Evaluation of Safety for Pedestrians at Macro- and Microlevels in Urban Areas

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In the modal hierarchy, pedestrians "encased in soft exposing shell" are the most vulnerable when exposed to conflicts and barriers. In dense urban areas, where walking is an important mode to complete short trips, there is a continual need for evaluation of the existing roads and walkways, so that appropriate actions can be taken to eliminate or redress conditions that compromise pedestrians' safety. This paper proposes a method that would enable professionals to examine different facets of safety. The proposed method evaluates the existing design and conditions at two levels: first, at macrolevel (Service Levels A-F), and second, at microlevel [Quality of Service (QOS) Levels A-F]. Also discussed in this work are the methodologic processes for using the service and QOS levels, and the strengths and weaknesses of the method.

In his book *Relations in Public,* Erving Goffman explained the differences between a vehicular and a pedestrian unit. His definitions captured the dissimilarity in essence. Goffman noted (*1*):

> A vehicular unit is a shell of some kind controlled (usually from within) by a human pilot or navigator.
> . . . a road and its traffic will support shells of somewhat different kinds—cars, bicycles, horse-drawn carts, and of course pedestrians. Viewed in this perspective, the individual himself, moving across roads and down streets—the individual as pedestrian—can be considered as encased in a soft exposing shell, namely his clothes and skin.

Goffman further commented:

> . . . the role of unintentional physical contact differs in the two systems, collision apparently being a matter of more concern on the road than on the sidewalk. Pedestrians can twist, duck, bend, and turn sharply, and therefore, unlike motorists, can safely count on being able to extricate themselves in the last few milliseconds before impending impact. Should pedestrians actually collide, damage is not likely to be significant, whereas between motorists collision is unlikely to be insignificant.

Given the above differences in pedestrians and vehicles, it is important to employ different design standards for each of them so that their paths only cross at defined locations. And, when their paths do cross, the safety of the pedestrians should not be compromised.

EVALUATION METHOD

A proposed method has been developed using design and planning principles that make the urban sidewalks and intersections safe for the vulnerable groups: the elderly, children, and physically impaired.

The method has two discrete evaluations: first, the Service Levels A-F (SL A-F) that evaluate the macrolevel design and conditions on the walkways and intersections; second, the Quality of Service Levels A-F (QOS Levels A-F) that evaluate the microlevel design and conditions on the walkways and intersections (Figure 1).

The proposed method was developed after extensive research and study of the existing literature on safety in engineering, planning, urban design, and environmental psychology. In addition to literature review, existing evaluation methods on safety developed by Braun and Roddin (*2*), Smith et al. (*3*), and Khisty (*4*) have been studied.

ESTIMATION OF SERVICE LEVELS A-F WITH RESPECT TO SEPARATION OF MODES

A review of the literature indicated that the emphasis in all pertinent research on safety in urban streets has been on the level and effectiveness of the separation between modes. Several authors have contributed to this subject, to cite a few (chronologically): Buchanan (*5*), Gruen (*6*), Rudofsky (*7*), Pushkarev and Zupan (*8*), Fruin (*9*), Prokopy (*10*), Breines and Dean (*11*), Brambilla and Longo (*12*), Braun and Roddin (*2*), Untermann (*13*), Smith et al. (*3*), Whyte (*14*), Zegeer and Zegeer (*15*), Tolley (*16*), Bach and Pressman (*17*), and Zegeer (*18*).

Others, such as the following, have discussed at length soft separation and traffic calming: Appleyard (*19*), Homburger et al. (*20*), Eubank-Ahrens (*21*), Hass-Klau et al. (*22*), Vahl and Giskes (*23*; interview with Vahl on October 16, 1993, in city of Culemborg, The Netherlands), and Bach and Pressman (*17*).

The proposed service levels were shaped by the author's understanding of the aforementioned research. These levels, based on the type of separation between different modes, will enable designers and planners to perform a qualitative evaluation of pedestrians' exposure to hazards.

The fundamental principle in forming this classification system is to offer directness and clarity in defining the proposed service levels, so that they can be used easily by a wide variety of groups, from professionals to community and neighborhood organizations.

The service levels proposed in this work have five levels of separation, from A-F, as defined in Table 1. "F" was used instead of "E" to emphasize the failing conditions of the road in affording safety.

Table 1 summarizes the essential conditions that are proposed to be included in each of the six service levels. The summary for each of the proposed service levels explains in essence the type of separation and the safety conditions that pedestrians would encounter.

Network of Employers for Traffic Safety (NETS), Regional Coordinator for San Diego, Customized Training, Building 1600, Southwestern College, 900 Otay Lakes Road, Chula Vista, Calif. 91910.

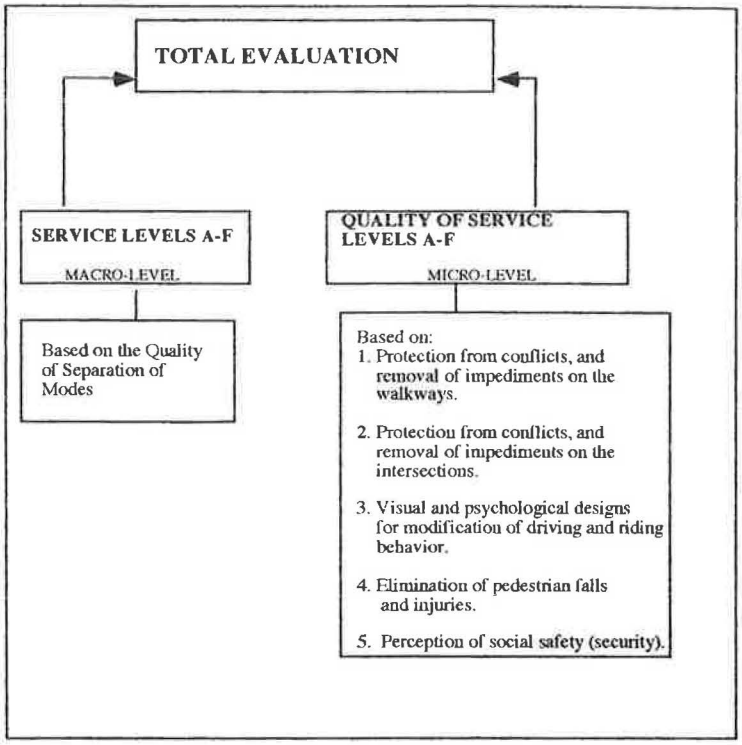

FIGURE 1 A summary of evaluation method.

METHODOLOGIC PROCESS FOR USING SERVICE LEVELS

The process for assigning a service level grade to a walkway requires eight steps, as illustrated in Figure 2. The process starts with a detailed survey of the site, examining the microlevel design, geometric, and operational aspects of the sidewalks and the intersections. To obtain an accurate idea of the weak links on any street, a block-by-block survey is conducted.

The second step results in the systematic itemization of all of the information on the site collected during the survey.

The following step involves an item-by-item comparison of the characteristics of the site, with those items included in the service levels.

The fourth step has two major processes (i.e., identification and elimination). Identification involves scanning the service levels to isolate those that are unsuitable for explaining the site characteristics of the surveyed walkway. Elimination is a decision step that excludes the irrelevant service levels while retaining those whose characteristics are more relevant to the surveyed site.

The fifth step requires a comparison of the characteristics of the surveyed site with the conditions proposed for the remaining service levels.

The next step (sixth) leads to the selection of the service level that meets most of the characteristics observed at the site.

Steps 1 through 6 are repeated for each block on the street.

In the seventh step, the grades assigned to each block on a street are shown together in a tabular form to establish the degree of variation in the safety conditions. The final format would look similar to the one shown for the hypothetical Chester Avenue in Figure 3.

The final step (eighth) requires the assignment of a grade for the entire walkway based on the principle of systems evaluation that states that "minimum capacity of a line defines the capacity of a line." On the basis of this principle, the entire street is assigned an overall grade based on the lowest grade received on any section or block.

EVALUATION USING QUALITY OF SERVICE LEVELS A-D

Service Levels A-F evaluate the macrolevel designs (quality of channelization) only, and they do not assess the microlevel designs or conditions on the walkway that could affect a pedestrian's safety. For example, a sidewalk may be well separated from other modes, but could have large pot holes that could cause injuries, or have poor visibility at intersections, compromising the safety of crossing pedestrians. These problems are not evaluated at a macrolevel, and yet if these quality conditions are ignored, pedestrians' safety is undermined significantly.

The QOS levels also have been developed using grades A through F (excluding "E"), with five levels of variations.

The microlevel components that contribute to the quality of safety are discrete entities, and they cannot be combined together to form one set of QOS levels. Therefore, to assist analysts in conducting accurate microlevel examinations, five disparate QOS levels have been developed using the following criteria:

1. Elimination of conflicts and impediments on the walkways;
2. Elimination of conflicts and impediments at intersections;
3. Visual and psychological designs for modification of driving and riding behavior to ensure pedestrians' safety;
4. Elimination of pedestrian falls and injuries through maintenance and design; and

TABLE 1 Service Levels A-F for Safety: Separation of Modes

Service Level	Pedestrians	Bicycles	Transit	Auto
A	• Exclusive pedestrian facility. • Vehicular intersections and crossings eliminated.	• Bicycles are allowed but only if they have been assigned separate of r/w. *They use the road with transit.* • Bicyclists have separate channelizations at intersections.	• Only Light rail is allowed. • Light rail has defined path.	• Autos are banned. • Autos are not allowed.
B	• Pedestrians have been assigned separate r/w **adequately** separated from bicyclists and vehicles, by bollards, curbs etc. • Pedestrians are provided with **exclusive time separation** at intersections. • They have well defined channelization at intersections.	• Bicycles are assigned with well defined separate r/w, separated by curbs or bollards from pedestrians and vehicles. • Bicycles are controlled by their own traffic signals. • They have separate channelizations a intersections.	• Transit is assigned with separate r/w. • Transit vehicles are controlled by their own traffic signals. • They have separate channel-izations at intersections.	• Autos have their separate r/w. • Autos have their own traffic signals. • They have separate channel-izations at intersections.
C	• Pedestrians have been assigned separate r/w **inadequately** separated from bicyclists. • Pedestrians **face conflicts with right turning vehicles,** and bicyclists, at the signal. • The channelization for pedestrians and bicyclists is **unclear at intersections.**	• Bicycles are assigned with inadequately defined separate r/w. *The bikepaths are placed on sidewalks distinguishable only by texture.* • Bicycles share signal timing with pedestrians. • The channelization for bicyclists and pedestrians is **unclear at intersections.**	• Transit has separate r/w. • Transit vehicles share the same traffic signals as autos. • They have separate channelizations at intersections.	• Autos have separate r/w. • Auto have their own traffic signals. • They have separate channel-izations at inter-sections.
D	• Pedestrians have been provided with separate r/w **but they are forced to share it with bicyclists.** • Pedestrians face **conflicts with right and left turning vehicles, and bicyclists, at the signal.** • There is no separate channelization for pedestrians and bicyclists at intersections.	• Bicyclists have not been provided with separate r/w. They use the sidewalks. • Bicyclists' behavior is indeterminate at intersections. • There is no separation between bicyclists and pedestrians at intersections.	• Transit is not assigned separate r/w. The share it with vehicles. • Transit vehicles share the same traffic signals as autos. • They have separate channelizations at intersections.	• Autos have more than adequate r/w. • Autos have their own traffic signals. • They have separate channel-izations at intersections.
F	• Pedestrians do not have separate r/w. • Traffic signals have not assigned time for pedestrians. • Pedestrians have no channelization at intersections.	• Bicycles do not have separate r/w. • Bicyclists' behavior is indeterminate at intersections. • Bicyclists use the road with other vehicles at intersections.	• Transit is not assigned separate r/w. The share it with vehicles. • Transit vehicles share the same traffic signals as autos. • They have separate channelizations at intersections.	• Autos have been assigned exclusive r/w. • Autos have their own traffic signals. • They have separate channel-izations at intersections.

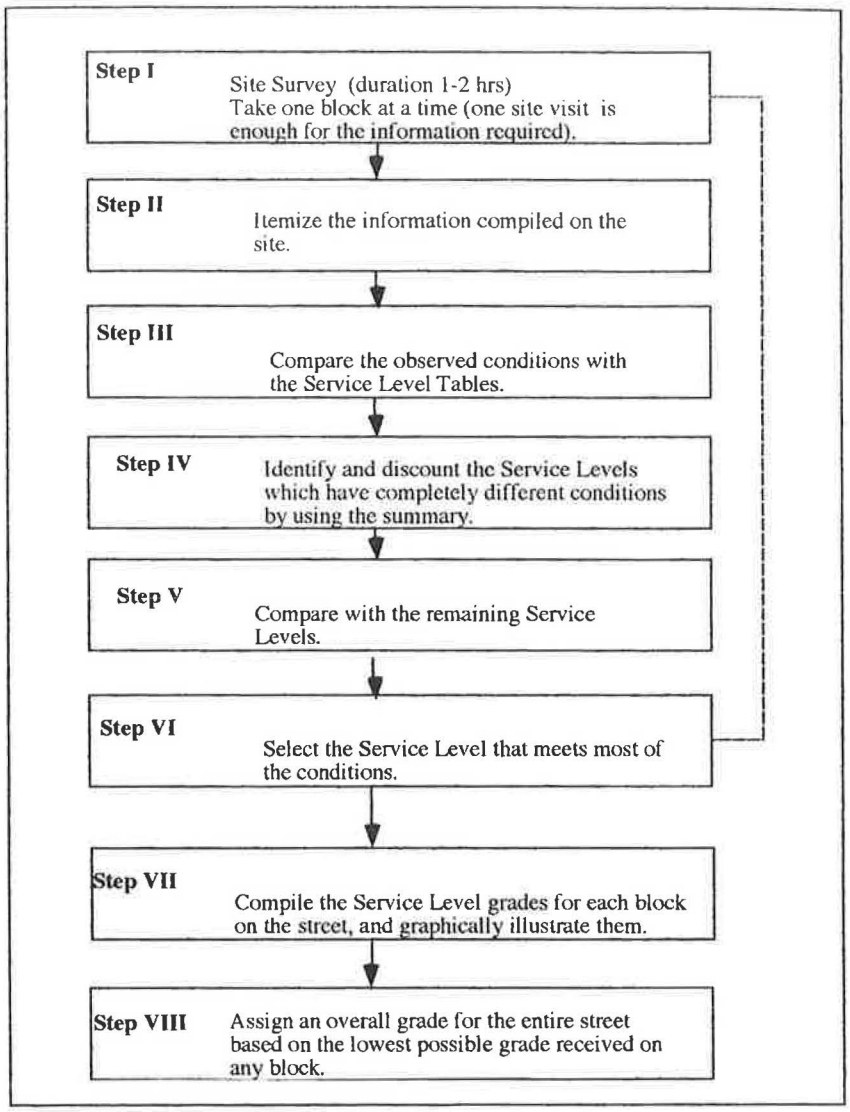

FIGURE 2 Methodologic process for assigning service level grades.

5. Planning and design principles that enhance the perception of social safety (security).

The summary of each of the above five components is as follows.

Elimination of Conflicts and Impediments on Walkways

The level of safety for pedestrians can be compromised by obstructions or barriers along the path.

Researchers such as Fruin (*9*), Braun and Roddin (*2*), Untermann (*13*), Smith et al. (*3*), Whyte (*14*), and Tolley (*16*) have discussed at length the possible barriers or obstructions that pedestrians experience on walkways.

Such impediments may be a result of inadequate ancillary walkway to place street furniture, poor enforcement of regulations to keep the effective walkway free of obstructions because of excessive commercial use, or illegal use of the walkways for parking. The variations in the level of obstruction are explained by the QOS Levels A-F, and shown in Table 2.

Elimination of Conflicts and Impediments at Intersections

Safety problems at intersections have been researched extensively by traffic engineers, planners, and environmental psychologists, such as Sandels (*24*), Mortimer (*25*), Knoblauch (*26,27*), Hauer (*28*), Zegeer et al. (*29*), Cynecki et al. (*30*), Robertson (*31*), and Oliver (*32*). Some of the pedestrian safety issues that have been mentioned consistently by the researchers are as follows:

1. Problems with turning movements concurrent to pedestrians' crossing;
2. Problems with four-way stop signs;
3. Visibility problems at intersections; and

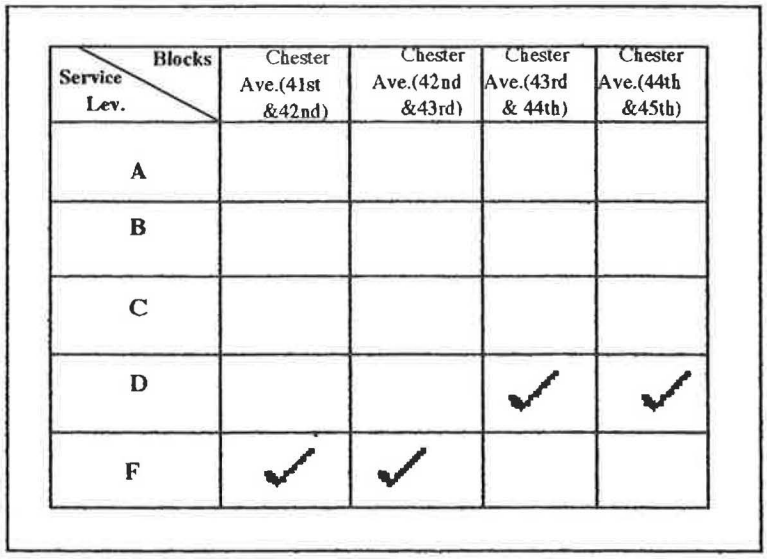

FIGURE 3 Graphic representation of evaluation on block-by-block basis on hypothetical Chester Avenue.

4. Effectiveness of traditional speed-reduction measures at intersections, such as rumble strips and pedestrian flashing beacons.

The definition QOS Levels A-F, shown in detail in Table 3, evince a degree of sensitivity to the various nuances and variations of design and regulations on walkways and at intersections.

Visual and Psychological Elements for Modification of Drivers' and Cyclists' Behavior

The importance of visual and psychological designs have been used extensively by urban designers and planners to modify driving and riding behavior. Some of the key proponents of such designs in the U.S. include Brambilla and Longo (*12*), Appleyard (*19*), Untermann (*13*), Homburger et al. (*20*), Whyte (*14*), and Rubenstein (*33*).

In Europe, visual and psychological designs have been used widely for traffic calming. A wide array of literature has been added on the subject, mostly in German, Dutch, and French. Some of the contributions in English have been from Appleyard (*19*), Homburger et al. (*20*), Eubank-Ahrens (*21*), Hass-Klau et al. (*22*), Tolley (*16*), Vahl and Giskes (*23*; interview with Vahl on October 16, 1993, in city of Culemborg, The Netherlands), and Bach and Pressman (*17*).

The QOS Levels A-F have been designed using the concepts and principles proposed by these authors (Table 4).

Elimination of Pedestrian Falls and Injuries on Walkways Through Maintenance and Design

This area has been most neglected. Very little research (*16*) or statistics have been compiled on the falls and injuries that pedestrians have suffered because of the conditions on the walkways, particularly the visually impaired and other physically challenged users.

The key aspects that are relevant to assess the probability of falls and injuries on walkways that have been used to develop the QOS levels are as follows:

1. The condition of the walkway surface;
2. Accommodation of needs of different user groups, such as people with assisting device, etc.;
3. The presence of tactile or sensory cues; and
4. Actions taken to prevent injuries that could be caused by inclement weather, such as excessive snow accumulation or icy patches on the walkways.

Table 5 explains the different QOS levels.

Planning and Design Principles That Enhance Perception of Safety (Security)

Perception of security plays an important role in the decision to walk. Researchers such as Jacobs (*34*), Fruin (*9*), Newman (*35*), Alexander et al. (*36*), Braun and Roddin (*2*), Gehl (*37*), Oc and Trench (*38*), and Rubenstein (*33*) have suggested different design and planning strategies that would improve security on walkways. Some of the frequently mentioned principles are as follows:

1. High levels of activity on the walkways throughout the day and night;
2. Orientation of buildings toward the streets;
3. Regular police patrol and presence of security devices; and
4. Low-level lighting.

All of these principles have been incorporated in the development of the QOS levels for security (Table 6).

METHODOLOGIC PROCESS FOR QOS LEVELS

The process for assigning a QOS level grade to a walkway has nine methodologic steps, as illustrated in Figure 4. The process is very similar to the one for service levels.

Steps 1 through 6 are repeated for each block on the street, and are illustrated graphically in the seventh step. Figure 5 offers an illustration for hypothetical Chester Avenue.

TABLE 2 QOS Levels A-F for Level of Conflicts and Impediments on Walkways

QOS Levels	Illegal Parking of Vehicles	Tactile Guidance to the Visually Impaired	Condition of the Effective Walkwidth	Condition of the Ancillary Walkwidth	Pedestrian -Bicycle Conflicts
A	• None • Vehicles are banned.	• Specially designed sensory cues.	• Free from obstructions.	• More than adequately wide for street furnishings.	• There are no conflicts. Bicycles are adequately separated.
B	• None • Illegal parking is prevented by bollards, landscaping, and curbs over 15 cm or 6".	• Specially designed sensory cues.	• Free from obstructions. • Strict enforcement to keep the effective walk free of commercial and other uses.	• Adequately wide for street furnishings.	• There are no conflicts. • Bicycles are adequately separated.
C	• None • Illegal parking is prevented by curbs over 15 cm or 6".	• Visually impaired guided by texture differences.	• Effective walk is marginally reduced at certain sections by street furnishings or vendors. • The reduction does not affect flow or movements. • Average enforcement to keep the effective walk free of obstructions.	• Adequate, but due to improper placement of street furniture, they encroach on to the effective walkway.	• There are some conflicts with bicycles because bike paths are designed on sidewalks with inadequate separation.
D	• Observed • Illegal parking is observed at certain sections because of low curbs.	• No tactile cues for the visually impaired.	• Effective walk is considerably reduced by street furnishings or vendors. • The reduction affects pedestrian flow and movements. • Poor enforcement to keep the effective walk free of obstructions.	• Ancillary walk is insufficient relative to the observed levels of uses and activities.	• There are frequent conflicts with bicyclists, because they use the walkway without any channelization.
F	• Frequent • Illegal parking is observed because of low curbs, poor design.	• No tactile cues for the visually impaired. • Extremely hazardous for them.	• Effective walk is serving other uses, and not pedestrians (parking). **or,** • The effective walk is missing at sections. • The pedestrians are forced to use the road due to paucity of space. • There is no enforcement to keep the effective walk free of obstructions.	• Ancillary walk is absent.	• There are no conflicts with bicyclists, because they use the roads under mixed traffic conditions.

TABLE 3 QOS Levels A-F for Level of Conflicts and Impediments at Intersections

QOS Levels	Conflicts with Vehicles	Conflicts with Bicyclists	Tactile Guidance to the Visually Impaired	Intersection Design	Speed Reduction Measures
A	• None • Vehicles are banned.	• None • Bicyclists use the roads with transit vehicles.	• Specially designed sensory cues.	• Well designed curbs with tactile guidance. • Pedestrian refuges are not needed. • There is no visibility problem as vehicles are banned.	• Speed reduction measures are not required because traffic is banned.
B	• None • Pedestrians have exclusive time separation.	• None • Bicycles have separate channelization, and time separation.	• Specially designed sensory cues. • Pedestrian actuated audible signals.	• Well designed curbs with tactile guidance. • Pedestrian refuges are well designed (with bollards and landscaping) and placed where needed. • High visibility of traffic through extended curbs.	• Speed is reduced using traffic calming measures.
C	• Possible • Pedestrians face conflicts from right turning vehicles.	• Possible • Bicycles use the crosswalks with pedestrians.	• Visually impaired guided by texture differences.	• Curb ramps are adequate and usable, but do not offer any tactile cues. • Pedestrian refuges are placed where needed. • Adequate visibility due to restrictions imposed on parking.	• Speed is reduced using conventional methods -- stop signs, flashing lights, rumble strips.
D	• Possible • Pedestrians face conflicts with right and left turning vehicles at signals.	• Possible • Bicycles use the crosswalks with pedestrians.	• No tactile cues for the visually impaired.	• Ramps are improperly aligned. • Pedestrian refuges are missing where needed. • Poor visibility, vehicles park very close to the crosswalk.	• There are no speed reduction measures.
F	• Very high • There are no traffic control devices, pedestrians are left to fend for themselves.	• Very high • There are no traffic control devices.	• No tactile cues for the visually impaired. • Extremely hazardous situation for them.	• Curb ramps are missing. • Pedestrian refuges are missing. • Extremely dangerous conditions, vehicles park on the crosswalk.	• There are no speed reduction measures.

TABLE 4 QOS Levels A-F for Visual and Psychological Designs to Modify Drivers' and Cyclists' Behavior

QOS Level	Speed Reduction Measures	Compliance with traffic signs and signals *(For every 50 vehicles observed)*	Street Layout and Design	Regulatory Signs
A	• Not required, because vehicles are banned.	• Over 100 percent	• Low level lights (4-5 m or 12-15 ft) • Pedestrian oriented design (wide walkways, landscaping)	• Regulatory signs are clear and prominently placed.
B	• Very effective. • Traffic calming designs -- such as– neck downs, raised crossings, pinch points etc. are placed.	• 80-85 percent	• Low level lights (4-5 m or 12-15 ft) • Completely pedestrian oriented design (wide walkways, landscaping, and traffic calming designs)	• Regulatory signs are clear and prominently placed.
C	• Partially effective. • Traditional methods of speed reduction are used -- such as-- stop signs, rumble strips, flashing beacons etc.	• 70-80 percent	• Moderate level street lights (5-7 m or 15-20 ft). • Partially pedestrian-oriented design (sufficiently wide walkways relative to the street cross-section; one way streets with one or two lanes, less than 3m or 10 ft etc.)	• Messages on the regulatory signs are unclear, although prominently placed.
D	• There are no speed reduction measures.	• 50-70 percent	• High level street lights over 7 m or 20 ft. • Vehicle oriented design (Wide roads and narrow sidewalks).	• Regulatory signs are improperly placed.
F	• Streets have been over-designed with wide lanes encouraging speeding.	• Less than 50 percent	• High level street lights over 7m or 20 ft. • Vehicle oriented design (Multi lane two way roads).	• Regulatory signs are missing.

TABLE 5 QOS Levels A-F for Possibility of Pedestrian Falls and Injuries

QOS Level	Condition of the Walking Surfaces	Conditions faced by Pedestrians with Assisting Devices	Other Hazardous Conditions
A	• Walking surfaces are in excellent condition. They are well maintained and in perfect condition. • There are no chances of tripping.	• Safe and injury free.	• Walkways **are enclosed or canopied,** and do not have: (a) drainage problems; (b) icy patches or snow accumulation; (c) litter.
B	• Walking surfaces are in good condition. Cracks and others problems have been repaired. • There are no chances of tripping.	• Safe and injury free.	• Walkways do not have: (a) drainage problems after rain; (b) icy patches or snow accumulation; (c) litter.
C	• Walking surfaces are in average condition. Uneven surfaces are found in some sections.	• Tripping is possible at certain sections.	• Walkways have: (a) minor drainage problems after rain; (b) icy patches at certain sections during winters.
D	• Walkways are in poor conditions. Broken uneven surfaces are found all along the walkway.	• Pedestrians can trip over or seriously hurt themselves, if they are not careful.	• Walkways have any one of these conditions all the time: (a) drainage problems; (b) slippery icy surfaces at sections; (c) litter -- trash bags or cans blocking walk.
F	• Walkway is unusable at stretches. Broken uneven surfaces with moderate to large pot holes.	• Major injuries can be sustained, particularly by the visually impaired.	• Walkways have any one of these conditions throughout the stretch, forcing pedestrians to use the road: (a) flooding after rain; (b) slippery surfaces and icy patches during winter; (c) uncleared snow during winter; (d) vehicles blocking walks; (e) litter -- broken bottles, glass fragments, sharp objects. (f) litter -- fairly large objects or trash bags blocking walk, furniture, appliances.

TABLE 6 QOS Levels A-F for Perception of Security

QOS Levels	Activity Levels	Lighting	Perception of the Environment	Surveillance
A	• Very high activity levels during the day. • Very high activity levels till late in the evening.	• Well lit by low level lights (4-5m or 12-15 ft).	• The environment fosters a secure image: (Any **three** of the conditions.) (a) various users are observed -- vendors, pedestrians, etc.; (b) stores line the walkways; (c) buildings along the walkways generate high levels of activity and turnover throughout the day till late in the evening; (d) buildings are oriented toward the street/ walk.	• Police surveillance is constant. • There are also security devices on each section of the walk.
B	• High activity levels through-out the day. • High activity levels till late in the evening.	• Well lit by low level lights (4-5m or 12-15 ft).	• The environment fosters a secure image: (Any **three** of the conditions.) (a) various users are observed --vendors, pedestrians, etc.; (b) stores line the walkways; (c) buildings along the walkways generate high levels of activity and turnover throughout the day till late in the evening; (d) buildings are oriented toward the street/ walk.	• Police patrols are frequent by foot or on bicycle. • There are also security devices on each section of the walk.
C	• Moderate to high activity levels during the day. • Sporadic and low during the evenings.	• Moderately lit by lights ranging from 5-7 m (15-20 ft) in height.	• The environment portrays a secure image only during the day: (Any **two** of the conditions.) (a) many users are observed on the walkways during the day; (b) stores close by late afternoon. (c) buildings along the walkways generate moderate levels of activity and turnover throughout the day till late in the afternoon. (d) buildings are oriented towards the street.	• Police patrols regularly in vehicles. • There are no security devices along the sidewalks.
D	• Low to moderate activity levels during the day. • Very low activity levels during the evenings.	• Inadequately lit by high level street lights.	• The environment portrays a negative image throughout the day and evening: (Any **two or more** of the conditions.) (a) few users are observed on the walkways; (b) stores are absent; (c) stores are heavily secured with minimum interaction with their customers; (d) buildings along the walks generate low levels of activity. (e) buildings have no interface with the walkways.	• Police patrols are infrequent and rare. • There are no security devices along the sidewalks.
F	Unfavorable activities observed (drug dealing etc.) especially during the evenings.	Street lights are missing, or broken.	• The environment reflects an unsafe image all the time: (Any **three** of the conditions.) (a) few users are observed on the walkways; (b) stores are absent; (c) stores are heavily secured with minimum interaction with their customers; (d) buildings have very little interface with the walkways; (e) buildings are boarded up; (f) graffiti, and vandalism are rampant.	• Police patrols are infrequent and rare. • There are no security devices along the sidewalks.

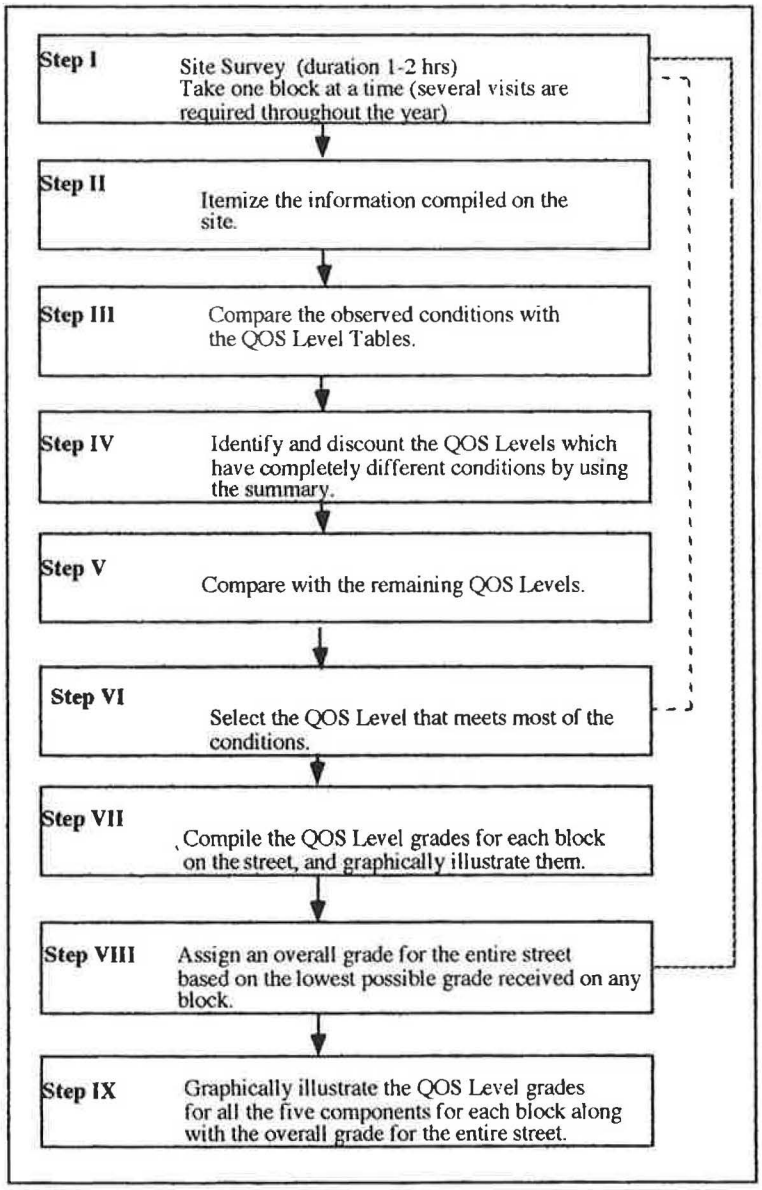

FIGURE 4 Methodologic process for assigning QOS level grades.

The eighth step involves assigning an overall grade for the entire street. The entire street is assigned a grade on the basis of the lowest grade received on any section or block.

The entire process is repeated for all of the five components mentioned earlier and shown in Figure 5.

In the last step, the grades assigned for each of the five components for each block are shown along with the overall street grade, similar to the one shown for the hypothetical Chester Avenue in Figure 5.

ASSESSMENT OF METHOD

The proposed method evinces both positive and negative attributes, as discussed next.

The advantages of the method are as follows.

Provides In-Depth Analysis of Macro- and Microlevel Conditions on Walkways

The evaluation of safety at both macro- and microlevels would enable planners and designers to obtain a more comprehensive picture of the conditions on the walkways. The grade on macrolevel conditions will indicate the quality of channelization for each mode to ensure a general level of safety, particularly for the pedestrians. At the microlevel, each of the five independent components, such as perception of security, or level of maintenance for elimination of falls and injuries, will indicate the qualitative conditions of these components in ensuring a conflict-free, safe pedestrian environment. By studying these microlevel elements separately, we can identify those that are independently influencing (positively or negatively) the safety of the pedestrians.

Blocks / Elements	41st-42nd	42nd-43rd	43rd-44th	44th-45th			(n-1)-nth	Overall Grade for the Street
Barriers and Impediments on Walkways	C	C	D	C			B	D
Barriers and Impediments at Intersections	C	D	C	C			C	D
Elimination of falls and injuries	D	D	C	C			C	D
Design for Drivers' Behavior Modification	D	C	D	D			C	D
Perception of Security	C	D	C	D			D	D
Service Level Grade	D	D	F	D			D	Overall SL F

FIGURE 5 Graphic illustration of QOS level grades and overall grades for hypothetical Chester Avenue.

Enables Faster Decisions on Actions to be Taken

A graphic representation (Figure 5) of the inventory on the strengths and weaknesses of each block of walkway on a street enables professionals to:

1. Make swifter decision on the actions to be taken.
2. Identify the sections or blocks that require immediate attention. For example, on the basis of the information provided in Figure 5, the block between 43rd and 44th streets on hypothetical Chester Avenue requires immediate attention because, compared with other sections, it received the lowest grades (three QOS D grades, and SL F for the type of separation).

Enables Professionals to Prioritize Work on Entire System of Walkways in a City

The tabulation of the overall street grade helps in prioritizing work on those streets that have received the lowest grade. In Figure 6, the hypothetical streets that have been evaluated for the quality of channelization (service levels) and elimination of conflicts and barriers on the walkways have been placed in the appropriate square in the matrix on the basis of their grades.

On the basis of these grades, Chester followed by Baltimore will need immediate attention, both at macro- and microlevel conditions.

DRAWBACKS OF METHOD

The proposed method does have some weaknesses.

Method Requires Considerable Amount of Financial Commitment and Manpower Resources

The block-by-block survey for large sections of the city using the service levels and the five disparate QOS levels require: first, a large number of skilled personnel, and second, several visits to each site. The involvement of a large number of surveyors is also necessary to complete the evaluation within a relatively shorter period.

After survey, the grades from all of the sites must be compiled and then graphically shown.

Unfortunately, all of these processes depend heavily on the availability of skilled manpower, and sufficient finances are required to pay for labor and other expenses. One way of alleviating the financial and manpower dependence would be by evaluating smaller sections of the city that are traversed frequently by pedestrians and contain at least one major origin and destination point.

Method May Suffer From Some Level of Subjectivity

Although effort has been made to reduce the level of subjectivity, it is very difficult to completely eliminate it. Because it is a qualitative evaluation of the conditions present at each site, the grade assigned by each surveyor can be colored to a certain extent by his or her personal perception of the conditions.

The problem of subjectivity can be mitigated to a large extent by sending different surveyors to the same site to gather the necessary information. This would not require additional work or manpower, because the evaluation of the five QOS levels (which are most prone to subjectivity) do require several site visits.

CONCLUSION

The proposed method attempts to evaluate safety on the walkways from different dimensions. First, different components of safety, such as conflict-free environments on the walkways and intersections, elimination of falls and injuries, and security, have all been included in the evaluation method to obtain a holistic view of the conditions of the walkways. Second, pedestrian mode has not been treated in isolation. The safety problems that result from interfaces

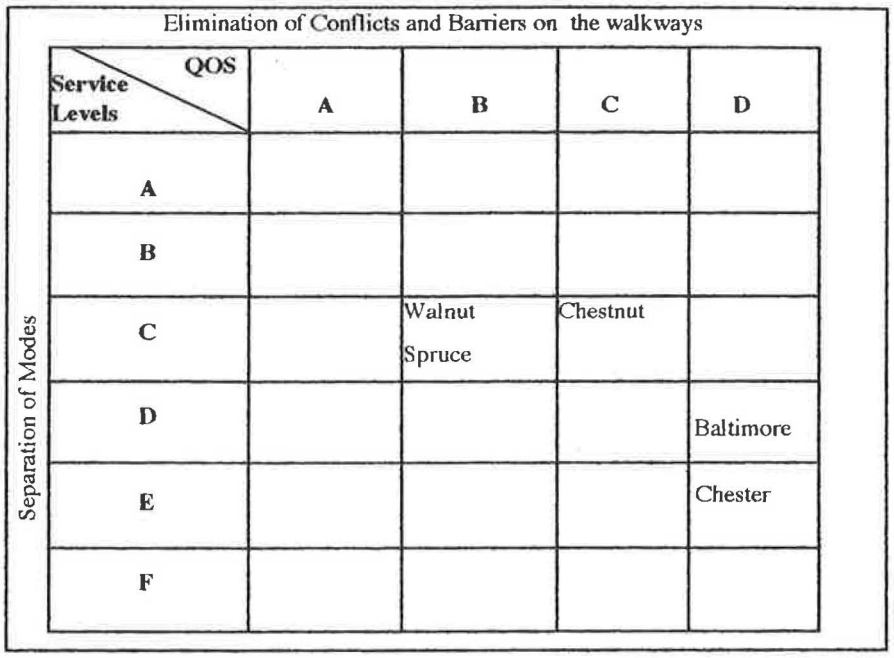

FIGURE 6 Qualitative evaluation of hypothetical streets using QOS and service levels.

with other modes along the walkways and at intersections are incorporated in the method.

In addition, the methodologic process discussed in this paper will enable the user of the method to derive the grades for service levels and QOS levels systematically, and then show the assessment for the street (on a block-by-block basis) and the entire network of streets in a city, through clear and useful graphic illustrations.

The method does evince some amount of subjectivity, as it is basically a qualitative evaluation. But it offers an alternative way of studying and evaluating walkways to enable traffic planners and engineers to plan and design a better and safe network of walkways for all types of users.

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