Safe Stopping Distance at Two-Way Stop Intersections
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Abstract

According to the Uniform Vehicle Code via Figure 3B-21 of the MUTCD, a 20ft No-Parking zone, as measured from the end parking space to the crosswalk, is required. Is this number appropriate in all circumstances? In situations where two-way stops and narrow streets exist, effective sight distance can be obscured by vehicles parked on the street. Therefore, it can difficult for vehicles, bicycles, and pedestrians stopped behind intersection thresholds with non-yielding cross-traffic to determine when the intersection can safely be cleared. A case study was made at the intersection of 5th Avenue and Pennsylvania Street in the City and County of Denver, CO. This is a two-way stop controlled intersection of two narrow, local streets with on-street parking. Using geometric lines of sight and intersection clearance time calculations outlined in the Highway Capacity Manual and AASHTO Green Book, sight triangles were created in order to determine (1) at what point cross-traffic becomes visible to the user behind the stop bar, (2) the available clearance time, and (3) whether 25mph is an acceptably safe speed for cross-traffic. Recommendations were made regarding safe speed and expansion of the No-Parking zones in order to enhance stopping sight distances. Greater elaboration of the role of on-street parking on sight triangles in the Green Book was desired.

Data on intersection width and no-parking zones was gathered principally through photo interpretation, with supplemental field measurements. Intersection type and speed limits were determined though data provided by the City and County of Denver GIS department. The HCM and AASHTO Green Book was used to determine auto and pedestrian clearance time, while bicycle clearance time was determined empirically.

Introduction

Two-way stop controlled intersections with unmarked crosswalks are commonly encountered in residential neighborhoods. At a two-way stop controlled intersection, traffic on the “minor” street is required to stop behind the crosswalk and yield to traffic on the cross (“major”) street before proceeding. Yet when on-street parking is present on narrow streets, users’ ability to recognize conflicting traffic can be impaired. The
HCM and Green Book make little mention of local street design, devoting the majority of their attention to roadways of higher volume and capacity.

It is entirely possible, however, that the design of local streets can play an important role in the safety of the overall transportation network. In a study of 24 California cities between 30,000 and 150,000 in population, Marshall and Garrick found that older cities and those with higher nodal intersection density to be significantly safer than those which incorporated later with a more curvilinear and hierarchical form (Street Network Types and Road Safety: A Study of 24 California Cities, 2010). In comparing intersection density, cities in the safer group experienced 40.6% fewer serious crashes with average intersection density of 106 per square mile, versus 63 per square mile for the less safe group. Cities in the safer group also had a significantly earlier date of incorporation (1895 vs. 1932) and experienced 73.2% fewer non-highway fatalities.

**Study Area Characteristics**

The central core of the Denver, Colorado (incorporated in 1861) is comprised of a number of residential neighborhoods which developed prior to the widespread adoption of automobile usage. The prevailing form of intermediate distance passenger transport prior to the auto era via the streetcar, with the “last mile” leg of the trip accomplished on foot. Therefore, residential neighborhoods developed during the era of the streetcar tended to have high nodal connectivity, sidewalks, and narrow streets. Today, many streets of the Capitol Hill/Alamo Placita neighborhood of the City and County of Denver have retained these original characteristics. Most streets with a local classification are 30-40 feet wide and allow for on-street parking on both sides of the street and unmarked crosswalks.
Sidewalks for these streets are detached. The unmarked speed limit for local streets in the City and County of Denver is 25 miles per hour (City and County of Denver GIS).

Most street centerlines are spaced 325 feet in the east-west direction and 600 feet in the north-south direction. The study area has 154 intersections per square mile. In part due to this tight intersection spacing, many of the intersections within this neighborhood are controlled by two-way stop intersections.

The question: Is 25 miles per hour an appropriate speed for the approaches to these two-way stop controlled intersections for passenger cars, bicycles, and pedestrians? Furthermore, do the Highway Capacity Manual (HCM), AASHTO “Green Book”, and Manual on Uniform Traffic Control Devices (MUTCD) adequately address this issue? Could safety be improved by increasing no-parking buffers on the major street approaches to the intersection?
Warrants

Section 2B.06 of the (MUTCD) warrants the following conditions for the placement of two-way stop controlled intersections:

The use of STOP signs on the minor-street approaches should be considered if engineering judgment indicates that a stop is always required because of one or more of the following conditions:

A. The vehicular traffic volumes on the through street or highway exceed 6,000 vehicles per day;

B. A restricted view exists that requires road users to stop in order to **adequately observe conflicting traffic** (emphasis added) on the through street or highway; and/or

C. Crash records indicate that three or more crashes that are susceptible to correction by the installation of a STOP sign have been reported within a 12-month period, or that five or more such crashes have been reported within a 2-year period. Such crashes include right-angle collisions involving road users on the minor-street approach failing to yield the right-of-way to traffic on the through street or highway. (US Federal Highway Administration, 2009)

The MUTCD goes on to state via UVC\(^1\) Sections 1-
118 and 11-1003 that a 20 foot buffer needs to be employed between the threshold of an unmarked crosswalk on the first and last on-street parking spaces, presumably in order to improve the ability to observe conflicting traffic.

**Sight Triangles**

The AASHTO Green Book defines a sight triangle as “Specified areas along intersection approach legs and across their included corners [that] should be clear of obstructions that might block the driver’s view of potentially conflicting vehicles (p.652)”. According to AASHTO, the dimensions of sight triangles are determined by observed driver behavior and documented by space time profiles and speed choices of drivers on intersection approaches. The Green Book differentiates between approach sight triangles (used in determining whether some form of intersection control is warranted) and departure sight triangles. Departure sight triangles are defined as a “sight triangle [that] provides sight distance sufficient for a stopped driver on a minor-road approach to depart from the

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**Figure 4: Sight Triangles (Harwood et al)**

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on Uniform Traffic Control Devices for Streets and Highways, and other standards issued or endorsed by the Federal Highway Administrator.”

“(b) The Manual adopted pursuant to subsection (a) shall have the force and effect of law.”

All States have officially adopted the National MUTCD either in its entirety, with supplemental provisions, or as a separate published document.”

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intersection and enter or cross the major road. The Green Book states that “departure sight triangles should be provided in each quadrant of each intersection approach controlled by a stop or yield sign (p. 653).”

Harwood et al, using video detection, recommended 7.5s of travel time at the design speed of the major road (Design policies for sight distance at stop-controlled intersections based on gap acceptance, 1999). Left turns were determined to require the greatest gap acceptance time.

AASHTO recommends this sight triangles be calculated considering both the horizontal and vertical dimension of the obstruction, and at a drivers’ eye height and object seen height of 3.5 ft. above the roadway surface. The object height is based on a vehicle height of 4.35, representing the 15\(^{th}\) percentile height of passenger cars as they existed in 2004.

The Green Book outline recommended sight triangles based on intersection control type. For two-way stop controlled intersections, Case B applies, with three subcases representing the three possible movements of the user on the minor approach. These distances may be adjusted for grade using Exhibit 9-53 of the Green Book, though for grades between -3.0% and +3.0% the grade remains static.

What is clear from Figure 4 is that if the distance of an actual site triangle’s major street leg (in this case \(d_1\) and \(d_2\)) is less than the minimum distance required for the driver on the major to recognize an obstacle and come to a complete stop, collisions are more likely to occur.

The Denver Streetscape Design Manual is very prescriptive on the role of vegetation on sightlines (including a 20 foot minimum corner triangle clear zone outlined by AASHTO); however, its realm is limited to obstructions lying within the curb line. On-street parking is not referenced (City and County of Denver, 1993)
Departure Sight Triangles

The Green Book expands on the concept of sight triangles by differentiating between approach sight triangles (used in the analysis of uncontrolled intersections) with departure sight triangles, which accurately describe the situation in our case study of a stopped vehicle determining the suitable of entering an intersection. Chapter Nine - Intersections outlines the following procedures for determining departure sight triangles in its Cases B1-3:
Departure sight triangles for traffic approaching from either the left or the right like those shown in Exhibit 9-50B should be provided for left turns from the minor road onto the major road for all stop-controlled approaches.

The vertex (decision point) of the departure sight triangle on the minor road should be 4.4m [14.5 ft] from the edge of the major-road traveled way. This represents the typical position from the minor-road driver's eye when a vehicle is stopped relatively close to the major road. Field observations of vehicle stopping positions found that, where necessary, drivers will stop with the front of their vehicle 2.0 m [6.5 ft] or less from the edge of the major-road traveled way. Measurements of passenger cars indicate that the distance from the front of the vehicle to the driver’s eye for the current passenger car population is nearly always 2.4 m [8 ft] or less. Where practical, it is desirable to increase the distance from the edge of the major-road traveled way to the vertex of the clear sight triangle from 4.4 m to 5.4 m [14.5 to 18 ft]. This increase allows 3.0 m [10 ft] from the edge of the major-road traveled way to the front of the stopped vehicle, providing a larger (emphasis added) sight triangle. The length of the sight triangle along the major road (distance a in Exhibit 9-50B) is the sum of the distance from the major road plus ½ lane width for vehicles approaching from the left, or 1-½ lane width for vehicles approaching from the right (p657-660).

![Figure 6: Exhibit 9-50B (AASHTO Green Book)](image)

Three points are notable: first, the Green Book recommends the stopping point be further from the intersection, requiring a larger decision sight triangle. Second, left turns require the largest sight triangles (and therefore stopping distances). Figures 7 and 8 and Table 1
and 2 outline these differences for a two-lane highway, with no median, a grade within +/- 3 %, and (presumably) no on-street parking. Third, little mention is made of the unique challenges that on-street parking imposes on sight triangles.

Table 1: Exhibit 9-55 Design Intersection Sight Distance - Case B1 - Left Turn From a Stop - G=+/− 3%, Two-Lane Highway, No Median (Green Book)
Figure 7: Exhibit 9-56 Intersection Sight Distance - Case B1 - Left Turn from a Stop (Green Book)

Table 2: Exhibit 9-57 Design Intersection Sight Distance - Case B2 - Right Turn From a Stop and Case B3 - Crossing Maneuver G=+/- 3% Two-Lane Highway, No Median (Green Book)
Methods

In order to determine whether 25 miles per hour is an appropriate speed for the study area’s narrow local streets, a representative study intersection was chosen. Then, using GIS, decision sight distances were calculated for passenger cars, bicycles, and pedestrians on the minor approach and compared to the safe stopping distances and times for passenger cars on the major approach. In the interest of simplifying calculations, only crossing maneuvers on the minor approach were analyzed.

Study Site

The site chosen for analysis was the intersection of 5th Avenue and Pennsylvania Street in the City and County of Denver, Colorado. This intersection is characterized by the following qualities:

- Width of both streets is 30 ft
- The speed limits of both street is unsigned and therefore 25 mi/h
On-street parking exists on both sides of both streets
Pennsylvania is stop-controlled (minor street)
5th Ave is not stop-controlled (major street)
No-Parking zone distances from unmarked crosswalks vary

Figure 9 outlines the layout of this intersection:

Figure 9: Street Geometry: 5th Ave and Pennsylvania St

Notably, the stop sign placement and No-Parking clear zones comply with MUTCD standards of 20 ft minimum. No-Parking zones on the major street, however, are more variable, ranging from a low of 10 ft to a high of 20 ft. Parked automobiles on the major street represent a significant obstacle, which will be illustrated in the Results and Discussion. Because the sight lines of the southbound approach are the most restricted,
only sight triangles viewed from the southbound approach are used in the following calculations.

**Intersection Sight Distance**

On pages 650-651, the Green Book states,

Sight distance is provided at intersections to allow the drivers to perceive the presence of potentially conflicting vehicles. This should occur in sufficient time for motorists to stop or adjust their speed, as appropriate, to avoid colliding in the intersection. The methods needed for determining sight distance are the same for determining stopping sight distance, but incorporate modified assumptions. Based on observed driver behavior at intersections….Sight Distance is also provided at intersections to allow the drivers of stopped vehicles a sufficient view of the intersecting highway to decide when to enter the intersecting highway or when to cross it. If the available sight distance for an entering roadway is at least (emphasis added) equal to the stopping sight distance for the major road, the drivers have sufficient sight distance to anticipate and avoid collisions.

The Green Book determines “Intersection Sight Distance” using Formula 9-1. That is,

\[ ISD = 1.47 \times V_{\text{major}} \times t_g \]

Where ISD = Intersection Sight Distance (length of the leg from the sight triangle along the major road (ft))

\( V_{\text{major}} = \) design speed of road (mi/h)

\( t_g = \) time gap for minor road vehicle to enter major road

Time gaps for passenger cars are determined to be 7.5 s for a stopped vehicle making a left turn onto a two-lane highway with no median and a grade of three percent or less. Using these metrics on a 25 mi/h road we find that ISD = 275.6 ft.
Safe Stopping Distance

Meanwhile, Garber and Hoel use a slightly different method to calculate safe stopping distance. According to Equation 3.27 safe stopping distance (SSD) is determined as,

\[ d_s = 1.47\frac{S_i + S_i^2}{(30\times(0.348+/-0.01G))} \]

- where \( d_s \) = Safe Stopping Distance (ft)
- \( S_i \) = Initial speed of vehicle, mi/h
- \( G \) = Grade (%)
- \( t \) = reaction time of 2.5s

Using Garber and Hoel calculation method and assuming grade to be level, we find a typical driver would need 151 ft to safely stop from 25 mi/h.

Major Street Passenger Car Stopping Time

The time required for the driver of a passenger car to recognize an obstacle and brake to a stop is calculated according the following method.

- AASHTO Stopping Sight Distance based on average deceleration rate \( (a_d) \) of 11.2 ft/sec\(^2\) per NUTCD (Acceleration Characteristics of Starting Vehicles, 2000)
- \( t_{stop} = \frac{v_0}{a_d} \) (assuming \( G = 0 \))
- \( v_0 = 25 \text{ mi/h} = 36.7 \text{ ft/s} \)
- Example: \( t_{stop} = \frac{36.7 \text{ ft/s}}{11.2 \text{ ft/sec}^2} = 3.3 \text{ s} \)

When reaction time (assumed at 2.5 s) is accounted for, total stop time is

\[ t_{TotalStop} = t_{stop} + t_{reaction} = 3.3 \text{ s} + 2.5 \text{ s} = 5.8 \text{ s} \]
Passenger Car Clearance Time

In order to calculate passenger car clearance time of the minor street, we deviate from typical engineering manuals and instead use a calculus-derived distance equation. Assuming grade to be level and an accelerating vehicle reaction time of 0s, then

\[ d_c = v_0t + 0.5at^2 \]

- where \( d_c \) = clearance distance = crossing distance + length of passenger car (L), taken from the Green Book to be 19 ft.
- \( a \) = average acceleration = 4.72 ft/s\(^2\) from 0-25 mi/h derived from the Green Book (Acceleration Characteristics of Starting Vehicles, 2000)
- \( v_0 \) = 0 mi/h

Therefore, \( t_{\text{clearance}} = (d \text{ ft}/4.72 \text{ ft/s}^2)^{0.5} \)

For example, if \( d_c = 45 \text{ ft} \), then \( t_{\text{clearance}} = (45 \text{ ft}/4.72 \text{ ft/s}^2)^{0.5} = 3.1 \text{ s} \)

Note that when on-street parking is present, the crossing distance for all modes is reduced by 7 ft, the width of a passenger car design vehicle (local residential streets).

Bicycle Clearance Time

Little data was available to calculate bicycle acceleration rates. Therefore clearance time data was obtained empirically. Ten runs were performed in which a bicycle accelerated from a full stop at the stop-sign of the minor road of the study site (Pennsylvania St) and traveled past the point at which the rear wheel of the bicycle cleared the farthest travel lane on the major street (5th Ave). This distance was measured to be 49 ft. The 15\(^{\text{th}}\) percentile slowest run was then used as the representative bicycle clearance time, yielding 6.1 s.
<table>
<thead>
<tr>
<th>Run</th>
<th>Travel Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.3</td>
</tr>
<tr>
<td>2</td>
<td>4.7</td>
</tr>
<tr>
<td>3</td>
<td>5.0</td>
</tr>
<tr>
<td>4</td>
<td>5.1</td>
</tr>
<tr>
<td>5</td>
<td>5.6</td>
</tr>
<tr>
<td>6</td>
<td>5.6</td>
</tr>
<tr>
<td>7</td>
<td>6.0</td>
</tr>
<tr>
<td>8</td>
<td>6.1</td>
</tr>
<tr>
<td>9</td>
<td>6.1</td>
</tr>
<tr>
<td>10</td>
<td>6.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Median</th>
<th>15th Pctl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.6s</td>
<td>6.1s</td>
</tr>
</tbody>
</table>

Table 3: Empirical Bicycle Acceleration Data, Stop Line to Full Clearance (5th Ave and Pennslvaniam St)

**Pedestrian Clearance Time**

Pedestrian clearance times were calculated using the HCM formula for minimum pedestrian green time when sidewalk width is less than or equal to 10 ft:

\[ G_p = 3.2(0.27N_{ped}) + (L/S_p) \]

Where:

- \( G_p \) = minimum pedestrian crossing time (s)
- \( L \) = length of crosswalk (ft.)
- \( S_p \) = ave. walking speed of pedestrians (3.5 ft/s)
- \( N_{ped} \) = number of pedestrians per phase in a single crosswalk

For example, if

- \( L = 30 \text{ ft} \)
- \( N_{ped} = 1 \)

Then \( G_p = (3.2 \text{ s}) \times (0.27 \times 1) + (23 \text{ ft} / 3.5 \text{ ft/s}) = 7.4 \text{ s} \)
Results and Discussion

Based on the previously outlined methods, clearance and safe stopping times were obtained for the representative intersection of 5th Ave and Pennsylvania St.

Minor Street Passenger Car Clearance

Based on sight triangles created in GIS, it was calculated that a passenger car on the minor approach would need a maximum of 3.7s and travel a maximum of 63 ft to clear this intersection. Meanwhile the decision sight distance (based on the HCM procedure of placing the driver’s eyes 8 ft behind the edge of the unmarked crosswalk) for the major street cross flow is 58 ft from the driver’s right side and 79 ft from the driver’s left side. Both 58 ft and 79 ft can be traveled in less time than the 2.5 s major street driver reaction time assuming a constant 25 mi/h (36.7 ft/s). The safe stopping distance at 25 mi/h is 151 ft and 5.8 seconds. Therefore, both of the actual sight triangles for the southbound approach imply that this intersection is unsafe given the existing speed limits and parking arrangement.

Figure 10: Passenger Car Clearance Distances and Times (5th Ave and Pennsylvania St)
Minor Street Bicycle Clearance
Based on sight triangles created in GIS, it was calculated that a bicycle on the minor approach would need a maximum of 6.1 s and travel a maximum of 49 ft to clear this intersection. It was assumed that the cyclist’s are 2 ft from the edge of the unmarked crosswalk. Meanwhile the decision sight distance for the major street cross flow is 61 ft from the cyclist’s right and left sides. 61 ft can be traveled in less time than the 2.5 s major street driver reaction time assuming a constant 25 mi/h. The safe stopping distance at 25 mi/h is 151 ft and 5.8 seconds. Therefore, both of the actual sight triangles for the southbound approach imply that this intersection is unsafe given the existing speed limits and parking arrangement.

![Figure 11: Bicycle Clearance Distances and Times (5th Ave and Pennsylvania St)](image)

Minor Street Pedestrian Clearance
Unlike the passenger car and bicycle examples, a pedestrian crosses from a different location. This leads to a shorter crossing distance, somewhat offsetting the relatively slower traveling speed. Based on sight triangles created in GIS, it was calculated that a pedestrian on the minor approach would need a approximately 7.4 s and travel a maximum of 23 ft to clear this intersection. It was assumed the pedestrian commits to
the crossing at the southern edge of the western sidewalk. The decision sight distance for the major street cross flow is 62 ft from the cyclist’s right side and more than 180 ft from the pedestrian’s left side. 62 ft can be traveled in less time than the 2.5 s major street driver reaction time assuming a constant 25 mi/h. The safe stopping distance at 25 mi/h is 151 ft and 5.8 seconds. Therefore, the right (western) sight triangle for the southbound approach implies that this intersection is unsafe given the existing speed limits and parking arrangement. Since the decision sight distance for the left (eastern) approach exceeds 151 ft, safe stopping distance is achieved.

![Decision Sight Distances Diagram](image)

**Figure 12: Pedestrian Clearance Distances and Times (5th Ave and Pennsylvania St)**

**Issues with Assumptions**

If in fact this intersection is “unsafe” based on the analysis of the sight triangles, why then are there not accidents at locations such as this on a daily basis? The following phenomena could be contributing to accident avoidance:

1. Narrow lanes are demonstrated to reduce speeds. Mitigation Strategies for Design Exceptions published the following table on this relationship (US Federal
Highway Administration, 2007). While the data below pertains to freeway lanes and therefore speeds), it is reasonable to believe that some of this effect remains at the lower speeds encountered on local streets.

<table>
<thead>
<tr>
<th>Lane width (ft)</th>
<th>Reduction in Free-Flow Speed (mi/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>0.0</td>
</tr>
<tr>
<td>11</td>
<td>1.9</td>
</tr>
<tr>
<td>10</td>
<td>6.6</td>
</tr>
</tbody>
</table>

Table 4: Operational Effects of Freeway Lanes Widths

2. On-street parking reduces by increasing “friction”. In a study of 250 Connecticut roadways, free-flow speeds on streets with on-street parking were found to be 2.3 mi/h less than those without on-street parking. Speed reduction were compounded when other street design factors, such as shorter building setbacks and road vs. street typology were considered (Reassessing On-Street Parking, 2008).

3. Road users, cognizant of the limited sight distances, exercise greater caution on intersection approaches.

4. Based on points 1, 2, and 3, free-flow speeds are likely lower than the speed limit of 25 mi/h.

5. Road users may not be strictly adhering to traffic laws; that is, users may not come to complete stops at the stop lines, but rather crawl through the intersection via rolling stops in order to gain better sight lines before committing to full passage (as referenced on p.657 of the Green Book).

Reccomendations

In order to enhance the safety of intersections with geometry such as that which has been examined, sight triangle should be improved so that safe stopping distances can be achieved. This objective can be achieved through increasing the major street’s No-Parking zone buffer from the intersection, reducing speeds, or some combination thereof.
If increasing the No-Parking buffer, the following distances were calculated iteratively by manipulating sight triangles within GIS. It is important to note that numbers vary substantially based on the chosen design vehicle.

<table>
<thead>
<tr>
<th>Design Vehicle</th>
<th>Cross Flow Approach</th>
<th>Distance from Crosswalk (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger Car</td>
<td>Left</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>50</td>
</tr>
<tr>
<td>Bicycle</td>
<td>Left</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>46</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>Left</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>48</td>
</tr>
</tbody>
</table>

Table 5: Recommended No-Parking Zone on Major Street for SSD @ 25 mi/h

If, conversely, neighborhood upheaval precludes any reduction in on-street parking capacity, the following table illustrates the speeds needed to achieve safe stopping distances.

<table>
<thead>
<tr>
<th>Design Vehicle</th>
<th>Cross Flow Approach</th>
<th>Decision Sight Dist (ft)</th>
<th>Speed (mi/h)</th>
<th>SSD (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger Car</td>
<td>Left</td>
<td>70</td>
<td>10</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>50</td>
<td>10</td>
<td>46</td>
</tr>
<tr>
<td>Bicycle</td>
<td>Left</td>
<td>67</td>
<td>10</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>46</td>
<td>10</td>
<td>46</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>Left</td>
<td>20</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>48</td>
<td>10</td>
<td>46</td>
</tr>
</tbody>
</table>

Table 6: Recommended Speeds without Parking Changes
Conclusion

While older street networks demonstrate better overall safety characteristics, the geometric characteristics of narrow, local streets with on-street parking still represent safety challenges. In a case study of the intersection of 5th Ave and Pennsylvania St, existing sight triangles were shown to provide inadequate safe stopping distances for passenger cars, cyclists, and pedestrians. Increases in the distances of No-Parking zones from intersections and reductions in speed limits to 10 mi/h were recommended in order to provide adequate stopping distances. Furthermore, it may be advisable to update the MUTCD in order to reflect the importance of No-Parking zones on major street intersection approaches in addition to the existing minor approaches. The Green Book and MUTCD in particular would benefit from a lengthier discussion of the impacts of on-street parking on signage and street geometry.
Bibliography


