INTERSECTION CONTROL EVALUATION (ICE)

Definition and Purpose

Engineers have an increasing number of options for intersection traffic control than they had in the past. Previously, the only solution to traffic delay and safety problems for at grade intersections was the installation of a traffic signal. Today, the engineer has a much wider number of options to choose from. Depending on a number of factors, the optimal choice for intersection control may not be a traffic signal. Therefore, it is imperative that an Intersection Control Evaluation (ICE) study be conducted during the planning phase of any intersection improvement project. Previously, Signal Justification Reports (SJR's) must be completed before a new signal or significant modification of a signal can proceed (MN MUTCD May, 2005 and Mn/DOT Traffic Engineering Manual updated July 1, 2003). An ICE would incorporate and expand the current process. All intersection treatments must be considered in the planning phase.

In order to determine the optimal intersection control strategy, the overall design of the intersection must be considered. The flexibility of significant change in intersection design will largely be decided by the scope and location of the project. Some general objectives for good intersection design that should be considered are:

- Provide adequate sight distance
- Minimize points of conflict
- Simplify conflict areas
- Limit conflict frequency
- Minimize the severity of conflicts
- Minimize delay
- Provide acceptable capacity

An ICE is not required for intersections that are determined to need minimal traffic control (two way stop or no control). However, for any other type of control (All way stop, roundabout, traffic signal, median treatment to reduce traffic movements or other advanced traffic control systems (continuous flow intersections)) an ICE is required.

The ICE report documents why a certain type of intersection control is preferred. It must also document why other types of intersection control were considered but were not recommended for the location. The report documents the engineering study and where engineering judgment was used to justify the recommended traffic control. The report should also show that the intersection control will improve the overall safety and/or operation of an intersection and be in the public's best interest. The goal is to select the optimal control for an intersection based on an objective analysis for the existing conditions and future needs. For some intersections a corridor analysis will be necessary. This will depend on the location of the intersection in relation to adjacent intersections and their respective traffic control.

Generally, intersection improvement projects are developed as a portion of a much larger project or as a safety or capacity project at a specific location. For smaller projects, the proposed intersection traffic control modification is usually the major component of these types of projects and the ICE process will have a major impact in the development process. However, as part of a larger project, intersection control treatments may be a much smaller component and other project decisions will have more impact on how ICE will proceed. It is important to emphasize that the ICE process occur as early in the project development process as practical so that the project proceeds smoothly.

Depending on a project's complexity and scope, a detailed ICE report may be unnecessary. The District Traffic Engineer in coordination with District management can reduce the amount of analysis and documentation if a preferred alternative is obvious. However, these decisions should be documented in the modified ICE report.

An ICE must be written under the supervision of a licensed Professional Engineer in the State of Minnesota and approved by the District Traffic Engineer before the preliminary plan is finalized.

ICE fits into the project development process as shown in Figure 1. The Intersection Control Evaluation study should be completed as indicated in conjunction with the development of the signed staff approved layout. Each District may have a slightly different approach to the timing of each portion of study depending on the complexity and size of the project being proposed.

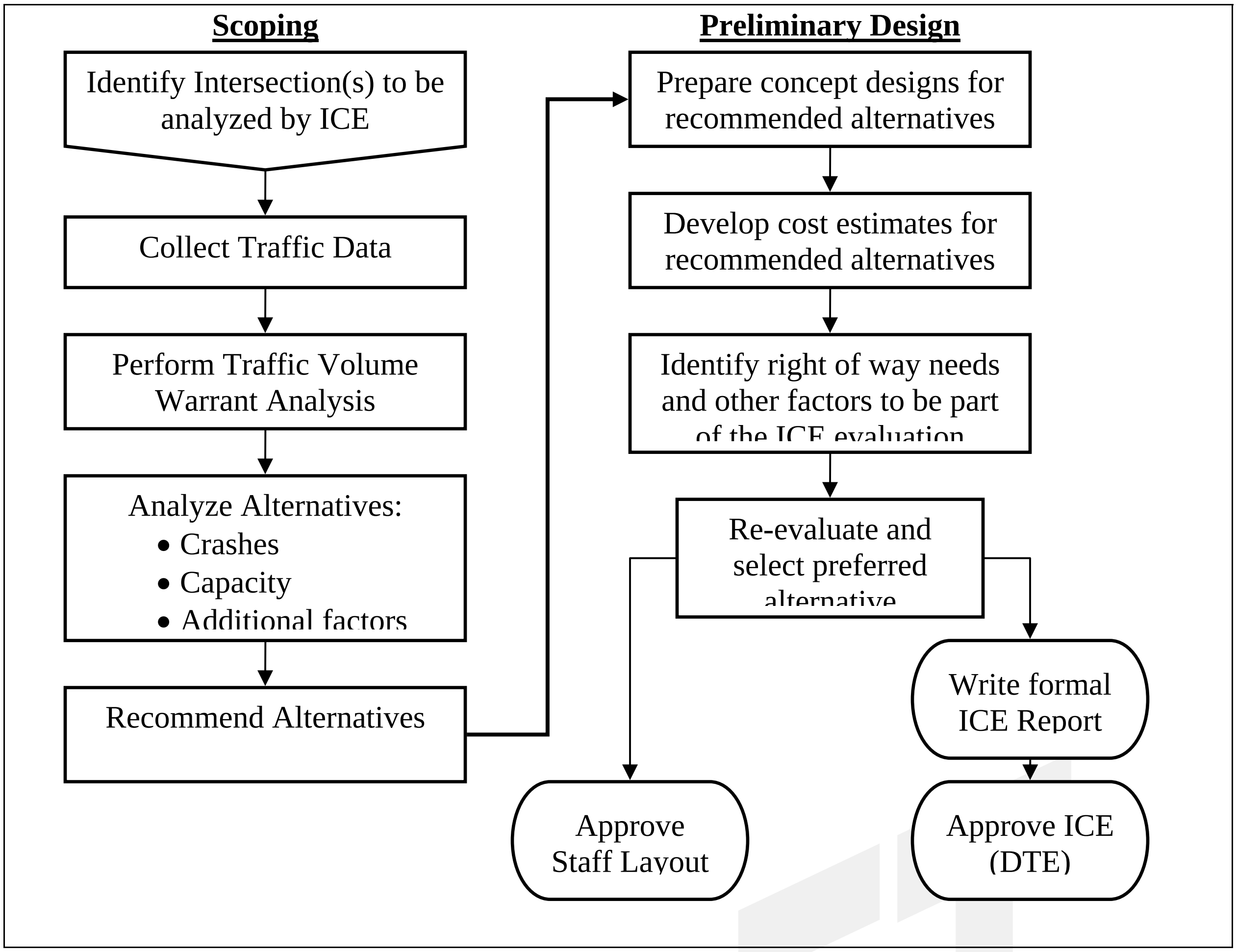

Figure 1

Intersection Control Alternatives

Engineers can select from a number of different alternatives for intersection control. Each type of control has advantages and disadvantages. Additionally, some types of control are not as pervasive in Minnesota as traditional traffic control methods (roundabouts versus traffic signals). Each type of control must also be acceptable to the general public, the local governmental unit, and the local road authority. The types of traffic control with their associated advantages and disadvantages are listed below. This is not intended to be an all-inclusive list of options. Depending on the existing circumstances and problems at a certain location, an entirely different or unique solution may be justified.

<u>Traffic Signals</u>

Advantages
- Provide for orderly flow of traffic
- Works extremely well in coordinated systems
- Reduce the severity and frequency of right angle and left turn crashes
- Interrupt heavy traffic to allow non-motorized travel to cross
- Through timing delay can be minimized for specific traffic movements

Disadvantages
- Crash frequency increases
- Costly and requires considerable maintenance
- Increases delay on the mainline
- Increased traffic volumes increase size of intersection
- Decreased efficiency with high left turning volumes
- Providing for U turns can be difficult and may be prohibited

All Way Stop Control

Advantages
- Provide for orderly flow of traffic
- Reduce the severity and frequency of right angle and left turn crashes
- Relatively inexpensive and quick to implement

Disadvantages
- Some types of crashes will increase
- Limited to lower volume intersections
- Increases delay to all legs of the intersection
- Works best with limited number of approach lanes
- Total intersection capacity is limited
- Providing for U turns can be difficult and may be prohibited

Roundabout

Advantages
- Provide for orderly flow of traffic
- Minimizes the severity and frequency of most crash types
- Lifecycle costs are less than traffic signals
- Width of approach legs can be minimized
- Comparable if not greater capacity than other alternatives
- U turns are easily handled
- Works very well with high percentages of left turning traffic
- Works extremely well at diamond interchange termini
- Typically less delay than other types of intersection control
- Handles multiple legs and skewed intersections better than other types of intersection control

Disadvantages
- May need additional right of way at intersection
- May operate very poorly if intersection is near signalized or all way stop controlled intersections
- Works best with limited number of approach lanes
- May operate poorly if traffic volumes are greatly unbalanced
- May hinder efficient traffic flow in a coordinated signal system
- May be infeasible in areas of steep terrain where grades would exceed 4 %

Non-Traditional Intersections

Decision makers have additional options in intersection design and control which may be appropriate for a given situation. There are a number of unique options for handling turning movements which improve the safety and capacity of an intersection. These options may include: Continuous Flow Intersections, Jughandle intersections, Quadrant roadway intersections or other designs. These designs may be advantageous over traditional designs depending on the existing or anticipated problems and the availability of right of way.

Advantages
- Usually reduce vehicular conflicts
- Increased capacity beyond traditional signalized intersection

Disadvantages
- Much higher cost than traditional signalized intersections
- Usually requires additional right of way

Access Management Treatments (Limit certain traffic movements through median construction or other treatments)

Advantages
- May reduce overall delay
- Reduce crashes by eliminating vehicular conflicts
- Provides refuge for pedestrians crossing roadway
- Minimize additional traffic control (signal may not be needed)

Disadvantages
- Reduces choices for drivers and may cause confusion
- May increase delay at adjacent intersections
- May not be politically acceptable
- Increases U-turn volumes at adjacent intersections

Grade Separation

If traffic volumes are so intense that all at grade control options will cause excessive vehicular delay, grade separation may be necessary. Additionally grade separation may be an option in order to solve a safety problem, improve access density, improve connectivity of the minor legs, or provide consistency of traffic control on the mainline. To determine if an interchange will be constructed and what type of interchange to construct should be based on an adopted corridor study or good access management practices.

Table 1 is included as a guide to assist in determining which intersection options should be evaluated based upon combined average daily traffic (ADT) volumes. The values are approximate and if an intersection is near a range change, consideration should be given to evaluating traffic control for both ranges. The ICE process is detailed oriented and will have high resource demands. The process should only be done for intersections in which traffic control other than thru-stop is required. As a guide, if the ADT for the minor leg or the intersection is less than 1000 ADT, an ICE is not required.

APPROXIMATE COMBINED ADT	FOUR WAY STOP	SIGNAL	ROUNDABOUT	NON-TRADITIONAL INTERSECTION	ACCESS MANAGEMENT TREATMENTS	GRADE SEPARATION
7500 - 10000	X		X		X	
10000 - 50000	X	X	X	X	X	X
50000 - 80000		X	X	X	X	X
> 80000						X

TABLE 1
INTERSECTION CONTROL TYPES WHICH SHOULD BE EVALUATED BASED UPON ENTERING ADT

The ICE Process

The process needed to complete an ICE is highly dependent on two factors. These factors will impact how much effort is involved in completing the study, who is involved in each stage of the study and what they are accountable for. These major factors are described below.

Project origination. The project can originate within Mn/DOT or from an outside jurisdiction. If the project originates from an outside jurisdiction, that entity is responsible for conducting the ICE. It is imperative that Mn/DOT Traffic units be involved early in the process to insure that the analysis will be accepted and approved. Within Mn/DOT projects can originate within or outside of Traffic Engineering. For those projects originating within Traffic Engineering, all of the responsibilities in completing the ICE will be coordinated through that unit. For all other projects, Traffic Engineering should be consulted early in the project development process to insure that an ICE can be completed in a timely manner. For all ICE's completed by outside jurisdictions or consultants, Traffic Engineering is responsible for review and approval.

Size/Type of Project. Generally, smaller projects will require less analysis and therefore less documentation. Preservation projects (i.e., Signal rebuilds) will require minimal analysis. However a memo/letter must be submitted for approval. The document should state rationale for the work being done and why other types of traffic control are not being considered. Stand-alone intersections will require safety and capacity analyses as well as documentation of other impacts (cost, ROW, political concerns, etc..). The amount of analysis will depend on each project's location and scope. Intersections which are a part of larger projects will probably require significant analysis and documentation. Coordination with Traffic Engineering on these projects is important. Making decisions on traffic control earlier in the project development process will improve the quality of the design and minimize conflicts with stakeholders.

As shown in Figure 1, the ICE is conducted in two distinct phases. The first phase, Scoping, is usually done very early in the project development process, oftentimes, before a project is programmed. The purpose of the first phase is to recommend one or more traffic control strategies for further development. Under normal circumstances an ICE would be needed if a safety or capacity problem has been identified, that has an associated infrastructure improvement. An ICE is also required for a new intersection being constructed due to development or expansion of the highway system. The second phase, Preliminary Design, involves other functional units (Design, Land Management, etc..) and parallels the process of developing an approved preliminary layout. Based on a number of factors the recommended traffic control is determined in this phase.

Depending on the complexity of each project, the steps necessary to complete an ICE are described below.

Warrants and Justification

In order for the engineer to determine if any traffic control is necessary at an intersection, data must be examined to determine if a "Warrant" is met for the particular intersection control alternative. Even if a "Warrant" is met, it may not be the correct action to take for a given situation. The engineer must determine if the treatment is "Justified". The "Warrant" and "Justification" process is detailed below.

Warrants

The MN MUTCD contains warrants for All Way Stops and for Traffic Signals. Generally speaking, warrants are met if the amount of vehicular traffic, crashes, or pedestrians is significant enough to meet minimum levels. These levels are based on research, which documented the conditions where additional traffic control was considered. Information needed to determine if a warrant is met is contained in the MN MUTCD and the Mn/DOT Traffic Engineering Manual.

A Mn/DOT District Traffic Engineer will interpret this information to determine which warrants apply to a given location and which warrants can be stricter in their application. For example, Appendix A is the Metro District's practice on traffic signal justification.

Warrants are commonly used to determine if either an all way stop control or a traffic signal should be considered for a location. Roundabouts are considered to be warranted if traffic volumes meet the criteria for either all way stops or traffic signals.

Justification

Even if an intersection meets a warrant for traffic control, that treatment may not be justified. The justification process requires a considerable amount of engineering judgement. Whether an intersection justifies a particular type of intersection control is based upon a number of factors. The ICE report should document these factors to support the alternative or not. These factors should include, but are not limited to, the following:

- Existing safety and congestion issues
- Plans for the roadway based on an adopted corridor study
- The spacing of nearby intersections or driveways and how they conform to adopted access management guidelines
- The environment in the corridor
- Future anticipated traffic volumes
- The distance to the nearest traffic controlled intersections
- The amount of turning traffic
- The breakdown and percentage of types of vehicles
- The amounts of non-motorized traffic
- Available right of way
- Available funds for construction
- Support of the local users and local agencies

Crash Evaluation

Depending on the existing crash pattern at an intersection, different traffic control treatments will have predictable impacts on these patterns. For each alternative an estimate of crash frequency should be completed. There are a number of methods for this task. The goal should be to determine the impacts of each alternative as accurately as feasible. The utilization of crash reduction factors, crash rates, comparisons to similar intersections, research and logic can all be used, but should be tempered by common sense. Consultation with Traffic Engineering is recommended on the most recent acceptable methods for a given treatment and location.

For existing intersections, crash records for the most recent three years should be obtained from Mn/DOT. This data should be displayed in a crash diagram. A comparison of existing crashes with anticipated crashes per traffic control alternative should be completed. The analysis should calculate crash reductions per year and an overall crash cost reduction per year. For new intersections, a comparison of anticipated crashes per treatment is needed.

Generally speaking, roundabouts can provide a possible solution for high crash rates by reducing the number of conflict points where the paths of opposing vehicles intersect. Crossing movements and left turning crashes are virtually eliminated with this design. However, increases in side swipes and rear end collisions may occur, although they will be less severe. Traffic signals can eliminate many right angle and left turning crashes also, but significant increases in rear end collisions will occur and the overall number of crashes will probably increase. Median treatments will also reduce the possibility of right angle and left turning crashes, dependent on the restriction in movements.

<u>Intersection Capacity Evaluation</u>

To evaluate the capacity and level of service of a particular intersection it is important to begin with basic traffic data:

1. Existing AM and PM turning volumes
2. Design year AM and PM turning volumes (Compare design year flows with the existing flows and check out any anomalies. It is critical that the design year flows do not exceed the capacity of the surrounding network.)
3. Design vehicle
4. Base Plan with defined constraints
5. Existing and design year pedestrian and bicycle volumes

For Phase 1 Scoping, the capacity analysis will vary depending on the type of project. The primary goal in Phase 1 is to determine if the alternative will operate at an acceptable level of service (for most areas this would require Level of Service C or better). A secondary goal is to provide a gross comparison between alternatives. Consult with the District's Traffic Engineering unit on acceptable procedures for this analysis. In all cases analysis with acceptable capacity analysis software will meet this condition. Simplified methods are being explored and developed.

For Phase 2, Preliminary Design, a more rigorous capacity analysis should be completed. An analysis using acceptable software is required. Currently, "RODEL" is required for roundabout analysis, "SYNCHRO, SIM-TRAFFIC" is required for traffic signals and four way stops, "VISSIM" is required for roundabouts which are a portion of an overall system of traffic control. Due to the high rate of change in modeling software and technology, these requirements could change, please consult with District Traffic Engineering to insure that a certain software is required.

The product of this analysis is a comparison of level of service, delay and queue lengths for each alternative. This analysis should of sufficient detail that comparisons between alternatives can be made.

For the "RODEL" software, the following guidelines are suggested.

Use the "RODEL" software at the 50% confidence level to analyze the capacity of the roundabout alternative for comparison to the other intersection treatments. Higher confidence levels are used for testing designs for robustness. "Delay" is the primary measure of effectiveness in determining the intersection level of service.

Determining the size and space requirements of a roundabout is an iterative process. However, it is appropriate to begin with certain default values for the key six geometric parameters (half width, entry width, effective flare length, inscribed diameter, entry radius, and entry angle) that are required to run the RODEL software. See Table 12-2.1B. Note that the default values for Items 7 and 8 are for general information and are not required in the RODEL analysis.

The circulating roadway width is typically 1.0 to 1.2 times the width of the widest entry into the roundabout. If no other initial circulating roadway width is available, use the value(s) listed. The initial exit radii are also listed. The default values are just the first step in the evaluation process. These initial default values are most likely not the final values used in the project.

The delay and Level of Service values provided by the RODEL software are based on total delay, which is similar to other highway capacity software. However, the delay thresholds used by RODEL to define LOS do not correspond to the Highway Capacity Manual thresholds. The LOS values in RODEL may be modified in the RODEL folder file called LOSDATA using MS Word or Notepad. For similar delay values, RODEL typically assigns a worse LOS. The 50 percent confidence level is the industry standard for software evaluating capacity, delay and queuing. The default confidence level for RODEL is also 50 percent, but the 85th percentile confidence level is also tested to verify the sensitivity of the design.

Table 12-2.01B
DEFAULT GEOMETRIC PARAMETERS[A] FOR BOTH URBAN & RURAL ROUNDABOUTS

Geometric Parameter	Single-Lane Entry	Dual-Lane Entry	Triple-Lane Entry
1 Half width[B]	Travel lane width approaching the roundabout prior to any flared section.		
2 Entry width[B]	Face of curb to face of curb shortest distance at yield point.		
3 Effective Flare length[B]	15-330 ft **(5-100 m)** if needed.		
4 Inscribed circle diameter	130 ft **(40 m)**	160 ft **(50 m)**	250 ft **(75 m)**
5 Entry Radius	65 ft **(20 m)**	80 ft **(25 m)**	100 ft **(30 m)**
6 Entry angle	30 Degrees		
7 Circulating roadway width	20-25 ft **(6-7 m)** (truck apron may be needed)	30 ft **(10 m)** (truck apron not needed)	45 ft **(14 m)** (truck apron not needed)
8 Exit radius	50-65 ft **(15-20 m)**	65-100 ft **(20-30 m)**	100-130 ft **(30-40 m)**

[A] At this time RODEL works only with metric values.
[B] High influence on capacity.

The results of the capacity analysis should be summarized in the report. Levels of Service, delay and maximum queue lengths should be reported for all approaches and/or traffic movements for all time periods and analysis years. It is recommended that an electronic copy of the analysis be provided as documentation.

<u>Right of Way Impacts and Project Cost</u>

Each alternative that is recommended to proceed to Phase 2, Preliminary Design, will have concept drawings prepared for the purposes of determining right of way impacts as well as construction costs. The level of detail in the design will be determined by the project manager depending on the location and other issues. The goal of this step is to have reasonable assurance that all right of way impacts are determined and an accurate cost estimate is obtained.

<u>Political Considerations</u>

Each feasible alternative should be assessed for political viability. In Phase 1, typically the local jurisdictions and other important stakeholders would be consulted to determine the acceptability of an alternative. If the result was negative, this alternative should be dropped from further consideration, especially if cost participation is required. During Phase 2, the degree of public involvement in the discussion of alternatives must be determined by the project manager in consultation with local stakeholders and Mn/DOT functional units. In any event, stakeholders should be aware of the technical merits of each alternative.

<u>Other Considerations</u>

Unconventional Intersection Geometry Evaluation. Conventional forms of traffic control are often less efficient intersections with a difficult skew angle, significant offset, odd number of approaches, or close spacing to other intersections. Roundabouts may be better suited for such intersections, because they do not require complicated signing or signal phasing. Their ability to accommodate high turning volumes makes them especially effective at “Y” or “T” junctions. Roundabouts may also be useful in eliminating a pair of closely spaced intersections by combining them to form a multi-legged roundabout. Intersection sight distance for roundabouts are significantly less demanding than for other conventional intersection treatments.

Terrain: Traffic Signals and Roundabouts typically should be constructed on relatively flat or rolling terrain:

- Traffic Signals: The maximum approach grade will vary depending on the ability for approaching traffic to see the signal heads and the impact of the approach grade on the operations of the predominate vehicle type.
- Roundabouts: Maximum approach grade of 4%

Grades approaching these values and steeper terrain may require greater transitions to provide an appropriate flat area or plateau for the intersection.

Adjacent Intersections and Coordinated Signal Systems. The spacing of all intersections (including roundabouts) along a highway corridor should be consistent with the spacing of primary full-movement intersections as shown in the Mn/DOT Access Management Policy. Generally speaking, positioning a roundabout within a coordinated signal system or very near to an adjacent signal is not preferred, however, under some circumstances it may be an acceptable option. A comprehensive traffic analysis is needed to determine if it is appropriate to locate a roundabout within a coordinated signal network.

System Consistency. On Interregional Corridors (IRC) or other highways where a corridor study has previously been prepared, any alternative should address the impact on the Interregional Corridor performance or should be compared to the recommendations of the corridor study. If the alternative adversely impacts the performance of the IRC or it is not consistent with the corridor study, justification for the alternative should be included.

Pedestrian and/or Bicycle Issues. Accommodating non-motorized users is a Mn/DOT priority. Depending on the volume of users and the sensitivity of the location, one alternative may be preferred to another. Additionally, if large number of non-motorized users are anticipated, they should be reflected in the capacity calculations.

The study should address any of the above issues, if applicable, and indicate how they are considered in the final recommendation.

The ICE Report/Memorandum

Depending on the amount of analysis a actual report may be unnecessary. For some projects, a memorandum may be all that is necessary (i.e., Traffic signal rebuild projects). In that case a memorandum signed by the District Traffic Engineer with rationale that supports the decision is sufficient. Otherwise, the ICE report should follow the outline below and thoroughly document the process described previously.

<u>Concurrence (Approval) Letter</u>

The cover letter must be addressed to the District Traffic Engineer. It should include the name and address of the submitter along with any specific information on expected project letting dates, funding sources and linkages to other projects. The submitter should allow at least one month to obtain approval.

<u>Cover Sheet</u>

The cover sheet requests the approval of the District Traffic Engineer for the recommendations contained in the report. A signature block must be included with spaces for the report preparer (must be a registered engineer in the State of Minnesota), the engineering representative for the agency(s) with jurisdiction over the intersecting roadway and the District Traffic Engineer.

<u>Description of Location</u>

The report must document the location of the project in relation to other roadways and include an accompanying map at a suitable scale.

Existing Conditions

The report must document the existing conditions of the roadway including existing traffic control, traffic volumes, crash data, roadway geometrics, conditions of the roadway, right of way limits, land use, etc.. A graphic/layout should be used to display much of this information.

Future Conditions

The report must document future conditions (normally 20 years) based on anticipated development including traffic volumes, new or improved adjacent or parallel roadways, anticipated change in access (additions or removals), etc.

Analysis of Alternatives

The report must include a discussion of each alternative and why it is recommended or not. The report should document the following analyses for each alternative considered: warrant analysis, crash analysis capacity analysis, right of way and construction cost impacts, political considerations, system consistency and other considerations. Warrant analyses are usually done for existing conditions, however, in some cases future volumes (usually no more than 5 years) can be used if the submitter can document that development is imminent. Crash analysis is done comparing the existing crashes with those anticipated after the change in traffic control. It may be necessary to analyze crashes at nearby intersections if access is proposed to be restricted at the subject intersection. A capacity analysis for each alternative must be completed for existing conditions with and without the improvement. Additionally, a capacity analysis must be done for future conditions (usually 20 years into the future, unless the improvement is anticipated to be temporary (in that case 5 years would be acceptable)). A discussion of the relative intersection delays for each alternative must be included. The Mn/DOT District Traffic Engineering unit should be contacted for acceptable software packages for capacity analysis for each alternative. Currently, RODEL is recommended for isolated roundabouts, VISSIM is recommended for roundabouts in close proximity to other roundabouts or signalized intersections, and SYNCHRO is recommended for traffic signals and all way stops.

Recommended Alternative

The report must recommend an alternative based upon the alternative analysis and a discussion of the justification factors. The report must document the justification factors which are appropriate for each alternative and come to a logical conclusion on which alternative is recommended.

Appendices

The report may include supporting data, diagrams and software reports that support the recommendations being made.

Data Requirements

For completion of the report the following data may be required. Some of these requirements can be waived depending on existing conditions and the available improvement alternatives. The District Traffic Engineer must be contacted to approve a change in requirements.

Traffic Volumes

- Hourly intersection approach counts (must be less than 2 years old)
- Turning movement counts for the AM and PM peak periods (3 hours each)(must be less than 2 years old)
- Future intersection approach volumes (only needed if Warrant is unmet in existing time period)
- Future turning movement volumes for the AM and PM peak hours
- Pedestrian and bicycle volumes by approach, if applicable

Crash Data

- Crash data for the last three full calendar years (Must be obtained from the Mn/DOT TIS database). Data should be displayed graphically in a crash diagram or strip map.

<u>Existing Geometrics</u>

- The existing geometrics of the intersection being considered for improvement must be documented. It is preferable to provide a layout or graphical display of the intersections showing lane configurations, lane widths, parking lanes, shoulders and/or curb treatments, medians, pedestrian and bicycle facilities, right of way limits and access driveways or adjacent roadways for all approaches. The posted speed limit and the current traffic control of each roadway must also be shown or stated.
- A larger scale map showing the intersection in relationship to parallel roadways and its relationship (including distances) to other access points along the corridor is also required.
- The locations of schools or other significant land uses, which may require more specialized treatment for pedestrians or vehicles, should be documented, if applicable.
- Geographic features must be shown if they will impact the selection of an alternative, such as severe grades, wetlands, parkland, etc…

<u>Proposed Geometrics/Traffic Control Alternative</u>

- A layout or conceptual plan showing the proposed geometrics for the recommended traffic control alternative must be included. The plan should document all changes from the existing conditions.

<u>Crash Diagrams</u>

- Crash diagrams must be included in the report. Rationale for crash reductions based on each alternative must be documented. Crash listings should be included in an appendix.

<u>Capacity Analysis</u>

- A summary table of delays for all movements, approaches and overall intersection delay must be provided for AM and PM peak hours, both existing and future conditions, for each alternative analyzed. Software output can be included in an appendix. An electronic copy of the analysis is preferred.

Additional data may be necessary depending on the location and alternatives analyzed. These could include – community considerations (need for parking, sidewalks, etc); future development plans, which may impact access; types of vehicles intersecting roadway, if unusual; transit routes and frequency; compatibility with corridor plans or local transportation plans; Interregional Corridor performance and political considerations.

Last updated 3/27/07

METRO TRAFFIC SIGNAL JUSTIFICATION METHODOLOGY

The decision to install a traffic signal at a trunk highway intersection in the Metro District is determined by the Program Support Unit of the Traffic Engineering Section. The installation of the signal must be justified through an engineering study. Contained in this document is the current methodology in determining if a signal installation is justified. If a location is justified, it does not necessarily mean that a signal will be programmed or the installation will occur immediately. Funding must be available and the location must be a higher priority than other safety needs.

QUALIFYING CRITERIA

For a specific intersection to be considered for a traffic signal installation one of the following criteria must be met.

1. The intersection meets Warrant 1A, 1B or 7 of the current MUTCD.
2. Current traffic volumes do not meet Warrant 1A or 1B, but development in the area will occur such that the warrants will be met in a reasonable period of time and state funds are not used for construction.
3. Current traffic volumes do not meet Warrant 1A or 1B, but a significant crash problem exists (at least 5 correctable crashes in any twelve months over the most recent 3 year period) and traffic volumes are likely to meet warrants within a reasonable period of time.
4. The intersection has significant amounts of pedestrian traffic, which can be documented.

MITIGATING FACTORS

As part of the engineering study, the following factors should be considered in determining if a signal installation is justified.

1. Access spacing guidelines: Is spacing between signals on the mainline adequate? Is spacing between all nearby public and private access points adequate?
2. Is the installation of a signal at this location consistent with an adopted access management plan for the roadway?
3. Lane geometrics: Metro requires a minimum of one lane of approach for each traffic movement for all directions of travel. For a typical four-legged intersection, a minimum of three lanes would be required for each approach, including the minor legs. (Metro will consider 2 lanes of approach from the minor legs under some conditions) Does the proposed layout provide minimal geometrics?
4. Each intersection should be modeled using acceptable simulation software in order to demonstrate acceptable traffic operations for opening day and for a reasonable period into the future (preferably 20 years). Adjacent intersections may be required to be included depending on spacing and other considerations. Will the proposed geometrics provide enough capacity for acceptable operations?
5. Is installation of a traffic signal the only solution or are better alternatives available?
6. Will the intersection be safer after the signal is installed?

WARRANTS

Warrant 1 – Eight Hour Vehicular Volume

If the intersection meets either Condition A (Minimum Vehicular Volume) or Condition B (Interruption of Continuous Traffic), then the intersection is considered to have met this warrant. Meeting a warrant does not necessarily mean the location is justified for a signal. Engineering judgment is required for that step and all mitigating factors must be considered.

Current traffic volumes must be collected to analyze the volume warrants. It is desirable to collect a 48-hour approach count AND a 6-hour turning movement count (3 in each of the peak periods) for each intersection. These counts should be done between Monday afternoons and Friday Mornings to accurately depict typical weekday traffic volumes.

<u>Right turning traffic from the minor leg is usually not included in the warrant analysis.</u>

The rationale for this practice is these movements are usually made relatively easily, have minimal conflicts and therefore do not require a traffic signal to minimize delay or improve safety. However, if right turning traffic is very high and gaps in the mainline cause significant delay a traffic signal may improve overall operations. After the traffic volume data is collected, the percentage of right turning vehicles from the minor legs is determined based upon the turning movement count. This percentage is applied to the approach counts to determine the number of left and through traffic volumes over the entire day. (It is assumed that the percentage of right turns during the two peak periods (6 hours) is representative of the entire day.) This is the data to be used in the warrant analysis.

In the event that there is a significant amount of right turning traffic and conflicting traffic, 50% of the minor street right turns can be added back into the approach counts. If the right turning volume exceeds 70% of its potential capacity (see Table 1) for any hour for each approach, 50% of the right turning volume for all hours should be added back in. Use Table 1 to determine the right- turn capacity for each minor approach. The capacity is based on the conflicting mainline approach traffic, in the lane the right turning vehicles are merging into. (For multiple through lane roadways divide the volumes evenly across each lane.) Utilizing the correct table (Two-Lane or Four-Lane), the user must determine if the right turn volume exceeds 70% of the potential capacity. (The capacity of the minor leg right turning volume is calculated based on procedures documented in the Highway Capacity Manual.)

TABLE 1- RIGHT TURN CAPACITY

Potential Capacity for Two-Lane Streets		
Major Leg Conflicting Flow Volume (Peak Hour)	Potential Hourly Capacity of Minor Leg RTL	70% of Potential Hourly Capacity of Minor Leg RTL
100	960	670
200	850	600
300	740	520
400	650	460
500	570	400
600	500	350
700	440	310
800	390	270
900	340	240
1000	300	210
1100	260	180
1200	230	160
1300	200	140
1400	170	120
1500	150	110
1600	130	90
1700	120	80
1800	100	70
1900	90	60
2000	80	60
2100	70	50
2200	60	40
2300	50	40
2400	40	30
2500	40	30
2600	30	20
2700	30	20
2800	20	10
2900	20	10
3000	20	10

Potential Capacity for Four-Lane Streets		
Major Leg Conflicting Flow Volume (Peak Hour)	Potential Hourly Capacity of Minor Leg RTL	70% of Potential Hourly Capacity of Minor Leg RTL
100	940	660
200	810	570
300	700	490
400	610	430
500	520	360
600	450	320
700	390	270
800	330	230
900	290	200
1000	250	180
1100	210	150
1200	180	130
1300	150	110
1400	130	90
1500	110	80
1600	100	70
1700	80	60
1800	70	50
1900	60	40
2000	50	40
2100	40	30
2200	40	30
2300	30	20
2400	30	20
2500	20	10
2600	20	10
2700	20	10
2800	10	10
2900	10	10
3000	10	10

For a signal to be warranted on a Metro District trunk highway, one of the following must occur:

1. Condition A or B is met for at least 8 hours a day as shown on the 100% column (Table 2).
2. Condition A or B is met for at least 8 hours a day as shown on the 70% column (Table 2) if the posted or 85th percentile speed on the mainline exceeds 40 MPH or the intersection lies within the built-up area of an isolated community having a population of less than 10,000.

TABLE 2 – WARRANT 1

Condition A – Minimum Vehicle Volume							
Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)			Vehicles per hour on higher-volume minor street approach (one direction only)		
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	100%[a]	80%[b]	70%[c]
1	1	500	400	350	150	120	105
2 or more....	1	600	480	420	150	120	105
2 or more....	2 or more	600	480	420	200	160	140
1	2 or more	500	400	350	200	160	140

Condition B – Interruption of Continuous Traffic							
Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)			Vehicles per hour on higher-volume minor street approach (one direction only)		
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	100%[a]	80%[b]	70%[c]
1	1	750	600	525	75	60	53
2 or more....	1	900	720	630	75	60	53
2 or more....	2 or more	900	720	630	100	80	70
1	2 or more	750	600	525	100	80	70

[a] Basic minimum hourly volume

[b] Used for combination of Conditions A and B after adequate trial of other remedial measures.

[c] May be used when the major street speed exceeds 40 mph or in an isolated community with a population of less than 10,000.

To determine the number of lanes to use in Table 2, the **proposed** lane geometrics must be used. Right turn lanes are not counted, but in most cases the row referring to two or more for both the major street and the minor street will be used. Left turn lanes are included in the total number of lanes.

Warrant 7 – Crash Experience

To meet this warrant two conditions must be met:

1. Five or more reported correctible crashes have occurred within any twelve-month period. Data can be used for the last 3 reported calendar years. Correctable crashes are left- turning crashes from either the mainline or the minor street, or right angle crashes. No other crash types are considered (rear ends, run off road, etc.).
2. The eight-hour vehicular warrant described above must be met for the 80% column for either Condition A or Condition B. The treatment of traffic volumes is the same as described above.

If you have questions, please contact Lars Impola, Metro Traffic Program Support, at 651-234-7820.