Title: Use of Decision Assistance Curves in Advanced Warrant Analysis for Indirect Left-Turn Intersections

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ABSTRACT

This paper develops decision assistance curves (DAC) to compare delay-based performance measures for three indirect left turn (ILT) intersections, namely median U-turn (MUT), continuous flow intersection (CFI), and jughandle, relative to a conventional signalized intersection. The DACs consist of two graphical tools: (i) DAC-classifier and (ii) two sets of DAC-contours. DAC-classifier plots are used to select the intersection type that produces the minimum system average delay for a specified main and cross-street volume configuration. DAC-contour plots are used to estimate the system average delay difference between a chosen ILT and a conventional signalized intersection as well as to estimate the increase in average delay as compared to a conventional signalized intersection for the most negatively impacted movement. These tools can be used by planners, engineers, or other decision makers to visually identify the intersection type that provides the least average system delay under given volume conditions as well as estimated tradeoffs for choosing a specific intersection type. It was found that the conventional signalized intersection, with protected left turns, was never optimal under studied scenarios. This implies that, for all the studied conditions, there exists at least one ILT or permitted left turn alternative that produces lower delay than the conventional signalized intersection.

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INTRODUCTION

One method available to address conventional intersections that fail to meet expected levels of operation and safety is to employ an indirect left turn (ILT) configuration. Multiple ILT designs are available that will result in lower system delays for a range of volume configurations. Given the choices available, a tool that allows a user to quickly screen the ILT alternatives for prevailing conditions of traffic, geometry, and control prior to embarking on time consuming microscopic-level investigation would be useful. This study develops such a graphical tool, named decision assistance curves (DAC), to provide a high-level screening for easier selection of an applicable ILT configuration using delay-based performance criteria.

This tool consists of two graphical elements. First, the DAC-classifier is a plot that can be used to select an intersection type that will minimize system average delay for specific main and cross-street volume configurations. Second, the DAC-contour plots, consisting of two separate graphical elements, are used to compare the average system delay between a chosen ILT and a conventional intersection, as well as estimate the increase in delay for the most impacted movement under a specific volume condition. The most impacted movement is defined as the movement that will likely see the most decrease in performance with the implementation of an ILT configuration, typically a left turn movement. Using these plots, a decision maker can easily analyze the performance of AM-peak, PM-peak, and off-peak conditions by plotting points on the DAC plots. In addition, a set of nomograph curves are also developed to graphically estimate performance as volume increases at a given growth rate. This nomograph, in conjunction with the DACs, can be used to perform a quick life cycle analysis for a selected ILT. While this study is focused specifically on three ILT intersections (Figure1): (i) median U-turn (MUT) (ii) continuous flow intersection (CFI) and (iii) jughandle , the proposed approach can easily be extended to include other alternative intersection types.

LITERATURE REVIEW

There is a significant body of literature that reports superior performance for ILT intersections, such as MUT, CFI and jughandles, as compared to a conventional intersection under a range of volume conditions. In this context, several studies *(1, 2, 3, 4, and 5)* have mentioned that MUT intersections have superior performance to conventional intersections in terms of capacity and delay. Several studies *(3, 4, 5, 6, and 7)* have also mentioned that MUT intersections have better performance than conventional intersections in terms of overall travel efficiency. Similarly, several studies *(8, 9, 10, 11, 12, 13 and 14)* have favored CFI over conventional and other types of intersections in terms of capacity, delay, and travel efficiency. Likewise, some studies *(15, 16)* have also found the operational performance of jughandles to be superior to that of conventional intersections.

There are very few decision assistance tools available to quickly compare multiple ILTs and quantify system- and movement-level performance. The existing tools either produce very simplistic performance measures or are very time consuming to use. This section provides a brief overview of the tools available to planners to choose an appropriate ILT for a given intersection.

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Most studies use micro-simulation tools to compare operational performance of ILT intersections (*5, 6, 8, 10, 12, 16, and 17).* These studies invest significant resources into running the micro-simulation models.

Some of the time consuming steps involved in performing micro-simulation runs are as follows:

i. Collecting and coding very detailed data on origin-destination (O-D) volumes and signal control inputs.
ii. Calibrating models to replicate observed driver behavior.
iii. Performing multiple runs for different volume scenarios. For example, 1,920 simulation runs are needed to evaluate 24 hourly volumes over a design life of 20 years for 4 intersection types, a reasonable effort required to adequately analyze a system.
iv. Lastly, given the amount of data that a simulation analysis produces, examining the results and reporting the decision choice can be very time consuming.

No tools exist that automate steps three and four described above. These steps need to be performed manually by the investigator for every new evaluation.

Several studies have developed statistical models that predict the micro-simulation–generated performance measures using a range of volume-based input variables *(15, 18, and 19)*. These models reduce the time spent in step three listed above, but steps one and four would still be time consuming. These statistical models also must be re-calibrated and re-evaluated prior to transferring the analysis to new conditions.

Another set of tools used for decision assistance are based on simplistic critical lane volume analysis. Examples of such tools include (i) Intersection Design Alternative Tool (IDAT), (ii) Alternative Intersection Selection Tool (AIST), and (iii) Capacity Analysis and Planning of Junctions (CAP-X). These MS Excel–based tools compare multiple intersection types on the basis of volume-to-capacity ratios generated using critical lane volume analysis *(20, 21, 22, and 23)*. The drawback for such tools is that the volume-to-capacity ratio is a very simplistic performance measure. In addition, the volume-to-capacity ratio is a concept that is not easily understood by decision makers or the general public and hence it is challenging to use it to communicate the results. Additionally, these ratios cannot easily be monetized to perform a benefit-to-cost analysis for the selected ILT.

Highway Capacity Software (HCS) can also be used to compare the performance of multiple ILTs. The benefits of using HCS as a screening tool are as follows:

i. HCS is faster than micro-simulation in generating estimates of performance measures.
ii. HCS is based on multiple studies conducted throughout United States. HCS uses results from these studies to generate appropriate calibration factors to calibrate itself for existing operating conditions.
iii. HCS produces several important performance measures such as delay and stops that can be easily understood and monetized.

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The software version available at the time of this study, HCS 2010 version 6.50, does not allow direct coding of ILTs, though there is a plan to include the direct coding of ILTs in the next release of the software. However, a few studies have used indirect techniques to successfully code ILTs in HCS *(24, 25)*. Despite the benefits listed above, completing multiple runs of HCS can be time consuming. Additionally, there are no tools that can quickly compile and report the performance of different ILTs for a given intersection.

The purpose of the DAC plots developed in this work is to combine the quick comparison abilities of critical lane volume tools with the more relevant performance measures, such as delay, as generated by HCS. The planners can use these curves to make their decisions about implementing ILTs instead of running HCS models individually for their respective demands. Subsequent sections of this paper will discuss the development of the DACs followed by a descriptive example illustrating the use of the tool.

DEVELOPMENT OF DECISION ASSISTANCE CURVES

The underlying principle of DAC is to synthesize important performance measures generated by the investigation of several thousand volume configurations and intersection types into easy-to-use plots. The performance measure (delay) was estimated using HCS 2010 for assumed volume levels for suburban road conditions. The steps taken to generate the DAC elements are listed below.

Step 1: Select Geometric, Speed, and Volume Configurations

The geometric configurations analyzed for this study are limited to three ILT intersections shown in Figure 1: the MUT, CFI, and jughandle. The MUT configuration, shown in Figure 1a, involves two stop-controlled median openings and a core signalized intersection with left turn restrictions for all approaches. The offset of median opening was fixed at 660 ft. The median width was kept fixed at 60 ft. to accommodate a tractor-semitrailer combination of trucks as the design vehicle. The CFI configuration, shown in Figure 1b, involves one core intersection and four other crossover intersections, which are all signalized. The left turners are diverted from the through vehicle stream at crossovers located at about 300 ft. to 400 ft. upstream of the core intersection. For the jughandle, shown in Figure 1c, this study is focused on the reverse/reverse (R/R) configuration. This ILT allows protected left turn movements from the minor street, but left turn movements from the major street depart the core signalized intersection through the ramps to the right, past the core intersection. The offsets of the crossovers are 170 ft. along the major street and 150 ft. along the minor street. Lastly, this study has also investigated the operations of a standard signalized intersection with all protected left turn movements (LT-protected), along with permitted left turns on the major street (LT-permitted). Thus, a total of five geometric/control configurations were explored for performance.

From a speed standpoint, because this study focused on the operation of suburban roads, the operating speeds at the intersections and crossovers were selected to reflect a reasonable suburban road speed. As such, the operating speed of the major street was fixed at 45 mph, and the operating speed of the minor street was fixed at 35 mph.

For volumes, bidirectional major street volumes ranging from 50 vehicles per hour (vph) to 2,400 vph in 50 vph increments were considered. For the minor street, unidirectional volumes ranging from 25 vph to 250 vph in increments of 25 vph were considered. In addition to the quantity of vehicles analyzed, the balance of traffic between approaches on a street was considered

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as well. The balance factor (BF) is defined as the ratio of the approach carrying the higher volume to the total approach volume. Three levels of balance factors, 0.5, 0.6, and 0.7, were considered for the major street. The balance factor for the minor street was kept fixed at 0.5. Also, three levels of left turn percentages (LTP) were considered for the major street, 5%, 10%, and 15%, while the left turn percentage for the minor street was kept fixed at 5%. Lastly, three levels of truck percentages (TP) were considered, 2%, 5%, and 10%. These were used for all approaches. Based on the directional splits (balance factor) and turn percentages, an origin-destination volume database for all volume combinations was constructed for all five types of intersections. The combination of all these levels of variable parameters produced a total of 12, 960 different volume configurations for each intersection.

Step 2: Estimation of Performance Measures: O-D–based Delay

The control delay for each movement at all the signalized crossovers and intersections was estimated with HCS. The travel delay, delay at the median openings of the MUT, and delay at the north and south crossovers of the jughandle were estimated separately and later added to get the total delay for each movement. Standard M/M/1 queueing theory was utilized to estimate the delay at the median openings of the MUT and the north and south crossovers of the jughandle. This method uses a Poisson distribution to model the arrival flow and an exponential distribution to model the user service. By summing together the two quantities for a given movement (control delay and queue delay), the average total delay for each movement (seconds per vehicle), average total intersection delay (seconds per vehicle) and total intersection delay (vehicle minutes) are calculated.

Step 3: Results Synthesis and Visualization

There are three questions that need to be answered prior to the selection of a specific intersection type for a given location:

(i) *Which intersection produces the minimum system delay for a given volume configuration?* Various time periods should be analyzed, including peak, off-peak, and special event volume conditions along with projected growth.

(ii) *What is the aggregate delay saving over a conventional signal?* This number can then be monetized to estimate the net fiscal benefits of the system for cost/benefit analysis.

(iii) *How much delay is added, if any, to the worst impacted movement*? In the case of the MUT and jughandle intersections, left turning vehicles have to cover additional distances and can be negatively impacted, despite the overall net benefits in reduced system delay.

A tool synthesizing performance measures obtained in Step 2 can be used by decision makers to answer the above three questions. Graphical tools have an advantage over tabular tools in that they are easy to use and can provide a holistic perspective to the problem. Two graphical tools were designed to synthesize the solution database for answering the above three questions. DAC-classifier plots address the first question regarding the preferred intersection type. Questions two and three are addressed with a set of two DAC-contour plots. Lastly, a set of nomograph

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curves are also produced to help graphically estimate performance over time as volume increases at a given growth rate.

DAC-Classifier Plots

Figure 2 shows a DAC classifier plot for the selection of the best performing alternative intersection type out of the ones addressed here. This plot uses a balance factor of 0.5, a left turn percentage of 15% on the major street, and a truck percentage of 5%. To use this classifier plot, the user simply plots a point for where the main street and minor street volumes intersect, Point A in this plot (major street volume of 1,900 vph; minor street volume of 150 vph). The only regions appearing on the plot are MUT, jughandle, and a LT-permitted conventional signal, separated by threshold curves. These regions indicate that the identified intersection/control types produce minimum system delay after all the five alternatives are compared. In other words, the CFI and LT-protected options are never optimal when compared against the remaining options. This classifier plot with the given volumes yields a jughandle configuration.

To develop the DAC classifier plot, the total intersection delay, in vehicle-minutes, of all five geometric/control combinations were compared for a given volume configuration. The geometric/control combinations producing minimal delay were noted for that specific volume combination. Likewise, the optimal intersection was assigned based on minimal delay production to each of the 12,960 volume data combinations. A matrix of intersection types producing minimum system delay for all of the volume conditions was generated using the database. Quadratic discriminant analysis (QDA) was then used to generate classifier boundaries to differentiate between the regions of optimality of a given intersection type under a certain volume configuration. QDA was chosen over linear discriminant analysis (LDA) because of three main reasons: First, QDA allows more flexibility for the covariance matrix for each class. Second, the boundary lines as observed from scatter plots were not linear. Third, QDA classified the clusters very accurately. DAC classifier plots were developed for all 27 combinations of balance factor, truck percentage, and left turn percentage. The performance of classifiers was tested using a precision and accuracy metric for each classifier. The accuracy is the proportion of true results to the total population. The precision is the proportion of true positives to the total predicted positives. Both precision and accuracy were greater than 95% for all of the classification boundaries.

DAC-Contour Plots

DAC-contour plots were developed to provide quantitative estimates of delay savings or dis-benefits to a specific movement within a chosen alternative. MUT, CFI, jughandle, and LT-permitted system delay differences from an LT-protected intersection were calculated for all volume combinations. Contour plots for major-minor volume configurations were generated for different balance factors and left turn and truck percentages. An example contour plot corresponding to total intersection delay loss or savings for MUT (versus an LT-protected intersection) is shown in Figure 3 with a balance factor of 0.7, left turn percentage of 15%, and truck percentage of 10%. In the contour plot, the positive magnitude of a contour represents a delay loss versus the base intersection (LT-protected), and the negative magnitude of a contour represents delay savings. Point A in Figure 3 lies on the contour of magnitude -3.5. Thus, a jughandle will have total intersection delay savings over an LT-protected intersection of 3.5 seconds/vehicle for the given volume configuration. Multiple time periods, presuming they have

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similar overall volume characteristics (balance factor and truck and turning percentages), can be easily evaluated by plotting multiple points on the same contour map.

Another set of DAC-contours are plotted that show the increase in delay on the most impacted movement when a particular ILT increases the delay of a particular movement. For example, Point A in Figure 4 lies on the contour of magnitude 6. Thus, the most impacted left turn movement for the jughandle has an additional delay of 6 seconds/vehicle over an LT-protected conventional intersection.

Growth Nomographs

A set of nomograph curves were also developed to graphically estimate intersection performance over time as the volume increases at a given growth rate. Figure 5 is the growth nomograph for a 2% annual growth rate for both major and minor street approach volumes. The curves on the lower half represent the 2% increase lines. For example, if the volume on the major street was 1,600 vph in year zero, the volumes in the subsequent years can be estimated by following the bold curve on the nomograph, highlighted in the lower half of the figure.

The complete use of the nomograph and DAC-contour can be shown by the following example. If the base year total major street approach volume is 1,600 vph and the minor street approach volume is 250 vph, Point A is the location of those volume criteria on the contour plot. From the location of Point A on the contour, it can be observed that the total intersection delay savings will be about 5.5 seconds/vehicle in the base year. If the increase in minor street approach volume is considered to be the same 2%, the line joining the origin and Point A represents the trend line. The delay savings for any other projected volume can be estimated by locating the respective points on the trend line. For example, Point B represents delay savings at the projected volume during the 10th year, about 3.5 seconds/vehicle. Similarly, the year at which MUT will fail if the volume is increased by the same rate can also be located on the plot by finding the point where the trend line meets the contour of magnitude 999 (MUT failure condition) in the contour space and then finding the corresponding year from the projection nomograph, shown in the lower half of the figure. In this example, the failure condition under these volume criteria will occur after 15.5 years.

If major street approach volume and minor street approach volume increase with different rates, it is also possible to get the delay savings for the projected volume by using the same projection plot and contour plot. The slope of the trend line for this case can be estimated from the following equation:

$$Slope\ of\ Projection\ Line = \frac{Y \times \left(1 + \frac{n}{100}\right) - Y}{X \times \left(1 + \frac{m}{100}\right) - X} = \frac{Yn}{Xm} \qquad 1$$

where X is the total major street approach volume for the base year, Y is the total minor street total approach volume for the base year, m is the annual percentage increment of the major street approach volume, and n is the annual percentage increment of the minor street approach volume.

HOLISTIC PATTERN OBSERVED IN DAC-CLASSIFICATION PLOTS

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The following holistic patterns were observed by plotting all 27 combinations of DAC-classifiers, shown in Figures 6 through 9 and Table 1.

MUT produced the minimum system delay for all combinations of volumes for a low left turn percentage (5%), except for a small region. Figure 6 shows an example DAC-classifier curve for a balance factor of 0.5, a left turn percentage of 5%, and a 2% truck percentage. As can be seen in the figure, MUT produces minimum delay for all but a small linear range at the bottom of the figure with a minor street volume of 50 vph and a major street volume ranging from 900–1,350 vph. A signalized intersection with a permitted left turn on the major street produces the minimum delay for this volume range. Table 1 lists nine scenarios, similar to the one described above, where MUT is optimal for the whole region except for the small range at the bottom. In this small range, noted in column 2, a signalized intersection with a permitted left turn on the major street produces the minimum delay. This implies that MUT produces minimum system delay for almost one-third of all studied volume scenarios and thus is the most dominant intersection type in producing minimum delays.

As the left turn percentages on the major movement start to go beyond 5%, jughandle and CFI starting gaining some regions of optimality. Figures 7 through 9 are plotted for an increasing order of truck percentages of 2%, 5%, and 10%, respectively. The left half of each figure represents a 10% left turn percentage on the major street, whereas right half represents a 15% left turn percentage. The balance factor increases starting at 0.5 at the top and ending at 0.7 at the bottom of each figure. In all of these figures, MUT covers the most region of optimality. Additionally, a very important point to be noted is that the conventional signalized intersection never shows up as optimal under any scenario of the studied volume conditions. This implies that for all of the studied conditions there exists at least one ILT or permitted left turn alternative that produces lower delay than a left turn protected intersection.

Jughandles cover the second largest region of optimality. The region of jughandle expands and cuts into the region of MUT as the left turn percentages or the balance factor increases (as shown in Figures 7a, 7b, and 7c). The increase in the dominance of jughandles with increasing left turn percentages is due to the principles of gap acceptance behavior of the turning movements. The gap acceptance threshold and follow-up headway for a U-turn movement, in MUT, is greater than those for right turn merging in jughandles. The MUT U-turn reaches its capacity much more quickly than a jughandle, and beyond this threshold MUT produces prohibitively high delays and loses its optimality. For 10% left turn traffic, the area of optimal performance of jughandles increases with the minor street approach volume for the balance factors of 0.5 and 0.6. However, this area decreases with the total minor street approach volume for the balance factor of 0.7 for the 10% left turn traffic condition and for the balance factors of 0.6 and 0.7 for the 15% left turn traffic condition.

CFI becomes optimal when either the left turn percentage or the balance factors are significantly higher for a high total major street approach volume. In these regions, merging from the right ramp starts producing excessive delays, and hence CFI gains optimality (as shown in Figures 7c, 7e, and 7f). The area of optimal performance of CFI increases with an increasing total minor street approach volume.

The impact of an increase in truck percentages can be visualized by comparing Figures 7 through 9. Trucks usually have higher gap acceptance thresholds and follow-up headways and therefore can increase the region of optimality for CFI, which provides protected left turn movements with cycle lengths lower than those of a conventional signalized intersection.

CONCLUSION

This study developed decision assistance curves to compare delay-based performance measures for three ILTs, MUT, CFI and jughandle, relative to a conventional signalized intersection.

Specific patterns were observed after developing the DAC-classifier plots. For low left turn traffic conditions, MUT was warranted for all volume criteria. For medium left turn traffic conditions when the flow was balanced in two directions on the major street, jughandle was warranted for a high major street approach volume. For the same left turn traffic conditions with unbalanced flow in both directions on the major street, CFI was warranted for a high major street approach volume and a high minor street approach volume. Jughandle was warranted for a high major street approach volume and a low minor street approach volume. The standard signalized intersection with left turn permitted was warranted for a low minor street approach volume and a low range of major street approach volumes. The presence of trucks favored the use of CFI as an ILT intersection treatment. For most volume criteria for all conditions of flow balance, left turn percentage, and truck percentage, MUT is the preferred alternative. Additionally, it was found that the conventional signalized intersection, with protected left turns, was never optimal under the studied scenarios. This implies that, for all of the studied conditions, there exists at least one ILT or permitted left turn alternative that produces lower delay than the conventional signal. The methodology developed in this paper can easily be extended to evaluate other alternate intersection types and can replace some of the existing warrant analysis curves.

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LIST OF TABLES AND FIGURES

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FIGURE 9 DAC at medium and high left turn percentages at truck percentage 10%

TABLE 1 Total Major Street Approach Volume Range for Optimality of Standard Signalized Intersection with Left Turn Permitted along Major Street

Combinations	**Total Major Street Approach Volume Ranges for Standard Signalized Intersection with LT Permitted along Major Street (vph)**
BF= 0.5, LTP = 5%, TP = 2%	900–1,350
BF= 0.5, LTP = 5%, TP = 5%	900–1,350
BF= 0.5, LTP = 5%, TP = 10%	850–1,350
BF= 0.6, LTP = 5%, TP = 2%	800–1,100
BF= 0.6, LTP = 5%, TP = 5%	750–1,100
BF= 0.6, LTP = 5%, TP = 10%	750–1,100
BF= 0.7, LTP = 5%, TP = 2%	700–950

BF= 0.7, LTP = 5%, TP = 5%	650–950
BF= 0.7, LTP = 5%, TP = 10%	700–950

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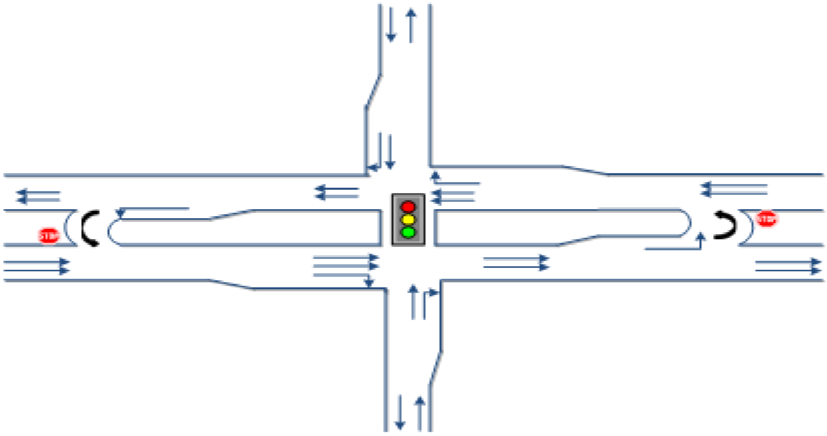
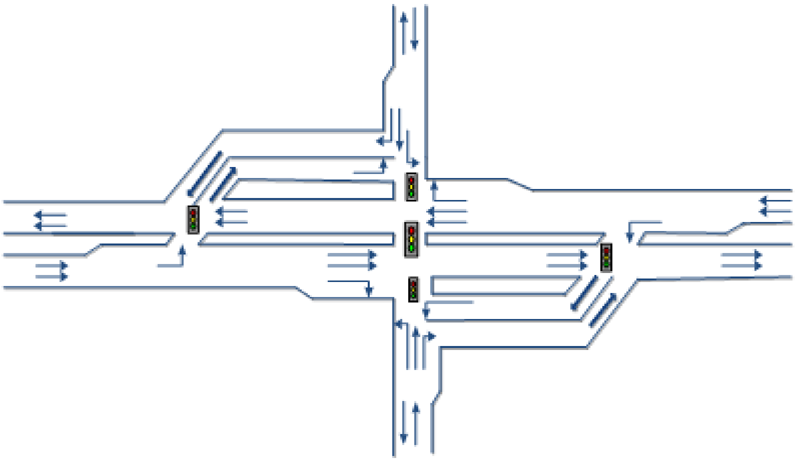
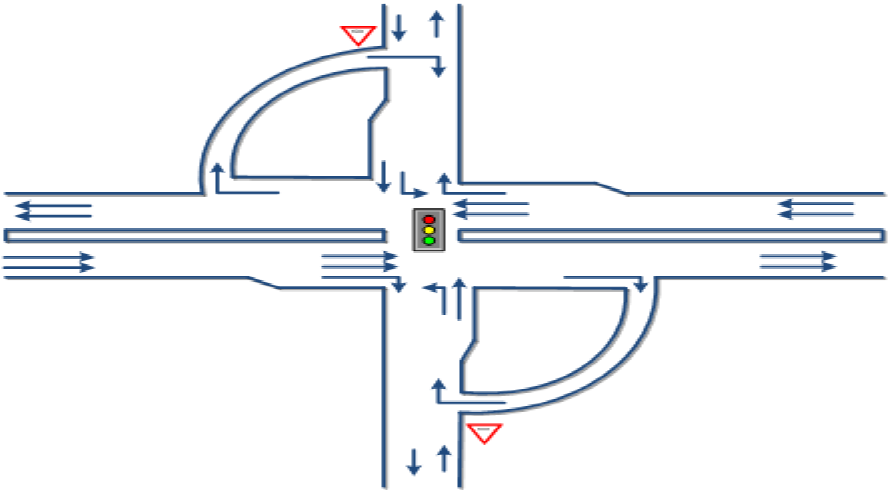


a. Median U-Turn



b. Continuous Flow Intersection - CFI



c. Jughandle (Reverse/Reverse)

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FIGURE 1 Studied indirect left turn intersections

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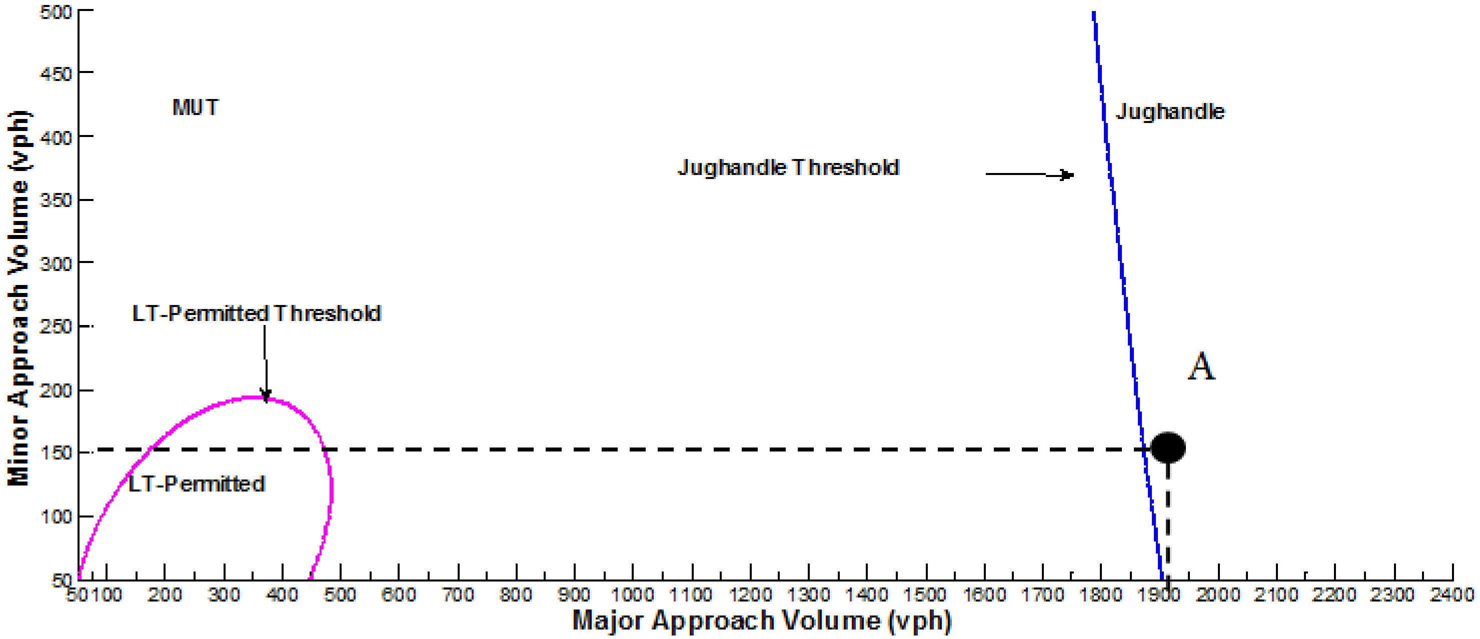

FIGURE 2 DAC-classifier plot for balance factor of 0.5, left turn percentage of 15%, and truck percentage of 5%

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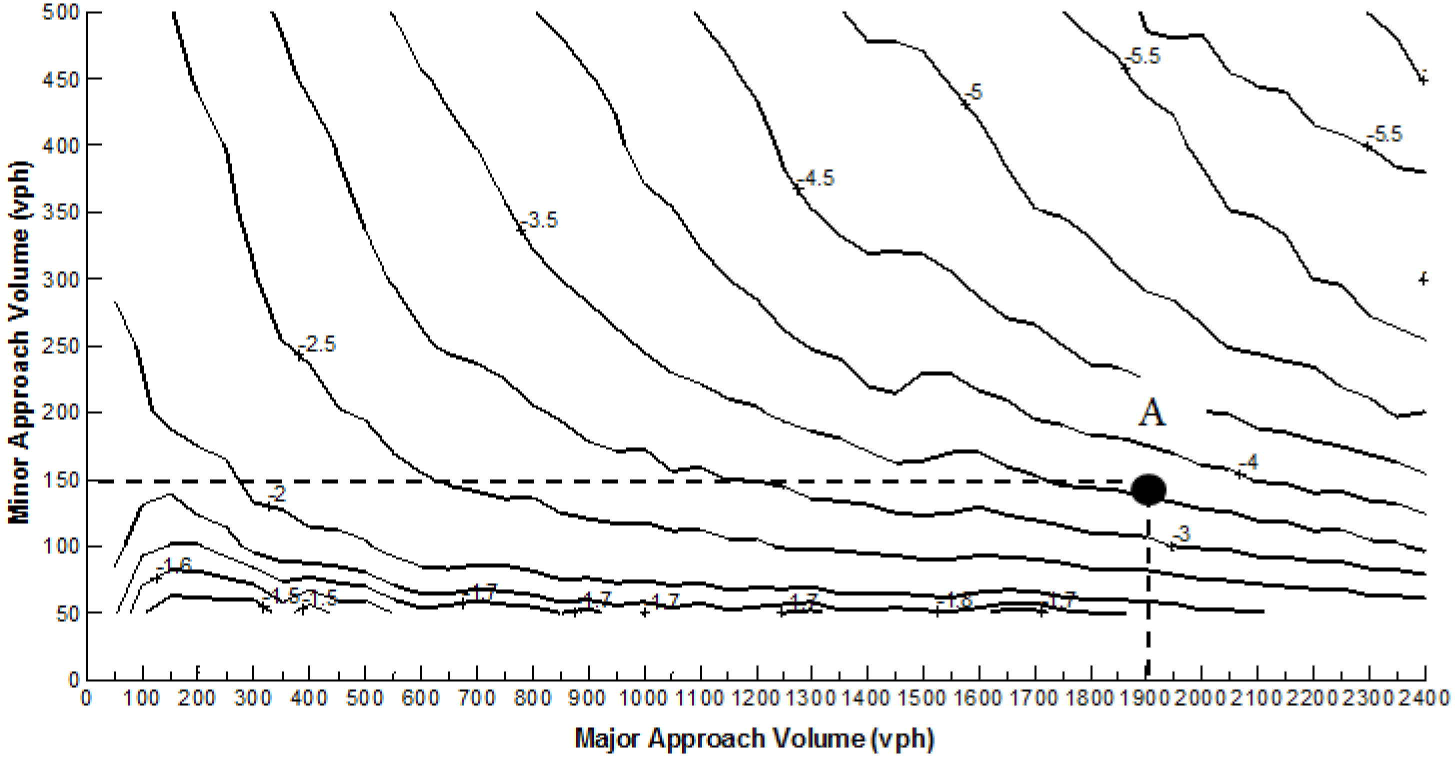

FIGURE 3 DAC-contour plot of jughandle for total intersection delay savings or loss at balance factor 0.5, left turn percentage 15%, and truck percentage 5%

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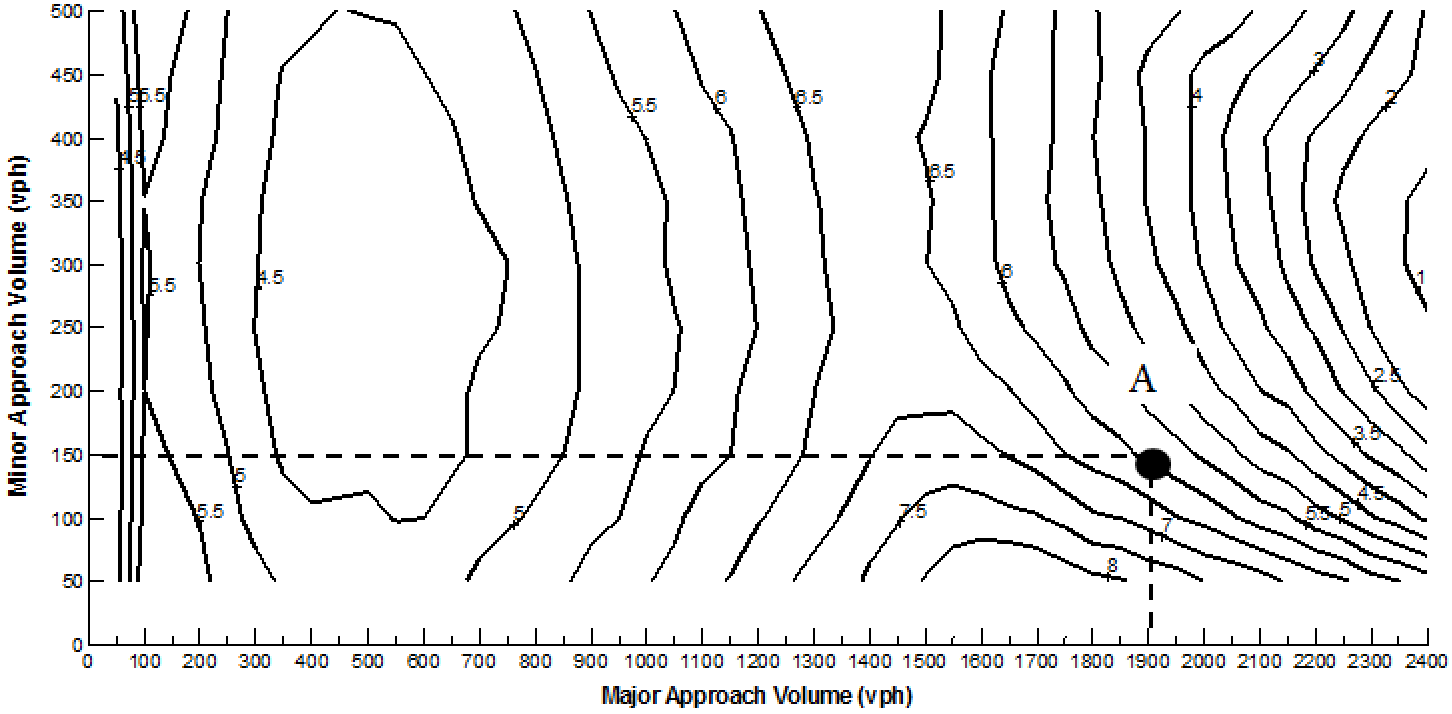

FIGURE 4 DAC-contour plot of jughandle for critical left turn delay savings or loss at balance factor 0.5, left turn percentage 15%, and truck percentage 5%

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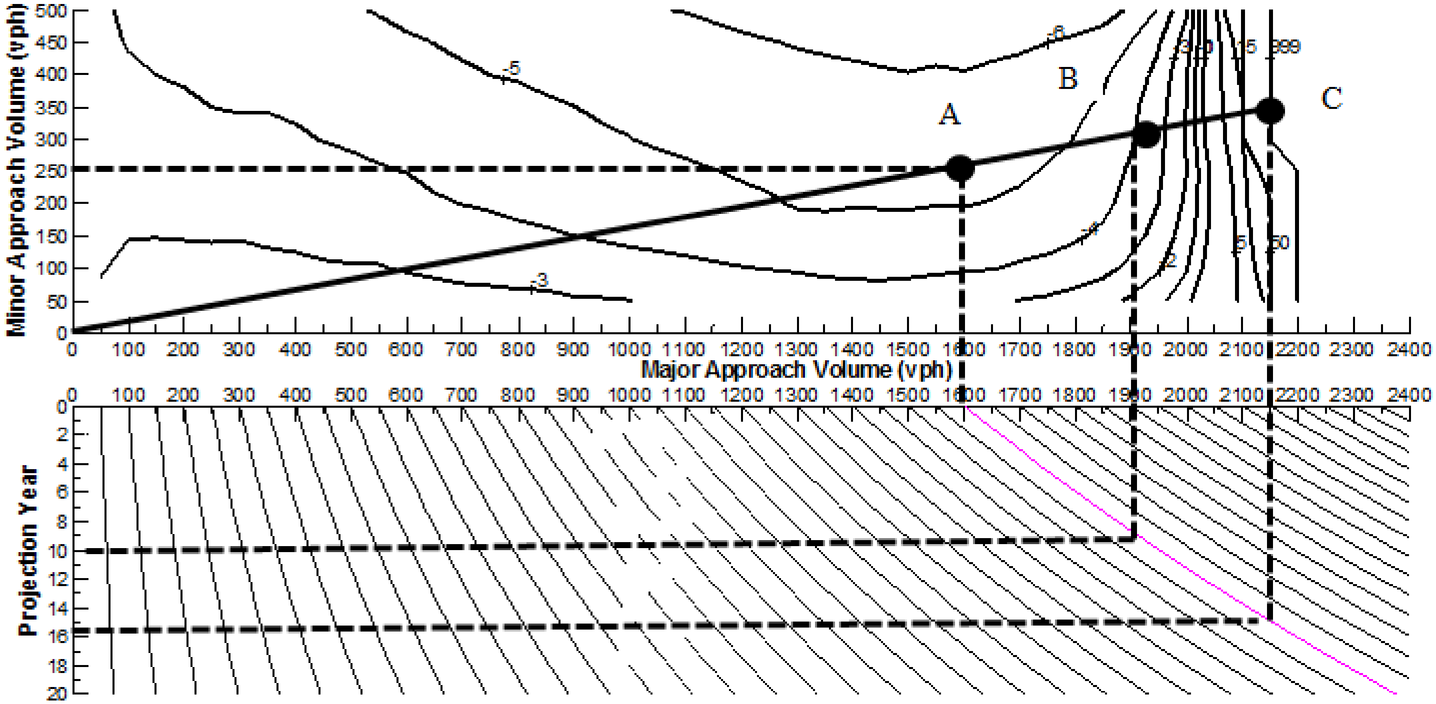


FIGURE 5 Delay savings for projected volumes for MUT total intersection delay savings or loss at balance factor 0.7, left turn percentage 15%, and truck percentage 10%

.

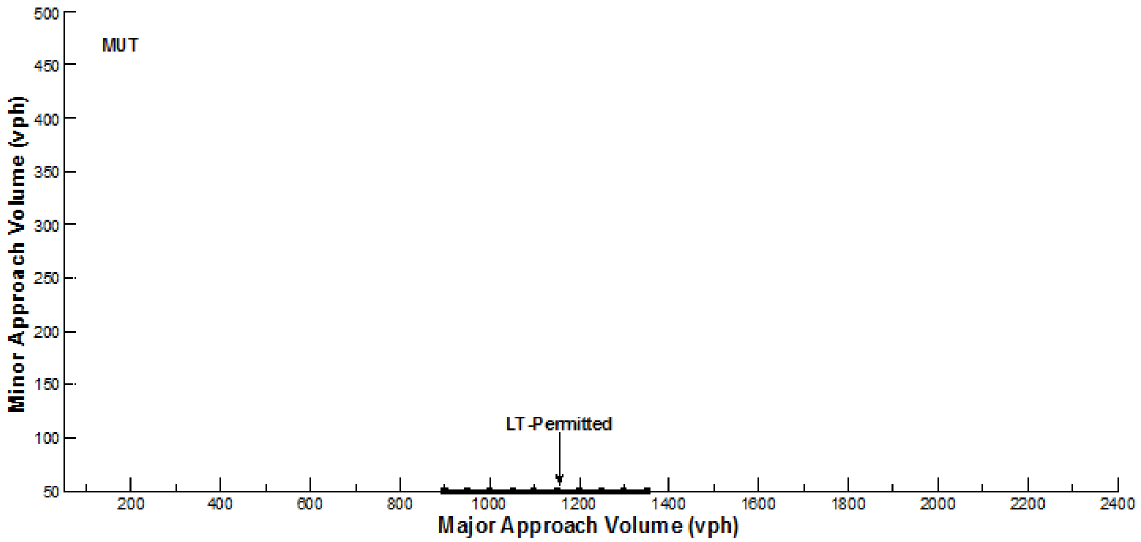
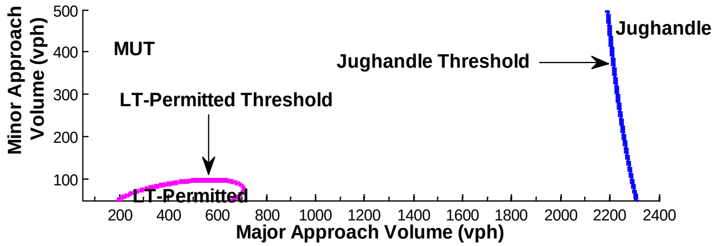
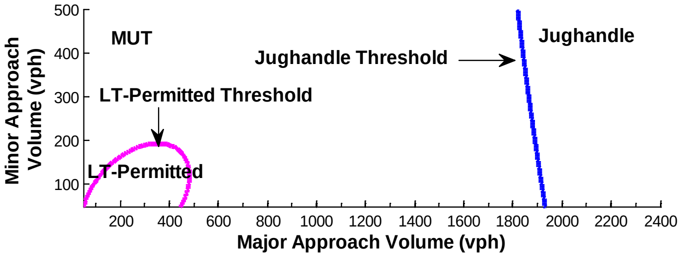


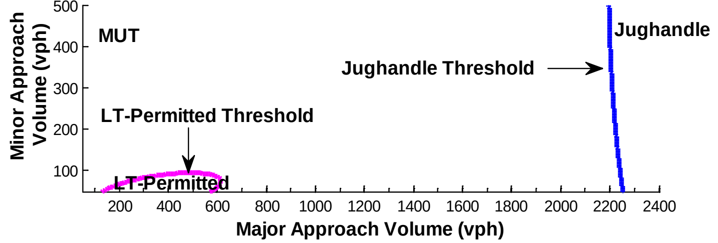
FIGURE 6 Representative DAC at a low left turn percentage (balance factor 0.5, left turn percentage 5%, truck percentage 2%)



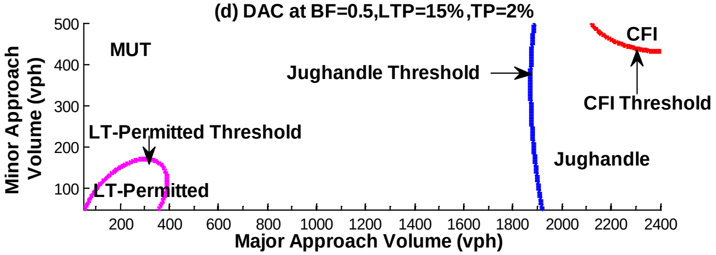
(a) DAC at BF=0.5,LTP=10%,TP=2%



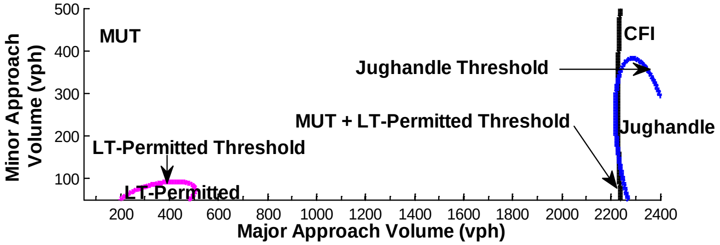
(d) DAC at BF=0.5,LTP=15%,TP=2%



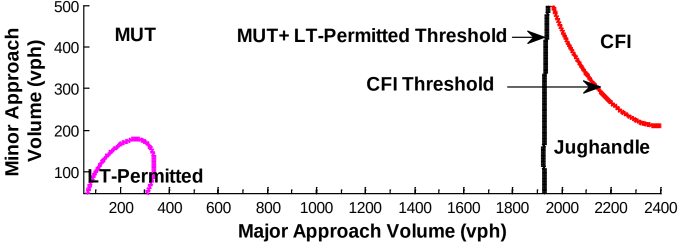
(b) DAC at BF=0.6,LTP=10%,TP=2%



(e) DAC at BF=0.6,LTP=15%,TP=2%

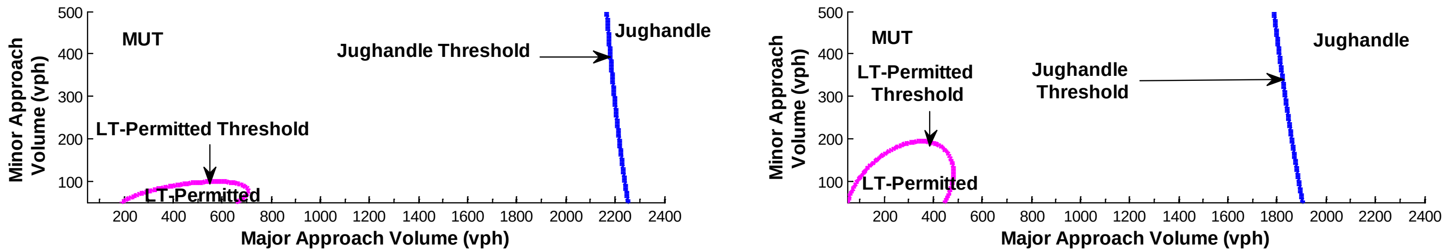


(c) DAC at BF=0.7,LTP=10%,TP=2%



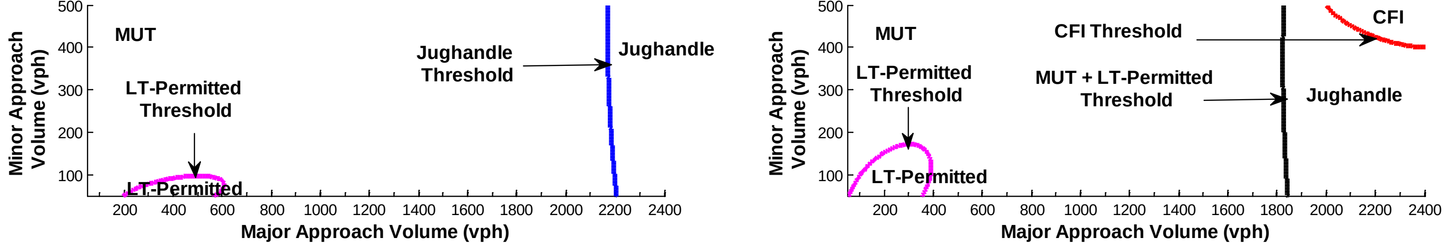
(f) DAC at BF=0.7,LTP=15%,TP=2%}

FIGURE 7 DAC at medium and high left turn percentages at truck percentage 2%



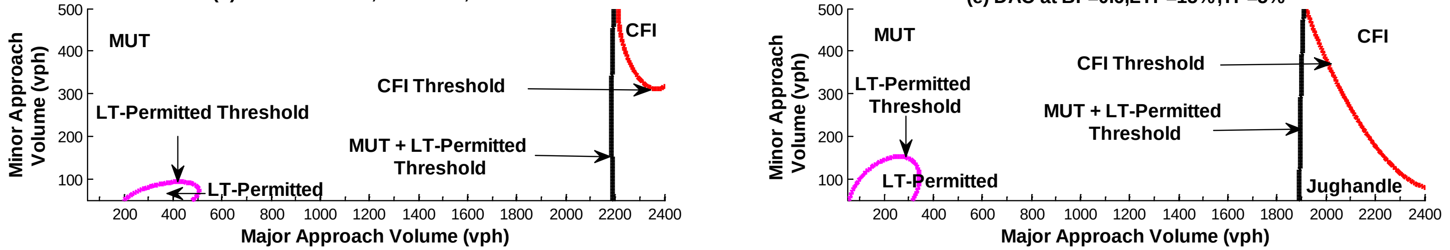
(a) DAC at BF=0.5,LTP=10%,TP=5%

(d) DAC at BF=0.5,LTP=15%,TP=5%



(b) DAC at BF=0.6,LTP=10%,TP=5%

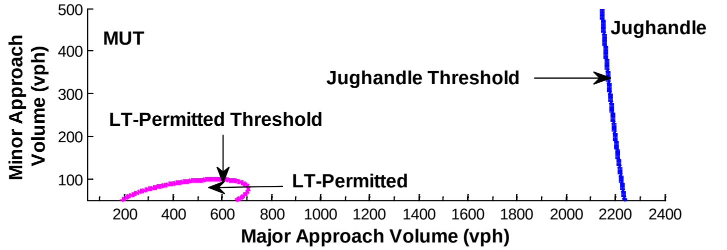
(e) DAC at BF=0.6,LTP=15%,TP=5%



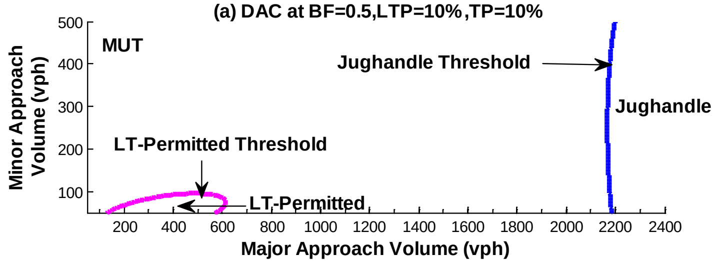
(c) DAC at BF=0.7,LTP=10%,TP=5%

(f) DAC at BF=0.7,LTP=15%,TP=5%

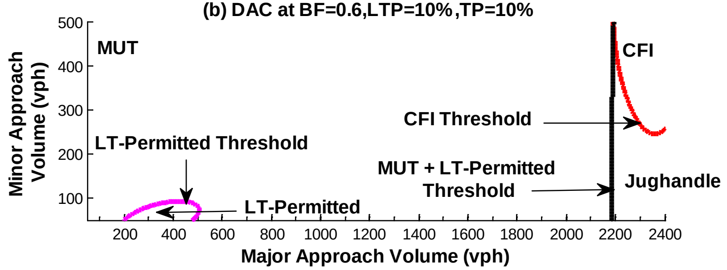
FIGURE 8 DAC at medium and high left turn percentages at truck percentage 5%



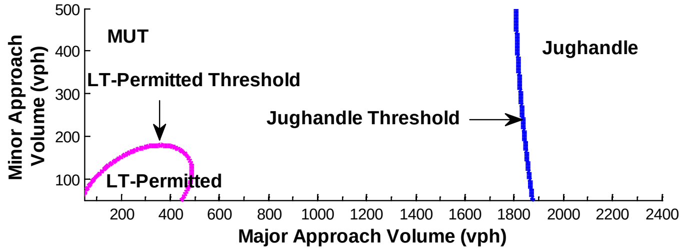
(a) DAC at BF=0.5,LTP=10%,TP=10%



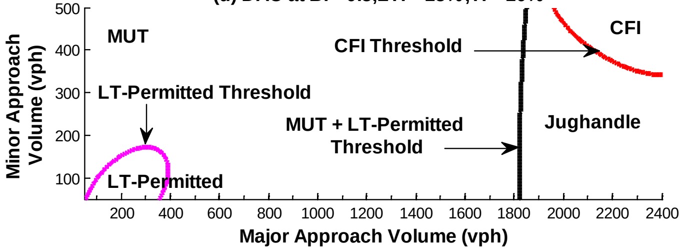
(b) DAC at BF=0.6,LTP=10%,TP=10%



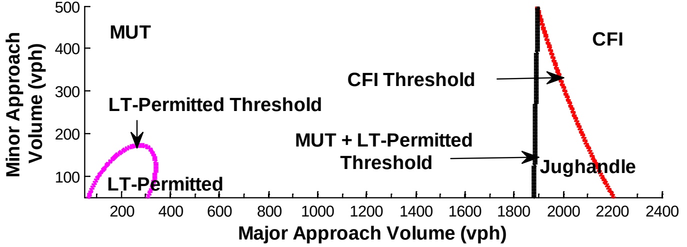
(c) DAC at BF=0.7,LTP=10%,TP=10%



(d) DAC at BF=0.5,LTP=15%,TP=10%



(e) DAC at BF=0.6,LTP=15%,TP=10%



(f) DAC at BF=0.7,LTP=15%,TP=10%

FIGURE 9 DAC at medium and high left turn percentages at truck percentage 10%