft . (A $1^{1 / 2} \mathrm{ft}$-buffer-strip is deducted along the platform edge.) Using a 15 min analysis period, the time-space available on the platform is $85,500 \mathrm{ft}^{2}-\mathrm{min}$.

## Walk Time-Space Required

Referring to Figure 2, the average distance a passenger will have to walk between the south stair and the midpoint of the bus loading area is 180 ft ; the average distance between the north stair and the loading midpoint is 200 ft . (The midpoint of the loading bus location is not the middle of the platform length because of the bus vehicle door location and the operational requirements of the bus platoon.)
The average walking speed is $250 \mathrm{ft} / \mathrm{min}$ or $4.1 \mathrm{ft} / \mathrm{sec}$. At this walk speed, the area per person is $22 \mathrm{ft}^{2}$. The average walk time between the stairs and the loading/unloading midpoint is 44 sec for the south stairs and 49 sec for the north stairs. From the south stairs, 474 people will walk to the bus loading area, whereas 20 people will walk in the reverse direction. Each of the 494 people will take 44 sec and $22 \mathrm{ft}^{2}$; the walk time-space requirement is $7,970 \mathrm{ft}^{2}-\min$ ( 494 people $\times 44 \mathrm{sec} \times 22 \mathrm{ft}^{2} / \mathrm{sec}+$ $60 \mathrm{sec} / \mathrm{min}$ ). On the north stair, the walk time-space required is $8,193 \mathrm{ft}^{2}-\mathrm{min}$ ( 456 people $\times 49 \mathrm{sec} \times 22 \mathrm{ft}^{2} / \mathrm{sec} \div 60 \mathrm{sec} / \mathrm{min}$ ). The total walk time-space required is $16,163 \mathrm{ft}^{2}$-min.

## Queue Time-Space Required

The average wait time per passenger on the platform will be 5.4 min (as determined from operational studies). Although
buses will be much more frequent than indicated by the average wait time, every bus platoon will not necessarily include the bus route for every passenger. Several bus platoons may pass before one containing a particular passenger bus route arrives. The 910 passengers $(474+436)$ will require $7 \mathrm{ft}^{2}$ per person. The queue time space required is $34,398 \mathrm{ft}^{2}-\min$ ( 910 people $\times$ $5.4 \mathrm{~min} \times 7 \mathrm{ft}^{2}$ ).

## Total Time-Space Required

The total walk time-space required is $16,163 \mathrm{ft}^{2}$-min, and the total queue time-space required is $34,398 \mathrm{ft}^{2}$-min. The total time-space required for passenger activities on the platform is $50,561 \mathrm{ft}^{2}-\mathrm{min}$. The platform has $85,500 \mathrm{ft}^{2}$-min available so that the overall platform area is adequate to meet expected passenger loads.

## Level of Detail 2

In the second example, calculation of passengers' time-space requirements considers the different paths and waiting times for each of four loading areas. The total time-space available is the same as in the previous example-85,500 $\mathrm{ft}^{2}$-min. Figure 3 shows a diagram of the platform, with the pedestrian flow volumes between the stairs and loading locations indicated.

## Walk Time-Space Required

The data in Table 1 show the calculation of time-space required by walking on the platform. The four loading locations are designated by the letters A through D. The two sets of stairs between the platform and the mezzanine are designated I for the south set and $\Pi$ for the north set. For each path, the distance is listed along with the walk time, calculated by using a walk speed of $250 \mathrm{ft} / \mathrm{min}$, or $4.1 \mathrm{ft} / \mathrm{sec}$. At this speed, the area per person required is $22 \mathrm{ft}^{2}$. The number of people walking between each stair-loading location pair is shown-those going to and from the buses. The walk time-space required for each path is the product of the walk time, the area per person, and the volume of people. The total walk time-space required (the sum of the individual path requirements) is $16,129 \mathrm{ft}^{2}-\mathrm{min}$.

## Queue Time-Space Required

The average wait time at each of the four loading locations is different because of differences in the number of bus routes that require stopping at each location and the headways. The average wait time by location is given in Table 1. The queue time-space by boarding location is the product of the average


FIGURE 2 Platform study level of Detall 1: simple network.


Peak 15-Minute Passengers
Between Stair I and Loading Location:

|  | A | B | C | D | Total |
| ---: | :---: | :---: | :---: | :---: | :---: |
| Into Station | 118 | 119 | 119 | 118 | 474 |
| Out of Station | 5 | 5 | 5 | 5 | 20 |
| Total | 123 | 124 | 124 | 123 | 494 |

Peak 15-Minute Passengers Between Stair II and Loading Location:

|  | A | B | C | D | Total |
| ---: | :---: | :---: | :---: | :---: | :---: |
| Into Station | 109 | 109 | 109 | 109 | 436 |
| Out of Station | 5 | 5 | 5 | 5 | 20 |
| Total | 114 | 114 | 114 | 114 | 456 |

FIGURE 3 Platform study level of Detall 2: complex network.
TABLE 1 TIME-SPACE CALCULATIONS PLATFORM STUDY LEVEL OF DETAIL 2

wait time, the number of waiting passengers, and the waiting, or queue, area per person ( $7 \mathrm{ft}^{2}$ per person). The total queue time-space required is $34,555 \mathrm{ft}^{2}-\mathrm{min}$.

## Total Time-Space Required

The walk time-space required is $16,129 \mathrm{ft}^{2}-\mathrm{min}$, and the total queue time-space required is $34,555 \mathrm{ft}^{2}-\mathrm{min}$. The total timespace required by passenger activities is $50,684 \mathrm{ft}^{2}-\mathrm{min}$. This
time-space requirement is less than the time-space available, $85,500 \mathrm{ft}^{2}-\mathrm{min}$, which indicates that overall the platform is adequate.

Increasing the analysis level of detail results in nearly identical time-space requirements- $50,561 \mathrm{ft}^{2}-\mathrm{min}$ for the previous, more aggregated analysis versus $50,684 \mathrm{ft}^{2}$-min determined here. No apparent benefit was gained from this added level of detail. The platform itself was still treated as one space. In the next example, the platform is subdivided into zones, and the time-space analysis is performed for each zone.

## Level of Detail 3

In the third example, the platform is subdivided in time-space zones that encompass the various types and intensities of passenger activities, and the time-space required in each zone is compared with the time-space available. This technique models the ways in which platforms are actually used.

## Platform Time-Space Zones

Two primary passenger activities occur on platforms: walking and waiting. These activities do not occur evenly over the platform area but take place in varying degrees on specific portions of the platform. Some portions are used primarily for walking, in this case those near the stair connections to the mezzanine and along the back edge of the platform. Other areas are used primarily for waiting, in this case the four loading and unloading locations. These four zones also are areas where walking takes place as people enter and leave the zone. Some areas of the platform, such as the "dead" areas between the bus loading locations, have little if any walking or waiting activity; because of their locations they are not used by passengers.

In this example, the platform is divided into time-space zones representing areas where walking and waiting activities occur in varying degrees. The total time-space required for walking and waiting activities in each zone is estimated and compared with the time-space available in each zone. In this way, the performance of the platform can be analyzed in a detailed disaggregated manner to determine how the various parts perform rather than in an aggregated manner, such as in the two previous examples, which may cover up problems. Treating the platform as a single area, or even as several large areas, does not recognize the way platforms are used and may give credit to areas that are not used, hiding overloaded areas.

The platform in the application study is divided into 14 zones (Figure 4). Zones E and N are the vestibules of the stairs and areas primarily used for walking. (The peak period when the primary passenger movement is into the station to board the buses is examined in this study. If the opposite peak period was analyzed; that is, when the primary passenger movement was out of the station, Zones E and N might also have queueing activity at the base of the stair because of the bulk discharge of passengers from the bus platoons.) Zones F, H, J, L, and M are along the back portion of the platform away from the platform edge, which is used as a corridor for walking between the loading/unloading locations and the stairs. (Presumably, some means will be provided to encourage this use.) Zones A, B, C, and D are the loading/unloading areas where passengers queue to wait for the buses. The passengers also walk in these areas to wait for the bus or to leave after stepping off the bus. Zones G, I , and K are the areas along the platform edge between the loading/unloading zones that are not generally used by passengers. The unused areas fall between the designated loading areas and are used only if the adjacent areas become overloaded.

The 16.5 -ft platform width is divided into three zones: 3.5 ft along the back edge is for walking and thus is the width of Zones F, H, J, L, and M; 11.5 ft is for waiting, loading, and unloading and is the width of Zones A, G, B, I, C, K, and D; and the remaining 1.5 ft is a safety strip along the edge where
vehicle movements take place; it is not part of the space available for passenger activities.
The length of the platform is divided as follows: each of the four loading/unloading zones is 60 ft long, reflecting the length of the articulated bus (all three sets of doors are used for loading and unloading). The spaces between the vehicles, not used by the waiting passengers, are 40 ft wide. The two vestibules at the ends of platforms are 10 ft long along the vehicle edge but widen to 20 ft along the back edge. The walk portion of the platform is divided according to changes in walk volumes between the various loading/unloading areas and the stairs (see Figure 4). The area of each zone is given in Table 2.

## Time-Space Available

The time-space available in each of these zones is determined by multiplying each area (in square feet) by the $15-\mathrm{min}$ analysis period. The results are given in Table 2.

## Time-Space Required

The total time-space required for each zone consists of the walk time-space and waiting (or queue) time-space requirements in the zone.

The walk time-space requirement for each zone is a function of the volume of people who walk through the zone, the time spent walking through the zone (which is a function of the walk distance and the walk speed), and the space (area) per person required for walking (at the walk speed used earlier). The walk time-space requirement for a zone is computed as follows:
$T-S$ walk $_{i}=P_{i} \cdot T_{i} \cdot M_{v}$
where

$$
\begin{aligned}
T-S \text { walk }_{i}= & \text { time-space requirement for walking for } \\
& \text { zone } i ; \\
P_{i}= & \text { volume of people walking in zone } i ; \\
T_{i}= & \text { walk time in zone } i, \text { which is a function of } \\
& \text { walk distance }\left(d_{i}\right) \text { and walk speed }(v) \text { or } \\
& d_{i} / v ; \text { and } \\
M_{v}= & \text { area per person required at walk speed } v .
\end{aligned}
$$

Figure 4 also shows a diagram indicating the volumes of people walking through each zone during the $15-\mathrm{min}$ analysis period. An estimate of the walk speed can be determined by calculating the level of service in walk zones along the back edge of the platform. The $15-\mathrm{min}$, two-way walk volumes range from 554 to 583 people, which for the $31 / 2$-ft wide space, result in flow rates of 10.6 to 11.1 people per min per ft width. The flow rate, equivalent to Level of Service C/D, requires a space module of $22 \mathrm{ft}^{2}$ per person and has an average walk speed of $245 \mathrm{ft} / \mathrm{min}$, or $4.1 \mathrm{ft} / \mathrm{sec}$. Average walk distance (in feet) in each zone is listed in Table 2, along with the walk time (in seconds) using a walk speed of $4.1 \mathrm{ft} / \mathrm{sec}$ and the volume of people walking through the zone. Multiplying the volume of people for each zone by the walk time in a zone results in the total walk time in a zone. Multiplying total walk time required by the $22-\mathrm{ft}^{2}$ per person space module, the walk time-space for a zone is determined. The calculations of the walk time-space requirement are given on the left-hand side of Table 2. Note


Flow Volume to/from South Stair


Flow Volume to/from North Stair


## Zonal Pedestrian Fow Volume

FIGURE 4 Platform study level of Detail 3: time-space zone.

TABLE 2 TIME-SPACE CALCULATIONS PLATFORM STUDY LEVEL OF DETAIL 3


* STAIRS AT PLATPORM ENDS
that the zones along the platform edge between the loading area have no walk time space-needs.

The queue time-space requirement for each zone is calculated by multiplying the number of people in queue by the average wait time and by the queue area per person. The number of people in queue and the average wait time are the same as in the two earlier examples. Only those zones representing the four bus loading/unloading areas have queue timespace needs.

The total time space requirement for a zone is the sum of the walk time-space and queue time-space requirements for each zone.

## Evaluation

The time-space required for each zone is compared with the time-space available to determine overloaded or underused portions of the platform. In Table 2, Zone B, one of the bus luading areas silows a siighi overioad-ime-space required exceeds the time-space available. Two other loading areas, A and D , have time-space requirements approaching the timespace available as do two walk corridor zones H and L . The zones adjacent to loading areas have excess available timespace where people can spill over. Also, the manner in which zone boundaries are defined can affect the outcome of the results and must be kept in mind when evaluating the findings.

## Analysis of Alternative Platform Configuration: Center Stairs

The platform in the preceding application has a set of stairs located at each end. Another possible stair location is at the center of the platform (see Figure 5). To further demonstrate the capabilities of the time-space concept, the station platform is analyzed with the stairs at the center location.

With the stairs located at the center of the platform instead of at the ends, there is a noticeable effect on the amount of walking required on the platform. With stairs at the ends of the platform, passengers coming down the stairs at one end who are destined for the loading location at the opposite end must walk nearly the entire length of the platform. With a center stair location, the maximum walking distance is less than one-half the length of the platform. A center stair, however, may increase the overall walk distance for a passenger between the loading/unloading location and passenger origin/destination, and the passenger may double back or back track.

In situations in which a constraint exists on the size of the platform, particularly the width, it might be appropriate to shift, as much as possible, the time-space requirements to another space, such as a mezzanine, even if the result is a net increase in the overall passenger walking distance. The increase in walking time may be more than offset by the reduced crowding, congestion, and delay time on the platform. The center stair platform configuration is analyzed in the following naragraphs by using the time-space concept; the procedural steps are the same.

## Platform Time-Space Zone

The platform is divided into time-space zones in a manner that is similar to the end-stair configuration (Figure 5). The size and shape of the zones are different, reflecting the location of the stairs at the center of the platform.

## Time-Space Available

The areas of each zone and the amount of time-space available in each area during a $15-\mathrm{min}$ analysis period are given in Table 3 (last two columns). Although the total time-space available on the platform is the same as the end-stair configuration, the time-space in the various zones does vary.


Flow Volume to/from Center Stair


FIGURE 5 Center stair platform time-space zone.

|  | WALK TIME-SPACE REQUIRED |  |  |  |  | QUELE TIPE-SPACE REQUIRED |  |  |  |  | \|available otme-space| |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Walk |  | TOTAL | 1 | NUMBER OF | AVEFAGE | average | total | total |  | - |
|  |  | TIME: |  | WALK | Whik | FEOPLE | WAI'J' | SQFT/ | WAIT | T-S | \| | T-S |
| zONE | distance | (seconds) | volume | TIME | T-S \| | WHO WAIT | TIfie | PEFECT | Y-s | pfeguired | 1 area | ava ilable |
|  | (ft) | e $4.1 \mathrm{ft} / \mathrm{sec}$ | vount | (min.) | e 22sqft/per. | Who War | (min.) |  | (sqft-n.in) | ( sqft -min) | 1 (sqft) | (sigft-min) |
| E | 5 | 1.2 | - | - | I |  |  |  |  | 1 - | 255 | 3825 |
| ${ }^{\prime}$ | 100 | 24.4 | 237 | 96.3 | 2120 |  |  |  |  | 2120 | 350 | 5250 |
| A | 5 | 1.2 | 237 | 4.8 | 106 | 227 | 5.8 | 7 | 9216 | 9322 | 690 | 10350 |
|  |  |  |  |  |  |  |  |  |  | \| 0 | 1 - |  |
| G | 5 | 1.2 | - | - | - 1 |  |  |  |  | I -- | 460 | 6900 |
| H | 40 | 9.8 | 475 | 77.2 | 1699 |  |  |  |  | 3699 | 181 | 2715 |
|  |  |  |  |  |  |  |  |  |  | \| 369 | 1161 |  |
| B | 5 | 1.2 | 238 | 4.8 | 106 | 228 | 6.8 | 7 | 10853 | 10959 | (1914 | 10260 |
|  |  |  |  |  |  |  |  |  |  | 1850 | 140 |  |
| 1 | 10 | 2.4 | 950 | 38.6 | 850 1 |  |  |  |  | \| 850 | 140 | 2100 |
| J | 5 | 1.2 | - | - | - 1 |  |  |  |  | 1 - | 320 | 4800 |
|  |  |  |  |  |  |  |  |  |  | 1 - 6012 |  |  |
| c | 5 | 1.2 | 238 | 4.8 | 106 | 228 | 3.7 | 7 | 5905 | 6012 | 684 | 10260 |
|  |  |  |  |  |  |  |  |  |  |  | 1 101 |  |
| K | 40 | 9.8 | 475 | 77.2 | 1699 \| |  |  |  |  | 1699 | 181 | 2715 |
|  |  |  |  |  | 2120 |  |  |  |  | 2120 | 1350 |  |
| L | 100 | 24.4 | 237 | 96.3 | 2120 |  |  |  |  | 2120 | 350 | 5250 |
|  |  |  | 237 | 4.8 | 106 | 227 | 5.4 | 7 | 8581 | - 8687 | 1690 | 10350 |
| D | 5 | 1.2 | 237 | - 8 |  | 227 | 5.4 |  |  | 868 | 1.60 |  |
| $\cdots$ | 5 | 1.2 | - | - | - I |  |  |  |  | 1 - | 460 | 6900 |
| $N$ | 5 | 1.2 | - | - | - 1 |  |  |  |  | - - | 255 | 3825 |
|  |  |  |  |  |  |  |  |  |  | , | 1 255 |  |
| total |  |  |  |  | 8912 \| |  |  |  |  | I 43467 | 15700 | 85500 |

## Time-Space Required

Figure 5 shows a diagram of the volume of people walking through each zone during the $15-\mathrm{min}$ analysis period. The walk speed is estimated to be $245 \mathrm{ft}-\mathrm{min}$, or $4.1 \mathrm{ft} / \mathrm{sec}$. The walk time-space required is calculated in Table 3. The total walk time-space for this platform configuration is $8,912 \mathrm{ft}^{2}-\mathrm{min}$, compared with the $15,718 \mathrm{ft}^{2}-\mathrm{min}$ required for the end-stair configuration. The queue time-space required is the same as in the previous configuration because the average waiting time and the number of waiting passengers at each location have not changed. The data in Table 3 show the queue time-space requirement for each zone. The total time-space requirement for each zone-the sum of the walk and the queue time-space requirement-is given in Table 3.

## Evaluation

The time-space required for each zone is compared with the time-space available to determine overloaded or underused portions of the platform. As can be observed from Table 3, Zone B , one of the bus loading areas, shows a slight overload, as was the case in the other platform configuration, primarily because of the long average wait time for the passengers in that zone. The zones on either side of Zone B have time-space available to accommodate the overflow.

The walk time-space required for the center stair platform is $8,912 \mathrm{ft}^{2}-\mathrm{min}$, as compared with $15,718 \mathrm{ft}^{2}-\mathrm{min}$ required for the end-stair platform, reflecting the reduced amount of walking that is necessary on the center-stair platform, particularly in the walk zones at the ends of the platform ( $\mathrm{E}, \mathrm{N}$ ).

## CONCLUSION

The time-space technique is a new way of looking at transit platforms. Dividing the platform into time-space zones enables the analyst to observe what happens in different areas of the platform. The time-space concept models the activities on the platform-walking and waiting-where they occur, the number of people involved, and the amount of time required. The time-space technique is able to model differences in platform configuration. In this example, access stairs at the ends of the platform versus one set of stairs in the center were modeled. The different amounts of walking that result from these different stair arrangements are reflected in station and zone walk time-space requirements.

The time-space technique offers a new tool for analyzing and designing platforms. Traditional techniques are not able to
consider the specific intensities and locations of the activities that occur on platforms. The time-space technique is able to model the way platforms are used and can analyze different configurations and types of user behavior. For instance, if passengers tend to cluster in certain parts of the platform, as they frequently do on rail transit platforms, the time-space technique can model their behavior in the same way that the passengers were assigned to specific locations of the bus platform for this analysis.

The time-space concept is applicable to a wide variety of spaces and situations involving pedestrian activitics, such as station fare control areas; elevator lobbies; vestibules for stairs and escalators; vestibules for auditoriums or stadiums; curbside areas at airports, hotels, or terminals; and museum and exhibition areas. The concept can address issues in spaces with many different activities and with multidirectional flows. In addition, the characteristics (walk speeds, space requirements, time to perform an activity) of different user groups (commuters, intercity travelers, shoppers. children, elderly, and handicanned) can be modeled.

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