Title
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Publication Date
2006-09-01

Year 2006 *Paper WP*-2006-11

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Abstract

This study and report is about street trees and intersection safety in urban contexts. The study derives from a rather simple, straightforward observation: that on the best tree-lined streets the trees come close to the corners. They do not stop at some distance back from the intersecting street right-of-way. Indeed, in Paris, a city noted for its street trees, if the regular spacing of trees along the street runs short at an intersection, there is likely to be an extra tree placed at the corner. For at least 250 years, the finest of streets the world over have been associated with trees. Elm or oak shaded residential and commercial main streets remain as memories, but seldom as realities, of the best American urbanism. In the automobile age, a real concern with safety has resulted in street tree standards in the United States that dictate long setbacks from intersections, ostensibly geared to achieving unobstructed sight lines for drivers. But are street trees the safety problem they are purported to be? And are other physical, controllable qualities more important for preserving sight lines at intersections?

Working Paper 2006-11

Street Trees and Intersection Safety

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with
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This paper was produced with support provided by the US Department of Transportation and the California State Department of Transportation (Caltrans) through the University of California Transportation Center.

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Acknowledgments

Many people have helped with this research project and the writing of this report. First and foremost are the three exceptional Berkeley students who worked on various parts of the project over the last two years. Alethea Harper did truly amazing work. She created the digital models, simulations, and video renderings with great diligence and care, creatively solving and overcoming the many problems and challenges that came along the way, and cheerfully adjusting directions when necessary as the research evolved. The research could not have been done without her. Jeff Williams also did remarkable work. With dogged determination in spite of encountering many obstacles, he gathered the city standards related to street trees, parked cars, and newspaper racks, and analyzed them with care. He also took a first pass at analyzing how AASHTO recommendations might apply to urban contexts. Jason Hayter joined the research team toward the end of the project, stepping in to assist with conducting the experiments performed with the drive-through simulations. I am grateful for his able assistance. For this final report, each student prepared draft outlines describing their areas of responsibility.

In addition, Dov Jelen provided technical assistance with the digital models, simulations, and renderings—including allowing us to use his “high-end” computer to perform the video renderings when our machines proved overwhelmed by the task.

The staff of UC Berkeley’s XLab, the Social Science Research Laboratory, were enormously helpful, providing support and facilities for conducting the experiments with the drive-through simulations. Thanks go to Brenda Naputi for her able administrative assistance and to Bob Barde for his enthusiastic support of the project. Special thanks go to Lawrence Sweet. The experiments could not have been accomplished with anywhere near the elegance and efficiency that was achieved without his creative thinking and technical expertise.

This research project was funded through a competitively awarded UCTC faculty grant. Thanks go to the several anonymous reviewers who gave the grant proposal high marks and urged its funding, and to Elizabeth Deakin, Director of UCTC, for her encouragement of this project. The recruiting of human subjects was made possible by a generous grant from UC Berkeley’s XLab.

Thanks are due to the staff at IURD, particularly Carey Pelton and Mary Altez for their administrative support. Without their kind and generous help, administering a project like this and producing this report, would not have been possible.

On a more personal note, special thanks go to my partner, Allan Jacobs, with whom I have worked on many challenging street design projects and who has shown by example how to do research that is useful to professionals. Thanks go as well to my urban design colleagues at the College of Environmental Design, with whom I enjoy a shared enquiry into the possibilities of urban form and the quality of everyday life—most particularly Richard Bender, Peter Bosselmann, Donlyn Lyndon, Louise Mozingo, Michael Southworth, Judith Stilgenbauer, and Clark Wilson. Further thanks go to the many professional colleagues with whom I've discussed the intersection sight triangle issue, particularly Rick Hall and Billy Hattaway. Finally, thanks go to the many smart students I've worked with over the years who constantly inspire me.

Street Trees and Intersection Safety

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CHAPTER 1

INTRODUCTION, METHODS, AND OBJECTIVES

This study and report is about street trees and intersection safety in urban contexts. The study derives from a rather simple, straightforward observation: that on the best tree-lined streets the trees come close to the corners. They do not stop at some distance back from the intersecting street right-of-way. Indeed, in Paris, a city noted for its street trees, if the regular spacing of trees along the street runs short at an intersection, there is likely to be an extra tree placed at the corner. For at least 250 years, the finest of streets the world over have been associated with trees. Elm or oak shaded residential and commercial main streets remain as memories, but seldom as realities, of the best American urbanism. In the automobile age, a real concern with safety has resulted in street tree standards in the United States that dictate long setbacks from intersections, ostensibly geared to achieving unobstructed sight lines for drivers. But are street trees the safety problem they are purported to be? And are other physical, controllable qualities more important for preserving sight lines at intersections?

Engineering geometric design policy manuals, such as those of the American Association of State Highway and Transportation Officials (AASHTO), recommend designing street intersections with clear sight triangles in order to improve a driver's ability to see potential conflicts with other vehicles before entering an intersection. These triangles extend hundreds of feet beyond the intersection. Within the clear sight triangles, the recommended design solution is to eliminate any object above sidewalk level that would intrude into the sight triangle and interfere with a driver's vision, *where practical.* (AASHTO 2004).

Traffic and highway engineering textbook examples describing the clear sight triangle concept generally show diagrammatic plan views of intersections with sidewalk trees indicated as the objects to be eliminated from the sight triangle. In the diagrams, trees are represented as solid circles, which implies they are solid cylinders going all the way to the ground (Garber & Hoel 1997). This representation is of course unrealistic because street trees are typically trimmed to be high branching. Although the intent of the clear sight triangle idea is to eliminate physical elements from a driver’s cone of vision, which operates in a three-dimensional world, the triangle is conceptualized in two-dimensional terms rather than three-dimensional terms. In reality, the part of a street tree that would intrude on a driver’s central cone of vision is the trunk, a relatively thin vertical element.

In practice, the engineering policy recommendations regarding intersection clear site triangles, and the embedded assumptions that street trees are the things that must be eliminated from them, has resulted in many cities adopting street design standards that include large set-back restrictions on sidewalk trees at intersections that often apply regardless of how a given intersection is controlled, while similar hold back regulations are not put in place for other things that commonly occur on sidewalks near intersections, such as newspaper racks, traffic signal poles, streetlights or parking meters. Furthermore, urban street design ordinances generally do not require holding on-street parking spaces back a large distance from an intersection, so in practice parking spaces often come right up to the stop limit line or backside of the crosswalk.

In sum, engineering policy recommendations regarding clear sight triangles have resulted in vigorous limitations on street trees near intersections but little regulation of other possible obstructing elements. This reality is of concern for two reasons. First, restricting street trees may not be solving the intersection visibility problem. Parked cars and SUVs near intersections, and possibly horizontally arranged blocks of newspaper racks, present more of an obstruction to driver’s sight lines than do street trees.

Second, restrictions on street trees at intersections mean that cities are creating streets that do not function as well as they might for pedestrians. Research coming from the social science and environmental design disciplines suggests that sidewalk street trees play a major role in creating well-defined, comfortable, safe feeling, and inviting pedestrian realms on streets, and so should not be restricted without careful consideration. Closely planted trees at the sidewalk edge create a transparent fence that helps protects pedestrians, psychologically and physically, from moving vehicle traffic on the adjacent roadway (Jacobs et al. 2002). Closely planted deciduous street trees also play a major role in contributing to the year round physical comfort of pedestrians. They provide shade on hot, sunny days, and some protection from rain. A recent body of public health research is finding associations between environmental form and levels of physical activity. The research suggests there is a relationship between environmental quality and people’s willingness to walk; they are more likely to walk where they feel comfortable and where the environment is pedestrian-friendly (Giles-Corti

& Donovan 2003; Frank & Engelke 2001; Humpel et al. 2002). Creating environments that are pedestrian-friendly and encourage walking is not unimportant, witness, if nothing else, the current obesity epidemic in the United States. In addition, environmental assessment research points to the psychological health benefits of nature in cities. Visual contact with even relatively small elements of nature, particularly trees, can lead to restoration from directed attention fatigue, thereby helping people regain their ability to be productive (Kaplan & Kaplan 1989, 2003). Streets make up the bulk of the public space in cities, and are distributed more evenly throughout the urban environment than are public parks. They offer the biggest opportunity for the public provision of trees within cities. Furthermore, research suggests that street trees can play an important role in helping to make urban environments legible for the people who live and work in them, at both the citywide and neighborhood level. Closely planted trees on urban streets can contribute to pathway imageability, which can help people make sense of urban spatial environments, help them create clear cognitive maps, and help them navigate from one place to another (Lynch 1960; Golledge 1992).

Given the pedestrian comfort and environmental legibility roles that sidewalk street trees play, how problematic is it to hold them back large distances from intersections? Very much so, empirical observations and research suggest. Intersection sidewalks are places where pedestrians tend to gather. Intersections are route choice points, where people often stop to ponder which direction to go, common meeting locations, because they are easily described and imaged, and favored locations for people to stop and talk with each other before going their separate ways (Whyte 1980). They are also places where traffic controls often oblige pedestrians to stop and wait. This suggests sidewalks near intersections should be designed with pedestrian comfort in mind, all the more so because intersections are the most potentially dangerous and uncomfortable places for pedestrians because it is where they come into closest contact with moving vehicles. In the book *Great Streets*, it was found over and over again that a common characteristic of the best streets is that street trees come all the way to the intersection; they do not set back (Jacobs 1993). In terms of legibility, holding street trees back a significant distance from intersections creates large gaps in the tree line, leading to weakened path imageability (Lynch 1960). Indeed, given setback standards for trees of 50 feet or more from intersections and given short blocks, the result can be so few trees along a street as to be meaningless in terms of any positive impact. On a typical Portland, Oregon, 200-foot wide block, for example, such a setback standard combined with a not uncommon 50-foot spacing standard would result in just three trees per block.

How important is it for traffic engineers to take these matters into account in their recommendations for geometric street design? The field of transportation planning has in recent years begun to adopt a more holistic and complex view of streets than was held in the past. Emphasis is shifting toward equity concerns, providing streets that work for all transportation modes, most especially pedestrians. As a case in point, for the last several years the Bay Area Metropolitan Transportation Commission has had in place a street redesign program that has been directed at achieving pedestrian comfort as well as safety. Achieving the first objective often proves difficult because of a conflict between those qualities that make the best pedestrian environments and local standards and norms that dictate against street trees or require such large spacing that the trees have little or no impacts.

A premise of this research study is that if communities are interested in creating streets that work for pedestrians as well as cars, they should not restrict sidewalk street trees unless it can be shown unequivocally that they create unsafe environments. If engineering policy guidance is going to continue recommending that trees be held back substantial distances from intersections, with no allowances made for the type of tree or how it is trimmed, then we need to be sure that all trees really cause significant visibility problems. Perhaps a middle ground is possible, where sidewalk trees could be allowed within the clear sight triangle as long as they meet the performance criteria of being relatively slender and high branching. If street trees contribute to pedestrian comfort and overall street memorability then there is no need to give them up or not plant them near intersections if their presence can be shown to not hinder safety.

Recent advances in three-dimensional spatial modeling, improved techniques for simulating movement through virtual spaces, and the availability of new digital tools that can perform complex spatial analysis, make it possible to explore the impact of intersection street trees on driver's visibility in a more precise manner than was possible in the past. This research study makes use of these new modeling techniques to address the following research questions: 1) Does the presence of high-branching sidewalk trees near intersections significantly impact a driver's ability to see approaching cars? 2) Does the presence of parked cars or banks of newspaper racks at intersections significantly impact a driver's ability to see approaching cars?

Study Objectives and Methods

This research study had three main objectives, each of which are associated with particular methods of investigation and analysis. In brief, the objectives and methods are as follows:

Objective 1: *To understand what AASHTO's recommendations for clear sight triangles are for a typical urban intersection.*

Prior experience and conversations with professional colleagues suggests that AASHTO guidelines regarding clear sight triangles pre-suppose suburban built form conditions (large building setbacks; no on-street parking or sidewalks along major streets) rather than urban conditions (little or no building setbacks; both on-street parking and sidewalks) and therefore present ambiguities regarding how to apply them in urban situations. The first objective of the research was to understand how the AASHTO guidelines would apply to typical urban situations, and to identify any ambiguities and/or conflicts that arise. The approach used was a step-by-step review of current AASHTO guidelines, followed by examples that illustrate their application to a typical urban intersection configuration.

Objective 2: *To investigate how various planning jurisdictions within California have interpreted AASHTO advice on clear sight triangles at intersections, in terms of the formal standards put in place to restrict street trees or other objects near intersections, and whether the standards are absolute or allow discretionary leeway.*

All cities have standards, whether written or unwritten, for the placement of street trees, on-street parking, and street furniture. Many of these standards have been shaped by traffic engineers, who seek to prevent collisions by maintaining a clear line of sight for drivers. Other standards exist because of concerns about maintenance, aesthetics, and functionality. As urban designers know from experience, these standards are not always written down and can be difficult to obtain. Also, cities are sometimes willing to violate their own standards for a particular streetscape project, though the conditions for doing so are not always well-defined.

The goal here was to compare the standards used by different cities in California, examine the similarities and differences between the standards, and learn how cities choose the standards they use. Note that the intent was *not* to document actual street designs in each city. In all cities, and especially in older cities, many streets have configurations that would not be allowed by current standards. Trees may be planted very close together, for example, and parking may be allowed up to the corner rather than held back by a red zone. The intent here was to determine what each city would require for a newly-created street or a redesign of an existing street.

Because it would be impractical to collect standards from every city in California, a sub-group of cities to investigate had to be determined. The decision was made to gather data on thirty cities falling into the following three groups:

- **Cities in the San Francisco Bay Area.** To make this research particularly relevant to professionals in the San Francisco Bay Area (where this research effort is being conducted), ten local cities were for picked for study. They were selected either because their recent planning efforts have been widely publicized or because they were close at hand and this would mean, it was hoped, an easier time with gathering needed material. The Bay Area cities looked at were Berkeley, Concord, Fremont, Napa, Oakland, Pleasanton, San Francisco, San Jose, Santa Rosa, and Walnut Creek.

- **Cities with the largest populations.** To determine how large and well-established cities have applied sight distance standards, the 10 cities with the highest population (excluding those already part of the previous Bay Area group) were selected for study (California Department of Finance 2005).[1] Because these cities are well established, it was felt they would be the most likely to have developed relevant standards. The cities looked at in this category were Anaheim, Bakersfield, Fresno, Long Beach, Los Angeles, Riverside, Sacramento, San Diego, Santa Ana, and Stockton.

- **Cities with the largest increases in estimated population between 2000 and 2004.** To determine how rapidly growing cities have applied sight distance standards, the 10 cities that have grown most recently since the turn-of-the-last century were selected for study (California Department of Finance 2005).[2] Because population growth and subdivision development often go hand-in-hand, it was felt that these fast-growing cities would be more likely to have clear standards for new development. Cities whose 2004 populations were

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[1] Population estimates from the California Department of Finance's Demographic Research Unit were used to identify these cities.

[2] Ibid.

> estimated at fewer than 5,000 people were excluded. Cities studied were Beaumont, Brentwood, California City, La Quinta, Lincoln, Murrieta, Rio Vista, Rocklin, Twentynine Palms, and Yuba City.

The researchers learned early on that it was impossible to gather standards for every piece of street furniture that might obstruct a driver's line of sight. There are simply too many kinds of poles, posts, and boxes to investigate, and city staff members contacted were overwhelmed by the scope of the requests. As a result, it was decided to concentrate on newspaper racks because they are likely to block a driver's line of sight due to their horizontality.

Whenever possible, a city's written, published standards were collected, on the assumption that these were the most official sources of information. In many cases, arborists, engineers, and code enforcement officers told the researchers that a particular standard was not available in writing—it existed only as a rule of thumb, an informal agreement between departments, or a series of professional judgments made on an individual basis. In these cases, there was little choice but to take the city staff at their word, knowing that others in the department might have described the standard differently.

As well as gathering data directly related to street trees, and on-street furniture, additional data on typical street configurations unrelated to line of sight concerns were collected in order to be able to make the digital models of intersections as realistic as possible.

Objective 3: *To use computer modeling, drive-through simulations, and graphic analysis techniques to analyze the amount of visual obstruction at intersections caused by street trees and other objects, and to test what drivers see.*

This objective was met by first creating digital models of a typical urban intersection in which the basic configuration was kept constant but locations of sidewalk trees, parked cars, and newspaper racks varied. The variations of these elements reflect AASHTO recommendations, the actual standards in place in one California city (Oakland) and a pedestrian-friendly option. The models were then animated with moving cars and drive-through simulations, from a driver's viewpoint, were created. These simulations were turned into videos, which were shown to "human subjects" in controlled laboratory experiments. People were asked to identify when they were able to first see particular test cars, and to fill out a short questionnaire. The results of the experiments were compiled and analyzed to determine the perceived visibility impacts of the various model configurations.

In an attempt to obtain an objective measure of the visibility impacts of each model, single-frame snap-shots were taken of the same key frames in each drive-through simulation. From these, areas of “roadway visibility” at critical driver decision points were explored using a digital program (Image J) that allowed spatial analysis computation. These explorations require further refinement to achieve precision and are not included within this report.

What Follows

Following, the report is organized into chapters that detail the various tasks undertaken in this project, and the findings associated with them. Although the tasks are presented in a neat succession of project phases, it should be understood that many of the tasks were actually undertaken simultaneously, or with much overlap. Early findings and preliminary analysis from one task informed the direction and decision-making within other tasks. Exploratory research of the kind undertaken here is of necessity an iterative process, rather than a linear one.

Chapter Two presents discussion of current AASHTO recommendations regarding intersection clear sight triangles, identifies what types of intersections have the most onerous standards associated with them, and analyzes how the standards would be applied to a typical urban intersection configuration. Implications for sidewalk trees, newspaper racks, and on-street parking are shown.

Chapter Three investigates the policies that a range of California cities have put in place regarding sidewalk trees, on-street parking, and newspaper racks near intersections. The policies are presented by streetscape element in such a way that cross-comparison between cities can easily be made.

Chapter Four begins with a discussion of the four digital intersection models that were created, including why certain decisions were made regarding how each would be configured in terms of dimensions and locations of streetscape elements. It then moves on to a discussion of the drive-through simulations that were created for each model for use in testing the visibility impacts of the different intersection configurations.

Chapter Five describes the controlled experiments that were conducted using videos of the drive-through simulations. It presents findings that come from analysis of the results of experiments with over 95 individuals, including responses to a short questionnaire.

Finally, a concluding chapter summarizes the overall research findings, proposes policy recommendations, and points to further research.

CHAPTER 2

AASHTO STANDARDS FOR SIGHT TRIANGLES AT INTERSECTIONS

AASHTO's 2004 *Policy on Geometric Design of Highways and Streets*, the most recent edition, was reviewed in regards to its recommendations for preserving clear sight distances at intersections. This permitted a determination of where sidewalk street trees, newspaper racks, and parked cars would be allowed if the recommendations were followed.

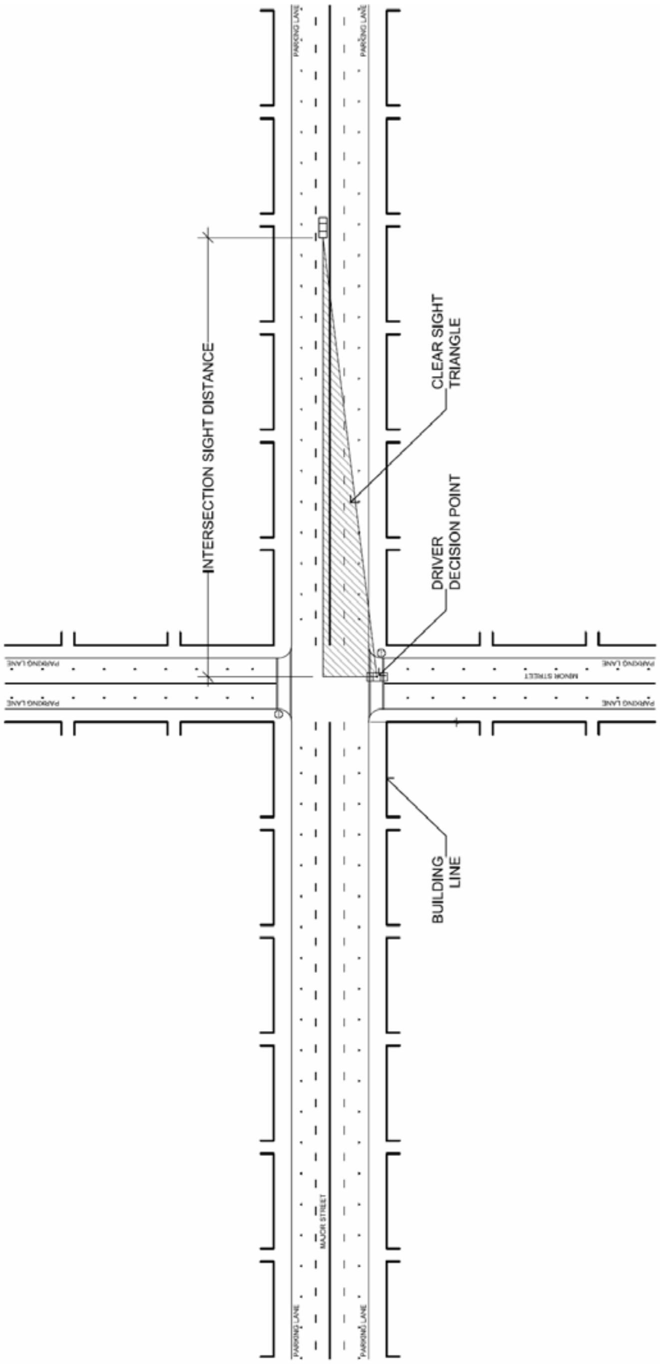
It should be noted that there was a major revision of the AASHTO handbook between 1994 and 2001, and the guidelines for determining sight distances were rewritten. The 2004 guidelines are basically the same as those from 2001. The old standards required complicated formulas with more inputs about lane width, turning radius, etc, whereas the current standards use a simplified formula. Sight distance recommendations for the simplest intersection configurations are presented in a table, with specified adjustments required for other configurations.

Intersection Sight Distance and Clear Sight Triangles

The idea behind AASHTO's concept of intersection sight distance is that the driver of a vehicle—either approaching an intersection while moving or departing an intersection from a stopped position—should have an unobstructed view of the intersection including sufficient lengths along intersecting approach roadways to permit the driver to see potentially conflicting vehicles and react in time to avoid a collision. Clear sight triangles are specified areas along approach legs and across intersection corners that are supposed to be kept clear of all obstructions to a driver's view of potentially conflicting vehicles or pedestrians. (See Figure 2.1.)

AASHTO is concerned with two types of intersection sight triangles: approach and departure. Approach sight triangles give unobstructed views to the driver of a moving vehicle approaching an intersection, and are used only at uncontrolled or yield controlled intersections. Departure sight triangles give unobstructed views to the driver of a vehicle stopped at an intersection stop sign and wanting to either cross the intersection or make a turn onto the intersecting street. Departure sight triangles are used at intersections where just one of the intersecting roadways has stop signs. AASHTO specifies no clear sight triangles for intersections with four-way stops. For signalized intersections, AASHTO recommends departure sight triangles only if moves requiring driver judgment are permitted, either right turns on red or

Figure 2.1: Intersection Sight Distance and Clear Sight Triangle



left turns where a separate “left-turn-only” signal phase doesn’t exist. AASHTO would almost always recommend a departure sight triangle at signalized intersections in California, since right turns on red are permitted except where specifically prohibited.

Non-controlled or yield controlled intersections are not commonly found in urban locales, so these were not studied in this research. Likewise, signalized intersections were not studied, as the specified sight triangle for a left turn would not cross a sidewalk (and hence affect street tree placement) and the specified sight triangle for the "right-turn-on-red" is the same as for intersections where just one of the intersecting roadways has stop signs. So, herein the focus is on intersections with stop control on just one roadway, and on departure triangles rather than approach triangles.

Intersections with Stop Control on the Minor Road

Control by stop signs on just one of the intersecting roads may occur where two minor roads intersect, or where a minor road intersects with a major road (minor, that is, either in terms of width or traffic volume, which are often related). AASHTO focuses on the latter situation, but its methods would hold true for the former as well.

For analysis, an intersection is divided into quadrants that consist of the area between the intersecting roadways. A typical intersection of two crossing streets has four quadrants. AASHTO specifies clear departure sight triangles for each quadrant of an intersection approach controlled by a stop sign. What this means is that for a typical intersection with two-way traffic on both intersecting streets, where all movements are allowed from the minor street (left turns, right turns, and crossing), clear sight triangles are supposed to emanate from a driver's position while stopped at either of the stop signs on the minor road, and extend down the major road to both the left and the right.

The triangles have a short leg that is set along the centerline of the lane on the minor road where the driver is stopped. The long leg of the triangle to the left (from the driver's vantage point) is set along the centerline of the nearest rightward-moving travel lane on the major road. The long leg of the triangle to the right is set along the centerline of the nearest leftward-moving travel lane. (See Figure 2.2.)

The length of the short leg of each triangle is determined via a fixed formula based on AASHTO's assumption about how far back from the intersection the stopped driver on the minor road will be positioned when s/he makes the decision to move into the intersection. This is called the *decision point*. The decision point (which is the vertex of the triangle) is to be set 14.5 feet[3] back from "the edge of the major-road traveled

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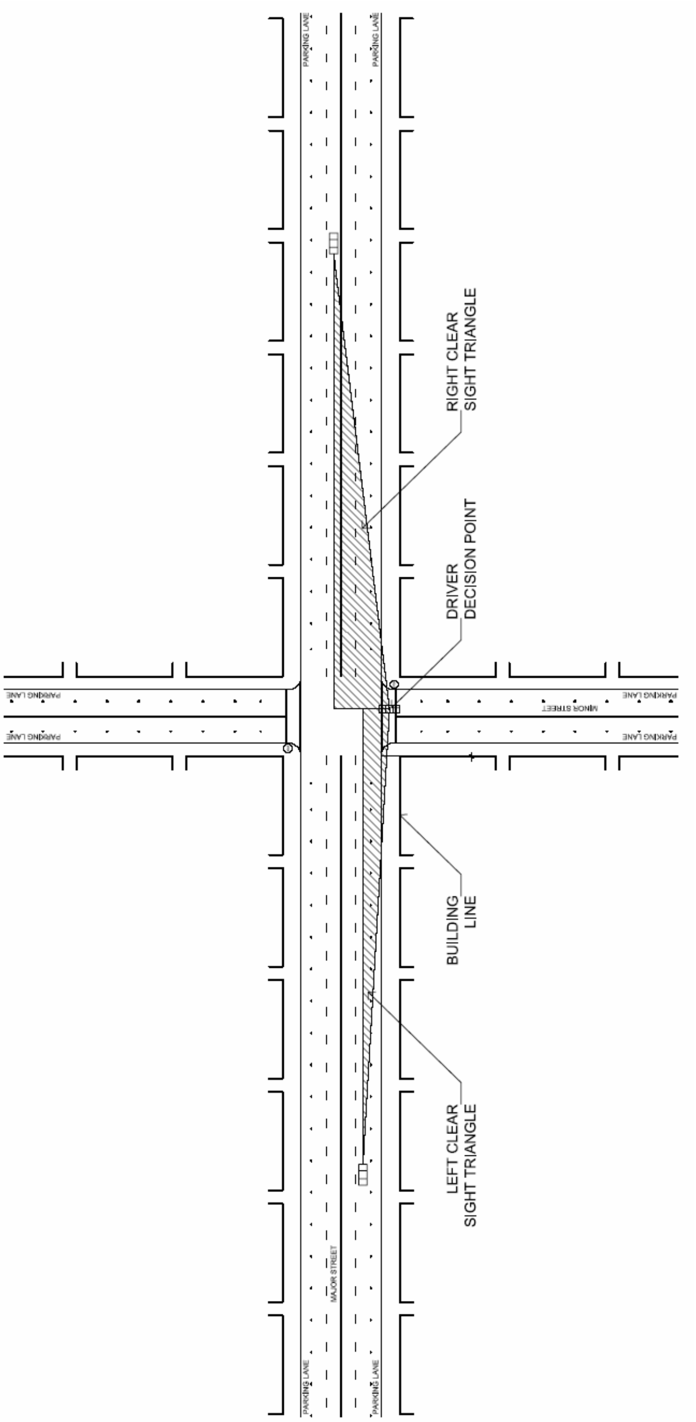
[3] AASTHO bases this number on the following assumptions: 1) that the driver will stop so that the front of her/his car is 6.5 feet or less from the edge of "the edge of the

Figure 2.2: Left and Right Clear Sight Triangles



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major-road traveled way;" and 2) that the driver's eye is typically 8 feet or less from the front of the vehicle. (The first assumption is supposedly based on observed driver behavior; the latter on measurements of U.S. passenger cars.) Hence: 6.5' + 8' = 14.5'.

way," preferably 18 feet back *where practical* (AASHTO 2004, 657). What constitutes "the edge of the major-road traveled way" in an urban environment, and whether or not AASHTO's assumptions about the location of the decision point make sense, are concerns that will be discussed later.

The length of the long leg of each triangle—known as the intersection sight distance (ISD)—is determined by doing calculations with an equation that includes variables based on the design speed and width of the major road. To figure the length of the long leg of the triangles, separate calculations using the equation are to be undertaken for each permitted move from the minor road—a left turn, a right, or crossing the intersection. The longest calculated intersection sight distance applies. The equation is as follows:

$$ISD = 1.47 * V_{major} t_g$$

Where:

ISD = intersection sight distance, in feet
V_{major} = design speed of the major road, in miles per hour
t_g = time gap for minor road vehicle to enter the major road, in seconds

For a given intersection, V_{major} would be the same when calculating for a left turn, a right turn, or a crossing. But t_g, the time gap, would vary. The time gap to be used comes from AASHTO's assumptions about what gap in traffic on the major road the driver on the minor road would accept to make her/his desired move. The 1.47 constant is a factor intended to "enhance traffic operations" (AASHTO 2004, 651), which will be discussed further later.

For a typical intersection where all three moves are allowed, the calculation for a left turn would rule, as it requires the largest assumed time gap and hence results in the greatest intersection sight distance length. The clear sight triangles imposed would be a narrow triangle extending to the left (so that the stopped driver can see cars on the near lanes coming from the left) and a wider triangle extending to the right (so that the stopped driver can see cars on the far lanes coming from the right). (See Figure 2.2.)

Left Turns

Figuring the time gap to use for left turns requires making a decision about what kind of stopped vehicle to design for—a car or a truck—as well as determining how many lanes (or equivalent lanes; more on this later) on the major road the crossing vehicle must cross before turning into the first left-bound lane, so that an appropriate time gap adjustment can be made, if necessary. In addition, if the minor road approach has a grade that exceeds 3 percent, then a further adjustment is required.

AASHTO provides a time gap table (see Table 2.1) for a base case simplest condition: a two-lane undivided major road carrying one lane of traffic in each direction, with the minor road having an approach grade of 3 percent or less.

Table 2.1: AASHTO Left Turn Time Gap

Design Vehicle	Time Gap (t_g)
Passenger Car	7.5 (seconds)
Single-Unit Truck	9.5 (seconds)
Combination Truck	11.5 (seconds)

Required Adjustments:

- If the approach grade on the minor street exceeds 3%, then 0.2 seconds are to be added for each percent of grade.
- Where the major street has a different configuration, an adjustment is to be made for "each additional lane, from the left, in excess of one, to be crossed by the turning vehicle." (AASHTO 2004, 660). If the design vehicle is a car, 0.5 seconds are added per extra lane; if a truck, 0.7 seconds per extra lane.

Based on the illustration that accompanies the table, which shows a plan view of the intersection, AASHTO seems to assume that the major road has no parking lanes or sidewalks. Situations other than the base case require interpolation on the part of the designer, which leads to an ambiguity that arises when trying to apply AASHTO's method to urban situations, where parking lanes and sidewalks are likely to be present. This is addressed below.

The adjustments seem straight-forward, except that in the written text AASHTO introduces the concept of "equivalent lanes" in regards center medians. A central median having a width approximately equal to a lane width would count as one additional lane to cross; a median approximately twice as wide would count as two additional lanes.[4] Once the need to adjust for equivalent lanes is introduced, it raises the question of whether or not to count a near side parking lane (perhaps even a sidewalk?), where it exists, as an additional lane to be crossed. AASHTO provides no help with this question.

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[4] If the median was large enough to store a vehicle without it intruding onto any travel lanes, then only the extra travel lane of near-side traffic would be counted for purposes of determining the time gap to use in the equation.

Our best interpretation of this ambiguity is that it depends on where the decision point is set—which means needing to understand precisely what AASHTO means by "the edge of the major traveled way" (which is central to determining the decision point, as discussed earlier) when a parking lane and sidewalk are present. Is it the curb edge or the edge of the near edge of the closest travel lane? Again, AASHTO provides no help. If the curb edge is used, then presumably the parking lane would count as an extra lane to be crossed when figuring the time gap adjustment; but what of a sidewalk? Presumably the presence of a sidewalk along the major road would mean a crosswalk (implied or marked) across the minor road. The crosswalk would likely be at least as wide as a traffic lane, perhaps wider. Should the decision point be moved back to the point where the driver's vehicle is completely clear of the sidewalk? Or might one assume that a driver would encroach into the crosswalk (and perhaps into the extension of the parking lane as well) in order to get a better view down the major roadway before deciding to execute the move s/he wants to make?

AASHTO gives no guidance on these questions, but some cities, such as San Mateo, California, have sought to clarify the ambiguity by writing clear sight triangle standards that are based on AASHTO's recommendations but incorporate as well the idea of a two-step stop, which is used to set the decision point (City of San Mateo 2004, Appendix A). Two-step stops are deemed to correspond with actual typical driver behavior. Basically, it is assumed that the driver will first stop behind the crosswalk (implied or marked), and then, when it looks like there will be no potentially conflicting crossing pedestrians, move up for better viewing of the major road. San Mateo thus assumes the decision point will set back from the edge of the first travel lane a distance essentially the same as the decision point AASHTO assumes for the base case scenario of a two-lane undivided highway without parking lanes or sidewalks—14.4 feet versus AASHTO's 14.5 feet.

Before going through examples of AASHTO's recommended departure sight triangles for left turns at a hypothetical "typical" urban intersection and the implications for street trees, parked cars, and newspaper racks, a brief summary of how the time gap variable is calculated for right turns and crossing is in order, to show why the left turn triangle typically governs.

Right Turns

For right turns, only a sight triangle to the left is required, which covers the approaching traffic on the lane to be turning into. For right turns, AASHTO's time gap table for the base case condition (two-lane undivided major road; 3% or less grade on the minor road approach) is as shown in Table 2.2.

Table 2.2: AASHTO Right Turn Time Gap

Design Vehicle	Time Gap (t_g)
Passenger Car	6.5 (seconds)*
Single-Unit Truck	8.5 (seconds)*
Combination Truck	10.5 (seconds) *

* Note that each of these is one second less than the corresponding figure for left turns.

Required Adjustments:

- If the approach grade on the minor street exceeds 3%, then 0.1 seconds are to be added for each percent of grade—i.e. one-half the adjustment to be made for left turns.
- No adjustment is to be made for crossing extra lanes, as it is assumed the driver will turn right into the closest travel lane.

Given the above, where both left and right turns are allowed, the left turn sight distance will always be longer and hence rule (except perhaps in cases where there is heavy truck traffic on the minor road and the trucks are forced to turn right at the major road….but this anomaly will not be addressed here.)

Crossing Maneuver

AASHTO states that in most cases, necessary intersection sight distances for crossing maneuvers are supplied by the left and right turn sight triangles, but advises checking in certain situations, paraphrased below:

1. If crossing is the only maneuver allowed.
2. When the crossing vehicle must "cross the equivalent width of six or more lanes"
3. When a substantial volume of trucks is expected to cross and the far side of the intersection has a steep grade.

When a calculation is necessary for the crossing maneuver, the right turn time gap table is used but adjustment must be made for each additional lane crossed. Just as with left turns, if the design vehicle is a car, 0.5 seconds are added per extra lane; if a truck, 0.7 seconds per extra lane. (Of course, the number of additional lanes figured would include travel lanes going in both directions, and, depending on the how "the edge of the major traveled way" is interpreted, perhaps the near parking lane as well.)

Intersection Sight Distance versus Stopping Distance

Another thing to ponder before getting to the hypothetical "typical" urban intersection examples concerns the 1.47 constant in the AASHTO clear sight triangle equation. Where does it come from? As mentioned earlier, its apparent purpose is to "enhance traffic operations." It seems that in addition to providing intersection sight distances that allow drivers to perceive traffic gaps that they can safely move into without getting hit, AASHTO wants to give a long enough sight distance so that drivers of vehicles on the major road won't perceive the need to slow much or at all when the minor road driver makes her/his move. And so, much more than necessary *stopping distance* is allowed for. For example, for the base case two lane undivided major road situation, where the design speed of the major road is 35 mph, the stopping distance for a vehicle on the major road is 250 feet, whereas the intersection sight distance AASHTO recommends is 390 feet. This is quite an increase.

Street Trees

By now, a reader might well be wondering how AASHTO's recommended sight triangles translate into setback requirements for trees or parked cars. AASHTO doesn't specify these setbacks directly, but leaves that determination up to the street designer. The criteria AASHTO does give to help the designer out are: 1) No object shall be placed within the recommended sight triangles that might obstruct the driver's view; and 2) Both the driver's eye height and the height of a vehicle to been seen are assumed to be 3.5 feet above the roadway surface.

Most, if not all, sidewalk trees, parked cars, and newspaper racks would intercept the 3.5 foot horizontal plane of the assumed critical sight line, so presumably AASHTO would want all of them set back from the clear sight triangles as they lay out on the ground. (This recommendation, however, is not absolute as AASHTO uses the caveat "*where practical*.")

To determine how much of a parking lane or a sidewalk is supposed to be kept clear, it is necessary to determine where the hypotenuse of the triangle crosses these elements. This requires a designer to perform geometrical calculations, or, more likely, to use a CADD program to lay the triangle out over a dimensionally accurate plan view of the intersection and then have the program measure the crossings.

Hypothetical "Typical" Urban Intersection Examples

In many older California cities, 100 feet is one of the standard right-of-way widths for a four lane major road with two lanes of travel in each direction, and 60 feet is a typical right-of-way width for a two-lane minor road. Both streets would likely have parking lanes and sidewalks along both sides, and the major road would likely have a central median (either raised or marked) that would become a dedicated left turn lane at intersections. Assuming the major street is a commercial street (where somewhat wide sidewalks would be appropriate), its right-of-way might very well be sub-divided with 14-foot sidewalks, 8-foot parking lanes, 11-foot travel lanes, and a 12-foot wide central median. (See Figure 2.3.) The minor street's right-of-way might very have 10-foot sidewalks, 9-foot parking lanes, and 11-foot travel lanes (See Figure 2.4.) [5]

Where sidewalk trees occur on urban streets, they are usually placed close to the curb. Assuming a 6-inch wide curb and a typical tree well size of 4 feet by 4 feet, the centerline of the trees would be 2.5 feet in from the curb edge. For a street with the typical dimensions described above, sidewalks would likely have 10-foot radii at intersection corners.

The two examples below illustrate the AASHTO recommended clear sight triangles and their implications for the placement of street trees, parked cars, and newspaper racks. They differ only in where the decision point is set (i.e., in how AASHTO's term "the edge of the major-traveled roadway" is interpreted.)

Example A: Decision Point Set 14.5 Feet Back from the Curb Edge

Assumptions:

- The design vehicle is a passenger car.
- The approach grade of the minor road is 3% or less.
- The design speed of the major road is 35 mph.

Left turn intersection sight distance calculation (ISD = $1.47 * V_{major} t_g$)

$V_{major} = 35$
$t_g = 9$ [i.e.7.5 + 1.5 for 3 additional lanes: parking lane, 2nd travel lane, median]
ISD = 1.47 (35*9) = 463, which is rounded up to 465 [AASHTO recommends this rounding]

Left turn short leg of triangle calculations
To the left: (length from decision point to the centerline of the nearest right-moving travel lane)
14.5' + 8' (*parking lane*) + 5.5' (*half of travel lane*) = 28'
To the right: (length from decision point to the centerline of the nearest left-moving travel lane)
14.5' + 8' (*parking lane*) + 22' (*2 travel lanes*) + 12' (*median*) + 5.5' (*half of travel lane*) = 62'

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[5] These dimensions derive from field observations of typical conditions along San Francisco Bay Area streets.

Figure 2.3: Cross Section of Major Street

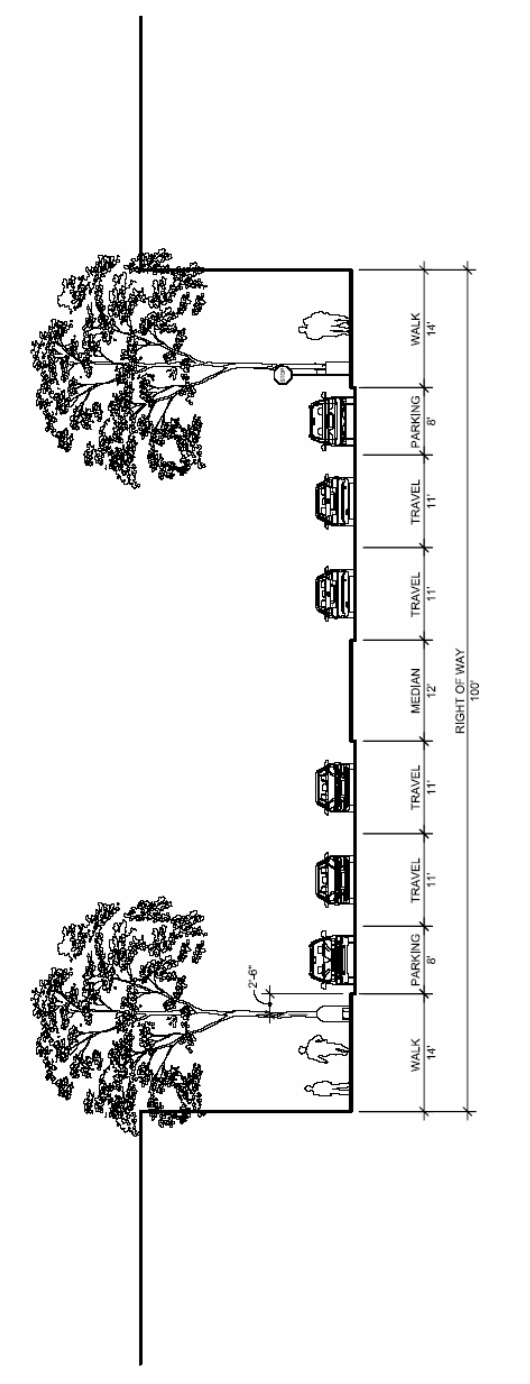
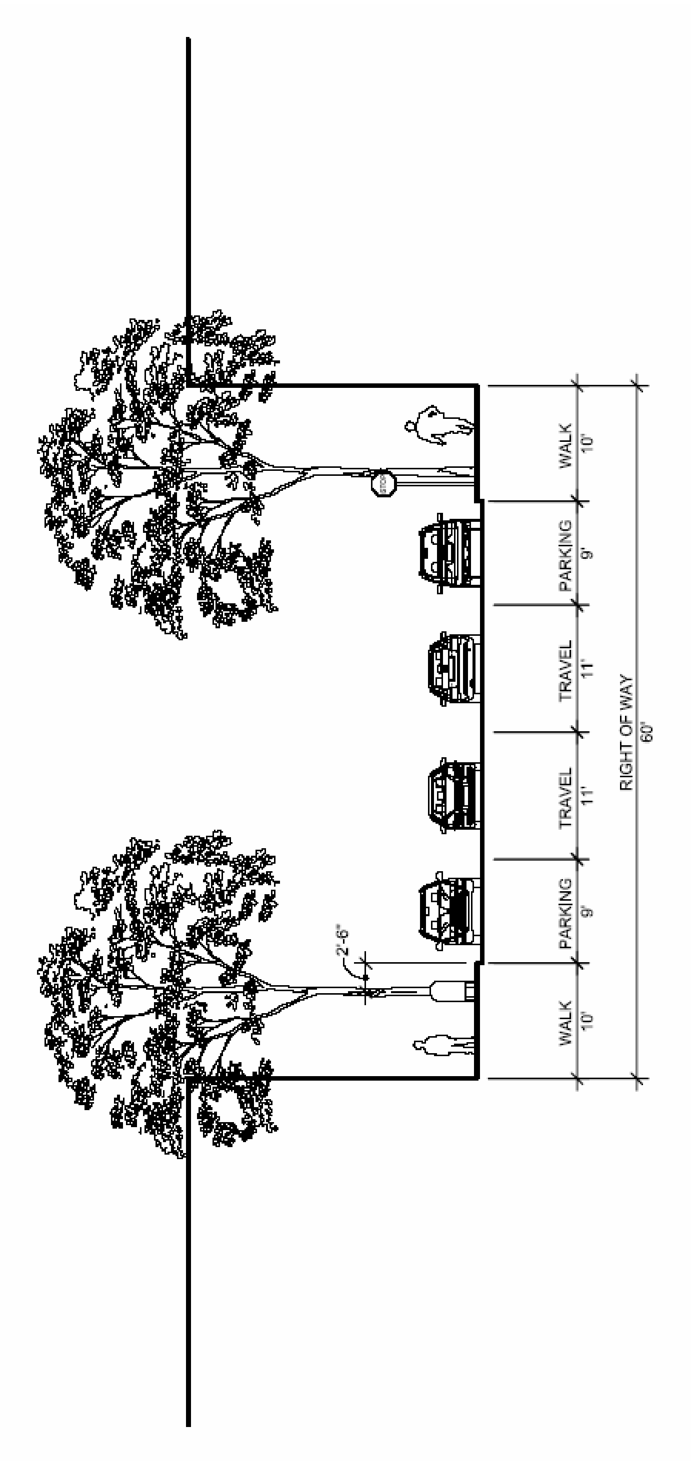


Figure 2.4: Cross Section of Minor Street



When the left clear sight triangle is laid over a plan of the hypothetical "typical" urban intersection described above, the hypotenuse crosses the outer edge of the tree trunk line 190'-10" back from the curb return and the outer front edge of the parking lane 319'-6" back from the curb return.[6] (See Figure 2.5.)

When the right clear sight triangle is laid over a plan of the hypothetical "typical" urban intersection described above, the hypotenuse crosses the outer edge of the tree trunk line 77'-9" back from the curb return and the outer front edge of the parking lane 133'-7" back from the curb return. (See Figure 2.5.)

Example B: Decision Point is Set 14.5 Feet Back from the Edge of the Near Travel Lane

Assumptions:

- The design vehicle is a passenger car.
- The approach grade of the minor road is 3% or less.
- The design speed of the major road is 35 mph.

Left turn intersection sight distance calculation ($ISD = 1.47*V_{major}t_g$)

$V_{major} = 35$

$t_g = 8.5$ [i.e.7.5 + 1.0 for 2 additional lanes: 2nd travel lane, median]

ISD = 1.47 (35*8.5) = 437.3, which is rounded up to 440

Left turn short leg of triangle calculations

To the left: (length from decision point to the centerline of the nearest right-moving travel lane)

14.5' + 5.5' (*half of travel lane*) = 20'

To the right: (length from decision point to the centerline of the nearest left-moving travel lane)

14.5' + 22' (*2 travel lanes*) + 12' (*median*) + 5.5' (*half of travel lane*) = 54'

When the left clear sight triangle is laid over a plan of the hypothetical "typical" urban intersection described above, the hypotenuse crosses the outer edge of the tree trunk line 87'-9" back from the curb

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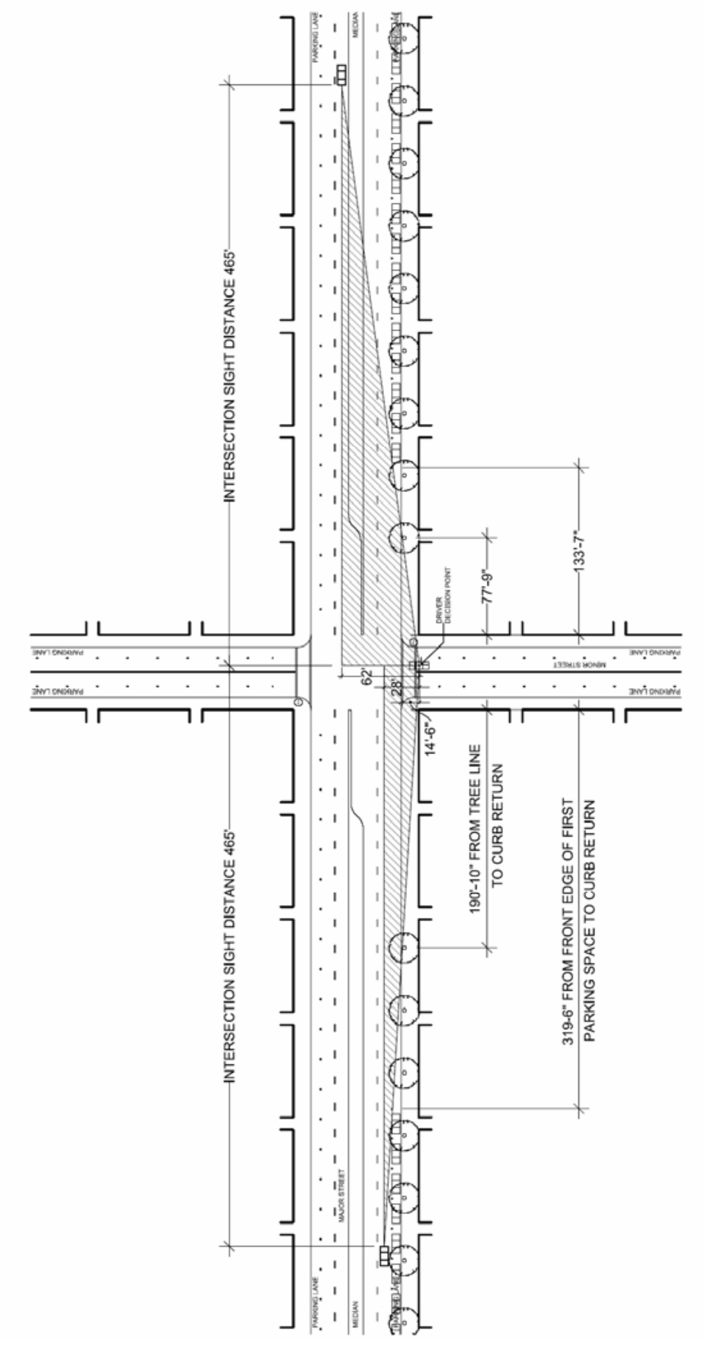
[6] How these dimensions were calculated requires some explanation:

a) They are given from the curb return because this is how California cities typically give required tree and parking set-backs. In the case of the hypothetical "typical" urban intersection used in this example, the curb return is lined up with the building edge, but this would not always be the case in practice as where the curb return lies depends on the width of the sidewalks on the minor road and the sidewalk corner radius.

b) The "outer edge of the tree trunk line" was figured as 1.5 feet beyond the tree centerline, toward the curb, to ensure that the clear sight triangle would remain unobstructed as the trees grow.

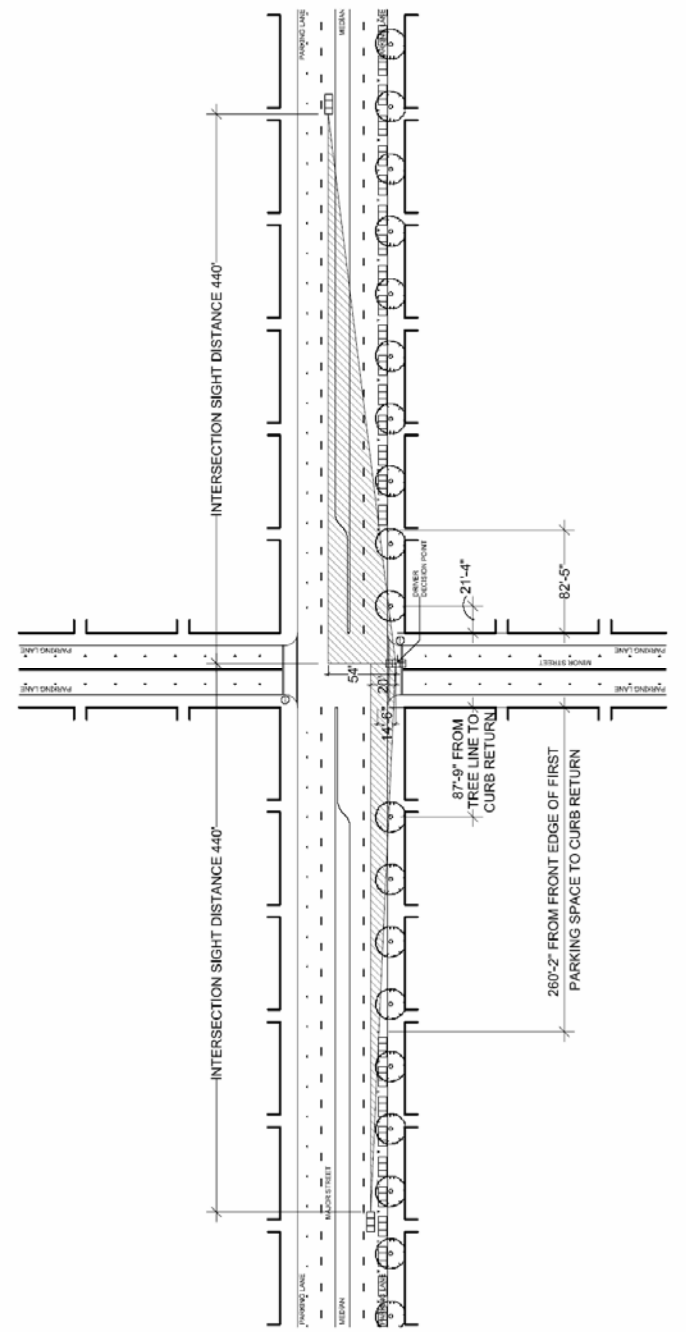
c) The "outer front edge of the parking lane" means the front edge of the parking space nearest the intersection, figured by determining where the clear slight triangle would intersect with a vehicle parked in this first space.

Figure 2.5: Clear Sight Triangles for Example A: Decision Point Set 14.5 Feet Back from the <u>Curb Edge</u>



return and the outer front edge of the parking lane 260’-2” back from the curb return. (See Figure 2.6.)

Figure 2.6: Clear Sight Triangles for Example A: Decision Point Set 14.5 Feet Back from the Edge of the Near Travel Lane



When the right clear sight triangle is laid over a plan of the hypothetical “typical” urban intersection described above, the hypotenuse crosses the outer edge of the tree trunk line 21’-4” back from the curb return and the outer front edge of the parking lane 82’-5” back from the curb return. (See Figure 2.6.)

Conclusions

In summary, the main findings that come from the above analysis of AASHTO recommendations for clear sight triangles are:

- The two types of typical urban intersections for which AASHTO recommends clear departure sight triangles likely to impact sidewalk street tree locations are where one street is controlled with a stop sign, and at signalized intersections where driver judgment is permitted. Since right turns on red are allowed at most signalized intersections in California, sight triangles would be recommended at them.
- There is a large safety factor built into AASHTO’s recommended sight distance, the purpose of which is to keep traffic flowing smoothly.
- AASHTO’s guidelines for determining recommended clear sight triangles are hard to apply to urban streets that have sidewalks, on-street parking, and buildings set at the property line, because the examples AASHTO gives show situations where these elements do not occur. Accordingly, assumptions must be made about how to figure the time-gap and where to set the decision point—14.5 feet back from the curb edge or 14.5 feet back from the edge of the near travel lane? Using a two-step stop approach, the determine the driver decision point, as the City of San Mateo does, seems to make sense for urban intersections as it more closely corresponds to actual driver behavior.
- Even if a two-step stop is assumed and the driver decision point is set 14.5 feet back from the edge of the near travel lane, maintaining the AASHTO recommended clear sight triangle at a typical urban intersection (100-foot wide major street; 60-foot wide minor street controlled with stop signs) would result in substantial setbacks for street trees, parked cars, and street furniture. To the left side of the intersection, street trees would need to be set almost 88 feet back from the curb return, and on-street parking would need to be set about 260 feet back.

- And finally, AASHTO's recommendations vary significantly based on the specifics of street configuration, unlike the one-size-fits-all setback requirements that cities generally adopt, as we shall see in the next chapter.

CHAPTER 3

CITY POLICIES REGARDING TREES, PARKING, AND NEWSPAPER RACKS NEAR INTERSECTIONS

To assess how California's cities regulate the placement of street trees near intersections, attempts were made to gather current standards from thirty cities around the state. (See Table 3.1.) Attempts were also made to gather these cities' standards regarding the location of on-street parking spaces and newspaper racks near intersections, in order to determine whether their placement is regulated more or less strictly than the placement of street trees. It was hypothesized that these two additional items had the greatest potential to obstruct a driver's line of sight.[7]

For each city, researchers began by looking for written standards on the city's website and in the Municipal Code. These written standards were used whenever they were available. When they were not, researchers contacted appropriate city staff by telephone and attempted to determine whether a standard existed and, if so, what it was. Some city staff members were able to provide unpublished memos or ordinances that explained their cities' requirements. In other cases, staff said that their cities have no formal standards, and instead described the requirements or rules of thumb that they typically apply. In more than a few cities, it was impossible to gather any information regarding standards for street-trees, on-street parking, or newspaper racks.

Experience had suggested that it might be challenging to gather standards from cities, but doing so was even more difficult and time-consuming than expected. In particular, it emerged that many cities lack written standards for these requirements, especially for the allowable location of on-street parking spaces. In addition, it was sometimes difficult getting city staff to respond to questions. Most of the city staff contacted were courteous and professional, and they did their utmost to answer questions quickly and accurately. However, staff from many of the smaller cities, especially those outside of the Bay Area, often failed to return phone calls. It seems likely that many of these cities are understaffed, and their arborists and engineers simply have no time to answer questions from a far-away university researcher. It may also be easier to ignore such questions when they are infrequent; in cities near Berkeley, staff members

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[7] The original intent was to look at all types of street furniture that could, in theory, obstruct a driver's line of sight, including utility poles, benches, and mailboxes. However, it quickly became apparent that doing so would be impossible. Too many agencies share responsibility for the various objects in the public right-of-way, and standards for the placement of these objects are often scattered to the four winds, when they exist at all.

Table 3.1: California Cities Investigated

City	County	2004 population estimated	Reason for including	Looked for standards online	Called	Tree standards collected	Parking standards collected	Newsrack standards collected
Anaheim	Orange	343,000	Top 10 population	X	X	X		X
Bakersfield	Kern	279,700	Top 10 population	X				
Beaumont	Riverside	16,350	Top 10 growth	X				
Berkeley	Alameda	104,300	Bay Area city	X	X	X	X	X
Brentwood	Contra Costa	37,050	Top 10 growth	X				
California City	Kern	11,300	Top 10 growth	X				
Concord	Contra Costa	124,900	Bay Area city	X	X	X		X
Fremont	Alameda	209,100	Bay Area city	X	X	X	X	X
Fresno	Fresno	456,100	Top 10 population	X	X	X	X	
La Quinta	Riverside	32,500	Top 10 growth	X		X		X
Lincoln	Placer	23,050	Top 10 growth	X	X			
Long Beach	Los Angeles	487,100	Top 10 population	X				X
Los Angeles	Los Angeles	3,912,200	Top 10 population	X	X	X	X	X
Murrieta	Riverside	77,700	Top 10 growth	X		X		
Napa	Napa	75,900	Bay Area city	X				
Oakland	Alameda	411,600	Bay Area city	X	X	X	X	
Pleasanton	Alameda	67,200	Bay Area city	X	X	X	X	X
Rio Vista	Solano	6,275	Top 10 growth	X				
Riverside	Riverside	277,000	Top 10 population	X				
Rocklin	Placer	48,900	Top 10 growth	X	X			
Sacramento	Sacramento	441,000	Top 10 population	X	X		X	X
San Diego	San Diego	1,294,000	Top 10 population	X		X		X
San Francisco	San Francisco	792,700	Bay Area city	X	X	X	X	X
San Jose	Santa Clara	926,200	Bay Area city	X	X	X		X
Santa Ana	Orange	349,100	Top 10 population	X		X		
Santa Rosa	Sonoma	154,400	Bay Area city	X	X			X
Stockton	San Joaquin	269,100	Top 10 population	X		X		
Twentynine Palms	San Bernardino	25,950	Top 10 growth	X				
Walnut Creek	Contra Costa	66,000	Bay Area city	X	X	X	X	X
Yuba City	Sutter	50,800	Top 10 growth	X				
			Total	**30**	**15**	**16**	**9**	**14**

NOTES:
"Top 10 growth" refers to the 10 cities with estimated 2004 populations above 5,000 that had the highest growth between 2000 and 2004. <http://www.dof.ca.gov/HTML/DEMOGRAP/HistE-4.htm>

are more likely to have fielded questions from city planning and transportation researchers. See Table 3.1 for a list of the California cities investigated.

On the other hand, researchers also encountered difficulties gathering standards for San Francisco and Oakland. San Francisco's Department of Public Works, which oversees the city's newspaper racks, claims on its website to have written guidelines for pedestal-mounted newspaper racks available for review (San Francisco Department of Public Works 2005). The appropriate public works official was contacted and a copy of the standards was promised, but they were never received, in spite of repeated inquiries by telephone and in person. Other Department of Public Works staff told us they were not aware of any guidelines for pedestal-mounted newspaper racks.

Difficulties were also encountered with the tree division of Oakland's Office of Parks and Recreation. Although the city completed and approved a street tree plan in 1998, the department's staff told researchers that neither they nor any other city department had any copies of the plan available for purchase or review. One of the city's arborists provided a verbal description of some of the city's standards for tree spacing. However, when a copy of Oakland's street tree plan was finally obtained from another source, it was found that the guidelines provided verbally by the arborist were far more restrictive than those in the written plan. For example, the written plan states that London plane trees can be planted as close as 25 feet apart on center, but the arborist told us that 50 feet was the minimum spacing for that type of tree (City of Oakland Parks, Recreation and Cultural Services Department 1998, 5).[8]

The standards able to be collected for each city are listed in Table 3.1. The actual content of the standards are listed by element in the sections that follow. Briefly, as expected, it was found that cities typically place stricter regulations on street trees than on other potential line-of-sight obstructions. Although newspaper racks are subject to a host of regulations, many cities allow them in places near an intersection where trees are prohibited. Similarly, parking spaces are often allowed nearer to the intersection than street trees.

As a cautionary note, the tables included in the following sections list the standards obtained, but urban designers are warned not to rely on them for streetscape design projects. The standards may have become out of date since they were collected, and there is no way of knowing how consistently each city applies its written standards, or whether city staff

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[8] Telephone conversation with arborist, City of Oakland (17 March 2005).

accurately described unwritten standards. Also, based on professional experience, it seems clear that cities can and do modify their street design standards on a project-by-project basis. For example, a developer could use a specific plan or a planned-unit development to create project-specific standards; also, a tenacious urban designer may be able to convince a city to plant trees closer to one another, or to an intersection, than the city ordinarily allows.

Standards for Street Trees

Researchers focused on collecting standards for the minimum distance that trees must be held back from an intersection; but related standards were also collected, such as the minimum spacing on center, in order to inform our simulations and to more comprehensively assess the restrictions on where trees can be planted in public rights-of-way.

Sources for Standards

When cities use written standards for the placement of street trees, they are most often in the construction drawings that each city uses for the construction of new public streets and infrastructure. These drawings, often called "standard details" or "standard plans," are prepared by a city's public works department; they show the city's requirements for building its mundane but necessary infrastructure, such as sewer lines and survey monuments. They also include standards of more interest to urban designers, including the required rights-of-way for various types of streets and the design of street lights on a typical street. Cities typically adopt the standard details through a City Council ordinance or resolution, then require contractors to follow the standard details, along with written requirements often called "standard specifications," when they design and build new infrastructure.[9]

Nearly all standard details and specifications include requirements for the planting of street trees. In many cities, these requirements focus on technical details, such as soil amendments and root control barriers, that are of limited interest to urban designers.[10] However, a number of cities'

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[9] The City of Oakland is a typical example. For the ordinance adopting its standard specifications and details, see Oakland ordinance 12498, in *City of Oakland Standard Details for Public Works Construction* (2002) p.1-2. For a bid request requiring contractors to use these standards, see *City of Oakland Construction Project Opportunity Notice, C167620 REBID International Boulevard Streetscape Project*, (December 20, 2005). Note, however, that many of Oakland's requirements for street trees are not included in the standard specifications and details.

[10] The City of Pleasanton is a typical example. See *City of Pleasanton Standard Details*, including drawings 601C, 601B, 603, and 808A.

standard details provide diagrams showing where trees may be planted in the public right-of-way. The diagrams typically show how much space must separate a street tree from the curb face, which is the plane of the curb that is perpendicular to the street, and the curb return, which is the line at which the curb face begins to curve. Also, the diagrams usually indicate how far each street tree must be separated from various other objects, including fire hydrants and driveways. Standards for tree spacing are sometimes, but not often, provided as well.

Most of the cities evaluated have developed their own unique collections of standard details. However, several cities in our study have adopted versions of the American Public Works Association (APWA) *Standard Specifications for Public Works Construction*, commonly known as the "Greenbook." [11] The Greenbook's standard details are similar in form and content to the standard details developed by individual cities.

A few of the cities studied were able to provide written standards for the placement of street trees, but do not include them in their standard specifications and details. San Francisco, for example, describes its street tree requirements in a publicly-available order from its Department of Public Works.[12] Typically, though, when researchers contacted cities that do not include these requirements in their standard specifications and details, they were told that the city does not have written requirements for the placement of street trees. Instead, researchers talked with arborists and traffic engineers, who described their cities' common practices for controlling the placement of newly-planted trees.

Findings

See Table 3.2, for a complete listing of the city standards regarding street trees that were gathered. The following is a summary of the key findings:

- Every city for which standards were gathered requires trees to be held back at intersections.
- Where a formal standard was provided, required setback ranged from 15 feet (Fremont) to 50 feet (Murrieta and Santa

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[11] The City of La Quinta, for example, uses a modified version of the APWA standard details to regulate the location of street trees. See City of La Quinta tree well standard 705. The City of Anaheim uses some APWA standard details, but it has its own standard details that regulate the location of street trees. See *City of Anaheim Department of Public Works Standard Plans and Details* (2004), p. 1, and standard detail 530-A.

[12] *City and County of San Francisco Department of Public Works Order No. 169,946.*

Ana, both of which use a version of the APWA Greenbook's tree standards).

- Where no formal standard was available, researchers were told that cities follow "AASHTO requirements" for clear sight triangles, or that arborists must negotiate with traffic engineers on a case-by-case basis. Several of the arborists and traffic engineers spoken with said that this had created conflicts between the two disciplines in the past. A Sacramento traffic engineer, for example, called trees the "textbook case" of an object that blocks a clear sight triangle (which is literally true; see Chapter 2).[13] A Berkeley traffic engineer commented that his city's arborists sometimes plant trees in locations where they obstruct visibility for motorists, especially when the trees are young.[14] A Walnut Creek arborist explained that he had tried and failed to get written standards for tree placement from his city's traffic engineers; he also noted that his own city's traffic engineers have complained about the low branching height of saplings, even though it's also unavoidable (his department generally prunes mature trees to a height of 14 feet above traffic lanes).[15]
- Pruning height above grade is also important for visibility and safety, and arguably more important for visibility than the placement of the tree. It was only possible to locate pruning standards for three cities; each required a 14-foot clearance above grade for traffic lanes and 6 to 8 feet above grade for pedestrian areas.
- Street tree spacing requirements were also hard to come by. Disregarding Oakland's 1998 street tree plan (since the city's verbal information is presumably closer to what they actually require), the standards gathered ranged from 20 feet (Fresno), which would be quite appropriate for many types of trees, to 50 feet (Murrieta), which would make it all but impossible to plant trees with overlapping canopies.
- Most cities also require clear areas between trees and various objects on the sidewalk, such as fire hydrants, traffic signs, driveways and utility poles. These requirements further limit the number of trees that can be planted along a street.

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[13] Telephone conversation with traffic engineer, City of Sacramento (22 March 2005).

[14] Telephone conversation with traffic engineer, Office of Transportation, City of Berkeley (4 February 2005).

[15] Telephone conversation with arborist, City of Walnut Creek (6 April 2005).

Table 3.2: California City Street Tree Standards

	Minimum Setback from Curb Return		Minimum Pruning Height		Minimum Tree Spacing		
City	Approach to Intersection	Departure from Intersection	Above Sidewalk	Above Traffic Lane	On Center	From Other Objects	Minimum Distance from Curb
Anaheim[16]	Signalized intersections: 25 feet for palm trees, 40 feet for others. Non-signalized intersections: 25 feet.	Signalized intersections: 15 feet for palm trees, 25 feet for others. Non-signalized intersections: 10 feet.	Not specified	Not specified	Not specified	• Fire hydrants: 5 feet • Roadway signs: 10 feet • Street lights: 10 feet for palm trees, 15 feet for others	3 feet
Berkeley[17]	25 feet	25 feet	Not specified	Not specified	Not specified	Not specified	Not specified
Concord[18]	City follows AASHTO standards, with occasional exceptions		Not specified	Not specified	Not specified	Not specified	Not specified
Fremont[19]	15 feet	15 feet	Not specified	Not specified	“Generally” 35 feet	• Driveways: 8 feet • Fire hydrants: 5 feet • Telephone/electrical lines: 5 feet • Street lights: 15 feet	“Typically” 8 feet

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[16] *City of Anaheim Department of Public Works Standard Plans and Details*, Number 530-A (2003). Accessed 11 February 2006 <http://www.anaheim.net/depts_servc/pub_works/StandardDetails/500/530A.pdf>.

[17] Telephone conversation with arborist, City of Berkeley (4 February 2005).

[18] Telephone conversation with arborist, City of Concord (15 April 2005).

[19] *City of Fremont Standard Landscape Details (SD-34) for City Projects and Right-of-Way*, Sheet 5 (2002). Accessed 11 February 2006 <http://www.ci.fremont.ca.us/NR/rdonlyres/eqbjcxq2hi2n5qd7g5gakwxfk7w3foabxyy66z2dt3gkk4wpzxxlac7dtwt4d5slyy5shs6kcxvuqoccz6acbbtzpbh/Landscape+Development+Requirements+%26+Policies.pdf>.

	Minimum Setback from Curb Return		Minimum Pruning Height		Minimum Tree Spacing		
City	Approach to Intersection	Departure from Intersection	Above Sidewalk	Above Traffic Lane	On Center	From Other Objects	Minimum Distance from Curb
Fresno[20]	30 feet	30 feet	Not specified	Not specified	20 feet	• Alleys: 15 feet • Driveways: 10 feet • Fire hydrants: 15 feet • Street lights: 20 feet • Power poles: 15 feet • Stop signs: 30 feet • Telephone/cable television lines: 3 feet	Not specified, but must be 3 feet from adjoining property line
La Quinta[21]	50 feet	15 feet	Not specified	Not specified	Not specified	• Driveways: 10 feet • Fire hydrants: 10 feet • Light poles: 20 feet	Not specified
Los Angeles[22]	45 feet	45 feet	Not specified	Not specified	25 to 40 feet, depending on species	• Alley entrances: 20 feet • Crosswalks: 6 feet • Driveways: 6 feet • Electric poles: 20 feet • Fire hydrants: 10 feet • Railroad tracks: 100 feet • Street lights: 20 feet • Water and gas meters: 6 feet	Not specified

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[20] *City of Fresno Standard Specifications*, page 199 (2002). Accessed 11 February 2006 <http://www.fresno.gov/public_works/technical_library/Standard_Spec/Spec/Section26.pdf>.

[21] *City of La Quinta Infrastructure Development Standards*, Standard 705 (2001). Accessed 11 February 2006 <http://www.la-quinta.org/publicworks/tract1/0_EngineeringDocs/LQ_Standards/La_Quinta_Standards.pdf>.

[22] City of Los Angeles, Bureau of Street Services – Street Tree Division, "Tree Spacing Guidelines" (undated). Accessed 11 February 2006 <http://www.lacity.org/BOSS/StreetTree/TreeSpacing.htm>.

City	Minimum Setback from Curb Return: Approach to Intersection	Minimum Setback from Curb Return: Departure from Intersection	Minimum Pruning Height: Above Sidewalk	Minimum Pruning Height: Above Traffic Lane	Minimum Tree Spacing: On Center	Minimum Tree Spacing: From Other Objects	Minimum Distance from Curb
Murrieta[23]	50 feet; prohibited within sight triangle	50 feet; prohibited within sight triangle	Not specified	Not specified	50 feet	• Driveways: 10 feet • Fire hydrants: 10 feet • Street lights: 20 feet	Not specified
Oakland (interview with staff)[24]	20 feet or more, depending on signalization and speed limit	20 feet or more, depending on signalization and speed limit	Not specified	Not specified	25 to 50 feet, depending on species	Not specified	Not specified
Oakland (Street Tree Plan)[25]	Not specified	Not specified	Not specified	Not specified	15 to 35 feet, depending on species	• Driveways, commercial: 10 feet • Driveways, residential: 5 feet • Fire hydrants: 5 feet • Parking meters: 3 feet • Utility poles: 15 feet • Water/gas meters: 5 feet	Not specified
Pleasanton[26]	City follows AASHTO standards, with some exceptions		Not specified	Not specified	Not specified	• Curb ramps: 4 feet • Driveways: 10 feet	Not specified

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[23] *City of Murrieta Standard Drawings*, Standards 214b, 615a, and 615b (1998). Accessed 11 February 2006 <http://www.murrieta.org/uploads/forms/publicworks/standard_drawings.pdf>.

[24] Telephone conversation with arborist, City of Oakland (17 March 2005).

[25] City of Oakland, Department of Parks, Recreation, and Cultural Services, *Street Tree Plan* (1998).

[26] Telephone conversation with arborist, City of Pleasanton (7 March 2005).

	Minimum Setback from Curb Return		Minimum Pruning Height		Minimum Tree Spacing		
City	Approach to Intersection	Departure from Intersection	Above Sidewalk	Above Traffic Lane	On Center	From Other Objects	Minimum Distance from Curb
San Diego[27]	25 feet	25 feet	6 feet	14 feet	Not specified	• Driveways: 10 feet • Fire hydrants: 10 feet • Stop signs: 20 feet • Traffic signals: 20 feet • Transformers: 10 feet • Utility poles: 10 feet	Streets with speed limit of 50 miles per hour or greater: 7 feet. Other streets: 2.5 feet.
San Francisco[28]	25 feet	10 to 15 feet, depending on species	8 feet	14 feet	Not specified	• Fire escapes: 10 feet • Fire hydrants: 5 feet • Parking signs: 3 feet • Sidewalk furniture: 3 feet • Traffic signs: 25 feet • Utility boxes: 3 feet • Utility poles: 6 feet	Not specified
San José[29]	40 feet	40 feet	Not specified	Not specified	Not specified	• Driveways (commercial): 10 feet • Driveways (residential): 5 feet • Fire hydrants: 5 feet • Street lights: 20 feet • Stop signs: 20 feet • Water meters: 5 feet	Not specified

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[27] *San Diego Municipal Code*, Sections 142.0409.a.2 and 142.0403.b.10 (1997). Accessed 11 February 2006 <http://clerkdoc.sannet.gov/legtrain/mc/MuniCodeChapter14/Ch14Art02Division04>.

[28] City and County of San Francisco, Department of Public Works, "Order No. 169,946" (1997). Accessed 11 February 2006 <http://www.sfgov.org/site/uploadedfiles/sfdpw/buf/StreetTreeGuidelines.pdf>.

[29] City of San José, Department of Transportation, "Tree Planting Setbacks" (undated; received via fax 11 April 2005).

	Minimum Setback from Curb Return		Minimum Pruning Height		Minimum Tree Spacing		
City	Approach to Intersection	Departure from Intersection	Above Sidewalk	Above Traffic Lane	On Center	From Other Objects	Minimum Distance from Curb
Santa Ana[30]	50 feet; prohibited within sight triangle	15 feet; prohibited within sight triangle	Not specified	Not specified	35 feet	• Driveways: 10 feet • Electric poles: 20 feet • Fire hydrants: 10 feet • Street lights: 20 feet	Not specified
Stockton[31]	40 feet, but Municipal Code authorizes trees within the line of sight if they are pruned 6 feet above the roadway	40 feet, but Municipal Code authorizes trees within the line of sight if they are pruned 6 feet above the roadway	Not specified	Not specified	40 feet	• Street lights: 15 feet • Street signs: 15 feet • Utility boxes: 6 feet	Not specified
Walnut Creek[32]	Determined through negotiation with Transportation Division		8 feet	14 feet	Determined through negotiation with Transportation Division		Not specified

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[30] *City of Santa Ana Standard Plans*, Numbers 1124 (1998), 1124B (2004), and 1125E (1990). Accessed 18 August 2005 <http://www.ci.santa-ana.ca.us/departments/pwa/engineering/design/standard_plans/street/pdf/st112a.pdf; http://www.ci.santa-ana.ca.us/departments/pwa/engineering/design/standard_plans/street/pdf/st1124b.pdf; http://www.ci.santa-ana.ca.us/departments/pwa/engineering/design/standard_plans/street/pdf/st1125e.pdf>; no longer available online.

[31] *City of Stockton Standard Drawings*, Number 5F (2003). Accessed 11 February 2006 <http://www.stocktongov.com/publicworks/standardsandspecs/1-10.pdf>; *City of Stockton Municipal Code*, Section 16-310.140.A (undated). Accessed 11 February 2006 <http://www.stocktongov.com/SMC/Chapter16/Article03/Division16-310.pdf>.

[32] Telephone conversation with arborist, City of Walnut Creek (6 April 2005).

Standards for On-Street Parking

It was theorized that parked cars could significantly obstruct visibility at intersections; therefore, the focus regarding on-street parking was exclusively on whether "no parking" zones were required at intersections, and if so, how large they had to be.

Sources of Standards

Since 1927, the United States Federal Highway Administration (FHWA) has published some version of its Manual on Uniform Traffic Control Devices (MUTCD). According to the most recent edition, the 2003 MUTCD, traffic control devices include any "signs, signals, markings, and other devices used to regulate, warn, or guide traffic, placed on, over, or adjacent to a street, highway, pedestrian facility, or bikeway by authority of a public agency having jurisdiction." (Federal Highway Administration 2003 (revised 2004), I-2.) Thus, the street signs and painted curbs that are used to control parking locations are considered "traffic control devices" and regulated by the MUTCD. Under current federal law, all states are required to adopt the manual.[33]

The 2003 MUTCD requires a 20-foot "no parking" zone on both sides of any intersection, measured from the pedestrian crosswalk or curb return to the first parking space (Federal Highway Administration 2003 (revised 2004), 3B-30).[34] At signalized intersections, the "no parking" zone on the approach to the signal must be 30 feet. California, like many states, adopted the MUTCD along with a supplement that modifies some of the MUTCD's requirements; although the supplement shows different methods of striping the parking spaces, it does not modify the required 20-foot and 30-foot distances (California Department of Transportation 2004, 3B-23).[35]

However, cities are not required to follow the MUTCD or California's supplement to it; the California Supplement says that it "is

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[33] See the Federal Highway Administration Adoption Webpage, http://mutcd.fhwa.dot.gov/knowledge/natl_adopt_2000_2003.htm

[34] Under California law, if no crosswalk is marked on the pavement, this distance is measured from the curb return, see California Vehicle Code Section 275, which defines a crosswalk, in part, as "[t]hat portion of a roadway included within the prolongation or connection of the boundary lines of sidewalks at intersections where the intersecting roadways meet at approximately right angles, except the prolongation of such lines from an alley across a street".

[35] The California Department of Transportation (2004) *MUTCD 2003 California Supplement* makes it clear that the required distance is measured from the curb return when no crosswalk is marked on the pavement.

furnished solely for the purpose of guidance and information, and is not a legal standard. Engineering judgment must be used to apply these guidelines and typical applications, or adjust them to fit individual field site conditions." (California Department of Transportation 2004, I1-I2). Therefore, we investigated each city's individual standards. A few cities that we studied have requirements in their municipal code regarding "no parking" zones at intersections. Most cities, however, have no written standards, so we contacted each city's traffic engineers to ask them what their cities typically require.

Findings

See Table 3.3, for a complete listing of the city standards regarding on-street parking that were gathered. The following is a summary of the key findings:

- The cities contacted have widely varying standards for holding parking spaces back at intersections. Only one city (Walnut Creek) said that it simply follows the MUTCD CA Supplement. A few other cities more or less follow the Supplement, with minor revisions.
- In larger cities with older neighborhoods—which typically have little off-street parking, and thus require that on-street parking be provided—it was found that traffic engineers were more flexible. Berkeley and Sacramento apparently have no consistent standard; Oakland typically requires a 10 to 20 foot "no parking" zone in commercial districts but has no consistent standard in residential districts. A San Francisco traffic engineer explained that the city not only had no minimum parking setback, but that the city had formally challenged the MUTCD California Supplement's requirement with Caltrans, on the grounds that it was not needed at most intersections. However, San Francisco still requires a no parking zone at some intersections on a case-by-case basis, where engineers think it is necessary to do so in order to create clear sight distances.[36]

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[36] Telephone conversation with traffic engineer, City of San Francisco (11 April 2005).

Table 3.3: California City Parking Standards

	Minimum Setback from Curb Return	
City	Approach to Intersection	Departure from Intersection
Berkeley[37]	No consistent standard	No consistent standard
Fremont[38]	20 feet from crosswalk or traffic signal in business districts, or as needed	20 feet from crosswalk or traffic signal in business districts, or as needed
Fresno[39]	12 feet	12 feet
Los Angeles[40]	25 feet from crosswalk, traffic signal, or stop sign; 15 feet from yield sign; 30 feet in a business district; 50 feet on arterials at unsignalized intersections; or as needed	25 feet from traffic signal or stop sign; 15 feet from yield sign; 30 feet in a business district and on arterials at unsignalized intersections; or as needed
Oakland[41]	10 to 20 feet in commercial areas; no consistent standard in residential areas	10 to 20 feet in commercial areas; no consistent standard in residential areas
Pleasanton[42]	20 feet	20 feet
Sacramento[43]	No consistent standard	No consistent standard

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[37] Telephone conversation with traffic engineer, City of Berkeley (28 April 2005).

[38] *Fremont Municipal Code*, Section 3-2908 (undated). Accessed 11 February 2006 <http://www.municode.com/resources/gateway.asp?pid=10734&sid=5>.

[39] Telephone conversation with traffic engineer, City of Fresno (14 April 2005).

[40] *Los Angeles Municipal Code*, Section 80.55 (18 April 2005). Accessed 11 February 2006 <http://www.amlegal.com/nxt/gateway.dll/California/lamc/municipalcode/chapterviiitraffic?f=templates$fn=document-frame.htm$3.0$q=$x=>; Memorandum by John E. Fisher, City of Los Angeles, “Red Curb at Unsignalized Arterial Street Intersections” (7 March 2000).

[41] Telephone conversation with traffic engineer, City of Oakland (14 March 2005).

[42] *City of Pleasanton Standard Details*, Drawing 603 (June 1999). Accessed 11 February 2006 <http://www.ci.pleasanton.ca.us/drawings/603.jpg>.

[43] Telephone conversation with traffic engineer, City of Sacramento (22 March 2005).

	Minimum Setback from Curb Return	
City	Approach to Intersection	Departure from Intersection
San Francisco[44]	None	None
Walnut Creek[45]	30 feet for signalized intersections; 20 feet for unsignalized intersections	20 feet

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[44] Telephone conversation with traffic engineer, City of San Francisco (11 April 2005).
[45] Telephone conversation with traffic engineer, City of Walnut Creek (28 March 2005).

Standards for Newspaper Racks

As with on-street parking, it was hypothesized that newspaper boxes, especially those combined into large racks, could significantly affect visibility; researchers focused on collecting standards related to visibility, particularly the minimum setback required at intersections and the maximum width and height of a group of newspaper racks.

Sources for Standards

When cities regulate newspaper racks, they almost always enact the regulations as part of their municipal codes, rather than placing the regulations in a less formal document. One reason for this may be that newspaper racks are protected to a large extent by the First Amendment; cities can impose narrowly-tailored restrictions on the location and appearance of newspaper racks, but they cannot, for example, ban them citywide, or give city officials unlimited discretion to decide where the racks can be placed.[46] As with signage regulations, which are also subject to First Amendment requirements, the safest course for cities is to regulate newspaper racks judiciously in their municipal codes and be explicit about what is allowed and forbidden, rather than leaving decisions to the discretion of city staff.

Most of the cities for which standards were found have extremely similar requirements for newspaper racks, which is not surprising. Professional experience suggests that cities often borrow legislation from one another, both informally and through formalized channels.[47] The complicated legal issues associated with newspaper racks create extra motivation for cities to reuse existing regulations rather than creating their own from scratch.

Several of the cities examined have ordinances very similar to one provided by the International Municipal Lawyers Association (IMLA). Their Model Ordinance Service, which IMLA updates in installments, includes ordinances that are ready for cities to pass into law with only minor changes. For example, its newspaper rack ordinance includes blanks

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[46] See *City of Lakewood v. Plain Dealer Publishing Co.*, 486 U.S. 750 (1998), in which the United States Supreme Court overturned an ordinance that allowed the mayor of Lakewood, Ohio, to deny a newspaper rack permit application for virtually any reason, or to place an unlimited number and variety of conditions on the granting of a permit.

[47] For a formalized means of sharing ordinances, see the League of CA Cities webpage, http://www.cacities.org/index.jsp: "The League's Inquiry Service collects ordinances, staff reports, surveys and other materials submitted by cities. We make these resources available online so that other city offiicials [sic], dealing with similar issues, may benefit from learning how other cities have addressed a particular concern."

for the city and state names and the cost of a newspaper rack permit. Everything else is provided, including the specific locations where newspaper racks would be prohibited, which are within five feet of a crosswalk, fire hydrant, or driveway, and so on (International Municipal Lawyers Association 2003, 18-1.5).

IMLA provides no justification for any of these specific requirements. It does, however, describe all of the legal precedents that affect how cities can and cannot regulate newspaper racks. The model newspaper rack ordinance is followed by a two-page "editor's commentary" that explains what regulations are allowed and forbidden, according to the opinions of various federal appellate courts (International Municipal Lawyers Association 2003, 18-1.9). Although the commentary is daunting, it at least provides some guidance to cities that want to modify the ordinance. There is no commentary to assist city staff who wonder why newspaper racks should be prohibited within five feet of a police call box, or why five feet is the appropriate number rather than ten or fifteen.

It is likely that the cities surveyed did not get the text of their ordinances from IMLA. Many cities' ordinances included passages that were similar to one another but did not appear in the IMLA ordinance. There is a chicken-and-egg problem as well, since IMLA's model ordinance is itself based on existing city ordinances (International Municipal Lawyers Association 2003, 18-1.9). Still, the fact of the model ordinance's existence suggests that many cities would prefer to adopt legally-proven standards for newspaper racks rather than trying to develop new, innovative regulations.[48]

Findings

See Table 3.4, for a complete listing of the city standards regarding newspaper racks that were gathered. The following is a summary of the key findings:

- Where newspaper racks are regulated, they tend to be regulated in great detail, with explicit standards for height, width, and setbacks from intersections. (Also, minimum setbacks from various objects such as fire hydrants, driveways, etc., are almost always specified, as with street trees. However, those

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[48] In contrast, IMLA's current Model Ordinance Service does not include requirements for street trees or parking locations; most of its model ordinances address newer arenas for regulation, such as the placement of cellular phone equipment. (An earlier incarnation of the Model Ordinance Service attempted to be more comprehensive, and it did, in fact, provide a model ordinance for street trees, although it had only minimal standards for their placement. See NIMLO Model Ordinance on Street Trees.

standards were not collected as this research is focused on regulatory impediments to the planting of trees, not the provision of newspapers.)

- Many cities have few written regulations for newspaper racks, perhaps because the court cases (such as *City of Lakewood*) that clarify how newspaper racks can and cannot be regulated were decided fairly recently.
- Newspaper rack regulations tend to say that the requirements apply only in commercial zoning districts, or in a specified downtown area, presumably because these areas are the only places where cities can justify the added expense of installing pedestal-mounted newspaper racks. (The regulations cited in Table 3.4 are the regulations for each city's downtown or commercial districts.)
- Although setbacks from intersections are usually required, they are much smaller than for street trees, even though newspaper racks are much larger and bulkier. Where marked crosswalks are provided, the required setback is often as little as 3 feet.
- The height of newspaper racks is often restricted, but the maximum height is usually as much as 4 or 5 feet. AASHTO's standards assume that a driver's eye and the object to be seen are 3.5 feet above the surface of the road, but most cities' standards would allow newspaper racks to completely obstruct a 3.5 foot tall object.
- The width of a group of newspaper racks is typically restricted as well, but the maximum width ranges from 5 feet (Berkeley's requirement where angled on-street parking is provided) to 15 feet (Anaheim)—far wider than the trunk of any street tree.
- A traffic engineer in Sacramento—the same city where another traffic engineer described street trees as a "textbook case" of an object that obstructs visibility—told researchers that she had not encountered any line-of-sight issues related to newspaper racks. She noted, however, that newspaper racks are often placed in downtown areas with signalized intersections, where AASHTO's standards for sight distances are more lenient.[49]

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[49] Telephone conversation with traffic engineer, City of Sacramento (5 May 2005).

Table 3.4: California City Newspaper Rack Standards

City	Minimum Setback from Curb Return	Maximum Size for a Group of Newsracks		Required Distance from Curb (if placed near curb)	Maximum Distance from Property Line (if placed near property line)
		Width	Height		
Anaheim[50]	15 feet	15 feet	4 feet	1.5 to 2 feet	0.5 feet
Berkeley[51]	Prohibited "within the area defined by the sidewalks intersecting at…street corners" and within 5 feet of crosswalk	Near parallel parking: 9 feet. Near angled parking: 5 feet.	4.5 feet	1.5 feet (minimum)	Not specified
Concord[52]	From marked crosswalk: 3 feet. From unmarked crosswalk: 15 feet.	Not specified, but newsracks must be "standard type"	Near intersections: 3 feet. All other locations: 5 feet.	1.5 to 2 feet	0.5 feet
Fremont[53]	Allowed only on private property, and must not "create an unsafe condition."				
La Quinta[54]	From marked crosswalk: 5 feet. From unmarked crosswalk: 15 feet.	12.5 feet	4 feet	Near red curbs: 1.5 feet (minimum). Elsewhere: 3 feet (minimum).	1.5 feet

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[50] *Anaheim Municipal Code*, Section 4.82.040 (2001). Accessed 12 February 2006 <http://www.amlegal.com/nxt/gateway.dll/California/anaheim/title4businessregulation/chapter482newsracksonpublicrights-of-way?f=templates$fn=document-frame.htm$3.0>.

[51] *Berkeley Municipal Code*, Section 16.40.080 (1996). Accessed 12 February 2006 <http://www.ci.berkeley.ca.us/bmc/Berkeley_Municipal_Code/Title_16/40/080.html>.

[52] *Concord Municipal Code*, Sections 90-133 and 90-134 (undated). Accessed 12 February 2006 <http://www.ci.concord.ca.us/citygov/municode/chapter090.htm>.

[53] *Fremont Municipal Code*, Section 8-21202 (2004). Accessed 12 February 2006 <http://library2.municode.com/mcc/DocView/10734/1/228/240/257>.

[54] *La Quinta Municipal Code*, Section 14.16.462 (1982). Accessed 12 February 2006 <http://www.qcode.us/codes/laquinta/view.php?topic=14-14_16-14_16_462>.

		Maximum Size for a Group of Newsracks			
City	Minimum Setback from Curb Return	Width	Height	Required Distance from Curb (if placed near curb)	Maximum Distance from Property Line (if placed near property line)
Long Beach[55]	From marked crosswalk: 3 feet. From unmarked crosswalk: 15 feet.	7.5 feet	5 feet	1.5 to 2 feet	0.5 feet
Los Angeles[56]	Requirements exist, but they are not yet enforced and are available only by visiting the Office of the City Clerk in person.				
Pleasanton[57]	3 feet from marked crosswalk (or from curb return, if crosswalk is unmarked)	12 feet	5 feet	0.5 feet (maximum, from back of planter strip)	0.5 feet
Sacramento[58]	Not regulated in Municipal Code, and the Division of Traffic Engineering and Transportation Planning, Department of Transportation, has not seen line-of-sight issues with newspaper racks.				
San Diego[59]	From marked crosswalk: 3 feet. From unmarked crosswalk: 12 feet.	10 feet	5 feet	1.5 to 2 feet	0.5 feet
San Francisco	Standards exist, but Department of Public Works staff did not respond to repeated requests for a copy.				

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[55] *Long Beach Municipal Code*, Section 14.20.040 (2004). Accessed 12 February 2006 <http://www.longbeach.gov/apps/cityclerk/lbmc/title-14/chapter-14-20.htm>.

[56] Telephone conversation with administrative assistant, Office of the City Clerk, City of Los Angeles (25 March 2005).

[57] *City of Pleasanton Standard Details*, Drawings 601B and 601C (2002). Accessed 12 February 2006 <http://www.ci.pleasanton.ca.us/drawings/601b.jpg; http://www.ci.pleasanton.ca.us/drawings/601c.jpg>.

[58] Telephone conversation with traffic engineer, City of Sacramento (5 May 2005).

[59] *San Diego Municipal Code*, Section 62.1005 (1996). Accessed 12 February 2006 <http://clerkdoc.sannet.gov/legtrain/mc/MuniCodeChapter06/Ch06Art02Division10>.

City	Minimum Setback from Curb Return	Maximum Size for a Group of Newsracks		Required Distance from Curb (if placed near curb)	Maximum Distance from Property Line (if placed near property line)
		Width	Height		
San José[60]	From marked crosswalk: 5 feet. From unmarked crosswalk: 15 feet.	8 feet	5 feet	1.5 to 2.5 feet	0.5 feet
Santa Rosa[61]	6 feet	Not specified	Not specified	Not specified	Not specified
Walnut Creek[62]	Not regulated in Municipal Code. City is in the process of drafting an ordinance.				

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[60] *San José Municipal Code*, Section 13.18.045 (undated). Accessed 12 February 2006 <http://www.amlegal.com/nxt/gateway.dll/California/sanjose/title13streetssidewalksandpublicplaces/chapter1318regulationofnewsracks?f=templates$fn=document-frame.htm$3.0>.

[61] City of Santa Rosa, City Council, "Council Policy 100-06: Standards for Newspaper Vending Machines" (1987).

[62] Telephone conversation with planner, City of Walnut Creek (7 April 2005).

Conclusions

Most of the California cities studied impose greater restrictions on street trees near intersections than on parking spaces or newspaper racks, however the minimum required set-backs for street trees are generally less than would be required if a strict interpretation of AASHTO recommendations was followed. The range of required distances from intersections for trees ranged from 15 to 50 feet among the 17 cities for which data was gathered. Interesting, only three of the 17 cities, San Francisco, San Diego, and Walnut Creek, have written requirements for tree pruning height, a physical reality that is more critical than tree trunks in terms of blocking views.

In the case of parked cars, cities are less strict—they often allow parking spaces much closer to intersections than recommended by Federal and State standards, either because of pragmatic concerns about providing adequate on-street parking or because of a genuine belief that parked cars do not obstruct visibility for drivers.

Requirements for newspaper racks impose height limits and setbacks from intersections, but the height limits in particular are so lenient, generally heights of four to five feet are allowed, that they do little to preserve visibility for drivers.

Many standards reflected attempts to ensure safety, simplify maintenance, or—in the case of newspaper racks—protect freedom of the press. However, the quality and character of a street that meets these standards was at best an afterthought, when it was thought of at all. A few arborists stated explicitly that the standards make it impossible to replicate their city’s most delightful streets and neighborhoods. In Sacramento, whose older neighborhoods are known for their dense urban forest, maintenance concerns have led the city to require wider spacing when it plants new trees.[63] In Pleasanton, an arborist said that heritage street trees are allowed to remain in places where a new tree would never be permitted.[64]

An urban designer who wanted to challenge a city’s requirements regarding street trees at intersections would generally be hard pressed to do so. Many cities rely on rules of thumb and case-by-case judgments rather than written standards, especially for the planting of street trees. Even when published standards exist, finding them is a time-consuming chore. What’s more, as was discovered in the case of Oakland’s standards for street trees, city staff may impose requirements that differ from the city’s published standards.

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[63] Telephone conversation with arborist, City of Sacramento (5 May 2005).

[64] Telephone conversation with arborist, City of Pleasanton (7 March 2005).

CHAPTER 4

THE DIGITAL MODELS, DRIVE-THROUGH SIMULATIONS, AND AREAS OF VISIBILITY

Following the reviews of AASHTO's clear sight triangle recommendations and how a sampling of California cities apply those recommendations, decisions were made regarding what digital models to create to show a range of possible placements of trees, parked cars, and newspaper racks near intersections. Once the digital models configurations were determined, further decisions were made about how to animate each model in order to create drive-through simulation videos for showing to "human subjects," in order to test the visibility impacts of the different configurations. These decisions were no easy matter as there were many possibilities.

An early decision made was to create the digital models using Maya, a powerful 3D modeling, animation and rendering program designed by Alias Systems Corporation. It is widely used in the video game and film industries, since it lends itself to creating realistic environments and accurately portraying the interaction of objects in real time. These characteristics made it the ideal program for developing realistic intersection models and video simulations. However, the realism and accuracy benefits had a downside in that Maya is a highly complex and time-consuming program to work with. Realistic three-dimensional streetscape elements, surfaces textures, and scene lighting needed to be created, along with moving cars (complete with turning wheels so as to not look artificial) and a car interior. Animating the scene in accurate real time—both for moving cars and driver head-turning in a smooth arc (discussed later)—required intensive mathematical precision. And, producing each video took days of frame-by-frame rendering on a dedicated powerful computer. Budget limitations dictated that only a limited number of models and animations could be made.

The Digital Models

The AASHTO analysis indicated that the most important type of intersection to test was a minor road/major road intersection with the minor road controlled by stop signs. To keep things simple, a single base intersection with constant street rights-of-way, travel lane, parking lane, and sidewalk widths, was created for use in all the models. The dimensions used for these constants correspond to the "typical" urban street cross sections discussed in Chapter Two. (See pages 26–32.) Both the major road design speed and the grade of the minor road (things which would affect the AASHTO intersection sight distance calculation) were also kept constant. The numbers used for these were the same as those used in the Chapter Two examples. To reiterate: the design speed is 35 mph; the minor road approach grade is 3% or less. (See pages 26–32.)

Other constants included the location of building lines; location of stop signs; intersection corner radii; crosswalk size and configuration; tree species, height, spread, pruning height, and proximity to curb face; parking lane length; make of parked vehicles; make of moving vehicles; and newspaper rack width, height, and proximity to curb face. See Table 4.1 for dimensions and other information related to each common streetscape element and where the dimensions come from. (Note that it was decided to place parked cars in all on-street parking spaces and to make them all SUVs in order to represent a worst case scenario. Parking spaces, once made available, are open to have any kind of vehicle parked in them. Given the high number of SUVs on American city streets, the likelihood of a whole row of them is not far-fetched.)

The model variables were the setback and spacing of sidewalk trees, the setback of parked cars, and the placement of newspaper racks. See Tables 4.2, 4.3, 4.4, and 4.5 for dimensions and other information related to each variable streetscape element and where the dimensions come from. Four models with different variable configurations were created, as follows: 1) AASHTO Recommended Standards—Suburban Decision Point Scenario, 2) AASHTO Recommended Standards—Urban Decision Point Scenario, 3) Oakland Standards Scenario, and 4) Urban Design Preferred Scenario.

The AASHTO, Oakland and Urban Design Preferred models differ from one another in terms of parking setbacks, street tree setbacks, and tree spacing.[65] The AASHTO models use the same newspaper rack setback, while the other two use different ones. In the Urban Design Preferred model the central median is brought to the intersection and the left turn lane is eliminated. The AASHTO and Oakland models include mailboxes near the intersection, whereas these are eliminated from the Urban Design Preferred model.

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[65] Note that in all the digital models, when the street and parking setbacks used were based upon AASHTO recommendations, the *largest* tree or parking setback required for either side of the intersection was used for both sides (i.e., the recommended setbacks that would apply to the left side of the intersection were also used for the right side). This was done because in practice designers often wish to create symmetrical arrangements around intersections.

Table 4.1: Constant Dimensions and Elements for All Digital Models

Both Streets		
Element	*Location/Dimension/Type*	*Source or Rationale*
Building line	At the edge of the R.O.W.	Typical urban condition
Curb radius	10’	Typical urban condition
Travel lane width	11’	Typical urban condition
Crosswalk width	10’	Oakland Standard Details (T-3)
Tree species	London Plane	Common urban street tree
Tree height	37’-6”	Low end of size range for mature Lond Trees (Sunset Western Garden Book). Urban street trees seldom achieve full
Tree spread	25’	Low end of size range for mature Lond Trees (Sunset Western Garden Book). Urban street trees seldom achieve full
Tree trunk diameter	1’	Field observation of typical trunk diame young mature London Plane street tre
Tree branching height	14’	Height specified by the cities of San Di San Francisco and Walnut Creek
Tree well configuration	4’x4’	Typical urban condition
Tree distance from outside face of curb	2’-6”	Based on tree well size
Make of parked vehicles	Volvo XC90	Mid-sized SUV
Make of moving vehicles	BMW X3	3-dimensional model available
Newspaper rack setback	5’ from crosswalk or 15’ from curb return	IMLA Model Newspaper rack Ordinanc (Sections 18-109.a.4.i, 18-109.a.4.ii)
Newspaper rack distance from curb	1’-6”	Many cities (For instance, San Jose M Code, Section 13.18.045.C.1)
Newspaper rack configuration	6’-7” wide x 5’ tall	Height: IMLA Model Newspaper rack C Section 18-110.a; Width: IMLA Section 18-109.a.3 specifies 8’ max

Major Street (100’ wide)		
Element	*Location/Dimension/Type*	*Source or Rationale*
Sidewalk width	14’	Typical urban condition
Parking lane width	8’	Typical urban condition
Central median width	12’	Typical urban condition
Left turn lane width (where occurs)	10’ (i.e., 2’ median remains)	Typical urban condition
Crosswalk location	Back aligned with curb return	Oakland Standard Details (S-4)
Turn arrow configuration	6’x8’	FHWA 2004 Standard Highway Signs, English Edition, page 10-10.

Minor Street (60’ wide)		
Element	*Location/Dimension/Type*	*Source or Rationale*
Sidewalk width	10’	Typical urban condition
Parking lane width	9’	Typical urban condition
Crosswalk location	Align front with cross street curb face	Typical urban condition
Stop sign location	At curb return, 1’-6” in from outside face of curb	Oakland field observations

Model #1 AASHTO Recommended Standards—Suburban Decision Point Scenario

This model represents a conservative interpretation of AASHTO recommendations regarding tree setbacks, combined with a more "real world" approach to parking setbacks and newspaper rack locations that derives for the analysis of city standards. (*Note: It was decided not to model an intersection in which all three elements—trees, parked cars, and newspaper racks—were eliminated from the AASHTO recommended clear sight triangles because there is no question about clear intersection sight distances with that configuration. For the two AASHTO Recommended Standards models, it was decided to eliminate trees from the sight triangle rather than the other elements, because the review of how California cities apply AASHTO recommendations found that trees tend to be more restricted than the other elements.)* The decision point is set 14.5 feet back from the curb edge, which means ISD = 465. (See the Hypothetical "Typical" Urban Intersection Example A on page 26 of this report.)

Table 4.2: Model #1 Dimensions (AASHTO Recommended Standards—Suburban Scenario)

Element	*Location/Dimension/Type*	*Source or Rationale*
Street tree setback	190'-10" from curb return (See Figure 2.5)	AASHTO sight triangle
Street tree spacing	50' on center	As AASHTO doesn't specify tree spacing, the widest spacing requirement imposed by any of the cities studied was used
Parking setback	20' from crosswalk or curb return	MUTCD 2003 California Supplement, page 3B-23
Newspaper rack setback	5' from crosswalk or 15' from curb return	IMLA Model Newspaper Rack Ordinance (Sections 18-109.a.4.i, 18-109.a.4.ii)

Model #2: AASHTO Recommended Standards—Urban Decision Point Scenario

This model is a slight variation on the previous one, in that the decision point (in terms of figuring the time gap for AASHTO's equation) is set 14.5 feet back from the edge of the near travel lane, which means ISD = 440 feet. (See the Hypothetical "Typical" Urban Intersection Example B on page 29 of this report.)

Table 4.3: Model #2 Dimensions
(AASHTO Recommended Standards—Urban Decision Point Scenario)

Element	*Location/Dimension/Type*	*Source or Rationale*
Street tree setback	87'-9" from curb return (See Figure 2.6)	AASHTO sight triangle
Street tree spacing	50' on center	As AASHTO doesn't specify tree spacing, the widest spacing requirement imposed by any of the cities studied was used
Parking setback	20' from crosswalk or curb return	MUTCD 2003 California Supplement, page 3B-23
Newspaper rack setback	5' from crosswalk or 15' from curb return	IMLA Model Newspaper Rack Ordinance (Sections 18-109.a.4.i, 18-109.a.4.ii)

Model #3: Oakland Standards

This model represents how a San Francisco Bay Area city interprets AASHTO recommendations regarding intersection sight distance. As with Model #2, the decision point (in terms of figuring the time gap for AASHTO's equation) is set 14.5 feet back from the edge of the near travel lane, which means ISD = 440 feet. (See the Hypothetical "Typical" Urban Intersection Example B on page 29 of this report.)

Table 4.4: Model #3 Dimensions
(Oakland Standards)

Element	*Location/Dimension/Type*	*Source or Rationale*
Street tree setback	20'	Personal conversation with arborist, Public Works Agency, City of Oakland, 03/17/2005
Street tree spacing	35' on center	City of Oakland 1998 Street Tree Plan, page 5
Parking setback	20' from crosswalk or curb return	MUTCD 2003 California Supplement, page 3B-23
Newspaper rack setback, major street	Centered between first two trees, 34'-2" from curb return	As close to IMLA Model Newspaper Rack Ordinance (Sections 18-109.a.4.i, 18-109 possible, but adjusted due to tree location
Newspaper rack setback, minor street	5' from crosswalk or 15' from curb return	IMLA Model Newspaper rack Ordinance (Sections 18-109.a.4.i, 18-109.a.4.ii)

Model #4: Urban Design Preferred

This model represents an interpretation of AASHTO recommendations that allows street trees to occur within the clear sight triangles, but excludes parked cars from them. The trees start at the curb return (so that they line up with the building edge) and are more closely spaced than on the other models in order that they will create a continuous canopy. These design moves would help create a better pedestrian environment along the sidewalk. As with Models #2 & #3, the decision point (in terms of figuring the time gap for AASHTO's equation) is set 14.5 feet back from the edge of the near travel lane, which means ISD = 440 feet. (See the Hypothetical "Typical" Urban Intersection Example B on page 29 of this report.)

Table 4.5: Model #4 Dimensions
(Urban Design Preferred)

Element	*Location/Dimension/Type*	*Source or Rationale*
Street tree setback, major street	At curb return	Aligns with building edge
Street tree setback, minor street	3' from curb return (5' from stop sign)	Aligns with building edge
Street tree spacing	25' on center	Maximum spacing that would still achieve a continuous tree canopy
Parking setback	260'-2" (See Figure 2.6)	AASHTO sight triangle kept clear
Newspaper rack setback	Centered between first two trees, 12'-7" from curb return	As close to IMLA Model Newspaper Rack Ordinance (Sections 18-109.a.4.i, 18-109 possible, but adjusted due to tree location

The Drive-Through Simulations

After the models were created, decisions were made regarding how the simulations would be set up. The simulations needed to present a realistic scene and yet also provide a testable experience for the people (the "human subjects") who would view them in the controlled experiments. The most straight-forward test—and one that did not require too long of an animation, thereby keeping video rendering time to a minimum—was to test when a "driver" (the person watching the video) could see a particular car as it approached the intersection. The intent was to determine if the "driver" could first see the "test" car before or after it entered the area of the AASHTO recommended clear sight triangle, and moreover to pinpoint how far from the intersection the car was when first seen. In order for the "test" car to stand out from other cars moving along the major street (included for realism), it would be colored red while the others would be a neutral color.

The simulations would, of course, represent the point of view of the driver on the minor road. The video begins with the driver approaching the intersection, while several cars (going 35 mph) traveled by on the major street and a car approached from the opposite direction on the minor road. The driver comes to a stop, and then looks for appropriate gaps in traffic—first to the left and then to the right—that will allow her/him to move into the intersection.

The camera representing the driver's point of view is placed within the interior of a simulated Volkswagen Golf, set at the mid-point of the driver's seat headrest, which puts it at 3.75 feet off the ground. (Note that this means that for the simulation the driver's eye height is 3-inches higher than the AASHTO assumed height of 3.5 feet off the ground. It was decided to use this actual height, rather than the AASHTO assumed height, because it was more realistic.) In all four animations, the Golf drives along the minor street, pulls up to the intersection and comes to a stop when the driver is 28' from the center line of the first travel lane (frame 00206/second 6.86667). At this point, the front bumper of the car intrudes slightly into the crosswalk. (Based on AASHTO's previously mentioned assumptions about typical U.S. car configurations, if a bigger car with a longer front had been used for the simulation, the car would have intruded as much as 3.5 feet into the crosswalk.) Upon stopping, the driver looks to the left, completing the rotation of the camera at frame 00326/second 10.86667, when she/he is looking toward the tip of the AASHTO recommended sight triangle. After this point, the simulation for the AASHTO Recommended Standards—Suburban model differs from the other three models, and will be discussed first.

AASHTO Recommended Standards—Suburban Scenario Simulation:

In this animation, the driver's ability to see anything in the intersection is severely constrained because the view is mainly of the corner building. Rather than moving forward to get a better view, the driver simply looks to the right, where the view is constrained by the other corner building. The specifics of the animation are as follows:

- The first red test car (which has been waiting 660 feet away from the intersection) starts moving left to right at frame 00505/second 16.83333.
- The driver starts turning to look to the right at frame 00900/second 30.00000, completing the rotation at frame 01200/second 40.00000. The second test car starts moving right to left at the same moment.
- The driver starts looking back to the center of the scene at frame 01588/second 52.93333, completing the rotation at frame 01708/second 56.93333.
- The simulation ends at frame 01729/second 57.63333.

This animation clearly shows that interpreting AASHTO's wording "the edge of the major-road traveled way" to mean the curb edge, and setting the decision point accordingly, doesn't work in typical urban situations where buildings are at the property line and the major road has parking lanes. That is, the driver can't see on-coming cars because the view is blocked by buildings. This is a major finding of the research. It meant, however, that it didn't make sense to test this video simulation in the controlled experiments, as will be discussed in the following chapter.

AASHTO Recommended Standards—Urban Simulation, Oakland Standards Simulation, and Urban Design Preferred Simulation:

In these animations, multiple-step stops were tested; first a two-step stop and then a three-step stop. Such stops, it was felt, correspond better with actual driver behavior in urban situations than a simple one-step stop.

After first stopping 28 feet from the centerline of the first cross-traffic lane and looking to the left for a gap in traffic, the driver almost immediately pulls 8 feet closer to the intersection to get a better view. The driver's eye is now 14.5 feet back from the edge of the first travel lane (in keeping with how the decision point and hence the sight triangles were set for the first two of these models), and the front bumper of the car extends halfway into the parking lane. (If a bigger car with a longer front end had been used for the simulation, the car's bumper would now be as much as 1.5 feet beyond the crosswalk.) After awhile, the red "test" car goes by. Then, while still looking to the left, the driver pulls another 6 feet closer to the intersection to obtain an even better view. (This three-step stop represents often observed real world driver behavior.) The driver's eye is now 8.5 feet back from the edge of the first travel lane, and the car bumper is more than halfway into the parking lane. (If a bigger car had been used, the car's bumper would now be as little as 6 inches away from the edge of the travel lane.) After awhile, a second red test car goes by. Then the driver looks to the right for a gap in traffic. After awhile, a third red test car goes by. The specifics of the animation are as follows:

- The driver pulls forward 8' closer to the intersection at frame 00345/second 11.50000, completing the movement at frame 00405/second 13.50000.
- The first test car (which has been waiting 660 feet away from the intersection) starts moving left to right at frame 00505/second 16.83333.

- The driver pulls forward again, 6’ closer to the intersection, at frame 00920/second 30.66667, completing the movement at frame 00965/second 32.16667. The second test car (which has been waiting 660 feet away from the intersection) starts moving left to right at the same moment.
- The driver starts looking to the right at frame 01330/second 44.33333, completing the rotation at frame 01630/second 54.33333. The third test car (which has been waiting 660 feet away from the intersection) starts moving right to left at the same moment.
- The driver starts looking back to the center of the scene at frame 01950/second 65.00000, completing the rotation at frame 02070/second 69.00000.
- The simulation ends at frame 02080/second 69.33333.

The four animations described above were rendered as videos for use in the experiments described in the following chapter.

CHAPTER 5

THE EFFECTS OF STREET TREES AND OTHER OBJECTS ON VISIBILITY AT INTERSECTIONS

Experiments were run at UC Berkeley's Experimental Social Science Laboratory (XLab) utilizing the drive-through simulation videos described in the previous chapter. A total of ninety-six people in eight separate groups of between seven and eighteen individuals took part in the experiments. The experimentation process and results are described below.

The Drive-Through Simulation Video Experiment Procedures

Spaced evenly in a quiet room, each participant used a laptop computer that utilized Windows operating software and had an external mouse attached. Participants were given both verbal and written descriptions about the general purpose of the research and the content of the videos. They were also given verbal instructions about how to operate the RealPlayer video program on which the videos would run, and were asked to be silent during the experiments so as to not distract their neighbors. Participants were instructed to press the pause button the moment they saw a red car appear in a video, to write on a provided form the elapsed video time associated with each pause (in minutes, seconds, and milliseconds)—this time appeared on a clock within the RealPlayer window—and then to start the video again and repeat the steps until the video ended. (The form, which includes the written project description, can be found in the Appendix, Form A.1.)

Before starting the actual experiments for each session, a test-run was conducted so that participants could familiarize themselves with the video player operations and the process of spotting red cars, pausing the video, and writing down the elapsed video time. The AASHTO Recommended Standards – Suburban Decision Point Scenario video was used for the test-run because this scenario, which combined an at-the-property-edge building line with a decision point set 14.5 feet back from the curb edge, resulted in the driver's view of the major road roadway being completely blocked by the building line, and hence no red car appearing until the very end of the video when the driver is looking straight ahead. While the utility of knowing that participants cannot see the car until the end of the video was not particularly high, it was important to familiarize individuals with a video that contained the same basic visual elements as the other simulations. Not unimportantly, the test-run also allowed the opportunity to isolate out any computers that may have had operating errors that day. Participants were encouraged to view the test-run video multiple times to make sure they understood how the experiments would work.

Once all the participants were ready to begin, the actual experiments were conducted using the remaining three video simulations. The laptops were pre-programmed so that a given video would begin simultaneously on all computers. In order to allow time for pausing, writing, and, if needed, changing computers, the videos were set up to run at ten-minute interval, always in the same order. Unlike the test-run video, participants were only allowed to watch these videos once. The first video shown was the AASHTO Recommended Standards – Urban Decision Point Scenario simulation, followed by the Oakland Standards simulation, then the Urban Design Preferred simulation (i.e., the simulations for Models 2, 3, and 4 described in Chapter 4). Each of these videos was 69.4 seconds in length.

Two individuals, an XLab technical expert and an assistant to Dr. Macdonald, supervised the participants while they were taking part in the experiments in order to make sure that they were all able to complete viewing each video and to ensure that nothing was going wrong that the participants themselves might not notice. In addition, a backup screen-capture video program running on each computer recorded individual participants' pause times. These back-up videos were created as a second point of reference in case problems developed with the self-reporting of the elapsed video times associated with each pause. Such problems did not develop, and so the screen capture videos were not in the end necessary.

The Drive-Through Simulation Video Experiment Results

All of the sessions ran with virtually no technical problems. Participants were all familiar with the software and every one was able to take part in the experiments fully.

Following the completion of all eight experiment sessions, participants' self-reported pause times were compiled and analyzed. The pause times represent how long the video had been playing (i.e., the elapsed video time) at the moment the pause button was pressed.

The average and median elapsed video times at which participants saw the test cars and pressed the pause button are shown in Table 5.1. (The individual results for each participant can be found in the Appendix, Table Set A.1.)

Table 5.1: Elapsed Time from the Start of Each Video for Viewers to See Test Cars Approaching the Intersection and Press the Pause Button

	Elapsed Video Time (in seconds)	
	Average	Median
Video 1: AASHTO Recommended Standards – Urban Decision Point Scenario		
Test Car 1	30.3	30.1
Test Car 2	44.3	43.9
Test Car 3	65.2	65.0
Video 2: Oakland Standards		
Test Car 1	30.7	30.8
Test Car 2	44.1	43.8
Test Car 3	63.8	63.7
Video 3: Urban Design Preferred		
Test Car 1	25.4	25.2
Test Car 2	40.2	40.0
Test Car 3	57.7	57.9

Using the formulas shown in Table 5.2, the data on the elapsed video time associated with each pause was converted into the distance from the intersecting street each test car was when the pause button was pressed (i.e., how far it was from the centerline of the minor road travel lane in which the viewing “driver” is situated, which corresponds with where AASHTO recommends placing the short edge of the clear sight triangle). One formula was used to calculate the distances for the first test cars in all three videos, another for the second test cars, and another for the third test cars.

Table 5.2: Formulas Used to Convert the Elapsed Video Times at which Test Cars were Seen into Distances from the Intersection the Test Cars were when the Pause Button was Pressed

Videos 1, 2, and 3	Conversion Formula
Position of Test Car 1	$D_{feet} = ((660-(T_{seconds}-16.83)*51.3)+5.5)$
Position of Test Car 2	$D_{feet} = ((660-(T_{seconds}-32.18)*51.3)+5.5)$
Position of Test Car 3	$D_{feet} = ((660-(T_{seconds}-54.33)*51.3)-5.5)$

These formulas convert the elapsed video time in seconds ($T_{seconds}$) into the distance from the centerline of the minor road travel lane in feet (D_{feet}). The formulas take into account the distance away from the centerline of the intersection at which the test car is situated when it begins to move (660 feet), the elapsed video time at which the test car begins to move (Car 1: 16.83 seconds; Car 2: 32.18 seconds; Car 3: 51.3 seconds), the speed at which the test car is traveling (51.3 feet per second, i.e. 35 miles per hour), and the distance from the centerline of the intersection to the centerline of the minor road travel lane where the viewing "driver" is situated (5.5 feet). Since test cars 1 and 2 come from the left, the formulas associated with them add the last distance, while for test car 3, which comes from the right, it is subtracted. The average and median distance from the intersecting street for each of the three videos are shown in Table 5.3. (The individual results for each participant can be found in the Appendix, Table Set A.2.)

Table 5.3: Average and Median Distances from Intersecting Street at which Test Cars Were Seen

	Distance From the Centerline of the Travel Lane of the Minor Intersecting Street (in Feet)*	
	Average	Median
Video 1: AASHTO Recommended Standards – Urban Decision Point Scenario		
Test Car 1	-23.7	-15.3
Test Car 2	45.5	64.3
Test Car 3	95.6	107.1
Video 2: Oakland Standards		
Test Car 1	-47.8	-51.2
Test Car 2	53.5	69.4
Test Car 3	168.5	173.8
Video 3: Urban Design Preferred		
Test Car 1	225.1	236.1
Test Car 2	254.2	264.3
Test Car 3	482.1	471.4

* Positive numbers mean distance *before* the intersection; negative number mean distance *after* the intersection.

Video 1: AASHTO Recommended Standards—Urban Decision Point Scenario

The first video viewed was the AASHTO Recommended Standards – Urban Decision Point Scenario drive-through simulation (Model #2). The average elapsed time after the start of the video that participants needed to see the first red test car and press the pause button was 30.3 seconds. With the exception of one outlier time of 52 seconds, response times ranged from 22.6 seconds to 32.2 seconds. The median time to seeing the first car and pressing the pause button was therefore slightly less, 30.1 seconds. In terms of distances, this means that, on average, participants pressed the pause button when the first test car was 23.7 feet past the centerline of the lane in which s/he was situated. While individual participants pressed the pause button when the red test car was in positions ranging from 369.5 feet before the centerline of the minor road travel lane to 123 feet beyond it, the greatest number of subjects (the median number) pressed the pause button when the car was 15.3 past the centerline of the minor road travel lane.

Participants saw the second red test car and pressed the pause button an average of 44.3 seconds into the video. With the exception of one outlier time of 64 seconds, response times ranged from 42.5 seconds to 46.3 seconds. The median time to seeing the second red test car and pressing the pause button was 43.9 seconds. This means that, on average, drivers pressed the pause button when the second red test car was 45.5 feet before the centerline of the minor road travel lane. While individual participants pressed the pause button when the red test car was at positions ranging from 136.1 feet before them to 58.9 feet past them, the greatest number of subjects pressed the pause button when this car was 64.3 feet before the centerline of the minor road travel lane.

Participants saw the third red test car and pressed the pause button an average of 65.2 seconds into the video. Response times ranged from 63.5 seconds to 68.3 seconds. The median time to seeing the third red test car and pressing the pause button was 65.0 seconds. This means that, on average, drivers pressed the pause button when the third red test car was 95.6 feet before their point at the centerline of the intersection. While individual participants saw the car and pressed the pause button when the car was in positions ranging from 184.1 feet before them to 61.2 feet past them, the greatest number of subjects pressed the pause button when this car was 107.1 feet before the centerline of the minor road travel lane.

Video 2: Oakland Standards

The second video viewed was the Oakland Standards drive-through simulation (Model #3), which represents how a San Francisco Bay Area city interprets AASHTO recommendations. Response times were generally somewhat faster for this video than the first video. The average elapsed time after the start of the video that participants needed to see the first red test car and press the pause button was 30.7 seconds. With the exception of one outlier time of 44.7 seconds, response times ranged from 22.5 seconds to 32 seconds. However, the median time to seeing the first car and pressing the pause button was very close to the average, 30.8

seconds. In terms of distances, this means that, on average, participants pressed the pause button when the first test car was 47.8 feet past the centerline of the minor road travel lane. While individual participants pressed the pause button when the red test car was in positions ranging from 374.6 feet before the centerline of the minor road travel lane to 112.7 feet beyond it, the greatest number of subjects pressed the pause button when the car was 51.2 past the centerline of the minor road travel lane.

Participants saw the second red test car and pressed the pause button an average of 44.1 seconds into the video. With the exception of one outlier time of 64.7 seconds, response times ranged from 43.1 seconds to 49.9 seconds. The median time to seeing the second red test car and pressing the pause button was 43.8 seconds. This means that, on average, drivers pressed the pause button when the second red test car was 53.5 feet before the centerline of the minor road travel lane. While individual participants pressed the pause button when the red test car was at positions ranging from 105.3 feet before them to 243.5 feet past them, the greatest number of subjects pressed the pause button when this car was 69.4 feet before the centerline of the minor road travel lane.

Participants saw the third red test car and pressed the pause button an average of 63.8 seconds into the video. With the exception of one outlier time of 68.9 seconds, response times ranged from 63.3 seconds to 64.9 seconds. The median time to seeing the third red test car and pressing the pause button was 63.7 seconds. This means that, on average, drivers pressed the pause button when the third red test car was 168.5 feet before their point at the centerline of the intersection. While individual participants saw the car and pressed the pause button when the car was in positions ranging from 194.3 feet before them to 112.3 feet before them, the greatest number of subjects pressed the pause button when this car was 173.8 feet before the centerline of the minor road travel lane.

Video 3: Urban Design Preferred

The third video viewed was the Urban Design Preferred drive-through simulation (Model #4), which represents an interpretation of AASHTO recommendations that allows street trees to occur within the clear sight triangles, but excludes parked cars from them. Response times for this video were the fastest overall. The average elapsed time after the start of the video that participants needed to see the first red test car and press the pause button was 25.4 seconds. Response times ranged from 24.6 seconds to 28 seconds. However, the median time to seeing the first car and pressing the pause button was very close to the average, 25.2 seconds. In terms of distances, this means that, on average, participants pressed the pause button when the first test car was 225.1 feet before the centerline of the minor road travel lane. While individual participants pressed the pause button when the red test car was in positions ranging from 266.9 feet to 92.5 feet before the centerline of the minor road travel lane, the greatest number of subjects pressed the pause button when the car was 236.1 before the centerline of the minor road travel lane.

Participants saw the second red test car and pressed the pause button an average of 40.2 seconds into the video. Response times ranged from 39.3 seconds to 43.2 seconds. The median time to seeing the second red test car and pressing the pause button was 40 seconds. This means that, on average, drivers pressed the pause button when the second red test car was 254.2 feet before the centerline of the minor road travel lane. While individual participants pressed the pause button when the red test car was at positions ranging from 300.2 feet before them to 100.2 feet past them, the greatest number of subjects pressed the pause button when this car was 264.3 feet before the centerline of the minor road travel lane.

Participants saw the third red test car and pressed the pause button an average of 57.7 seconds into the video. Response times ranged from 53.1 seconds to 62.3 seconds. The median time to seeing the third red test car and pressing the pause button was 57.9 seconds. This means that, on average, drivers pressed the pause button when the third red test car was 482.1 feet before their point at the centerline of the intersection. While individual participants saw the car and pressed the pause button when the car was in positions ranging from 717.6 feet before them to 245.6 feet before them, the greatest number of subjects pressed the pause button when this car was 471.4 feet before the centerline of the minor road travel lane.

Reaction Time Corrections

When considering the above results, including the apparent anomaly that some of the test cars were not “seen” until after they were beyond the intersection, and, more importantly the differences between the distances away from the intersection at which the test cars were “seen” versus the AASHTO recommended intersection sight distance of 440 feet for the roadway configurations that were modeled in this research (see Figure 2.6), it is important to understand that the experiment results contain reaction time deficits. In other words, they contain time-lags between when each participant saw the test car and when s/he pressed the pause button.

Determining an appropriate reaction time correction is no easy matter, even for controlled laboratory experiments, because individual reaction times to any given stimuli are determined by a complex combination of components—individual mental processing time, expectation regarding the potential need to react, sense of urgency, cognitive load, age, gender, the nature of the stimuli, visibility, and the complexity of the necessary response—and therefore can vary considerably (Green 2000). The standard reaction time number used in traffic accident reconstruction analysis is 1.5 seconds (Green 2000). Data from somewhat dated but still commonly referenced driver behavior studies in which drivers were alert and expected to apply their brakes suggests that individual brake reaction time under these conditions varies from 0.4 to 1.7 seconds (Massachusetts Institute of Technology 1935; Normann 1953; Johansson and Rumar 1971.) With the goal of encompassing the reaction times of nearly all drivers under actual highway conditions, rather than laboratory conditions, the standard brake reaction time used by AASHTO in its formulas is 2.5 seconds (AASHTO 2001, 111).

It was beyond the scope of this research project to determine the individual reaction times of each of the participants. So, the commonly used standard reaction time number of 1.5 seconds was used as an approximate correction. Applying this correction to the experiment results, as shown in Table 5.4, means that participants would have actually seen the test car when it had traveled 77 feet (1.5 seconds * 51.3 feet per second) less than the distances shown in Table 5.3. With this correction, the anomaly mentioned earlier is cleared up as the corrected data indicates that all the test cars in all three videos were actually seen before they entered the intersection.

The corrected distances also provide a more realistic comparison with the AASHTO recommended clear sight distance of 440 feet than do the uncorrected distances, especially since the AASHTO number itself encompasses a reaction time correction. While the corrected data indicates that none of the test cars in any of the three models were seen at the full intersection sight distance recommended by AASHTO, it is clear that only the Urban Design Preferred model comes close.

Going back to the issue raised in Chapter 2 regarding the difference between the AASHTO recommended intersection sight distance and the actual presumed stopping distance of a car traveling on the major roadway (i.e., the test cars in our simulations) adds more insight to the performance of the three models. To reiterate, AASHTO calculates the *stopping distance* of a car traveling at 35 mph on a roadway configured like the ones modeled in this research to be 250 feet. This includes a

Table 5.4: Average and Median Distances from Intersecting Street at which Test Cars Were Seen, Corrected for a Standard 1.5 Second Response Time Delay

	Distance From the Centerline of the Travel Lane of the Minor Intersecting Street (in Feet)	
	Average	Median
Video 1: AASHTO Recommended Standards – Urban Decision Point Scenario		
Test Car 1	54.3	61.7
Test Car 2	122.5	141.3
Test Car 3	172.6	184.1
Video 2: Oakland Standards		
Test Car 1	29.2	25.8
Test Car 2	130.5	146.4
Test Car 3	245.5	250.8
Video 3: Urban Design Preferred		
Test Car 1	302.1	313.1
Test Car 2	331.2	341.3
Test Car 3	559.1	548.4

braking reaction time distance of 128.6 feet (2.5 second reaction time * 51.3 feet/second) plus a braking distance of 117.6 feet.[66] However, the AASHTO calculation used to determine the *recommended intersection sight distance* for the same case adds substantial additional distance that comes from factors related to a “time gap” (for the most onerous case of left turns from the minor road, this is determined by the number of lanes the crossing vehicle must cross before it is out of the way of the approaching vehicle) and presumed extra space needed to maintain the smooth operation of the major roadway (i.e., so that approaching vehicles won’t need to slow down to avoid the crossing vehicle). Hence, the 440 foot recommended intersection sight distance for the models studied in this research.

While none of the test cars in any of the three videos were seen when they were the full AASHTO recommended sight distance away from the intersection, all of the test cars in the Urban Design Preferred model appear to have been seen, on average, before the required stopping distance. This finding suggests that accidents might not occur on roadways where street trees, parked cars and newspaper boxes are arranged like

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[66] The braking distance is determined by the formula $d = 1.075\ V^2/a$, where d = the braking distance in feet, V = the design speed of the major roadway in mph, and a = the deceleration rate in feet/second^2. The recommended deceleration rate is 11.2 feet/ feet/second$^{2.}$ (AASHTO 2001, 111.)

those in with the Urban Design Preferred model, or at least are less likely to occur than on roadways where these elements are arranged like those in the AASHTO Recommended Standards – Urban Decision Point Scenario model or the Oakland Standards model.

The Surveys

After viewing the videos, each participant was given a brief, five question survey in which they were asked to provide basic information about themselves—age, gender, whether or not they had a driver's license and, if so, how long had they had it for—as well as their perceptions related to the videos. (The survey can be found in the Appendix, Form A.2.) All of the questions on the surveys were answered by all participants.

Survey results on participant characteristics, shown in Table 5.5, revealed that the male-to-female ratio was 59 to 41 percent, and that 70 percent of the participants were between 20 and 29 years of age. Of the remaining participants, 28 percent were under 20 years old, and 2 percent were between 30 and 39. The large majority of participants, approximately 94 percent, had a driver's license, with the median length of possession being 3.5 years.

Table 5.5: Participant Characteristics

	Total	Percent
Number of Participants	96	100.0%
Gender		
Male	39	40.6%
Female	57	59.4%
Age		
<20	27	28.1%
20-29	67	69.8%
30-39	2	2.1%
Driver's License		
Possessed License	90	93.8%
Median Years w/ License	3.5	

The survey contained two questions intended to elicit participant perceptions regarding the different physical configurations presented in the three test videos:

- "In the three videos of intersections you just watched, was there a feature that you perceived to cause the greatest barrier to visibility? If yes, what was it?" (Question 4)
- "Was there a feature along the sidewalk that you generally perceived to not cause a barrier to visibility? If yes, what was it?" (Question 5)

A total of 91 participants (95%) answered that there was, in fact, a feature that acted as greatest barrier to visibility. (See Table 5.6.) A total of 106 objects were listed (some participants listed multiple features.) Of those obstacles listed the most frequently, the object cited the most was parked cars – noted by 80 participants, and accounting for 76% of items listed. This was followed, at a distant second, by trees, noted by 17 participants and accounting for 16% of items listed. Mailboxes and newspaper stands, often listed together by participants, were counted as a single item, and were listed a total of 6 times, accounting for 6% of responses. Buildings/walls were listed twice (2%) and signs were listed once (1%). The complete list of the full written-in answers to the second part of Question 4 is contained in the Appendix, Response List A.1.

A total of 66 participants (69%) felt that there was a street feature that did not obstruct their vision. A total of 74 objects were listed (again, some participants listed multiple features.) Of these, the feature listed most often was trees, noted by 39 participants and accounting for 53% of the items listed. This was followed by mailboxes and newspaper stands, again listed together by many participants, which was listed a total of 26 times, accounting for 35% of responses. Signs were listed three times, accounting for 4% of responses, and buildings/walls was listed twice, and qualified for 3% of the responses. The sidewalk, parked cars, telephone poles, and "Lack of garbage cans," were each listed once, and each qualified for 1 percent of responses. The complete list of full written-in answers to the second part of Question 5 is contained in the Appendix, Response List A.2.

Conclusions

In Chapter 1, two questions were posed as the central foci of this research:

1) Does the presence of high-branching sidewalk trees near intersections significantly impact a driver's ability to see approaching cars?

2) Does the presence of parked cars or banks of newspaper racks at intersections significantly impact a driver's ability to see approaching cars?

Table 5.6: Participant Perceptions of Visibility Barriers

	Total	Percent of all participants	Percent of all answers
Number of Participants	96		
Question 4: Was there a feature that caused the greatest barrier to visibility? *Number of Participants Who Answered Yes*	*91*	94.8%	
Total number of objects listed	106		
Parked Cars	*80*		75.5%
Trees	*17*		16.0%
Mailboxes/Newspaper Stands/Thing	*6*		5.7%
Buildings/Walls	*2*		1.9%
Signs	*1*		0.9%
Question 5: Was there a feature that caused no barrier to visibility? *Number of Participants who Answered Yes*	*66*	68.8%	
Total number of objects listed	74		
Trees	*39*		52.7%
Mailboxes/Newspaper Stands/Thing	*26*		35.1%
Buildings/Walls	*2*		2.7%
Signs	*3*		4.1%
Sidewalk	*1*		1.4%
Lack of Garbage Cans	*1*		1.4%
Parked Cars	*1*		1.4%
Telephone Poles	*1*		1.4%

The primary conclusions that can be drawn from both the experiment results and the survey answers is that, first, the presence of high-branching sidewalk trees near intersections does *not* significantly impact a driver's ability to see approaching cars – or at least impacts the driver's ability to see approaching cars considerably less than the presence of other equally common curbside objects such as parked cars and newspaper racks. This conclusion is supported by the survey results in which trees were perceived as a "greatest barrier to visibility" in only 16 percent of the answers, while qualifying as a "no barrier to visibility" almost 53 percent of the time.

Second, the presence of a combination of parked cars near intersections and newspaper racks near intersections *does* significantly impact a driver's ability to see approaching cars, regardless of whether street trees are kept clear of the AASHTO recommended clear sight triangle or not. This conclusion, especially as related to parked cars, is supported by the relatively minor differences between the results for Video 1, the AASHTO Recommended Standards – Urban Decision Point Scenario and Video 2, the Oakland Standards model. In both of these models parked cars begin 20 feet back from the intersection, whereas within them tree setbacks from the intersection (87'-9" and 20' respectively) varies considerably. The conclusion regarding the negative impact of parked cars is additionally supported by the survey results in which two-thirds of "greatest barrier to visibility" objects listed by participants were parked cars, while only one participant listed them as a "no barrier to visibility."

By far, the Urban Design Preferred model performed the best of the three models. With it, participants saw the red test cars on average 4.9 to 7.5 seconds earlier than with the AASHTO Recommended Standards – Urban Decision Point Scenario model, and between 3.9 and 6.1 seconds earlier than with the Oakland Standards model. The differences in distances between when the test cars were first seen in the Urban Design Preferred model versus the AASHTO Recommended Standards – Urban Decision Point Scenario model or the Oakland Standards model translates, in every instance, into hundreds of feet. In short, holding on-street parking clear of the AASHTO recommended clear sight triangle while allowing street trees (that are high-branching, have relatively narrow trunks, and spaced 25 feet on center) to substantially encroach on it, results in greater visibility of approaching cars than does holding street trees clear of the AASHTO recommended clear sight triangle while allowing parked cars to substantially encroach on the triangle.

However, even though the Urban Design Preferred model performed better than the other models, it did not result in participants seeing the car at the full intersection sight distance recommended by AASHTO. It did, though, allow participants to see the test cars before they reached the critical stopping distance point.

As clear as these results may be for our collected set of data, there are areas where this experiment could be expanded in the future so as to provide a wider array of information and a fuller picture of how the placement and physical characteristics of street trees, parked cars, and sidewalk furniture affect intersection safety. For example, the fact that our "human subject" pool for the simulations was relatively young, with all but 2 participants younger than 30 years of age, may have had affected response times. (Although this may have been compensated for somewhat by the relative short tenures the participants had as licensed drivers at the time of the simulation.) Here a more diverse age set may provide somewhat different results in future experiments. Likewise, introduction of less predictability into the number and timing of test cars may also provide for somewhat different results. Lastly, positive and negative nuances could be tested by creating models having greater variation in parked car sizes (the simulations used lines of SUVs as a plausible worse case scenario), and the presence of less-than-perfectly trimmed trees.

All told, the results of the simulations and surveys appear to have proven correct the assumptions which initially motivated this research. The larger conclusions drawn from this project are summarized in the following chapter.

CHAPTER 6

CONCLUSIONS, POLICY RECOMMENDATIONS, AND FURTHER RESEARCH

This research started with a strong questioning of the assumption that street trees are the primary elements that obstruct visibility for drivers at urban intersections, and so must be held back some distance from intersections.

The basic conclusion of the research is that street trees—if properly selected, adequately spaced, and pruned for high branching—do not create a strong visibility problem for drivers entering an intersection. Rather, on-street parked cars, particularly large ones such as SUV's, create substantially more of a visibility problem. As well, newspaper racks near intersections appear to create some visibility problems.

Returning to the three main objectives of the study, the most significant findings related to each are:

Objective 1: *To understand what AASHTO's recommendations for clear sight triangles are for a typical urban intersection.*

Applying AASHTO recommended clear sight triangles to typical urban intersection configurations results in very large lengths of streets that are supposed to be kept clear of obstructions. If the recommendations were followed precisely, depending on a number of factors, such as street width and design speed, many urban blocks would have few street trees and little on-street parking; street trees, parking spaces, and street furniture would all need to be clustered at the middle of blocks.

The research uncovered a major problem, which is that the AASHTO guidelines contain ambiguities that make it difficult to interpret how to apply them in urban situations. The most difficult thing to figure is where to set the location of the driver decision point, a decision which has major implications on the short leg of the clear sight triangle and hence how much of the triangle overlaps the parking lane and sidewalk. Using a conservative interpretation of where to set the decision point—i.e. 14.5 feet back from the curb edge—makes no sense at all in cases where buildings occur at the property line, as from that point drivers are afforded almost no view of the approach roadway because the corner building is in the way. On urban streets where sidewalks and parking lanes are present, a two-step stop approach, with the final driver decision set 14.5 feet back from the edge of the near travel lane, makes much more sense. And, if actual driver behavior is taken into account, basing the final driver decision point on an assumed three-step stop may make even more sense.

Objective 2: *To investigate how various planning jurisdictions within California have interpreted AASHTO advice on clear sight triangles at intersections, in terms of the formal standards put in place to restrict street trees or other objects near intersections, and whether the standards are absolute or allow discretionary leeway.*

While AASHTO differentiates between different types of intersections in terms of how they're controlled and makes different clear triangle recommendations for different cases, many of the California cities studied adopt "one-size-fits-all" street tree setbacks from intersections.

Most of the California cities studied have adopted more onerous restrictions for street trees than for on-street parking. Those cities that have adopted standards for newspaper racks invariably permit them to be much closer to intersections than either trees or parked cars, and generally allow them to be both quite long (7.5 to 15 feet) and to extend above the eye level of a driver in a typical car.

As well as setback and spacing requirements, many cities have adopted additional restrictions on street trees, such as required minimum distances from driveways, street lights, signs, fire hydrants, gas meters, water meters, transformers, or parking meters. The cumulative effect of so many restrictions severely limits where sidewalk street trees may be placed along the whole length of city blocks as well as near intersections.

There is a great variety of street tree setback and spacing requirements among the California cities studied; setbacks range from 15 to 50 feet back from the curb return, and minimum spacing ranges from 20 to 50 feet.

In practice, it seems that many cities use a great deal of discretion regarding setbacks and spacing, that is, decisions are apparently often made on a case by case basis. The widespread use of discretion means that urban designers are likely not to know the rules of the game or to be able to successfully challenge them.

Objective 3: *To use computer modeling, drive-through simulations, and graphic analysis techniques to analyze the amount of visual obstruction at intersections caused by street trees and other objects, and to test what drivers see.*

Simulation seems to work well as a way of testing visibility at intersections, but needs to reference actual behavior of drivers rather than assumptions about what they would do. The method is particularly useful because it prods analysts to confront three-dimensional realities they might not otherwise consider, such as that tree canopies generally start some distance above the ground and that nuances related to a street's spatial dimensions and where a driver is looking from can have big effects on visibility.

The simulations tested suggest that in urban situations street trees near intersections cause less of a visibility problem than either cars parked in on-street parking spaces or newspaper racks. Put simply, a strong case can be made that street trees planted close to intersections and reasonably closely spaced, as little as 25 feet apart, which are pruned so that horizontal limbs and leafing start about 14 feet off the ground, do not constitute a visibility safety hazard on urban streets.

Policy Recommendations

For almost every city studied, as well as the AASHTO standards, street tree location standards need rethinking.

Rather than adopting prescriptive "one-size-fits-all" intersection setback requirements and minimum spacing for street trees, cities could adopt performance based guidelines. Such guidelines might stipulate that three aspects of trees—species trunk width, spacing, and branching height— be considered in concert to attain desired visibility results.

Cities should consider placing greater restrictions on parked cars near intersections. They might consider holding on-street parking spaces further back from intersections. Although it might be hard to put into practice, and to police, cities might also consider restricting tall or bulky vehicles from on-street parking spaces near intersections—something of a "compact car only" zone.

Cities should consider restricting the bulk and height of newspaper racks on the approach side of an intersection.

Further Research

This research can and should be taken much further. To start, the drive-through simulations that have been created should be tested with people of different age groups. Different types of trees could be placed in the models already developed and new drive-through simulations created and tested. Many additional base intersection models could be created, representing a greater variety of urban street conditions.

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APPENDIX

FORMS AND RESPONSE TABLES

Form A.1: Explanation and Fill-in Sheet

Urban Intersections Study
Professor Elizabeth Macdonald

You are about to watch three separate videos. Each is a simulation of a car approaching an intersection, with you positioned as the driver in the car. The intersections are similar, but somewhat different in their configurations.

Each video will begin with the car you are presumed to be in driving up to an intersection and stopping. You will turn to look for a red car coming from the left. Keep your finger on the “pause” button (the “start” button turns into the pause button after the video is started), and hit the pause the instant you see the red car. In the space provided below, record the elapsed time indicated on your computer screen.

Hit the pause button again to resume playing the video. The car you are in will move up closer to the intersection and you will look for another red car coming from the left. Keep your finger on the “pause” button, and hit the pause the instant you see this second red car. In the space provided below, record the elapsed time indicated on your computer screen.

Hit the pause button again to resume playing the video. You will turn your head to the right to look for a red car coming from the right. Keep your finger on the “pause” button, and hit the pause the instant you see this third red car. In the space provided below, record the elapsed time indicated on your computer screen.

Hit the pause button again to resume playing the video until the end. Then repeat the above steps for the other videos.

Video #1

Pause time for first red car: ________________________

Pause time for second red car: ________________________

Pause time for the third red car: ________________________

Video #2

Pause time for first red car: ________________________

Pause time for second red car: ________________________

Pause time for the third red car: ________________________

Video #3

Pause time for first red car: ________________________

Pause time for second red car: ________________________

Pause time for the third red car: ________________________

Form A.2: Survey Questions

Now that you have watched the three videos, please answer the following questions:

1. What is your age?
   ☐ less than 20 ☐ 20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60 or over

2. What is your sex? ☐ Female ☐ Male

3. Do you have a driver's license? ☐ yes ☐ no

   If yes, for how many years have you been licensed?

4. In the three videos of intersections you just watched, was there a feature that you perceived to cause the greatest barrier to visibility? ☐ yes ☐ no

   If yes, what was it?

5. Was there a feature along the sidewalk that you generally perceived to not cause a barrier to visibility? ☐ yes ☐ no

   If yes, what was it?

Table Set A.1: Time Summaries for Each Video, by Group, in Seconds

Group 1

	1	2	3	4	5	6	7	8	9	10	11	Average	Median
Video 1													
Car 1	32.2	30.5	30.2	52	31	31.1	30.9	30.3	30.3	30.3	31.2	32.7	30.9
Car 2	46.3	44.3	43.8	64	45.3	43.6	44.8	43.8	43.7	44.3	44.9	46.3	44.3
Car 3	68.3	65.7	64.7	n/a	66.9	63.5	66.4	64.8	65.2	65.8	66.6	65.8	65.8
Video 2													
Car 1	31.4	31.2	31.1	44.7	31.1	31.1	31.9	30.9	31.1	31.9	31.9	32.6	31.2
Car 2	44.2	43.9	43.7	64.7	44	43.7	44.6	43.7	43.5	44.7	44.3	45.9	44.0
Car 3	64.1	63.7	63.5	68.9	63.7	63.5	63.9	63.7	63.9	63.8	63.9	64.2	63.8
Video 3													
Car 1	25.5	25.2	25.4	27	25.3	24.9	25.6	25.1	27.2	25.9	25.5	25.7	25.5
Car 2	42.2	40.3	40.3	41.8	40.5	39.9	41	40.2	40.3	40.6	41	40.7	40.5
Car 3	59.8	57.9	56.2	60.7	56.5	57.4	58.4	56.1	56.9	58.6	59	58.0	57.9

Group 2

	1	2	3	4	5	6	7	8	9	10	11	12	Average	Median
Video 1														
Car 1	30.9	30.4	25.7	30.3	30.7	30.9	30.7	29	31.2	30.9	31.2	31	30.2	30.8
Car 2	44.7	44.2	45.7	44.1	44.9	44.5	44.6	44.2	45.3	44.8	45	45.1	44.8	44.8
Car 3	65.9	65.1	67.6	65.3	66.3	65.8	66.5	65.6	67.2	66.7	66.3	66.9	66.3	66.3
Video 2														
Car 1	31.3	31.2	31.6	30.9	31.3	30.8	31	28.7	31.5	31.2	31.2	31.3	31.0	31.2
Car 2	43.9	43.8	44.5	43.7	43.8	43.8	43.7	43.8	44.6	43.8	43.9	43.9	43.9	43.8
Car 3	63.7	64	64.2	63.6	63.7	63.6	63.7	64.1	63.8	63.8	63.8	63.8	63.8	63.8
Video 3														
Car 1	24.9	25.6	26.8	27	25.2	24.8	25.4	28	25.8	25.8	26.1	25.9	25.9	25.8
Car 2	39.8	40.5	41.5	40.4	40.3	40.3	40.3	42.4	41.1	40.8	40.5	43.2	40.9	40.5
Car 3	56	59.2	60.2	57.1	56.4	55.6	57.3	60.3	60.8	58.4	59.2	56.6	58.1	57.9

Group 3

	1	2	3	4	5	6	7	8	9	10	11	12	Average	Median
Video 1														
Car 1	29.8	30.4	30.3	30.2	29.9	29.6	29.7	29.5	29.7	29.6	30.8	30.2	30.0	29.9
Car 2	43.8	44.1	43.9	44	43.7	43.8	43.8	43.8	43.9	43.8	44.3	43.8	43.9	43.8
Car 3	64.6	65.1	65.1	65.1	64.8	64.5	64.8	64.5	64.6	64.7	65.7	64.9	64.9	64.8
Video 2														
Car 1	30.5	30.7	31	30.7	30.9	30.6	30.8	30.6	31.1	30.6	31.2	30.7	30.8	30.7
Car 2	43.7	43.8	43.9	43.7	43.7	43.9	49.9	43.8	43.9	43.7	44.1	43.9	44.3	43.9
Car 3	63.6	63.7	63.8	63.7	63.9	63.6	63.9	63.7	63.8	63.7	63.7	64.9	63.8	63.7
Video 3														
Car 1	26.7	25.9	25.2	24.7	27.2	24.6	25.6	25	24.7	25.8	25.4	25	25.5	25.3
Car 2	41.2	39.3	39.9	39.6	40	39.7	39.9	40	40	40.3	40.2	39.3	40.0	40.0
Car 3	56.3	58.3	58.6	55.8	58.8	57.9	59.1	58.3	59	57.8	57	58.3	57.9	58.3

Group 4

	1	2	3	4	5	6	7	Average	Median
Video 1									
Car 1	29.5	30	29.8	29.3	n/a	29.6	29.9	29.7	29.7
Car 2	43.7	44	43.8	43.6	n/a	43.7	43.7	43.8	43.7
Car 3	64.7	65.4	64.8	64.7	n/a	64.9	65	64.9	64.9
Video 2									
Car 1	30.8	30.9	30.7	30.5	23.8	30.6	31.8	29.9	30.7
Car 2	43.7	43.6	43.7	43.6	43.7	43.8	44.2	43.8	43.7
Car 3	63.7	63.6	63.7	63.6	63.8	63.8	63.6	63.7	63.7
Video 3									
Car 1	26	25.1	24.7	24.5	24.8	24.8	25.4	25.0	24.8
Car 2	40.6	40	39.5	39.4	39.8	39.6	40.3	39.9	39.8
Car 3	56.8	58.5	55.3	56.5	58	58.3	56.2	57.1	56.8

Group 5

	1	2	3	4	5	6	7	8	9	Average	Median
Video 1											
Car 1	30.1	29.8	30	29.8	29.5	30.1	30.1	29.6	29.6	29.8	29.8
Car 2	44.5	43.8	43.9	43.7	43.9	43.7	43.9	43.6	43.9	43.9	43.9
Car 3	65.1	64.9	64.8	64.8	64.9	64.7	65	64.5	64.6	64.8	64.8
Video 2											
Car 1	31	31	30.8	30.6	30.6	30.9	30.5	30.4	30.4	30.7	30.6
Car 2	44	43.8	43.7	43.7	43.9	43.9	43.8	43.6	43.6	43.8	43.8
Car 3	64.2	64.1	63.7	63.6	63.9	63.7	63.6	63.5	63.7	63.8	63.7
Video 3											
Car 1	27	25.3	25.2	24.9	25.8	26	24.8	24.8	24.8	25.4	25.2
Car 2	39.7	40.4	39.9	39.9	39.9	40.9	39.6	39.4	39.5	39.9	39.9
Car 3	58.1	58.9	55.7	55.5	58.5	56.5	58.1	57.6	57.8	57.4	57.8

Group 6

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average	Median
Video 1																
Car 1	30	30.3	30	30.1	29.5	30.3	30.4	30.8	31.4	29.7	28.6	29.7	30.8	30	30.1	30.1
Car 2	43.8	44.1	44	44	43.7	43.8	44	44.2	44.7	43.9	42.5	43.6	44.4	43.7	43.9	44.0
Car 3	64.7	65.3	64.8	65.2	64.7	65	65.3	65.4	65.8	64.7	64.7	64.9	65.6	64.8	65.1	65.0
Video 2																
Car 1	30.7	30.7	30.8	30.4	n/a	28.9	30.6	30.5	31	31	28.5	30.5	30.7	31.3	30.4	30.7
Car 2	43.9	43.8	43.9	43.7	n/a	43.9	43.7	43.6	43.9	43.8	43.1	43.6	43.9	43.9	43.7	43.8
Car 3	63.6	63.9	63.9	63.7	n/a	63.9	63.7	63.7	63.8	63.7	63.2	63.6	63.9	63.7	63.7	63.7
Video 3																
Car 1	25.6	24.9	25.4	26.1	n/a	25	25.2	24.8	25.7	24.9	24.8	24.7	26.9	24.8	25.3	25.0
Car 2	39.8	39.7	39.9	39.7	n/a	39.9	40.4	39.5	40.2	39.6	39.6	39.4	40	40	39.8	39.8
Car 3	59.2	55.7	58.2	55.3	n/a	55.3	57.8	56.4	56.7	55.5	56.6	58.6	57.8	58.2	57.0	56.7

Group 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	Average	Median
Video 1															
Car 1	29.5	29.3	30.2	29.9	29.6	30.4	30.1	30.3	30.2	22.6	30.2	29.8	30.2	29.4	30.1
Car 2	43.7	43.8	43.8	43.8	43.6	43.8	43.8	44.2	43.9	43.3	43.7	43.8	44	43.8	43.8
Car 3	64.5	64.8	64.8	64.6	64.5	64.9	64.9	65.4	65	64.4	64.9	65	64.9	64.8	64.9
Video 2															
Car 1	30.6	30.6	31.1	30.5	30.4	30.1	30.9	30.2	31.1	23.1	28.7	30.6	31	29.9	30.6
Car 2	43.8	43.8	43.8	43.7	43.7	43.7	43.9	43.8	43.8	43.2	43.7	43.7	43.6	43.7	43.7
Car 3	63.9	63.7	63.7	63.6	63.5	63.8	63.7	63.9	64	63.3	63.6	63.6	63.6	63.7	63.7
Video 3															
Car 1	24.7	25	25.2	24.9	24.5	25.3	25.1	25.2	25.1	24.7	24.8	24.8	25.1	25.0	25.0
Car 2	39.4	39.8	40.5	39.9	39.3	40.4	40	39.9	40.6	39.4	39.4	39.8	40	39.9	39.9
Car 3	58.9	58.7	56.5	58.6	56.4	59	59	59.1	58.7	55.3	58.5	55.4	53.1	57.5	58.6

Group 8

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average	Median
Video 1																				
Car 1	30	30.1	30	30.6	30.3	30.4	30.2	29.7	30.8	30.1	30	29.9	29.8	29.7	29.8	29.9	30.2	30.4	30.1	30.1
Car 2	43.7	43.7	43.7	44.4	43.9	45.3	43.9	44	44.5	43.7	43.7	43.8	43.9	43.7	44	43.9	43.9	43.9	44.0	43.9
Car 3	65.4	65.6	64.8	65.7	65.4	65.6	65.1	65.2	66.1	65	64.7	65.1	65.2	64.6	65	64.8	65.1	64.9	65.2	65.1
Video 2																				
Car 1	30.8	30.7	30.9	31.5	31	32	30.6	30.9	30.8	30.7	30.8	31.2	22.5	30.8	31.4	32	30.7	30.9	30.6	30.9
Car 2	43.6	43.5	43.7	44.5	43.9	44.4	43.8	43.7	43.6	43.7	43.7	43.7	43.6	43.8	43.8	44.5	43.7	43.9	43.8	43.7
Car 3	63.6	63.6	63.5	64.2	63.7	64.2	63.8	63.8	63.6	63.7	63.6	63.6	63.5	63.6	63.7	63.8	63.7	63.9	63.7	63.7
Video 3																				
Car 1	25.1	24.6	25.2	26.1	26	25.9	25	25.7	25.3	25.1	24.8	25.3	25.2	24.8	26.7	26.4	24.8	25.4	25.4	25.3
Car 2	40.5	39.7	40.5	41.1	39.9	40.8	40	40.6	40.5	40.4	40.3	40.2	40.4	39.7	40.3	40.8	39.7	40	40.3	40.4
Car 3	59.5	55.3	57.2	57.6	58.9	59.5	55.4	59.7	56.7	57.1	58.7	58.1	56.3	58.7	57.1	62.3	58.5	59.4	58.1	58.3

Table Set A.2: Distance Summaries for Each Video, by Group, from Centerline

Group 1

	1	2	3	4	5	6	7	8	9	10	11	Average	Median
Video 1													
Car 1	-123.0	-35.8	-20.4	-1138.7	-61.4	-66.6	-56.3	-25.5	-25.5	-25.5	-71.7	-150.0	-56.3
Car 2	-58.9	43.7	69.4	-966.9	-7.6	79.7	18.1	69.4	74.5	43.7	13.0	-56.5	43.7
Car 3	-62.2	71.2	122.5		9.7	184.1	35.3	117.4	96.9	66.1	25.0	66.6	68.7
Video 2													
Car 1	-81.9	-71.7	-66.6	-764.2	-66.6	-66.6	-107.6	-56.3	-66.6	-107.6	-107.6	-142.1	-71.7
Car 2	48.9	64.3	74.5	-1002.8	59.1	74.5	28.4	74.5	84.8	23.2	43.7	-38.8	59.1
Car 3	153.3	173.8	184.1	-92.9	173.8	184.1	163.6	173.8	163.6	168.7	163.6	146.3	168.7
Video 3													
Car 1	220.7	236.1	225.9	143.8	231.0	251.5	215.6	241.2	133.5	200.2	220.7	210.9	220.7
Car 2	151.5	248.9	248.9	172.0	238.7	269.5	213.0	254.1	248.9	233.6	213.0	226.6	238.7
Car 3	373.9	471.4	558.6	327.7	543.2	497.0	445.7	563.7	522.7	435.4	414.9	468.6	471.4

Group 2

	1	2	3	4	5	6	7	8	9	10	11	12	Average	Median
Video 1														
Car 1	-56.3	-30.6	210.5	-25.5	-46.0	-56.3	-46.0	41.2	-71.7	-56.3	-71.7	-61.4	-22.5	-51.2
Car 2	23.2	48.9	-28.1	54.0	13.0	33.5	28.4	48.9	-7.6	18.1	7.8	2.7	20.2	20.7
Car 3	61.0	102.0	-26.3	91.7	40.4	66.1	30.2	76.3	-5.7	19.9	40.4	9.7	42.1	40.4
Video 2														
Car 1	-76.8	-71.7	-92.2	-56.3	-76.8	-51.2	-61.4	56.6	-87.1	-71.7	-71.7	-76.8	-61.4	-71.7
Car 2	64.3	69.4	33.5	74.5	69.4	69.4	74.5	69.4	28.4	69.4	64.3	64.3	62.6	69.4
Car 3	173.8	158.4	148.2	178.9	173.8	178.9	173.8	153.3	168.7	168.7	168.7	168.7	167.8	168.7
Video 3														
Car 1	251.5	215.6	154.0	143.8	236.1	256.6	225.9	92.5	205.3	205.3	189.9	200.2	198.1	205.3
Car 2	274.6	238.7	187.4	243.8	248.9	248.9	248.9	141.2	207.9	223.3	238.7	100.2	216.9	238.7
Car 3	568.8	404.7	353.4	512.4	548.3	589.3	502.1	348.2	322.6	445.7	404.7	538.0	461.5	473.9

Group 3

	1	2	3	4	5	6	7	8	9	10	11	12	Average	Median
Video 1														
Car 1	0.1	-30.6	-25.5	-20.4	-5.0	10.4	5.3	15.5	5.3	10.4	-51.2	-20.4	-8.8	-2.4
Car 2	69.4	54.0	64.3	59.1	74.5	69.4	69.4	69.4	64.3	69.4	43.7	69.4	64.7	69.4
Car 3	127.6	102.0	102.0	102.0	117.4	132.8	117.4	132.8	127.6	122.5	71.2	112.3	114.0	117.4
Video 2														
Car 1	-35.8	-46.0	-61.4	-46.0	-56.3	-40.9	-51.2	-40.9	-66.6	-40.9	-71.7	-46.0	-50.3	-46.0
Car 2	74.5	69.4	64.3	74.5	74.5	64.3	-243.5	69.4	64.3	74.5	54.0	64.3	42.0	66.8
Car 3	178.9	173.8	168.7	173.8	163.6	178.9	163.6	173.8	168.7	173.8	173.8	112.3	167.0	173.8
Video 3														
Car 1	159.2	200.2	236.1	261.8	133.5	266.9	215.6	246.4	261.8	205.3	225.9	246.4	221.6	231.0
Car 2	202.8	300.2	269.5	284.9	264.3	279.7	269.5	264.3	264.3	248.9	254.1	300.2	266.9	266.9
Car 3	553.4	450.8	435.4	579.1	425.2	471.4	409.8	450.8	414.9	476.5	517.5	450.8	469.6	450.8

Group 4

	1	2	3	4	5	6	7	Average	Median
Video 1									
Car 1	15.5	-10.1	0.1	25.8		10.4	-5.0	6.1	5.3
Car 2	74.5	59.1	69.4	79.7		74.5	74.5	72.0	74.5
Car 3	122.5	86.6	117.4	122.5		112.3	107.1	111.4	114.8
Video 2									
Car 1	-51.2	-56.3	-46.0	-35.8	307.9	-40.9	-102.5	-3.5	-46.0
Car 2	74.5	79.7	74.5	79.7	74.5	69.4	48.9	71.6	74.5
Car 3	173.8	178.9	173.8	178.9	168.7	168.7	178.9	174.6	173.8
Video 3									
Car 1	195.1	241.2	261.8	272.0	256.6	256.6	225.9	244.2	256.6
Car 2	233.6	264.3	290.0	295.1	274.6	284.9	248.9	270.2	274.6
Car 3	527.8	440.6	604.7	543.2	466.2	450.8	558.6	513.1	527.8

Group 5

	1	2	3	4	5	6	7	8	9	Average	Median
Video 1											
Car 1	-15.3	0.1	-10.1	0.1	15.5	-15.3	-15.3	10.4	10.4	-2.1	0.1
Car 2	33.5	69.4	64.3	74.5	64.3	74.5	64.3	79.7	64.3	65.4	64.3
Car 3	102.0	112.3	117.4	117.4	112.3	122.5	107.1	132.8	127.6	116.8	117.4
Video 2											
Car 1	-61.4	-61.4	-51.2	-40.9	-40.9	-56.3	-35.8	-30.6	-30.6	-45.5	-40.9
Car 2	59.1	69.4	74.5	74.5	64.3	64.3	69.4	79.7	79.7	70.5	69.4
Car 3	148.2	153.3	173.8	178.9	163.6	173.8	178.9	184.1	173.8	169.8	173.8
Video 3											
Car 1	143.8	231.0	236.1	251.5	205.3	195.1	256.6	256.6	256.6	225.9	236.1
Car 2	279.7	243.8	269.5	269.5	269.5	218.2	284.9	295.1	290.0	268.9	269.5
Car 3	461.1	420.1	584.2	594.5	440.6	543.2	461.1	486.7	476.5	496.4	476.5

Group 6

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average	Median
Video 1																
Car 1	-10.1	-25.5	-10.1	-15.3	15.5	-25.5	-30.6	-51.2	-81.9	5.3	61.7	5.3	-51.2	-10.1	-16.0	-12.7
Car 2	69.4	54.0	59.1	59.1	74.5	69.4	59.1	48.9	23.2	64.3	136.1	79.7	38.6	74.5	65.0	61.7
Car 3	122.5	91.7	117.4	96.9	122.5	107.1	91.7	86.6	66.1	122.5	122.5	112.3	76.3	117.4	103.8	109.7
Video 2																
Car 1	-46.0	-46.0	-51.2	-30.6		46.3	-40.9	-35.8	-61.4	-61.4	66.8	-35.8	-46.0	-76.8	-32.2	-46.0
Car 2	64.3	69.4	64.3	74.5		64.3	74.5	79.7	64.3	69.4	105.3	79.7	64.3	64.3	72.2	69.4
Car 3	178.9	163.6	163.6	173.8		163.6	173.8	173.8	168.7	173.8	199.5	178.9	163.6	173.8	173.0	173.8
Video 3																
Car 1	215.6	251.5	225.9	189.9		246.4	236.1	256.6	210.5	251.5	256.6	261.8	148.9	256.6	231.4	246.4
Car 2	274.6	279.7	269.5	279.7		269.5	243.8	290.0	254.1	284.9	284.9	295.1	264.3	264.3	273.4	274.6
Car 3	404.7	584.2	456.0	604.7		604.7	476.5	548.3	532.9	594.5	538.0	435.4	476.5	456.0	516.3	532.9

Group 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	Average	Median
Video 1															
Car 1	15.5	25.8	-20.4	-5.0	10.4	-30.6	-15.3	-25.5	-20.4	369.5	-20.4	0.1	-20.4	20.3	-15.3
Car 2	74.5	69.4	69.4	69.4	79.7	69.4	69.4	48.9	64.3	95.0	74.5	69.4	59.1	70.2	69.4
Car 3	132.8	117.4	117.4	127.6	132.8	112.3	112.3	86.6	107.1	137.9	112.3	107.1	112.3	116.6	112.3
Video 2															
Car 1	-40.9	-40.9	-66.6	-35.8	-30.6	-15.3	-56.3	-20.4	-66.6	343.8	56.6	-40.9	-61.4	-5.8	-40.9
Car 2	69.4	69.4	69.4	74.5	74.5	74.5	64.3	69.4	69.4	100.2	74.5	74.5	79.7	74.1	74.5
Car 3	163.6	173.8	173.8	178.9	184.1	168.7	173.8	163.6	158.4	194.3	178.9	178.9	178.9	174.6	173.8
Video 3															
Car 1	261.8	246.4	236.1	251.5	272.0	231.0	241.2	236.1	241.2	261.8	256.6	256.6	241.2	248.7	246.4
Car 2	295.1	274.6	238.7	269.5	300.2	243.8	264.3	269.5	233.6	295.1	295.1	274.6	264.3	270.6	269.5
Car 3	420.1	430.3	543.2	435.4	548.3	414.9	414.9	409.8	430.3	604.7	440.6	599.6	717.6	493.1	435.4

Group 8

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average	Median
Video 1																				
Car 1	-10.1	-15.3	-10.1	-40.9	-25.5	-30.6	-20.4	5.3	-51.2	-15.3	-10.1	-5.0	0.1	5.3	0.1	-5.0	-20.4	-30.6	-15.5	-12.7
Car 2	74.5	74.5	74.5	38.6	64.3	-7.6	64.3	59.1	33.5	74.5	74.5	69.4	64.3	74.5	59.1	64.3	64.3	64.3	60.3	64.3
Car 3	86.6	76.3	117.4	71.2	86.6	76.3	102.0	96.9	50.7	107.1	122.5	102.0	96.9	127.6	107.1	117.4	102.0	112.3	97.7	102.0
Video 2																				
Car 1	-51.2	-46.0	-56.3	-87.1	-61.4	-112.7	-40.9	-56.3	-51.2	-46.0	-51.2	-71.7	374.6	-51.2	-81.9	-112.7	-46.0	-56.3	-39.2	-53.7
Car 2	79.7	84.8	74.5	33.5	64.3	38.6	69.4	74.5	79.7	74.5	74.5	74.5	79.7	69.4	69.4	33.5	74.5	64.3	67.4	74.5
Car 3	178.9	178.9	184.1	148.2	173.8	148.2	168.7	168.7	178.9	173.8	178.9	178.9	184.1	178.9	173.8	168.7	173.8	174.6	173.0	174.2
Video 3																				
Car 1	241.2	266.9	236.1	189.9	195.1	200.2	246.4	210.5	231.0	241.2	256.6	231.0	236.1	256.6	159.2	174.6	256.6	214.9	224.7	233.6
Car 2	238.7	279.7	238.7	207.9	269.5	223.3	264.3	233.6	238.7	243.8	248.9	254.1	243.8	279.7	248.9	223.3	279.7	253.3	248.3	246.4
Car 3	389.3	604.7	507.3	486.7	420.1	389.3	599.6	379.0	532.9	512.4	430.3	461.1	553.4	430.3	512.4	245.6	440.6	394.4	460.5	450.8

Response List A.1: Written Responses to Question 4, Second Part

Responses appear approximately as written on forms.

Group 1

1. Cars parked along curb
2. Cars parked close to intersection
3. Cars parked on the sides near you
4. Wall
5. The row of parked cars, esp. b/c they were big/tall
6. The cars parked on the sidewalk.
7. Cars parked all along the sides of the street
8. Parked cars and trees. But we need parking and oxygen.
9. All the cars lined up on the streets.
10. Parked cars
11. Other cars parked on the street

Group 2

1. Cars parked on side
2. The parked cars
3. Cars parked too close to the intersection and driver not looking at the intersection. Why was the view so focused on the newspaper boxes along the side of the road? Also visibility in the 3rd video was much better due to no cars parked along the road.
4. Other cars parked on the street
5. PARKED CARS!!!
6. Volvo SUV's
7. The parked cars on the sidewalk
8. Trees along the sidewalk and cars that parked along the sidewalk. Also, mailboxes and newspaper stand blocked the sight of view at intersections
9. Parallel parked cars
10. The cars parked on the streets
11. Cars parked on the side of the streets

Group 3

1. The parked cars and trees (even though they make the sidewalk look pretty)
2. Cars that were parked along the curb
3. Cars parked on sidewalk!
4. Parked cars
5. Trees lining the sidewalk

6. There were two: the tree along the sidewalk and the cars on the street. The parked cars made it difficult to see
7. Parked cars on the street
8. Parked cars
9. Newspaper dispensers and parked vehicles; trees should not be planted so close to the intersection
10. Parked cars
11. The rows of cars

Group 4

1. The newspaper holders distracted me
2. The cars parked on the side of the road
3. The parked cars on the side of the road
4. Trees
5. Cars on the sideway
6. Stationary/parked cars

Group 5

1. The car parking next to the sidewalk and very close to the intersection (Small diagram drawn)
2. The second video, the trees and cars parked along the curb made it incredibly hard to see cars going through the intersection. I always feel like I'm put into a dangerous position when I have to pull that far forward to see traffic. In the third video, the trees were really close together, so it was hard to see things moving between them.
3. Parked cars
4. Parked cars on road. Trees slightly block view but not as much.
5. Cars parked too close to intersection.
6. The cars that parked on the side block most of the vision angles.
7. The parked cars.
8. The first car parked on the lefthand side.
9. Cars parked too close to the turn (Small diagram drawn)

Group 6

1. The cars
2. The row of cars parked next to the sidewalk, as well as the large newspaper vendors next to the cars.
3. Other cars parked along sidewalk.
4. It was mostly the parked cars blocking visibility on the right
5. Parked cars
6. The cars parked on the side of the road.
7. Parked cars on the side of the street impeded view until the red car was extremely close, trees from a certain angle also impeded view

8. The cars parked, trees
9. Parking
10. The cars parked on the street
11. The cars parked along the street
12. Parked cars at the corner
13. The cars park along the sidewalk
14. The cars on the side of the road, the parked cars and the trees on the sidewalk

Group 7

1. Parked cars
2. Stop signs
3. The SUV vehicles are too tall and they block the view when the red car comes near the intersection
4. The trees along the roads.
5. Cars
6. Trees
7. Cars parked along sidwalk and magazine vending machines
8. Trucks
9. Well, obviously the parked cars
10. Trees
11. Other cars
12. Parked SUV
13. A continuous line of parked cars to the left as one was looking to turn right

Group 8

1. The SUVs
2. The cars parked on the side of the road.
3. Rows of newspaper bins.
4. Parked cars
5. There were a lot of big cars parked along on the street [sic] of the road, which make me [sic] difficult to see the red car
6. Parked cars
7. Trees
8. No too parking-plx [sic] on left side and right side.
9. The walls (minor), trees -especially for the 3rd video
10. The SUVs
11. Cars parked along the side of the roads near the intersection
12. Big SUVs or cars parked near the intersection which blocked the view of the street.
13. Newspaper/post boxes, other parked cars
14. Street parking and also walls of buildings
15. Front two parked cars on the street

16. Cars parked along the side of the road
17. Compare to the other two, the 1st one causes the greatest barrier

Response List A.2: Written Responses to Question 5, Second Part

Responses appear approximately as written on forms.

Group 1

1. Mailboxes
2. Trees spaced out nicely
3. Trees
4. Tree
5. Trees that had long trunks, not bushy & short.
6. Mailboxes, newspaper stands, & stop signs
7. The trees
8. Trees
9. Mailboxes
10. The trees added a pleasant view but they were not in the way but perhaps they could be a distraction because they are attractive.
11. Trees
12. This is kind of a leading question, but those unexplained objects on the sidewalk didn't seem to block anything.

Group 2

1. (1) Newspaper boxes would not be disturbing to me but this driver seemed to be spending a fair amount of time looking at them. (2) Trees were not an obstacle.
2. Mailboxes, newsstands
3. Trees, mailbox, newspaper things all ok
4. Mailboxes and newspaper stands
5. The trees w/o cars in front of them.
6. Distance between the trees provide a gap that we can see cars on the road easily.
7. Mailbox, trees
8. Trees

Group 3

1. The newspaper stand
2. The trees! They weren't in the way b/c they were tall & well trimmed
3. The mailboxes
4. Space between trees
5. The newspaper dispensers should not be aligned so closely toward the intersection

6. Those boxes did not block view. Trees did, but not as much as parked cars. Plus trees are pretty.
7. Trees

Group 4

1. The trees because they were all the same so it didn't really stick out
2. Trees
3. Trees
4. Nothing on the corner
5. Mailbox
6. Buildings

Group 5

1. The 4 mailboxes along the sidewalk. They are short/small enough not to cause any barrier. But best if they are not there. The third video was great
2. The mailboxes?
3. Trees
4. The boxes on the sidewalk
5. Trees are ok because of the spaces between them
6. Building
7. The spaces between the trees were helpful
8. Trees w/ gaps between them (i.e., 3rd video)

Group 6

1. The street signs and mailboxes were never a barrier to visibility

2. The USPS drop off box
3. Trees
4. The trees.
5. I don't think newspaper stands or mailboxes at all, or would have, had there been no parked cars.
6. Stop sign
7. Parking
8. Street signs
9. The stop signs

Group 7

1. Trees
2. Mailboxes and trees
3. The sidewalk itself
4. These are strange questions. I'm guessing your real intention is to take away parking near corners (nooo) while adding trees

(random). It's good to know that biased studies haven't gone out of fashion.
5. Trees
6. Lack of garbage cans helped
7. Trees
8. Well-spaced trees

Group 8

1. Telephone poles, single mail boxes, trees
2. The newspaper stand and the postal stand blocked my vision
3. Post box, trees
4. The thing along the sidewalk will distract me
5. USPO mailbox
6. Mailboxes
7. Trees
8. Trees
9. Trees -tall (last video)- mailboxes, newstands small enough
10. Mailboxes
11. The trees
12. Cars parking along sidewalk.
13. Trees are better than cars.