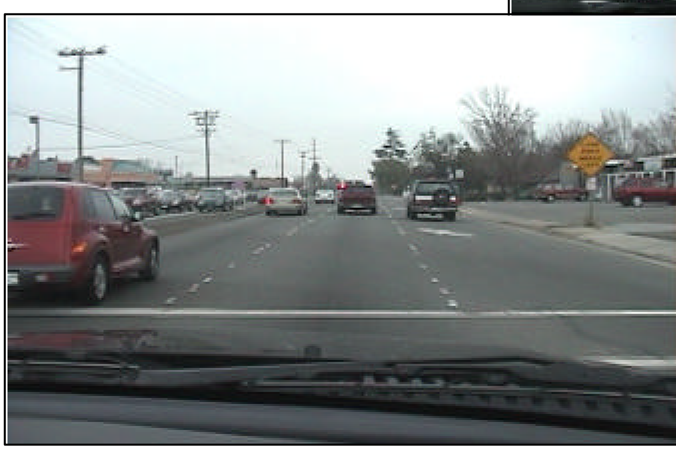
Quality of Service and Customer Satisfaction on Arterial Streets

Final Report



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EXECUTIVE SUMMARY

This report presents the results of a qualitative study of driver perception of quality of service (QOS) on urban arterial streets. The purpose of the study was to identify the factors that are important to drivers of personal automobiles (non-commercial) regarding the quality of their driving experience. The study used an in-vehicle, on-the-road methodology in which drivers drove their own vehicles and talked out loud about the driving experience. This method provided the opportunity for drivers to respond to events as they occurred during the drive and to express their reactions to actual roadway elements and circumstances. Participants also completed a written survey after the drive about the relative importance of roadway, operational, and environmental conditions on urban arterials.

Information about driver perception of QOS is integral to the development of tools used to measure customer satisfaction. Customer satisfaction is increasingly relevant to the efforts of transportation agencies at the state and local levels. For example, the United States Department of Transportation (USDOT) identified customer satisfaction as one of the “few good measures” that should be used when evaluating Intelligent Transportation Systems (ITS). The value of including measures of customer satisfaction, along with standard traffic engineering measures, is that they provide an indication of how well a service is functioning, where changes are most needed, and whether changes in service are likely to result in improvements from the driver’s perspective.

The study included 22 participants in four locations: Chicago, Illinois; Tallahassee, Florida; Atlanta, Georgia; and Sacramento, California. The participants drove on routes pre-selected by the researchers to offer a range of conditions in accord with the Highway Capacity Manual’s description of urban arterials. The same route was used in each city but at different times of the day: morning peak, midday, and afternoon peak. Each participant drove the route once using his or her personal vehicle for about 45 minutes, with an interviewer in the passenger seat and a traffic engineer in the back seat. As they drove, participants identified roadway elements and conditions that they said were relevant to the quality of the trip.

The drivers identified a wide variety of factors that influenced the perception of quality. The factors ranged from elements related to traffic operations (e.g., signal timing), roadway geometry (e.g., lane width), aesthetic aspects (e.g., presence of trees), sign visibility, and other road users. The data from the drives and the surveys were summarized and categorized into “QOS factors” and “driver needs.” QOS factors are specific features or conditions of an urban arterial that drivers identified as being important to the quality of their driving experience. An example of a QOS factor is pavement quality. In contrast, driver needs are fundamental characteristics of quality. An example of a driver need is sense of safety.

Drivers identified a total of 45 factors that influence QOS. The QOS factors fall into the following eight investment areas: cross-sectional roadway design, arterial operations, intersection operations, signs and markings, maintenance, aesthetics, other road users, and other (including ITS). The 45 QOS factors support the following four driver needs: efficiency in traffic flow, a sense of safety, aesthetics, and positive guidance.

In addition to understanding what it is that drivers value on urban arterials, another objective was to obtain qualitative information related to customer satisfaction with ITS operational improvements. The investment area within urban arterials in which ITS can play a significant role is *intersection operations*. For example, drivers specifically identified signal timing and left-turn arrows as relevant to quality. From the point of view of the driver, ITS enhancements to these service elements affect overall arterial operations because they affect traffic flow by reducing delay. ITS enhancements also impact the investment area identified as *other road users*. Drivers expressed concerns about road users who ran red lights, blocked intersections, or made illegal lane maneuvers, among other things. Some of these concerns could be mitigated through the implementation of red light running cameras and aggressive driver imaging.

In summary, the study produced an inventory of QOS factors and driver needs that represent how drivers define value on urban arterials. The inventory of QOS factors and driver needs can be used to further investigate customer satisfaction and QOS tools. The results are also useful in the development and application of guidelines for ITS evaluation studies.

1 INTRODUCTION

Customer satisfaction is an increasingly used measure of performance of transportation systems. Many state and local departments of transportation (DOT) and the United States DOT (USDOT) seek to integrate information about customer values and needs with objective measures of performance to improve investment strategies. (1) Of particular interest is understanding the factors that affect road users' perceptions of service quality and satisfaction in order to make effective operational and infrastructure investments. Yet, despite the need for information on customer satisfaction with transportation systems, little research and few tools currently exist that allow decision-makers to assess easily road users' satisfaction and complaints. To obtain information needed to make investment decisions, many state DOTs use procedures outlined in the Highway Capacity Manual (HCM)(2) that estimate capacity and level of service (LOS). While the HCM is not an official standard of practice at the national level, the American Association of State Highway and Transportation Officials Policy (AASHTO) on Geometric Design of Highways and Streets (4) (the "Green Book") includes a guide for selection of design levels of service, thus creating a de facto standard of practice in the HCM.

The Transportation Research Board's Committee on Highway Capacity and Quality of Service (HCQS), which oversees the development of the HCM, has formally recognized the need to improve the current level-of-service methodologies in the Manual. Among the questions about the methodologies is the extent to which level-of-service estimates represent or correspond to road users' perceptions of quality. In July 2001, at the mid-year meeting of the HCQS Committee, the HCQS Committee passed a motion that stated, "The Committee recognizes that there are significant issues with the current level-of-service structure and encourages investigations to address these issues." (4) Various workshop sessions were held at the mid-year meetings in 2001 and 2002 during which the Committee members and friends raised the following concerns about the current HCM level-of-service methodologies:

- The lack of input from road users regarding identification of factors that influence their perception of service quality,
- The selection of levels of service without input from the traveling public,
- The insensitivity to variations in road user expectations across geographic locations, and
- The need for more or fewer levels of service to meet the needs of transportation professionals.

Consequently, the Committee is in the process of formulating research statements to address road users' perceptions of service quality and will incorporate relevant research findings into future editions of the Manual. The Committee is aware of the current research project and has expressed interest in the results.

The measure of customer satisfaction is of similar relevance to agencies that receive Intelligent Transportation Systems (ITS) Integration Program funds. Such agencies are required to perform self-evaluations to assess how well their projects meet goals, and to share this information with other decision makers. (5) The ITS Joint Program Office has identified five goal areas for ITS deployments:

- Safety
- Mobility

- Efficiency
- Productivity
- Energy and Environment

Within each of these goal areas, several measures of effectiveness (MOE) have been identified. These MOEs include traditional transportation measures such as changes in crash frequency and crash rates, increases in throughput and capacity, cost savings, and emission levels. In addition, a recommended MOE in the mobility goal area is customer satisfaction. Currently, there are no standardized measures or methodologies for measuring customer satisfaction. As ITS projects compete with traditional transportation improvement projects for state funds, standards for measuring customer satisfaction with infrastructure investments will provide a new and useful basis for selection.

1.1 Problem Statement

The current HCM level-of-service procedures use engineering-based measures such as speed and density for evaluations of service. Although the HCM states that, "each level of service represents a range of operating conditions and the driver's perception of those conditions", [2] factors identified by road users as influential to their perceived service quality are not explicitly used. Similarly, the level-of-service thresholds (LOS A-F) for each facility type have not been defined by users.

Investment decisions that do not include information about the perceptions of road users may not produce results that improve customer satisfaction. In view of the fact that transportation is a service paid for and provided to the public, it is important that transportation agencies use customer satisfaction, in addition to standard measures of effectiveness, in the development and evaluation of improvement projects.

1.2 Objectives

The goal of this study is to lay the foundation for developing tools to measure customer satisfaction and quality of service. (While "customer" is a broad term, the customers considered in the current study were drivers of personal automobiles (non-commercial) on arterial streets.) In order to measure customer satisfaction with the transportation system, it is first necessary to understand what characteristics of the transportation system are important to drivers and how each of these affect their level of satisfaction. A literature review revealed studies of driver perception of service quality with urban freeways, rural freeways, and signalized intersections. To add to the knowledge about driver perception of service quality, this study focused on identifying driver' perceptions of urban arterials. This study contributes to the existing body of knowledge by addressing urban arterials, a facility not yet studied from the driver's perspective. The objectives of this study were to:

1. Develop and test a methodology to obtain drivers' opinions with regard to roadway quality of service;
2. Identify the universe of factors that affects drivers' perceptions of service quality and satisfaction on urban arterials; and
3. Provide a qualitative foundation for the development of tools to measure the impact of these factors on driver satisfaction with urban arterials and urban arterial enhancements, including ITS deployments.

1.3 Hypotheses

A set of study hypotheses was generated from knowledge obtained from the literature review and recommendations from an expert panel. The hypotheses formed the basic research questions for this study, and also helped guide the selection of a field approach to data collection as well as the items on a written survey. The hypotheses for the overall study were as follows:

1. There are engineering factors other than average speed (currently the MOE used to determine LOS in the HCM) that affect drivers' perceptions of service quality on urban arterials.
2. There are factors other than those related to the design and operation of arterials (e.g., presence of trees, aggressive drivers) that affect drivers' perceptions of service quality on urban arterials.
3. Safety has an influence on drivers' perceptions of service quality and overall satisfaction.
4. The findings from this study will provide the basis for the information needed to develop tools for measuring service quality and driver satisfaction.

2 BACKGROUND INFORMATION

This section describes four studies related to assessing drivers' perceptions of service quality. The focus of these four studies was on automobile drivers. Each study focused on a different transportation facility type and used a different methodology. In one study, a focus group was used to determine drivers' perceptions of service quality along an urban freeway. Another study employed an in-vehicle approach to determine drivers' perceptions of service quality along a stretch of rural freeway. The third and fourth studies conducted video laboratory experiments to determine drivers' perceptions of service quality at signalized intersections. There have also been several recent studies to assess pedestrian and bicyclist perceptions of service quality; however, due to the focus of this research, these studies are not discussed in this report but are cited for the reader's reference.[6,7,8,9,10]

2.1 Focus Group Approach

Hall, Wakefield, and Al-Kaisy conducted a study to examine user's perceptions of quality of service on freeways. [11] The objective of this study was to identify the aspects of freeway travel that are important to motorists. The authors employed a focus group methodology. Focus group participants were asked questions pertaining to their perceptions of trip quality, the factors that influence trip quality, and the factors that influence changes in perceptions from trip to trip. Participants were asked to analyze factors from the perspective of both a driver and a passenger. Participants, who were faculty members from various departments at McMaster University in Hamilton, Ontario, routinely traveled on the stretch of freeway on which the study concentrated. Nine men and three women participated in the focus groups.

For the data analysis, important themes identified by participants were grouped by keywords of theme codes. The most important themes were then identified according to a number of criteria, including:

- Relevance to the research focus
- Frequency (number of focus groups in which a theme was mentioned)
- Intensity (number of times an issue was mentioned within each focus group and by the amount of written text about the issue)
- Universality (predominance of the same themes among different participants) and/or differentiation (importance of different themes to different sets of participants)
- Emphasis (emphatic or emotional speech)

The results showed that participants identified four primary themes or factors that affected their perception of service quality on the freeway segment, including: travel time, density, safety, and traveler information. Secondary issues included: driver civility, weather conditions, and presence of photo radar (included because of recent use in the area).

Two important issues related to LOS analysis emerged from this study. First, the drivers did not view their trips as a series of segments; rather they tended to view the trip as a whole, or as divided into two or three segments of 20 to 30 kilometers each. The significance of this finding is that it differs from the level of service analysis described in the HCM, which is based on short freeway segments. Second, the participants implied that the perceived LOS breakpoints, in terms of speed or density, are different than those described in the HCM for freeway LOS. As a result, the researchers recommended additional research to determine the need for LOS thresholds for speed on rural freeways.

2.2 In-Vehicle Approach

Nakamura, Suzuki and Ryu conducted a study to assess drivers' perceptions of service quality on a section of rural motorway in Japan. (12) The objective of the study was to quantitatively analyze the interrelationship between driver behavior, the degree of driver satisfaction, and the actual traffic flow conditions. For this analysis, the authors assumed a cyclical structure of the "cause and effect" relationship between driver perception of traffic flow conditions and driving behavior.

The authors measured driver satisfaction on a 9.3 km, rural, four-lane basic motorway section between an on-ramp and an off-ramp on the Tomei Expressway in uncongested traffic flow conditions. Twenty-four participants drove their own vehicles in both directions in the study segment for a total of 105 test runs. The 24 participants were staff and students of Nagoya University.

During the field test, a variety of data collection techniques were used. Video cameras were mounted on the test vehicle to record travel time, number of lane changes, time of a car-following situation by lane, and elapsed travel time by lane. Ten vehicle detectors were also placed along the test section of roadway to record traffic volume, spot speed, and occupancy by lane. After each one-way trip was completed, the subjects were asked to express their level of satisfaction with traffic conditions on a five-point scale: dissatisfied, somewhat dissatisfied, medium, fairly satisfied, and satisfied.

The results of the data collection during the field study showed that the degree of driver satisfaction under uncongested traffic flow conditions was revealed through driving behavior, mainly by lane changing activity and speed. For example, as traffic volume increased, the number of lane changes increased, and the spot speed decreased. The driver satisfaction data were transformed into scores by applying the Method of Successive Intervals (MSI) in order to be assessed quantitatively. The MSI analysis showed that rate of traffic flow influenced driver satisfaction the most of all the factors. Other factors affecting the drivers' assessments of the traffic conditions were: number of lane changes, elapsed time of a car-following situation, and driver experience.

The authors concluded with a recommendation for further research to address how geometric conditions might also affect the degree of driver satisfaction. It was also recommended that a similar study be done during congested conditions.

2.3 Video Laboratory Approach

Sutaria and Haynes conducted a study that focused on determining the different levels of service at signalized intersections from the drivers' perspective. (13) The researchers investigated thirty isolated, fixed-time, signalized intersections in the Dallas-Fort Worth area. Their investigation revealed that only one of the thirty intersections experienced the full range of LOS conditions described in the HCM (then based on Load Factor, the ratio of the total number of green signal intervals that are fully utilized by traffic during the peak hour to the total number of green intervals). The intersection of Lemmon and Oaklawn Avenues in Dallas was filmed using 16mm cameras for several hours to gather video clips of operating conditions ranging from LOS A to E. Fourteen video clips of delays ranging from 42 to 193 seconds were shown to the participants. The 14 video clips were broken into two groups of seven each: (1) microviews that showed the traffic situation from the view of an individual driver seated in an automobile and (2) macroviews that showed the overall traffic situation on a given approach from high above the roadway.

Three hundred and ten drivers participated in the study. The participants were given a questionnaire regarding their perceptions of signalized intersections before viewing the video clips. The participants were asked to indicate, in order of importance, the factors that affected their perceived quality of flow at signalized intersections. They were given five factors to rank: delay, number of stops, traffic congestion, number of trucks/buses, and difficulty in lane changing. Prior to viewing the video clips, the participants ranked the factors as follows:

1. Delay
2. Number of stops
3. Traffic congestion
4. Difficulty in lane changing
5. Number of trucks/buses

After viewing the films, the rankings changed only slightly:

1. Delay
2. Traffic congestion
3. Number of stops
4. Difficulty in changing lanes
5. Number of trucks/buses

After viewing each of the 14 video clips, the participants were asked to score the service quality on two different opinion scales. One scale was a six-point quantitative scale with 0 being "very poor" and 5 being "excellent." The other was the following qualitative scale:

> *I would describe the traffic situation presented in this film segment as a condition of:*
> - *(a) Free flow or as "free flowing" as can be expected if there is a traffic signal at the intersection under study.*
> - *(b) Tolerable delay, and nearly as good as could be expected at a signalized intersection.*
> - *(c) Considerable delay but typical of a lot of ordinary signalized intersections during busy times.*
> - *(d) Unacceptable delay and typical of only the busiest signalized intersections during the rush hour.*
> - *(e) Intolerable delay and typical only of the worst few signalized intersections I have seen.*

Based on input gathered from this study, the researchers developed a nomograph that depicted the relationship between perceived or rated level of service and three measures: average intersection delay, load factor, and volume to capacity ratio. The researchers recommended that: 1) average intersection delay should be used to predict level of service instead of load factor, 2) similar studies should be conducted on signalized intersections without full actuation, and, 3) simultaneous filming and field studies should be conducted to allow for accurate measurement of traffic engineering measures captured on film.

The results of this study led the Highway Capacity and Quality of Service Committee to revise the 1985 HCM to use average intersection delay as the new MOE for signalized intersections (as opposed to load factor).

Pecheux, Pietrucha and Jovanis also conducted a study to assess user perception of level of service at signalized intersections. [14] The objective of this study was to assess the appropriateness of the HCM levels of service for signalized intersections in terms of users' time-estimating capabilities and level-of-service perceptions, and to identify the factors that affect users' perceptions of level of service.

The researchers conducted a video laboratory experiment in which subjects participated in two different laboratory sessions: one session to estimate the time at the signal, and one session to rate quality of service (QOS). Laboratory sessions contained seven to ten subjects. At the beginning of the first laboratory session, subjects were given an instruction sheet explaining the task. The subjects then viewed the videotape, which was shot from the perspective of the driver. The videotape contained a series of short video clips of approaches to different signalized intersections. The delays at the signalized intersections shown in the video clips ranged from 3 to 110 seconds. After the second laboratory session, a questionnaire was administered to the subjects. The questionnaire was designed to accomplish three objectives: (1) to explore the subjects' attitudes about driving in certain situations, (2) to explore personal characteristics of the subjects, and (3) to obtain socio-demographic information. After the questionnaires were complete, the subjects discussed, as a group, the factors that affected their QOS ratings.

A total of 98 subjects participated in the study. Participants were recruited through an advertisement in the local paper, and all those wishing to participate were allowed to do so. Fifty-two participants were female and 46 were male. Half of the participants were between the ages of 21 and 30, 37 of the participants were between the ages of 31 and 60, and 12 of the participants were over 60 years old. The participants represented the full range of education (high school graduate to some graduate school) and income levels (under $25,000 to over $100,000).

The results of the study showed that, on average, subjects' delay estimates were fairly accurate; however, the individual subject delay estimates were widely variable. The results of a cluster analysis on subjects' QOS ratings suggested that participants perceived service quality on three or four levels, as opposed to the six levels of service (A – F) defined in the HCM. The subjects identified at least 15 factors that influenced their QOS ratings:

- Delay
- Traffic signal efficiency
- Arrows/lanes for turning vehicles
- Visibility of traffic signals from queue
- Clear/legible signs and road markings
- Geometric design of intersection
- Leading left-turn phasing scheme
- Visual clutter/distractions

- Size of intersection
- Pavement quality
- Queue length
- Traffic mix
- Location
- Scenery/aesthetics
- Presence of pedestrians

The authors suggested that the most important factors found to influence users' perceptions of service should be controlled in future experiments. Also, location should be a main consideration in future experiments because of the differences in delays/congestion and the experiences and expectancies of drivers across locations. A final recommendation was to further examine whether average delay, as calculated in the HCM procedures, characterizes the delay experienced by all drivers in a lane group or by individual drivers who make multiple trips through the same intersections. The authors suggested this be researched with studies at individual intersections to determine how users form an overall perception of service quality based on multiple trips through one intersection versus one trip through several different intersections.

2.4 Summary

The literature reviewed for this study not only provided a background of the different methodologies that have been used to assess drivers' perceptions of service quality, but also helped to identify a preliminary list of operational, roadway, and environmental characteristics shown to influence drivers' perceptions of service quality.

3 METHODOLOGY

This study used an in-vehicle field approach to determine the operational and roadway conditions that drivers identified as influencing their perception of service quality on urban arterials. Given that the focus of this study was to gain insight into drivers' thoughts, perceptions, and evaluations of roadway conditions, the in-vehicle approach provided the opportunity for drivers to experience real-world driving conditions and talk out loud about their reactions to the driving environment as events unfolded. Using this method enabled the collection of driver opinions that were spontaneous and presumably genuine (i.e., personally meaningful). Important, too, is the fact that during data collection, drivers were experiencing the actual driving environment, which is complex and dynamic. Moreover, since this research was exploratory, it was critical to allow the drivers to speak for themselves, rather than have the researchers define the issues and set the agenda. Finally, the in-vehicle approach narrowed the drivers' attention (and hence their comments) to the arterials on which they were driving. In this way, feedback on specific arterial features was obtained from drivers, rather than generalizations about the whole of their driving experience.

A number of assumptions were made in the development of the research methodology. These assumptions included:

- Contextual factors, such as geographic location and urban density and population, influence drivers' experiences and their perceptions of service quality.
- Exposure to a variety of roadway designs and conditions will lead drivers to identify a diverse set of issues that are of importance to them.
- Drivers' perceptions vary according to the level of congestion to which they are exposed.
- Selecting drivers who are experienced and familiar with the route will facilitate the identification of factors that are important to them.
- Gender, age, and household composition (specifically whether there are young children in the home) may affect their perceptions of quality of service.

3.1 Study Overview

Participants (accompanied by an interviewer and a traffic engineer) were asked to speak about their driving experience and the factors that influence their perception of service quality while driving on a pre-selected route. Four field sites were chosen based on a range of contextual factors, which are described in Sections 3.2 and 3.3. At each field site, a specific route was selected that offered a range of conditions in accord with the Highway Capacity Manual's description of urban arterials. The route was standardized so that comparisons could later be made across participants, and the field drives were conducted in the morning peak, midday, and afternoon peak to capture a range of traffic conditions. While there may be unique factors that contribute to drivers' perceptions of service quality and customer satisfaction at night, only daytime drives were conducted in this study.

Prior to the field drives, a pilot study was conducted in Northern Virginia (Washington, D.C. area). The pilot study enabled the study team to refine the pre-drive introduction and orientation, the field procedures, and the post-drive protocol and survey instruments. The pilot study revealed a number of important issues related to the test drives. First, the routes needed to contain a variety of different roadway designs, environments, and traffic conditions to invoke a multiplicity of issues important to the drivers. Second, it was apparent that the field drives should be limited to no more than 40 minutes to minimize participant fatigue. Third, the pilot study provided valuable training for the interviewers.

3.2 Location Selection

Field data were collected in four locations: Chicago, Illinois; Sacramento, California; Tallahassee, Florida; and Atlanta, Georgia. The rationale for the selection of different types of urbanized areas across the country was that the context (e.g., transportation network, age and size of city, driving culture) would influence drivers' experience and expectations of roadway conditions. The objective for this qualitative stage of the study was to include contextual diversity in the sample so as to observe as many differences as possible. The specific criteria for selection were geographic location, population, and convenience (the presence of a contact or a shared business trip).

The key location characteristics used as a basis for choosing each site are outlined below:

- Chicago, Illinois: Midwest; large urban area
- Tallahassee, Florida: Southeast; small urban area
- Atlanta, Georgia: Southeast; large urban area
- Sacramento, California: West; small urban area

A map of the study areas is shown in Figure 3-01.

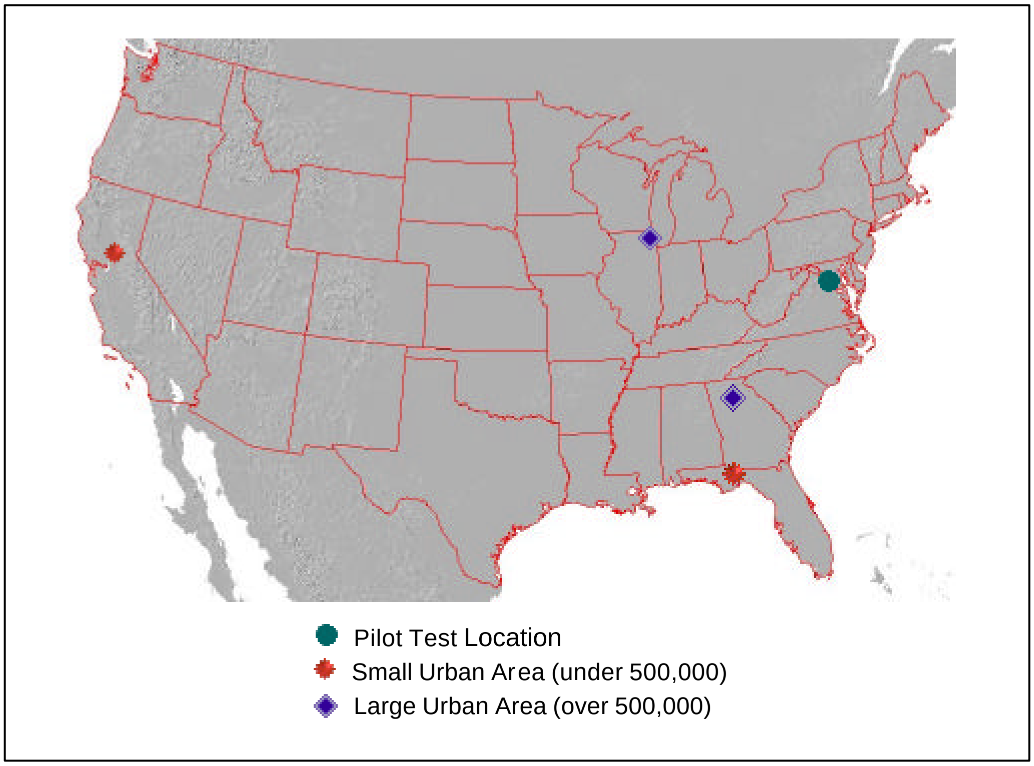

Figure 3-01: Map of Study Locations

3.3 Route Selection

For each of the four field sites, one route was developed. The criteria used for arterial selection were based on Chapter 10, Urban Street Concepts, of the HCM. [2] The HCM outlines characteristics of three arterial design categories as shown in Table 3-1. Because it would have been difficult to include each arterial design category on every route (as the route would be too long and participants would fatigue over time), "suburban" and "intermediate" arterials were included in the routes in the small urban areas (i.e., Sacramento and Tallahassee), and "intermediate" and "urban" arterials were included in the routes in the large urban areas (i.e., Chicago and Atlanta).

Table 3-1: Criteria for Arterial Selection

Criterion	Design Category		
	Suburban	Intermediate	Urban
Driveway/access density	Low density	Moderate density	High density
Arterial type	Multilane divided; undivided or two-lane with shoulders	Multilane divided or undivided; one-way two-lane	Undivided one-way, two-way, two or more lanes
Parking	No	Some	Significant
Separate left-turn lanes	Yes	Usually	Some
Signals/mile	1-5	4-10	6-12
Speed limit	40-45 mph	30-40 mph	25-35 mph
Pedestrian activity	Little	Some	Usually
Roadside development	Low to medium density	Medium to moderate density	High density

Taken from Chapter 10 – Urban Street Concepts, HCM 2000

At each field site, local contacts were provided with the appropriate arterial selection criteria, along with general parameters on how long it should take to drive the route. The local contacts then selected a specific route for the field drives, based on the design criteria. A roadway inventory, conducted by the interviewer and the traffic engineer prior to the field drive, provided an opportunity to adjust the route, if necessary.

A brief description of the four study routes is provided below. The descriptions are provided to help orient the reader to the conditions experienced by the study participants.

3.3.1 Atlanta, Georgia

The Atlanta study route began in an area with primarily medium-density commercial development. The roadway cross-section began with a four lanes and expanded to six lanes at various points (mainly near busy intersections). There were curbs, gutters, and sidewalks, but neither medians nor shoulders. There was on-street parking at several locations along the route, but not along its entirety.

The route also passed through two residential areas that connected two parallel high-density streets. The roads through much of the residential areas were two-lane and curvy, although they did widen to four-lanes on occasion (again at busy intersections). There were short stretches of sidewalk along the route, but no medians. Along part of the route there was a two-way center left-turn lane.

The last section of the route led back to the commercial area of Atlanta. The road was four lanes with sidewalks, but no medians. Further along the route, the road widened to six lanes with on-street parking on the right.

3.3.2 Chicago, Illinois

The Chicago study route was located in downtown Chicago, near the Sears Tower and around busy commercial areas near the financial district. The Loop elevated transit system was present at the beginning of the route, and as a result, pedestrian traffic was high along many areas of the route. The streets were very urban, with transit bus service and limited landscaping. Sidewalks were provided on all streets along the route. The route contained some one-way, two-lane streets; one-way, three-lane streets; two-way, four-lane streets, and two-way, six-lane streets, with and without medians. Street parking was available on almost all streets along the route. One portion of the route included an urban residential setting with less traffic and low-rise residential buildings (such as town homes) and small commercial buildings.

3.3.3 Sacramento, California

All of the roads traveled in Sacramento were two-way, and there was noticeably very little on-street parking. For most of the route, there were two-way center left-turn lanes; however, there were medians at several points. The route began with three lanes in each direction, sidewalks, and a median with very dense commercial development close to the roadway (e.g., shopping malls, strip malls). The roadway eventually narrowed down to four lanes and then to two lanes after crossing over the American River, where it entered a very industrial area with significant truck traffic. On the north end of the route, the roadway had two lanes in each direction, with a raised grassy median and large trees.

3.3.4 Tallahassee, Florida

The Tallahassee route began with a suburban-rural, four-lane cross-section with a wide grassy median. The route continued into an urban area with primarily light to medium density commercial development. The route then continued on an urban street with a shared left-turn lane and a sidewalk. As the route approached downtown Tallahassee, areas of on-street parking were present, landscaping became more apparent, and the two-way center turn lane ended. The route eventually widened to six lanes, with some increase in pedestrian traffic. Portions of the route also contained a four-lane divided street with designated bike lanes and sidewalks.

3.4 Participant Selection

Five to six participants were selected (22 in all) to drive on the pre-selected route at each of the four sites. Participants were selected on the basis of gender, age, and family status (children versus no children), in order to capture a range of opinions and attitudes about driving on urban arterials. In addition, it was desired that all drivers participating in this study: (1) be generally familiar with one or more of the roadways on the test route, (2) drive somewhat frequently (at least three to four days per week), (3) have a minimum of two years driving experience, and (4) not be a transportation professional. The participants represented a variety of backgrounds and occupations. Because this study was exploratory in nature, the sample set of 22 drivers was not meant to be representative of the driving population.

Participants were recruited primarily through the personal network of the local area contact. Table 3-2 outlines the demographic characteristics of the participants at each field site.

Table 3-2: Data Collection Summary: Characteristics of Participants

Field Site	Number of Participants	Ages	Gender
Northern Virginia (Pilot location)	4	2 20 - 30 year olds 2 35 - 50 year olds	2 women 2 men
Chicago	5	2 20 - 30 year olds 3 35 - 50 year olds 0 60 - 75 year olds	3 women 2 men
Tallahassee	5	1 20 - 30 year old 2 35 - 50 year olds 2 60 - 75 year olds	3 women 2 men
Atlanta	6	0 20 - 30 year olds 3 35 - 50 year olds 3 60 - 75 year olds	3 women 3 men
Sacramento	6	1 20 - 30 year olds 3 35 - 50 year olds 2 60 - 75 year olds	4 women 2 men

3.5 Equipment

A video camera, microphone and tri-pod were the equipment used during the field drive. The video camera and microphone were mounted in the back seat of the participant's vehicle and were used to provide a video and audio record of each drive. The video portion provided time and location information corresponding to the transcript and also provided supplemental information to help understand participant comments.

3.6 Participant Contact

Upon selection of the participants, the interviewer or engineer contacted each participant to confirm their willingness to participate, to verify their socio-demographic profile, and to determine a convenient meeting time and location for conducting the field drive. Prior to the field drive, a letter was sent to the participant confirming the meeting time and location. The letter included a description of the study, a route map, and a consent form. A few days prior to the field drive, the interviewer conducting the experiment confirmed participant participation with a phone call.

3.7 Data Collection Procedures

The data collection procedures consisted of two separate, but related, activities: (1) the drive and (2) the post-drive survey. These are discussed in further detail in the following sections.

3.7.1 Drive

At each field site, a research team of two (an interviewer and a traffic engineer) accompanied each participant on his or her drive. Upon the arrival of the participant to the prescribed meeting location, introductions were made, and the interviewer reviewed the overall interview protocol and went over the route with the participant. The consent form (see Appendix A) was reviewed and signed by the participant and a witness. After the informed consent form was signed, the interviewers instructed the driver on how to proceed (See Appendix B for experiment instructions). The traffic engineer was responsible for mounting the video camera and testing its functionality. Upon completion of these introductory tasks, a “practice drive” was performed.

3.7.1.1 Practice Drive

The purpose of the practice drive was to familiarize the participant with the experimental procedures and to allow him or her to become accustomed to talking out loud about the driving experience. This gave the interviewer an opportunity to communicate with the participant, particularly if the participant appeared nervous, intimidated, or not especially vocal. The practice drive occurred on a pre-defined course and took about 5 to 10 minutes to complete. However, if the participant was having difficulties, the course was repeated to give him or her more time to become comfortable in the experimental conditions.

3.7.1.2 Data Collection Drive

Twenty-two data collection drives were completed. In addition, four pilots on routes in Northern Virginia were conducted, but the pilot data were not analyzed and are not reported here. During the field drives, the role of the participants was to talk out loud about their perceptions and opinions regarding the driving experience and the driving environment. The interviewer sat in the front passenger seat and answered any questions that the participant had during the drive. However, the interviewer limited initiating conversation with the participant. In addition, it was made clear to the participant that he or she was to initiate conversation and that the interviewer would not express her opinion. The interviewer was trained to prompt the driver for more detail when necessary or to probe for clarification if an ambiguous comment was made.

During the field drive, the traffic engineer sat in the back seat and was primarily responsible for operating the video equipment. The traffic engineer also made note of ambiguous comments that were not clarified through the probing of the interviewer, so that these comments might be addressed at the end of the field drive.

3.7.2 Post-Drive Survey

Following the field drive, the interviewer and the traffic engineer asked the participant to clarify any ambiguous comments made during the course of the drive, and the driver was asked to complete the post-drive survey. The post-drive survey was used to explore participants' opinions about urban arterials as well as to obtain more general concerns that they may have about driving. The survey also provided the opportunity to compare what drivers said was important while driving, to what they said was important after the drive. In this way, the study team could gain a better understanding of what factors were important to the driver, beyond what was experienced on the field drive. The first part of the survey pertained to specific features of urban arterials. The second part of the survey contained questions that expanded beyond urban arterials to explore drivers' experiences on all types of local area roads. The survey was four pages (see Appendices C and D) and required approximately ten minutes to complete.

3.7.2.1 Questions about Urban Arterials

The first part of the survey presented a list of urban roadway features and asked the driver to review and select (check) the top ten features of urban arterials of most importance to them as a driver. The driver then ranked the top five features from the chosen ten in order of importance to their satisfaction or dissatisfaction. In addition, drivers were asked to list three to four characteristics or conditions that would comprise their ideal and their least favorite urban arterial.

3.7.2.2 General Questions

The second part of the survey included the following general questions about roads and traffic conditions:

- What are some of the concerns you have regarding the roads on which you travel?
- Are you satisfied with the roads in your area? Why or why not?
- How do traffic conditions and the roads affect your quality of life?
- If you could make changes to the roads on which you drive, what would they be?

After the participant completed the survey, the interviewer briefly reviewed the survey instruments with the participant to obtain more detailed information regarding their responses. The study team thanked the participant for his or her participation and paid each participant 50 dollars in recognition of the value of their contribution to the study.

3.8 Data Analysis Approach

The data analysis approach involved the extraction of factors and issues that were revealed or identified by the drivers on the road and in their written responses to the post-drive survey. The results from the drive and post-drive are presented in sections 4.1 and 4.2, respectively. A more detailed analysis and comparison of the data follow in section 4.3.

3.8.1 Analysis of Driver Comments

The data collected during the 22 drives produced approximately 200 pages of transcribed dialogue. The transcribed text was imported into an Excel spreadsheet for review. A senior researcher parsed the dialogue into smaller sections of text related to a particular subject, characteristic, or experience. Next, senior traffic engineers reviewed the parsed transcript files and translated the opinions into engineering terms. Once expressed in engineering terms, the opinions were clustered into "quality of service (QOS) factors." Table 3-3 provides an example of dialogue from a drive in Sacramento, California, in which the driver describes the effect of buses on moving traffic.

Table 3-3: Example of Driver Dialogue, QOS Factor and Investment Area

The Dialogue Reveals ➔	QOS Factor
Driver: These buses should have their own lane on that side because most of the time this is a very busy street.	Bus Pull-Out
Researcher: And do the buses make it much worse?	
Driver: Yes. When it is busy, if they block the whole thing…whenever possible, if there is a wider space for them it would make it easy to drive through.	

Finally, identified QOS factors were grouped into broad categories referred to as "investment areas." Investment areas were identified by the engineering team and loosely reflect the departments generally housed within traditional transportation agencies.

3.8.2 Analysis of Survey Data

The survey data supplemented the driver transcripts in the following ways: first, by providing information about the priorities drivers have regarding features and conditions on urban arterials; second, by allowing the means to compare what drivers said on the road to their responses on a written questionnaire; and third, by giving the drivers an opportunity to describe the issues and concerns that they have in general about driving. Toward that end, the survey data was summarized so that driver ranking of roadway features as well as definitions of the "ideal" and "least favorite" urban arterial were made comparable to the QOS factors identified during the drive.

4 RESULTS

The study produced two different sets of data: the transcripts from the drives and the written responses to the post-drive survey. The field drives provided an exploratory method to address, in context, the relationship between characteristics of the driving conditions and the drivers' immediate reactions and evaluations. The survey used context-independent questions to gather drivers' opinions about specific features of urban arterials and other general issues about driving.

The objective of this study was to identify the universe of factors influencing road users' perceptions of service quality and customer satisfaction; however, the research team envisions that the ultimate goal of this research area will be to incorporate road user input from this study into the development of improved tools for measuring QOS and customer satisfaction. Figure 4-01 illustrates how the data from this study led to the inventory of quality of service (QOS) factors and driver needs, and how these findings could be used in the development of QOS and customer satisfaction tools. Chapter 4 describes in detail the relationship between the study data and QOS factors, and Chapter 5 describes driver needs as revealed by the QOS factors.

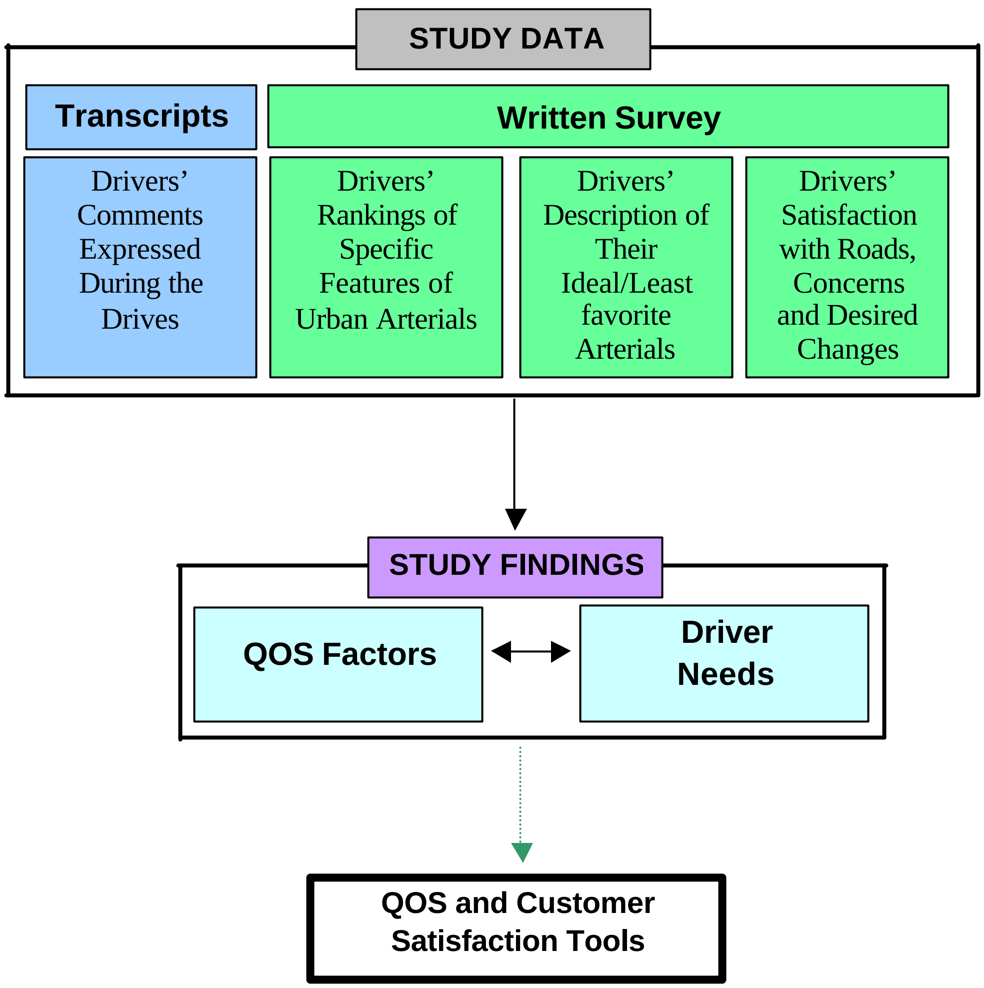

Figure 4-01: Flowchart of Study Data and Findings, and Potential Applications

4.1 QOS Factors Identified from Driver Comments

The QOS factors and investment areas identified from driver comments are shown in Table 4-1. Figure 4-02 through 4-09 graphical present the links between the subjects' opinions, QOS factors, and investment areas as they were identified through the transcript reviews for each investment area in Table 4-1. The blue boxes on the right side of each chart show condensed driver opinions about each QOS factor (from the driver transcripts). The driver opinions are followed by letter-number codes that correspond to location and subject number. For example, the first driver in Chicago is coded as C1. The identification numbers were included in the charts to demonstrate that, in many cases, different drivers across a variety of locations and conditions identified the same factors.

Table 4-1: Investment Areas and QOS Factors

Investment Area	QOS Factor	
Cross-Section Roadway Design	Lane width # of lanes/roadway width Turning lanes/bays Lane drop/add Medians	Pedestrian/bicyclist facilities Bus pull-outs Parking Access management Two-way center left turn lane
Arterial Operations	Number of traffic signals Volume/congestion Traffic flow	Presence of large vehicles Travel time Speed
Intersection Operations	Signal failure/inefficient signal timing Turning Timing of signals Traffic progression	
Signs and Markings	Quality of pavement markings Lane guidance—signs Lane guidance—pavement markings Sign legibility/visibility Sign presence/usefulness	Advance signing Too many signs
Maintenance	Pavement quality Overgrown foliage	
Aesthetics	Presence of trees Medians with trees Visual clutter Cleanliness Roadside development	
Other Road Users	Illegal maneuvers Driver courtesy Aggressive drivers Improper/careless lane use	Careless/inattentive driving Use of turn signals Pedestrian behavior Blocking intersection
Other	Intelligent transportation systems Planning Roadway lighting	

Subject Opinions | **QOS Factors** | **Investment Area**

- Lanes too narrow at intersection (T1)
- Wide lanes give a feeling of safety (T1)
- Wide lanes nice (T1,T4,T5)
- Lane width is good – it accommodates volume (A2)
- Lane width is too narrow for existing congestion (A5)
- Narrow lanes lead to lack of maneuverability (C1,C5)

→ **Lane Width**

- Too few lanes to handle traffic volume (S1)
- Number of lanes sufficient to handle traffic volume (T2,S5,C2)
- Adding lanes has improved traffic flow (S2,S3,S4,S6,T1,T2,T5)
- Adding lanes in only some places leaves bottleneck (S4)
- Widening is needed (S2)
- Wide road is good (T2,C5)
- Fewer lanes better (A5)
- Shoulder needed (A5)
- 2-3 lanes needed to allow for maneuvering (C1)

→ **Number of Lanes/ Roadway Width**

- Dual left-turn lanes important to traffic flow (C2,S2)
- Number of left-turn lanes (A4)
- Channelized right-turn lanes good (T2)
- Lack of turn lanes (T2,A1,A2)
- Mid-block turning bays needed (T2)
- Lack of turn bays into developments (T2,A4)
- Frequent turn bays should be connected into one turn lane (A4)
- Need long storage lanes for turners (S1,T2,A2,A4)

→ **Turning Lanes/Bays**

- Unexpected lane drops not desirable (need continuity) (S1,S3,T2)
- Left lane drop more confusing that right lane drop (S5)
- Need merging lanes (T2)
- Lots of adding/dropping lanes not good (A2,A4)

→ **Lane Drop/Add**

- Nice painted median (T2)
- Raised median good (T2)
- Median with trees/plants visually appealing (C5,T5)
- Medians good (A4,C1)
- Medians with large plants block view of roadway (C3)
- Medians give you a little more room (C1)
- Need median on high-speed roads (C5)

→ **Medians**

Lane Width, Number of Lanes/Roadway Width, Turning Lanes/Bays, Lane Drop/Add, Medians → **CROSS-SECTIONAL ROADWAY DESIGN**

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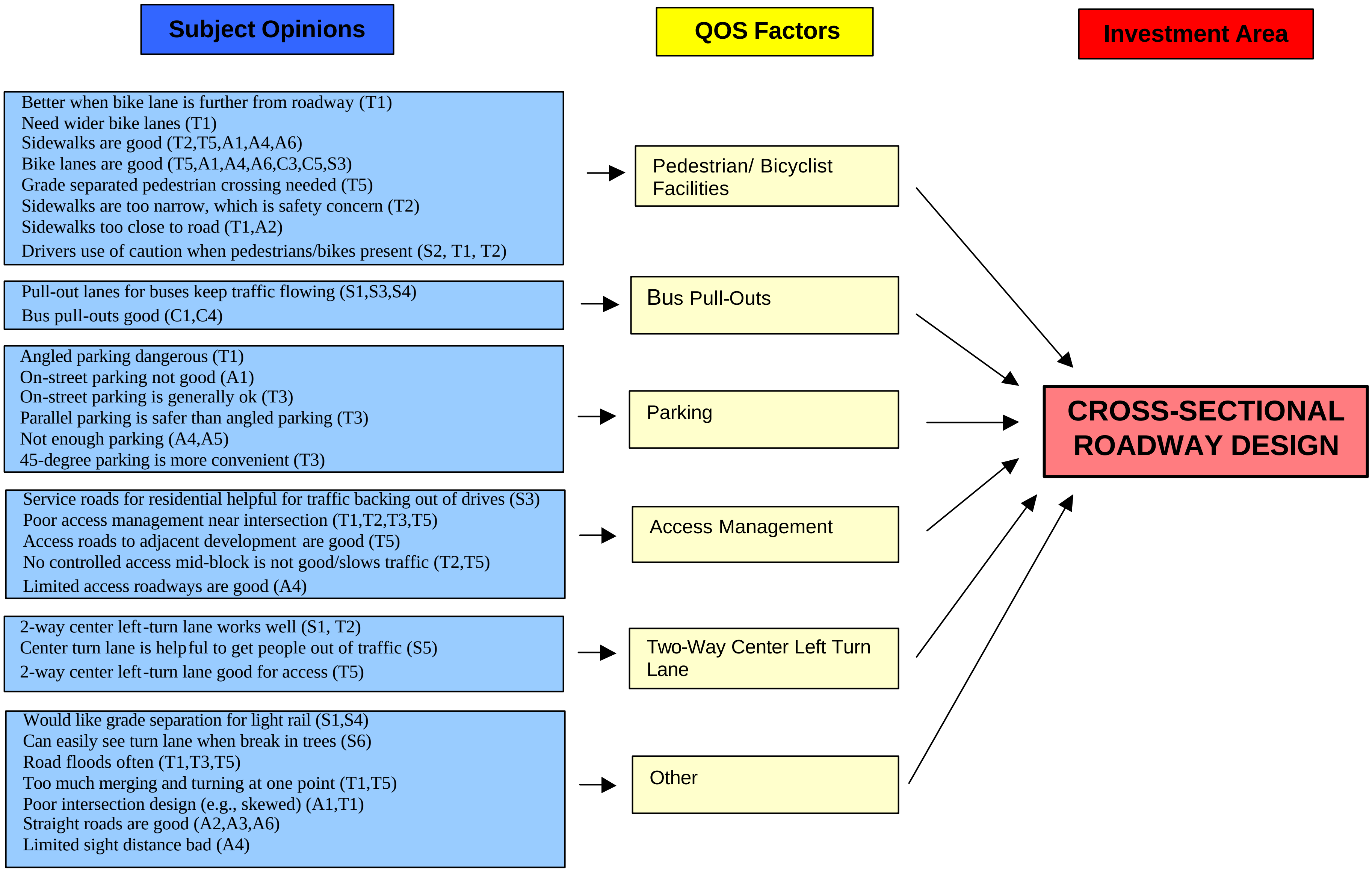


Figure 4-02: QOS Factors in the *Cross-Sectional Roadway Design* Investment Area

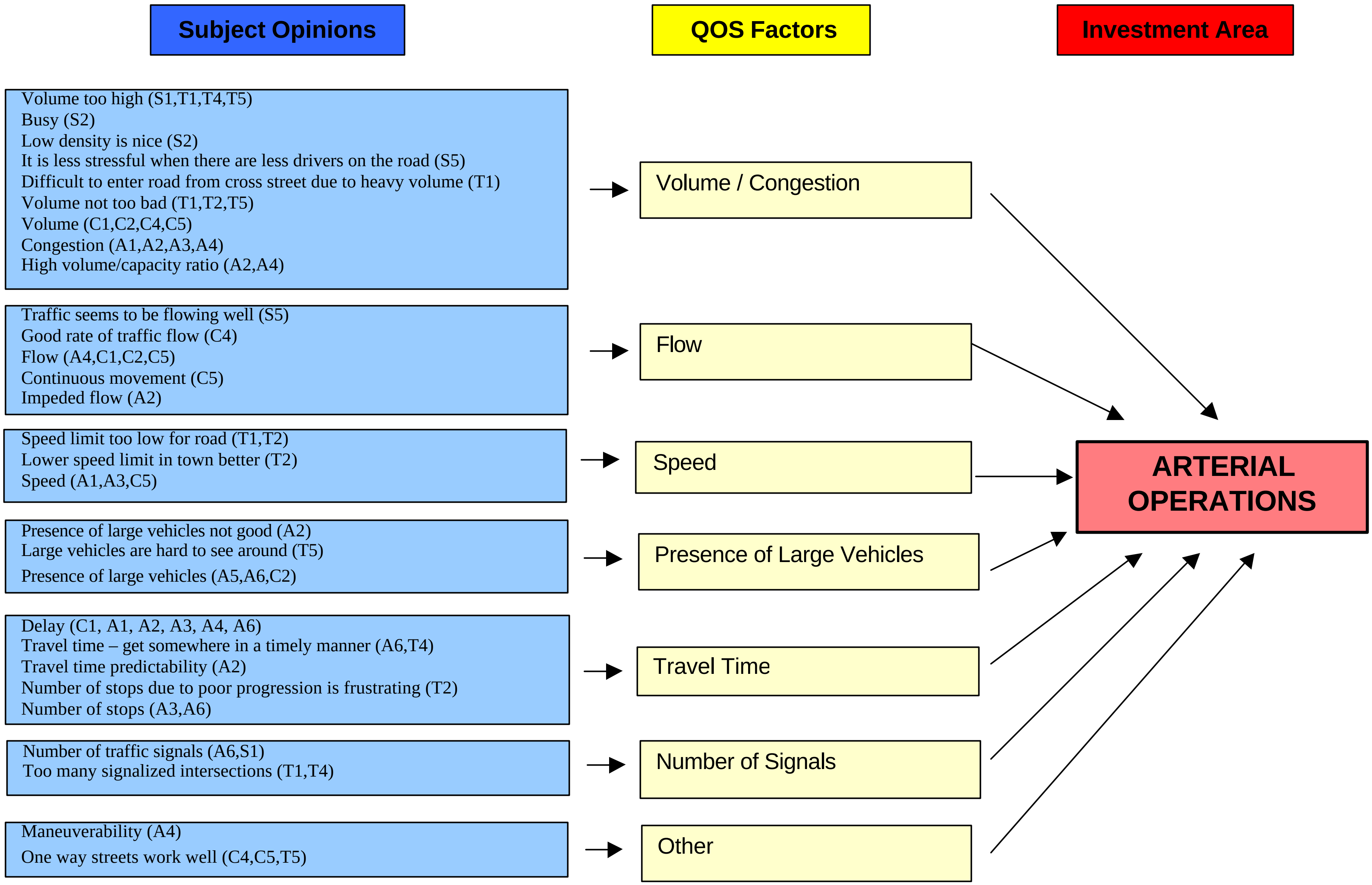


Figure 4-03: QOS Factors In the *Arterial Operations* Investment Area

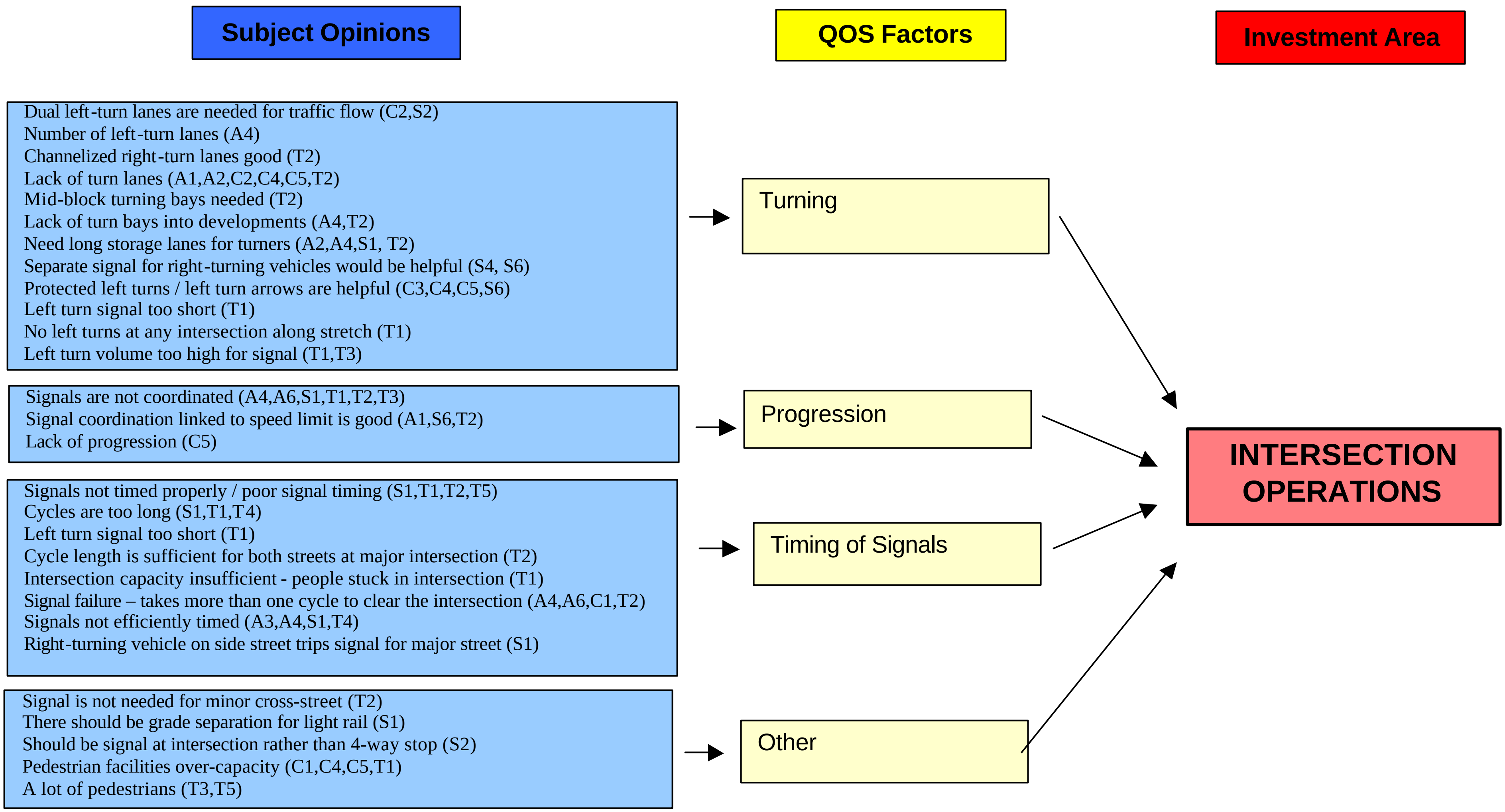
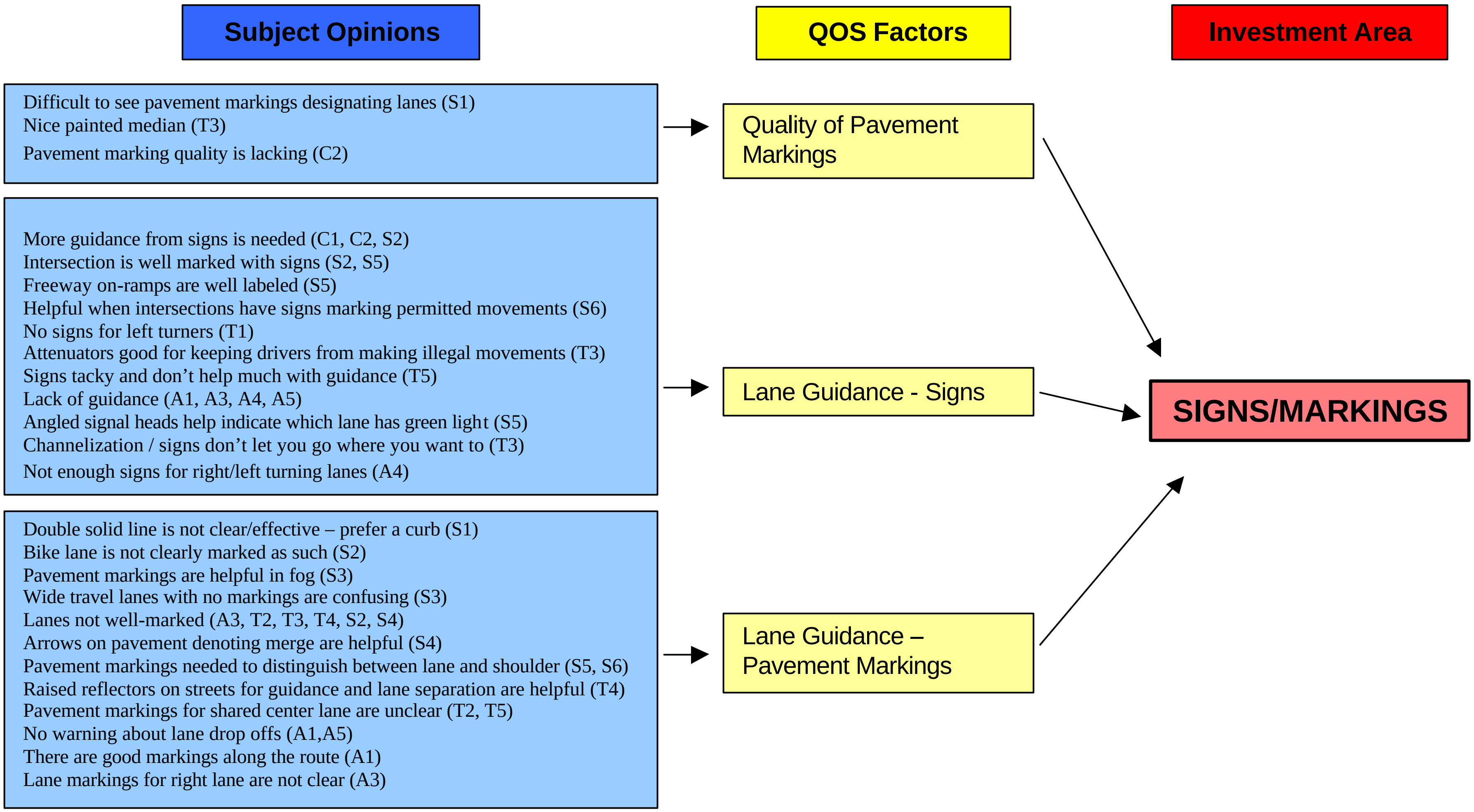


Figure 4-04: QOS Factors In the *Intersection Operations* Investment Area



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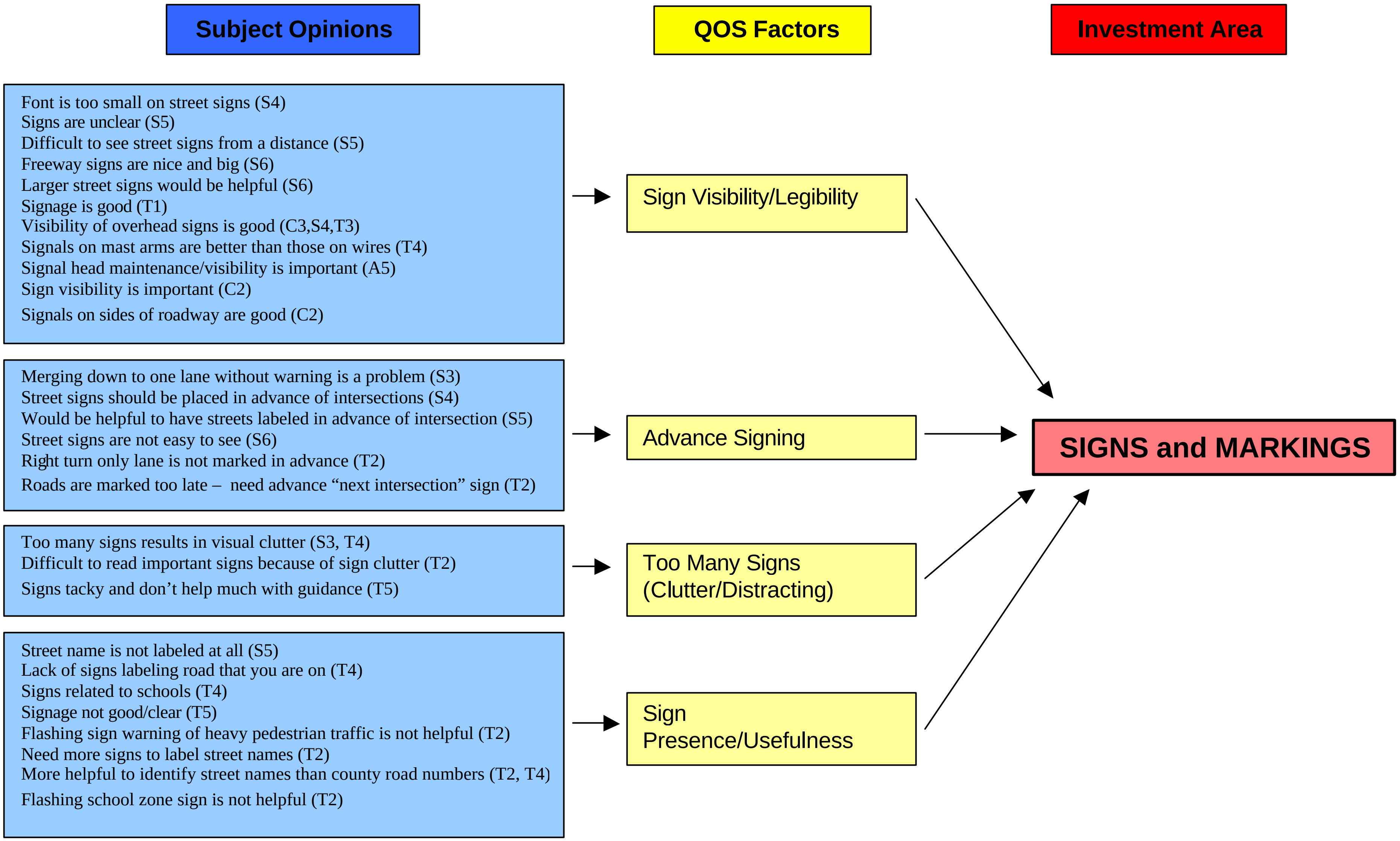

Figure 4-05: QOS Factors In the *Signs and Markings* Investment Area

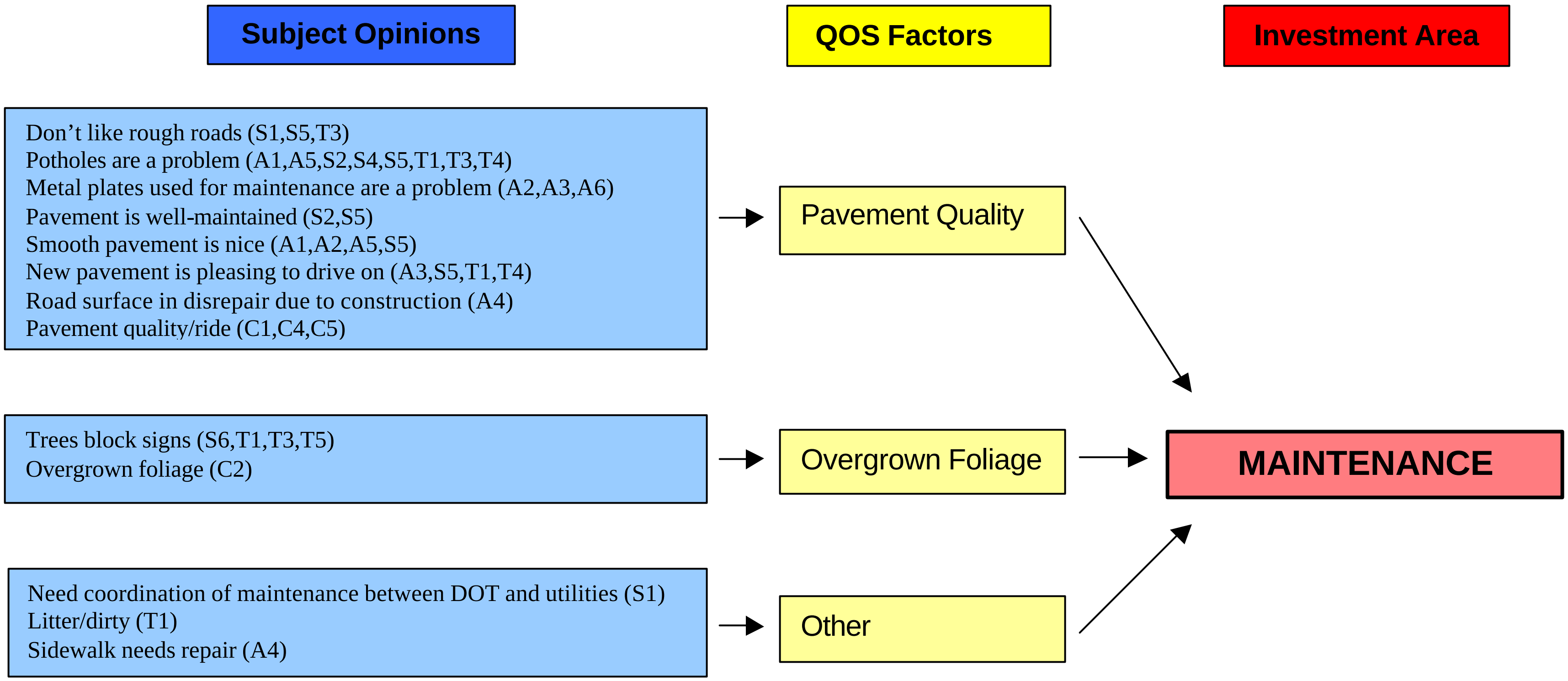

Figure 4-06: QOS Factors In the *Maintenance* Investment Area

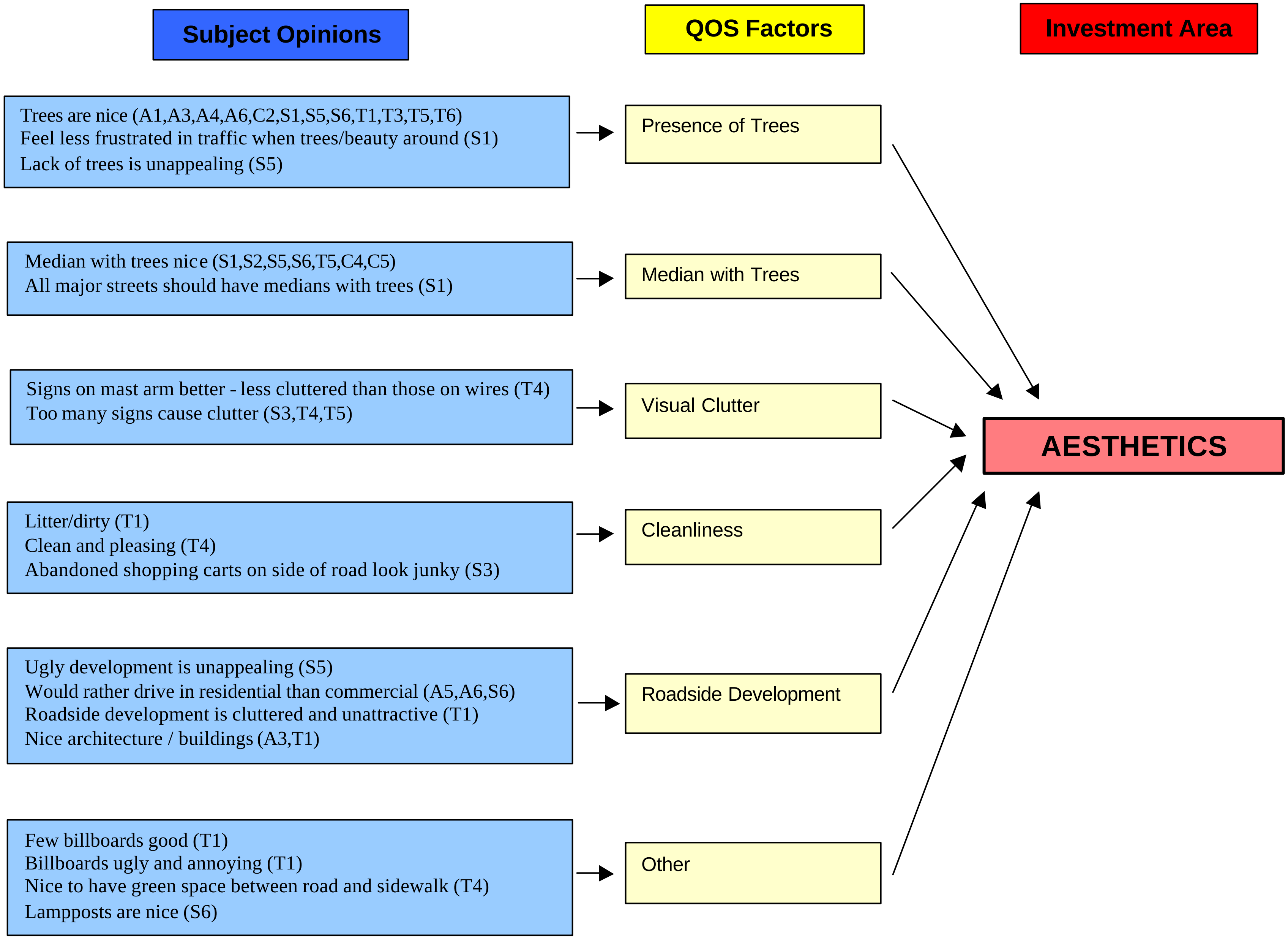

Figure 4-07: QOS Factors In the *Aesthetics* Investment Area

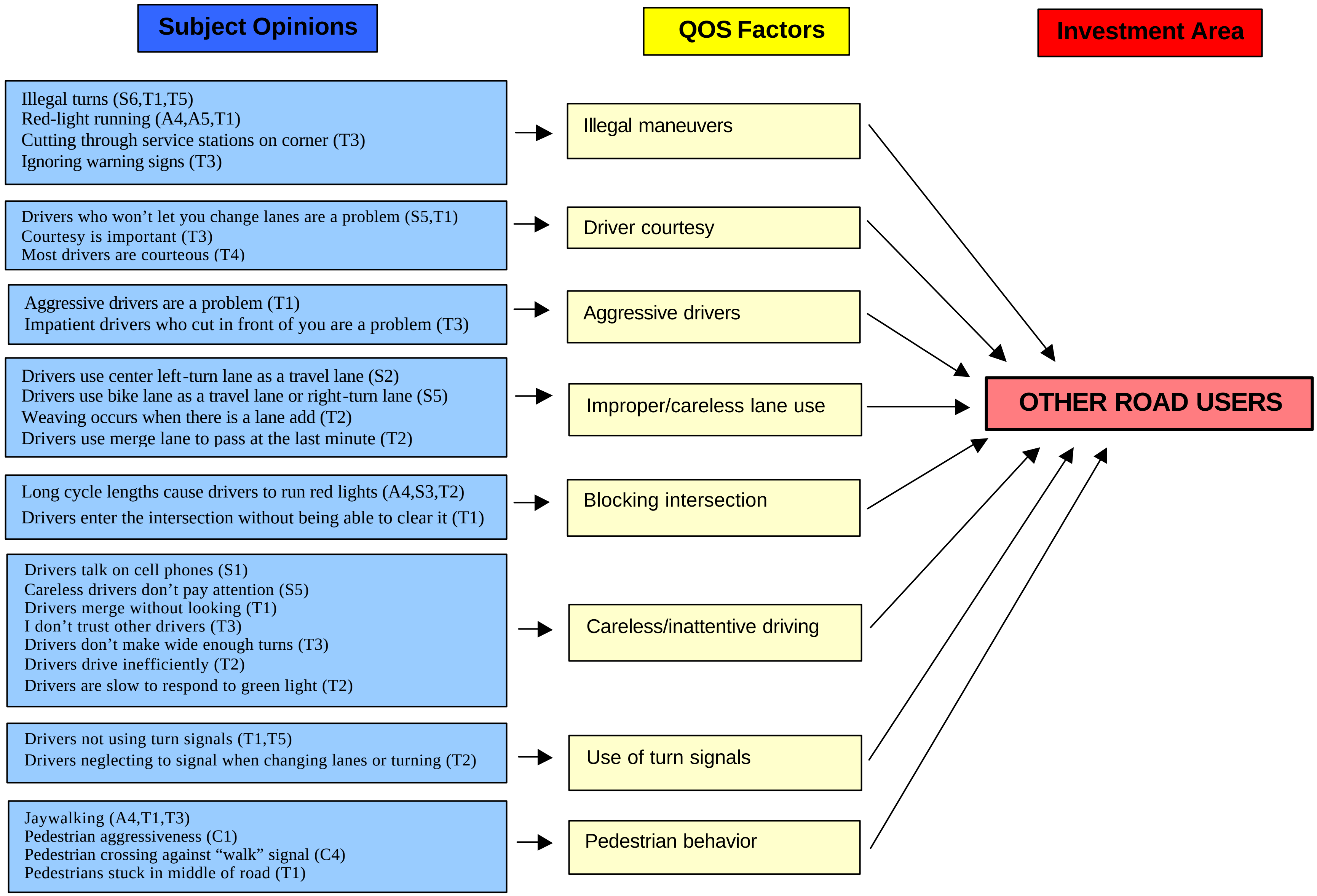

Figure 4-08: QOS Factors In the *Other Road Users* Investment Area

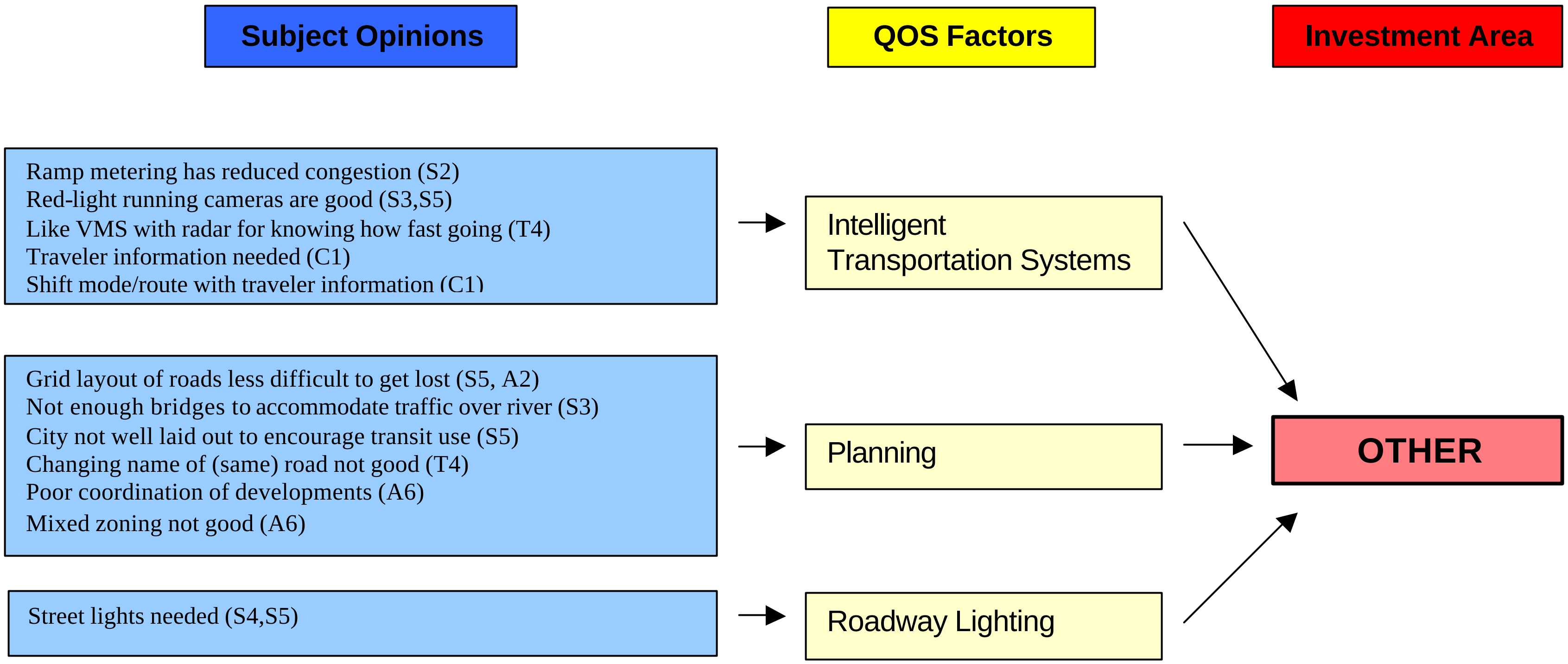

Figure 4-09: QOS Factors In the *Other* Investment Area

Each QOS factor listed in Table 4-1 is discussed in further detail in section 4.3, after presentation of the post-drive survey results. To have a full appreciation of the importance of each QOS factor, one needs to consider not only the information obtained during the drives, but also from information obtained from the survey instrument. The post-drive survey provides supplemental information to that obtained during the drives. A detailed discussion of quality of service factors follows in Section 4.3.

4.2 Post-Drive Survey Results

The goal of administering the post-drive survey was to explore drivers' attitudes and opinions about urban arterials beyond that of the particular route just driven. It was assumed that any one route could not be all encompassing or contain all factors that might influence drivers' perceptions of service quality. The survey inquired (implicitly and explicitly) about the whole of the experience on urban arterials, not just about the current location. As described in section 3.7.2, the survey included two parts. The first part of the survey addressed the question of relative importance of different features of urban arterials. Drivers provided information about urban arterials by selecting and ranking features that are important to them and by defining the characteristics or conditions that would comprise their ideal and least favorite urban arterials. In the second part of the survey, drivers answered general questions about driving.

4.2.1 Important Features of Urban Arterials

After the drive, drivers reviewed a list of 26 characteristics of arterials, which were selected a priori. The list of features was based on a review of the literature and on expert opinion. The list contained a wide range of traffic engineering elements on urban arterials as well as features related to safety and aesthetics. From this list, the drivers were asked to select the ten features that they considered to be the most important to their perceived service quality.

Table 4-2 shows the number of drivers that selected each feature as being one of the ten most important on urban arterials. The table shows that each of the 26 features was selected at least once, which indicates that drivers attribute importance to a wide range of features and characteristics. This result supports the view that drivers perceive many varied aspects of the driving environment as being integral to satisfaction. A majority of the drivers selected the following features as being among the ten most important:

- Visibility of signs and/or traffic signals
- Rate of traffic flow (smoothness, pace, continuity, etc.),
- Pavement quality,
- Left-turn only lanes intersections,
- Traffic volume (amount of traffic on roadway), and
- Ability to maneuver vehicle (change lanes, merge into traffic, etc.),
- Aggressive drivers

Table 4-2: Features Selected as One of the Ten Most Important in Urban Arterials

Features of Urban Arterials	Number of Drivers Selecting the Feature
Visibility of signs and/or traffic signals	17 (77%)
Rate of traffic flow (smoothness, pace, continuity, etc.)	17 (77%)
Pavement quality	17 (77%)
Left-turn only lanes at intersections	16 (73%)
Traffic volume (amount of traffic on roadway)	12 (55%)
Ability to maneuver vehicle (change lanes, merge into traffic, etc.)	12 (55%)
Aggressive drivers	11 (50%)
A divided roadway (with a center median or barrier)	9 (41%)
Signalized intersections (or number of signals)	9 (41%)
Timing of traffic signals (length of red/green for each movement)	9 (41%)
Right-turn only lanes at intersections	9 (41%)
Overall travel time to destination	9 (41%)
Consistency/reliability of travel time to destination	8 (36%)
Number of lanes on roadway	8 (36%)
Spacing of moving vehicles (density of traffic)	7 (32%)
Roadway width (overall roadway width)	7 (32%)
Interaction between vehicles	7 (32%)
Trees	6 (27%)
Frequency of merging traffic	6 (27%)
Truck and/or bus traffic	6 (27%)
Sidewalks	5 (23%)
Two-way center left-turn lane	4 (18%)
Frequency of unsignalized cross-streets and driveway entrances	4 (18%)
Consistency of speed	3 (14%)
Pedestrians or bicyclists	3 (14%)
Speed limit	2 (09%)

After choosing the ten features most influential to their satisfaction with urban arterials, drivers were asked to refine their selection by ranking the top five in order of importance (with 1 being the most important). These rankings were then converted into scores by reversing the rankings (so that the most highly ranked features would have the highest scores). Features that were ranked #1 were given a score of 5; a #2 ranking received a score of 4, a #3 ranking received a score of 3, and so on. All of the scores were then added up across features and subjects. For example, if three subjects ranked pavement quality as #1, #2, and #4, pavement quality would receive three scores: 5 (for the #1 ranking), 4 (for the #2 ranking), and 2 (for the #4 ranking), for a total score of 11. The total scores for the top 13 features (those with a total score at least 10) are shown in Table 4-3.

Table 4-3: Overall Scores and Rankings of Top Features

Features of Urban Arterials	Scores and Ranking *Based on Top 5 Only*		Scores and Ranking *Based on Top 5 and Top 10*	
	Total Score	**Overall Ranking**	**Total Score**	**Overall Ranking**
Visibility of signs/ signals	43	1	49	1
Timing of traffic signals	32	2	34.5	2
Ability to maneuver vehicle	24	3	27.5	6
Left-turn only lanes at intersection	21	4	31	3
Rate of traffic flow	21	4	25	7
Traffic volume	21	4	28	5
Divided Roadway	19	7	21.5	8
Overall travel time to destination	19	8	21.5	8
Pavement quality	18	9	29.5	4
Consistency/ reliability of travel time to destination	15	10	18.5	12
Signalized Intersections	15	11	19.5	11
Aggressive drivers	14	12	20.5	10
Interaction between vehicles	10	13	13.5	13

There are two sets of scores shown in Table 4-3. The scores in each set are determined by allocating points in a slightly different way. The total score and overall ranking set on the left are based on the drivers' rankings of their top five features only (as explained in the previous paragraph). The set of scores on the right of the table includes an extra ½ point given for a feature each time it was included in a driver's top ten, but not top five. In other words, if a driver chose pavement quality as one of his or her top ten features, but did not rank it as one of the top five features, pavement quality would then receive a ½ point for this driver. The point allocation for scores was done this way to weight those features selected in the top ten (and therefore important), but not in the top five. These scores provide a somewhat different ranking for comparison and analysis purposes.

While Table 4-2 indicates the importance of the features by the number of drivers that selected them as important, it gives no indication of the relative importance of the features. For example, Table 4-2 shows that 77 percent of the drivers chose visibility of signs/signals, rate of traffic flow, and pavement quality as important features; however, it is not known which factor, if any, is most important. The scores and rankings shown in Table 4-3 indicate that visibility of signs/signals could be the most important of the three. In fact, the other two features, while selected as important by 77 percent of drivers, are perhaps less important than what could be concluded from Table 4-2 alone. On the contrary, timing of traffic signals, ability to maneuver vehicle, and left-turn only lanes at intersections are perhaps more important when considering the drivers' rankings.

4.2.2 Ideal and Least Favorite Urban Arterial

Drivers were also asked to describe three to four conditions or characteristics that would comprise their ideal urban arterial, as well as three to four conditions that would comprise their least favorite urban arterial. These questions were included as an attempt to produce an indication of which features are the most important to drivers. In addition, asking drivers to use their own words allowed the opportunity to obtain information about drivers' values in their terms, as opposed to the list of features given to them previously.

Tables Table 4-4 and Table 4-5 present the written responses from drivers describing their ideal and least favorite urban arterial. Each row shows the response from one driver. Presenting the data this way enables a read-through of each driver's idealized (or least preferred) route. For example, the responses from the driver on the first row suggest that this driver would enjoy driving on an arterial that has few vehicles, is aesthetically pleasant, and has few traffic lights. In contrast, this driver would not enjoy driving on an arterial that has many vehicles (especially Sport Utility Vehicles (SUVs)), many traffic lights, and a bad road surface. The results from this section are compared to the factors identified in the driver transcripts and the post-drive survey and are further discussed in the next section.

Table 4-4: Drivers' Definitions of Their Ideal Urban Arterial

Traffic & Roadway Conditions that Comprise an Ideal Urban Street			
Condition 1	**Condition 2**	**Condition 3**	**Condition 4**
Lack of other vehicles	Attractive buildings on roadside	Trees on roadside	Lack of traffic lights
Traffic flows through intersections easily	Lights are timed at reasonable rates	Speed limit seems appropriate to road conditions	Plenty of greenery and nice plantings
Considerate drivers	Well-marked intersections	Absence of SUV's and/or aggressive drivers	Left-turn signals
Well paved	Clearly marked lanes and crosswalks	Adequate signals - # of signals and timing	Left-turn lanes at intersections
Space/accommodations for peds/bicyclists	Reasonable flow of traffic with synchronized traffic lights	Sufficient left and right turn lanes	Not provided
At least two lanes each direction	Left turn lanes	Interesting scenery	Well regulated movement (signal timing)
Wide lanes	Trees	Few Billboards	Lights synchronized well
Enough lanes to carry traffic	Good signage for upcoming events	Adequate number of turning lanes	Signalization Timing
Wide lanes	Clear directional and street signs	Lowest of allowable speeds	Travel through clean safe areas
Good flow	Least amount of stop lights	Well paved and signed	Green space on all sides
Timing of traffic signals	Medians, sidewalks and trees (calming influences)	Efficiency/Reliability (travel time)	Courteous and intelligent Drivers
Divided road	Minimum access	Smooth pavement	Trees/landscaping
Enough lanes to deal with the daily flow	Clear signs posted before intersection	Turn lanes for both right and left turns	Center divides with trees
Should have clear and visible signs	Safe and enough space between the lanes	Enough space for right or left turns	Enough space for buses/trucks and reduce travel time
Two to three lanes in width	Medians with trees and flowers	Identifying road sign visibility	Smooth pavement
Few lights	Streets that accommodate heavy traffic	Plan and develop according to population	Not provided
Good flow to traffic	Not overcrowded (low volume)	Clearly marked cross-streets	Greenery (trees, groundcover, flowers)
Good road surface condition	Street name signs hanging over middle of intersection	Lack of pedestrian crowds	Pedestrians that respond to crossing signals
Traffic flow should be good	Constant speed	Double left-turn lanes	
Medians with flowers	Aesthetics of road	Crossing guards (traffic police) who help drivers negotiate through pedestrian crossing areas	
Quality of neighborhood, pleasing surroundings	Signal timing efficiency	Ability to get through 2-3 lights without having to stop	Left-turn signals
Pavement in good condition, no potholes	Lane markings visible and in good condition	Presence of effective traffic police to help drivers negotiate through heavy pedestrian crossing	Planters on medians are pleasant to look at and blocks visual distractions

Table 4-5: Drivers' Definitions of Their Least Favorite Urban Arterial

Traffic & Roadway Condition that Comprise a Least Favorite Urban Street			
Condition 1	**Condition 2**	**Condition 3**	**Condition 4**
Many vehicles (esp. SUVs)	Many traffic lights	Bad road surface	Not provided
Traffic slows/stops freq & does not flow through intersections easily	Frequent potholes	Primarily cement along roadside	No turning lanes so turn vehicles block traffic flow
No sense of human scale	Muddled direction signs	No streetscape	Not provided
Bad pavement - potholes, bumps, plates	Unclearly marked lanes & crosswalks	Inadequate signals	Lack of turning lanes & other impediments to smooth flow of traffic
Pedestrians walking on side of road w/o sidewalk	Non-Synchronized traffic signals	Vague or non-existing signage	Potholes/Rough pavement
Too narrow, too few lanes	Too much traffic for space	Unpredictable regulation (lights, construction, police,)	Difficult to see ahead
Narrow lanes	Lots of clutter (billboards, signs, parking)	No trees	No clear pedestrian markings or poorly spaced crosswalks
Lanes end abruptly	Confusing or no signage	Roadway inadequate size for turning	Inappropriate speed limits
Narrow lanes that don't accommodate trucks	Frequent curb cuts	Beautification projects that prohibit view	Travels through undesirable areas
Heavy traffic	Too many stoplights	Poor pavement, narrow streets	Not well signed
Congested	Noisy	Bumper to bumper	Grid lock
Unlimited access	Rough pavement	Changing widths of roadway [number lanes and lane width]	Uncontrolled signals [fixed, not actuated]
Unclear lane markings	Not enough lanes	No street signs or signs posted at intersection	No center divide (too many accidents happen if no 'raised' center divide)
Narrow lanes with reduced lanes	Not enough street lights on the road (bad weather, i.e. Fog/rain)	The absence or the reduction of upcoming street names	Poor pavement on the road.
Rush hour traffic due to congestion	One lane streets when two are needed	No left turn lanes at busy intersections	No trees or flowers in sight
Heavily congested	Long lights (timing)	Stop-and-go traffic	No alternative routes to travel
Overcrowded street	Aggressive/ careless drivers	Poorly marked streets, lanes, signals	Poor aesthetics (trash, concrete, etc)
Medians that block information about opposing traffic	no left-turn signals	No bus lanes on busy streets	Poor lane markings
Large vehicles on the road; they block view	Other drivers not signaling when they turn, or when they turn when not in turn lane	Poor lane markings	No left-turn signals, which reduce traffic flow
No medians	Lack of left-turn signals	Potholes	Pedestrians not abiding by the crossing signals
Ugly environment	No medians	Poor pavement	
Congestion (stop and go)	Lack of maneuverability in heavy congestion	Low travel speed	Poor pavement quality

4.3 Discussion of QOS Factors

Table 4-6 shows the number of drivers that referred to each QOS factor during the drive, listed it as one of the top ten features of urban arterials in the post-drive survey, or named it as a characteristic of their ideal or least favorite arterial. The discussion of QOS factors that follows is centered on the results presented in this table.

It should be specifically noted that the values in the table are simply the frequency of drivers that commented on a factor or chose it to be important. While these numbers might suggest the overall or relative importance of a factor, they should be interpreted cautiously; the sample size was not representative or large enough to make definitive conclusions about which factors are the most important. In addition, while drivers in all of the locations referred to most of the QOS factors, there are a few factors that were not mentioned in one or more locations. This can be attributed to the fact that every route did not expose drivers to all of the QOS factors. As a result, there were fewer comments related to these factors, causing them to appear to be less significant. For example, *pedestrian behavior* was mentioned in all locations except Sacramento. This is not necessarily an indication that drivers in Sacramento were not concerned about pedestrians. In fact, the route in Sacramento did not include areas with much pedestrian activity. In contrast, a factor such as *pavement quality* was experienced by all drivers, regardless of location or route, and was mentioned by drivers in all four study locations.

Table 4-6: Number of Drivers Commenting on Identified QOS Factors

Investment Area	QOS Factor	Transcripts	Survey: Top 10 [1] Features	Survey: Ideal Arterial	Survey: Least Favorite Arterial
Cross-Sectional Roadway Design	Lane width	7	N/A	3	4
	Number of lanes/roadway width	14	8/7[2]	5	4
	Turning lanes/bays	6	16/9[3]	7	3
	Lane drop/add	7	N/A	0	3
	Medians	6	9	7	4
	Pedestrian/bicyclist facilities	13	3	0	2
	Bus pull-outs	5	N/A	0	1
	Parking	5	N/A	0	0
	Access management	6	4	1	2
	Two-way center left turn lane	4	4	0	0
Arterial Operations	Number of traffic signals	4	9	3	2
	Volume/congestion	15	12	2	9
	Traffic flow	7	17	3	2
	Speed	5	N/A	2	1
	Number of lanes	14	0	0	0
	Two-way center left-turn lane	4	0	0	0
	Lane drop/add	7	N/A	0	0
	Bus pull-outs	5	N/A	0	0
	Travel time	8	9	2	0
	Parking	6	N/A	0	0
	Presence of large vehicles	5	6	0	0
Intersection Operations	Turning	13	16/9	1	3
	Timing of signals	9	9	6	1
	Traffic progression	9	N/A	2	1
Signs and Markings	Quality of pavement markings	3	N/A	0	2
	Sign legibility/visibility	9	17	2	0
	Sign presence/usefulness	4	N/A	4	7
	Lane guidance—signs	12	N/A	0	0
	Lane guidance—pavemnt markings	13	N/A	1	3
	Advance signing	5	N/A	2	0
	Too many signs (clutter/distracting)	4	N/A	0	0
Maintenance	Pavement quality	16	17	6	10
	Overgrown foliage	5	N/A	0	0
Aesthetics	Presence of trees	12	6	9	5
	Medians with trees	7	N/A	2	0
	Visual clutter	3	N/A	0	1
	Cleanliness	3	N/A	1	1
	Roadside development	6	N/A	1	1
Other Road Users	Illegal maneuvers	6	N/A	0	0
	Driver courtesy	4	N/A	1	0
	Aggressive drivers	2	11	1	1
	Improper/careless lane use	3	N/A	0	1
	Blocking intersection	4	N/A	0	0
	Careless/inattentive driving	5	N/A	0	0
	Use of turn signals	3	N/A	0	1
	Pedestrian behavior	5	N/A	4	1
Other	ITS	5	N/A	0	0
	Planning	5	N/A	0	0
	Roadway lighting	2	N/A	0	0

[1]The list of urban arterial features in the survey contained 26 features compiled prior to the study. "N/A" refers to features identified during the drive, but were not part of the list in the survey.
[2]8 drivers selected number of lanes, while 7 drivers selected roadway width
[3]16 drivers selected left-turn lanes, while 9 drivers selected right-turn lanes

4.3.1 Cross-Sectional Roadway Design

After reviewing the individual transcripts and categorizing the various opinions, ten QOS factors were identified in the C*ross-Sectional Roadway Design* investment category: *lane width, number of lanes/roadway width, turning lanes/bays, medians, pedestrian/bicyclist facilities, bus pull-outs, parking, access management, and two-way center left turn lane*. In addition, some of the driver comments were grouped into an "other" category, as they did not correspond with a specific QOS factor. The QOS factors associated with cross-sectional roadway design are discussed in more detail in the following sections.

4.3.1.1 Lane Width

Seven drivers referred to the width of lanes during their drives. Two primary themes can be identified through review of the various driver opinions: 1) drivers appreciate wider lanes as they provide a sense of safety, and 2) drivers feel more comfortable when they have room to maneuver. *Lane width* was not a feature listed on the post-drive survey; however, three drivers said that wide lanes were part of their ideal arterial, and four drivers said that narrow lanes were a characteristic of their least favorite arterial. What cannot be demonstrated through these results is where the threshold lies when lane width begins to become uncomfortable for drivers.

4.3.1.2 Number of Lanes/Roadway Width

The primary theme about the number of lanes or overall roadway width was that of having sufficient lanes to accommodate demand. On the post-drive survey, eight drivers chose *number of lanes on roadway* as one of the top ten features of urban arterials, and seven drivers chose *roadway width* as one of the top ten features of urban arterials. A wide roadway was listed by five drivers as one of the features that would comprise their ideal arterial, and a narrow roadway was mentioned by four drivers as a feature of their least favorite arterial.

The number of lanes or the overall width of the roadway was an issue brought up by 13 of the 22 drivers, and in each of the study locations. Therefore, it can be concluded that the number of lanes or roadway width is an issue that is important to drivers, independent of location. The most common comment, which was made by seven drivers in two different locations, was that adding lanes has improved the traffic flow. Four drivers in three locations made comments related to the need for an adequate number of lanes to accommodate the traffic volume.

Although more than half of the drivers commented on the number of lanes during the drive, none chose *number of lanes on roadway* on the post-drive survey when asked to select the ten most important features of urban arterials or to indicate the features that comprise their ideal and least favorite arterials.

4.3.1.3 Turning Lanes/Bays

The desire to have adequate turning lanes or bays was expressed by six of the drivers. Specific comments were related to the need for turn lanes to accommodate turns into and out of developments as well as long queues for turning vehicles at intersections, and the need for channelized right turns in some instances. Drivers noted the need for separate turning facilities to keep the facility running smoothly (as shown in Figure 4-10). Interestingly, drivers also complained that too many curb cuts and frequent, short, turn lanes along arterials were unnecessary.

In addition to the drive, 16 and 9 drivers chose *left-turn only lanes at intersections* and *right-turn only lanes at intersections* respectively, as being part of the top ten features of urban arterials. When asked about features of their ideal arterial, seven drivers referenced good accommodations for turning vehicles, while three drivers made reference to poor accommodations for turning vehicles as part of their least favorite arterial.

Figure 4-10: A Left-Turn Bay for Mid-Block Turns in Sacramento

4.3.1.4 Lane Drop/Addition

Lane drops or adds (illustrated in Figure 4-11) were mentioned by 7 of the 22 drivers, and in three of the four study locations (all with the exception of Chicago). Five drivers commented that sudden or unexpected lane drops are not desirable, as continuity is important. Other drivers indicated that frequent lane adds/drops are a problem. While *lane drops* was not a feature listed on the post-drive survey, three drivers named frequent lane drops/additions as a feature of their least favorite arterial.

Figure 4-11: A Lane Drop in Tallahassee

4.3.1.5 Medians

The use of medians to separate opposing traffic streams was noted by 6 of the 22 drivers in three of the four study locations (all with the exception of Sacramento). In all but one case, drivers found that the medians were pleasing and that they provided a sense of safety due to the division between opposing traffic streams (as illustrated in Figure 4-12). Drivers also made note of the visual appeal of planted medians. One driver commented that medians with very large trees and plants were visually distracting. This driver felt that it is important to be able to see the entire roadway to be able to drive defensively, and that the large trees and plants block the view of parts of the roadway.

In addition to the driver transcripts, *divided roadway* was chosen by 6 of the 22 drivers as being one of the ten most important features of urban arterials. When drivers were asked to indicate the features that represent their ideal and least favorite arterial in the post-drive survey, seven drivers mentioned medians for their ideal arterial, while four drivers mentioned lack of medians for their least favorite arterial.

Figure 4-12: A Median in Northern Virginia

4.3.1.6 Pedestrian/Bicyclist Facilities

Thirteen drivers in all four of the study locations mentioned pedestrian or bike facilities during the drive. Seven drivers mentioned sidewalks, with some noting that the sidewalks were too close to the road (as illustrated in Figure 4-13), that a buffer was needed between the roadway and the sidewalks (as illustrated in Figure 4-14), or that the sidewalks were too narrow.

Figure 4-13: A Sidewalk Close to Road in Sacramento

Figure 4-14: A Sidewalk Set Back from Roadway in Chicago

One driver noted that a grade-separated pedestrian crossing was needed. Seven drivers commented that they liked bike lanes, and one mentioned that he or she preferred the bike lane to be located further from the roadway. Another driver stated that he or she felt the need to be more cautious when pedestrians or bicyclists were present.

Three of the drivers chose *pedestrians or bicyclists* on the post-drive survey when asked to select the ten most important features of urban arterials. In addition, two drivers named the absence of pedestrian/bicyclist facilities in the description of their least favorite arterial, while none chose the presence of these facilities in the description of their ideal arterial.

4.3.1.7 Bus Pull-outs

Five drivers in two locations (Chicago and Sacramento) made note of the need for bus pull-outs to keep traffic moving along the arterials. Several of the drivers experienced situations where they were forced to travel behind city buses (as illustrated in Figure 4-15) and many made note of the need for separate facilities or pull-outs to move the buses out of the through lanes when they are loading and unloading passengers.

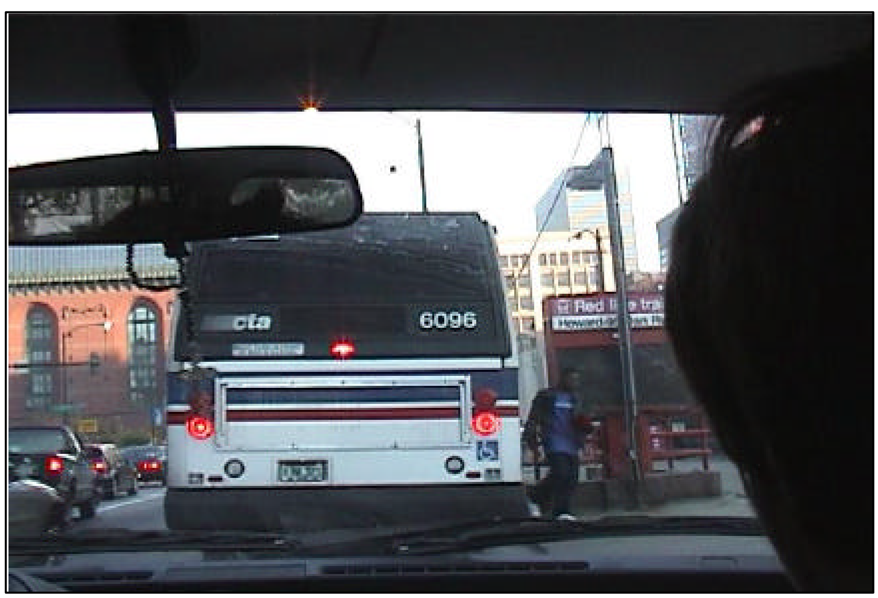

Figure 4-15: A Bus Stopped in a Travel Lane in Chicago

This factor was not listed on the post-drive survey and was not mentioned by any of the drivers as a feature of their ideal arterial, although the lack of bus pull-outs was mentioned by one driver as a characteristic of his or her least favorite arterial.

4.3.1.8 Parking

Five drivers mentioned parking during their drive regarding the safety, convenience and availability of different types of parking. This factor was not listed on the post-drive survey and was not mentioned by any of the drivers as a feature of their ideal or their least favorite arterial.

4.3.1.9 Access Management

Interestingly, 6 of the 22 drivers made comments related to the control (or lack of control) of access. Four drivers (all from Tallahassee) commented on poor access management near intersections (e.g., driveways close to intersections are dangerous), while two drivers mentioned that a lack of access control mid-block slows traffic flow. Finally, two drivers said they liked access roads for residential areas and developments.

In addition to the drives, four drivers chose *frequency of unsignalized cross-streets and driveway entrances* as one of the ten most important features of urban arterials. One driver named “minimal access” as a feature of his or her ideal arterial, and two drivers named “frequent curb cuts” and “unlimited access” as features of their least favorite arterial.

4.3.1.10 Two-way Center Left-Turn Lane

The desire for two-way center left-turn lanes was noted by four drivers in Tallahassee and Sacramento (see Figure 4-16). Specific comments were that center turn lanes work well, are helpful to get turners out of traffic, and are good for access.

In addition, *two-way center left-turn lane* was chosen by four drivers as being one of the ten most important features of urban arterials; however, no drivers listed the presence or absence of a center turn lane as a feature of their ideal or least favorite arterial.

Figure 4-16: A Two-Way Center Left-Turn Lane in Sacramento

4.3.1.11 Other

Several comments in the *cross-sectional roadway design* investment area did not fit well into any of the QOS factors previously discussed. As a result, these comments were grouped into an additional category called "other." These comments were varied and include the following:

- Road floods often (3 drivers)
- Straight roads are good (3 drivers)
- Would like grade separation for light rail (2 drivers)
- Too much merging and turning at one point (2 drivers)
- Can easily see turn lane when break in trees [in center median] (1 driver)
- Poor intersection design (e.g., skewed) (2 drivers)
- Limited sight distance is not good (1 driver)

4.3.2 Arterial Operations

Eleven QOS factors were identified in the *Arterial Operations* investment category: *travel time, number of signals, presence of large vehicles, volume/congestion, traffic flow,* and *speed*. In addition, some of the driver comments were grouped into an "other" category since they did not correspond with a specific QOS factor. The QOS factors associated with arterial operations are discussed in more detail below.

4.3.2.1 Travel Time

Travel time was brought up by 8 of the 22 drivers in three of the four study locations (all with the exception of Sacramento). Comments related to travel time, delay, and number of stops were grouped together in this QOS factor. Six drivers made comments related to delay, three made comments related to travel time (one in particular to travel time predictability), and three made comments related to number of stops.

In addition to the driver transcripts, *overall travel time to destination* was chosen by 9 of the 22 drivers as being one of the ten most important features of urban arterials. When drivers were asked to indicate the features that represent their ideal and least favorite arterial in the post-drive survey, two drivers mentioned minimal travel time for their ideal arterial, while none of the drivers mentioned long or unpredictable travel time for their least favorite arterial.

When considering the scores for drivers' rankings of the top five features in Table 4-3, *overall travel time to destination* was ranked 5th, and *consistency or reliability of travel time* was ranked 6th. When considering the top ten features that were chosen by drivers, *overall travel time to destination* was ranked 8th and *consistency or reliability of travel time* was ranked 11th. It is apparent from the number of drivers that mentioned travel time during the drives, and from the results of the post-drive survey, that travel time is an important factor in determining a driver's perception of quality of service on urban arterials.

4.3.2.2 Number of Signals

The number of signals was brought up by 4 of the 22 drivers in three of the four study locations (all with the exception of Chicago). All four drivers commented that there were too many signalized intersections in a short distance. In addition to the driver transcripts, *signalized intersections (or number of signals)* was selected by 9 of the 22 drivers as one of the ten most important. When asked to indicate the features that represent their ideal and least favorite arterial, three drivers mentioned few traffic signals as part of their ideal arterial, and two drivers mentioned a lot of traffic signals as part of their least favorite arterial.

When drivers were asked to rank the five most important features of urban arterials, *signalized intersections (or number of signals*) was ranked 6th when considering the top five features, and 10th when considering the top ten features in Table 4-3. Although many drivers ranked this feature fairly highly and included it in the lists for ideal/least favorite arterial, most drivers did not specifically mention it during the drive. This discrepancy could be due to the fact that the drive was not time-constrained, and thus drivers were not as sensitive to the presence of the number of signals as they might be if faced with a time constraint. Another interpretation is that the delay associated with the number of signals coincides with other factors that drivers did mention, including volume and congestion.

4.3.2.3 Presence of Large Vehicles

The presence of large vehicles was brought up by 5 of the 22 drivers in three of the four study locations (all with the exception of Sacramento). Drivers mentioned that large vehicles are hard to see around and that, in general, the presence of large vehicles is not desirable. An excellent example of the presence of large vehicles is shown in Figure 4-17, where the driver is experiencing bus and truck traffic in downtown Chicago.

In addition to the driver transcripts, *truck and/or bus traffic* was chosen by 6 of the 22 drivers as being one of the ten most important features of urban arterials. However, none of the drivers included large vehicles in their ideal and least favorite arterial in the post-drive survey.

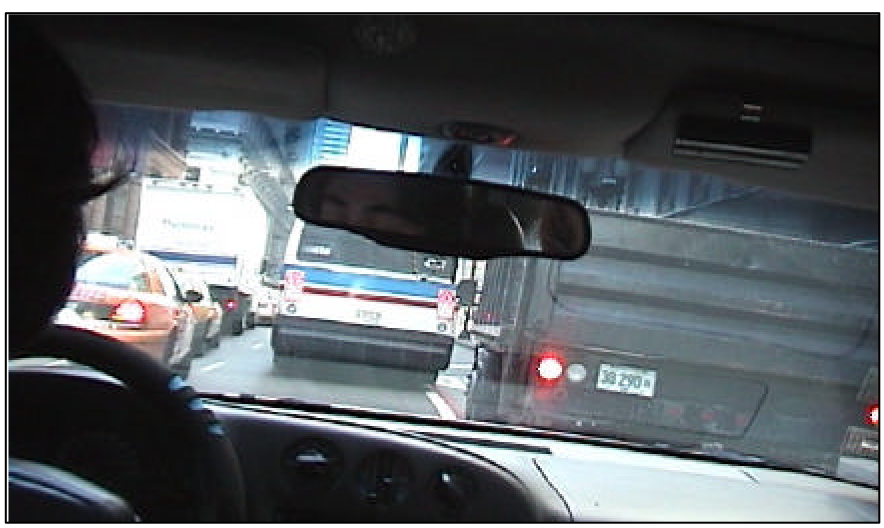

Figure 4-17: Large Vehicles in Chicago

4.3.2.4 Volume/Congestion

Volume or congestion was brought up by 15 of the 22 drivers in all four of the study locations. Therefore, it can be concluded that volume or congestion is an issue that is important to drivers, independent of location (Figure 4-18). When referring to the volume, eleven of the drivers mentioned that it was too high, while only four mentioned that it was not bad. One of the drivers noted that driving is less stressful when there are fewer drivers on the road. Another noted that the heavy volume on the major street would make it difficult to enter traffic from a cross street.

Traffic volume was chosen by 12 of the 22 drivers as being one of the ten most important features of urban arterials. In addition, when drivers were asked to indicate the features that represent their ideal and least favorite arterial in the post-drive survey, only two drivers mentioned low volume/congestion as part of their ideal arterial, while nine of the drivers mentioned high volume/congestion as part of their least favorite arterial. The fact that more drivers mentioned volume/congestion when describing their least favorite arterial than when describing their ideal arterial may be an indication that the presence of congestion has a greater influence on perceived quality of service than the absence of congestion.

Drivers consistently selected and ranked *traffic volume* highly, as shown in Table 4-3. It was ranked 4th when considering the top five features, and 5th when considering the top ten features. The fact that many of the drivers mentioned volume either during the drive and/or in the post-drive survey strongly suggests that it is an important factor in perception of quality of service on arterials.

Figure 4-18: Arterial Street Congestion in Northern Virginia

4.3.2.5 Flow

Flow was brought up by 7 of the 22 drivers in three of the four study locations (all with the exception of Tallahassee). Almost all of the comments referred to the fact that the traffic was flowing well along that segment of the route. One driver specifically mentioned that continuous movement is important. In addition to the driver transcripts, *rate of traffic flow* was chosen by over half of the drivers (12 of the 22) as being one of the ten most important features of urban arterials. When drivers were asked to indicate the features that represent their ideal and least favorite arterial in the post-drive survey, three drivers mentioned good traffic flow as part of their ideal arterial, and two mentioned poor traffic flow as part of their least favorite arterial.

The drivers ranked *rate of traffic flow* 4th in the top five features and 7th in the top ten features, as shown in Table 4-3. Many of the drivers talked about the importance of flow during the drive or indicated its relevance on the post-drive survey suggests that it is an important factor in determining a driver's perception of quality of service on arterials.

4.3.2.6 Speed

Speed was brought up by 5 of the 22 drivers in three of the four study locations (all but Sacramento). Two drivers mentioned that the speed limit was too low for the road, and the other comments referred to speed alone. This factor was not listed on the post-drive survey (although the survey did list *rate of flow*) and none of the drivers included it in their list of features on the ideal or least favorite arterial. Yet, many drivers revealed a concern about factors associated with speed, including volume/congestion, delay, efficient traffic flow, capacity and travel time. This discrepancy may be partly due to the fact that the facility in question was urban arterials, where the notion of speed may be less prominent than it is for other facilities (such as highways). The key operative on urban arterials may be continuous flow or the absence of delay caused by red lights, other vehicles, buses, etc. Also, the fact that the drive was not a time-constrained trip could have reduced the likelihood that drivers would directly mention the importance of speed.

4.3.3 Intersection Operations

Three QOS factors were identified in the *Intersection Operations* investment category: *turning, progression,* and *timing of signals*, discussed below. (Note that some comments are grouped into an "other" category because they did not correspond with a specific QOS factor.)

4.3.3.1 Turning

Comments related to turning lanes or turning arrows were made by 14 of the 22 drivers in all four study locations. Therefore, it can be concluded that turning lanes and turning arrows are issues that are important to drivers, independent of location. Seven drivers (in three of the study locations) commented on the lack of turn lanes, and some drivers noted that the specific turn bays were not long enough for the intersection, or that there should be more turn lanes to handle the traffic flow at the intersection. Others noted that the presence of a channelized right-turn lane or a separate signal for right-turning vehicles at intersections is valuable (see Figure 4-19).

Four drivers described protected left turns as helpful, and three drivers mentioned that a particular protected left-turn phase was not long enough. Two drivers mentioned that more turn bays were needed to access new developments.

In addition to the driver transcripts, 16 of the 22 drivers selected *left turn only lanes at intersections* (as illustrated in Figure 4-20), and 9 of the 22 drivers selected *right turn only lanes at intersections* as one of the ten most important features of urban arterials. In addition to this, *left-turn only lanes at intersections* was ranked 4th when considering the top five factors and 3rd when considering the top ten factors. When drivers were asked to indicate the features that represent their ideal and least favorite arterial in the post-drive survey, one driver mentioned “adequate turning lanes” as part of his or her ideal arterial, while three mentioned lack of turning lanes as part of their least favorite arterial. Many drivers highlighted the importance of left- or right-turn lanes either during the drive or on the survey.

Figure 4-19: A Channelized Right-Turn Lane in Atlanta

Figure 4-20: A Left-Turn Only Lane at an Intersection in Chicago

4.3.3.2 Progression

Progression was brought up by 9 of the 22 drivers in each study location. Therefore, it can be concluded that progression is an issue that is important to drivers, independent of location. Six drivers commented that the signals were not coordinated along a corridor, and three drivers commented that it is helpful when the signal coordination is linked to the speed limit along a corridor. Another driver commented that the corridor had a lack of progression. While progression was not a factor listed on the post-drive survey, two drivers listed good progression as a characteristic of their ideal arterial, and one driver listed poor progression as a characteristic of his or her least favorite arterial.

4.3.3.3 Timing of Signals

Timing of signals was brought up by 9 of the 22 drivers in all of the four study locations. Therefore, it can be concluded that signal timing is an issue that is important to drivers, independent of location. Four drivers commented that some signals were poorly or improperly timed, three drivers mentioned that the cycles were too short for the major street, and one commented that the left-turn signal was too short. Four drivers commented that it took more than one cycle to clear an intersection and four other drivers commented that the signals were not timed efficiently. While the majority of the comments related to signal timing were negative, one driver made a positive comment by noting that a particular cycle length was sufficient for both streets at a major intersection.

When drivers were asked to choose the top ten features of urban arterials most important to them, and to rank the top five, *timing of traffic signals* was ranked 2nd in both cases. *Timing of traffic signals* was chosen by 9 of the 22 drivers as being one of the ten most important features of urban arterials. When drivers were asked to indicate the features that represent their ideal and least favorite arterial in the post-drive survey, six drivers mentioned good signal timing as part of their ideal arterial, but only one mentioned poor signal timing as part of his or her least favorite arterial. The data suggest that signal timing is an important factor in driver's perception of quality of service on arterials.

3.4.3.5 Other

Several comments that were made did not fit well into any of the groups of QOS factors related to intersection operations. As a result, these were grouped into an additional category for other comments. The majority of the comments (six out of nine) were related to the high volumes of pedestrians and to pedestrian facilities being over-capacity. In addition, comments were that a light-rail crossing should be grade separated, a signal was not needed at a minor cross-street, and a specific intersection should have a signal as opposed to a four-way stop.

4.3.4 Signs and Markings

Seven QOS factors were identified in the *Signs and Markings* investment category: *quality of pavement markings, sign legibility/visibility, sign presence/usefulness, lane guidance—signs,* *lane guidance—pavement markings, advance signing,* and *too many signs (clutter/distracting).* These QOS factors are discussed in more detail is this section.

4.3.4.1 Quality of Pavement Markings

Three of the drivers (in three different locations) made reference to the importance of the quality of pavement markings for both designating lanes and designating the median (as shown in Figure 4-21). This was not a feature listed on the post-drive survey.

While good quality pavement markings was not mentioned by any of the drivers as a feature of their ideal arterial, two drivers noted that poor quality pavement markings was a quality of their least favorite arterial.

Figure 4-21: Good Quality Pavement Markings in Tallahassee

This QOS factor might also fall in the maintenance investment area; while the quality of pavement markings may be very good when they are new, over time the quality may deteriorate due to traffic and weather. Therefore, proper maintenance also has an impact on the quality of pavement markings.

4.3.4.2 Sign Legibility/Visibility

Nine of the 22 drivers commented on the importance of sign legibility or visibility. Examples of comments in this factor are as follows:

- Visibility of overhead signs is good (3 drivers)
- Signal head maintenance/visibility is important (3 drivers)
- Difficult to see street signs from a distance/larger is helpful (2 drivers)
- Font is too small on street signs (1 driver)
- Sign visibility is important (1 driver)

In addition to the comments made during the drives, 17 drivers chose *visibility of signs and/or traffic signals* as being amongst their top ten important features of urban arterials on the post-drive survey. In fact, *visibility of signs and/or traffic signals* was ranked as the number one factor when considering the scores in Table 4-3. It is apparent from the number of drivers who mentioned sign legibility/visibility during the drives, and from the results of the post-drive survey, that this feature of urban arterials was possibly one of the most important features identified in the study.

When asked to describe their ideal and least favorite arterials, two drivers included visible or legible signs as a characteristic of their ideal arterial, but no drivers included this as a characteristic of their least favorite arterial.

4.3.4.3 Sign Presence/Usefulness

During the categorization of the driver comments into QOS factors, *sign presence/usefulness* was separated from *sign legibility/visibility*, as drivers seemed to be referring to two important, but different, factors related to signs. Some of the comments were specific to the ability to see the sign, either due to the placement (overhead versus on the side of the road) or the actual sign (font size too small). Other comments related more to whether or not signs were present or clear in their meaning. While these comments were initially clustered, a look at the number of comments in the category made it clear that two QOS factors were needed to adequately represent the comments. Therefore, a *sign presence/usefulness* QOS factor was created, with four drivers making comments related to this factor. Comments regarding this factor are as follows:

- Signage not clear/helpful (2 drivers)
- Need more signs to indicate cross-street names (2 drivers)
- More helpful to identify street names than county road numbers (2 drivers)
- Lack of signs indicating road that you are on (1 driver)

This factor was not listed on the post-drive survey. Sign presence was mentioned, however, by four drivers as being a feature of their ideal arterial and by seven drivers as being a feature of their least favorite arterial. The fact that the lack of clear, meaningful signage was mentioned by nearly a third of the drivers as being a feature of their least favorite arterial indicates the importance of this factor to drivers' perceptions of arterial quality of service.

4.3.4.4 Lane Guidance—Signs

While it was anticipated that the visibility of signs would be an issue important to drivers, it was somewhat surprising to hear 12 of the 22 drivers comment on road and street signs in terms of guidance. There were a multitude of comments related to lane guidance through signing. A few examples of the comments (both positive and negative) related to signage are listed below:

- More guidance from signs is needed (7 drivers)
- Helpful when intersections have signs marking permitted movements (3 drivers)
- Intersection is well marked with signs (2 drivers)
- Freeway on-ramps are well labeled (1 driver)
- Signs are tacky and don't help much with guidance (1 driver)
- Channelization/signs don't let you go where you want to (1 driver)

Figure 4-22 illustrates good lane guidance through signage. The photo shows overhead lane signs designating the left-turn, through, and right-turn movements at the upcoming intersection.

Lane guidance—signs was not a feature listed on the post-drive survey and was not mentioned by any of the drivers as a feature of their ideal or least favorite arterial.

4.3.4.5 Lane Guidance—Pavement Markings

It was also somewhat surprising that over half of the drivers (13) commented on lane guidance in terms of pavement markings. These comments differed from the comments related to the quality (or maintenance) of pavement markings in that they more specifically called out the need for guidance through pavement markings. A few examples of the comments related to pavement markings are listed below:

- Lanes not well-marked (6 drivers)
- Pavement markings needed to distinguish between lane and shoulder (3 drivers)
- Pavement markings for shared center lane are unclear (2 drivers)
- No warning about lane drop offs (2 drivers)
- Bike lane is not clearly marked as such (1 driver)
- Wide travel lanes with no markings are confusing (1 driver)
- Arrows on pavement denoting merge are helpful (1 driver)

Figure 4-23 shows clear, positive lane guidance through pavement markings, designating the left-turn, through, and right-turn lanes for the upcoming intersection.

Lane guidance—pavement markings was not a feature listed on the post-drive survey. The importance of guidance through pavement markings was mentioned by one of the drivers as a feature of his or her ideal arterial, and three drivers noted that a lack of guidance through pavement markings was a quality of their least favorite arterial.

4.3.4.6 Advance Signing

The need for advance signing was mentioned by five drivers in two locations (Sacramento and Tallahassee). Comments related to advance street signing were as follows:

- Street signs should be placed in advance of intersections (3 drivers)
- Merging down to one lane without warning is a problem (1 driver)
- Right turn only lane is not marked in advance (1 driver)

Advance signing was not listed on the post-drive survey. It was mentioned, however, by two drivers as being a feature of their “ideal,” but by no drivers as being a feature of their least favorite arterial.

Figure 4-22: Lane Guidance through Signage in Tallahassee

Figure 4-23: Lane Guidance through Pavement Markings in Tallahassee

4.3.4.7 Too Many Signs (Clutter/Distraction)

Four drivers (three in Tallahassee and one in Sacramento) said that too many signs causes visual clutter and can be distracting, making it difficult to pick out and read the important signs. One went as far to say that many signs are "tacky" and do not help to guide drivers.

The presence of too many signs was not a feature listed on the post-drive survey and was not mentioned by any of the drivers as a feature of their ideal or least favorite arterial.

4.3.5 Maintenance

Two QOS factors were identified in the *Maintenance* investment category: *pavement quality* and *overgrown foliage*. These QOS factors are discussed in more detail below.

4.3.5.1 Pavement Quality

Pavement quality was an issue brought up by 16 of the 22 drivers and in all four study locations. Therefore, in can be concluded that pavement quality is an issue that is important to drivers, independent of location. Some drivers commented that the pavement was smooth or that they liked newly-paved roadways. Others made comments when the pavement was rough. There were eight drivers who made specific comments about potholes.

In addition to the driver transcripts, *pavement quality* was chosen by 17 of the 22 drivers on the post-drive survey as being one of the 10 most important features of urban arterials. In the post-drive survey, when drivers were asked to indicate their idea of the ideal and least favorite arterial in terms of features, six drivers mentioned good pavement quality for their ideal arterial, and ten drivers mentioned poor pavement quality for their least favorite arterial. The fact that more drivers referred to poor pavement quality than good pavement quality may be an indication that the presence of poor pavement quality is more important than the presence of good pavement quality. In other words, good pavement quality may be something that drivers expect, meaning that a city or state's quality of service rating may not receive "points" for good pavement quality, but would certainly lose points if the pavement quality were poor.

4.3.5.2 Overgrown Foliage

Overgrown foliage was brought up by five of the 22 drivers in three of the four locations (all except Atlanta). Four of the five drivers specifically mentioned that trees blocking signs or signals were a problem (as illustrated in Figure 4-24), in terms of safety and the obscured directional information. This factor was not listed on the post-drive survey and was not mentioned by any of the drivers as a feature of their ideal or least favorite arterial.

Figure 4-24: Foliage Covering Sign in Tallahassee

4.3.6 Aesthetics

Five QOS factors were identified in the *Aesthetics* investment category: *presence of trees, medians with trees, visual clutter, cleanliness,* and *roadside development*. These QOS factors are discussed in more detail in this section.

4.3.6.1 Presence of Trees

Surprisingly, the presence of trees along the roadway was mentioned by 12 of the 22 drivers on the road and in each study location (Figure 4-25). In addition, six drivers chose *trees* on the post-drive survey as being one of the 10 most important features of urban arterials.

Figure 4-25: Trees Lining Roadway in Chicago

When asked to indicate their idea of the ideal and least favorite arterial in terms of features, nine drivers mentioned presence of trees as part of their ideal arterial, and five drivers mentioned a lack of trees as part of their least favorite arterial.

It is interesting that while nine drivers stated that the presence of trees would be a characteristic of their ideal arterial, only six drivers chose presence of trees out of a list of 25 other features as being in their top most important features of a roadway. Perhaps when placed next to operational and design features, trees are not as important as these other features. This result is somewhat contradictory and would need to be further explored in future research.

4.3.6.2 Medians with Trees

The QOS factor, m*edians with trees* (as illustrated in Figure 4-26), although not different from *presence of trees*, reflects more specific comments from 7 of the 22 drivers. While four of the seven also mentioned the presence of trees in general, four mentioned this more specific factor without mentioning the more general one.

What is interesting about this factor is that drivers specifically liked the appearance of arterials with trees in a center median, possibly because the median provided, in addition to aesthetics, a sense of protection from opposing traffic. This factor was not listed on the post-drive survey. *Medians with trees* was not listed by any driver as a feature of their ideal arterial, but the lack of medians with trees was listed by two drivers as a characteristic of their least favorite arterial.

Figure 4-26: A Median with Trees in Sacramento

4.3.6.3 Visual Clutter

Three of the 22 research drivers, two in Tallahassee and one in Sacramento, mentioned visual clutter. Each of the three drivers commented that too many signs cause clutter and can be distracting. One of the drivers also mentioned that he preferred signals on mast arms rather than hanging from wires across the middle of intersections, as those on mast arms are less cluttered looking. This factor was not listed on the post-drive survey and was mentioned by only one driver as a feature of his or her least favorite arterial.

4.3.6.4 Cleanliness

Cleanliness was mentioned by only three of the 22 drivers, each of whom referred to different elements that were grouped together to form the cleanliness QOS factor. The specific comments were related to litter, a "clean and pleasing" environment, and abandoned shopping carts along the roadway. This factor was not listed on the post-drive survey and was mentioned by only one of the drivers as a feature of his or her ideal arterial and only one driver as a feature of his or her least favorite arterial (i.e., a lack of cleanliness).

4.3.6.5 Roadside Development

Six of the 22 drivers referred to the roadside development during their drive. These comments came in a range of opinions that were grouped together to form the *roadside development* QOS factor. Comments included the unattractiveness of some roadside development, the attractiveness of other roadside development, and that they preferred to drive in residential areas to commercial areas (see Figure 4-27 and Figure 4-28). This factor was not listed on the post-drive survey and was mentioned by only one of the drivers as a feature of his or her ideal arterial and only one driver as a feature of his or her least favorite arterial (i.e., a lack of cleanliness).

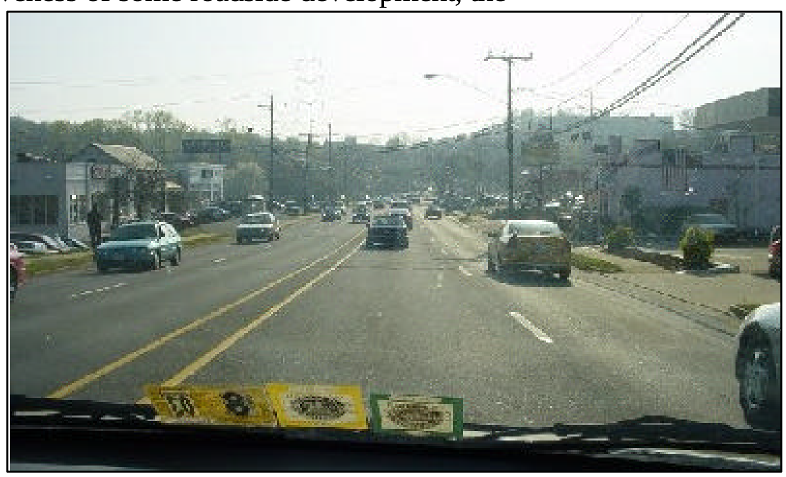

Figure 4-27: Example of Commercial Roadside Development in Northern Virginia

Figure 4-28: Example of Residential Roadside Development in Northern Virginia

4.3.7 Other Road Users

Eight QOS factors were identified in the *Other Road Users* investment category: *aggressive drivers, driver courtesy, illegal maneuvers, improper/careless lane use, blocking intersection, careless/inattentive driving, use of turn signals,* and *pedestrian behavior*. While *Other Road Users* may not be an investment category strictly related to traffic engineering, it is a category that states are interested in through their investment in driver education programs and police enforcement. Further, it appears to be a category that is important to drivers. Overall, 13 of the 22 drivers made at least one comment related to other road users (primarily other drivers). All drivers in Tallahassee commented about other drivers, with three of the drivers making six or more comments each. All but one of the drivers in Sacramento commented about other drivers. Five drivers referred to pedestrian behavior in Tallahassee, Chicago, and Atlanta.

Issues related to other drivers, with the exception of aggressive drivers, were not listed on the post-drive survey, and in general, were not mentioned as features of the drivers' ideal or least favorite arterial. Interesting, however, when asked, "What changes would you make to roads or traffic conditions?", testing older drivers more regularly, educating drivers, being stricter with drunk drivers, policing poor drivers, and having more strenuous traffic enforcement in general were all responses to this question. It is interesting that "engineering," "education," and "enforcement" are issues that arose during this study.

The QOS factors related to other drivers are discussed in more detail below.

4.3.7.1 Aggressive Drivers

Only two drivers specifically mentioned that aggressive drivers were a problem. Interestingly, however, half of the drivers chose *aggressive drivers* from the post-drive list of features most important to arterials. Perhaps the drivers on the test drive did not encounter any aggressive driving and were not reminded of it. However, the absence of aggressive driving was listed by one of the drivers as a feature of his or her ideal arterial, and one driver listed the presence of aggressive drivers as a feature of his or her least favorite arterial. These results suggest that the presence of aggressive drivers will negatively affect drivers' perceptions of service quality, a factor not previously considered. Presumably, drivers see aggressive driving as a safety concern.

4.3.7.2 Illegal Maneuvers

Six drivers made reference to other drivers making illegal maneuvers. Illegal maneuvers included illegal turns, red-light running, ignoring warning signs, and cutting through service stations on the corner of intersections. Illegal maneuvers, such as those previously mentioned, may be made by aggressive drivers; however, *illegal maneuvers* was defined as a separate QOS factor because drivers who may not typically be considered as aggressive may still make illegal maneuvers out of frustration with roadway design, configuration, or signing. One example that was described by one of the drivers was the posting of no left-turn signs at every intersection along a stretch of roadway. The driver commented that drivers who needed to turn left would do so despite the signs forbidding the movement. This may be a case where traffic engineers posted the signs to eliminate left turns (perhaps during peak periods) to keep traffic flowing due to the lack of left-turn bays or a two-way center left-turn lane. However, by doing so, it makes it difficult for drivers to make the maneuvers they wish. In the interest of traffic flow, the needs of some drivers have been ignored.

This factor was not listed on the post-drive survey and was not mentioned by any of the drivers as a feature of their ideal or least favorite arterial.

4.3.7.3 Driver Courtesy

The importance of driver courtesy was another issue that came up during multiple drives. One driver made a general statement that driver courtesy is important. Two drivers specifically mentioned that there is a problem with other drivers not allowing people to change lanes when they want or need to. Finally, one driver from Tallahassee said that while there are issues with other drivers, most drivers are courteous. This factor was not listed on the post-drive survey, but one driver included it as a feature of his or her ideal arterial.

4.3.7.4 Improper/Careless Lane Use

Three drivers mentioned other drivers' improper or careless lane use. More specifically, drivers made reference to other drivers' use of the center turn lane, right turn lane, or bike lane as a through lane to get around traffic. Another driver said that other drivers sometimes use merge lanes to pass at the last minute (which might also be classified as an aggressive or discourteous behavior). Figure 4-29 shows a driver squeezing through cars to use the merge lane to "jump" the queue of vehicles on the left. *Improper/careless lane use* was not listed on the post-drive survey, but one driver listed it as a feature of his or her least favorite arterial.

Figure 4-29: Example of Improper Lane Use

4.3.7.5 Blocking Intersections

Four of the 22 drivers mentioned that other drivers typically block a specific intersection making it difficult, if not impossible, for the cross street traffic to move through the intersection when it receives the green signal. While this is discourteous, not to mention illegal, it is often a result of driver frustration with signal timing (i.e., cycles too long) or demand exceeding capacity (i.e., grid lock). However, when drivers enter the intersection without being able to clear it, it only exacerbates the problem and causes further frustration. This is an issue that could be addressed in driver education programs.

This factor was not listed on the post-drive survey and was not mentioned by any of the drivers as a feature of their ideal or least favorite arterial.

4.3.7.6 Careless/Inattentive Driving

Five drivers raised an array of issues related to careless or inattentive driving. These issues included cell phone use, careless and inattentive drivers, merging without looking, not making wide enough turns, driving inefficiently (e.g., slow traffic driving in the left lane), and being slow to respond to green lights at intersections. While these are issues not easily addressed through engineering measures, they could be addressed in driver education programs.

This factor was not listed on the post-drive survey and was not mentioned by any of the drivers as a feature of their ideal or least favorite arterial.

4.3.7.7 Use of Turn Signals

Three drivers specifically said that other drivers not using turn signals was a problem, presumably because it is a safety concern. This factor was not listed on the post-drive survey, but one driver listed the lack of use of turn signals as a feature of his or her least favorite arterial.

4.3.7.8 Pedestrian Behavior

Pedestrian behavior was mentioned by five drivers in three of the four study locations. Comments about pedestrian behavior centered on jaywalking, pedestrian aggressiveness, pedestrians crossing against the “walk” signal, and pedestrians getting stuck in the middle of the road. Pedestrian behavior was not listed on the post-drive survey, but was mentioned by four of the drivers as a feature of their ideal arterial and one driver as a feature of his or her least favorite arterial.

4.3.8 Other

Three QOS factors were identified that did not clearly fit in any of the previously identified investment categories and were therefore placed in a category called *Other*. These QOS factors include: *intelligent transportation systems, planning,* and *roadway lighting*.

4.3.8.1 Intelligent Transportation Systems

Five different research drivers made reference to four types of intelligent transportation systems: ramp metering, variable message signs with radar, traveler information, and red-light running cameras. All comments were positive in that the drivers liked the systems and thought they were needed. While this was not a factor listed on the post-drive survey and was not mentioned by any of the drivers as a feature of his or her ideal or least favorite arterial, three subjects did make reference to the need for more ITS signal technologies in their response to the question, “What changes would you make to roads or traffic conditions?” In addition, one subject said that “more information is needed about everything,” making reference to the need for more traveler information.

The significance of this QOS factor is that ITS technologies provide solutions to concerns of customers about the transportation system in regards to signal timing, red-light running, and traveler information. In addition, ITS technologies can address concerns about other road users including aggressive driving, improper lane use, illegal maneuvers, blocking intersections, and pedestrian behaviors, particularly because these QOS issues are not easily mitigated through traditional traffic engineering improvements. (ITS and customer satisfaction are addressed in more detail in the Chapter 6.)

4.3.8.2 Planning

Five study drivers referred to issues that were classified as “planning” issues: grid networks, city layout as it relates to the provision of transit, mixed zoning, poor coordination of developments, too few river crossings to accommodate demand, and having several changing names of the same street. While these issues vary widely, it is obvious from them that some drivers are concerned with issues other than those related strictly to the road and roadsides through which they travel. No planning issues were listed in the post-drive survey and none were brought up by drivers in the post-drive discussion.

4.3.8.3 Roadway Lighting

Finally, the need for more street lights was mentioned by two drivers, both in Sacramento. The need for street lights was not included as a feature on the post-drive survey and was not mentioned by any of the drivers as a feature of their ideal or least favorite arterial.

4.4 General Questions about Roads and Traffic Conditions

The final four questions of the post-drive survey were not expressly limited to urban arterials. These questions were posed to drivers to develop a greater understanding of what they really value when it comes to the roadways and traffic conditions in their area. The questions were:

1. What are some concerns that you have regarding the roads on which you travel?
2. Are you satisfied with the roads in your area? Why or why not?
3. How do the traffic conditions and the roads affect your quality of life?
4. If you could make changes to the roads or to traffic conditions, what would you do?

The responses to these questions are presented here, as they reinforce the issues that were discussed during the drive and the driver opinions that comprise the QOS factors.

Drivers expressed a wide range of concerns about roads including safety, other drivers, pavement quality, signage, and operations issues such as signal timing. None of the concerns expressed by drivers were new issues, as they had already been identified during the drive or in the first part of the post-drive survey.

The majority of drivers indicated that they were satisfied with the roads in their area (68 percent). The reasons they gave for why they were or were not satisfied were again issues that had been previously discussed. The reasons cited for why drivers were satisfied included: presence of trees, wide lanes, good traffic flow, and good pavement quality. The reasons cited for why drivers were not satisfied included: congestion, potholes, inadequate signage, frequent lane drops or additions, and narrow lanes.

The majority of drivers (77 percent) responded that traffic conditions and roads do affect their quality of life. The most common response to this question was that traffic constrains when and where they travel. Drivers used words such as "aggravated," "challenging," "stress," "tension," and "nervous" to describe traffic and the effects it has on them. Some drivers also noted that time spent on busy roads means less time for other things, such as work or leisure activities. A few drivers noted that safety is a big concern and that this concern is related to quality of life. One driver even stated that the traffic he experienced during his commute determines the way he starts his day, while another stated that traffic "affects my mood." It is interesting to note that while drivers acknowledged the stress associated with driving, a few also affirmed the pleasurable aspect of driving, especially on roads that have aesthetic value.

Finally, drivers offered a range of changes or improvements they would make to roads or traffic conditions: prompt repair of potholes, more trees/greenway on side of road, wider lanes, better-timed traffic signals, stricter enforcement, more street signs over intersections, sensors on all traffic lights, more pavement markings for merging and turn lanes, wider roads, more medians, bigger street signs in advance of intersections, and more commuter rails. It is interesting to note that these recommendations pertain to every investment area identified in this study.

The responses to these questions did not introduce new issues or factors about service quality, but rather reinforced the topics identified in the transcripts of driver comments. The full set of responses to each question is presented in Appendix E.

4.5 Summary

The process of reviewing the drivers' comments and opinions resulted in the identification of 45 QOS factors across 8 investment areas. This section summarizes the QOS factors in terms of "new" factors. New factors are those that were not on the list of features on the post-drive survey but that emerged from the driver comments during the drive as well as driver responses to open-ended questions on the survey. Also, this section presents hypotheses about which factors may be among the most important to perceptions of service quality with urban arterials.

4.5.1 Newly Identified QOS Factors

Most of the features in the survey were included because of their reference in the literature or expert opinion. These features are primarily related to the design and operation of arterials. Additional features were included in the survey, such as *visibility of signs and/or traffic signals, pavement quality*, *aggressive drivers*, *pedestrians or bicyclists*, and *trees*, because of the hypothesis that factors other than those related to design and operations would affect perception of quality. The results support this hypothesis. Specifically, the newly identified QOS factors belong to the investment areas beyond design and operations, including *Signs and Markings*, *Other Road Users*, *Aesthetics*, and *Maintenance,* shown in Table 4-7.

Table 4-7: Newly Identified Investment Areas and QOS Factors

Investment Area	QOS Factor
Signs and Markings	Quality of pavement markings Lane guidance—signs Lane guidance—pavement markings Sign legibility/visibility Advance signing Too many signs (clutter/distracting) Sign presence/usefulness
Maintenance	Pavement quality Overgrown foliage
Aesthetics	Presence of trees Medians with trees Visual clutter Cleanliness Roadside development
Other Road Users	Illegal maneuvers Driver courtesy Aggressive drivers Improper/careless lane use Blocking intersection Careless/inattentive driving Use of turn signals Pedestrian behavior
Other	Intelligent transportation systems Planning Roadway lighting

While *sign legibility/visibility* (as *visibility of signs and/or traffic signals*) was included on the list of features in the survey (as indicated by the asterisk), in fact there was a multitude of issues related to signage that drivers identified as important to their perception of service quality. Likewise, while *aggressive drivers* and *pedestrians or bicyclists* were included on the list of features, there are in fact many other factors related to other road users that were identified by drivers in this study. In addition, while *trees* was included on the list, there were other factors related to aesthetics, such as *cleanliness* and *roadside development* that were identified by drivers as important to their perception of service quality and satisfaction. The identification of these investment areas and QOS factors provides increased opportunities for improving customer satisfaction through non-traditional means such as driver education, enforcement, and aesthetics.

4.5.2 Hypothesized Most Influential Factors

While it is too soon to determine which factors most influence drivers' perceptions of service quality, one can speculate which factors might be among the most important by noting how many drivers commented on them. It is worthwhile to remind the reader here that because the study did not use a representative sample, only speculations can be made at this point about the relative importance of the factors. Table 4-8 provides a glimpse of which factors these might be by showing the number of drivers that: 1) referred to each QOS factor during the drive, 2) listed it as one of the top ten features in the survey, and/or 3) named it as a characteristic of their ideal or least favorite arterial. To be included in Table 4-8, a QOS factor had to have been:

- mentioned by at least 50 percent (n=11) of the drivers during the drive,
- chosen by at least 50 percent (n=11) of the drivers as one of the top ten features of urban arterials on the post-drive survey, or
- named as one of the characteristics of their ideal or least favorite arterial by at least one-third (n=7) of the drivers.

Table 4-8: Hypothesized Most Influential Factors
(Based on the Number of Drivers Who Identified Them as Important)

Investment Area	QOS Factor	Identified During the Drive	Selected as 1 of the Top 10 [1]	Listed as Part of the Ideal Arterial	Listed as Part of the Least Favorite Arterial
Cross-Section Roadway Design	Number of lanes/roadway width	14	8/7[2]	5	4
	Turning lanes/bays	6	16/9[3]	7	3
	Medians	6	9	7	4
	Pedestrian/bicyclist facilities	13	3	0	2
Arterial Operations	Volume/congestion	15	12	2	9
	Traffic flow	7	17	3	2
	Number of lanes	14	0	0	0
Intersection Operations	Turning	13	16/9[3]	1	3
Signs and Markings	Sign legibility/visibility	9	17	2	0
	Sign presence/usefulness	4	N/A	4	7
	Lane guidance—signs	12	N/A	0	0
	Lane guidance—pavement markings	13	N/A	1	3
Maintenance	Pavement quality	16	17	6	10
Aesthetics	Presence of trees	12	6	9	5
Other Road Users	Aggressive drivers	2	11	1	1

[1]The post-drive survey had a list of 26 urban arterial features compiled prior to the study. "N/A" refers to features that were identified during the drive, but that were not on the list in the post-drive survey.
[2]8 drivers selected number of lanes, while 7 drivers selected roadway width.
[3]16 drivers selected left-turn lanes, while 9 drivers selected right-turn lanes.

The QOS factors shown in Table 4-8 span a range of investment areas, a finding which supports the hypotheses that 1) multiple factors are important to drivers, and 2) factors other than those related to design and operations impact drivers' perceptions of service quality on urban arterials.

5 QOS FACTORS AND DRIVER NEEDS

The purpose of this chapter is to determine what the QOS factors reveal about drivers' needs on urban arterials. Driver needs are essential requirements of service. Driver needs are the link between QOS factors and customer satisfaction because the degree of satisfaction is proportional to the extent that needs are met. QOS factors are the means of meeting the needs. A bus pull-out (a QOS factor identified from the data) provides an example of this difference. From the point of view of a driver, a bus pull-out reduces the delay created when a bus stops to unload and pick up passengers, and therefore, a bus pull-out improves service because it supports a basic requirement of service, namely, a need for efficient traffic flow. The driver needs that were revealed in this study include needs for a sense of safety, efficient traffic flow, positive guidance, and aesthetics, as shown in Figure 5-01.

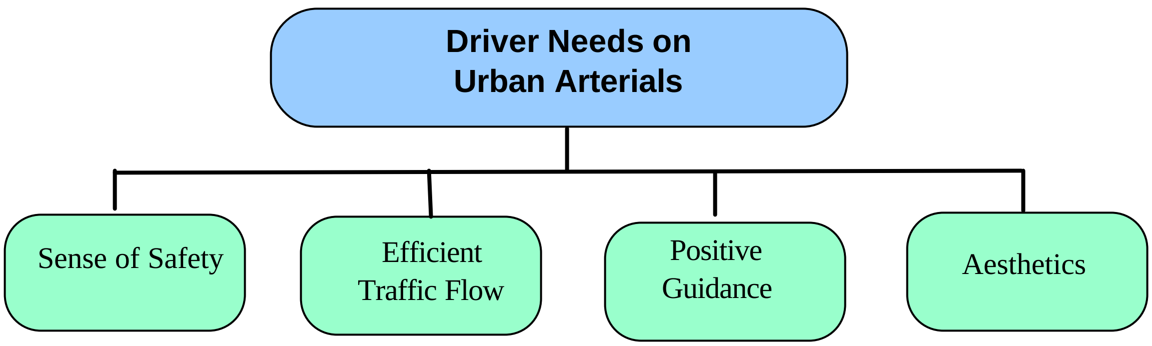

Figure 5-01: Driver Needs on Urban Arterials

5.1 Sense of Safety

One of the study hypotheses was that safety affects drivers' perceptions of service quality as well as their overall satisfaction with urban arterial performance. This hypothesis has been supported by the findings because drivers noted, across all locations, that safety was relevant to many of the QOS factors. Factors related to a sense of safety, that were specifically mentioned by drivers, included factors associated with roadway design (e.g., lane width, divided roadways, and frequency of lane drops/adds), arterial operations (e.g., speed and the presence of heavy vehicles), other road users (e.g., the presence of pedestrians), signs and markings (e.g., advance warning), maintenance (e.g., pavement quality), and ITS (e.g., red-light running cameras). Figure 5-02 illustrates how the QOS in different investment areas relate to the drivers' sense of safety.

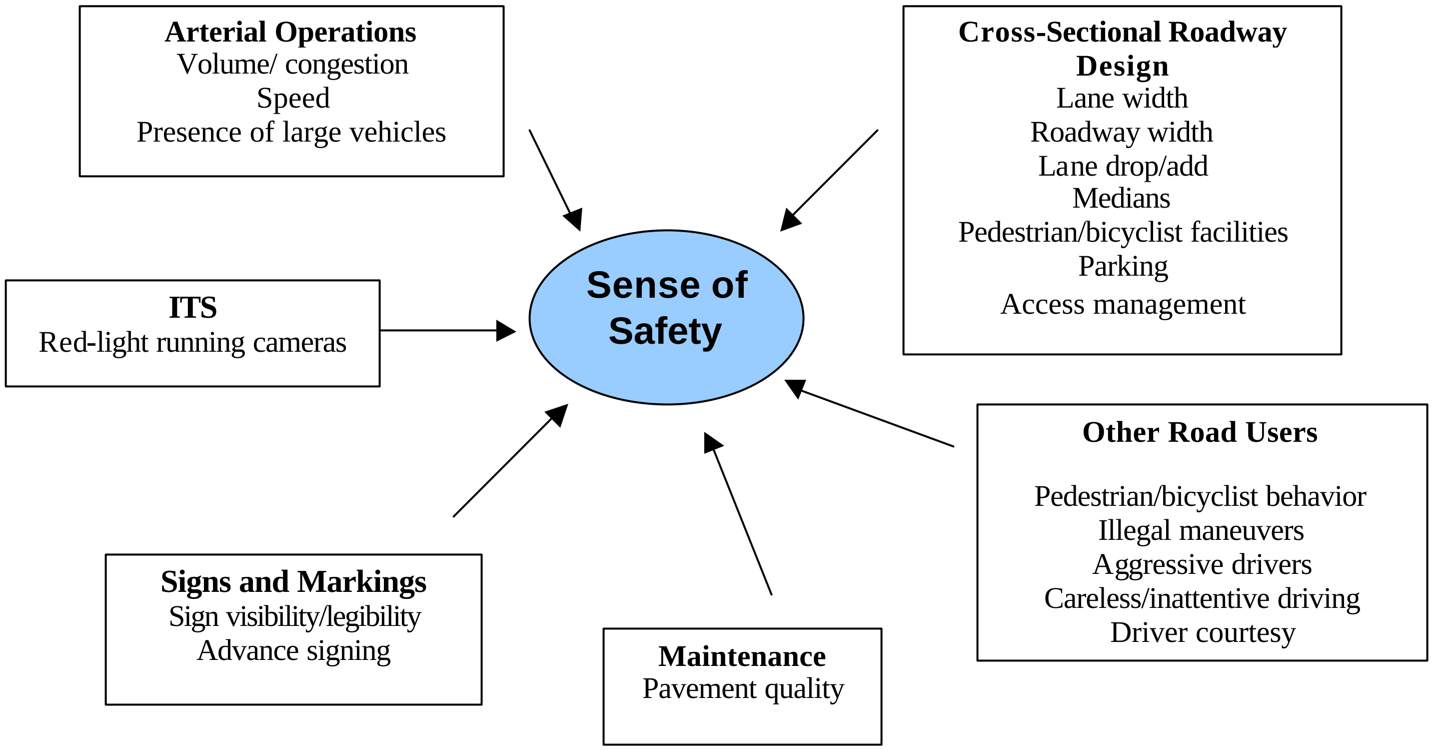

Figure 5-02: QOS Factors that Influence Sense of Safety

5.2 Efficient Traffic Flow

A cluster of QOS factors revolved around the need for efficient traffic flow. These QOS factors included turning lanes and protected left-turn arrows at intersections, coordinated signal timing, bus pull-outs, and sufficient capacity. This factor, noted by 13 drivers during the test drive, was ranked 9th out in the list of top 10 factors on the post-drive survey. Drivers explained that these QOS factors helped reduce delay and facilitated traffic flow. Finally, drivers' suggestions to have signal timing set to allow for continuous movement through several signals is another example of their desire for efficient traffic flow.

Surprisingly, drivers did not express a desire to travel at higher speeds. In fact speed was only noted by five of the drivers during the test drive and only noted by one driver as being a factor that comprised his or her ideal arterial. This suggests that drivers might have different expectations about speed on arterials than they do on freeways, perhaps because of the inevitable, and therefore expected, delays caused by signalized intersections.

5.3 Positive Guidance

During the drives, drivers made many comments relating to sign visibility, the quality of pavement markings, the lack of or presence of lane guidance, and the ability to see street names, all of which comprise the need for positive guidance. QOS factors that support positive guidance relate to the drivers' ability to distinguish and categorize the roadway environment into coherent segments and then make appropriate decisions about what to do, based on the information obtained. Drivers need to identify multiple aspects of the environment that are essential to driving including: where lanes begin and end, when traffic signals change, the location of other road users, the legality of maneuvers (such as right-turn-on-red), and navigational information (such as street signs). Finally, positive guidance is related to efficiency and safety because drivers who are lacking accurate, timely information about their location and heading may make wrong turns (leading them astray) or may execute erratic, slow, or otherwise unsafe maneuvers.

5.4 Aesthetics

The drivers expressed a need for aesthetic value in the roadway environment. This need is revealed by QOS factors such as the presence of trees, medians with trees, and cleanliness. Not surprisingly, drivers strongly preferred that their roads had visual appeal. What was surprising is the degree to which it apparently is important to drivers. Drivers in this study showed much concern for and interest in the quality of the aesthetic aspects of the roadway environment. The quality of the trip seemed to be influenced by multiple aspects of the aesthetics of the physical environment. For example, many drivers expressed a desire to see cleaner streets, more foliage and less commercial signage. Several drivers at each of the test sites verbalized the desire to see more trees and "green spaces" as part of the roadway landscape and appreciated efforts by local agencies or developers to improve landscaping. Some drivers expressed disappointment and concern when trees were removed for development or construction, and other drivers suggested that the environmental appeal of a roadway segment could mitigate feelings of stress or frustration due to slow-moving or otherwise difficult traffic situations. Some drivers noted that long delays at intersections are not as frustrating when the roadway environment includes visually appealing plants or trees.

6 MEASURING CUSTOMER SATISFACTION WITH ITS ENHANCEMENTS

The ITS Joint Program Office has emphasized the importance of customer satisfaction by including it as one of six measures of effectiveness applied to evaluate the impact of ITS programs. Because there are no established, standardized measures of customer satisfaction with the quality of service, the ITS program has a need to establish guidelines for customer satisfaction evaluations with ITS enhancements of arterials, intersections, and other operational improvements. This study provides a qualitative foundation for the development of a standard approach for conducting studies on customer satisfaction with ITS operational improvements of transportation facilities.

6.1 Customer Satisfaction Hypotheses

By allowing drivers to speak for themselves about their perceptions of roadway conditions, the qualitative approach employed in this study provides insight into the roadway elements and conditions that are of genuine concern to drivers on urban arterials. In this way, it is possible to explore the following sequence of customer satisfaction hypotheses, presented here as assertions:

1. Drivers will, independent of prompting, identify ITS-mediated service elements among the factors that influence their satisfaction with their driving experience on urban arterials.
2. Given a diverse group of individual drivers, different cities, and different driving conditions, there will be a core set of measures common to the group that can form the basis of a standard national evaluation of customer satisfaction with ITS enhancements on urban arterials and other roadways.
3. It is possible to prescribe a defined evaluation approach to measure customer satisfaction with ITS enhancements on urban arterials and other transportation facilities that can be applied uniformly across the country.

This chapter will narrow the discussion of QOS factors on urban arterials to those that are amenable to ITS enhancements, based on the findings of this research. The main investment area in which ITS can have a significant impact is *Intersection Operations*, and more specifically, *signal timing* and *left turn arrows*. From the point of view of the driver, ITS enhancements to these service elements affect overall arterial operations, in that they result in smoother traffic flow and less delay. A common theme that emerged from drivers' comments at all of the field sites is the great value placed on efficient traffic flow.[1] The importance of issues related to efficient traffic flow was echoed in the post-drive surveys. When asked to rank the top five features in terms of importance (presented in Table 4-3), drivers ranked *timing of traffic signals* second, *left turn only lanes at intersections* fourth, and *rate of traffic flow* fifth.

Another investment area in which ITS enhancements can have an impact is driver safety. A number of drivers in this study raised concerns regarding the aggressive or careless driving

[1] As noted previously, comments about flow were not associated with speed directly. Drivers did not indicate that they wanted to drive at high speeds; rather, they stated a preference to drive at a constant speed.

behavior of other road users. Such behavior was seen as influencing perceived safety as well as the flow of traffic. More specifically, drivers expressed concern or frustration by other drivers who ran red lights, blocked intersections, or made illegal left turns, among other illegal or unsafe maneuvers. Drivers were also concerned with pedestrians and bicyclists, and the effects that these road users have on continuous flow and safety. Red light running cameras or aggressive driver imaging are ways of directly influencing driver safety. Moreover, it is also plausible to assume that other ITS enhancements, such as improvements in signal timing, may indirectly affect drivers' perceptions of safety. A transportation system that has a smoother flow of traffic and that is characterized by greater predictability may have positive effects on driver behavior, which in turn, can have positive effects on drivers' sense of safety.

6.2 Findings on Drivers' Perceptions of ITS-Mediated Service Elements

Findings from this study reveal that drivers do, in fact, notice roadway and driving conditions that are mediated by ITS enhancements. In the four urban areas considered for this study -- Atlanta, Tallahassee, Chicago and Sacramento -- drivers were acutely aware of ITS-related service elements and they consistently identified the same types of ITS-related service elements across all four sites. Moreover, it is clear that these ITS-related service elements have an impact on drivers' level of satisfaction. Drivers tended to be most satisfied when there was continuous flow to traffic, with minimal waiting at signalized intersections. In particular, drivers at all four sites expressed awareness of signal timing as a key service element affecting their level of satisfaction.

With respect to signal timing, drivers noted several interrelated concerns. First, drivers observed that signals were often inefficiently timed, so that they had to spend too much time waiting at an intersection. The following comments illustrate drivers' perceptions regarding this aspect of signal timing:

> "*This intersection is very difficult because the lights don't change often enough… the cycle of the lights are very long on Peachtree and very short on these…*"

> "*If I were in a hurry to get somewhere, this would be horrendous, because we're probably going to have to go through two to three cycles to get down this short block.*"

> "*Shorter lights…I'm a believer in shorter lights instead of these minute to minute lights, because all they do is create long strings of traffic, which is not very efficient.*"

Drivers also spoke of signal timing with respect to the coordination of multiple traffic lights:

> "*I do wish Atlanta could get their traffic lights synchronized in some way and then they could control traffic speed if they'd just get their ducks in a row. Surely it could be computerized now and if you drove at the required speed or just about that, then you would get a flow.*"

> "*If you know that if you go between 25 and 30* [mph] *you'll hit all the greens then cars won't speed as much and the traffic will flow smoother cause it won't be stop and go*."

> "*But it is the stop and go that is frustrating because you can never get a rhythm going. I have always thought of driving in traffic to me is like watching a dance troupe. Everybody knows where they are going, everybody has a role. And it is very carefully choreographed. When you have things like this* [inefficient signal timing] *the choreography all goes to hell.*"

In a number of observations, drivers expressed the need for sensors to coordinate traffic signals with volume of traffic:

> "*And at the corner of Peachtree and Spring Street, for instance, they have a light there that gives an equal time for people exiting a parking lot at a business as they do the main thoroughfare, and there are times that I'm prone to want to run that traffic light just because it's stupid sitting there and waiting when traffic needs to flow.*"

> "*You'd think that in a big city that they would have sensor lights, but they don't.*"

Drivers also identified left turn arrows as having an effect on the flow of traffic:

> "*The left turn light doesn't stay on very long so only a few cars can get through*."

> "*I love these arrows, I think they're really useful. In some cases it would be really hard to make these intersections work without them*."

In addition to issues of efficient traffic flow and travel predictability (evidenced through comments on signal timing and left turn arrows), drivers were also preoccupied with the behavior of other road users and the implications for safety. The field drives illustrate that drivers value a safe driving environment, where road users respect the laws and are courteous to one another. Of particular concern to drivers were red light running and the blocking of intersections:

> "*Another thing we didn't see tonight is that this town is notorious for running red lights. I think they ought to have a camera on every intersection*."

> "*Here's another major intersection, which is probably one of the lights people would run through it because it would take forever to get through*

it. In some areas they have those cameras that catch you if you run the red. I think those are good."

"Drivers in Atlanta are just awful for running red lights, they really are. That's the most frightening thing about driving in the city that I know of."

"*The only thing that is frustrating is when people block the intersections…they'll try and get through the light and it turns red and they're just sitting there, so you can't go anywhere*."

Issues related to pedestrians were also a concern, though this issue resonated differently with drivers in different locations. In Chicago, for example, drivers were deeply frustrated by pedestrians, for they perceived pedestrians as demonstrating little respect for signals. According to drivers, pedestrians were both a safety hazard, as well as an impediment to the flow of traffic. As Chicago drivers related:

"*Right now I'm stressed about hitting somebody. The train station is right there and there are just masses of people who don't mind walking against their walk signal*."

"*Can I talk about pedestrians? That's a big aggravation down here. They think it's just…well, now it's "walk" and I don't care, but when it comes to 'don't walk' and watch how many go. And I think that's a big thing that causes traffic also*."

In Atlanta, however, drivers were more likely to frame the issue in terms of drivers having little respect for pedestrians. Drivers in Atlanta and Tallahassee also mentioned the absence of sidewalks as being a pedestrian safety problem in their city.

"*The other thing I don't like about Atlanta is that people are not very cognizant about pedestrians…pedestrians don't seem to have the right of way. In California people will walk right in front of you because they know you'll stop…and you don't do that here because they won't stop*."

"*The biggest complaint about Georgia roads is that they don't believe in sidewalks down here, apparently don't believe in walking, and so it's a hazard to walk*."

In sum, there is overwhelming evidence that drivers, independently of prompting, do notice roadway and driving conditions that are mediated by ITS-related service elements, and these conditions clearly influence their level of satisfaction with urban arterials. As illustrated by their comments across all four sites, drivers become frustrated with the "stop and go" traffic that results from poorly timed signals or the inefficient allocation of green time between main streets and cross streets. Drivers are unhappy with long traffic lights and traffic backups that they feel could be alleviated by improvements in signal timing. Moreover, they are concerned with the aggressive and careless behavior of other road users who make arterial operations (and more specifically intersection operations) less safe and less predictable. Drivers identified several different ways in which traffic operations could be improved, such as with the use of sensors, changes in signal timing, and the installation of cameras to monitor red light running.

Despite the common concerns raised across all four interview sites, the transcripts from the field drives also revealed that drivers had subjective measures in their minds when evaluating ITS-related service elements, such as signal timing. For some drivers, signal timing was evaluated according to the number of light cycles they had to sit through at an intersection. Based on their experience with the route, drivers had developed expectations regarding how many cycles they typically had to wait through before passing through an intersection, and this has provided them with a benchmark against which it is possible to measure improvements. That is, an improvement to traffic operations would be measured by a decrease in the number of cycles waited. For other drivers, the subjective measure was time. Again, drivers had developed some sense of how long a certain drive should take, under usual driving conditions, and so they would perceive a decrease in travel time (achieved on a consistent basis) as an improvement.[2]

Overall, these findings suggest that:

1) It is possible to measure changes in customer satisfaction due to ITS enhancements, and
2) Future studies need to take into account the different subjective measures that drivers use when measuring their satisfaction.

6.3 Measuring Customer Satisfaction with ITS Enhancements

The current study provides sufficient evidence that drivers will, independent of prompting, identify and rank as significant, operational conditions that are mediated by ITS. Perhaps more important, these conditions have a significant influence on their level of satisfaction with urban arterials. Based on these findings, a standard approach to measuring customer satisfaction with urban arterials and other transportation facilities can be applied uniformly across the country. Given the similarities in the ways in which drivers commented on these service elements – even across diverse field sites – it is also possible to develop a core set of questions that can form the basis of a standard national evaluation of customer satisfaction for a particular application.

The standardized approach involves evaluating a planned ITS enhancement and has two main components:

1) Conduct a qualitative pilot study to better understand the contextual variation at the selected site and to test the survey for local relevance,[3] and

2) Conduct a pre- and a post-study with a large panel of the same drivers, on routes that have planned ITS enhancements.

[2] Conversely, drivers who were not familiar with a specific route may not have developed these subjective measures. As one driver revealed, "I don't think I've used this light in a long time, so I don't really know what to tell you about this intersection."

[3] It may be possible to phase out the "qualitative pilot study," once a sufficient number of studies have been conducted to feel confident in the overall evaluation approach. However, flexibility should be built into the method, such that pilot studies can be conducted if a better understanding of the contextual variation at a new field site is needed.

Drivers familiar with the route that has a planned ITS enhancement will be recruited for the panel. Panel members will drive on the route before the ITS enhancement has been implemented (the pre-treatment condition), as well as after implementation (the post-treatment condition). Unlike the methodology used in this study, where an engineer and an interviewer accompanied drivers, the panel of participants will conduct the drives on their own, without members of the study team being present in the vehicle. Immediately following the field drives in both the pre- and the post-treatment, drivers will be asked to complete a quantitative survey that measures level of satisfaction with different aspects of roadway conditions and operations. In this way, it is possible to measure changes in customer satisfaction resulting from the ITS enhancement.

The following are two hypotheses to be tested:

1. If there is sufficient[4] improvement in traffic flow resulting from changes in signal timing, then it will be possible to measure increased levels of satisfaction among drivers.

2. If there is sufficient decrease in drivers who run red lights resulting from the installation of cameras at intersections, then it will be possible to measure an increase in sense of safety among drivers.

6.4 Recommended Guidelines for ITS Customer Satisfaction Evaluations

Before conducting future customer satisfaction studies, detailed protocols regarding sampling and methodology need to be developed. The findings from the driving interviews support continued use of these study guidelines:

- **Drivers should be very familiar with the route under consideration; and in fact, the drives for the panel study should be conducted at times of the day when participants would normally make the trip.** In this way, the panel study would approximate, to the greatest extent possible, a "natural" drive. Participants have developed expectations and personal measures of performance regarding roadway conditions, based on the time of day that that they drive a given route. Hence it will be easier for participants to assess the effects of the ITS enhancement against their expectations if they are driving on the route at the time of day when they would normally be making the trip.

- **The sample needs to account for a range of driver characteristics in order to accurately identify QOS factors and to better understand differences in level of satisfaction.** If large samples are used in future studies (on the order of 400 cases), then a representative sampling of drivers will result in sufficient numbers of different groups (i.e. younger and older drivers, men and women). However, if smaller sample sizes are used (on the order of 40 to 100 cases), consideration should be given to stratifying the sample by key demographic variables. At this point, the recommendation is to stratify by gender and age. Characteristics such as race, income and education were not explicitly accounted for in the current sample of drivers, so there is insufficient data to determine if there is a need to stratify by these factors.

[4] Consideration needs to be given to what qualifies as "sufficient" improvement (as there are no established thresholds). We posit that the degree of improvement needed to affect drivers' level of satisfaction will be locally defined; that is, based on characteristics of the location, such as population and density.

- **The sample needs to be stratified by trip purpose**. The sample should include a diverse set of trips, including commute trips, personal appointments, and recreational trips, among others. In this way, it is possible to determine whether trip purpose is related to customer satisfaction.

- **The pre- and post-studies should include drives at both congested and uncongested times of the day.** As the current study reveals, congestion affects drivers' perceptions of quality of service. Consequently, it will be important to conduct drives at both congested and uncongested times of day, so as to account for the effects of congestion on customer satisfaction.

- **Contextual conditions in the pre- and post-studies need to be similar.** The field drives for the pre- and the post-treatment need to be conducted on the same day of the week, at the same time of day, in order to have similar contextual conditions in both experiments. To the extent that contextual conditions can be held constant, it will be easier to measure changes in level of satisfaction. Unusual congestion due to an incident or weather conditions in either the pre- or the post-treatment would warrant a rescheduling of the drive.

- **Future studies need to account for the fact that drivers have different subjective measures for assessing roadway operations.** In the current study, drivers used different subjective measures for expressing their level of satisfaction. For some it was the number of traffic lights they had to sit through; for others it was the length of the traffic back up. Future quantitative surveys need to include questions that account for different subjective measures.

- **For future quantitative surveys, it is not clear what specific scale should be used to measure customer satisfaction.** The tentative conclusion is that an 11-point Likert scale would capture the complexity of drivers' perceptions, and would also enable us to measure changes in level of satisfaction (by tracking individual changes in ratings from the pre- to the post-study). However, further research is needed to explore alternative scale formats for measuring changes in customer satisfaction.

- **The issue of "network effects" needs to be considered.** An ITS enhancement implemented on a specific route should have a positive impact on customer satisfaction among the users of that route; however, it is likely that there will be an impact on the overall network as well. More specifically, it is plausible that user capacity will be redistributed across the network, as some drivers gravitate to the route with the ITS enhancement, thus increasing capacity on other routes.

6.5 Recommendations for Next Steps

There are four main components to the recommendations regarding the next steps to a standard ITS customer satisfaction evaluation approach:

- Fully develop guidelines for the standard evaluation approach measuring customer satisfaction with ITS enhancements
- Pursue additional background research
- Test the proposed standard evaluation approach
- Finalize the standard evaluation approach

The first step is to fully develop the standard evaluation approach to be used in measuring customer satisfaction with ITS enhancements. Detailed procedures and guidelines regarding the administration of future panel studies need to be outlined. Things to consider include: how the panel of drivers would be recruited, under what conditions a qualitative pilot study should precede a panel study, and what the procedures should be for conducting the drives. The guidelines for the standard evaluation approach would address all aspects of how to conduct the panel studies.

The second recommendation is to pursue further research on some of the questions raised by this study. Most important, a topic that requires additional research is the measurement or quantification of customer satisfaction. This involves obtaining a better understanding of the type of scale that is best suited to capturing the complexity of drivers' perceptions. A 7-point scale may be sufficient, but an 11-point scale may be more appropriate. Further research is also needed to help determine whether it is necessary to stratify the sample by race, income or education. While the data from this study are not sufficient to address this question, there may be other studies that can shed light on the importance of these characteristics as factors that influence drivers' perceptions. Finally, background research would be useful in determining the appropriate sample size for future evaluation studies.

The third recommendation is to take advantage of a planned ITS enhancement to test the hypotheses and the prototypical evaluation approach that are presented in this chapter. The current study has provided a strong qualitative foundation upon which to base future research. In order to further refine and test the method and hypotheses, however, it is critical to test the proposed method at the site of a planned ITS enhancement. The following is a general list of steps for conducting the next customer satisfaction evaluation:

- Identify the study site(s). Sites will be chosen based on whether there are planned ITS enhancements (of sufficient magnitude to be noticed by drivers) that will be implemented in the near future and that are suitable for customer satisfaction evaluation.

- Based on findings from the current study, develop a quantitative survey that measures different aspects of customer satisfaction with the particular ITS enhancement being evaluated. A core set of questions that can be used to evaluate a broad range of ITS enhancements will be developed. However, it is anticipated that there will be a need to design specific questions tailored to the particular ITS enhancement being evaluated.

- Conduct a qualitative pilot study. Recruit 5-6 drivers who will drive on a pre-selected route (which includes the site of the planned ITS enhancement). As in the current study, drivers will talk-aloud about their driving experience and the factors that influence their perception of service quality. Drivers will be probed on specific ITS-related service elements, such as signal timing. In this way, the interviewer can obtain a better understanding of the different subjective measures that drivers use when evaluating traffic operations. At the end of the drive, participants will complete the quantitative survey.

- Use the findings from the Pilot study to refine the quantitative survey. The Pilot study may reveal contextual factors (i.e., geographical or cultural) unique to the specific site that were not accounted for and that need to be included in the survey. In the interviews in Atlanta, for example, the lack of sidewalks and the curving roads were issues that were not raised at other sites (or were much less salient). In addition, if an intersection were being evaluated, the pilot study would reveal if there were particular concerns or issues regarding that intersection, from the driver's perspective, that were not anticipated.

- Recruit a panel of drivers to be used in the pre-post study. Ideally, a control panel would also be recruited. At the same time that the panel is driving on the route with the planned ITS enhancement, the control panel would be driving on a comparable route that has no planned ITS enhancement. The control panel will help test the hypothesis that it is possible to measure changes in customer satisfaction in a real-life driving situation.

- Upon recruitment of the panel, conduct the pre-experimental treatment. Surveys are mailed to participants, and they are asked to drive on the route (which includes the site of the planned ITS enhancement) at a specified date and time. At the end of the drive, participants complete the quantitative survey and mail it back. The control panel follows the same overall procedures (with drives conducted on a comparable route with no planned ITS enhancement).

- After the planned ITS enhancement has been implemented, conduct the post-treatment. The panel of participants receives another copy of the survey, and they are asked to repeat the drive conducted in the pre-treatment. After the drive, participants complete the survey and mail it back. The control panel follows the same procedures.

The hypothesis is that, on the route with the planned ITS enhancement, there should be a significant increase in satisfaction among drivers (from pre- to post-treatment), whereas there should be no significant change with the control panel. This next step, a quantitative evaluation of an ITS enhancement, serves as a test of the method proposed in this paper and is necessary to develop confident recommendations for a standardized approach.

The fourth recommendation involves finalizing the standard evaluation approach. Based on findings from the testing of the proposed approach, the guidelines and procedures would be further refined and appropriate changes would be made to the survey instrument.

7 CONCLUSIONS AND HYPOTHESES

The purpose of the study was to identify the factors that are important to drivers regarding the quality of their driving experience on urban arterials. The focus was on non-commercial drivers of passenger vehicles. The study used an in-vehicle methodology in which drivers talked out loud about the driving experience as they drove their own vehicles. The in-vehicle method provided the opportunity for drivers to respond in real-time to different events that occurred during the drive and express their reactions to actual roadway elements and circumstances.

Drivers identified a total of 45 factors that are relevant to their perception of service quality on urban arterials. These factors were grouped into the following eight investment areas: cross-sectional roadway design, arterial operations, intersection operations, signs and markings, maintenance, aesthetics, other road users, and other (including ITS).

The results showed that the drivers appeared quite comfortable expressing their views in the presence of the interviewer and the traffic engineer and as they operated the vehicle. In fact, many drivers seemed to enjoy the opportunity to share their opinions with individuals who were clearly interested in hearing what they had to say. The drivers expressed their opinions about a wide range of issues, including simple observations (such as the presence of a sign), more detailed evaluations (such as the relationship between signal coordination and traffic flow), and broad concerns related to the roadway environment (such as the presence of green space).

7.1 Initial Hypotheses

The hypotheses at the start of the study included the following:

1. There are engineering factors other than average speed (currently the MOE used to determine LOS in the HCM) that affect drivers' perceptions of service quality on urban arterials.
2. There are factors other than those related to the design and operation of arterials (e.g., presence of trees, aggressive drivers) that affect drivers' perceptions of service quality on urban arterials.
3. Safety has an influence on drivers' perceptions of service quality and overall satisfaction.
4. The findings from this study will provide the basis for the information needed to develop tools for measuring service quality and driver satisfaction.

The hypotheses were supported by the results of the research for the following reasons:

1. The study revealed 45 factors (across eight investment areas) that affected the participants' perceptions of service quality and satisfaction on urban arterials.
2. Many of the QOS factors identified were "new" factors, in that they were unexpected based on the body of literature that was reviewed prior to conducting the study. These factors were not only related to traffic engineering, but also driver education and police enforcement.
3. Safety was an underlying issue identified throughout this study. Some drivers made explicit references to safety (e.g., "I don't feel safe on this section of roadway."), while

others referred to safety indirectly (e.g., "These lanes are too narrow," or "The sidewalks are too close to the roadway."). Each of the eight investment areas includes QOS factors with safety implications, and at least 25 of the 45 QOS factors are somehow related to safety.

4. By identifying a wide range of factors that influence drivers' perceptions of service quality on arterial streets, this study has laid the groundwork for future quantitative work aimed at developing QOS and customer satisfaction tools.

7.2 Research Needs

The information obtained from the study was subjective and qualitative, consisting solely of drivers' statements about their attitudes and their explanations of their preferences and choices. The knowledge obtained in this study about QOS factors and driver needs must be extended if it is to be applied to measures of customer satisfaction. The specific gaps in information that remain and that require more research include:

- Identifying the thresholds of tolerance for the QOS factors,
- Integrating QOS factors with the MOEs currently recommended by the HCM, and
- Developing approaches and tools (e.g., models) to measure service quality and customer satisfaction.

7.3 Comparisons to Previous Research

A summary of research on driver perception of service quality was presented in Chapter 2, and it is worth comparing the of this study to these previous studies. Clearly, many of the QOS factors revealed in the current study had been also found in earlier work. For example, Hall, Wakefield, and Al-Kaisy studied user's perceptions of quality of service on freeways and found that travel time, density, safety, and traveler information were of primary importance, and that driver civility, weather conditions, and the presence of photo radar were of secondary importance.[11] Similar or identical QOS factors were revealed in the current study, including travel time, volume/congestion, driver courtesy, and illegal maneuvers. In addition, a sense of safety emerged as a driver need in the current study, which overlaps with the safety factor in Hall, et al. Traveler information (a primary issue in Hall, et al.) was not frequently mentioned during the drive in the current study; however, a few drivers remarked on the need for more information, and in particular, for advance information. The need for traveler information was directly demonstrated in responses to the post-drive surveys. For example, one driver wrote, "more information about everything" and another driver specifically mentioned the need for more variable message signs in response to a question regarding concerns about the roads and driving. Weather conditions were not a factor in the current study, because the data collection trips were limited to good weather conditions.

The driver needs revealed in this study overlap with the factors in studies of driver's perception of level of service at signalized intersections. In Sutaria and Haynes.[13]) delay, traffic congestion, number of stops, difficulty in changing lanes, and number of trucks/buses emerged as important factors. Likewise, the results from the current study showed a need for efficient traffic flow (an inverse of delay), and volume/congestion and presence of large vehicles factors.

The drivers in the current study did not directly indicate that the number of stops or difficulty in changing lanes were important to perceptions of service quality; however, number of stops and difficulty in changing lanes are associated with congestion, a QOS factor found here.

Pecheux, Pietrucha and Jovanis used a video laboratory approach to investigate driver perception of level of service at signalized intersections and found at least 15 factors that influenced drivers' QOS ratings. (14)) The factors were:

- Delay,
- Traffic signal efficiency,
- Arrows/lanes for turning vehicles,
- Visibility of traffic signals from queue,
- Clear/legible signs and road markings,
- Geometric design of intersection,
- Leading left-turn phasing scheme,
- Visual clutter/distractions,
- Size of intersection,
- Pavement quality,
- Queue length,
- Traffic mix,
- Location,
- Scenery/aesthetics, and
- Presence of pedestrians.

Each factor found in Pecheux, et al. to be relavant to perception of quality was found to be important to drivers in the current study as well, with two exceptions: queue length and location. Although drivers in the current study did not refer specifically to queue length, they did describe problems associated with a lack of sufficiently long turning lanes or bays to accommodate vehicles waiting to turn. The drivers in the current study expressed in different ways the need for lanes for storing turning vehicles so that the vehicles did not block through traffic. The terminology used by different researchers seems to vary slightly, which precludes direct comparisons of QOS factors across studies.

The video laboratory approach used in Pecheux, et al. produced results that are similar to results obtained from the in-vehicle method used in the current study. There were fewer factors identified in Pecheux, et al., but this could be explained by the study's exclusive focus on approaches to red traffic lights. In contrast, the current study included multiple aspects of driving along a variety of different arterials in their entirety for a total of about 45minutes. Because of the broader focus in the current study, it is not surprising that more factors were identified here. Yet, many of the factors identified in the current study involving signalized intersections overlap with those found from the video laboratory study. The similarity of results suggests that the video laboratory approach is valuable in obtaining information that would be obtained in field approaches to data collection.

In summary, the current study found QOS factors and driver needs that are similar or identical to those found in previous studies, but the results from the current study demonstrate that many additional factors are influencing quality. Factors identified in the current as well as previous studies may be among the most important to quality and should be evaluated in controlled experiments in order to find the thresholds of user tolerance.

7.4 Findings Regarding Study Methodology

Assumptions about the methodology included the following (initially presented in Chapter 3):

1. Contextual factors, such as geographic location and urban density and population, influence drivers' experiences and their perceptions of service quality.
2. Exposure to a variety of roadway designs and conditions will lead drivers to identify a diverse set of issues that are of importance to them.
3. Drivers' perceptions vary according to the level of congestion to which they are exposed.
4. Drivers should be familiar with the test route as this will result in more meaningful and comprehensive responses.

Each of the assumptions regarding the methodology is addressed below.

1. Contextual factors, such as geographic location and urban density and population, influence drivers' experiences and their perceptions of service quality.

Four different types of urbanized areas from across the country were chosen as field sites in order to capture a range of contextual diversity. Across all four sites, there was overlap in the comments made by drivers; that is, drivers raised many of the same types of issues as factors influencing their level of satisfaction. In particular, the issues of traffic flow and driver safety were prominent at all four sites. Drivers complained about traffic volume and its effect on traffic flow (especially during peak congestion times) in each location. Drivers from smaller urban areas were just as likely to raise these issues as drivers from larger urban areas, lending support to the notion that congestion is relative. As a Tallahassee driver observed, "It gets super, super congested here in the evenings, but super congested for me is probably different for you since you come from up north, I've been in Tallahassee all my life so this is a lot of traffic for me."

Despite commonalities, the drivers responded to contextual features unique to their area. For example, in Chicago a significant concern was aggressive pedestrian behavior, whereas in Atlanta, drivers talked about the lack of sidewalks as a threat to pedestrian safety (also mentioned in Tallahassee, to a lesser extent). With respect to bicyclists, Chicago drivers emphasized the risky riding behavior of bicyclists, but Tallahassee and Sacramento drivers were more likely to make references to bike lanes (i.e., presence, absence, width, etc). In Chicago and Sacramento, drivers had strong opinions about the raised medians (with plantings), but as this roadway feature is not prominent at the other two field sites, there was little or no mention of it in Tallahassee or Atlanta. The differences in drivers' comments across the four field sites suggest that contextual factors do influence drivers' perceptions about service quality. While there is a core set of factors common to different urban areas, there are also certain features or issues unique to particular sites. In order to understand the full range of quality of service factors important to a given site, future studies will need to determine whether or not there are factors unique to that site that have not been identified in the current research, and what it is about those factors that concerns local drivers.

2. Exposure to a variety of roadway designs and conditions will lead drivers to identify a diverse set of issues that are of importance to them.

At each of the four field sites, drivers were exposed to a variety of roadway designs and roadside features, and as hypothesized, drivers responded to these different stimuli by talking about a wide range of issues, including traffic flow, road design, signage, maintenance, and aesthetics, among other quality of service factors. It was clear from the transcripts that drivers noticed changes in their environment. For example, drivers pointed out differences in the roadways and in roadside development when moving from a commercial area to a residential area

3. Drivers' perceptions vary according to the level of congestion to which they are exposed.

To test this hypothesis, field drives were conducted at both peak and non-peak congestion times. Drivers during peak congestion times tended to comment on the level of traffic congestion that they were experiencing. However, many drivers talked about issues related to traffic volume, congestion, or traffic flow, regardless of the timing of their field drive. Even in the drives conducted during non-peak congestion times, drivers made frequent reference to rush hour conditions. Whether they were actually driving in congested traffic, or merely referring to conditions during peak congestion, drivers agreed that driving conditions during peak congestion (compared to traffic at other times of the day), was both more stressful and less efficient.

> *"I don't think the turn lanes are ever long enough, especially during commute time."*

> *"A lot of times in rush hour people aren't very nice about letting you in."*

> *"These series of lights up to Tallahassee Mall is very congested in the afternoon and morning with rush hour. Traffic gets backed up and it's very hard to turn onto this road from any of those businesses."*

4. Drivers should be familiar with the test route as this will result in more meaningful and comprehensive responses.

Drivers were selected who drive somewhat frequently (at least three to four days per week), and who were familiar with the test route. It was apparent that drivers, familiar with the selected route, had developed expectations about the roadways, which enabled them to talk with greater knowledge and in more depth about their experiences and the factors that affect their level of satisfaction. In fact, some drivers were able to provide detail about traffic conditions and problems that occurred at times of the day other than when they were on the test drive. As a result, more information about that route and the driver's experiences on that route was made available. For example, at an intersection in Atlanta, one driver described long queues resulting from signal failure in an opposing direction of traffic. His familiarity with the route enabled him to provide additional information about the intersection operations and his perceptions of the conditions. In contrast, a driver who is unfamiliar with the route would not have been able to provide this additional information since they would be limited to speaking only about the immediate conditions. For example, a driver in Atlanta said, "I don't think I've used this light in a long time, so I don't really know what to tell you about this intersection."

7.5 Hypotheses for Future Studies

This study has answered valuable questions about the factors that influence drivers' perceived service quality and level of satisfaction, and the results presented herein should be valuable to the traffic engineering community. Based on the results of this study, the following are the hypotheses worthy of pursuit:

1. With this research as a foundation, quantitative studies can identify and stratify the most influential QOS factors in a way that will represent the range of drivers' perceptions of service quality and satisfaction.
2. Customer satisfaction on urban arterials will increase when improvements are made to the QOS factors that directly impact the key driver needs identified in this study: *(perceived) safety, optimal flow, legibility, and comfort*.
3. New quality of service/customer satisfaction tools can be developed that better represent drivers' perceptions of service quality and their levels of satisfaction.
4. If a new level-of-service tool were developed that included multiple QOS factors, appropriate investments would be made, and drivers would be more satisfied with urban arterials.
5. A variety of new tools could provide assistance to different decision makers at different levels (e.g., a broad regional model for policy makers, and more specific operational models for local planners and transportation professionals).
6. More intense driver education, that includes basic traffic engineering principles (like the effects of slow traffic in the left lane or of red-light running), and training, will result in better, more courteous drivers, which will increase customer satisfaction.
7. Increased enforcement (through police presence or ITS enhancements) will improve customer satisfaction.

7.6 Summary

In summary, the contribution of the study is that it increases knowledge and understanding of the needs and values of automobile drivers. Transportation providers make decisions about short-term and long-range investments to facilities and want to include the road user's perspective in their decision-making processes. Including the perspective of the users, of course, requires an understanding of how they define value, information about the features that are noticed and are of concern to them, and their priorities.

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APPENDIX A: INFORMED CONSENT FORM

The purpose of this project is to obtain driver opinion about roadway conditions and features. In the study, you will be asked to drive your personal vehicle during the day on roads in your hometown and talk out loud about the things that you are thinking about in terms of driving and the driving environment. The project can benefit drivers indirectly by helping traffic engineers further understand the features and factors on roadways that are important to the driving public. There are no direct benefits to you; however, the project may help traffic engineers further understand the features and factors on roadways that are important to the driving public.

A researcher will sit in the front passenger seat and take notes as you drive, and may prompt you for clarification about particular items during the drive. In addition, an assistant will sit in the back seat to operate a video camera. The camera will be used to record videotape of the roadway scene. All videotape will be secured at George Mason University and kept confidential. Only researchers working on this project will have access to the videotapes, and the tapes will be destroyed at the completion of the project. The drive is not expected to take more than 60 minutes.

After the drive, you will be asked to return to the start point and park your car. At this point, the researcher may ask you some questions regarding your opinion of the roads and your driving experience. You will also be asked to rate traffic- and roadway-related factors in terms of their importance to you. This part of the project should take about 20 minutes to complete.

After completing the study, we will provide payment to you and answer any questions that you may have about the project.

Please note the following:

- Your participation is voluntary. You may discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled.
- You may experience some discomfort while driving due to the presence of the research; however, the researchers will maintain a quiet demeanor and presence in the vehicle to minimize distraction.
- You will be paid $50 for your participation, which should take about 2 hours.
- All data collected in this study are confidential. All surveys will be discarded after the data analysis.

This study is being conducted by Deborah Boehm-Davis in the Psychology Department at George Mason University. Dr. Boehm-Davis may be contacted by email at dbdavis@gmu.edu or at 703-993-8735 should any question arise. You may also contact the George Mason University Office of Sponsored Programs at 703-993-2295 if you have any questions or comments regarding your rights as a participant in this research. The project has been reviewed according to the George Mason University procedures governing your participation in research. The Federal Highway Administration is funding the study.

I have read this form and agree to participate in the study.

Consent signature: ____ Date: ___________

Witness signature: ____ Date: ___________

APPENDIX B: INSTRUCTIONS AND PRE-DRIVE BRIEF

"The purpose of this project is to better understand the things that influence drivers' perceptions of the driving experience such as: roadway conditions, traffic conditions, environmental conditions, aesthetics, etc. As you know, you will be driving your vehicle along a designated route for the next 45 - 60 minutes. While you are driving, we would like you to talk out loud about the things that you are thinking about in terms of driving and the driving environment. You should feel free to speak to me at anytime; however, neither of us will initiate any conversation or express our opinions to you."

"Specifically, what we would like to know are the things that you find satisfactory and unsatisfactory. For example: What is it you like about the road or the traffic conditions? What is it you don't like? What is frustrating to you about driving? What makes you comfortable? What is annoying? What is pleasing? We want you to identify anything and everything that is important to you about the driving experience. While talking out loud about the driving experience may not be something that you are used to doing, please try your best to be as detailed as possible about what you are referring to."

"The transportation system is a service, and you are the customer. We want you, the customer, to tell us what you think about the service. To give you a better idea of the feedback we are looking for, please think about and describe a trip you make on a regular basis. Consider using some of the following words to describe your experience during your trip:

- Satisfactory
- Unsatisfactory
- Like
- Dislike
- Pleasing
- Frustrating
- Annoying
- Confusing
- Easy
- Difficult

BUT please use other words as you see fit. This list is provided as an example."

"Now that you have an idea of the type of feedback that we are looking for, let's try a practice run for about five minutes. The practice drive will give you time to get used to talking out loud about the driving experience. During the drive, we would like you to talk out loud about driving as much as possible. Let's go!"

APPENDIX C: POST-DRIVE SURVEY: URBAN ARTERIALS

1. An **URBAN STREET** is a major roadway that generally has 2 or more lanes of traffic in each direction, signalized intersections, speed limits of 35-50 mph, and carries fairly large volumes of traffic. Examples of urban arterials are the roads we drove on today.

(1) Please read the entire list of features found on most urban streets.

(2) Place a check in the first column next to the 10 most important features to you as a driver.

(3) In the 2nd column, rank the top five features of those you checked that you consider to be the most important, with 1 being the most important.

Features	Check the 10 Most Important Features	Rank the Top 5 of those Checked
A divided roadway (with a center median or barrier)		
Signalized intersections (or number of signals)		
Timing of traffic signals (length of red/green for each movement)		
Visibility of signs and/or traffic signals		
Left-turn only lanes at intersections		
Right-turn only lanes at intersections		
Sidewalks		
Trees		
Rate of traffic flow (smoothness, pace, continuity, etc.)		
Traffic volume (amount of traffic on roadway)		
Overall travel time to destination		
Consistency/reliability of travel time to destination		
Spacing of moving vehicles (density of traffic)		
Roadway width (overall roadway width)		
Two-way center left-turn lane		
Pavement quality		
Frequency of unsignalized cross-streets and driveway entrances		
Aggressive drivers		
Consistency of speed		
Interaction between vehicles		
Number of lanes on roadway		
Speed limit		
Ability to maneuver vehicle (change lanes, merge into traffic, etc.)		
Frequency of merging traffic		
Pedestrians or bicyclists		
Truck and/or bus traffic		
Other (please write in):_________________________		

2. Using the definition of an Urban Street given on the first page of this survey, please list the traffic and roadway conditions that together comprise your "ideal" urban street.

1)____

2)____

3)____

4)____

3. Using the definition of an Urban Street given on the first page of this survey, please list the traffic and roadway conditions that together comprise your "least favorite" urban street.

1)____

2)____

3)____

4)____

APPENDIX D: POST-DRIVE SURVEY: GENERAL QUESTIONS

1. What are some concerns that you have regarding the roads on which you travel?

2. Are you satisfied with the roads in your area?

Why or why not?

3. How do the traffic conditions and the roads affect your quality of life?

4. If you could make changes to the roads or to traffic conditions, what would you do?

APPENDIX E: DRIVERS' RESPONSES TO GENERAL SURVEY QUESTIONS

Table E-1: Drivers' Concerns Regarding the Roads on Which They Travel

Drivers' Concerns Regarding Roads on Which They Travel
Other drivers
Aggressive drivers affect safety; Merging areas on highways where accidents commonly occur; Too many things at once; Seems like more hwy accidents than in other regions.
Roughness - holes & concrete drippings; Left-turn lights
Emphasize maintenance of roads & urban street - free as possible from potholes and other obstructions
Lack of sidewalks on main roads; Disjointed acceleration/deceleration lanes in new developments; Drivers ignoring traffic laws/lights.
Other drivers, more than roadway; Advanced notification of road situations, disappearing lanes, etc.
Safety at intersection (red light running); Difficulty turning onto main roads from businesses; Lanes too narrow.
Inattention of drivers; Poor signalization of t??; Frequent changes in lanes.
If I don't leave early enough for commute to work, I get trapped in traffic.
Lights not timed correctly; Congestion.
Drivers
Potholes Prefer divided boulevards
Visibility; Potholes; Construction signage; Left-turn signals.
Physical condition of roads; Roads should give as much info as possible.
Quality of pavement, lane widths, aggressive drivers, people passing on right, slow traffic not moving right.
Time to destination and maneuverability in traffic; Signage (for lanes, lane changes, turning lanes); Road condition (broken pavement, narrow lanes).
Capacity [ability to move traffic], Roadway conditions, pavement surface
All of the street signs were small and placed at the intersection, therefore, unless you know the streets you miss your turn.
See above ("least favorite" urban street)
1) potholes 2) 4-way stop signs because they are inefficient and other drivers sometime don't stop 3) children on bikes, skateboards, scooters, etc that can run into the road
Too many homes and businesses being built. Not enough streets/main arterials to accommodate traffic.
Poor drivers (careless drivers), poorly marked intersections, overcrowded roads during non-rush hours.

Table E-2: Drivers' Responses to "Are you Satisfied with the roads in your area?" and "Why or why not?"

Satisfied with roads?	Why or why not?
Yes	The ones with tress are pleasant to drive on and traffic mostly moves smoothly
Yes	Like wide lanes, pavement condition, flows OK after rush hour, signage is good
Yes	Overall satisfied with physical road conditions, but too congested during peak times.
Yes	Most in the area are well-maintained (i.e., surface is maintained, no potholes) and are well-marked (ie, lane divisions, stop bars)
Yes	However, I foresee big problems because of the amount of construction in the area.
Yes	The actual quality of the physical roads in Sacramento is good. Drivers in Sacramento seem to be overly distracted, and there are far too many cars on the roads.
Yes	
Overall yes	Due to growth and sewer replacement, there are a lot of closing of traffic lanes and barriers
Not always	Roads narrow or widen when least expected.
No	Too many vehicles
No	See driver's concerns.
No	Too crowded
No	Potholes
No	More freeways are needed to get cars off the local roads
No	Lack of street signs. Narrow lanes. Winding, curving roads because it is time-consuming and it reduces ability to see signs, lights, etc.
Mostly	See driver's concerns.
Mostly	Lights need better timing
Mostly	Roads have been improved over past 2 years
Mostly	More improvements in pavements; Sensor traffic lights help improve traffic flow; more info boards are posted near congested areas
Generally	Would like more sidewalks/bike lanes; More advance notification
For the most part	They are fine except for reasons stated previously [in the "concerns" question]
Fairly	During commuter time, congestion is frustrating, but other times is fine.

Table E-3: Drivers' Responses to the Quality of Life Question

How Do Traffic Conditions and Roads Affect Quality of Life
Tends to become aggravated
Traffic constrains when & where I travel, since I avoid congested areas.
Very little.
Can be challenging to get safely to work and other destinations.
Adds a level of stress, but can also be pleasurable.
Arranges commute to avoid peak conditions; Can create great tension or develop coping skills;
Reduces stress when traffic flows well and street has more trees than businesses.
Starts day well or badly depending on traffic during commute.
They require more travel time when roads are congested and result in less time for other things; Ill maintained roads cause more repair and expense.
Able to get to destination safely in timely manner
I plan accordingly
Not too much; like to have less traffic.
Affects my moods and stress level.
The better traffic flow and roads, the less stressed I have to be about my commute.
Make me later; Bad drivers make me more nervous; Dense driving makes me nervous and more cautious.
Affect my decisions about whether to drive; Quality of roads & signage has a significant effect on my stress level while driving.
Not to a great extent. [I am] retired and plan travel during non-peak times.
I know that I need to leave earlier if I am going to certain parts of town. Because congestion on freeways is high, then accidents can occur and create more congestion.
Yes, they can lead to delay, being late, or making you leave early.
No
Adds stress. At times, I won't leave the house in order not to have to deal with the traffic during certain periods of the day.
Since the roads are crowded, I try to stay off them as much as possible. That simplified my life and does not harm the quality of my life

Table E-4: What Changes Would You Make to Roads or Traffic Conditions?

What Changes Would You Make to Roads or Traffic Conditions?
Ban SUVs (until they conform to pollution restrictions for cars); Test older drivers regularly; Computerize traffic lights so travel is possible at the speed limit.
Fewer cars; Prompt repair of potholes/problems in pavement; More trees/greenway on side of road in business areas (not too close to roadway).
More thoughtful drivers - safer; Smoother streets.
Better maintained city streets with fewer potholes & steel plates
All previously mentioned.
Make mass transit more practical, in turn reduce traffic volume and improve predictability.
Add more trees and widen the lanes.
Re-plan lights & lanes; Police poor drivers much more closely; Do away with one-way pairs; Have planners drive routes and make changes if necessary.
Make some roads one way during peak hours, especially if purchase of ROW for widening was cost prohibitive.
Quicker light times, timed better.
Educate drivers; Repeal stupid speed limits - ineffective traffic
Be stricter with drunk drivers; Do more strenuous traffic enforcement in general.
Lanes clearly marked; More restrictions for cabs & buses; More turn signals for turning lanes.
More street name signs in the middle of intersections; Less median construction; More turn signs especially for left turns; More info about everything incl. traffic coming up.
Add sensors to all traffic lights
Increase pavement markings for merging & turn lanes so drivers can anticipate necessary lane changes; Reduce # of cars on road during peak times.
Improve current roads - utilize existing right-of-way for more lanes, turn cuts, etc. Use signal technology to improve traffic flow. Budget for periodic road maintenance and stick to the schedule/plan, coordinate with utilities.
Widen roads, put more center aisles like on Watt and La Riviera, make bigger street signs and before the intersection.
Add another lane where necessary.
Don't know
Increase commuter rails. Add underground/BART/subway systems.
I would take cars off the road and put more drivers in public transportation. I would make sure all intersections are clearly marked in adequate time to change lanes.