STATE OF INDIANA
INTERSECTION TRAFFIC ANALYSIS PROCEDURES

Traffic Engineering Division

In Coordination with:

Design Standards Office
District Traffic Offices
Federal Highway Administration

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PURPOSE OF DOCUMENT

The purpose of this document, Intersection Traffic Analysis Procedures, is to standardize the procedures of intersection traffic analysis. An intersection in this context includes those standing alone, part of service interchanges and on arterial systems. The Indiana Department of Transportation (INDOT) recognizes that at the preliminary engineering stage of project development, it is important to have a clear expectation of acceptable methods of analysis, a common procedure so that all proposals can be evaluated accurately and fairly. The document will provide guidance for the overall process of intersection traffic analysis and associated documentation/deliverables to the District Traffic Office and/or Corridor Development Office for review and approval. In some cases, those two will also be carrying out the analysis. In other cases, the analysis will be done by external parties.

There are many reasons a site may be brought forth for evaluation, for instance, safety, preservation of physical assets or operations (traffic flow, congestion, mobility). However, the Intersection Traffic Analysis Procedures provides guidance for intersection traffic operations analyses only. Requests for a break in access along a partially limited access facility will also warrant assessment through this process. This procedure is not to be used to justify breaks in fully access-controlled facilities such as freeways or to address intersection traffic safety performance. The former should be coordinated through the Corridor Development Office using the *State of Indiana Interstate Access Request Procedures*, even if on a non-Interstate highway facility. Needs related primarily to intersection safety deficiencies should be evaluated through safety procedures and coordinated with the INDOT District Technical Services or the Traffic Safety Office.

The document will establish a uniform process for review and approval of traffic operations analyses. The review level and which office will have review authority will be determined early on by INDOT. There are expectations related to analysis type, level and documentation depending on the site involved. Some sites are simple while others are complex.

INDOT's *Intersection Decision Guide* prescribes the method in decision-making relative to essential intersection geometric form. Traffic operations analysis is an element of that decision process, notably in Stage 2, "Secondary Expanded Performance Assessment." The *Intersection Traffic Analysis Procedures* supplements the *Intersection Decision Guide* relative to "the choice one makes to explain traffic operational performance." That is, for reasons of consistency and quality, the *Intersection Traffic Analysis Procedures* imposes a standard process.

This new, standardized expectation for traffic analysis applies to all intersection projects or actions to INDOT jurisdictional roads. Local road intersection projects with Federal-aid funding should also follow the procedure. Any roundabout analysis in Indiana, regardless of jurisdiction, should use the inputs herein.

DATA COLLECTION AND FORECASTING

Background information is important to ensure all aspects are addressed at a site during the evaluation process. Determine the site history, makeup of the surrounding area and intersection existing conditions. Establish the project study area that is necessary for accurate assessment. Subject intersections located on an arterial should be addressed from a corridor perspective rather than site by site. Adjacent intersections on minor roadways impacted by the subject intersection or corridor should also be considered.

Appropriate, sanctioned traffic data (turning movement counts) provided or explicitly approved by the Technical Planning and Programming Division's Statewide Modeling and Traffic Counting section should be used as the basis for operational analysis for the intersection assessment process. Describe in the *Alternative Analysis Technical Report* the methodology, including assumptions, used in developing those traffic numbers. In some cases, existing traffic data will be available, but it is important to note the date that traffic was collected relative to the study. If the data is more than 3 years old, it is possible that traffic volumes or patterns will have changed, making a new traffic count important for proper assessment. Additionally, the analyst should verify that the data is valid and free from any inconsistencies due to the possibility of an equipment malfunction during data collection or a previously unknown event resulting in data that does not represent normal traffic conditions. Traffic data collection should be scheduled such that the resulting data is as representative of typical traffic conditions as possible. Avoid counting during times when short-term abnormal traffic patterns may be present (such as during construction or holidays).

Growth rates used to forecast the data will be provided through coordination between the INDOT Modeling and Traffic Counting sections and the Metropolitan Planning Organization (MPO) associated with the project area, if applicable. The growth rates used for the forecast should not simply be from historical traffic data trends, especially over a short period of time, but rather be a result of multiple data sources such as the Statewide and MPO travel demand models and growth/development information for the subject study area. If a traffic impact study (TIS) has been conducted for proposed development in the area, it is important to avoid "double counting" traffic growth in both the growth rate and TIS forecast volumes.

Discuss the years to be used for operational analysis that will associate with existing conditions, any necessary interim periods, such as opening year, and design year. AM and PM peak periods, representative off peak and any other special periods (such as special events or factory/warehouse shift change) if relevant should be included. The design year should be 20 years from the anticipated project opening date. INDOT will consider a modified design year horizon in certain circumstances.

TRAFFIC ANALYSIS PROCESS AND METHODOLOGY

Traffic analysis should be completed for not only the subject intersection but also for associated intersections. A network model should be completed for corridor or multiple intersection analysis while a single site analysis can be completed for investigation of an isolated intersection. For a corridor analysis, it is important to know the performance of each intersection but also how traffic flow interacts from location to location. Without the network model, single site analysis will only show part of the picture.

The operational analysis should be extended as far along the mainline as necessary, including adjacent downstream and upstream intersections, to establish the extent and scope of the impacts. The intensity and extent of analysis/simulation will be greater for complex cases. This is particularly critical in urban areas with closely spaced intersections. As a minimum, the operational impact on the mainline roadway between the proposed new or revised access and immediately adjacent existing downstream and upstream intersections on either side must be analyzed (exceptions may be granted if adjacent intersections are a significant distance away). The exact adjacent intersections to be analyzed will be determined by District Traffic and/or Corridor Development. Analysis of adjacent intersections on the crossroad is always required at the subject (core) intersection(s) so that all impacts are known. Analysis of adjacent intersections on the crossroads of the adjacent downstream and upstream intersections may or may not be required depending on site characteristics.

The latest edition of Highway Capacity Manual (HCM) or associated software (HCS) shall be the basis, default choice for intersection traffic analysis. Other methods or software applications that precisely mimic methodology (equations) of the HCM are permitted substitutes. Synchro Traffic Signal software is one such software that is well suited for analysis of signalized intersections and traffic signal networks. INDOT will advise which substitute method or software is appropriate for each project, and whether any supplemental, more advanced method or software is required. All roundabout analysis shall be completed using SIDRA Intersection software. The version of all software used shall be communicated to and approved by INDOT before any analysis is performed.

Assumptions made during the analysis and any simulation phase shall be discussed with and approved by District Traffic and/or Corridor Development. Though Level of Service (LOS) is not the sole measure of effectiveness (MOE) relevant to assessing intersection performance, the target is to attain minimally acceptable LOS for overall intersection performance, with each approach to the intersection no more than one LOS worse for design year traffic conditions. Circumstances may arise where adverse right of way or environmental impacts will incur costs that outweigh the benefit of the LOS improvement. In these cases, document the thought process and engineering judgment that guided the decision making. Note that extraordinary measures (right of way or environmental impact) should not be taken to improve a poor LOS for a low volume movement. In many cases, significant improvements in delay and speed can be attained in a cost-effective manner even with seemingly minimal LOS improvement. Coordination with INDOT Environmental Services and/or Real Estate is encouraged when needed.

MEASURES OF EFFECTIVENESS

Multiple measures of effectiveness provide a good overall evaluation of the merits of each alternative and ensure achievement of the stated objectives. The MOE to be used in each analysis will be determined by District Traffic and/or Corridor Development at the Framework Meeting and outlined in the *Framework Document*. The MOE shall be computed for the existing or open to traffic year, the design year and for any intermediate years as directed for AM and PM peak periods in all cases and in select cases for other special peaks and representative off-peak periods. The MOE should be displayed to show performance of each approach with specific movements called out if noteworthy. Analysis summary results should be documented.

The following MOE shall be used.

- Level of Service (LOS) as defined by HCM is a basic indicator of intersection performance but is not always understood when displayed in a report alone.
- Delay in seconds per vehicle is the service measure that determines LOS but should be explicitly stated to aid understanding of the LOS.
- Volume to Capacity Ratio (V/C Ratio) is a ratio of existing traffic volume to available intersection capacity.
- Average and 95th Percentile Queue Length for each intersection movement will show both typical performance and worst-case conditions to ensure storage lengths are adequate and one intersection is not impacting another.
- Aggregate Travel Time of all vehicles using a corridor can be useful for comparison of corridor build alternatives. Aggregate travel time, not end to end travel time is used to most accurately capture the performance of the corridor for all trips, given that not all trips pass from one end of a corridor to the other, particularly in urbanized areas.
- Average Travel Speed per vehicle, a function of travel time and distance, is of value for comparison of alternatives in corridor analysis.

In the case of innovative intersections that involve diverted or rerouted movements (particularly displaced left turn and median U-turn intersections), Experienced Travel Time (ETT) should be used to account for the additional control delay and diverted path travel time that applies to certain movements at these intersections. Using ETT to then obtain LOS for each movement at these intersection types provides an analysis metric that is commensurable with the analysis of the existing intersection. See the HCM (Chapter 23) for additional information about calculating ETT.

ANALYSIS TOOL SELECTION

Choosing the correct tool to complete analysis of an intersection or network of intersections is important. Likewise, understanding the methodology, its associated software and limitations is also critical to producing usable analysis that can guide programming decisions. To that end, the analyst must be a qualified user of the given method/software. The user should review method/software defaults to ensure they are appropriate for the given analysis and site. If those defaults are not appropriate, changes and assumptions should be documented. Table 1 displays methods/software that will be accepted for given intersection types.

TABLE 1: INTERSECTION FORMS WITH APPROPRIATE TRAFFIC ANALYSIS SOFTWARE

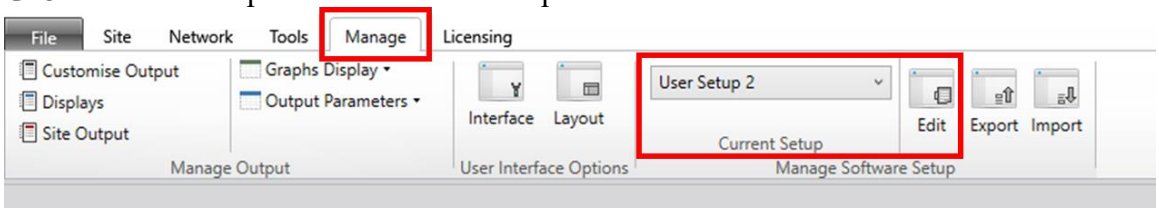
Intersection Form	HCM/HCS	Synchro/SimTraffic	SIDRA	Vissim
Standard	✓	✓		
Median U-Turn		✓		✓
Roundabout	✓		✓	✓
Arterial System	✓	✓		
Displaced Left Turn	✓	✓		✓
Other Forms		✓		✓

Table 1 Notes:

- For Synchro software, simulation is not necessary in every case.
- Vissim traffic simulation software should be used to evaluate multiple roundabout intersection systems.
- Median U-Turn intersection form refers to the innovative intersection form that utilizes median U-Turn treatments such as Reduced Conflict Intersections (RCI), Restricted Crossing U-Turn Intersections (RCUT), and Boulevard Left Turn Intersections. The HCM labels as Median U-Turn (MUT) what INDOT references as a Boulevard Left (also often called a Michigan Left).
- Arterial system refers to a series of two or more intersections.
- When traffic simulation is required, it need not be completed with Synchro and Vissim, but rather one or the other.
- HCM/HCS may or may not have an application/methodology aligned with "other" intersection forms.
- In cases where a corridor model is required along a corridor with both roundabout and non-roundabout intersections, a combination of SIDRA and Synchro/Vissim software may be appropriate. It is necessary to analyze individual roundabouts in SIDRA but also understand how they perform as part of the network via simulation in Synchro or Vissim.

SIDRA is a software application called out exclusively for roundabout analysis. Performance measures generated from SIDRA are sensitive to inputs. Specific INDOT directed SIDRA inputs are outlined here. INDOT requires the use of SIDRA INTERSECTION version 9.0 or newer. Default settings will be used unless otherwise noted below. The criteria from the Washington Department of Transportation roundabout analysis method will be used for analysis.

For simplicity, many of these parameters can be set globally by selecting "Manage" from the ribbon menu. Choose "User Setup 2" as the current setup and click "Edit".



At minimum, the following values must be changed:

General Options Tab:

- Site Level of Service Method: Delay & Degree of Saturation (SIDRA)
- Site Performance Measure: Degree of Saturation
- Percentile Queue: 95%

Model Parameters Tab:

- Uncheck all boxes under Delay and Queue (Geometric Delay, HCM Delay Formula, HCM Queue Formula)

Roundabouts Tab:

- Circulating Width: single lane minimum 18 feet to 20 feet, multi-lane 15 feet each
- Entry Radius: 90 feet - 110 feet (unless site specific)
- Environmental Factor: 1.0
    - 1.1 can be used initially in areas without other existing roundabouts to account for slightly reduced initial capacity due to driver unfamiliarity.

Roundabout Models Tab:

- Roundabout Capacity Model: SIDRA Standard
- Roundabout LOS Method: Same as Signal Control

Pedestrians Tab:

- Walking Speed (Average): 3.5 ft/sec

Lanes Tab:

- Roundabout Lane Width: 14 feet minimum (unless analyzing existing roundabout)

Additionally, the following procedures will apply for roundabout analysis:

- Build analysis will include scenarios for opening year and design year for the AM and PM peak hours, and occasionally other traffic scenarios as directed by INDOT.
- Bypass lanes at roundabouts are generally not desirable, their use must be justified through additional analysis showing the performance of the roundabout with and without inclusion of the bypass lanes.
- Multilane roundabouts must first be analyzed as single lane roundabouts to document that a single lane or 2x1 roundabout does not perform acceptably as a build alternative.
- Roundabout diamond interchanges or other scenarios with multiple roundabouts in close proximity should be analyzed as a system by first configuring each roundabout independently and then configuring all roundabouts in the system into a network using the "Network" tab.
    - These scenarios should also be evaluated through the use of simulation in another analysis tool (Synchro SimTraffic or Vissim) as directed by the Corridor Development Office.

An analyst wanting to deviate from the parameters or procedures listed above will be required to submit a formal request with documentation and rational to the District Traffic Engineer and/or Corridor Development for approval prior to conducting and submitting any SIDRA analysis and results.

If any of the geometric or traffic parameters change within the course of the project development, the analyst should provide a revised analysis consistent with the final design.

PROCESS STRUCTURE

There are sequential steps in the process to secure an approved project scope (outline of essential corrective treatment to address a problem). These steps may be executed for a work proposal, funded project, or permit study on an INDOT route as well as access or control changes for major traffic generators or facilities. Traffic analysis is a key piece of the overall scoping process.

1. Assignment & Framework: The intersection traffic analysis work may be completed by INDOT or by a consultant hired by INDOT. In some cases, a third party (local government or business entity) may hire a consultant to work on a proposal on or related to an INDOT route. In the latter case, the third party and consultant must coordinate with INDOT District Traffic and/or Corridor Development prior to beginning work and during the process. Local Public Agency (LPA) proposals using Federal aid funding will need to use this procedure as well.

   The early coordination will be a framework meeting where the intent and parameters of the study are clearly established and agreed upon by District Traffic and/or Corridor Development as well as the analyst completing the traffic analysis. The result of the meeting should be the *Framework Document* stating the scope of study relative to analysis of alternatives as discussed and agreed upon at the framework meeting. The document should have concurrence lines for District Traffic and Corridor Development representatives to sign. Within the *Framework Document*, identify, address, and

document any issues, risks, or challenges (environmental, utility, public involvement, geometrics, etc.) from the perspective of INDOT that may delay the schedule or have an influence on intersection type selection.

2. Alternative Feasibility Check: For most sites, there are only a few alternatives that actually pass a feasibility check. To that end, INDOT does not wish for alternatives that are not feasible to be included in the primary traffic analysis of the *Engineering Assessment*. The screening of alternatives should occur in conjunction with the *Intersection Decision Guide* which accounts for not only traffic mobility, but also traffic safety, cost effectiveness metrics and qualitative judgements of efficiency. In some cases, the alternative feasibility check may have been completed prior to the assignment of work. The alternative feasibility check should be presented to District Traffic and Corridor Development in the form of a short Technical Memorandum that states why each alternative has been declared either feasible or not feasible. The District Traffic Office and/or Corridor Development will then instruct the analyst which alternatives to carry forward for further traffic analysis.

3. Traffic Analysis of Alternatives: The alternatives deemed to be feasible will then be analyzed using traffic analysis methods, including specific software, agreed upon in the Framework Meeting. The traffic analysis will be summarized in a Technical Report that recommends a preliminarily preferred alternative from the traffic operations perspective. This will be submitted to District Traffic and/or Corridor Development for review along with the analysis files.

4. Other Documentation (Engineering Assessment & Additional Scoping): Once the traffic analysis has been approved by INDOT, the analyst will proceed with preparation of the *Engineering Assessment*. This document will be required to identify the site, background information, deficiencies, alternatives, proposals, impacts (right of way, utility and environmental), constructability, expandability, safety operational performance, cost effectiveness and a recommendation for funding and/or further development. The report will document traffic operations performance of each alternative (carried forward from the Alternatives Analysis Technical Report) regarding the intersection itself and impacted nearby intersections as necessary. The document will be reviewed and approved by District Traffic and/or Corridor Development.

   Ideally, the Intersection Traffic Analysis Procedure will be completed prior to and as a means to secure project funding. This should certainly be the case for INDOT intersection improvement projects. If the aforementioned steps took place prior to project funding, then further scoping work to identify environmental and right of way impacts as well as utility coordination will be completed as an amendment to the *Engineering Assessment*. This work does not need to be an entirely separate report and should not repeat work already completed. The additional scoping will be included in the *Engineering Assessment* if the project is already funded.

DOCUMENTATION

The following items are deliverables expected by District Traffic and/or Corridor Development during the intersection traffic analysis process to enable review and approval of intersection traffic operations analysis.

- Framework Document
- Alternative Feasibility Technical Memorandum
- Alternative Analysis Technical Report - Concise, complete documentation explaining the traffic analysis process and results
- Analysis Software Files (electronic)
- Any other documentation to assist the reviewer in awareness of the project site(s) that would allow a more complete understanding of the traffic analysis (e.g., Engineering Assessment Report or Scoping Report).

REVIEW PROCESS

The intersection traffic analysis documents/items listed as deliverables above are to be submitted to District Traffic and/or Corridor Development for review and approval if appropriate. A second iteration of submission and review may be necessary to arrive at a final product. An example review schedule is shown below.

- Framework Document 2 weeks
- Alternative Feasibility Technical Memo 2 weeks
- Alternatives Analysis Technical Report/Software Files/Other Documentation 4 -6 weeks

The overall schedule should be prepared based on the expected review timelines shown above with some flexibility for multiple reviews when necessary. Multiple reviews can be avoided with ongoing coordination.