

Traffic Analysis Toolbox Volume XII: Work Zone Traffic Analysis – Applications and Decision Framework

Executive Summary

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Traffic Analysis Toolbox Volume XII

Work Zone Traffic Analysis – Applications and Decisions Framework

Work Zone Traffic Analysis (WZTA) is the process of analyzing the work zone traffic impacts and related impact mitigation strategies of construction, maintenance, or rehabilitation projects. The purpose of this document is to provide guidance on work zone traffic analysis applications and decision framework. It serves as a useful resource for practitioners in understanding the analytical methods involved in conducting a work zone traffic analysis.

Defining Goals and Objectives

Before starting a work zone traffic analysis, it is important to define the goals and objectives of the analysis. By establishing a set of goals and objectives, an agency has a clear vision on what needs to be evaluated, such as the traffic impacts, benefits, and costs of the work zone project.

Determining Measures of Effectiveness (MOE)

Once goals and objectives have been established, MOEs and thresholds should be set to determine the performance standards for the mobility, safety, and constructability of the work zone. The MOEs and thresholds selected

EXAMPLE MOE: OHIO DOT QUEUE THRESHOLDS

- For queues less than 0.75 miles, the work zone impacts are acceptable.
- For queues greater than 0.75 miles and less than 1.5 miles, the work zone impacts are acceptable if the queue exceeds 0.75 miles for 2 hours or less. Where queues are expected to exceed 0.75 miles for any period of time, additional advanced work zone warning signing should be specified.
- For queues longer than 0.75 miles for more than 2 hours or longer than 1.5 miles for any period of time, the work zone impacts are unacceptable.

EXAMPLE: GOALS & OBJECTIVES

- Goal: Keep work zone congestion at preconstruction levels.
- Objectives: Optimize lane closure strategies; determine the impact of detours; and evaluate alternative work schedules (i.e., nighttime, weekend work).

should be customized to the agency's goals and project characteristics. The MOEs and thresholds set a minimum performance standard that the objectives should meet or exceed.

Identifying Maintenance of Traffic (MOT) Alternatives

MOT alternatives generally have the following five factors:

- 1) Construction approach;
- 2) Traffic control and operations;
- 3) Public information and outreach;
- 4) Incident management and enforcement; and
- 5) Travel demand management (TDM).

Conducting Fatal Flaw Analysis

Once identified, the preliminary MOT alternatives are first evaluated to determine if an alternative has a "fatal flaw" i.e., some factor that renders the alternative infeasible. These factors may include constructability, schedule, and cost. If a fatal flaw is found, the alternative

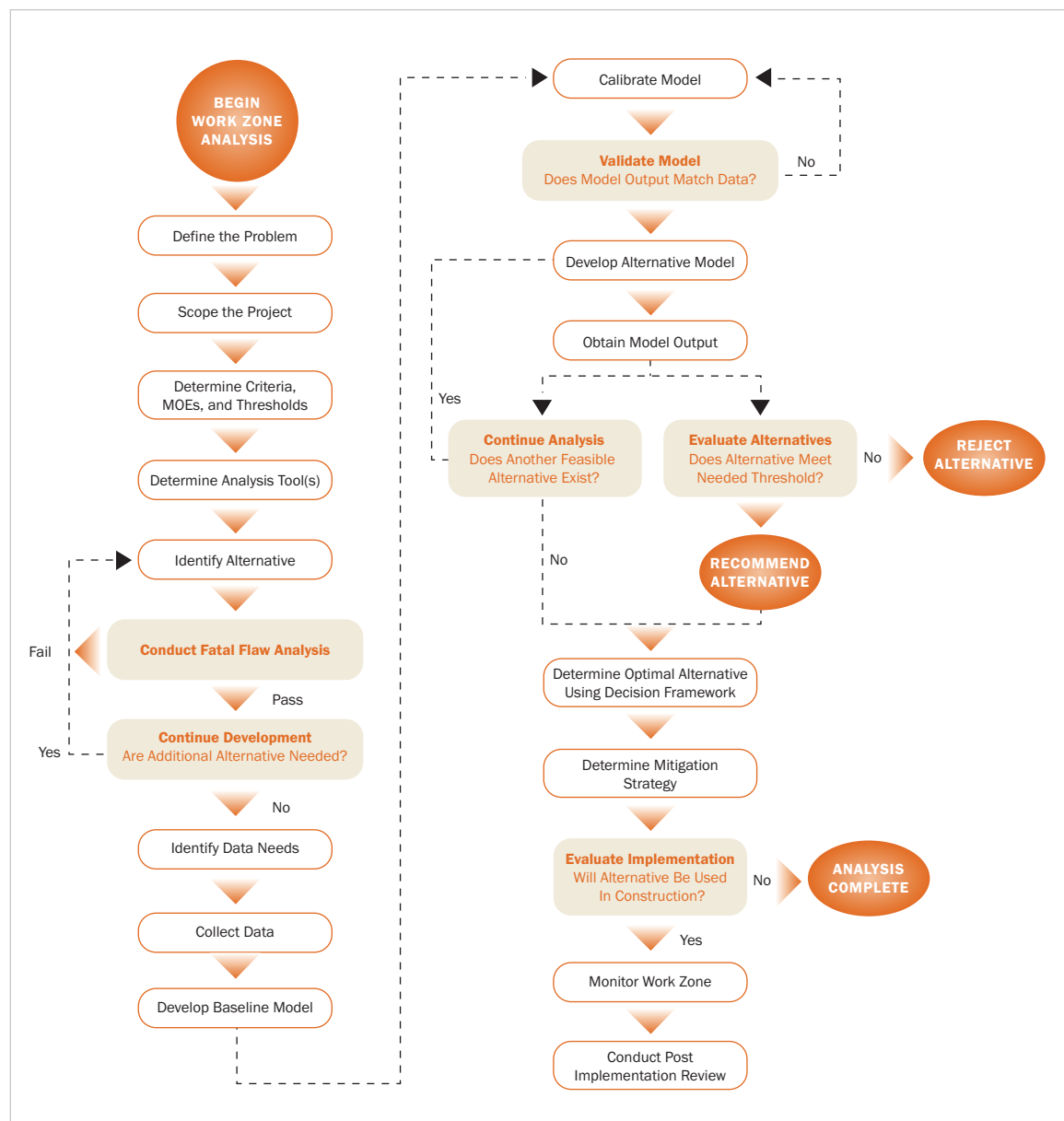


is dismissed from further consideration. While this review may result in the elimination of alternatives, it also can result in refinement of the proposed alternatives. However, care must be taken not to cut too deeply with the fatal flaw analysis process as some of the more innovative strategies, which may utilize unconventional approaches, could be lost.

Establishing an MOTAA and Decision Framework Process

Figure 1 presents typical steps involved in the application of a maintenance of traffic alternatives analysis (MOTAA) and decision framework. While work zone traffic analysis can vary in complexity, there are common steps that can be categorized into the following stages:

Figure 1: MOTAA and Decision Framework Flowchart



(Source: Cambridge Systematics, Inc.)

- 1) Project planning and data collection;
- 2) Work zone impacts analysis;
- 3) Decision-making criteria;
- 4) Impact mitigation; and
- 5) Monitoring and post-implementation.

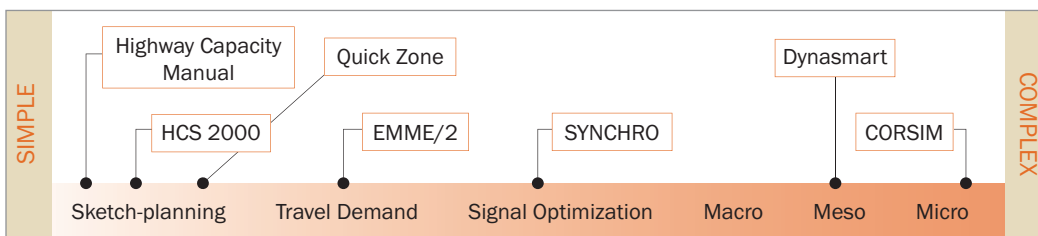
Identifying Work Zone Traffic Analysis Tool Types

Figure 2 depicts a continuum of traffic analysis tools from simple to complex. Simpler tools

include the categories of HCM and sketch planning, travel demand models, and signal optimization tools, while the more complex tools include macro-, meso-, and micro-scopic simulation software.

The spectrum includes several commonly used transportation analysis tools for assessing the impacts of roadway construction projects. As the diagram shows, the resources needed increase with the increase in complexity of the tool.

Figure 2: Work Zone Modeling Spectrum



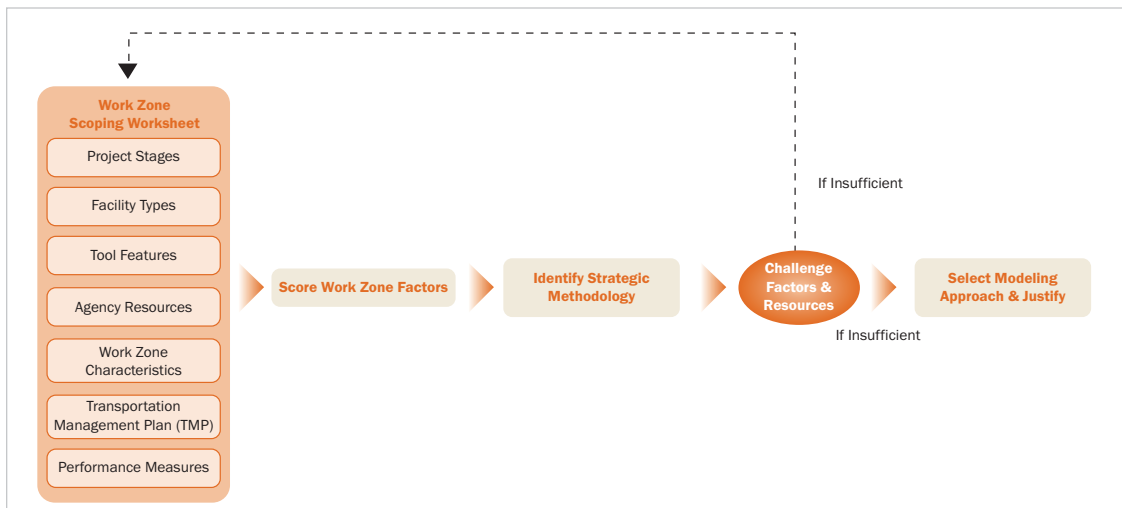
(Source: Hardy and Wunderlich, 2009.)

Selecting the Appropriate Traffic Analysis Tool

Each tool is unique and has its own set of capabilities and limitations. There are many factors that go into determining which tool is right for the work zone analysis, and there is no “one-size-fits-all” approach. More than one tool might be needed to address the analysis needs, particularly as the project progresses

from planning to design to construction. A step-by-step guidance has been developed to assist the analyst in determining the suitable tool(s) to perform work zone analysis. Figure 3 illustrates the seven factors involved to assist the analyst in identifying the most appropriate modeling tool(s).

Figure 3: Framework for Identifying Appropriate Modeling Tool for Work Zones



(Source: Cambridge Systematics, Inc.)

The tool selection process involves four major steps:

- 1) assign criteria relevance weight;
- 2) assign tool relevance values;
- 3) calculate criteria score; and
- 4) calculate total score.

The tool type(s) with the highest totals are the most appropriate tools for the work zone analysis. A work zone analysis scoring worksheet is provided to assist in selecting the analysis tool(s) using the proposed methodology. An example is provided in order to demonstrate the steps of this approach.

Identifying Key Considerations for Modeling Approach

After a suitable analysis tool is selected, the next step is to determine the impacts of a work zone. Key considerations when applying

various modeling tools for work zone traffic analysis are discussed. In particular, roadway capacity is one of the most important factors in work zone analysis. Table 1 lists work zone lane capacity defaults for use based on previous studies for long-term work zones (in passenger cars per hour per lane or PCPHPL). It is strongly recommended, though, that local data at work zones be collected and used instead whenever possible and applicable. Some state DOTs and other agencies may have their own guidelines on work zone capacity and related defaults. In the absence of better local data, the analyst may use these defaults as the starting point and make necessary adjustments accordingly to reflect local work zone conditions.

Table 1: Capacity of Long-Term Work Zones (PCPHPL)

Default Type	NORMAL LANES TO REDUCED LANES					
	2-1	3-2	3-1	4-3	4-2	4-1
Range	1,200-1,800	1,300-1,600	1,200-1,800	1,300-1,600	1,300-1,600	1,200-1,600
Single Value	1,400	1,450	1,450	1,500	1,450	1,350

(Source: Transportation Research Board, 2011. Weng and Meng, 2011. WSDOT Work Zone Safety and Mobility, 2009.)

Some other key considerations covered in the document include:

- Study network;
- Variability of capacity and time-of-day models;
- Analysis period;
- Changes in traffic pattern;
- Data collection;
- Error checking;
- Number of runs;
- Dynamic traffic assignment (DTA);
- Network convergence;
- Model calibration; and
- Level of effort.

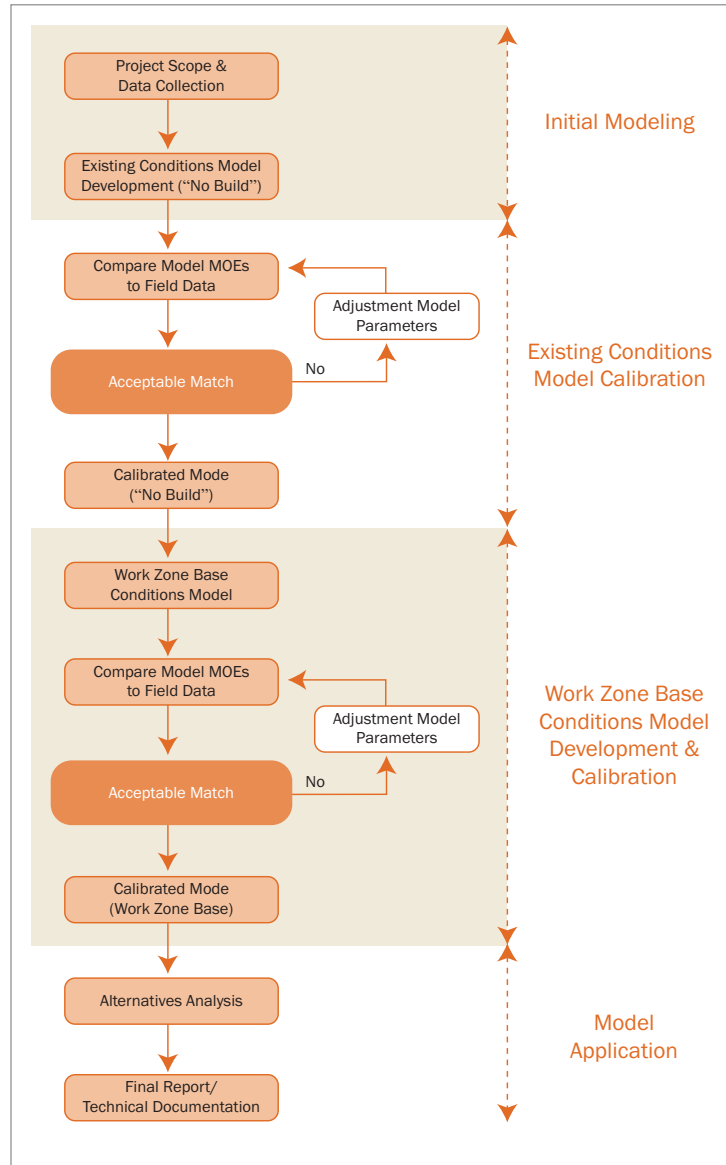
Establishing Model Development and Application Process

The overall process of developing and applying models to work zone analysis is illustrated in a flowchart (Figure 4). The major tasks involved in the process include:

- 1) Identification of project scope and data collection;
- 2) Existing conditions model development and calibration;
- 3) Work zone base conditions model development and calibration;
- 4) Alternatives analysis; and
- 5) Final report/technical documentation.

Each tool has its own set of parameters that may need to be adjusted for work zone analysis. For instance, Table 2 lists major parameters that the analyst may adjust for several commonly used microsimulation software packages.

Figure 4: Typical Model Development and Application Process for Work Zone Analysis



(Source: Cambridge Systematics, Inc.)



Table 2: Typical Parameters to Adjust for Work Zone Analysis in Microsimulation Software

MICROSIMULATION SOFTWARE	PARAMETERS		
	SPEED	CAR-FOLLOWING	LANE-CHANGING (BEFORE APPROACHING WORK ZONE)
AIMSUN	<ul style="list-style-type: none"> • Maximum speed • Turn speed at intersections • Lane speed limit 	<ul style="list-style-type: none"> • Reaction time factor • Minimum headways 	<ul style="list-style-type: none"> • Maximum delay time to remove vehicles • Look ahead distance • Lane changing model • Lane selection model • Global reaction time and local reaction time factor
CORSIM	<ul style="list-style-type: none"> • Speed limit 	<ul style="list-style-type: none"> • Car-following sensitivity • Headway factor by vehicle type • Rubbernecking factor 	<ul style="list-style-type: none"> • Time to complete lane change maneuver • Percentage of drivers yielding the right-of way to lane changing vehicles • Gap acceptance
PARAMICS	<ul style="list-style-type: none"> • Speed limit • Roadway type 	<ul style="list-style-type: none"> • Headway factor • Reaction factor 	<ul style="list-style-type: none"> • Lane choice • Signposting
VISSIM	<ul style="list-style-type: none"> • Reduced speed area • Desired speed decision 	<ul style="list-style-type: none"> • Standstill distance (CC0) • Headway time (CC1) • Following variation (CC2) 	<ul style="list-style-type: none"> • Look-back distance • Safety distance reduction factor • Waiting time before diffusion • Maximum deceleration
TRANSMODELER	<ul style="list-style-type: none"> • Lane width factor • Tunnel factor • Max speed difference • Speed limit 	<ul style="list-style-type: none"> • Desired speed model • Headway thresholds 	<ul style="list-style-type: none"> • Look ahead • Critical distance

Reconciling Inconsistencies and Conducting Sensitivity Analysis

Throughout the project development process, different analysis tools may be used which may produce inconsistent output. For instance, one tool may use a jam density of 190 vehicles/mile (or 28 feet/vehicle) while the other may use 250 vehicles/mile (or 21 feet/vehicle). This would result in inconsistent queue length estimation. This guidebook highlights various ways to reconcile inconsistencies.

Input data (e.g., traffic demand and capacity) are often subject to uncertainty, which results in uncertainties in model output (e.g., delay and queue length). Sensitivity analysis is suggested to improve understanding of the effect of these potential variations on model output and the following assessment of impacts and benefits.

Identifying Factors for Alternative Recommendation

In addition to the mobility-based performance measures (e.g., delay, queue length, and speed), a variety of quantitative and qualitative factors that may be considered in an MOTAA also are presented in this document. These factors include environmental and land use impacts, project costs, safety, surrogate safety measures, and road user costs (RUC).

Work Zone Road User Cost (WZ RUC) is defined as the incremental cost or value incurred by highway users and the community at-large as a result of a work zone alternative.

It primarily refers to monetary and nonmonetary components of work zone impacts, e.g., delay cost (passenger cars and trucks), vehicle operating cost, and crash cost. The costs of such impacts can be used for multiple applications such as evaluation of different work zone alternatives, assessment of acceleration construction techniques, and computation of incentives/disincentives.

Establishing an MOTAA Decision Framework

After models are developed and alternatives are analyzed, a set of performance measures are generated which can be used to determine how well the alternative meets the goals and objectives of the project using a decision framework. A typical decision framework often has two levels of analysis:

- **Level 1:** Factor prioritization analysis methods that prioritize and/or assign weights to the factors that are used to compare and evaluate potential work zone alternatives.
- **Level 2:** Scoring techniques for recommending alternatives which provide the structure for the decision framework.

Table 3 lists typical methodologies used for both levels of analysis in a decision framework.

Table 3: Decision Framework Methodologies

DECISION FRAMEWORK	METHODS
<p>LEVEL 1:</p> <p>Factor Prioritization Methods</p>	<ul style="list-style-type: none"> • Delphi • Factor Analysis • Ranking • Ratio • Paired Comparison Analysis • 100-Point Distribution
<p>LEVEL 2:</p> <p>Scoring Techniques</p>	<ul style="list-style-type: none"> • Simple Additive Weighting (SAW) • Analytical Hierarchy Process (AHP) • Kepner Tregoe (KT) Method • Benefit/Cost Analysis

Table 4 shows an example application of the simple additive weighting method. For each criterion, the alternatives are scored based on a scale of 10 (not effective) to 30 (most effective). In this example, Alternative 2 scores the highest and is recommended.

Table 4: Example Application of Simple Additive Weighing (SAW) Method

ALTERNATIVE	CRITERIA AND WEIGHTS					
	SPEED REDUCTION POTENTIALS (0.27)	CAPITAL AND O&M COSTS (0.33)	QUEUE LENGTH (0.20)	TRAVEL TIMES (0.13)	PROJECT DURATION (0.07)	TOTAL WEIGHTED SCORE
1	25	20	15	30	15	21.30
2	10	30	20	30	30	22.60
3	30	10	30	10	10	19.40

Referencing Checklists

A high-level checklist for performing work zone traffic analysis is provided in the document for each modeling tool type for quick reference. Table 5 provides a sample checklist for microscopic simulation tools.

Table 5: Microscopic Simulation Model Development and Application – Checklist

✓ Determine Study Objectives	✓ Check Errors
✓ Identify Needed Coordination Tasks	✓ Calibrate Existing Conditions Model
✓ Determine Study Network	✓ Verify Network Convergence
✓ Determine Analysis Time Period	✓ Determine Number of Runs
✓ Confirm Analysis Method	✓ Develop Work Zone Base Conditions Model
✓ Select MOEs and Thresholds	✓ Simulate Work Zone Taper
✓ Collect and Analyze Data	✓ Calibrate Work Zone Base Conditions Model
✓ Identify Work Zone Alternatives	✓ Conduct Alternatives Analysis
✓ Conduct Fatal Flaw Analysis	✓ Recommend Best Alternative
✓ Determine Work Zone Capacity	✓ Document Findings
✓ Determine Initialization Period	
✓ Develop Existing Conditions Model	

Developing Analysis Report Structure

Once the analysis is complete, the final step is to prepare a report. A sample analysis report structure is illustrated in Figure 5. The essential components of an MOTAA report include:

- ✓ Introduction and project background;
- ✓ Existing and future conditions;
- ✓ Alternatives considered;
- ✓ Alternatives analysis and decision framework methodology;
- ✓ Analysis results, recommended alternative, and mitigation strategies;
- ✓ Post implementation and monitoring plan; and
- ✓ Appendices.

Figure 5: Sample Analysis Report

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(Source: Cambridge Systematics, Inc.)

Case Studies

Eleven (11) work zone analysis projects, as summarized in Table 6, are presented using steps shown in Figure 4.

Table 6: Work Zone Analysis Examples

NO.	PROJECT TYPE	WORK ZONE TYPE	STATE	CATEGORY OF ANALYSIS TOOL
1	Rural Arterial	Simple Flagging	MD	Traffic Signal Optimization
2	Rural Freeway	Lane Closure	MD	Sketch Planning
3	Rural Freeway	Lane Closure	TX	Mesoscopic Simulation
4	Rural Freeway	Lane Closure	IA	Microscopic Simulation
5	Urban Freeway	Lane Closure	NC	Analytical/Deterministic Tools (HCM-based)
6	Urban Freeway	Lane Closure	MI	Sketch Planning
7	Bridge	Temporary Two-Way One-Lane Operation	MD	Traffic Signal Optimization
8	Urban Arterial	Lane Closure	MD	Traffic Signal Optimization
9	Interchange	Ramp Closure	IN	Traffic Signal Optimization and Microsimulation
10	Urban Freeway/ Bridge	Lane Closure	OH	Travel Demand Modeling
11	Urban Freeway	Lane Closure/ Ramp Closure	NJ	Mesoscopic Simulation

Summary

In summary, this document provides guidance on Work Zone Traffic Analysis (WZTA) applications and presents the steps involved in the application of an MOTAA and decision framework. It covers the following major components:

- Identification of MOT alternatives;
- Establishment of an MOTAA and decision framework process;
- Work zone traffic analysis tool types;
- Selection of the appropriate traffic analysis tool(s);
- Key considerations for modeling approach;
- Model development and application process;
- Reconciliation of inconsistencies and conducting sensitivity analysis;
- Factors for alternative recommendation;
- MOTAA decision framework;
- Analysis report structure; and
- Case studies.

More information can be found in the full document: *Work Zone Traffic Analysis – Applications and Decision Framework*, Federal Highway Administration, U.S. Department of Transportation, FHWA-HOP-12-009, April 2012. <http://ops.fhwa.dot.gov/publications/fhwahop12009/index.htm>.



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