UTILIZATION OF A PEDESTRIAN SIMULATOR TO PRESERVE AND ENHANCE A SIDEWALK SPACE

Analysis of Potential Pedestrian Crowding Near Subway Stations

Robin Blair
Karen Heit

Los Angeles isn't noted as a transit or pedestrian city, so the prospect of extreme pedestrian congestion around a major rail station was met with a degree of disbelief. There were several causes of the potential congestion. The rapid development of office, hotel and retail uses in the immediate vicinity of 7th and Figueroa would create high"ambient" sidewalk volumes, while one of the highest activity subway station, at the intersection of two new rail lines, would intermittently discharge additional volumes onto the already crowded sidewalks.

The limited sidewalk capacity at that site would be further diminished by plans of the City to expedite auto traffic through the same intersection, plans which entail cutting back on sidewalk widths in order to provide turning lanes. Further confounding the situation was a policy of the redevelopment agency to enhance surface level pedestrian activity by encouraging street level shopping, a policy which came about as a response to both the unwanted dilution of surface pedestrian volumes (at other locations) by skybridges, and the desire to create an active streetscape.

All these forces combined create a potentially monumental pedestrian jam-up, a phenomenon seldom encountered in Los Angeles. In RTD's perspective, it would limit the effectiveness of a major capital investment intended to overcome Los Angeles' auto dependency.

If the combined volumes at the sidewalk level are so high in the immediate vicinity of the street intersection, it may be necessary to take some of the pedestrians further from their origin, the subway platform, before having them merge with pedestrians on the sidewalks. This means providing for alternate passageways. In addition the continued erosion of the sidewalk width would further aggravate the problem. The issue was a question of fact. What was the actual potential for extreme crowding?

Analytical techniques for pedestrian traffic have never received as much attention as for vehicle traffic. Design of access to the subway station had been based on calculations of hourly averages, and had been thought to be reasonable before these several forces acted independently to raise the issue of peak sidewalk overloads. A more explicit representation of the dynamics was required in order to express the technical and abstract elements of the pedestrian overflow problem in terms understood by community groups and agency personnel unfamiliar with the issue.

The need to articulate the issue led RTD to produce a computer model capable of displaying the problem in a graphic fashion. The model is in a pilot state but has proved to be useful in communicating the unique characteristics of pedestrian movements to both professional and lay groups. The limitations and applications of the simulation model are presented in this document. Suggestions for improving the model would be appreciated.

PLANNING FOR PEDESTRIANS

This study was directed to the identification of the aggregate impact these disparate policies would have on the portal area located at the northeast intersection of 7th and Figueroa Street in the Los Angeles Central Business District (CBD).

Until recently, the pedestrian activities and pedestrian flows in the downtown area have been an area of little concern by the land use and transportation policy makers that have had impact on downtown Los Angeles' development direction. As a result, the future of pedestrian circulation near Metro Rail portals is headed for a congestion problem of significant proportions. There are three agencies and three separate land use policy positions that will ultimately contribute to this crisis in pedestrian circulation. The three agencies are the Community Redevelopment Agency (CRA), the Los Angeles Department of Transportation (DOT) and the Southern California Rapid Transit District (SCRTD).

The station areas in the first segment of the Metro Rail System (MOS-1) were placed and constructed with the financial and logistic constraints of building a completely new transit system in the heart of one of the highest population density cities in North America. Designs of the early eighties could not have reflected the reduction in pedestrian levels of service (LOS) which would derive from the policies of the CRA and the Department of Transportation (DOT). Combined with the placement of the Metro Rail system in the CBD is the consideration of a significant future redirection of the current bus service by the SCRTD. The current level of bus activity in the CBD facilitates the loading and unloading of CBD patrons at hundreds of downtown locations spaced every few hundred feet. The operation of the Metro Rail System will consolidate and centralize much of the transit activity in the CBD at or near the station portals. The independent programs and policies of these different agencies didn't account for the full combined impact of future pedestrian activity induced by local causes and Metro Rail.

The CRA has as a stated goal of the Central Business District (CBD) redevelopment project area, the creation of a street level pedestrian environment. New developments are required to include street level retail and pedestrian space. The policy of CRA to create pedestrian activity is strongly supported by RTD. However, when the street level retail is combined with the pedestrian activity generated by Metro Rail the walkways near the portals will be overtaxed. Concurrent with the CRA policy to encourage street level activity is the action of the Department of Transportation to reduce sidewalk width by expanding auto lanes. The reduction of sidewalk width has been taken to reduce auto congestion in the CBD. The current policies and programs of the CRA and the Department

of Transportation combined with new development projects will further aggravate a severe restriction of pedestrian flow near any Metro Rail portals in the CBD.

Pedestrians at the 7th and Flower Station will enter and leave through three portals. The one of most concern is the Figueroa portal located on the northeast corner of 7th and Figueroa. Current modeling projects that 50% of all Metro activity at the station will enter or exit from this portal. Studies of the pedestrian activity at 7th and Figueroa display a high volume of pedestrian activity even during construction of the Metro Rail facility.

The station is expected to open for light rail (Blue Line) activity in early 1991, with heavy rail (Red Line) activity added in September 1993.

CRA's peripheral parking policy, which requires substitution of spaces outside the CBD for spaces nominally required within the CBD, will encourage use of the transit system and increase pedestrian activity in the CBD beyond these simulation projections. The Department of Transportation's continuing plans to develop right- and left-turn lanes near the portal areas, through the reduction of sidewalk widths, will also increase pedestrian densities beyond this simulation.

An Earlier Study

The CRA commissioned Wilbur Smith and Associates to provide an analysis of the pedestrian activity in the Metro Rail Stations areas in 1984.[1] This study was completed with assumptions and conclusions that have significantly changed since 1984. The assumption in 1984 was that the CBD would build-out to 25 million square feet of office space upon opening of the Metro Rail Red Line. The current CBD is 31 million square feet, with currently planned projects bringing the CBD to 41 million square feet upon completion of the Metro Red Line system. The anticipated developments south of 7th were nowhere near the scale now being proposed. Developments currently being planned near Figueroa and south of 7th exceed the 1984 pedestrian study projections by at least 4 million square feet. In addition, no consideration has been given to the impact of the anticipated 25 million square feet of additional space included with the Central City West (CCW) plan. CCW is an approximately 400-acre masterplanned development immediately west of the CBD that would connect to the Metro Rail system at the 7th and Flower station.

These new assumptions portend a much higher level of pedestrian activity at the 7th and Flower Station. The Wilbur Smith and Associates study projects 1.7 midday pedestrian trips per thousand square feet of office space, and 17.4 midday pedestrian trips per thousand square feet of retail. The proposed Macklowe and Metropolis developments adjacent to the station together exceed 400,000 square feet of retail. That means for these developments alone over 6,000 midday pedestrian trips will be generated from the retail elements. Together, unanticipated retail and office developments

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[1] *Community Redevelopment Agency Pedestrian Study of Metro Rail Station Areas.* Wilbur Smith and Associates, September 1984. (unpublished).

near the 7th and Figueroa portal will generate over 12,000 additional midday pedestrian trips in excess of the projections of the 1984 study.

The 1984 Wilbur Smith study utilizes the definitions of Pushkarev and Zupan to classify pedestrian densities. The classifications have been adjusted by RTD Planning to correspond to the categories in the 1985 HCM. **Open** and **Unimpeded** correspond to LOS A at .05-2 P/F/M. **Impeded** to **Constrained** correspond to LOS B to C at 2-10 P/F/M. **Crowded** is roughly equal to LOS D, (Crowded being 10-14 P/F/M while LOS D is 10-15 P/F/M). It should be noted that these are levels of services before Platooning. The effect of Platooning decreases the LOS by one level (i.e. A to B).

THE MODEL

Initially, the calculation methodology from the Pedestrian chapter of the Highway Capacity Manual (HCM) was used to estimate sidewalk widths. Decision-makers unfamiliar with the phenomenon of high pedestrian flow found the resulting graphs and charts too abstract. The simulation was undertaken as a way of being more pictorial.

The first stage of the analysis was an estimate of maximum flows likely to occur with simultaneous train arrivals, using static values of passenger arrival rates to estimate congestion levels at bottlenecks near portals. This was followed by development of a spreadsheet-base pedestrian flow simulator using random arrivals. Both analyses were based on information from the Pedestrian section of the HCM. The simulation model assumes one-dimensional pedestrian movement, (i.e., no passing, dodging,weaving). The lateral friction which determines flow rate limits is assumed to be a deterministic function of volume and effective sidewalk width, with the effective width determined by obstacles and other edge conditions. The model is forced by random pedestrian arrivals entering into congested sidewalk sections. Assumptions are made about average ambient sidewalk volumes and the added surges of pedestrians brought by loaded trains.

Basis for the Model

The model utilizes assumptions provided by Pushkarev and Zupan in the HCM Manual. The simulation provides a gross view of activities adequate to demonstrate the result of sidewalk overcrowding. Assumptions and limitations include:

Adjustments to Pedestrian Speeds:

The model does not alter pedestrian speeds with local differences in Levels of Service.

Auto/Pedestrian Interaction:

The model does not consider the impact of auto interaction with pedestrians in the crosswalk area.

Bus Interface:

The impact of bus loading on the sidewalk activity is not included in the simulation. Numerous regional express buses as well as local circulators will interface with the Metro Rail System at this location. The significant number of waiting and disembarking bus patrons will aggravate the problems identified in the simulation.

Pedestrian Speed:

The pedestrian speed is approximately 200 feet per minute.

Platooning:

Platooning is represented by a numeric figure. The model does not separate the platoon once it has been created.

Portal Capacity:

The portal contains two reversible escalators capable of delivering 360 pedestrians per minute to the street level. A 12-foot wide stairway is located between the two escalators with an estimated capacity of over 300 pedestrian per minute. The elevator located near the portal is not considered significant to the calculations and is not included in the evaluation. For purpose of the simulation the portal volume is estimated at 360 pedestrians per minute.

Scale:

Scale is approximately three feet per cell on the sidewalk elements only.

Signal Timing:

Signal timing is consistent with the existing intersection signaling.

Street Widths:

Street widths are not to any scale. Pedestrian activity in the street crosswalks is assumed to be constant. Street crosswalk widths in all cases significantly exceed sidewalk widths. Street crosswalk widths do not restrict pedestrian flows from the smaller sidewalks widths, with the exception of autos stopping in the street crosswalk.

Time of Day:

The simulation is directed to morning peak-hour activity.

How the Model Works

The model was created on a Lotus 1-2-3 spread sheet to calculate and display the space and volume of a specified object in a given area. Simply stated, Lotus moves a number of pedestrians to a given area and then measures the area occupied by the pedestrians. The HCM calculations are made recursively to determine the results of the pedestrian movements. Pedestrians are randomly generated with a predetermined route through the model. Factors restricting movement and direction (traffic signals, train arrivals, sidewalk edge, etc.) are considered. Volumes can be easily altered by changing a random probability number. Each pedestrian is represented by a visual character on the computer screen, providing a graphical representation on the Lotus spreadsheet.

The simulator is operated on an IBM compatible 386, 2 megabyte machine using Lotus 123.

Consequences of Using the Model

The 7th and Figueroa conclusions from the simulation model resulted in the CRA requiring the development of an additional Metro Rail portal at the 7th and Figueroa intersection. The portal on the southside of the street at mid-block approximately 200 feet from the current portal. The model was a contributing factor to the recent increase in sidewalk width along 7th Street. The expansion was requested by the area merchants concerned with the diminishing pedestrian space along the street. The model was critical to quantifying the impact of reduced sidewalk capacity. The public sidewalk width was increased as part of the reconstruction of the street from 10 to 12 feet. Sidewalk width is actually 15 feet including the 3-foot setback that is part of the walkway right-of-way.

The simulator is currently being used to quantify the impact of reducing the Figueroa Street sidewalk from 22 feet to 15 feet. The simulator has also been used to support preservation of 15-foot sidewalk that was proposed to be reduced to 10 feet. The sidewalk is adjacent to the proposed Wilshire/Vermont Metro Rail station.

The results of the analysis made a convincing case for additional access portals, and increasing and preserving sidewalk widths. The benefits conferred on commerce in the area and the limitation of pedestrian/auto conflict easily warrant the investment that will be required. The model is expected to be applied at an earlier stage of planning for the areas surrounding subway stations to be constructed in the future.

DEFINITIONS

(from the Highway Capacity Manual, Special Report #209, Transportation Research Board, National Research Council.)

Pedestrian flows are defined as level of services (LOS) similar to auto traffic level of services. LOS as established by the Transportation Research Board is defined in a progressive scale of A to F. Definitions of each of the different LOS are included below. The most significant variables affecting the LOS are the number of pedestrians, platooning, net sidewalk width, direction of pedestrian flow, cross flows and surges.

The following definitions are provided to better understand the variables affecting the LOS:

Direction of Pedestrian Flow: The identification of pedestrian flow is important in establishing the total capacity of a walkway. Pedestrian flow restricted to one direction significantly increases the capacity of a walkway.

Intersection or Cross Flows: Once intersection or cross flows are introduced the active LOS greatly changes. Intersection activity exaggerates platooning, forces changes in walkway speeds and dramatically increases pedestrian densities. Intersections result in auto/pedestrian mix and the reduction of capacity of both road and walkways. Cross flows result when walkways intersect.Cross flow problems expand geometrically as densities increase.

Number of Pedestrians: The total number of pedestrians in a given space, or that cross a given area.

Net Sidewalk Width: The net sidewalk width is the effective walkway width after subtracting for "obstacles" from the designed sidewalk width. The obstacles accounted for are the following: One is street level retail, especially where displays or entries interact with pedestrian flows. The Special Report #209 data indicates that the presence of "window shopping" reduces the sidewalk widths by a minimum of three feet. This accounts for pedestrians stopping or slowing to look in windows. The effective sidewalk width is further aggravated by the introduction of pedestrian flows entering or exiting from buildings or retail portals without adequate "assimilation" space. This assimilation space is the area needed to merge with the current flow of pedestrian traffic before directional conflicts can occur. Small retail shops typically constrict pedestrian flow because of a lack of adequate merging or assimilation space. The CRA's encouragement of street level retail exiting directly into pedestrian flows reduces the net sidewalk width and thus the net possible flow of pedestrian activity.

Combining with the retail reduction of sidewalk width is the placement of sidewalk obstacles in the same area. Sidewalk obstacles include street lights, signage, fire hydrants, tree boxes, planters, newsstands, seating, parking meters, etc. These obstacles usually direct pedestrian flows to the center of the sidewalk and away from the curb area. The safety benefit of these obstacles is to inhibit pedestrians from walking into the street. The net reduction of sidewalk width from these obstacles

is considered to be three to four feet.

Platooning: A natural grouping of people occurs because of different walking speeds, passing of obstacles, and intentional grouping.

Surges: Surges develop when a large number of pedestrians are released from a signal corner or from a transit vehicle.

Super-Surges[2]: Surges from east/west and north/south trains arriving or departing at the same time at the same station with a significant number of patrons exiting from all trains. The possibility of occurrence is dependent on the frequency of arrivals, unloading times, variables altering schedules, length of system, coordination of Red and Blue Line activity and any other variable altering the flow of trains.

The frequency of super-surge activity can be reduced by schedule and operations management planning, but will occur daily even with the best planning. Super-surge activity is only critical during peak activity hours. Morning (approx. 8:00 am), Noon (approx. 11:45 am-1:15 pm) and after noon (approx. 5:00 pm) peak hours with a station exit time of one to two minutes increase the chance of super-surge activity as headway times are reduced. Less critical but still significant is simultaneous arrival of the northbound Blue Line trains. This station will be the final destination of much of the Blue Line morning patrons. That implies that a large portion of potential train capacity will disembark at this location. Even though the number of potential pedestrians is not as great as for the Red Line, the presence of the additional patrons can have a substantial impact on the pedestrian activity surfacing in the area.

Levels of Service[3]

Level of Service A. At walkway LOS A, pedestrians basically move in desired paths without altering their movements in response to other pedestrians. Walking speeds are freely selected, and conflicts between pedestrians are unlikely.

Level of Service B. At LOS B, sufficient area is provided to allow pedestrians to freely select walking speeds, to bypass other pedestrians, and to avoid crossing conflicts with others. At this level, pedestrians begin to be aware of other pedestrians, and to respond to their presence in the selection of walking paths.

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[2] Surges and Super-surges are definitions provided by the planning department for pedestrian activity specific to transit operations. The Transportation Research Board currently has no information on incremental influxes of pedestrian activity.

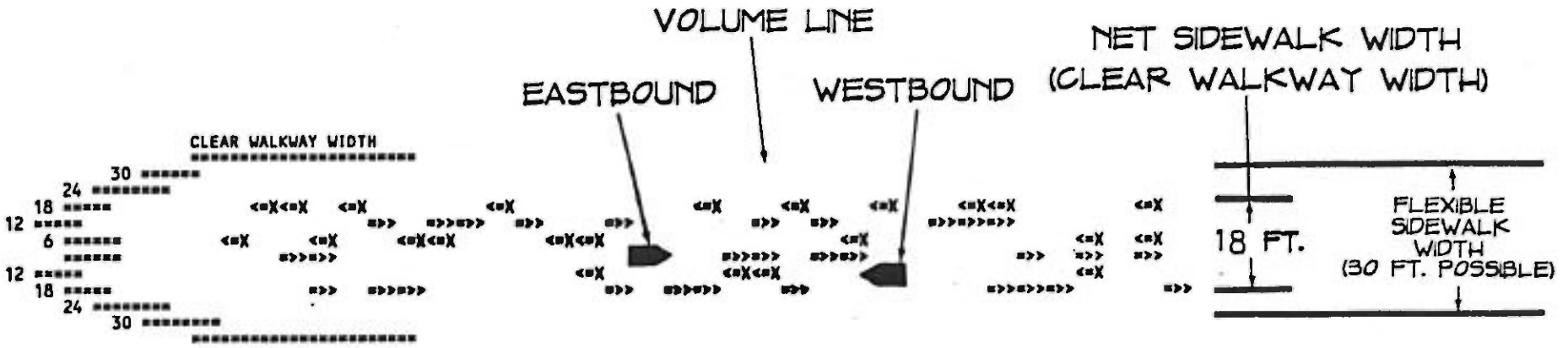
[3] as defined by the Highway Capacity Manual, Special Report #209, Transportation Research Board, National Research Council.

Level of Service C. At LOS C, sufficient space is available to select normal walking speeds, and to bypass other pedestrians in primarily unidirectional streams. Where reverse-direction or crossing movements exist, minor conflicts will occur, and speeds and volume will be somewhat lower.

Level of Service D. At LOS D, freedom to select individual walking speed and to bypass other pedestrians is restricted. Where crossing or reverse-flow movements exist, the probability of conflict is high, and its avoidance requires frequent changes in speed and position. The LOS provides reasonably fluid flow: however, considerable friction and interaction between pedestrians is likely to occur.

Level of Service E. At LOS E, virtually all pedestrians would have their normal walking speed restricted, requiring frequent adjustment of gait. At the lower range of this LOS, forward movement is possible only by "shuffling". Insufficient space is provided for passing of slower pedestrians. Cross-flow or reverse-flow movements are possible only with extreme difficulties. Design volumes approach the limit of walkway capacity, with resulting stoppages and interruptions to flow.

Level of Service F. At LOS F, all walking speeds are severely restricted, and forward progress is made only by "shuffling." There is frequent, unavoidable contact with other pedestrians. Cross-flow and reverse-flow movements are virtually impossible. Flow is sporadic and unstable. Activity is more characteristic of queued pedestrians than of moving pedestrian streams.



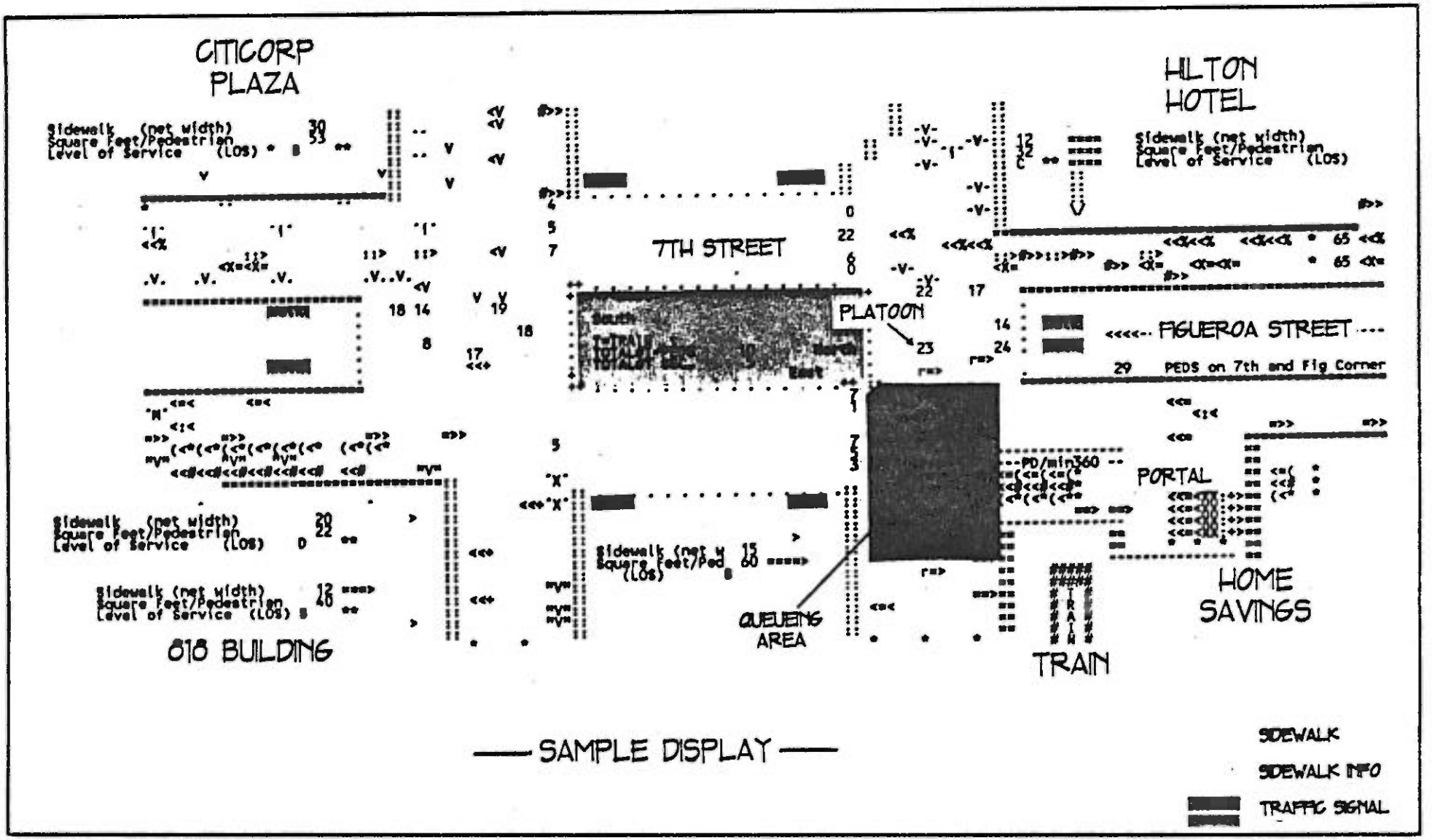
SIDEWALK LENGTH 0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51 54 57 60 63 66 69 72 75 78 81 84 87 90 93 96 99

119	VOLUME OF PEDESTRIANS '(PER MINUTE)
219	AVERAGE PEDESTRIAN SPEED (feet per minute)
6.8	PEDESTRIANS PER MINUTE (per foot of width)
18	CLEAR WALKWAY WIDTH (net width)
32	FEET PER PEDESTRIAN
C	LEVEL OF SERVICE (LOS)

SAMPLE DISPLAY

RTD

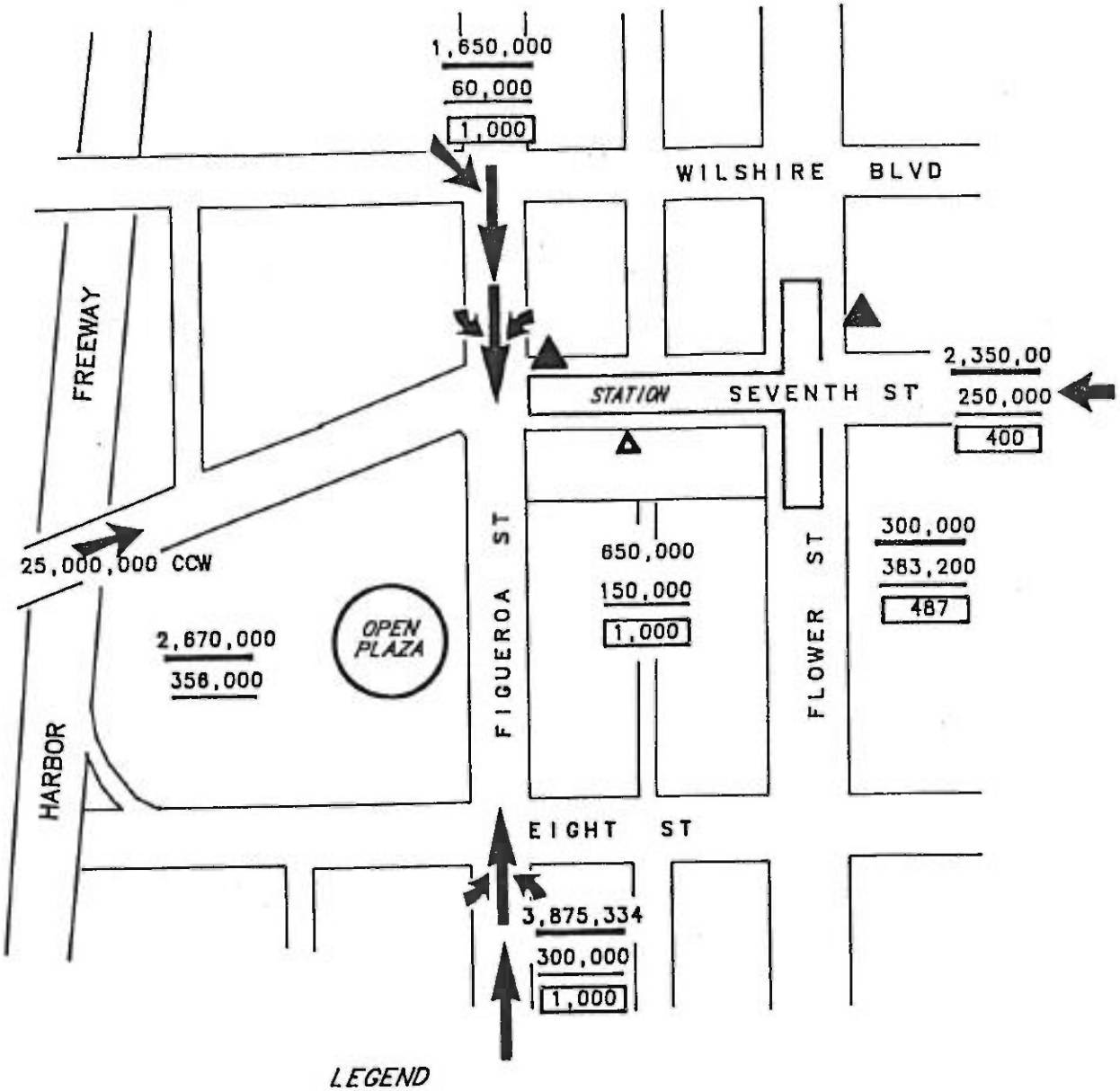
SIDEWALK WIDTH CAPACITY SIMULATION



RTD

7TH/FIGUEROA PEDESTRIAN SIMULATION

SEVENTH AND FIGUEROA STREET STATION AND DEVELOPMENT



LEGEND

(EXISTING AND PLANNED MALOR DEVELOPMENT)

SQ. FT. OFFICE

SQ. FT. RETAIL

0000 NUMBER OF HOTEL ROOMS

PLANNED PORTAL

METRO RAIL PORTALS (UNDER CONSTRUCTION)

N

NOT TO SCALE

128:ROBIN