Final Research Report
Research Project T1803, Task 32
Access Management

ECONOMIC IMPACTS OF ACCESS MANAGEMENT

by

Patrick Vu
Cambridge Systematics, Inc.
150 Cambridge Park Drive, Suite 4000
Cambridge, Massachusetts 02140

Venky Shankar
Associate Professor

Songrit Chayanan
Research Assistant

Department of Civil & Environmental Engineering
University of Washington, Box 352700
Seattle, Washington 98195

Washington State Transportation Center
University of Washington, Box 354802
1107 NE 45th Street, Suite 502
Seattle, Washington 98105

Washington State Department of Transportation
Technical Monitor
John Milton
Assistant State Design Engineer, Northwest Region

Prepared for

Washington State Transportation Commission
Department of Transportation
and in cooperation with
U.S. Department of Transportation
Federal Highway Administration

December 2002

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
WA-RD 554.1		

4. TITLE AND SUBTITLE	5. REPORT DATE
ECONOMIC IMPACTS OF ACCESS MANAGEMENT	December 2002
	6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Patrick Vu, Venky Shankar, Songrit Chayanan	

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. WORK UNIT NO.
Washington State Transportation Center (TRAC) University of Washington, Box 354802 University District Building; 1107 NE 45th Street, Suite 535 Seattle, Washington 98105-4631	11. CONTRACT OR GRANT NO. Agreement T1803, Task 32

12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Research Office Washington State Department of Transportation Transportation Building, MS 47370 Olympia, Washington 98504-7370 James Toohey, Project Manager, 360-407-0885	Final Research Report 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

Access management has been widely defined as the planning, design, and implementation of land-use and transportation strategies that control the flow of traffic between roads and surrounding land. Management and control of vehicular, pedestrian, bicycle, air, and sea traffic occurs through various forms of access, including traffic signals, turning lanes and restrictions, driveway spacing management, intelligent transportation systems, gating and hubbing schemes, and port terminal management. The engineering of transportation systems thus involves access management as a critical negotiations tool. Previous studies on access management have focused mainly on the positive benefits of access management relating to reductions in accident counts and severities, and improvement in traffic flow. However, the evolution of transportation systems design is also influenced greatly by the perceptions of system users, and to date, research on perceptions of access has been limited. User perceptions of access affect business vitality as well as residential quality of life. This study addressed the perceived economic impacts that access management has specifically on businesses.

This study collected 280 surveys from businesses along six major commercial corridors in Western Washington, as well as business-related data from geographic information systems. The researchers then focused on statistical frameworks for analyzing perceived economic impacts. Perceived economic impact due to access management was first assumed and then later proven to correlate implicitly and explicitly to perception of accessibility for any given business. Model estimation was conducted by using joint density models to capture the perceptual inter-relationships between business accessibility and patronage. Factors found to be statistically significant included business type, business operational variables, corridor and street environment variables, and willingness-to-pay amounts. The identification of significant business factors offers insights into how businesses view access management. In the dialogue on design requirements between public development review units and private land developers, such information can provide a successful and efficient negotiations tool.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
Access management, land use, economic impacts	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None		

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Washington State Transportation Commission, Department of Transportation, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

TABLE OF CONTENTS

LIST OF FIGURES

Figure *Page*

LIST OF TABLES

Table *Page*

LIST OF ABBREVIATIONS

WSDOT – Washington State Department of Transportation

WTP – Willingness-to-pay

ADT – Average daily traffic

GIS - Geographic information systems

TRIPS – Transportation Information Planning Support

TWTL – Two-way turn lane

SR – State Route

BFGS - Broyden-Fletcher-Goldfarb-Shanno

BHHH - Berndt-Hall-Hall-Hausman

RIRO – Right-in/right-out

LOD – Level of development

EXECUTIVE SUMMARY

Access management has been widely defined as the planning, design and implementation of land use and transportation strategies that control the flow of traffic between roads and surrounding land. Management and control of vehicular, pedestrian, bicycle, air and sea traffic occurs through various forms of access, including traffic signals, turning lanes and restrictions, driveway spacing management, intelligent transportation systems, gating and hubbing schemes, and port terminal management. The engineering of transportation systems hence involves access management as a critical negotiations tool.

Previous studies on access management have focused mainly on the positive benefits of access management relating to reduction in accident counts and severities, and improvement in traffic flow. However, the evolution of transportation systems design is also influenced greatly by the perceptions of system users, and to date, research on the perceptions of access has been limited.

User perceptions of access affect business vitality as well as residential quality of life. To ensure optimal design, a necessary step in the design development process involves a well-thought out array of negotiable factors based on a sound understanding of issues important to businesses, residences, and users of the transportation system. This study addressed the perceived economic impacts that access management has specifically on businesses. In a large systems context, factors found to be relevant in this study would be significantly interconnected with the residential and user components.

The first portion of this study focused on gathering relevant data about contributory factors. Over 1,900 surveys were hand distributed to collect information on

characteristics of individual businesses. In addition, business-related data from geographic information systems (GIS) were compiled and collated with individual business respondees. Approximately 280 businesses along six major commercial corridors in Western Washington provided detailed responses about their business, perceptions of the impacts of access management on their patronage, and perceptions of traffic safety and congestion in their corridors.

The second portion of this study focused on statistical frameworks for analyzing perceived economic impacts. Perceived economic impact due to access management was first assumed and then later proven to correlate implicitly and explicitly to perception of accessibility for any given business. Model estimation was conducted by using joint density models to capture the perceived inter-relationships between business accessibility and patronage. Bivariate probit and simultaneous logit models were used. The former allows for implicit correlation through joint density of the unobserved effects. The latter formulation allows for explicit formulation through an endogenous relationship. Factors found to be statistically significant included business type, business operational variables, corridor and street environment variables, and willingness-to-pay (WTP) amounts.

The identification of significant business factors offers insights into how businesses view access management. In the dialogue on design requirements between public development review units and private land developers, such information can provide a purposeful, and potentially successful and efficient, negotiations tool.

INTRODUCTION

Access management has been widely defined as the planning, design and implementation of land use and transportation strategies that control the flow of traffic between roads and surrounding land (1). The intent of managing access is to allow reasonable access from roadways to adjacent properties, yet still maintain traffic flow, capacity, and an acceptable level of safety (2). Generally, access management plans include combinations of roadway engineering and land-use planning. Roadway design involves driveway geometry and spacing, median treatments and turn lanes, traffic signals, and other connecting roadways. The land-use components of access management include appropriate land-use regulations, development standards, and development incentives (3).

Since 1991, the State of Washington has had a comprehensive statewide access management law, Revised Code of Washington (RCW) 47.50 (3). This law requires the Washington State Department of Transportation (WSDOT) to create an access permitting process and a roadway classification system (3). The roadway classification system consists of five categories based on roadway speeds, shown in Table 1. With higher roadway speeds, the classification system requires more restrictive roadway access in terms of allowable driveway spacing densities. A combination of the roadway speed category with a connection category (Table 2), which classifies the level of traffic for a particular access road or driveway, provides the information on which a review agency can base a decision to grant access. The access permitting process provides the means for the state and local agencies to achieve efficient and safe driveway spacing and design.

Table 1. WSDOT access classifications for roadways.

Class	**Speed Limits MPH**	***PLANNED* distances between driveways (PRIVATE) or intersections (PUBLIC)**	***PERMITTED* Distance**	**Non-conforming**
Class One	50 to 60	Private: None. Public: 1 mile.	Private: upgrades to preexisting or 1320 feet when there is no alternative. Public: 0.5 miles only when there is no alternative access.	Private: only when there is no alternative access. Public: less than 0.5 mile only when there is no alternative access.
Class Two	Urban: 35 to 60 Rural: 45 to 60	Private: None. Public: 0.5 mile.	Private: upgrade to preexisting or permitted when there is no alternative, at 660 feet intervals. Public: less than 0.5 MILE (800M) when there is no alternative access.	Private: when access to a local street would cause operational or safety concerns or there is no alternative option. Public: between 0.5 mile and 660 feet (intervals.
Class Three	Urban: 30 to 40 Rural: 45 to 60	Private and Public 0.5 mile.	Private: upgrade to preexisting, no more than one to a parcel under one ownership, or permitted when there is no alternative, 330 feet intervals. Public: less than 0.5 MILE when there is no alternative access.	Private and Public: when additional access connections would not adversely affect the safety and operation of the state highway or there is no alternative options.
Class Four	Urban: 30 to 35 Rural: 35 to 45	Private and Public: 0.5 mile.	Private: 250 feet when no alternative options is available Public: 250 feet when no alternative options is available--probably will need to be signalized.	Private: when no alternative option is available. Public: may require a licensed engineering analysis and signalization.
Class Five	25 to 35	Private: 125 feet. Public: 0.25 mile.	Private: 125 feet or one per ownership. Public: 125 feet when no alternative options is available--probably will need to be signalized.	Private: 125 feet or one per ownership. Public: 125 feet when no alternative options is available--probably will need to be signalized

*Source: http://www.wsdot.wa.gov/regions/northcentral/planning/ncr_suterf_101.html

Table 2. WSDOT categories for roadway connectors.

Category I (Minimum Connection)	Field (Agricultural forest lands, utility operations an maintenance. For each residential dwelling unit (up to 10 units) utilizing a single connection point. Other, with less than 100 AWDVTE* or less.
Category II (Minor Connection)**	Less than 1,000 AWDVTE. 1,000 to 1,500 AWDVTE.
Category III (Major Connection)**	1,500 to 2.500 AWDVTE Over 2,500 AWDVTE.
Category IV	Temporary Connections.
*Average Week Day Vehicle Trip Ends. (One way trips, from one location to another.)	
**Require a traffic analysis, signed by a professional engineer, licensed in accordance with RCW 18.43.	

*Source: http://www.wsdot.wa.gov/regions/northcentral/planning/ncr_suterf_101.html

The permitting process also allows the state to collect fees for providing access or to compensate businesses for loss of access.

During the planning and permitting process, public involvement is crucial for success. Public involvement may entail educating the public on access management, seeking public input, and responding to concerns. Effective involvement of stakeholders has been shown to reduce project delays, reduce litigation, provide better solutions, and increase public acceptance (4).

It is especially important for business owners to be engaged in the process. Their economic well-being and vitality are directly affected by their access to customers. Any plan or discussion of modifying or limiting access will certainly elicit strong responses from the business community. Therefore, to better anticipate responses to access modifications or plans, understanding businesses' perceptions of access management is vital.

Perception of access management varies according to a business's characteristics and experience with access. Different business types, such as a retail service stores,

convenience stores, and restaurants, may perceive access management differently. In addition, views of access management may be shaped by business operational characteristics, such as days of operation, number of employees, and advertising methodologies. Also influential are the characteristics of the roads surrounding the businesses, for instance the level of roadway congestion and number of driveways. As important to understanding business attitudes toward access management are businesses' access experiences. Conceivably, if a business already had unlimited roadway access, it would find any access management restriction to be detrimental, whereas a business with highly restrictive access might be used to the idea of restricting access. By accounting for business attributes and experience, the perceptions of the impacts of access management can be better discerned.

The intent of this study was to understand businesses' perceptions of access management. The first portion of this study focused on gathering relevant data concerning business perceptions and characteristics. The methods of data collection involved hand distributing a survey and augmenting the results with data from geographic information systems (GIS) databases. The second portion of this study investigated statistical frameworks for analyzing businesses' perceptions of access management in relation to business characteristics and experience with access. A goal of this study was to improve the efficiency and efficacy of the access management process by understanding businesses' points of view.

PREVIOUS RESEARCH

Historically, access management has dealt with traffic delay and safety concerns. Past studies have shown the benefits of access management to include the following (1, 3, 5, 6, 7):

1. improvement of safety by reducing conflicting traffic movements along roadways and preserving traffic flow
2. reduction in traffic congestion by increasing roadway capacity and thus also reducing the need for costly road widening
3. reduction in travel times and associated decreases in energy consumption and air pollution
4. promotion of more desirable land use patterns conducive to alternative transportation modes such as walking, bicycling, and transit
5. provision of safer access points for adjacent property owners and businesses .

Given these findings, many state, regional, and local agencies have adopted laws and regulations on access management.

Recently, attention has shifted toward the economic impacts of access management on businesses (8). A study conducted by Levinson and Gluck (9) focused on the economic impacts of medians and presented a methodology for quantifying these impacts. Levinson and Gluck, building on previous research, suggested that economic impacts be calculated by numbers of left turns denied in proportion to the percentage of pass-by trips a particular business depends upon. By summing the impacts on individual businesses, an overall economic impact can be assessed for a roadway corridor. This

methodology for assessing impacts is directly observable. In contrast, in a different study by Eisele and Frawley (10), impact assessment relied on a survey to ascertain businesses' and customers' perceptions of economic impacts. The surveys illustrate the varying perceptions of impacts before and after implementation of center medians. However, much work remains to be done to understand the ramifications of access treatments on business vitality.

Studies of the economic impacts of access management on businesses have been limited in several ways. First, they have focused on corridors in which raised medians have been installed, but other access control types, such as two-way turn lanes (TWTL), turn refuge pockets, and traffic signals have not been included. Second, business characteristics and existing access conditions have not been controlled for when impacts have been calculated. More statistically rigorous models, such as the bivariate probit and simultaneous logit, can better explain implicit and explicit relationships between how businesses view impacts due to access and experiences businesses have had with access (11).

Furthermore, economic theory suggests that willingness-to-pay (WTP) should be considered when relative economic impacts are analyzed (12). WTP theory is relevant because if businesses are given choices for alternative access control types, they may be willing to pay differing amounts for each type. For instance, a business that currently has poor access may be willing to pay to relocate for better access, while another business may find relocating cost prohibitive. Therefore, these two businesses would potentially differ on their assessment of the impact that access management had on them. In the larger context, given unique business profiles, WTP thresholds will vary in relationship

to perceived economic impacts. Therefore, the intention of this study was to build upon previous research and address the above-mentioned concerns.

SURVEY DESIGN AND GIS DATA

The six corridors chosen for the study were all in King County, Washington, and had a mixture of land uses. A majority of the corridors had land use designated for commercial development, such as strip retail development and shopping malls. One corridor, however, had a segment designated for industrial land use with warehouses and manufacturing facilities. These corridors were all designated as "urban principal arterial" by WSDOT and had access classifications of 3 and/or 4 (see Table 1 for definition). Access management treatments ranged from no access control to fully controlled, with right-in, right-out, and consolidated driveways. Table 3 summarizes the characteristics of the six corridors, including length, number of businesses, average daily traffic (ADT), functional class, and access classification.

To assess the business impacts of access management, a survey was designed to collect information from individual businesses. Surveys were only given to businesses with frontage access along the six state routes (SR). Those totalled 1,900 businesses. The 25-question surveys were printed on colored paper specific for each business corridor and were hand distributed in April and May 2001. Survey respondents had written instructions to return by mail the pre-paid postage surveys within a one-month period.

The questions in the distributed survey captured various business characteristic (see Appendix). These characteristics included existing access management conditions (e.g., current access type, number of driveways), preferences for access management (e.g., would like traffic signals, center median), business operations characteristics (e.g., days of operation, number of customers, revenue), business types (e.g., retail goods, retail

Table 3. Characteristics of the six corridors used in the study.

Corridor Name	*Number of Businesses*	*MP Start*	*MP End*	*Length (Miles)*	*ADT*	*Access Classification*	*Functional Class*	*Speed Limit (MPH)*	*Land Use*	*Surveys Returned (#)*	*Returned (%)*
SR 99 S. Pacific HGWY	100	6.15	21.51	15.36	9693 to 17264	4	Urban Principal Arterial	40 to 50	Commercial Development	10	10.0%
SR 99 N. Aurora	125	34.73	43.48	8.75	16192 to 21513	3 and 4	Urban Principal Arterial	30 to 40	Commercial Development	14	11.2%
SR167 Renton	33	26.47	27.27	0.8	18187	4	Urban Principal Arterial	45	Commercial Development	6	18.2%
SR181 East Valley HGHY	400	5.32	11.37	6.05	16036	3	Urban Principal Arterial	35 to 50	Commercial Development, Industrial Manufacturing	71	17.8%
SR 522 Lake City Way	500	0.52	10.59	10.07	30000 to 57000	4	Urban Principal Arterial	30 to 45	Commercial Development	87	17.4%
SR 908 Kirkland-Redmond	750	3.63	6.66	3.03	17656	3 and 4	Urban Principal Arterial	35 to 40	Commercial Development	95	12.7%

service, restaurants), street environment (e.g., congestion level), and attitude of respondent (e.g., state of the economy).

Additional data were also gathered from the King County tax assessor's office and WSDOT. Information about properties, such as land values and property square footage, along the six corridors was collected by using the geographic information system (GIS) database provided by King County. Corridor roadway information was obtained from WSDOT's Transportation Information Planning Support (TRIPS) database. Information obtained from the database included numbers of intersections, lengths of transit lanes, lengths of two-way turn lanes (TWLT), and roadway geometric information.

STATISTICAL FRAMEWORK FOR ANALYZING PERCEPTIONS

To construct explanatory models that provide insights into the factors that contribute to business perceptions of access management, several methodological issues must be addressed: a) correlation between access management and patronage impact perceptions, b) simultaneity in the relationship between patronage impact perceptions and accessibility perceptions, and importantly, c) the relevance of model structures to the roadway design process.

A key contributor to the efficiency of the design process is the negotiation stage in development review. Perceptions of accessibility and patronage impact are the two key ingredients to the negotiation process. Accessibility is a measure of the ease of entry into and exit from the business, and hence largely governed by available roadway capacity and safety. Patronage impact could include impact on the number of customers using the business or the impact on business revenue. In constructing models, this study assumed that by measuring perceptions on patronage impact and accessibility, insight can be gained into "how a business would perceive impacts" during the negotiation process.

Correlation between accessibility and perceptions on patronage impact could occur in two plausible ways, as implicit or explicit relationships. Since correlation has not been previously explored, no theoretical basis exists to dictate which approach is more desirable than the other. Therefore, this study modeled both implicit and explicit relationships in joint likelihood models. The next two sections explain further the appeals of the two approaches.

Bivariate Probit Model

The first modeling approach follows a process induced by unobserved factors. Factors that critically affect perceptions on patronage impact and accessibility can be broadly classified into five types: business use, business operation, access management and street environment, and business corridor characteristics. Customer related characteristics such as awareness of access control functionalities, and business characteristics such as awareness of access management practices are dominant unobserved effects that could induce causality. The causality is induced because these unobserved effects are shared between perceptions of patronage impact and accessibility. Since perceptions of patronage impact and perceptions of accessibility are inter-related implicitly, the methodological framework could follow a bivariate probit rule as follows.

Let $Y_1 = 1$; if $Y^* > 0$, and let $Z_1 = 1$; if $Z^* > 0$, where Y^* and Z^* are latent (unobserved) variables related to patronage impact and accessibility, respectively; and Y_1 and Z_1 are observed binary variables related to perceptions on patronage impact and accessibility, respectively. To be specific, $Y_1 = 1$ implies that the observed perception of patronage impact is "no impact," "minor positive impact," or "major positive impact," while $Y_1 = 0$ stands for observed perception of "minor negative impact" or "major negative impact." The binary variable Z_1 stands for observed perception of accessibility of "minor concern" or "major concern," while $Z_1 = 0$ stands for "no concern."

The general model specification is then:

$$Y^* = \beta X + \varepsilon$$

$$Z^* = \theta W + \xi$$

where X and W are sets of observed variables relating to business use, business

operation, access management and street environment, and where β and θ are estimable vectors of coefficients. The random error terms ε and ξ are normally distributed such that E(ε) = 0 and E(ξ) = 0, with variances equal to unity and covariance equal to ρ. The covariance term is a measure of the shared unobservables between the probit equation for patronage perception, Y^*, and the probit equation for accessibility, Z^*. Since we were interested in an explanatory model that would allow us to predict the probability of Y_1 and probability of Z_1, conditioned on a set of business use, business operation, and access management and street environment variables, it was important to account for the effect of the shared unobservables on the probabilities of Y_1 and Z_1. To this end, a joint density function was based on the normal distribution with parameters ε and ξ, such that

$$\phi(\varepsilon, \xi) = \frac{1}{2\pi\sigma_\varepsilon\sigma_\xi\sqrt{1-\rho^2}} \exp\left[-\frac{1}{2}\left(\frac{\varepsilon^2 + \xi^2 - 2\rho\varepsilon\xi}{1-\rho^2}\right)\right]$$

This density function could then be used to construct a bivariate normal cumulative distribution function that could be evaluated by the method of simulated probabilities. In this study, the Broyden-Fletcher-Goldfarb-Shanno (BFGS) simulator was used with 100 replications to approximate the joint probability of Y_1 and Z_1.

Simultaneous Logit Model

An alternative causal relationship explicitly links accessibility with patronage impact. Logically, if a business perceived itself more accessible, then it would consider itself more exposed to customers, whereas a less accessible business would have a smaller customer base. It is equally conceivable that a business can have a preconceived

notion of its customer base and from there conclude its relative accessibility to customesr. For any particular business, the causality sequence between accessibility and patronage can go in either direction and may in fact dynamically vacillate. Therefore, the causal relationship could be explicitly formulated through an endogenous relationship between accessibility and perceived impacts. The simultaneous logit model would be the preferred method to explore these behavioral linkages.

Let perceived impacts and accessibility be represented again by the variables Y_1 and Z_1, where the causality is explicit between accessibility and perceived impacts. $Y_1 = 1$ implies that the observed perception of patronage impact is "no impact," "minor positive impact," or "major positive impact," while $Y_1 = 0$ stands for observed perception of "minor negative impact" or "major negative impact." The binary variable Z_1 stands for an observed perception of accessibility of "minor concern" or "major concern," while $Z_1 = 0$ stands for "no concern." The simultaneous logit specifications is then:

$$\log\left[\frac{P(Y=1\,|\,Z)}{P(Y=0\,|\,Z)}\right]_t = \beta R_t + \alpha Z_t$$

$$\log\left[\frac{P(Z=1\,|\,Y)}{P(Z=0\,|\,Y)}\right]_t = \gamma Q_t + \alpha Y_t$$

where R_t and Q_t are vectors of exogenous variables that affect the values of Y_1 and Z_1, respectively, and β and γ are their estimable vectors of coefficients.

Model estimation proceeds with calculating the probabilities of the various possible occurrences of each outcome. According to the above specification, the

probabilities are as follows:

$$P_{00t} = P(Z_t = 0, Y_t = 0) = 1/\Delta_t$$
$$P_{01t} = P(Z_t = 0, Y_t = 1) = \exp(Q_t\gamma)/\Delta_t$$
$$P_{10t} = P(Z_t = 1, Y_t = 0) = \exp(R_t\beta)/\Delta_t$$
$$P_{11t} = P(Z_t = 1, Y_t = 1) = \exp(R_t\beta + Q_t\gamma + \alpha)/\Delta_t$$

where

$$\Delta_t = 1 + \exp(R_t\beta) + \exp(Q_t\gamma) + \exp(R_t\beta + Q_t\gamma + \alpha)$$
$$t = 1,2,...,T$$

Then we can construct the likelihood function as follows:

$$L = \prod_{t=1}^{T} \left(P_{00t}\right)^{(1-Z_t)(1-Y_t)} \left(P_{01t}\right)^{(1-Z_t)Y_t} \left(P_{10t}\right)^{Z_t(1-Y_t)} \left(P_{11t}\right)^{Z_tY_t} = \prod_{i=0}^{1}\prod_{j=0}^{1}\prod_{t\in\Theta_{ij}} P(Z_t = i, Y_t = j)$$

$$\ln(L) = \sum_{i=0}^{1}\sum_{j=0}^{1}\sum_{t\in\Theta_{ij}} \ln\left(P(Z_t = i, Y_t = j)\right)$$

where

$$\Theta_{ij} = \left\{t \mid Z_t = i, Y_t = j\right\}$$

To approximate the maximum likelihood, the algorithm Berndt-Hall-Hall-Hausman (BHHH) was used to estimate statistically significant factors that affect business perceptions of accessibility and patronage.

In estimating statistically significant factors while controlling for business use, operation, and street environment variables, this study hypothesized that available access (through driveway controls) could have significant marginal impacts on perceptions of patronage. In sum, the theoretical framework for assessing the relationship between access management and perceived impacts on patronage can be based on implicit or

explicit correlation. By estimating the set of business use, operation, access management, and street environment variables in the equations for Y and Z, public agencies can identify, for a given business, the likelihood of perceived impact due to access management. They can then formulate design strategies that are sensitive to business concerns, thus making the design negotiation process more efficient.

SURVEY RESULTS

The average response rate for the hand distributed survey was 14.8 percent, with 1,908 surveys distributed and 283 returned. The response rates ranged from a high of 18.2 percent for SR 167 corridor to a low of 10 percent for the SR 908 corridor. A possible explanation for the lower response rate for SR 908 may be that a second set of surveys had to be distributed. The first set of surveys was handed out at night, resulting in a zero response rate; therefore, a second set of differently marked surveys was distributed during the day to get responses. Businesses along SR 908 may have thought that the double set of surveys was not part of a legitimate research study. Response rates from the two SR 99 corridors and SR 522 were higher than from the other three corridors because of the longer corridor lengths and greater number of businesses. Table 3 shows the numbers and percentages of surveys returned.

The following sections summarize responses to key questions asked in the survey. These responses provide general insight into business attitudes about access management. The questions presented relate to business establishment types, current access control treatments, existing traffic conditions, perceived impacts, and preference for access management treatments.

Types of Business Establishment

Respondents were asked to categorize their business in terms of several choices. The following categories were chosen to reflect some assumptions of the most likely business types due to be economically impacted by access control: retail goods, retail

services, fast food, restaurant, convenience store, grocery store, and gas station. Survey respondents were allowed to check more than one category because businesses such as pawnshops sell goods and also provide a lending service.

For the study, surveys checked with the "other" category were distributed into the category most similar to that business type. For example, banks were distributed to the service category. Two new categories were also created, auto shop and industrial. The auto related business category combines gas stations and shops such as oil change shops, tire stores, and car dealerships. Industrial businesses include warehouses, distribution centers, and factories. The majority of respondents, 63 percent, qualified as retail service oriented, while 41 percent of businesses described themselves as the retail goods type. For the entire distribution of business types see Figure 1.

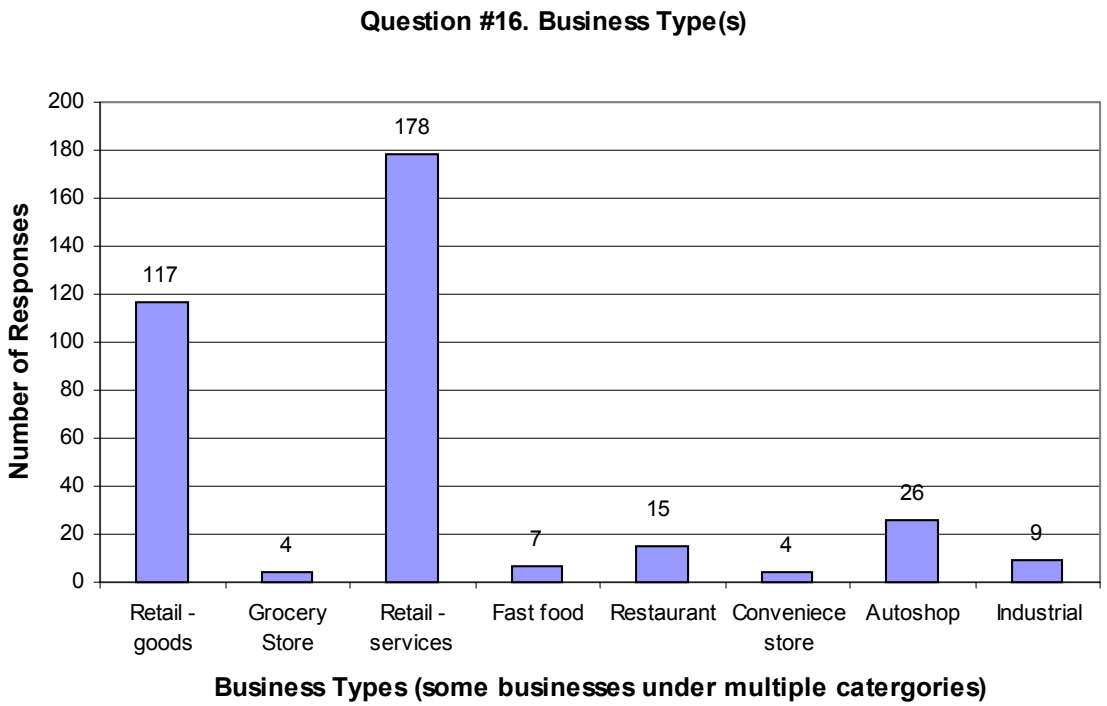


Figure 1. Business types who responded to the surveys.

Types of Current Access Control Treatment

Pictures and descriptions were provided to aid respondents in identifying their access types (see Appendix 1). Access types were no access management, two-way turn lanes (TWTL), left turn merge and turn pockets, left turn pockets only, right-in/right-out only, consolidated driveways, traffic signals, and others. Respondents were allowed to check all applicable access types, since businesses may have more than one entrance. Although the most restrictive access may not have been connected to the state route, the presence of such an access may affect views toward access management.

Figure 2 shows the distribution of access types. The most prevalent form of access treatment was TWTL, with 52 percent of businesses reporting this. Nearly 21 percent of businesses had accesses with right-in/right-out, the most restrictive access control type. Nearly 15 percent had no access management, and 13 percent had consolidated driveways. Other types of access were at less than 3 percent of businesses.

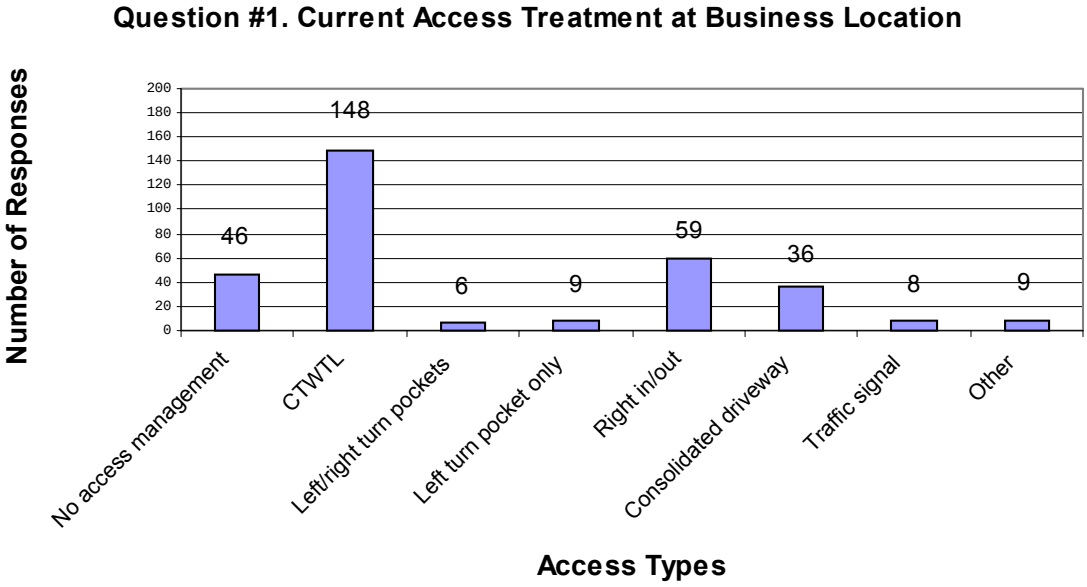


Figure 2. Current access treatment at business location.

Traffic Concerns at the Business Location and Along the Corridor

Businesses' access management-related traffic concerns included the ability of vehicles to exit the driveway, the ability of vehicles to enter the driveway, high traffic volumes, high traffic speeds, pedestrians (high pedestrian traffic, pedestrian visibility), buses (buses stopping, buses merging, bus stop locations), and others.

Respondents had the option to rate these individual choices as "not a concern," "minor concern," or a "major concern." Respondents were asked to report concerns for their business as well as the corridor (see figures 3 and 4).

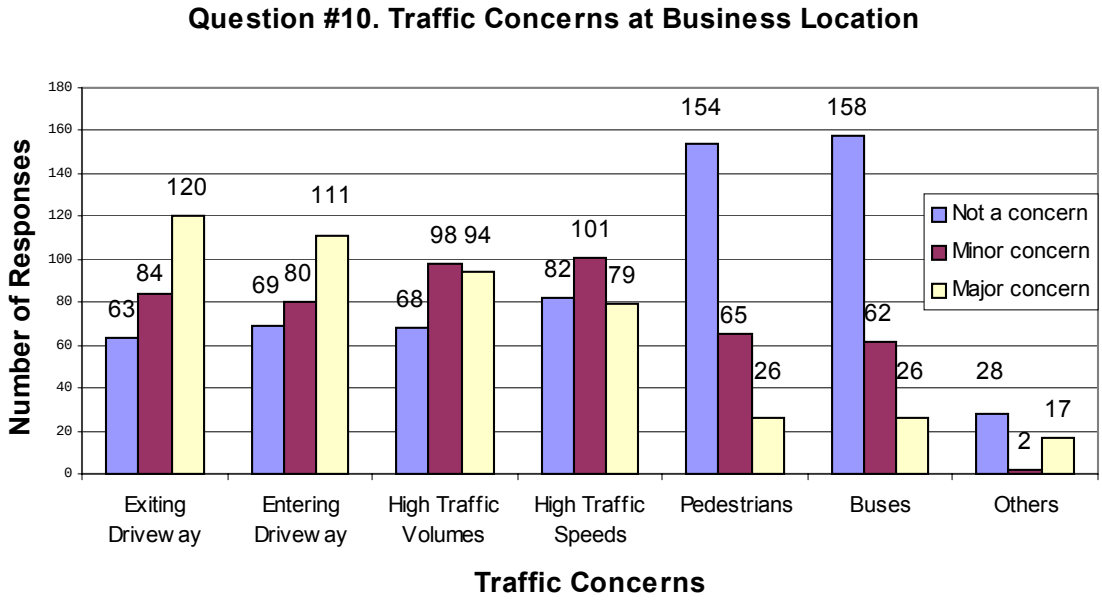


Figure 3. Traffic concern at business location.

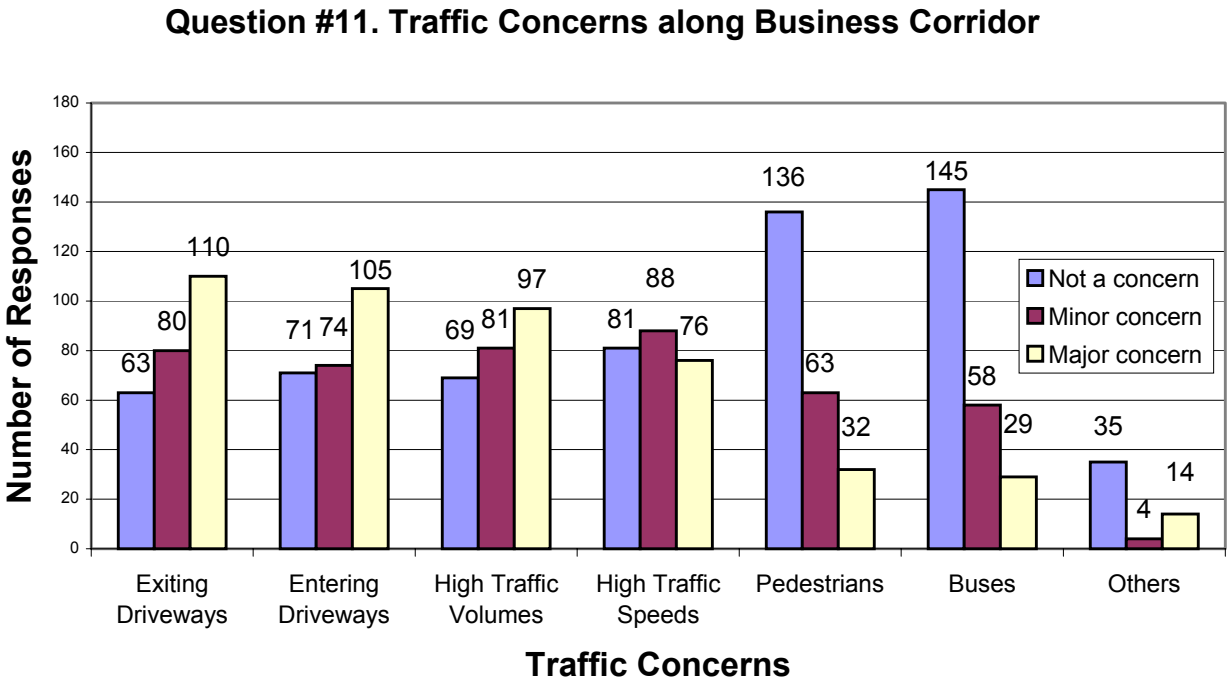


Figure 4. Traffic concerns along business corridor.

The majority of businesses had some degree of concern about the ability of vehicles to exit and enter their driveway, at 76 percent and 73 percent, respectively. Given that they had concerns, the majority of businesses indicated that exiting and entering driveways were of "major concern." High volumes and high speeds near their businesses were also concerns, with 74 percent concerned about volumes and 68 percent about speeds. However, the majority of concerned businesses only marked "minor concern." Overwhelmingly, nearly two-thirds of respondents thought pedestrian and bus issues were "not a concern" to them. Businesses may lack concern for pedestrian and transit because they may not view them as potential sources of customers.

For business corridors as a whole, the patterns of concerns were similar to those found at individual business locations. For exiting driveways, 75 percent had concerns,

and for entering driveways, 71 percent had concerns, with a majority rating these two issues as "major concerns." High volumes and high speeds along the corridor were also concerns, with 72 percent and 67 percent marking so, respectively. However, unlike the previous set of business location-specific questions, the concern over high volumes along the corridor was marked as a "major concern" by a majority of respondents. High speeds were a "minor concern" for most of those who listed it. Again, for pedestrian related issues, 58 percent thought they were "not a concern," while 60 percent of respondents felt that bus issues were "not a concern."

A comparison of responses about the business location and the whole corridor shows perceptions to be similar. This can mean that how a business views traffic concerns at its location can be used to gauge how it views conditions along its business corridor. The reverse can be as equally true: a business may view itself in the relative context of the corridor in which it is located.

Customer and Revenue Impacts of Current Access Control

A contentious argument over access management is the impact it has on patronage and revenue. The general perceived impacts on business patronage are summarized in Figure 5. The majority of businesses, 52 percent, felt that their current access management negatively affected customer patronage. Close to 31 percent indicated that access management did not affect their number of customers. Only 17 percent thought that access management had a positive impact on business patrons. Similarly, for impacts on business revenue, most businesses, 52 percent, reported negative effects due to their current access management. Thirty-three percent thought no

impact was attributable to access management, and 15 percent thought it caused a positive impact. Customer impacts seem to logically affect business revenues, as shown with the closely matching survey results in Figure 6. It is therefore plausible to assume that perception of customer impacts can be viewed as a proxy or scalar representation of business revenue impacts.

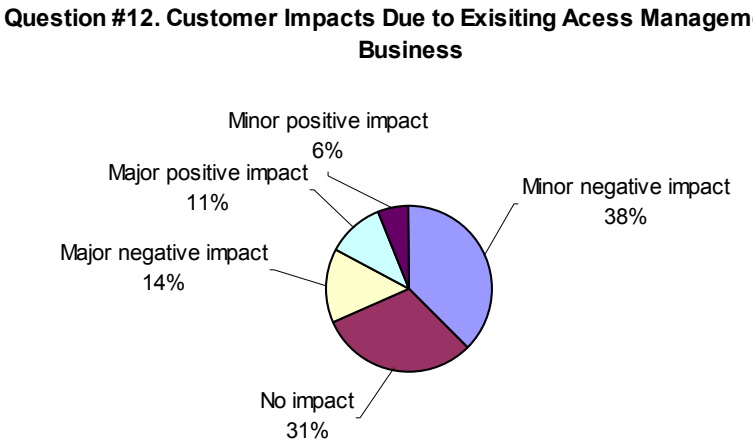


Figure 5. Perceived customer impacts due to existing access management at business.

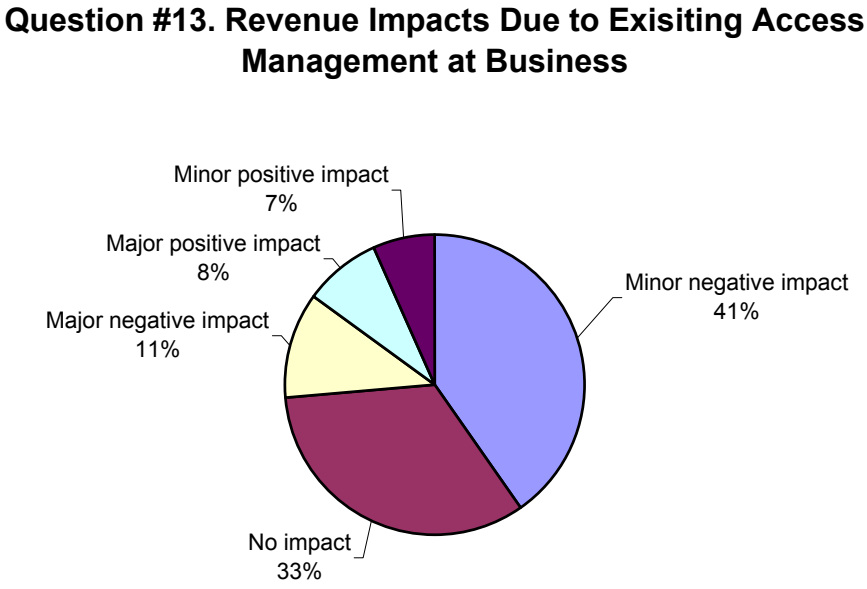


Figure 6. Perceived economic impacts due to existing access management at business.

Preferences for Access Control at the Business and Along the Corridor

Businesses were asked to indicate their preference for various access modification options for their business location and along their business corridor. With respect to their location, 63 percent of businesses were willing to have two-way turn lanes (TWTL). Nearly 26 percent supported center turn and merge pockets, while only 17 percent supported the relatively more restrictive center turn pockets, and 9 percent supported the most restrictive access option of right-in/right-out driveways. Although traffic signals may not restrict traffic movements, 78 percent rejected this modification for their business location (see Figure 7).

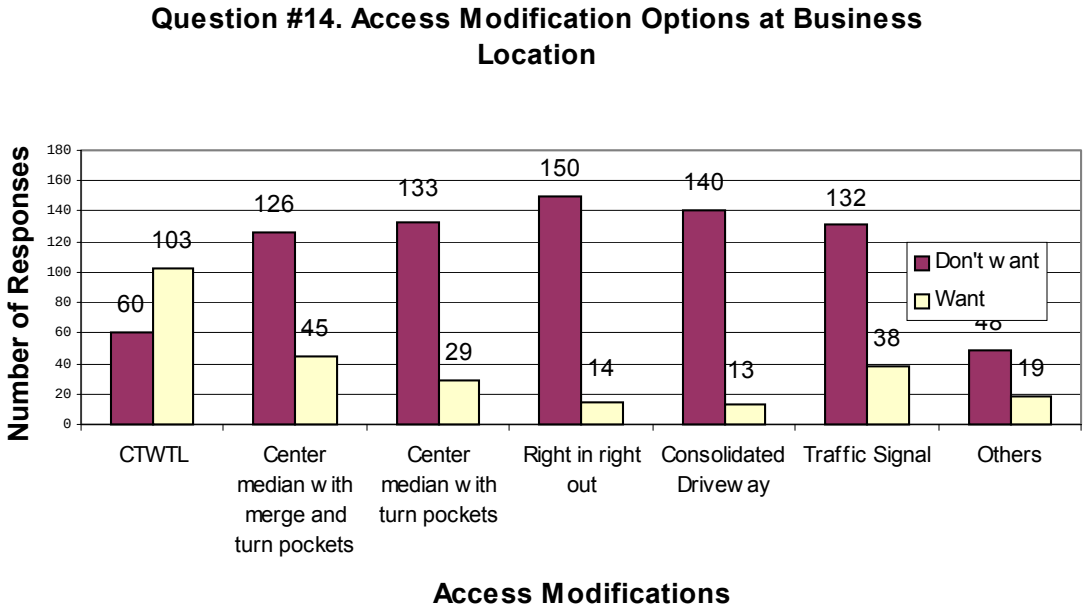


Figure 7. Preference for access management options at business location.

A similar trend was found for the corridor as a whole. Although 62 percent supported TWTL, other forms of access management were rejected more frequently as the movement restrictions increased. The less restrictive center median with turn and merge pocket had the support of 28 percent of respondents, but the most restrictive

option of right-in/right-out had support from only 10 percent of respondents (see Figure 8).

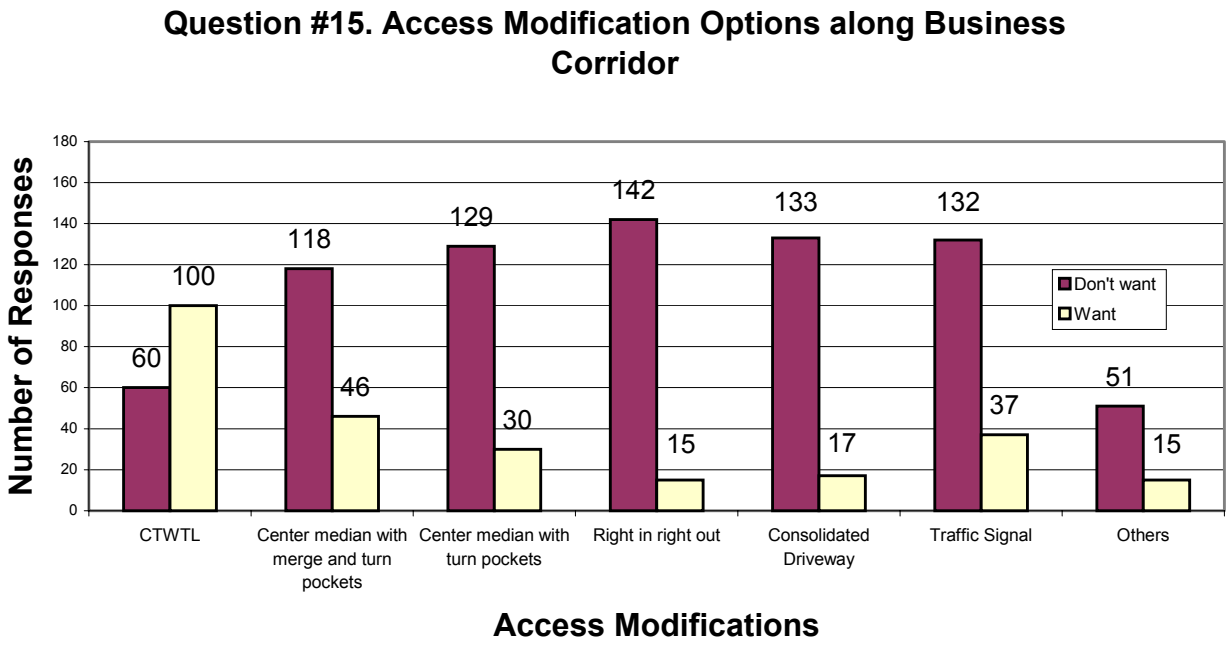


Figure 8. Preference for access management options along business corridor.

Again, as with in the traffic concerns responses, the corridor versus business-specific location questions elicited parallel responses. Businesses perceive their business location and corridor to be indistinguishable in terms of how they want them to be treated.

RESULTS OF PERCEPTION MODELS

The two bivariate probit and simultaneous logit model analyses of business perceptions assessed contributory factors related to business use, operation, access management, the street environment, and the business corridor. Table 4 shows a side-by-side comparison of the two models with variable coefficient values, sign of their effects, and their significance. The hypothesis that the joint likelihood models account for implicit or explicit correlation between perceptions of patronage impact due to access management and perceptions of business accessibility at driveways appears justifiable given the significance of the correlation coefficient (at the 99 percent level). Because both implicit and explicit models appear to successfully capture the correlation, this suggests that both approaches are equally plausible. In addition, for the bivariate probit model, chi-squared tests (significant at the 99 percent level) between the joint model likelihood and the individual probit equation likelihoods suggested rejection of the hypothesis that the joint model is statistically similar to the individual probit equations system. The same was found for the simultaneous logit, as the individual logit equations were found to be significantly different than the simultaneous model.

Comparing the two models to each other, many similarities exist between the two. Overall, the correlation between perceived patronage and accessibility for the bivariate probit and simultaneous logit models agree with each other, –0.51 and -1.27 respectively. The correlation is of the correct sign, indicating that as business perceptions of

Table 4. Side-by-side model comparisons of perceived impacts

Equations for perceptions on access management impacts on business patronage: -Observed preference rating =1 if perception includes "no impact, minor positive impact, major positive impact" -Observed Preference Rating = 0 if perception includes "minor negative impact" or "major negative impact"				
	Bivariate Probit		**Simultaneous Logit**	
Variable	Coefficient	**t-statistic**	Coefficient	**t-statistic**
Constant	0.90	3.32	0.74	0.71
Business operation variables				
Business location willingness to pay (difference in monthly payment for similar business location, continuous$)	-0.000085	-1.15	-0.00015	-1.78
Business employment level indicator (1 if the number of business employees is between 10 and 100; 0 otherwise)	-0.73	-3.50	-0.86	-2.23
Business days of operation indicator (1 if business is open 7 days a week; 0 otherwise)	-0.27	-1.59		
Business revenue indicator (1 if business revenue is under $1,000,000 annually; 0 otherwise)	-0.48	-2.59	-0.97	-2.93
Driveway use indicator (1 if business shares driveway; 0 otherwise)			0.72	2.12
Business customer base indicator (1 if business has more than 250 customers daily; 0 otherwise)			-0.75	-1.97
Patronage attraction method indicator (1 if business employs signs outside business; 0 otherwise)	-0.61	-2.93	-0.96	-2.76
Business use variables				
Retail-related business use indicator (1 if business use includes predominantly retail service oriented establishments; 0 otherwise)	0.26	1.52		
Retail-related business use indicator (1 if business establishment is a convenience store; 0 otherwise)			2.36	2.16
Access management and street environment variables				
Access management indicator (1 if one or more driveway is a right-in/right-out type; 0 otherwise)	-0.77	-3.56	-1.40	-3.46
Access management indicator (1 if one or more driveway is controlled by a traffic signal; 0 otherwise)			1.88	2.60
Congestion indicator (1 if corridor in the proximity of the business is perceived to be uncongested; 0 otherwise)	0.65	2.42	0.77	1.74
Business corridor specific variables				
Two way turn lane presences indicator (average length of two way turn lane per mile)			4.73	2.03
Transit lane presences indicator (average length of transit lane per mile)			-3.46	-2.44

Table 4 (cont.). Side-by-side model comparisons of perceived accessibility

Equations for perceptions on business accessibility at driveways: -Observed preference rating =1 if perception includes "minor concern or major concern" -Observed preference rating = 0 if perception includes "no concern"				
	Bivariate Probit		**Simultaneous Logit**	
Variable	Coefficient	**t-statistic**	Coefficient	**t-statistic**
Constant	1.17	2.86	2.77	4.06
Business operation variables				
Business location willingness to pay (difference in monthly payment for similar business location, continuous$)	-0.000056	-0.9	-0.00012	-1.56
Business employment level indicator (1 if the number of business employees is less than 10; 0 otherwise)	-0.54	-2.45	-0.82	-2.41
Driveway number indicator (1 if business has on-street access, or a single driveway; 0 otherwise)	0.39	2.12	0.53	1.74
Driveway use indicator (1 if business shares driveway; 0 otherwise)	0.86	3.14	1.53	3.55
Parking lot access indicator (1 if access to parking lot is from one major and minor street; 0 otherwise)	0.41	1.73		
Parking lot access indicator (1 if access to parking lot is not from any major or minor street; 0 otherwise)	-0.72	-2.34	-1.27	-2.34
Access management and street environment variables				
Congestion indicator (1 if corridor in the proximity of the business is perceived to be highly congested; 0 otherwise)	0.55	1.85	0.96	2.48
Congestion indicator (1 if corridor in the proximity of the business is perceived to be uncongested; 0 otherwise)	-0.9	-3.72	-1.21	-2.82
Business corridor specific variables				
Level of Development (Average of Cost of Building/Gross Building sqft)			-0.021	-1.93
Correlation coefficient	-0.52	-5.06	-1.27	-4.48
Log-likelihood at convergence	-283.7		-280.5	
Adjusted ρ^2	0.213		.224	
Number of observations	259		259	

accessibility at driveways shifts toward the "no concern" level, business patronage perceptions are more likely to be at the "no impact," "minor positive impact," or "major positive impact" levels. The two models also share many common variables, and of those that are common to both, all the have same signs. These common variables include business operations variables, access management indicators, and street environmental variables. The only observable difference between the two models is that the simultaneous logit model found business corridor variables to be significant, indicating that there are some underlying subtleties between explicitly and implicitly relating accessibility and perceived impacts. The following section details our findings on contributory factors.

Contributory Factor Results: Bivariate Probit Model

The bivariate probit analysis of business perceptions assessed contributory factors relating to business use, operation, access management, and the street environment. Table 5 shows variable coefficient values, sign of their effects, and their significance. All variables are of plausible sign.

Business operation variables (affecting perception of patronage impact)

In examining willingness-to-pay, the more money a business is willing to pay to relocate to a different location, the more pessimistic view it has of access management's impact on patronage. This indicates that economic thresholds exist for any particular business, and at a certain limit the loss of patronage due to access will force it to consider relocating to maintain economic viability.

Table 5. Bivariate probit estimation results for perceptions of access management impacts on patronage.

Probit equation for perceptions on access management impacts on business patronage: -Observed preference rating =1 if perception includes "no impact, minor positive impact, major positive impact" -Observed Preference Rating = 0 if perception includes "minor negative impact" or "major negative impact"			
Variable	Coefficient	t-statistic	Standard Error
Constant	0.90	3.32	0.27
Business operation variables			
Business location willingness to pay (difference in monthly payment for similar business location, continuous$)	-0.000085	-1.15	0.000074
Business employment level indicator (1 if the number of business employees is between 10 and 100; 0 otherwise)	-0.73	-3.50	0.21
Business days of operation indicator (1 if business is open 7 days a week; 0 otherwise)	-0.27	-1.59	0.17
Business revenue indicator (1 if business revenue is under $1,000,000 annually; 0 otherwise)	-0.48	-2.59	0.19
Patronage attraction method indicator (1 if business employs signs outside business; 0 otherwise)	-0.61	-2.93	0.21
Business use variables			
Retail-related business use indicator (1 if business use includes predominantly retail service oriented establishments; 0 otherwise)	0.26	1.52	0.17
Access management and street environment variables			
Access management indicator (1 if one or more driveway is a right-in/right-out type; 0 otherwise)	-0.77	-3.56	0.22
Congestion indicator (1 if corridor in the proximity of the business is perceived to be uncongested; 0 otherwise)	0.65	2.42	0.27

Table 5 (cont.). Bivariate probit estimation results for perceptions of access management impacts on patronage.

Probit equation for perceptions on business accessibility at driveways: -Observed preference rating =1 if perception includes "minor concern or major concern" -Observed preference rating = 0 if perception includes "no concern"			
Variable	Coefficient	t-statistic	Standard Error
Constant	1.17	2.86	0.41
Business operation variables			
Business location willingness to pay (difference in monthly payment for similar business location, continuous$)	-0.000056	-0.90	0.000062
Business employment level indicator (1 if the number of business employees is less than 10; 0 otherwise)	-0.54	-2.45	0.22
Driveway number indicator (1 if business has on-street access, or a single driveway; 0 otherwise)	0.39	2.12	0.18
Driveway use indicator (1 if business shares driveway; 0 otherwise)	0.86	3.14	0.27
Parking lot access indicator (1 if access to parking lot is from major and minor street; 0 otherwise)	0.41	1.73	0.24
Parking lot access indicator (1 if access to parking lot is not from any major or minor street; 0 otherwise)	-0.72	-2.34	0.31
Access management and street environment variables			
Congestion indicator (1 if corridor in the proximity of the business is perceived to be highly congested; 0 otherwise)	0.55	1.85	0.29
Congestion indicator (1 if corridor in the proximity of the business is perceived to be uncongested; 0 otherwise)	-0.90	-3.72	0.24
Business corridor specific variables			
Level of Development (Average of Cost of Building/Gross Building sqft)	-0.01	-1.76	0.0064
Correlation coefficient	-0.52	-5.06	0.10
Log-likelihood at convergence[1]	-283.70		
Adjusted ρ^2			
Number of observations	259		

[1] The chi-squared value for test of significant difference between the joint model and individual logit models is significant at 99% confidence level.

The business employment level (between 10 to 100 employees) and business revenue level (under $1 million annually) variables act as business size indicators. These variables indicate that medium size businesses perceive patronage impacts more negatively. This shows that perhaps medium-size businesses are by nature more sensitive to patronage level changes. These businesses can be near customer base thresholds, where they can either expand or not make it economically.

The business operating days and business attraction method variables capture businesses' need to be exposed to customers. If a business depends on being open all week and/or invests in an outdoor sign to attract customers, these may indicate that the business relies heavily on being seen and exposed to all potential customers, including those who happen to drive by.

Business use variables (affecting perception of patronage impact)

Businesses in retail service, such as salons, banks, and clinics, are more likely to perceive no impact, or minor or major positive patronage impacts. This may be due to the fact that these businesses already have customers willing to make a trip to them. Therefore, these businesses view access management's impact not so much as a customer base detractor, but rather as a customer base enhancer, making the driving experience to their business safer and more pleasant.

Access management and street environment variables (affecting perception of patronage impact)

When business use and business operation variables are controlled for, significant access management effects relate mainly to right-in/right-out driveway operations. Businesses that have at least one right-in/right-out driveway are more likely to perceive a minor or major negative impact on patronage. In contrast, other driveway functionalities

such as two-way turn lanes (TWTL), consolidated access, left-in/right-in/right-out, or full-movement driveways are not significant. Note that congestion effects are also controlled for. If the corridor is perceived to be uncongested, then businesses are more likely to perceive no impact, or minor or major positive impact on patronage.

Business operation variables (affecting perception of accessibility)

Although the willingness-to-pay variable was not found to be statistically significant with a t-statistic of –0.9, economic theory dictates its inclusion in the accessibility equation. The negative sign of the variable does show that a business's willingness to move to a different location does affect its view toward accessibility. The more a business is willing to pay, the more likely it is to perceive patronage impacts negatively.

The business employment variable (under 10 employees) acts as a business size indicator. Smaller businesses tend to view accessibility as not a concern. With a small business, accessibility may not be as much of a concern because only a few access options may exist for its location.

Four significant variables behave as indicators for the general physical layout of businesses. Three of these—the driveway number indicator (has on-street parking or a single driveway), driveway use indicator (shares driveway with neighbor), and parking lot access (entrance from a major street and minor street) —contribute to concerns about accessibility. These indicators may elicit concerns because they illustrate underlying problems with physical layouts of businesses. Only one physical layout variable, parking lot access not from a minor or major street, decreased the concern over accessibility. This may be because a business with such a layout does not have a driveway or parking

lot to worry about.

Access management and street environment variables (affecting perception of accessibility)

No access management variables significantly affect business perceptions of accessibility. This finding is consistent with our earlier hypothesis that while restrictiveness of access, i.e., access management, affects business patronage perceptions, accessibility, i.e., the measure of ease of entry or exit at driveways, should be unaffected by access management and more by street environment variables. Importantly, when one controls for business operation variables, as mentioned previously, congestion effects remain significant in their influence on accessibility perceptions. A highly congested roadway contributes to accessibility concerns while an uncongested road lowers concerns.

Contributory Factor Results: Simultaneous Logit Model

The simultaneous logit analysis of business perceptions assessed contributory factors relating to business use, operation, access management and the street environment. The model explicitly relates perceived patronage impacts with perceived accessibility. Table 6 shows variable coefficient values, sign of their effects and their significance. All variables are of plausible sign.

Table 6. Simultaneous logit estimation results for perceptions of access management impacts on patronage.

Simultaneous Logit equation for perceptions on access management impacts on business patronage: -Observed preference rating =1 if perception includes "no impact, minor positive impact, major positive impact" -Observed Preference Rating = 0 if perception includes "minor negative impact" or "major negative impact"			
Variable	Coefficient	t-statistic	Standard Error
Constant	0.74	0.71	1.04
Business operation variables			
Business location willingness to pay (difference in monthly payment for similar business location, continuous$)	-0.00015	-1.78	0.000083
Business employment level indicator (1 if the number of business employees is between 10 and 100; 0 otherwise)	-0.86	-2.23	0.39
Business revenue indicator (1 if business revenue is under $1,000,000 annually; 0 otherwise)	-0.97	-2.93	0.33
Driveway use indicator (1 if business shares driveway; 0 otherwise)	0.72	2.12	0.34
Business customer base indicator (1 if business has more than 250 customers daily; 0 otherwise)	-0.75	-1.97	0.38
Patronage attraction method indicator (1 if business employs signs outside business; 0 otherwise)	-0.96	-2.76	0.35
Business use variables			
Retail-related business use indicator (1 if business establishment is a convenience store; 0 otherwise)	2.36	2.16	1.09
Access management and street environment variables			
Access management indicator (1 if one or more driveway is a right-in/right-out type; 0 otherwise)	-1.40	-3.46	0.41
Access management indicator (1 if one or more driveway is controlled by a traffic signal; 0 otherwise)	1.88	2.60	0.72
Congestion indicator (1 if corridor in the proximity of the business is perceived to be uncongested; 0 otherwise)	0.77	1.74	0.44
Business corridor specific variables			
Two way turn lane presences indicator (average length of two way turn lane per mile)	4.73	2.03	2.33
Transit lane presences indicator (average length of transit lane per mile)	-3.46	-2.44	1.42

Table 6 (cont.). Simultaneous logit estimation results for perceptions of access management impacts on patronage.

Simultaneous equation for perceptions on business accessibility at driveways: -Observed preference rating =1 if perception includes "minor concern or major concern" -Observed preference rating = 0 if perception includes "no concern"			
Variable	Coefficient	t-statistic	Standard Error
Constant	2.77	4.06	0.68
Business operation variables			
Business location willingness to pay (difference in monthly payment for similar business location, continuous $)	-0.00012	-1.56	0.000075
Business employment level indicator (1 if the number of business employees is less than 10; 0 otherwise)	-0.82	-2.41	0.34
Driveway number indicator (1 if business has on-street access, or a single driveway; 0 otherwise)	0.53	1.74	0.30
Driveway use indicator (1 if business shares driveway; 0 otherwise)	1.53	3.55	0.43
Parking lot access indicator (1 if access to parking lot is not from major or minor street; 0 otherwise)	-1.27	-2.34	0.54
Access management and street environment variables			
Congestion indicator (1 if corridor in the proximity of the business is perceived to be highly congested; 0 otherwise)	0.96	2.48	0.39
Congestion indicator (1 if corridor in the proximity of the business is perceived to be congested; 0 otherwise)	-1.21	-2.82	0.43
Business corridor specific variables			
Level of Development (Average of Cost of Building/Gross Building sqft)	-0.021	-1.93	0.0011
Correlation coefficient	-1.27	-4.48	0.30
Log-likelihood at convergence[2]	-280.5		
Adjusted ρ^2			
Number of observations	259		

[2] The chi-squared value for test of significant difference between the joint model and individual logit models is significant at 99% confidence level.

Business operation variables (affecting perception of patronage impact)

The willingness-to-pay variable, as in the bivariate model, plays a significant role in influencing business perception of the effects of access on patronage. The more a particular business is willing to pay, the more it tends to view the impact on patronage negatively. Businesses have varying levels of tolerance for patronage impact, but conceivably, as economic vitality limits are surpassed, businesses may consider moving to locations with more suitable access.

The business employment level (between 10 to 100 employees) and business revenue level (under $1 million annually) variables appear in the simultaneous logit model and appear to act as business size indicators. These variables indicate that medium size businesses perceive patronage impacts more negatively.

The driveway use indicator (shares driveway with neighbor) reflects the general physical layout of businesses. If a business has a shared driveway, it views patronage impact as positive. This may be attributable to the fact that businesses that share driveways tend to be at location where access management has already been implemented. Therefore, first hand knowledge and experience with access may be influencing business views.

Two variables, business customer base (more than 250) and business attraction method (sign outside business), describe businesses' exposure to customers. Businesses with a large customer base find the impact of access on patronge to be negative. Perhaps larger sized businesses are afraid of possible access restrictions that would affect their exposure to customers. The business sign attraction variable indicates that a business has found passer-by traffic to be a large enough potential customer base to be worthy of

investment in an outdoor sign to attract them. Any limiting of access would hence be perceived as negatively affecting patronage.

Business use variables (affecting perception of patronage impact)

If a business describes itself as a convenience store, its perception of access management is positive. This may seem counter-intuitive at first; however, this indicator may have to do more with the business location than with business type. Because convenience stores rely heavily on passer-by patronage, convenience stores tend to be economically self-selective in their location. Stores located at prime spots such as intersections would prosper over time, whereas a badly located, mid-block store would find itself severely economically handicapped. These prime intersection spots also tend to benefit from more access management. Therefore, convenience stores that find themselves still in business over time would likely have a positive outlook on effects on patronage.

Access management and street environment variables (affecting perception of patronage impact)

When business use and business operation variables are controlled for, significant access management effects relate mainly to right-in/right-out driveway operations and traffic signals. Businesses perceive RIRO as the most restrictive form of access and, therefore, naturally conclude a negative patronage impact. On the other hand, a traffic signal would enhance customer access to a business, a positive impact from a business standpoint. Congestion also plays a significant role in perception of patronage impacts. Businesses perceive an uncongested roadway as having a positive impact because customers are able to access businesses more safely.

Business corridor variables (affecting perception of patronage impact)

Two variables, TWTL indicator and transit lane indicator, reflect the overall conditions of the corridors along which businesses are located. The presence of a TWTL enhances perceptions of access management as a positive modification. TWTL enables businesses to maintain full access, yet also serves the purpose of access management, enhancing turning movement safety and traffic flow. The transit lane indicator is seen as the antithesis of the TWTL indicator, having a negative impact on patronage. An explanation may be that transit lanes may be perceived as not contributing to the economic vitality of businesses, as noted earlier. The added transit lanes also add lanes that vehicles must traverse when turning in or out of businesses, increasing the risk of turning-related accidents. The combination of transit lanes being irrelevant to the business community and adding to driver discomfort creates an overall negative view of transit lanes from the standpoint of businesses.

Business operation variables (affecting perception of accessibility)

The willingness-to-pay variable was again statistically significant in the accessibility equation. The negative sign of the variable shows that a business's willingness to move to a different location does affect its view toward accessibility.

Similar to the bivariate model, the business employment variable (under 10 employees) acts as a business size indicator. Smaller businesses view accessibility as not a concern, since their size dictates the limited access options available to them.

Three significant variables behave as indicators for the general physical layout of businesses. Two of these, the driveway number indicator (has on-street parking or a single driveway) and driveway use indicator (shares driveway with neighbor), contribute

to concerns about accessibility. These indicators may capture physical layout concerns at the business location. The parking lot access (not from minor or major street) indicator contributes to decreasing concern about accessibility. Most likely this is because a business with such a layout does not have either a driveway or a parking lot.

Access management and street environment variables (affecting perception of accessibility)

No access management variables significantly affect business perceptions of accessibility. This finding is consistent with our earlier hypothesis that while restrictiveness of access, i.e., access management, affects business patronage perceptions, accessibility, i.e., the measure of ease of entry or exit at driveways, should be unaffected by access management and more by street environment variables. Importantly, when business operation variables are controlled for, as mentioned previously, congestion effects remain significant in their influence on accessibility perceptions. A highly congested roadway contributes to accessibility concerns, while an uncongested road lowered concerns.

Business corridor variables (affecting perception of accessibility)

One corridor variable, the level of development (LOD) indicator, was significant in affecting perception of accessibility. The LOD variable captures the overall corridor cost per square foot of building space. By observing the relative affluence of the corridor through LOD, the subtler corridor-level qualities can be captured. LOD can serve as a proxy to explain how much thought and design have gone into the development of the business corridor. A corridor with desirable development patterns will naturally be more in demand, and this will be reflected in the LOD.

CONCLUSIONS AND RECOMMENDATIONS

This research effort provides insight into significant factors that affect how businesses perceive the impacts of access management on patronage and accessibility. A disaggregate survey captured business characteristics and access management treatments. From the resulting body of information, behavioral models of business perceptions were constructed.

The major types of significant factors include business use, business operation, access management, street environment, and corridor variables. Both unobservable effects and direct correlation influence the relationship between perceived customer impacts due to access and perceived accessibility. The bivariate probit model captures the implicit linkage between patronage impact and accessibility through shared unobservables. The simultaneous logit model explicitly relates patronage impact and accessibility through an endogenous formulation. Results from the two models confirmed the correlation. However, without a theoretical basis as a guide, both implicit and explicit model results need to be viewed equally. The presented framework appears to be a promising tool for gaining behavioral insights into how businesses view access management.

The empirical framework was limited to six state highway corridors. For future studies, a more diverse geographic survey would be appropriate. This includes expanding surveyed areas and collecting specific business location information. Supplementing the perceived survey dataset with revenue and safety data would enable parallel and simultaneous modeling of perception with actual conditions.

REFERENCES

1. Humstone, E. and Campoli, J. Access Management: An Overview. *Planning Commissioners Journal*. Issue 29, Winter 1998.

2. Washington State Department of Transportation. US Route 12 Route Development Plan, *Olympic Region Route Development Team*. April1999, pp. 1-10.

3. Washington State Department of Transportation. Access Management Primer. *Mount Baker Area Planning Office*. World Wide Web: http://www.wsdot.wa.gov/regions/northwest/mtbaker/planning/access_management_primer.htm, 2001.

4. Access Management Awareness Program Phase II Report: Maze T. *Iowa State University, Ames, Center for Transportation Research and Education*, Ames, IA, 50011, USA; Iowa Department of Transportation, 800 Lincoln Way, Ames, IA, 50010, USA., 1997/12.

5. Minnesota Department of Transportation. Corridor Management. *MN/DOT Office of Investment Management*. World Wide Web: http://www.dot.state.mn.us/access/, 2001.

6. Washington State Department of Transportation. Access Management. *North Central Region.* World Wide Web: http://www.wsdot.wa.gov/regions/northcentral/planning/ncr_accessmanagement.htm, 2001.

7. Ivey, Harris & Walls, Inc. Corridor Land Use, Development & Driver/Business Survey Analysis, *District Wide Median Evaluation Technical Memorandum*, final report prepared for the Florida Department of Transportation, Winter Park, Florida, November 1995.

8. Economic Effects of Restricting Left Turns: NCHRP Research Results Digest. 1998/08.

9. Levinson, H. and Gluck, J. The Economic Impacts of Medians: An Empirical Approach. *4Th National Conference on Access Management*, August 13-16, 2000.

10. Eisele, W. and Frawley, W. Case Studies of Economic Impacts of Raised Medians on Adjacent Businesses: Study Methodology and Results. *4Th National Conference on Access Management*, August 13-16, 2000.

11. Schmidt, P. and Strauss, R. Estimation of Models with Jointly Dependent Qualitative Variables: A Simultaneous Logit Approach. *Econometrica*, 43, 4 (July, 1975), 745-755.

12. Giraud, K., Loomis J., Johnson, R. Internal and External Scope in Willingness-to-pay Estimates for Threatened and Endangered Wildlife. *Journal of Environmental Management*, 1999, pp 221-229.

APPENDIX

Sample Survey Distributed

University of Washington
Civil and Environmental Engineering

Access Management Questionnaire

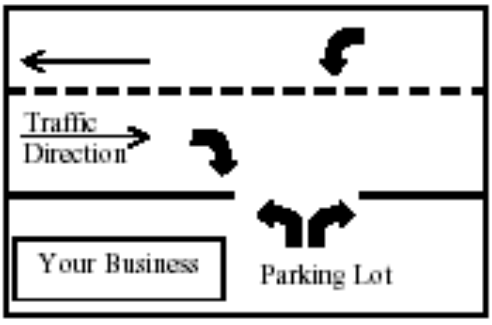
The goal of this survey is to obtain your opinion on the economic effects felt by your business from access management. Your views, experiences and valuable insights will be greatly appreciated. Survey results will help research on determining the full economic impacts of access management in the Puget Sound area. **Results from surveys will be kept strictly confidential and will be used for research purposes only.**

Please have a manager or an owner fill out the survey and return it in the mail by May 20, 2001. Simply refold and tape so the "Business Reply" address is visible and place in a mailbox. **No postage is necessary.** If you have any questions, feel free to call Patrick Vu at (206) 547-5223 or via email at vudoo@u.washington.edu. Thank you for your participation.

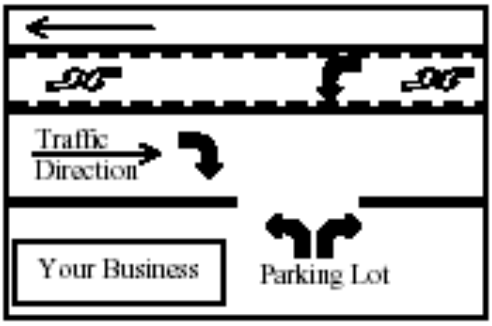
Approximate time to complete survey: 10 minutes

A. General Information

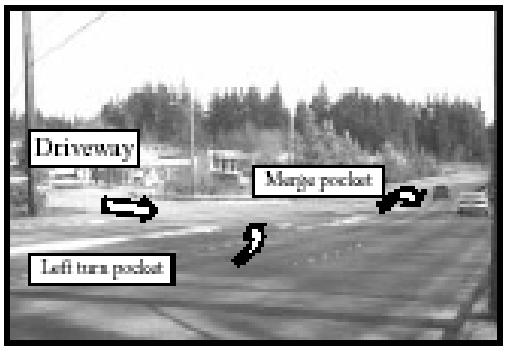
1. Provided below are examples of access management treatments. Access management is the intent is to control access to driveways for traffic safety and traffic flow purposes. What different types of access management design does your business location have? (Check **ALL** that apply)

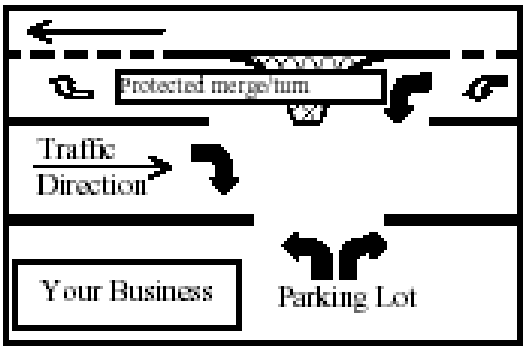


☐ **Example 1a.** No access management. Vehicles can enter or exit with left or right turns.

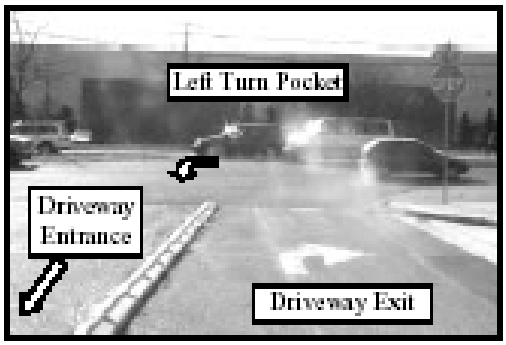


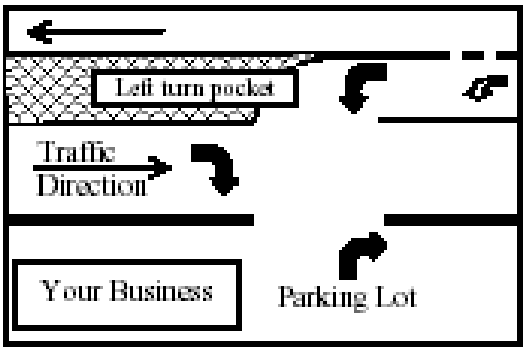
☐ **Example 1b.** Two Way Turn Lane. Vehicles have a center lane to enter and exit.



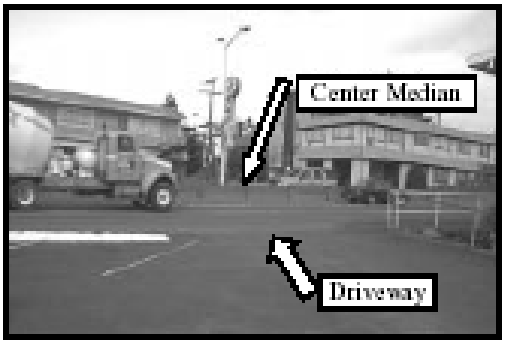


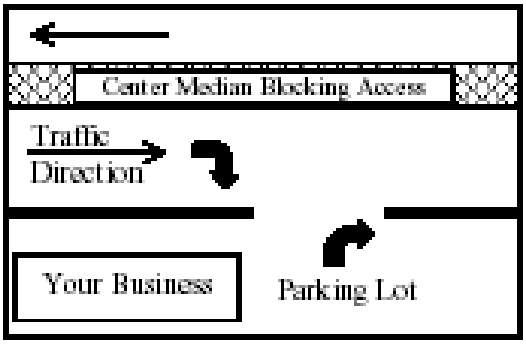
☐ **Example 1c.** Left turn pocket in, right in, right out left merge pocket out. Vehicles can enter with a left or right turn.



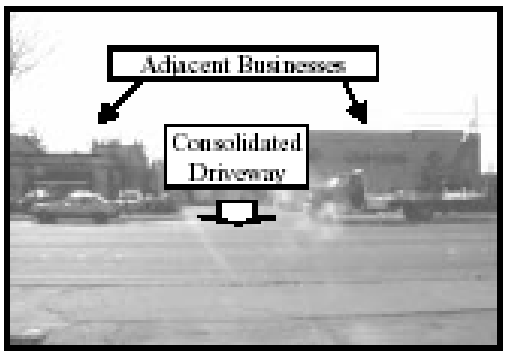


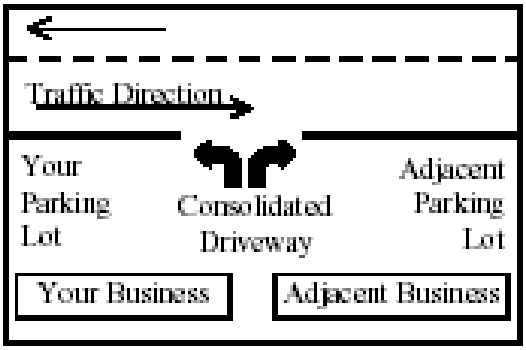
☐ **Example 1d.** Left turn pocket in, right in, and right out. Vehicles can enter with a left or right turn, but can only make a right turn when exiting.



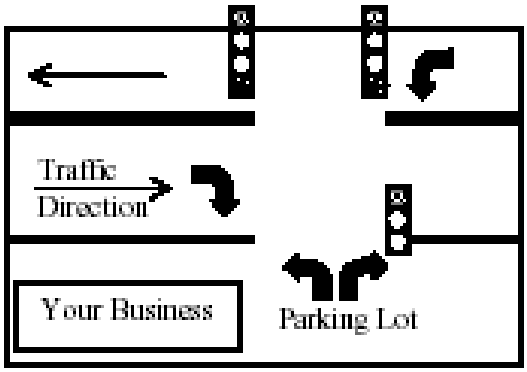


☐ **Example 1e.** Right in and right out. Vehicles can only make right turns when entering and exiting.





☐ **Example 1f.** Consolidated driveways. Adjacent properties share a common driveway to access their parking lots.



☐ **Example 1g.** Traffic Signal. The entrance or exit to your business is controlled by a traffic signal.

☐ **Others** (please explain and/or draw below):

2. How many parking spaces are dedicated to your business?

☐ 0-10 ☐ 11-20 ☐ 21-30 ☐ 31-40 ☐ Greater than 40
☐ Street parking

3. How do drivers access your parking lot? (Check all that apply)

☐ No parking lot exists for your business
☐ Enter parking lot from the major street to your business's driveway
☐ Enter parking lot from the minor street to your business's driveway
☐ Enter your parking lot through your neighbor's parking lot
☐ Shared driveway to your parking lot and your neighbor's parking lot
☐ Others (please specify): _____

4. If your business has a parking lot, how many driveways does it have?

☐ Not applicable ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ Greater than 5

5. How many customers do you have per day?

☐ Less than 100 ☐ 100-249 ☐ 250-499 ☐ Greater than 500

6. What time of day is <u>busiest</u> for you in terms of customers coming in?

☐ 6:00 AM - 8:00 AM ☐ 11:00AM – 1:00PM ☐ 4:00 PM – 6:00 PM
☐ Other time during the day ☐ Other time during the night

7. What day(s) do the majority of your customers come in? (Check all that apply)

☐ All week ☐ Monday ☐ Tuesday ☐ Wednesday ☐ Thursday
☐ Friday ☐ Saturday ☐ Sunday

8. How would you describe the traffic immediately surrounding your business?

☐ Not congested ☐ Congested ☐ Very congested

9. What is the speed limit of the main street in front of your business?

☐ 25 MPH ☐ 30 MPH ☐ 35 MPH ☐ 40 MPH ☐ 45 MPH
☐ Greater than 50 MPH

10. What types of traffic concerns do you have at **your business's driveway**?

	Not a concern	Minor Concern	Major Concern
A. Ability of vehicles exiting your driveway	☐	☐	☐
B. Ability of vehicles entering your driveway	☐	☐	☐
C. High traffic volumes next to your driveway	☐	☐	☐
D. High traffic speeds next to your driveway	☐	☐	☐
E. Pedestrians (high pedestrian traffic, pedestrian visibility, etc)	☐	☐	☐
F. Buses (buses stopping, buses merging, bus stop locations, etc)	☐	☐	☐
G. Others (please specify): _____	☐	☐	☐

11. What types of traffic concerns do you have along the **corridor your business is located on**?

	Not a concern	Minor Concern	Major Concern
A. Ability of vehicles exiting your driveway	☐	☐	☐
B. Ability of vehicles entering your driveway	☐	☐	☐
C. High traffic volumes next to your driveway	☐	☐	☐
D. High traffic speeds next to your driveway	☐	☐	☐
E. Pedestrians (high pedestrian traffic, pedestrian visibility, etc)	☐	☐	☐
F. Buses (buses stopping, buses merging, bus stop locations, etc)	☐	☐	☐
G. Others (please specify): _____	☐	☐	☐

B. Your Opinions on Access Management

Please indicate the impacts of access management on your business:

12. What is the impact of existing access management on **your business's** number of CUSTOMERS?

☐ No impact
☐ Major negative impact ☐ Minor negative impact
☐ Major positive impact ☐ Minor positive impact

13. What is the impact of existing access management on **your business's** REVENUE?

☐ No impact
☐ Major negative impact ☐ Minor negative impact
☐ Major positive impact ☐ Minor positive impact

14. What access control modifications you would like to see made to **your business**?

	Don't Want	Want
A. Two Way Turn Lane (TWTL) (example 1b)	☐	☐
B. Center median with turn and merge pockets (example 1c)	☐	☐
C. Center median with turn pocket (example 1d)	☐	☐
D. Right turn in and right turn out only (example 1e)	☐	☐
E. Consolidated driveways (example 1f)	☐	☐
F. More Traffic Signals (example 1g)	☐	☐
G. Others (please explain):	☐	☐

15. What access control modifications you would like to see made to the **corridor your business is located on**?

	Don't Want	Want
A. Two Way Turn Lane (TWTL) (example 1b)	☐	☐
B. Center median with turn and merge pockets (example 1c)	☐	☐
C. Center median with turn pocket (example 1d)	☐	☐
D. Right turn in and right turn out only (example 1e)	☐	☐
E. Consolidated driveways (example 1f)	☐	☐
F. More Traffic Signals (example 1g)	☐	☐
G. Others (please explain):	☐	☐

C. Your Business

16. What category describes your business?

☐ Retail - Goods ☐ Grocery Store ☐ Retail - Services
☐ Fast Food ☐ Restaurant ☐ Gas Station
☐ Convenience Store ☐ Other Business (Please Specify): _____

17. What is the monthly cost of renting/owning your current place of business? (Please specify amount)

Rent $_____ Mortgage $_____

18. What is the maximum monthly amount you would pay for your current business location?

Please specify amount: $_____

19. Approximately how much revenue does your business generate per year?

☐ Under $100K ☐ $1M - $2.49M
☐ $100K - $249,999 ☐ $2.5M - $4.90M
☐ $250K - $499,999 ☐ $5.0M - $9.99M
☐ $500K - $999,999 ☐ Over $10M

20. How much floor space does your business occupy?

☐ Under 499 ft^2 ☐ 1,000 - 1,999 ft^2 ☐ 3,000 - 3,999 ft^2 ☐ Over 5,000 ft^2
☐ 500 - 999 ft^2 ☐ 2,000 - 2,999 ft^2 ☐ 4,000 - 4,999 ft^2

21. How many employees does your business have at this location?

☐ Under 10 ☐ 25 - 99 ☐ 500 - 999
☐ 10 - 24 ☐ 100 - 499 ☐ Over 1000

22. What type of hours does your business operate within?

☐ 7 AM – 7 PM ☐ 9 AM – 5 PM ☐ 9 AM – 9 PM ☐ 10 AM – 6 PM
☐ 6 AM –10 PM ☐ Other hours (Please Specify):_____

23. How does your business attract customers? (Check all that apply)

☐ Advertising media ☐ Yellow pages ☐ Sign outside business ☐ Internet
☐ Referrals ☐ Word of mouth ☐ Other:_____

24. How do you think the economy is doing now?

☐ Poorly ☐ Somewhat Okay ☐ Okay ☐ Very Well

25. How do you think the economy will be doing next year?

☐ Poorly ☐ Somewhat Okay ☐ Okay ☐ Very Well

Do you have any additional comments or suggestions regarding access management at you business location?

_____

_____

_____

_____