PRIORITIZING ACCESS MANAGEMENT IMPLEMENTATION

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ABSTRACT
Traffic volumes and congestion continue to increase on arterial roads. As such the safety and performance of these roads is a continual concern. Transportation systems must be evaluated on an ongoing basis to ensure that people and goods can be moved as efficiently and safely as possible. Safety and performance indices provide a method to numerically measure given data about a system so that comparisons and rankings on safety and performance can be made as objectively as possible. One of the sets of tools that have proven successful in improving the safety and efficiency of arterial roads are access management techniques. To determine which roads can most benefit by the implementation of access management techniques, a prioritization process was developed to guide decision makers in the implementation process. Recommendations were given in the form of a decision tree classifying existing or future road segments into subcategories based on volume, signal spacing, adjacent land use, and other criteria. The objective of this paper is to document the steps followed to develop the prioritization process based on principles of performance indices that can be utilized to target arterial roads that would benefit from access management techniques and principles. Utilizing the results of the research, decision makers can better determine which sections of roadway can benefit from controlling driveway access, installing raised medians, providing future planning, or looking to a solution other than access management.

INTRODUCTION

Traffic volumes and congestion continue to increase on arterial roads. As such the safety and performance of these roads is a continual concern throughout the nation. Transportation systems must be evaluated on an ongoing basis to ensure that people and goods can be moved as efficiently and safely as possible given the various 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 on safety and performance can be made as objectively as possible.

Appropriate access management techniques have proven successful in improving the safety and efficiency of arterial roads. Access management techniques such as traffic signal spacing, unsignalized access spacing, corner clearance criteria, median treatments, left-turn lanes, U-turns as alternatives to direct left turns, access separation at interchanges, and frontage roads reduce traffic conflicts and crashes, reduce traffic congestion, preserve roadway capacity, reduce pollution and fuel consumption, and improve economic benefit to businesses (*1*, *2*, *3*, *4*). Although several access management principles and techniques exist, the three utilized for the research in this paper include traffic signal spacing, unsignalized access spacing, and median treatments. These access management techniques and their potential benefits have been researched in great detail and are well established in the literature (*3*).

A prioritization process was developed in the state of Utah to determine which sections of state highways can most benefit by the implementation of access management techniques and subsequently to recommend access management techniques and treatments for these sections. 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 using a geographic information system (GIS) enabled web delivered data almanac (*5*). Stepwise linear regression was applied to the data collected to determine which characteristics of the roads were correlated with crash rate, crash severity, and collision type. A performance-index-based prioritization process was developed based on these relationships, while recommendations for access management techniques and treatments were provided in the form of a decision tree to classify existing or future road segments into subcategories based on volume, signal spacing, adjacent land use, and other criteria.

The objective of this paper is to document the steps followed to develop the prioritization process based on principles of performance indices that can be utilized to target arterial roads that would benefit from access management techniques and principles. Utilizing the results of the research, decision makers can better determine which sections of roadway can benefit from controlling driveway access, installing raised medians, providing future planning, or looking to a solution other than access management.

STATISTICAL ANALYSIS

Research completed for the Utah Department of Transportation (UDOT) in 2007 sought to identify and investigate relationships between access management principles and the safety characteristics of several arterials in urbanized areas of Utah. This analysis included data collection, safety evaluation, and stepwise linear regression analysis (*2, 6*).

Data Collection

A database was compiled comprising of 175 arterial road segments totaling 207 miles. The database included identifying features (e.g., state route number, county, street name, milepost numbers, and descriptions of the starting and ending points); independent variables such as access management techniques (e.g., median type, access density, signals per mile, access category) and geometric and traffic characteristics (e.g., length, number of lanes, speed limit, orientation, adjacent land use, and traffic volume); and dependent variables including crash rates, crash severities, and collision types.

Safety Evaluation

To evaluate the safety of each road segment, the crash rate was calculated for the segment and an analysis of crash severity and collision types was undertaken. Because crash rates and collision types were not used as a basis for the decision tree, they will not be discussed in this paper. More detail on these methodologies can be found in the literature (*2*). Crash severity, however, was utilized in this analysis and is summarized in this section.

Crash severity corresponds to one of five levels of injury severity as outlined by the National Safety Council to describe the most severe injury of all those resulting from a given crash (*7*). The crash severity levels include fatal, incapacitating injury, non-incapacitating evident injury, possible injury, and non-injury. The crash severity levels are commonly abbreviated with the letters ‘K,’ ‘A,’ ‘B,’ ‘C,’ and ‘O’ from most serious to least serious.

Schultz et al. developed and/or adapted from the literature five methodologies to quantify the overall severity of all crashes occurring on each road segment in the database over a specified time period. Of the five methods developed, the method based on UDOT crash costs was used as a basis for the prioritization process and is outlined in the following section. More details on the remaining four methods can be found in the literature (*2, 6*).

UDOT Crash Costs Method

The UDOT Crash Costs Method is based on crash values obtained from the UDOT *Roadway Safety Improvement Program* (*8*). The methodology assigns crash costs to different severity levels such that fatal and incapacitating injury crashes are equal in weight. Table 1 summarizes the cost per crash for each severity level as determined by UDOT as well as the equivalent number of non-injury crashes per severity level.

TABLE 1 UDOT Crash Costs

	Severity Level	**Cost/Crash**	**Equivalent Non-Injury Crashes**
K	Fatal	$465,000	200
A	Incapacitating injury	$465,000	200
B	Non-incapacitating evident injury	$46,500	20
C	Possible injury	$23,200	10
O	Non-injury	$2,350	1

To obtain a severity score, the number of crashes per mile of each severity level are multiplied by the respective number of equivalent fatal, incapacitating injury, non-incapacitating evident injury, possible injury, and non-injury crashes and summed to obtain the overall crash severity score as outlined in Equation 1.

$$S_{UDOT} = O + (10*C) + (20*B) + (200*A) + (200*K) \quad (1)$$

where: S_{UDOT} = severity score for UDOT Crash Costs Method,
O = non-injury crashes per mile,
C = possible injury crashes per mile,
B = non-incapacitating evident injury crashes per mile,
A = incapacitating injury crashes per mile, and
K = fatal crashes per mile.

Stepwise Linear Regression Analysis

To pare down the numerous dependent variables collected for the database, stepwise linear regression was utilized to remove those variables with little impact on the safety of the road segments. This analysis was completed using the computer software tool SPSS® 14.0 (*9*). Multiple linear regression was used to finalize the relationship and develop the final equation after the appropriate variables were determined from the stepwise linear regression.

Statistical analyses showed that the lack of access management techniques (e.g., high access density, numerous signals per mile, and no medians) were positively correlated with increased crash rate and severity as well as certain collision types. Adjacent land use was also identified as being highly correlated with the safety of arterial roads as those road segments with adjacent commercial land use tended to have higher crash rates and severity scores. Detailed results of the statistical analysis are readily available in the literature (*2*, *6*).

PRIORITIZATION PROCESS

Decision Tree Components

The primary method used to develop the performance-index-based prioritization process was that of a decision tree. Decision trees utilize a graphical approach to classify decisions based on their possible consequences, including chance event outcomes, resource costs, and utility (*10*, *11*). Decision trees have been utilized in pavement management to determine which preventative maintenance techniques should be used and when maintenance should occur based on characteristics of the road as well as predetermined goals for the facility (*12*).

Decision trees are often subjective in nature, however, cutoff values can also be based on empirical data, thus making them more objective. One method to determine empirical values for decision trees relies on the procedure developed by Breiman et al. known as Classification and Regression Trees (CART) (*13*). The computer program CART™ was developed using this methodology to classify categorical data or continuous data with the use of decision trees (*14*). According to the CART™ program documentation, "CART's goal in a regression tree is to partition the data into relatively homogeneous (low standard deviation) terminal nodes…" (*15*).

The decision tree developed in this research was based on the results of statistical analyses performed on the data, specifically the analysis results of the previously discussed UDOT Crash Costs Method, as well as recommendations found in the literature. The decision tree was created to determine appropriate countermeasures for safety problems based on known characteristics and crash histories of given segments.

To create decision trees, data are classified into small categories or groups using cutoff values. To classify the data into these smaller subsets, road segments were separated into groups with similar characteristics and crash histories. Characteristics by which the data could be classified were then considered, as well as cutoff values for those characteristics that had continuous values. Possible methods for determining cutoff values included: 1) arbitrarily choosing values, 2) identifying natural breaks in the data, 3) searching the literature for commonly used cutoff values, and 4) choosing cutoff values such that the standard deviation of dependent variables was at a minimum.

CART™ was utilized primarily to assist in determining which variables were most important so that the data could be classified into smaller groups as well as to determine which cutoff values should be used. As with other statistical software, independent and dependent variables are necessary to perform this analysis. Each variable can be designated as a 'Target' (or dependent) variable, 'Predictor' (or independent) variable, 'Categorical' variable, or 'Weight' variable in the model setup. For this analysis, length was chosen as the 'Weight' variable so that shorter road segments would have less effect on the outcome. The 'Regression' tree option was chosen because the target variable (crash severity score) was continuous and not categorical (*15*).

After completing the model setup, the software was utilized to partition the data into smaller groups with progressively smaller standard deviations using a process known as 'binary recursive' partitioning. 'Binary' means that each 'parent' node (or starting group of data) is split into exactly two 'child' nodes (or subcategories of data), while 'recursive' means that each 'child' node then becomes a new 'parent node.' The process of splitting data into groups with smaller standard deviations is repeated until the data can no longer be split into more groups. The relative error (a measure of variance) is then calculated for each possible decision tree and the tree with the smallest relative error is selected as the 'best' tree (*15*). An example decision tree utilizing this methodology is provided in Figure 1.

Based on the statistical analysis and the CART™ analysis, volume and signal spacing were found to be the two most important variables in determining crash severity score when utilizing the UDOT Crash Costs Method. To illustrate the relationship that exists between crash severity score and volume, represented as average annual daily traffic (AADT), and between crash severity score and signal spacing, the results of the relationships were plotted. Figure 2 shows the general relationship between volume and crash severity score, while Figure 3 shows the general relationship between signals per mile and crash severity score for all road segments for which data were collected.

Figure 2 and Figure 3 show the correlation for both volume and signal spacing with crash severity score. Figure 2 shows that crash severity score increased linearly with AADT with an R-squared value of 0.43. Figure 3 shows that crash severity score also increased linearly with signals per mile with an R-squared value of 0.36. Detailed statistical analyses were not completed on the data shown in Figure 2 and Figure 3; rather these figures were presented to show the general relationship between these two characteristics and UDOT Crash Costs Method crash severity score.

The following sections discuss how the cutoff values for volume and signal spacing were chosen to categorize the road segments into smaller subsets of data.

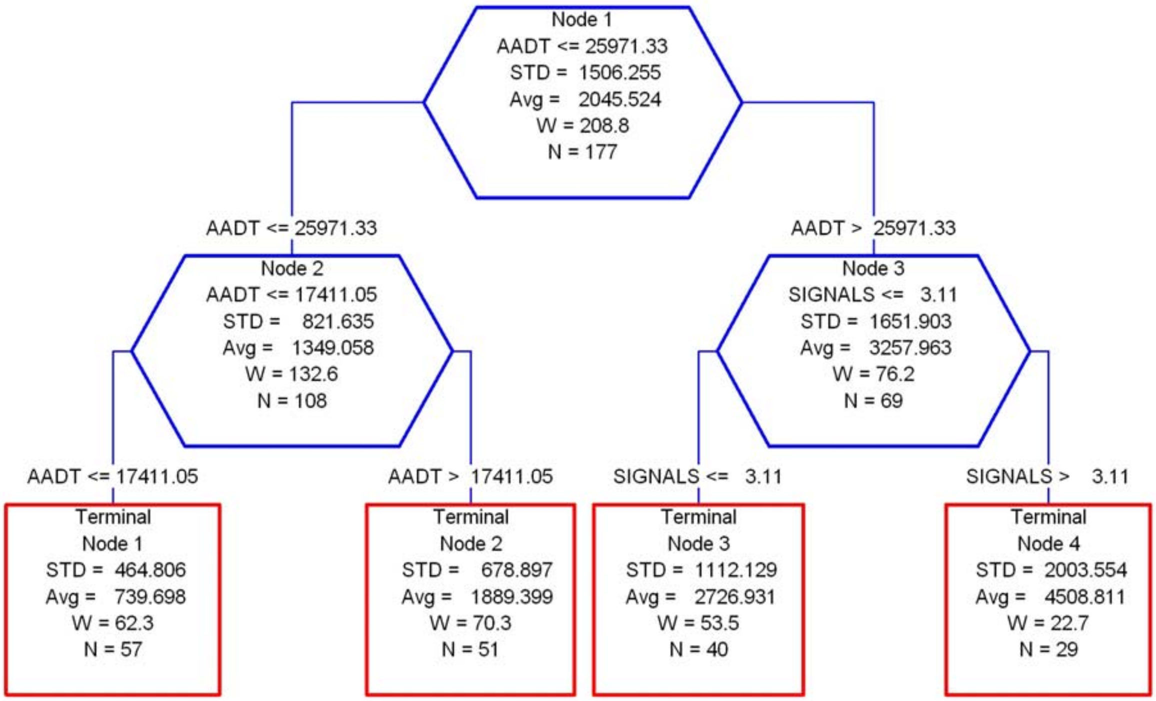

FIGURE 1 Details of CART™ decision tree.

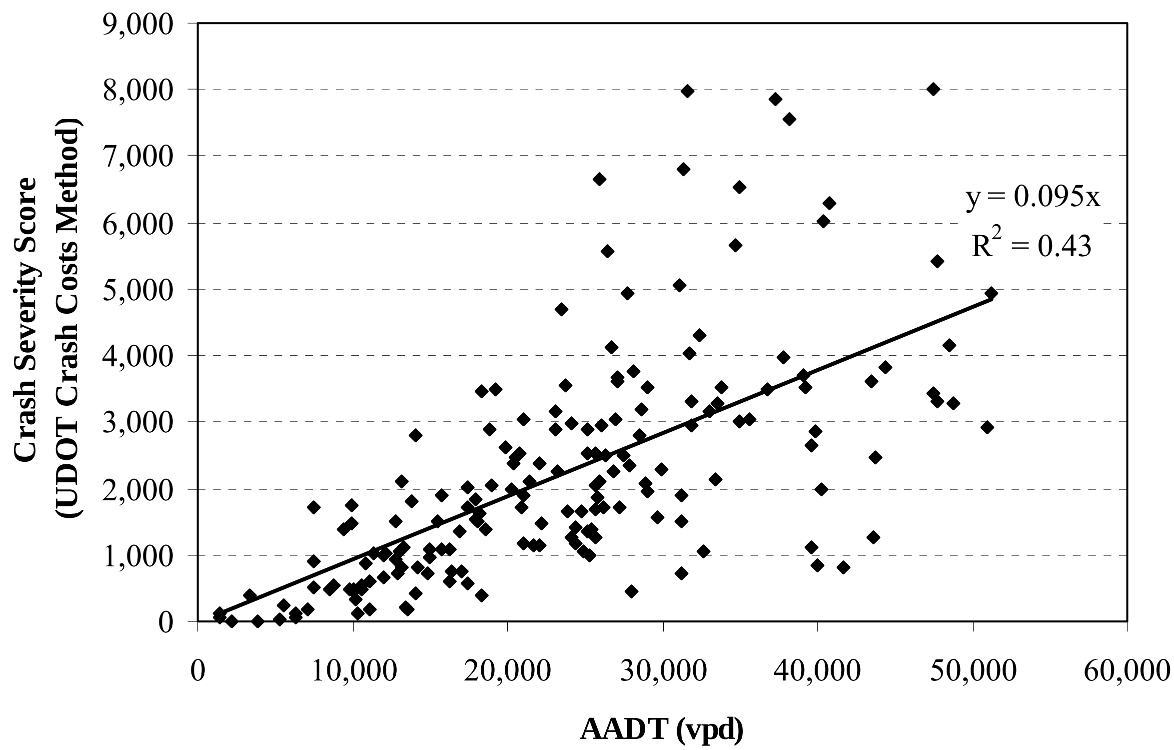

FIGURE 2 Crash severity score versus AADT.

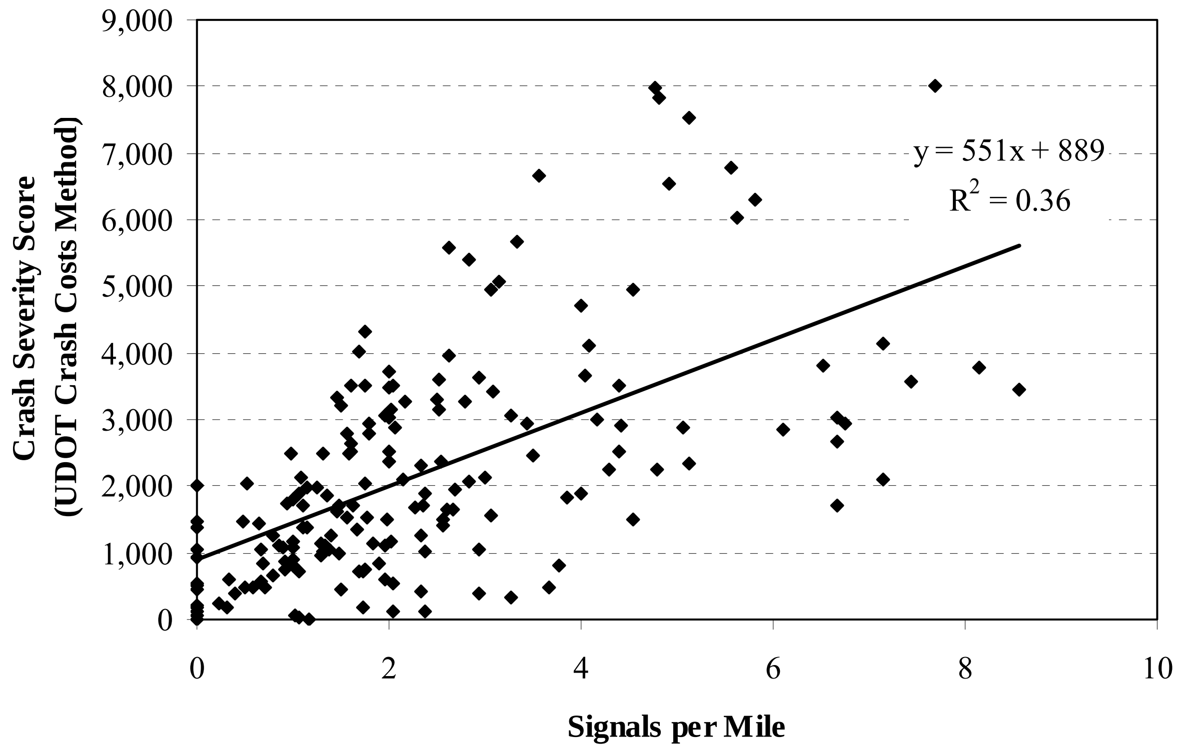

FIGURE 3 Crash severity score versus signals per mile.

Volume

Potential cutoff values for volume data were chosen by examining three primary sources: 1) the literature, 2) the distribution of data collected, and 3) CART™. Sensitivity analyses utilizing descriptive statistics were then conducted to determine which of the potential cutoff values would be used for the analysis. According to the literature, the point at which raised medians become advantageous over two-way left-turn lanes (TWLTLs) is between 24,000 and 28,000 vehicles per day (vpd) (*1*). Therefore, the first potential cutoff value was determined to be 26,000 vpd. Natural breaks in the data collected were observed to be at approximately 10,000 vpd and 30,000 vpd, therefore, the second potential cutoff values were set at 10,000 vpd and 30,000 vpd. The third set of potential cutoff values was determined utilizing CART™. In this scenario AADT was partitioned by CART™ into three groups: 1) under 17,500 vpd, 2) between 17,500 and 26,000 vpd, and 3) over 26,000 vpd. Finally, by dividing the data into exactly three sections (weighted by length), the potential cutoff vales were determined to be 18,000 vpd and 27,000 vpd. Table 2 provides a summary of the three different sources analyzed as well as the equal groups used to determine potential cutoff values for the volume data.

TABLE 2 Potential Cutoff Values for volume data (vpd)

Source	Low AADT	Medium AADT	High AADT
Literature	< 26,000	-	> 26,000
Natural Breaks	< 10,000	10,000 - 30,000	> 30,000
CART™	< 17,500	17,500 - 26,000	> 26,000
Equal Groups	< 18,000	18,000 - 27,000	> 27,000
Rounded Values	< 15,000	15,000 - 25,000	> 25,000

Sensitivity analyses were completed by examining the mean and standard deviation of the data categorized by each of the potential cutoff values. The results of this analysis indicated that the cutoff values obtained from the CART™ program yielded the overall lowest standard deviations. Additional sensitivity analyses were conducted on the data by dividing the categories into the following rounded number groups: 1) less than 15,000 vpd, 2) between 15,000 and 25,000 vpd, and 3) greater than 25,000 vpd, as illustrated in the last row of Table 2. These rounded values yielded category standard deviations within 10 percent of the values obtained from the CART™ program and were therefore carried forward to the next categorization because they yielded sufficiently similar groups of data and because their cutoff values were within acceptable ranges based on the results in the literature.

Signal Spacing

As with the volume data, potential cutoff values for signal spacing were chosen by examining three primary sources: 1) the literature, 2) the distribution of data collected, and 3) CART™. Sensitivity analysis was then conducted to determine optimal cutoff values. According to the literature, 2 signals per mile (i.e., one-half-mile separation) is the optimal spacing for traffic signals (*1*). Signal spacing of 4 signals per mile is also acceptable for minor arterials and densely developed areas where lower operating speeds are acceptable. As a result, potential cutoff values of 2 signals per mile and 4 signals per mile were identified from the literature. By examining the distribution of the data collected, potential cutoff values were identified as 2.02 signals per mile, corresponding to the weighted mean, and 1.69 signals per mile, corresponding to the weighted median. Finally, potential cutoff values of 0.83 signals per mile, 1.99 signals per mile, and 3.11 signals per mile were determined utilizing the CART™ program. Table 3 summarizes the potential cutoff values identified from the three different sources.

Cutoff values selected for sensitivity analyses were 1, 2, 3, and 4 signals per mile, based on the potential cutoff values discussed in the previous paragraph. The cutoff values of 3 and 4 signals per mile yielded higher standard deviations. The smallest standard deviation values were associated with the groups created by categorizing the road segments into groups less than, and greater than, 1 signal per mile. However, with a cutoff value of 1 signal per mile, some categories had a very low sample size in terms of road segments. While the standard deviations for the groups using 2 signals per mile were not as low as those associated with 1 signal per mile, the road segments were more evenly distributed. Furthermore, 2 signals per mile (one-half-mile spacing) is recommended in the literature as the optimal signal spacing for an arterial road (*1*).

TABLE 3 Potential Cutoff Values for Signal Spacing

Source	Low Signals per mile	High Signals per mile
Literature	< 2	> 2
Literature	< 4	> 4
Mean	< 2.02	> 2.02
Median	< 1.69	> 1.69
CART™	< 0.83	> 0.83
CART™	< 1.99	> 1.99
CART™	< 3.11	> 3.11

Six categories of road segments were created, as shown in Table 4, by categorizing the road segments using the selected cutoff values for volume and signals per mile.

TABLE 4 Six Categories of Road Segments

AADT (vpd)	Signals per Mile
≤ 15,000	> 2.0
≤ 15,000	≤ 2.0
15,000 < AADT ≤ 25,000	> 2.0
15,000 < AADT ≤ 25,000	≤ 2.0
> 25,000	> 2.0
> 25,000	≤ 2.0

Access Management Techniques

Each set of road segments were categorized using the methodology discussed above and then examined to determine which access management techniques were the most appropriate. The results of this analysis are summarized in the following sections organized by AADT and signals per mile. Within each section the data were also categorized by land use characteristics (i.e., commercial or residential) to account for the relationships identified.

AADT Less than 15,000

Arterial road segments with AADT less than or equal to 15,000 vpd were analyzed according to the number of signals per mile. The results are summarized in the following subsections describing those segments with greater than 2 signals per mile and those with less than or equal to 2 signals per mile.

Greater than 2 Signals per Mile Because all but one of the road segments in this category had commercial adjacent land use, and because only approximately 3 miles of data were in this category, the data for this category were combined with the commercial land use arterials with less than 2 signals per mile discussed in the next subsection. No statistically significant correlations were identified between crash severity score and access management techniques for the data in this category.

Less than or Equal to 2 Signals Per Mile The majority of road segments with under 15,000 vpd and less than or equal to 2 signals per mile had adjacent residential land use. However, those road segments that did have adjacent commercial land use were combined with the commercial land use arterials with greater than 2 signals per mile for the reasons identified in the previous subsection. Linear regression analysis performed on the data in this subcategory showed that crash severity scores were positively correlated with access density at the 84 percent confidence level. Therefore, limiting access density was recommended as the preferred access management treatment for arterials with AADT less than or equal to 15,000 vpd and adjacent to commercial land use.

The road segments with adjacent residential land use showed no correlation between crash severity score and access density. Furthermore, none of the road segments in the database contained in this subcategory had raised medians, so no recommendation for raised medians could be given. Residential arterial road segments with less than 15,000 vpd and greater than 2 signals per mile tended to have similar severity scores regardless of their access density. The recommended access management techniques for low-volume roads with adjacent residential land use was determined to include a focus on planning for road segments with potential for future growth. Future planning should include 2 signals per mile spacing, sufficient right-of-way for future medians, and access spacing guidelines to ensure that these low-AADT residential arterials with the potential for future development will grow appropriately. No recommendation for access management techniques are given for road segments in this subcategory with no potential for future growth.

AADT Greater than 15,000 and Less than or Equal to 25,000

This section discusses arterial roads with AADT greater than 15,000 vpd and less than or equal to 25,000 vpd. The following two sections show that signal spacing is important for this range of AADT. Those sections with 2 or less signals per mile were far less sensitive to changes in access density compared to sections with greater than 2 signals per mile. This could be due to the fact that fewer access points were located near intersections because there were fewer intersections on those arterial segments.

Greater than 2 Signals per Mile The road segments with greater than 2 signals per mile were separated by adjacent land use. In addition to low R-squared values, linear regression revealed a significance level of only 69 percent for the independent variable of access density. However, a general trend of increasing crash severity score with increasing access density was observed. For commercial arterials, the severity score increased for each additional access provided. Crash severity scores associated with residential arterials increased at about half the rate of commercial arterials for each additional access provided. This would tend to indicate that access density is more significant for residential arterials when the AADT is higher. This is intuitive because, despite the residential land use, the number of conflicts is higher with added vehicles on the road.

Less than or Equal to 2 Signals Per Mile Road segments in this category were less sensitive to changes in access density. The results of this analysis yielded a fairly level trend line with a low R-squared value suggesting that access density was not very well correlated with crash severity score. Linear regression also yielded a low significance level of approximately 85 percent. Furthermore, the mean value for the crash severity score in this category was approximately 1,500 compared to approximately 2,300 for segments with the same AADT but greater than 2 signals per mile.

The focus on planning for road segments in this subcategory was recommended to be placed on the potential for future growth. Future planning should include 2 signals per mile spacing, sufficient right-of-way for future medians, and access spacing guidelines to ensure that these arterials with the potential for future development will grow appropriately. Only one arterial road segment had a raised median, so no analysis was performed to determine whether median types were correlated to crash severity scores for this category of road segments.

AADT Greater than 25,000

This section discusses arterial roads with AADT greater than 25,000 vpd and is organized into subsections describing road segments with greater than 2 signals per mile and those with 2 or less signals per mile.

Greater than 2 Signals per Mile Various regression models were tested for the data in this category with more than 2 signals per mile. Special attention was placed on determining how raised medians were correlated to severity scores, as the literature recommends installing raised medians when the AADT reaches 24,000 vpd to 28,000 vpd (*1*, *3*).

The statistical analysis completed showed that road segments with raised medians were correlated with severity scores approximately 1,000 points lower than road segments without raised medians. The linear regression model analyzed to come to this conclusion also included signals per mile. Therefore, given two road segments in this category with equivalent numbers of signals per mile, the segment with a raised median would have a severity score 1,000 points less than a segment without a raised median.

Interestingly, with only 2 additional signals per mile the safety benefits of adding a raised median are offset. That is, a raised median is correlated with a decrease in crash severity score of approximately 1,000 points, while 2 signals per mile correspond to an increase in severity score of approximately 1,000 points. Furthermore, for those road segments in this subcategory that already had raised medians, access density was positively correlated with crash severity score. For each additional access point added the severity score was increased by approximately 25 points.

Less than or Equal to 2 Signals Per Mile For road segments with less than or equal to 2 signals per mile, the analysis results showed a positive correlation between access density and crash severity score in commercial areas but no correlation in residential areas. With respect to arterials with adjacent commercial land use, linear regression showed positive correlation between crash severity score and access management with an 81 percent confidence level.

Limiting access density is recommended for road segments with commercial adjacent land use because, for each additional access point, the crash severity score increased by approximately 15 points.

Arterials were less affected in residential areas by high access density, most likely because the volumes at the driveways were insignificant compared to the volumes of a comparable number of driveways in commercial areas.

The focus on planning for road segments in this subcategory should be placed on the potential for future growth and volumes. Future planning should include 2 signals per mile spacing, sufficient right-of-way for future medians, and access spacing guidelines to ensure that these arterials with the potential for future development will grow appropriately.

DECISION TREE

Based on the analysis in the previous sections, a decision tree was generated as illustrated in Figure 4. The decision tree is presented in a step-by-step procedure to arrive at recommendations for access management techniques and treatments on arterial road segments. The six steps of the decision tree are discussed in the following sections.

Step 1: Obtain Data

The first step in the decision tree is to collect data for the road segment being analyzed, including the AADT, signals per mile, adjacent land use, and potential for future development.

Step 2: Classify by Volume

Next, the road segment being analyzed is categorized as having low, medium, or high volume corresponding to less than or equal to 15,000 vpd, greater than 15,000 vpd and less than or equal to 25,000 vpd, or greater than 25,000 vpd, respectively. Alternatively, a road segment could also be categorized by future expected volume in order to determine future needed access management treatments.

Step 3: Classify by Signals per Mile

Following classification by volume, the road segment is classified by signal spacing based on whether the segment has 2 or less signals per mile or greater than 2 signals per mile.

Step 4: Classify by Land Use

Depending on the classification of the road segment according to its volume and signals per mile, segments are further classified as having either adjacent commercial or residential land use.

Step 5: Other Classification

Based on the overall characteristics of the road, some road segments are classified according to the potential for future growth. Additionally, high volume arterials with greater than 2 signals per mile are classified according to median type (i.e., raised median or no raised median).

Step 6: Recommended Access Management Treatments

Access management treatments are recommended based on the classification from steps two through five, including limit access density, install raised median, future planning, and no recommendation. The recommendations are summarized in the following subsections.

Limit Access Density

Limiting access density is recommended for five of the 12 subcategories shown in Figure 4. Limiting access density can include consolidating driveways, eliminating driveways, or creating backage roads. This recommendation is given to subcategories where access densities were positively correlated with crash severity scores. While the degree to which these correlations were significant varied based on volume and signals per mile, the primary technique correlated with lower safety was limiting access density.

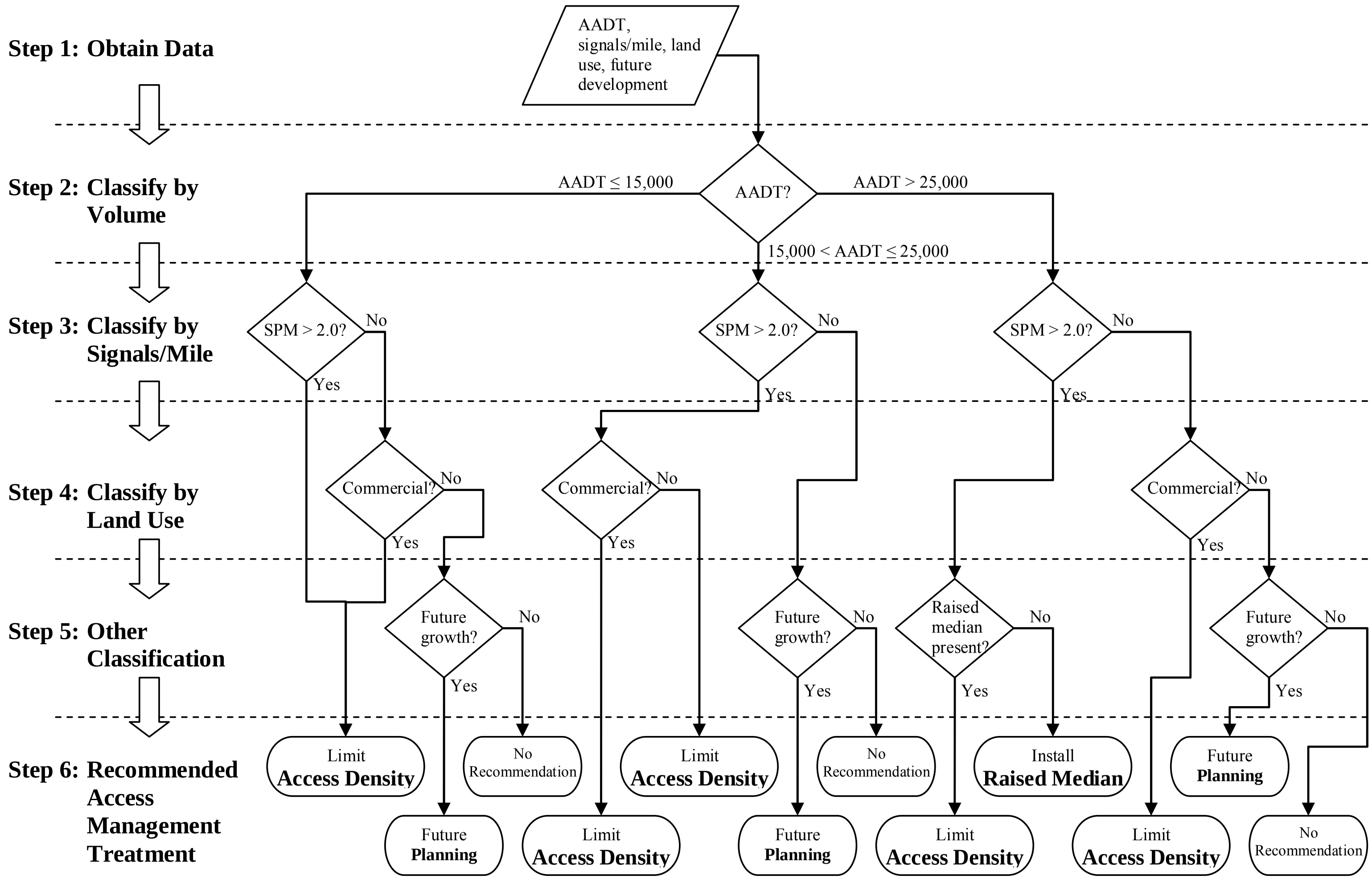

FIGURE 4 Decision tree for determining recommended access management techniques.

Install Raised Medians
As shown in Figure 4, installing a raised median is only recommended in one of the 12 subcategories, namely high-volume segments with more than 2 signals per mile. Statistical analyses showed that raised medians corresponded to lower crash severities than did TWLTLs. This could be due to the fact that as arterials become more congested, more conflict points exist. Furthermore, the more signals that are installed, the more likely these conflict points occur in the functional areas of the signalized intersections, thereby creating a larger need for raised medians.

Future Planning
Future planning is recommended for three of the 12 subcategories shown in Figure 4. Determining future growth and land use changes are critical in planning for safe and effective access management, especially for those roads that are adjacent to undeveloped land. Signal spacing, number of access points, and right-of-way sufficiently large enough for future median treatments are all aspects of a corridor that can be planned well in advance but may be too difficult or costly to change in the future. For example, once a road segment has multiple signals per mile, removing any of those signals would be very difficult. However, by planning the quantity and location of signals on a given corridor years before development is expected, recommended signal spacing can be achieved and maintained.

No Recommendation
Finally, three subcategories out of 12, as shown in Figure 4, are given no recommendation for access management treatments because no correlation between crash severity score and any access management treatment for the road segments contained in these subcategories was apparent. These road segments are those with low signals per mile and little expected future growth. As available funds for access management treatments are limited, it would be recommended that other areas be targeted instead of these road segments.

CONCLUSIONS
This paper has discussed the performance-index-based prioritization process developed to recommend access management principles and techniques for state routes, specifically applied to the state of Utah. A decision tree was developed to classify road segments into smaller subcategories by determining appropriate characteristics and cutoff values to categorize the data. The goal of classifying the data was to find subcategories of road segments with similar characteristics and crash severity scores. This goal was accomplished by collecting existing characteristics and crash histories and determining the impact of access management on the safety of arterial roads. Access management techniques were then recommended for each subcategory based on correlations between access management techniques and crash severity score. The decision tree was illustrated and a step-by-step process for using the decision tree was outlined. 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 included 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. Based on the conclusions of this research, it is recommended that access management be continually implemented on arterial roads in the state of Utah because of the positive impact of access management in reducing crash severity.

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