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A PRIORITIZATION PROCESS FOR ACCESS MANAGEMENT IMPLEMENTATION IN UTAH
Executive Summary

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Utah Department of Transportation Research and Development Division

Submitted By:

Brigham Young University
Department of Civil and Environmental Engineering

Authored By:

Grant G. Schultz, Ph.D., P.E., PTOE
Assistant Professor

Kordel T. Braley, EIT
Graduate Research Assistant

Date:

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UDOT RESEARCH & DEVELOPMENT REPORT ABSTRACT

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16. Abstract

Appropriate access management techniques can improve the safety and efficiency of arterial roads. To determine which roads can most benefit by the implementation of access management techniques, a prioritization process was developed to recommend various access management treatments. To serve as the basis for the performance index, a database was created including identifying features, characteristics, and crash history for 175 arterial road segments on Utah state routes. Stepwise linear regression was applied to the data collected to determine which characteristics of the roads were correlated with crash rate, crash severity, and specific collision types. Recommendations for access management treatments were given in the form of a decision tree to classify existing or future road segments into subcategories based on volume, signal spacing, land use, and other criteria, with recommendations provided for each subcategory.

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Executive Summary

Transportation systems must be continually evaluated to ensure that people and goods can be moved as efficiently and as safely as possible given the financial constraints of the agency responsible for the system. Safety and performance indices provide a method to numerically measure given data about a system so that comparisons and rankings can be made as objectively as possible. Because traffic volumes and congestion across the state of Utah have continued to increase in recent years, particularly on arterial roads, the safety and performance of arterial roads has become a concern for the Utah Department of Transportation (UDOT).

The purpose of this report is to present the results of a study conducted to develop a prioritization process for the implementation of access management techniques in the state of Utah. The study was part of a research project funded by UDOT and conducted by researchers at Brigham Young University (BYU) that began in March 2006.

Report Objectives

The objective of the research was to develop a prioritization process based on principles of performance indices that can be utilized to target arterial roads that would benefit from the implementation of various access management principles and techniques. This was accomplished by collecting existing characteristics and crash histories to determine the impact of access management on the safety of arterial roads. A performance-index-based prioritization process was created using these relationships as the basis for a decision tree that can be used to evaluate the need for access management on a given road segment. The results of this research can provide direction and guidance to UDOT personnel on the prioritization of corridors that could benefit from the implementation of access management principles and techniques.

Secondary objectives of this research were to determine how access management principles and techniques were related to crash severity, to expand the literature on the safety benefits of access management principles and techniques, and to show the specific relationship between access management and crash severity in the state of Utah.

Background

The American Association of State Highways and Transportation Officials (AASHTO) *A Policy on Geometric Design of Highways and Streets* (AASHTO Green Book) states "[a]rterials are expected to provide a high degree of mobility for the longer trip length. Therefore, they should provide a high operating speed and level of service. Since access to abutting property is not their major function, some degree of access control is desirable to enhance mobility" (AASHTO 2004). The increase in traffic volumes combined with the desire to provide access to adjacent properties can have a negative effect on the safety and operational characteristics of arterial roads. When unlimited access is provided to adjacent properties, the result oftentimes is a decrease in speed, level of service, and more importantly, safety. In an effort to combat the safety concerns associated with this access, specific principles and techniques have been implemented in an effort to control access and improve safety. These "access management" techniques are defined by the Transportation Research Board (TRB) as "the systematic control of the location, spacing, design, and operation of driveways, median openings, interchanges, and street connections to a roadway" (2003).

The implementation of access management principles and techniques has continued to be placed at the forefront of importance for state departments of transportation (DOTs) across the nation. UDOT has followed suit in this effort, having established state highway access management guidelines as part of the Administrative Rule R930-6, *Accommodation of Utilities and the Control and Protection of State Highway Rights of Way* (UDOT 2003). This document aims to provide guidance to DOT personnel in maintaining and preserving both existing and future capacity on the state roadway network. It also provides guidance for design, operations, and project management to better implement access management techniques in both existing and future projects.

The process of evaluating access management techniques in Utah, specifically raised medians, began by research completed at BYU (Saito et al. 2005). The results of this research established a procedure to guide state engineers through the evaluation process of identifying the need for a raised median section on a given highway. Further research has identified locations where access management techniques have been implemented throughout the state of Utah and identified the safety impacts of those installations (Schultz and Lewis 2006).

Facility Evaluation

A database of arterial roads was compiled to summarize state routes in the urbanized areas of six counties in Utah. The database was comprised of 175 segments of 49 different state routes totaling 207 miles of arterial roads. The three major components of the database included: 1) identifying features of each road segment, 2) independent variables, and 3) dependent variables.

Identifying Features

The identifying-features portion of the database included descriptive data to uniquely differentiate the segments from one another. Data in this section included the state route number, the county in which the segment was located, the street name, and the mile post numbers of the beginning and end points. Descriptions of the endpoints were also given, consisting of cross streets or other landmarks.

Independent Variables

Independent or explanatory variables include those characteristics of the road segments that had possible correlation with the safety or operational characteristics of the roadway. It was important to consider as many characteristics as possible at the onset to be able to properly account for any variables influencing the crash histories of the segments. Independent variables collected in this database included length, access category, number of lanes, median type, orientation, adjacent land use, posted speed limit, access density, average annual daily traffic (AADT), and signals per mile.

Dependent Variables

Dependent variables, or response variables, included those characteristics of a road segment that were believed to be the result of the various roadway characteristics discussed above. The dependent variables obtained for this database included the number of crashes aggregated by severity and collision type over the three-year period of 2002 to 2004. These crash histories included over 28,800 crashes.

Data Collection Methodology

Several web-based tools were used to collect the data used for this database including various UDOT documents and maps (UDOT 2004, 2006a), the UDOT Road Viewer Program (UDOT 2006b), Google Maps (Google 2006), and the UDOT web-based crash almanac (Anderson et al. 2005).

Safety Evaluation

Statistical analysis was performed on the data contained in the database to determine which characteristics were correlated to roadway safety aspects, including crash rate, crash severity, and collision type.

Statistical Methodology

Computer software SPSS® 14.0 was utilized to perform stepwise linear regression in order to determine which independent variables were related to each dependent variable analyzed (SPSS 2005). In addition to the stepwise linear regression, the "weight cases" option was also utilized to weight each individual segment by its length to ensure that short segments would not skew the data.

After the significant variables were identified from the stepwise procedure, multiple linear regression was used to identify the regression coefficients and their respective *t*-statistics and *p*-values. The null hypothesis was that the regression coefficients were zero. The intent of determining regression coefficients was not necessarily to predict crash rates, crash severities, or collision types, but to determine which characteristics were correlated with crash history. The regression equations should not be used to predict crashes but can be examined to see patterns in the data.

Crash Rate

Crash rates, in units of crashes per million vehicle miles traveled (MVMT), are a common method used in evaluating the safety of roads and intersections. They were calculated for each road section in the database as a function of the number of crashes, volume, and length. Stepwise linear regression showed statistically significant correlation of crash rates to signal spacing, adjacent land use, speed limit, and median type.

Crash Severity

Crash severity refers to the severity corresponding to the most severe injury of all those resulting from a given crash. According to the National Safety Council (1996), the five categories are fatal accident, incapacitating injury accident, non-incapacitating evident injury accident, possible injury accident, and non-injury accident. A common abbreviation for these severity levels is referred to as the KABCO scale, with each letter, "K" through "O", representing fatal through non-injury levels of severity, respectively. In Utah, slightly different language is used to define these severity levels as identified in the report.

Five methods were developed to create crash severity scores for each road segment as a function of the quantities of each severity level of crash and weighting factors. The methods developed are as follows:

1. Federal Highway Administration (FHWA) Crash Costs Method,
2. Magnitudes of Ten Method,
3. Exponential Method,

4. Three Category Method, and
5. UDOT Crash Costs Method.

Each method was used to calculate a severity score and differed in the way that the different severity levels were weighted. Stepwise linear regression was completed on all five methods to determine the correlation of road characteristics and crash severity scores.

While multiple linear regression yielded different results for each method, many results were similar. Table ES.1 summarizes all of the variables identified with the stepwise linear regression as being correlated to the crash severity score of the segments in the database. A "+" symbol indicates positive correlation, while a "-" symbol indicates negative correlation. Blank cells indicate no correlation for the respective variable and method.

Table ES.1 Summary of Correlations of Independent Variables with Crash Severity

Variable	Method 1	Method 2	Method 3	Method 4	Method 5
Signals/Mile	+	+	+	+	+
AADT/Lane	+	+	+	+	+
Commercial	+	+	+	+	+
Residential					-
Speed Limit	+	+			+
TWLTL	+	+	+	+	
Access Density	+	+			+

Note: A "+" indicates positive correlation and a "-" indicates negative correlation.

Collision Type

Analyzing crashes by collision type has two apparent advantages: 1) it identifies specific geometric characteristics of the roadway, such as those that are related to access management, that may have caused or failed to prevent the crash, and 2) locations with high frequencies of certain crashes normally thought to yield more severe results are identified as hazardous, whether or not severe injuries occurred. The latter advantage is further magnified when sample sizes are lower and variability is higher.

For collision-type analysis, crash rates were determined for each type of collision and then compared with the respective crash rates of other locations. Statistical analysis included stepwise linear regression on the dependent variables of right-angle collisions, rear-end collisions, side-swipe collisions (in the same direction), single-vehicle collisions, and head-on and side-swipe collisions (from opposite directions).

Table ES.2 summarizes all of the variables identified with the stepwise linear regression as being correlated to various collision types of the road segments in the database. A "+" symbol indicates positive correlation, while a "-" symbol indicates negative correlation. Blank cells indicate no correlation for the respective variable and collision type.

Table ES.2 Summary of Correlations of Independent Variables with Collision Type

Variable	Right-Angle	Rear End	Side-Swipe	Opposite-Direction	Single-Vehicle	Other
Signals/Mile	+	+	+			
AADT/Lane	-	+			-	-
Commercial	+		+			+
Residential		-		+		-
Speed		-			-	-
Raised Median	-					
TWLTL				+		
Access Density			+			

Note: A "+" indicates positive correlation and a "-" indicates negative correlation.

Prioritization Process

A performance-index-based prioritization process was developed to make decisions regarding access management techniques that should be utilized on arterial roads. The primary method to develop this process was by utilizing a decision tree. The decision tree developed in this research was based on the results of statistical analyses performed on the data, as well as recommendations found in the literature. Decision criteria and cutoff values were determined by analyzing the data using statistical software programs CART™ and SPSS as well as utilizing recommendations from the literature.

Figure ES.1 shows the decision tree developed. Six steps can be followed to arrive at three different access management recommendations including limiting access density, installing raised medians, and future planning. Additionally, some segments are given no recommendation.

Conclusions and Recommendations

Conclusions

The purpose of this report was to develop a prioritization process based on principles of performance indices that can be utilized to target arterial road segments that would benefit from the implementation of various access management principles and techniques. This was accomplished by collecting existing characteristics and crash histories and determining the impact of access management on the safety of arterial roads. A performance-index-based prioritization process was created using these relationships as the basis for a decision tree that can be used to evaluate the need for access management on a given road segment.

A secondary purpose of this research was to determine how access management principles and techniques were related to crash severity and to expand the literature on the safety benefits of access management techniques. Statistical analysis showed that the lack of access management, such as high access density, numerous signals per mile, and lack of medians, were positively correlated with increased crash rates and increased crash severity. Certain collision types, such as right-angle, side-swipe, and opposite-direction crashes, were also more likely to occur when access was not effectively managed. Furthermore, land use plays a significant role in the safety of arterials. Road segments with adjacent commercial land use tended to have higher crash rates and severity scores.

Finally, this research shows that in addition to the safety benefits well established in the literature, access management positively benefits safety in the state of Utah.

Recommendations

Based on the conclusions of this research, it is recommended that access management be continually implemented on arterial roads in the state of Utah. A decision tree was outlined that can assist UDOT personnel in determining which arterial roads might benefit the most from various access management techniques. To use the decision tree, information about AADT, signals per mile, adjacent land use, and future growth is needed to classify arterial road segments. Possible recommendations include limiting access points, installing raised medians, and planning for future growth by implementing standards for adequate signalized and unsignalized access spacing and obtaining sufficient right-of-way for future medians.

Future Research

Further research is recommended in the areas of safety and access management. A crash prediction model should be developed to assist planners in understanding the impact of future growth on state routes. Empirical Bayesian methodology has been developed in the literature and would be an effective means of conducting this analysis. Access management should be a key component in this model to show the effect it has on the predicted safety of state routes.

Other research recommended in order to study the effects of access management could include examining the relationship between crashes and the number of conflict points. Additionally, the effect of access in the vicinity of signalized intersections could be analyzed. Finally, a methodology could be developed to examine crashes most likely caused by access density instead of all crashes in general. This could more accurately show the benefits of access management on arterial roads.

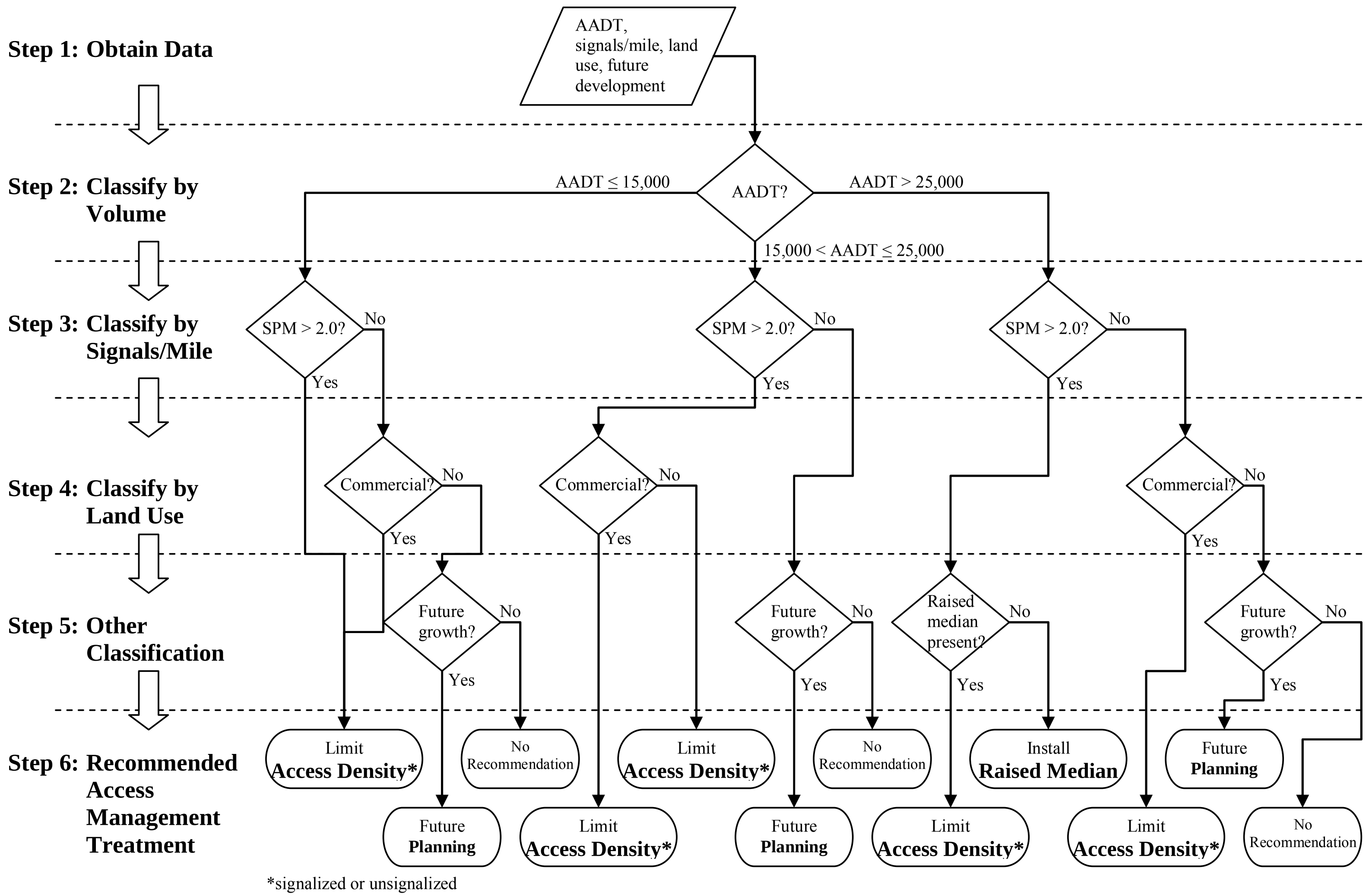

Figure ES.1 Decision tree for determining recommended access management techniques.

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