

**PROCEDURES FOR  
NEW OR REVISED  
FREEWAY ACCESS  
IN ARKANSAS**

June 2011



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Prepared by:  
Arkansas State Highway and Transportation Department  
Arkansas Division Office of the Federal Highway Administration

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# 1. INTRODUCTION

Section 111 of Title 23, United States Code (23 USC 111) requires that proposed new or revised Interstate access must be approved by the Federal Highway Administration (FHWA) before such access modifications can be made. This report explains the FHWA policy (The Policy) for new or revised Interstate access proposals and establishes procedures for applying that policy in Arkansas. The Policy was originally issued in 1990 and then revised in February 1998 and in August 2009.

While The Policy applies to new or revised access points to the Interstate System, the Arkansas State Highway and Transportation Department (AHTD) and the Arkansas Division Office of FHWA have jointly agreed to apply The Policy to all fully access-controlled freeways in Arkansas regardless of the source(s) for funding the changes. The Policy applies to all federal, state, and local government agencies and private entities that propose and/or finance projects for new or modified access. Further, The Policy does not imply that the AHTD is relinquishing its authority over any part of the State Highway System.

## A. Basis of Policy and General Requirements

The AHTD and the FHWA have a substantial investment in the fully access-controlled freeways in Arkansas. The freeway system in Arkansas makes up less than 5% of the 16,000-mile State Highway System but carries approximately 30 percent of the vehicle miles of travel and serves as the backbone of the System. Full control of access along the freeway main-lanes and ramps, along with control-of-access on the local roadway network at interchanges, is critical to providing the highest levels of service in terms of safety and mobility. Therefore, the decision to approve new or revised access points to the freeway system should be supported by substantiated information justifying and documenting that decision.

The AHTD and FHWA's interest is to ensure all new or revised access points:

- are considered using a decision-making process that is based on information and analysis of the planning, environmental, design, safety and operational effects of the proposed change;
- support the intended purpose of the freeway system;
- do not have an adverse impact on the safety or operations of the freeway system, connecting local roadway network, or other elements of the transportation system; and
- are designed to acceptable standards.

The AHTD and FHWA have determined that the approval procedure will be a two-step process. The first step is a finding of engineering and operational acceptability in accordance with The Policy. The second step is final FHWA approval which constitutes a Federal Action, and as such requires that the National Environmental Policy Act (NEPA) procedures are followed. All of these are discussed in detail in Section 4. See Appendix A for definition of terms.

## **B. Interchange Spacing**

The spacing of adjacent interchanges has a pronounced effect on the operation of freeways. As a rule of thumb, the minimum interchange spacing is one mile in urban areas as measured from the intersecting crossroads. More space is generally required for freeway-to-freeway interchanges due to their larger footprint and higher ramp volumes. Proposed interchanges spaced less than one mile in urban areas may still be considered with appropriate geometric designs (i.e., collector-distributor roads or braided ramps). In rural areas, the minimum interchange spacing is three miles for Interstates and two miles for non-Interstate freeways as measured from the intersecting crossroads.

## **C. Re-evaluations**

If the design or operation of a project that was previously accepted is significantly changed (e.g., land use, traffic volumes, roadway design, environmental impacts, etc.), then a re-evaluation is required. The scope of the changes and the factors justifying the change will determine the level of analysis required.

If an accepted change in access has not progressed to construction within eight years after receiving affirmative determination of the engineering and operational acceptability from the FHWA, a re-evaluation is required. The NEPA re-evaluation period is different from the freeway system access re-evaluation. NEPA documents require re-evaluation in three years (23 CFR 771.129) if major steps to advance the proposed project have not occurred.

If the re-evaluation is performed after the planning, air quality conformity, and NEPA processes are completed, documentation must be provided on how these processes were amended. The documentation should include the results and/or conditions that are addressed in the re-evaluation to allow the AHTD and FHWA to make an informed decision on the change in access.



## 2. FHWA POLICY REQUIREMENTS

The Policy states that new or revised access points to the existing Interstate System should meet eight specific requirements. The AHTD and the Arkansas Division of the FHWA have determined that a new or revised access point on any fully access-controlled freeway must also meet these requirements, as shown below.

*1. The need being addressed by the request cannot be adequately satisfied by existing interchanges to the Interstate, and/or local roads and streets in the corridor can neither provide the desired access, nor can they be reasonably improved (such as access control along surface streets, improving traffic control, modifying ramp terminals and intersections, adding turn bays or lengthening storage) to satisfactorily accommodate the design-year traffic demands (23 CFR 625.2(a)).*

The intent of this requirement is to demonstrate that an access point is needed for regional traffic needs and not to solve the needs associated with local traffic. While the freeway facility should not be allowed to become part of the local circulation system, it should be maintained as the main regional facility. Improvements to parallel facilities should be considered in lieu of new access wherever feasible.

*2. The need being addressed by the request cannot be adequately satisfied by reasonable transportation system management (such as ramp metering, mass transit, and high occupancy vehicle facilities), geometric design, and alternative improvements to the Interstate without the proposed change(s) in access (23 CFR 625.2(a)).*

Improvements within an existing interchange should be considered prior to new access. This requirement does not mean that ramp metering, mass transit, and high occupancy vehicle (HOV) facilities are the only transportation system management (TSM) alternatives that should be considered. Analysis needs to be provided that addresses the design, safety, and operational considerations of these alternatives.

The proposed change in access also needs to document the consistency of any proposed change with regional, corridor, or system-wide assumptions of special use lanes, transit, or other alternatives to ensure the change in access does not preclude implementation of these TSM alternatives in the future.

*3. An operational and safety analysis has concluded that the proposed change in access does not have a significant adverse impact on the safety and operation of the Interstate facility (which includes mainline lanes, existing, new, or modified ramps, ramp intersections with crossroad) or on the local street network based on both the current and the planned future traffic projections. The analysis shall, particularly in urbanized areas, include at least the first adjacent existing or proposed interchange on either side of the proposed change in access (23 CFR 625.2(a), 655.603(d) and 771.111(f)). The crossroads and the local street network, to at least the first major intersection on either side of the proposed change in access, shall be included in this analysis to the extent necessary to fully evaluate the safety and operational impacts that the proposed change in access and other transportation improvements may have on the local street network (23 CFR 625.2(a) and 655.603(d)). Requests for a proposed change in access must include a description and assessment of the impacts and ability of the proposed changes to safely and efficiently collect, distribute and accommodate traffic on the Interstate*

*facility, ramps, intersection of ramps with crossroad, and local street network (23 CFR 625.2(a) and 655.603(d)). Each request must also include a conceptual plan of the type and location of the signs proposed to support each design alternative (23 U.S.C. 109(d) and 23 CFR 655.603(d)).*

The operational and safety analysis performed needs to include all elements of the freeway system, including collector-distributor roads, and provide a comparison of the no-build and build conditions that are anticipated to occur through the design year of the project. The analysis may be extended beyond the minimum requirements outlined above to establish the potential extent and scope of the impacts, particularly in urbanized areas with closely spaced interchanges. The analysis should demonstrate the engineering and operational acceptability of the proposed change in access. When considering the impacts of various alternatives, priority needs to be given to the performance of the freeway system within the context of the local planning, environmental, design, safety, and operational conditions.

*4. The proposed access connects to a public road only and will provide for all traffic movements. Less than "full interchanges" may be considered on a case-by-case basis for applications requiring special access for managed lanes (e.g., transit, HOV, or high occupancy toll lanes) or park and ride lots. The proposed access will be designed to meet or exceed current standards (23 CFR 625.2(a), 625.4(a)(2), and 655.603(d)).*

All interchanges need to provide for each of the eight basic movements (or four basic movements in the case of a three-legged interchange), except in the most extreme circumstances. Partial interchanges usually have undesirable operational characteristics. If circumstances exist where a partial interchange is considered appropriate as an interim improvement, then commitments need to be included in the request to accommodate the ultimate design. These commitments may include purchasing the right-of-way required during the interim improvements.

Access to special use lanes, transit stations, or park and ride lots that are part of the freeway system are special cases, and the movements requiring access should be determined on a case-by-case basis.

*5. The proposal considers and is consistent with local and regional land use and transportation plans. Prior to receiving final approval, all requests for new or revised access must be included in an adopted Metropolitan Transportation Plan, in the adopted Statewide or Metropolitan Transportation Improvement Program (STIP or TIP), and the Congestion Management Process within transportation management areas, as appropriate, and as specified in 23 CFR part 450, and the transportation conformity requirements of 40 CFR parts 51 and 93.*

The freeway system access change request needs to include a discussion as to how the proposal is consistent with the transportation planning activities for the area. If the project will be added to the planning process in the future, a discussion needs to be provided that indicates how the project will affect the current plan.

Although the FHWA may review a proposed change in access prior to its inclusion in the transportation plans, final approval cannot be given until the project is adopted in the metropolitan planning organization's (MPO) metropolitan transportation plan (MTP) or TIP within metropolitan areas and the STIP in rural areas. This would include funding from any sponsor, including a State, local agency, or

private developer. Additionally, if approval of the access hinges upon improvements to the local street network, those local improvements must also be included in the TIP and STIP.

*6. In corridors where the potential exists for future multiple interchange additions, a comprehensive corridor or network study must accompany all requests for new or revised access with recommendations that address all of the proposed and desired access changes within the context of a longer-range system or network plan (23 U.S.C. 109(d), 23 CFR 625.2(a), 655.603(d), and 771.111).*

Sufficient review and coordination needs to be performed to avoid conflicts with other proposed changes in access or corridor improvements. If two or more changes in access are being considered in the same vicinity, then these changes should be analyzed together. The combined effect of the proposed change in access is especially important when several new interchanges are proposed.

The intent of this requirement is to avoid isolated, piecemeal analysis for access change decisions. Where multiple access changes are anticipated in the vicinity, analysis must consider the possible, cumulative effects if all were to be implemented.

*7. When a new or revised access point is due to a new, expanded, or substantial change in current or planned future development or land use, requests must demonstrate appropriate coordination has occurred between the development and any proposed transportation system improvements (23 CFR 625.2(a) and 655.603(d)). The request must describe the commitments agreed upon to assure adequate collection and dispersion of the traffic resulting from the development with the adjoining local street network and Interstate access point (23 CFR 625.2(a) and 655.603(d)).*

Highways should be developed in an orderly and coordinated manner to serve the public. When new development is the driving force behind the need for access, it is expected that the appropriate coordination and analysis is performed to achieve mutual benefits with minimal adverse impact on freeway travelers. As a condition of approval, certain parts of the local circulation system may be required to be constructed or improved before the new or change in access is opened to traffic. Coordination and cooperation is essential to ensure that when several projects are linked to the approval of a change in access that they are constructed according to an appropriate phasing plan. A commitment of funding or inclusion of projects as part of the planning process prior to final approval of the change in access may be required.

*8. The proposal can be expected to be included as an alternative in the required environmental evaluation, review and processing. The proposal should include supporting information and current status of the environmental processing (23 CFR 771.111).*

The Policy allows for a two-step approval process. The first step is the determination of engineering and operational acceptability. The final approval can be granted only after the NEPA process is completed. The NEPA process must be followed regardless of the source of funding (including private funding) for the project, since approval of the proposed change in access constitutes a Federal Action. The development of final plans, specifications and engineering, and right-of-way acquisition and construction may be performed only after this final environmental approval is granted.

### 3. POLICY APPLICABILITY

An access point is defined as an entrance or exit point on the freeway mainline, including “locked gate” access. For example, a diamond interchange configuration has four access points. A proposal to revise or modify the existing access or the interchange configuration is considered a change even though the number of actual points of access may not change. For example, replacing one of the direct ramps of a diamond interchange with a loop or changing a cloverleaf interchange into a fully directional interchange is considered an access modification.

All proposals for additional or modified access must comply with Federal regulations, policies, and applicable design standards—such as the American Association of State Highway Transportation Officials’ (AASHTO) *A Policy on Geometric Design of Highways and Streets* and *A Policy on Design Standards - Interstate System*—as well as AHTD policies and practices. Exceptions to these regulations, policies, and design standards must be documented and are subject to the approval of the AHTD and the FHWA. Final project designs are subject to review and approval by the AHTD, and the FHWA if applicable.

The applicant must follow all NEPA and other applicable federal regulations such as the Section 106 process of the National Historic Preservation Act and should consider environmental and social impacts during the project development process. The NEPA process must be completed before final access approval can be given. Final compliance with NEPA procedures may either precede or follow a determination of engineering acceptability and feasibility.

#### A. Actions Requiring FHWA Access Approval

- New freeway-to-freeway interchange.
- New service interchanges providing access between a non-freeway local roadway network (arterial, collector, or local road) and the freeway.
- Modification of freeway-to-freeway interchange configuration; for example, adding new ramp(s), abandoning/removing ramp(s), completing basic movements, and reconstruction of structures.
- New partial interchanges or new ramps to-from continuous frontage roads that create a partial interchange.
- Modification of existing interchange configuration, such as adding a loop to a diamond interchange.
- Completion of basic movements at partial interchange, for example, completing a partial diamond interchange by adding a ramp.
- “Locked gate” access, (e.g., access via locked gates for emergency response).
- Abandonment of ramps or interchanges.
- Access to special use lanes such as HOV, high-occupancy toll (HOT) or truck only lanes (from the street network) within the freeway system should be treated similar to any other access.
- Relocation of a ramp terminus to a different local road.
- Changes in operation of managed-lane access to general-purpose access to the freeway.

## **B. Actions not Requiring FHWA Access Approval**

Although access approval may not be needed, coordination with the FHWA Arkansas Division Office is recommended to determine if any analysis is required based on the context of the project. If it is determined these changes may require an analysis of the planning, environmental, design, safety, or operations of the proposed improvements, the AHTD will coordinate with the FHWA Division Office to determine the type and extent of analysis required. The following changes to freeway facilities may not require approval under The Policy:

- Shift of a ramp's location within the same interchange configuration, which results in ramp spacing that meets FHWA's design criteria. If the interchange is reconfigured in such a way that the travel patterns change with the same number of access points, coordination of the project should be performed with the FHWA Division Office to determine the type of review. Changing the location of a ramp could result in changes to the safety and operational performance of the freeway system.
- Addition of lanes to an on-ramp may not require a freeway system access change request be submitted; however, based on coordination with the FHWA, analysis of the potential consequences of this change on the safety and operational performance of the freeway may be required.
- Addition of left-turn storage lanes, right-turn storage lanes, and through travel lanes at the terminus of existing ramps.
- Relocation or shifting of the existing on-ramp or off-ramp termini (i.e., moving the ramp end that connects with the local road) along the same roadway.
- Addition of a single auxiliary lane between two adjacent interchange ramps where the single auxiliary lane does not function as a mainline travel lane.
- Modification of the length of acceleration or deceleration lanes involved with any ramp.
- Improvement of traffic signals at ramp termini with local roads do not require approval but should be reviewed to ensure that the changes in the signalization do not result in queue spillback into the mainline lanes of the freeway and that sufficient storage is provided.
- Implementation of ramp metering or other active control of vehicles entering the freeway system.
- Construction of new signing, striping, and/or resurfacing of a freeway on-ramp or off-ramp, where geometric features are not changed.
- Installation of roadside guardrail and concrete barriers (such as for resurfacing and safety projects).
- Construction of overpasses or grade separation structures without ramps along freeway facilities. The approval of air-rights over freeway facilities is addressed as part of the location and design concept acceptance with the NEPA process and approval of plans, specifications, and estimate.
- Changes in access between managed lanes and general purpose lanes on the freeway.

The AHTD and the FHWA Division Office will jointly determine the applicability of The Policy to any circumstances not specifically listed above.

## **4. PROCEDURE FOR APPROVAL REQUEST**

A request for new or revised freeway access is a two-step process that consists of (1) a finding of engineering and operational acceptability and (2) final approval. The purpose of a two-step process is to help the entity requesting the access change manage risk and provide flexibility. It is intended to identify fatal flaws and to help ensure the investments in the subsequent phases of production, including any environmental documents, are not wasted. A finding of engineering and operational acceptability and final approval is valid for an eight-year period based upon the original scope and purpose of the proposal (see Section 1.C).

A request for new or revised freeway access should be accompanied by an Interchange Justification Report (IJR) that supports the request and addresses the FHWA Policy requirements. This section is written as if the proposing entity is not the AHTD. If the proposing entity is the AHTD, the same process would still follow. The basic process for this approval procedure is shown in Figure 1.

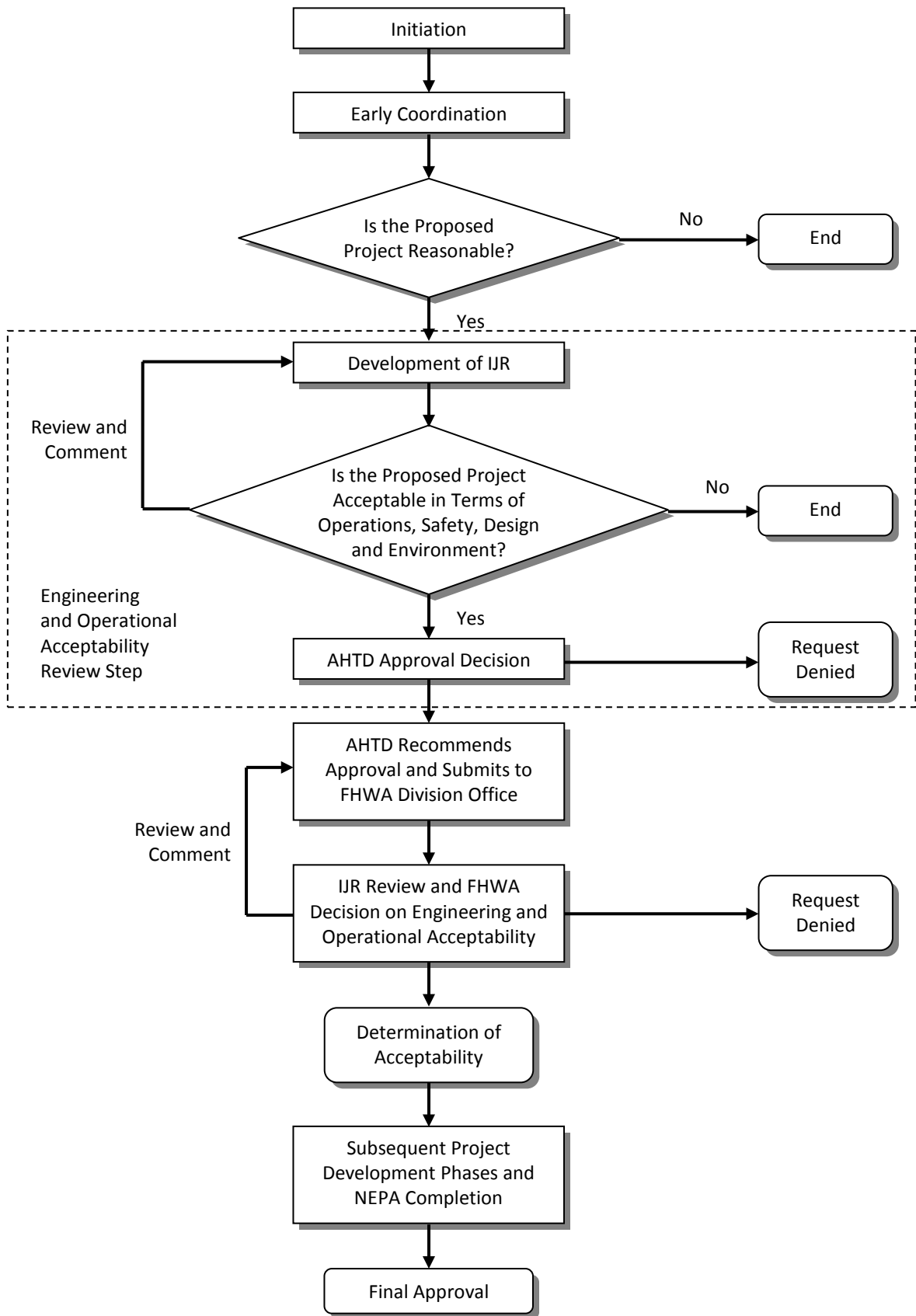
### **A. Procedure Summary**

The typical process begins within the statewide or metropolitan planning process. Ideally, the change in access has been through a transportation planning process that has involved the stakeholders to ensure the project is in the appropriate transportation plan and a system or corridor study has been completed. The work completed in this transportation planning process can be used to define the initial scope and nature of the project. This can include an interchange access in an MPO's MTP, but its inclusion in the plan should not be interpreted as approval and should not be the basis for justification in the access request.

Before making a formal request for new or revised freeway access, early coordination between the entity proposing the access change, the AHTD, the FHWA Division Office, the MPO (if applicable), and appropriate stakeholders (if applicable) should happen as soon as possible in order to refine the scope of the required analysis and to discuss the reasonability of the proposed project in accordance to The Policy.

If the proposed project appears reasonable, the proposing entity will prepare an IJR. It is recommended that there is close coordination with the AHTD and FHWA through the IJR development process. Once complete, the IJR is formally submitted to the AHTD with a request for a finding of engineering and operational acceptability. If the AHTD concurs, the request is sent to the FHWA Arkansas Division Office with a recommendation of approval. If the FHWA determines the request is acceptable in accordance to The Policy, the project may proceed to the development of final design and right-of-way plans and eventually final approval. Completion of the IJR does not guarantee approval of any new access or changes to the access; however, it does provide a framework for the analysis of the potential benefits and consequences of the proposed project.

The second step is the final FHWA approval which constitutes a Federal Action, and as such, requires that NEPA procedures are followed. Compliance with the NEPA procedures need not precede the determination of engineering and operational acceptability. Final approval of access can only be granted upon the completion of NEPA and the approval of final design and right-of-way plans. Approval of access is granted as long as there are no changes to the location or design of the "accepted" concept.



**Figure 1.** New or Revised Freeway Access Request Approval Process

Regardless of the funding source, since approval is considered a Federal Action, the project's final approval is contingent on the successful completion of the same process as used in the planning, engineering, and environmental phases for any federally funded project. The freeway system access change request also must be adopted as part of a conforming transportation plan and STIP and TIP (if applicable) to receive final approval. Review of the plans, specifications, and estimate is also performed by the FHWA prior to construction. This is the final opportunity to review and approve proposed changes in access. The final design is the recommended construction plan and should be consistent with the engineering concepts approved under The Policy. If the final design is not consistent with the approval under The Policy, a re-evaluation is necessary.

## **B. Early Coordination**

Coordination with the AHTD and the FHWA should happen as early as possible in order to avoid unnecessary effort on the part of the proposing entity. If a consulting firm will be utilized, early coordination should occur as soon as possible to help define the scope of the contract. An early coordination meeting should include, but is not limited to:

- The AHTD. The Planning and Research Division should coordinate the meeting with appropriate staff, which typically includes representatives from the Roadway Design, Environmental, Bridge, Right of Way, and Surveys Divisions, as well as the relevant District.
- The FHWA Division Office.
- The MPO (if applicable).
- The entity proposing the new or revised freeway access request.
- Transit Operators (if applicable).
- Emergency management personnel (if appropriate).

The following issues should be addressed as part of the coordination meeting:

- Reasonability of the request in accordance to The Policy.
- Need for AHTD and FHWA review and action.
- Study area and scope of the analysis.
- Defining the purpose and need of the access request.
- Performance objectives and measures.
- Technical analysis requirements for the planning, environmental, design, safety, and operations issues. The appropriate operational analysis tool(s) and a data collection plan should be discussed.

The Planning and Research Division staff will be responsible for documenting the meeting minutes.

## **C. Engineering and Operational Acceptability Review**

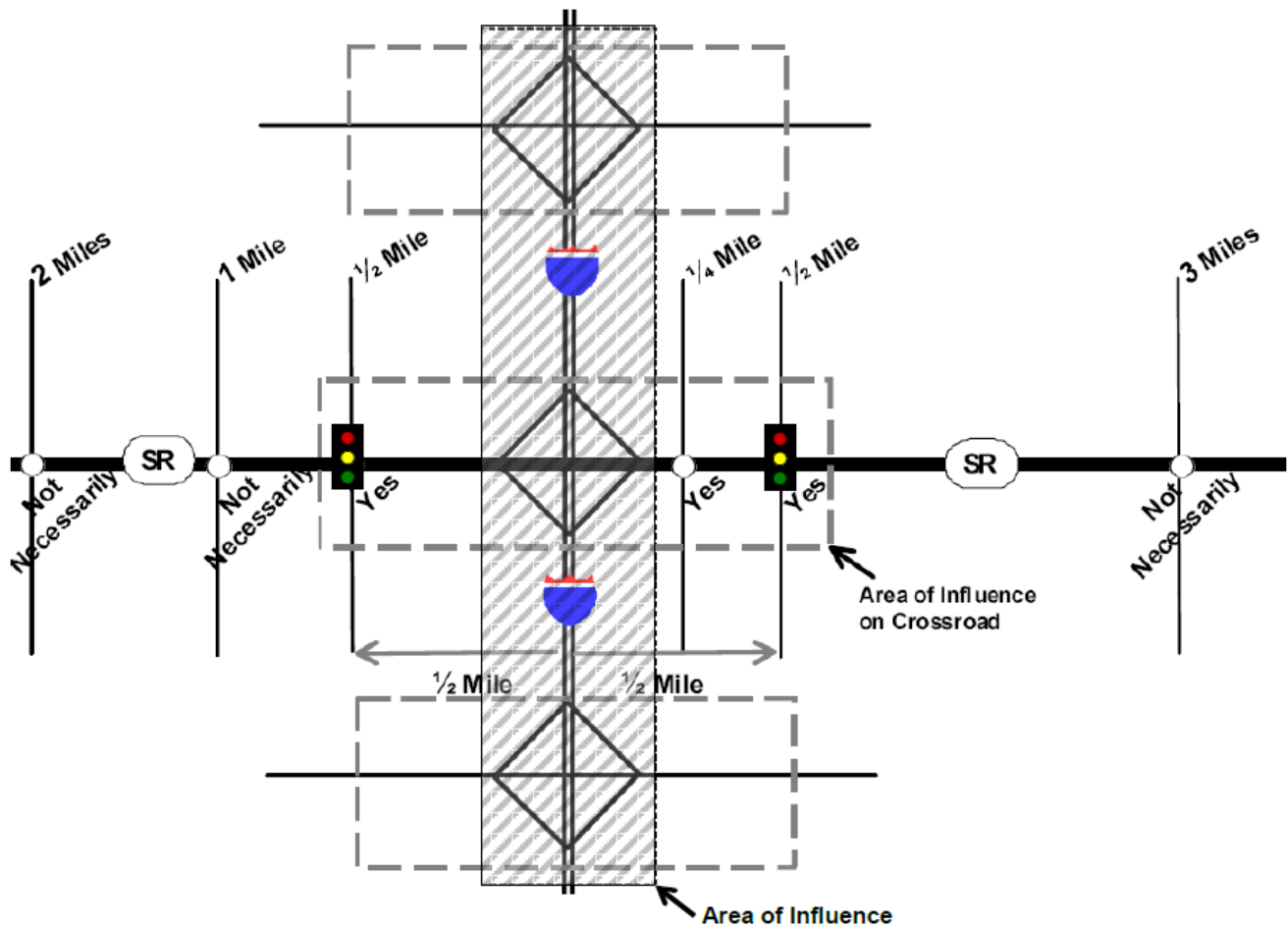
Once early coordination has occurred, the proposing entity can begin development of an Interchange Justification Report (IJR). A scope of work for the IJR should be developed by the proposing entity and coordinated with Planning and Research staff and appropriate stakeholders. The IJR should address the eight FHWA Policy requirements described in Section 2. If the proposing entity is not the AHTD, close



coordination with AHTD Planning and Research staff should occur. If the proposing entity is the AHTD, the Planning and Research Division will be responsible for preparing the document. If the proposing entity is utilizing a consulting firm, close coordination with the AHTD Consultant Coordinator should take place. See Appendix B for technical resources for additional information and guidance.

The following information is expected in the IJR:

- **Introduction** – An introduction to the proposed project should be provided that summarizes the following:
  - **Project Location** – Include an overview map of the proposed project location. A second, more detailed, map should also be included that shows the area of influence (or study area) of the proposed project. This map should be to scale and can consist of schematic drawings that show distances between interchanges, intersections, and other key features. The study area should include, at a minimum, the adjacent interchanges on the freeway and the first major intersections along the crossroad as appropriate. See Figure 2 for an illustration of the area of influence concept. Factors used to define the study area should be discussed, including interchange spacing, signal locations, anticipated traffic impacts, anticipated land use changes, or proposed transportation improvements.
  - **Background** – Any background or supporting information that explains the basis for the proposal (e.g., proposed arterial on an MPO MTP, proposed project from a corridor study, planned private development, known political support, etc.).
- **Purpose and Need** – The project’s purpose and need should be identified in this section. This section should include the following:
  - **Existing Conditions** – This section should identify current conditions. Text, figures, and tables should be used as appropriate to describe the existing land use, transportation system, demand, performance, and environmental conditions considering the following:
    - **Land Use** – Existing land use within and around the study area should be summarized by general land use classifications (residential, commercial, industrial, recreational, etc.). Nearby major developments should be identified and any local land use plans should be provided as appropriate. Aerial photos or maps should be utilized as appropriate.
    - **Transportation Network** – Roads and highways within and around the study area should be identified by functional classification, numbers of lanes, and other relevant descriptions. Any nearby relevant transportation projects—under construction, programmed, or planned—should be identified. Maps, including any local master street plans, should be included as appropriate.
  - **Operational Analysis** – The results from an operational analysis of the no-build alternative including the methodology, assumptions, and conclusions should be summarized. Current and future year no-build traffic—including average daily traffic (ADT) and peak hour or peak period traffic—should be shown along with a discussion of the methodology and assumptions of forecasted traffic. Maps, photos, tables, and figures should be utilized as appropriate. See Section 5 for more details.
  - **Safety Analysis** – The results from a safety analysis of the existing conditions including the methodology and conclusions should be summarized. Maps, photos, tables, and figures should be utilized as appropriate. See Section 6 for more details.



Source: Adapted from Florida Department of Transportation, *Interchange Handbook*

**Figure 2.** Area of Influence (or Study Area)

- **Environmental Constraints** – Any environmental constraints, particularly any potential fatal flaws or areas of concern, within the vicinity of the proposed project should be identified and briefly discussed. This analysis is not intended to provide extensive examination of environmental and community impact issues that will be accomplished in the NEPA process.
- **Compatibility with Transportation Plans** – This section will discuss the proposal’s relationship to any existing corridor studies or similar investment studies. The relationship of the proposed project to the TIP, STIP, or an MPO MTP should be also discussed, as well as the attainment status of the area for the National Ambient Air Quality Standards (NAAQS) established in the Clean Air Act Amendments.
- **Compliance with Policies and Engineering Standards** – This section will document the consistency with AHTD and FHWA policies and engineering standards for design. Any design exceptions based on the preliminary engineering concepts must also be documented.
- **Coordination** – Any coordination between stakeholders or any public involvement that occurred should be documented.
- **Proposed Alternatives** – This section should describe each proposed alternative along with an analysis of each, which should include the following:

- **Initial Alternatives** – Any initial alternatives that were considered and removed from further analysis should be included. Reasons why each initial alternative was removed from further consideration should be discussed. Layouts of any initial design alternatives should be included as appropriate.
- **Alternatives Description** – A description of each alternative carried forward should be included. Layouts of each alternative on a current aerial photo where one inch equals 200 feet should be shown that includes lane and shoulder widths, auxiliary lane lengths, taper lengths, ramp radii, intersection turning radii, grades, and other relevant geometric information. Existing and proposed right of way and control of access limits should also be shown. Lane configuration schematics should also be included for complex alternatives as needed.
- **Conceptual Signing Plan** – A conceptual signing plan layout of each alternative on a current aerial photo where one inch equals 200 feet (or other scale as appropriate) should be provided. It should include all signs required for each alternative as well as any modifications to existing signage that would be required.
- **Alternatives Analysis** – The results from an operational analysis of the alternatives should be provided. Forecasted traffic for the build alternatives should be shown on maps and figures. Measures of effectiveness (e.g., delay, travel time, queues, LOS, etc.) should be described in text, figures, or tables as appropriate. Other considerations, such as environmental constraints, safety issues, signing, and costs should be discussed as appropriate. A comparison of each alternative should be included, in either tabular form (e.g., evaluation matrix), discussion of advantages and disadvantages of each alternative, or some other form of evaluation as appropriate.
- **Funding Plan** – A funding plan that includes proposed funding sources (e.g., private development, local, State or Federal-Aid funds) for all phases of the proposed project should be included.
- **Appendices** – Appendices should include operational analysis documentation, master street plans, meeting minutes, or other relevant supporting documents.

Once the IJR is complete, an appropriate number of copies should be submitted to the AHTD Chief Engineer along with a letter requesting a finding of engineering and operational acceptability. If the AHTD concurs, the request will be forwarded to the FHWA Division Office with a copy of the IJR for review and consideration. If the FHWA determines the request is acceptable, project development may continue.

The AHTD and FHWA concurrence with the finding of engineering and operational acceptability is valid for eight years. If the project has not received final approval within that time, or if there is a significant change in conditions or design, a re-evaluation must be made through a revised IJR (see Section 1.C). The process for determining the nature and scope of the revised IJR should be jointly determined by the AHTD, the FHWA, the MPO (if applicable), and the proposing entity. The revised IJR should contain an updated analysis explaining the changes that have occurred since the initial finding of engineering and operational acceptability.

Documentation of the alternatives analysis from the IJR must be included in the environmental documentation. All feasible and reasonable alternatives must be carried through the NEPA process. The NEPA documentation should also include reasons for discarding alternatives. Although it is only required that the NEPA process be completed before final access approval is given by the FHWA, it is recommended that the NEPA process and the determination of engineering and operational acceptability

through the IJR be accomplished concurrently. This is to ensure that both the purpose and need and the alternatives analysis meet the needs of the NEPA process.

#### **D. Final Approval**

A request for final approval for a proposed new or revised freeway access can be submitted to the AHTD once the appropriate planning, air quality conformity, and environmental processes under NEPA have been completed. The project should also be included in the TIP/STIP and the MPO's MTP prior to final approval. The request for final approval should be accompanied by the final design and right-of-way plans for construction. If the AHTD determines all appropriate processes have been completed and concurs with the request, the AHTD will forward it to FHWA with a recommendation for final approval.

## **5. OPERATIONAL ANALYSIS**

The operational analysis should demonstrate the proposed new or revised freeway access will not have a significant or adverse impact on the safe operation of the freeway system. The operational analysis is integral to understanding the benefits and potential impacts to the freeway system and local roadway network. A detailed traffic operational analysis must accompany all requests through the IJR. Defining the scope of the operational analysis will primarily be driven by the purpose and need of study. The type of operational analysis will primarily be determined by the defined operational performance measures that relate to the purpose and need.

The intent of this section is to present considerations that the proposing entity should address in the operational analysis. Details of specific analysis tools and technical guidance can be found in Appendix B.

### **A. Relation to Purpose and Need**

Before embarking on any major analytical effort, the purpose and need (or problem, goal, or objective) must be identified. If the purpose and need, for example, is to reduce the back-of-queue of an adjacent exit ramp from extending onto the freeway main lanes, the operational analysis should be focused accordingly. The purpose and need will be a major factor in defining the scope and performance measures of the operational analysis, and in the selection of an appropriate analysis tool. The purpose and need should be developed to a level of detail suitable for use in the NEPA documentation.

### **B. Scope of Analysis**

Once the purpose and need has been identified, the next step is to define the scope of the operational analysis—both geographic and temporal. This should be accomplished during early coordination before the IJR is developed. When developing the scope of the operational analysis, several questions should be considered, including:

- What are the limits of the proposed project?
- What is the proximity to adjacent interchanges and intersections?
- How does the study area influence operations at adjacent locations within the transportation network?
- What alternatives are likely to be considered?
- What physical elements within the network can be analyzed to support the purpose and need?
- How many hours of congestion are present today, and how will this likely change in the future?
- Will the operational characteristics of the surrounding area change in the future and if so, will an understanding of how this relates to the study area warrant analysis?
- What degree of precision is required to make an informed decision?
- Will varying travel demand patterns and land use scenarios be considered to assess how robust and flexible the alternatives are?
- In corridors where the potential exists for future multiple interchange additions, has a corridor study been completed?

### C. Define the Design Year and Analysis Period

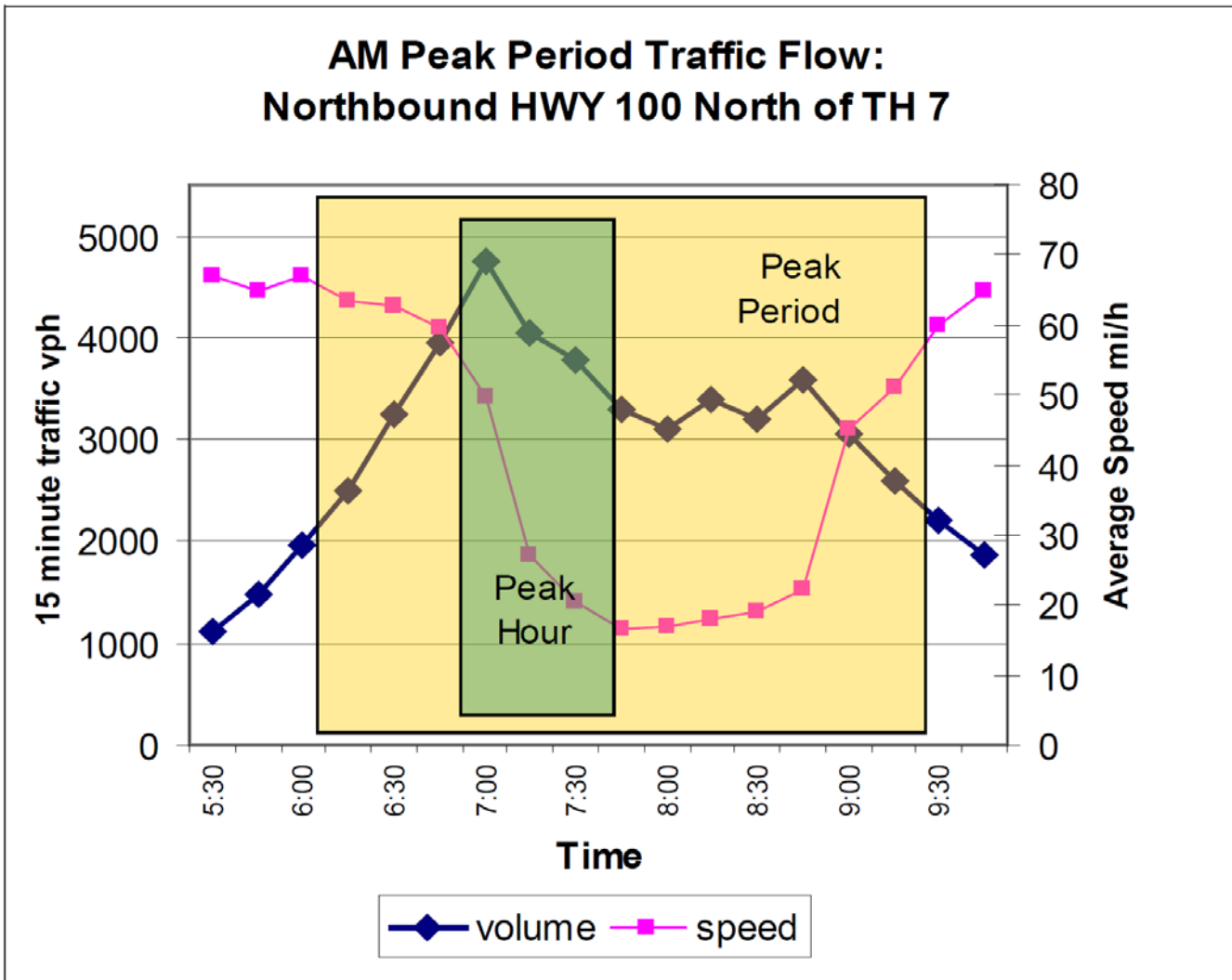
Traditionally, the design year reflects a 20-year horizon from the anticipated opening date of the project. A minimum design year based on 20 years following the approval of the plans, specifications, and estimates for a project is required by 23 U.S.C. Section 109(b), which states:

*(b) The geometric and construction standards to be adopted for the Interstate System should be those approved by the Secretary in cooperation with the State transportation departments. Such standards, as applied to each actual construction project, should be adequate to enable such project to accommodate the types and volumes of traffic anticipated for such project for the twenty-year period commencing on the date of approval by the Secretary, under section 106 of this title, of the plans, specifications, and estimates for actual construction of such project.*

According to AASHTO's *Geometric Design of Highways and Streets* (2004), the 30th highest hourly volume (30 HV) in the design year is recommended for design. If year-round traffic counts are available from a nearby count station, it should be utilized to estimate the 30 HV. If not, it is recommended that at least two typical weeks of traffic data should be obtained for each ramp, crossroad, frontage road, freeway main lanes, etc., as appropriate. One day's worth of turning movement counts per intersection may be sufficient; however, in many cases it will not. A traffic data collection plan should be discussed during early coordination.

In addition to the existing and design years, interim years may need to be considered—resulting from phased construction, changes in land use, or other projects within the study area. With construction phased over an extended period of time, analysis should be provided for each phase to evaluate operations until the next phase will be implemented.

Recognizing that congested conditions may extend beyond a single hour in some cases, analysis of the peak hour may not be adequate for the operational analysis. For locations and conditions in which a facility is at or near capacity today or in the future, a multi-hour time period would likely be required for proper analysis. As depicted in Figure 3, while the peak period and peak hour relate to each other, the average speed and traffic flow vary within each and have different maximums and minimums.



Source: *Traffic Analysis Toolbox Volume IV: Guidelines for Applying CORSIM Microsimulation Modeling Software*, January 2007

**Figure 3.** Selecting a Peak Period for Analysis

#### D. Define Performance Measures

The performance measures for the operational analysis should be discussed and defined during early coordination. The performance measures can influence the scope of the analysis and the choice of analysis tools, and should relate to the purpose and need of the proposed project (i.e., reducing the queue at an existing nearby off-ramp, improving the LOS at adjacent interchanges, etc.).

For the performance measures to be useful, they must ultimately provide information that can be used to make investment and management decisions. Since every proposal is unique and rarely requires the same level of analysis to make an informed decision, it is up to the proposing entity to establish the appropriate performance measures for the proposal. Interpretation of the performance measures to distinguish between acceptable and unacceptable traffic operations is also the responsibility of the proposing entity.

## E. Select an Operational Analysis Tool

There are many traffic operational analysis tools available for different situations. These can include deterministic tools such as the Highway Capacity Software (HCS) based on the Highway Capacity Manual (HCM), or stochastic microsimulation tools such as VISSIM. It is widely understood that in many situations around freeway interchanges, particularly in urban areas, the HCM methodology alone is not likely sufficient for appropriate analysis.

To obtain meaningful results from the operational analysis, having a clear understanding of the context for analysis is vital to the selection of the appropriate analysis tool. Answering the questions identified in Figure 4 about the context for the analysis will assist in defining the needs and requirements of the analysis tool. It is the responsibility of the proposing entity to make this selection, which should be discussed during early coordination. Guidance for selecting appropriate tools can be found in the FHWA *Traffic Analysis Toolbox*.

Analysis Context: Planning, Design, or Operations/Construction						
1	2	3	4	5	6	7
Geographic Scope	Facility Type	Travel Mode	Management Strategy	Traveler Response	Performance Measures	Tool/Cost-Effectiveness
What is your study area?	Which facility types do you want to include?	Which travel modes do you want to include?	Which management strategies should be analyzed?	Which traveler responses should be analyzed?	What performance measures are needed?	What operational characteristics are necessary?
<ul style="list-style-type: none"> <li>• Isolated Location</li> <li>• Segment</li> <li>• Corridor/Small Network</li> <li>• Region</li> </ul>	<ul style="list-style-type: none"> <li>• Isolated Intersection</li> <li>• Roundabout</li> <li>• Arterial</li> <li>• Highway</li> <li>• Freeway</li> <li>• HOV Lane</li> <li>• HOV Bypass Lane</li> <li>• Ramp</li> <li>• Auxiliary Lane</li> <li>• Reversible Lane</li> <li>• Truck Lane</li> <li>• Bus Lane</li> <li>• Toll Plaza</li> <li>• Light Rail Line</li> </ul>	<ul style="list-style-type: none"> <li>• SOV</li> <li>• HOV (2, 3, 3+)</li> <li>• Bus</li> <li>• Rail</li> <li>• Truck</li> <li>• Motorcycle</li> <li>• Bicycle</li> <li>• Pedestrian</li> </ul>	<ul style="list-style-type: none"> <li>• Freeway Mgmt</li> <li>• Arterial Intersections</li> <li>• Arterial Mgmt</li> <li>• Incident Mgmt</li> <li>• Emergency Mgmt</li> <li>• Work Zone</li> <li>• Spec Event</li> <li>• APTS</li> <li>• ATIS</li> <li>• Electronic Payment</li> <li>• RRX</li> <li>• CVO</li> <li>• AVCSS</li> <li>• Weather Mgmt</li> <li>• TDM</li> </ul>	<ul style="list-style-type: none"> <li>• Route Diversion               <ul style="list-style-type: none"> <li>- Pre-Trip</li> <li>- En-Route</li> </ul> </li> <li>• Mode Shift</li> <li>• Departure Time Choice</li> <li>• Destination Change</li> <li>• Induced/Foregone Demand</li> </ul>	<ul style="list-style-type: none"> <li>• LOS</li> <li>• Speed</li> <li>• Travel Time</li> <li>• Volume</li> <li>• Travel Distance</li> <li>• Ridership</li> <li>• AVO</li> <li>• v/c Ratio</li> <li>• Density</li> <li>• VMT/PMT</li> <li>• VHT/PHT</li> <li>• Delay</li> <li>• Queue Length</li> <li>• # Stops</li> <li>• Crashes/Duration</li> <li>• TT Reliability</li> <li>• Emissions/Fuel Consump</li> <li>• Noise</li> <li>• Mode Split</li> <li>• Benefit/Cost</li> </ul>	<ul style="list-style-type: none"> <li>• Tool Capital Cost</li> <li>• Effort (Cost/Training)</li> <li>• Ease of Use</li> <li>• Popular/Well-Trusted</li> <li>• Hardware Requirements</li> <li>• Data Requirements</li> <li>• Computer Run Time</li> <li>• Post-Processing</li> <li>• Documentation</li> <li>• User Support</li> <li>• Key Parameters User Definable</li> <li>• Default Values</li> <li>• Integration</li> <li>• Animation/Presentation</li> </ul>

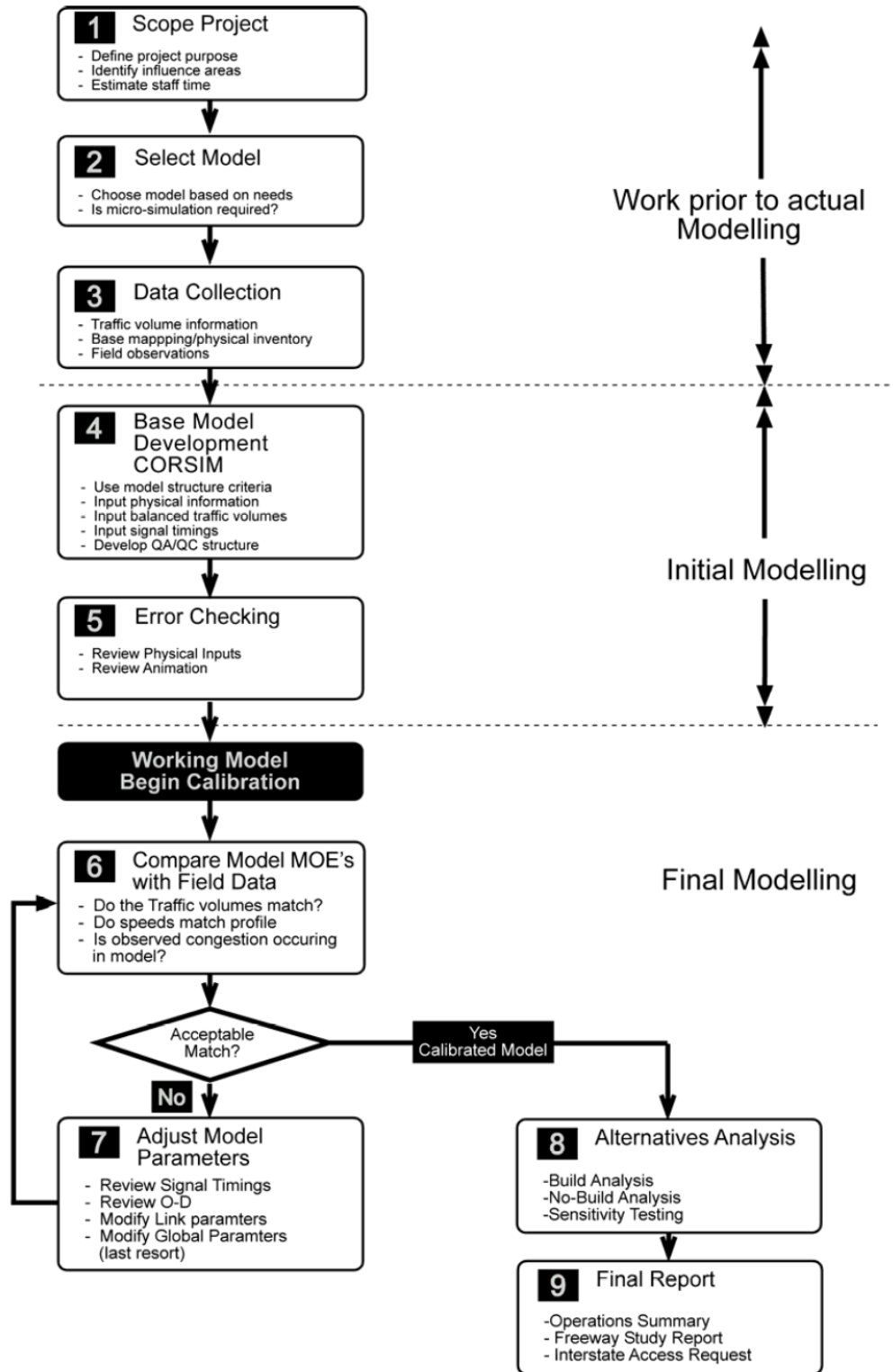
Source: *Traffic Analysis Toolbox Volume II: Decision Support Methodology for Selecting Traffic Analysis Tools*, January 2007

**Figure 4.** Decision Support Methodology for Selecting Traffic Analysis Tools

Regardless of which tool(s) is selected, it is not only important to understand the limitations of the chosen tool(s), it is also essential to apply the tools in a manner which supports a verifiable, reproducible, and accurate analysis. This includes the effective calibration of the chosen tools and proper interpretation of



the output. Figure 5 presents a process for the application of a microsimulation tool. While developed for microsimulation, the overall framework may be used to support any traffic analysis, regardless of tool type.



Source: *Advanced CORSIM Training Manual*, Minnesota Department of Transportation

**Figure 5.** Modeling Process—Guidelines for Applying Traffic Microsimulation Modeling Software

## F. Data Collection and Preparation

A data collection plan should be established once the performance measures and analysis tools are selected. The data collection plan should be discussed during early coordination. Data collection may include geometric data, existing traffic demand, existing turning movement volumes, origin-destination data, and data to support the calibration of the chosen analysis tool(s). Existing databases and studies can assist the proposing entity when considering data collection, and should be discussed during early coordination.

## G. Assessment of Existing Conditions

Other than to support the purpose and need by analyzing the no-build alternative, assessing the existing conditions is essential to calibrate the chosen analysis tool(s). Any chosen analysis tool **must** be calibrated. This applies to tools such as Synchro/SimTraffic, HCS, CORSIM, and VISSIM.

Some of the key issues to calibration include:

- Identification of necessary calibration targets of acceptability (i.e., calibrating the through-put turning movement volumes at existing intersections to within 10 percent).
- Allocation of sufficient time and resources to achieve calibration targets.
- Selection of the appropriate calibration parameters to best match local observations (i.e., saturation flow-rate, travel time, average speed, through-put volume, etc.).

Because existing conditions within each proposal study area will be unique, and because the level of calibration effort, which can be complex and time-consuming, can depend on the chosen tool, discussion with AHTD Planning and Research staff should occur during early coordination.

## H. Alternatives Analysis

Defining the alternatives to be analyzed is an essential part of specifying the scope of the operational analysis. For any request for new or revised freeway access, the following alternatives should be analyzed:

- **No-Build Alternative** – This alternative describes the conditions that will exist if the proposal is not completed. The alternative should be analyzed in the existing condition and the design year to establish a baseline for the analysis of the potential benefits and impacts of the proposal. If other improvements, such as adding lanes to the freeway or local streets, are being considered, then those improvements should be evaluated without the proposal to demonstrate whether or not the new access is necessary. See Policy Requirement 1.
- **TSM and Other Improvements Alternative** – This alternative should clearly show that there are no other alternatives which could meet the needs addressed by the proposal. This alternative will demonstrate the need being addressed by the request cannot be adequately satisfied by existing interchanges to the freeway. This alternative will demonstrate that local streets in the corridor can neither provide the desired access or be reasonably improved (such as increasing access control, improving traffic control, or adding turn bays) to satisfactorily accommodate design-year traffic demands. This alternative will also demonstrate that the need being addressed by the request

cannot be adequately satisfied by reasonable TSM strategies (such as ramp metering, mass transit, and managed lane facilities), geometric design, and alternative improvements to the freeway without the proposed change in access. See Policy Requirements 1 and 2.

- **Build Alternative(s)** – Only after the TSM and other improvements have been analyzed to demonstrate that they cannot meet the needs being addressed in the request, should new or modified access be considered. The analysis of these alternatives should consider the operational, safety, design, and environmental consequences of the proposal as compared to the No-Build Alternative.

## I. Sensitivity Analysis

Because all traffic forecasts are subject to uncertainty, there is inherent risk in any decisions based on the operational analysis (and other analyses as well) of alternatives. Traffic forecasts for a new interchange may be realized in 10 years instead of 20. Also, changes in land use—such as a new high-traffic shopping center immediately nearby—can have significant impacts on the adequate operation of an interchange.

Realizing that even a slight increase or change in traffic demand could result in nearly saturated or oversaturated operations, proposed alternatives **must** be tested under a variety of traffic demand scenarios, commonly referred to as a sensitivity analysis. It is recommended that at least a 10 percent increase in traffic demand should be included in the sensitivity analysis. Other factors, such as potential changes in land use and upstream capacity restraints, should be considered on a case by case basis.

The main purpose of the sensitivity analysis is to identify any risks associated with any alternatives that should be considered by decision makers. For example, the sensitivity analysis may show that a 10 percent increase in traffic demand may increase the length of the 95th percentile back-of-queue for a ramp terminal intersection such that it would exceed the storage space provided between it and a frontage road intersection. In this example, the risk of such overflow of queuing may be unacceptable because of the potential costs of relocating the frontage road intersection once development occurs.

## **6. SAFETY ANALYSIS**

The safety analysis should demonstrate the proposed new or revised freeway access will not have significant or adverse impact on the safe operation of the freeway system. If part of the purpose and need for the proposed project is to address existing or future safety issues—for example, to reduce the number of rear-end crashes during peak periods due to an over-saturated exit ramp—then it should be reflected in the purpose and need. The level of appropriate effort in the safety analysis should be correlated to the purpose and need of the proposal, and to the proposed alternatives themselves.

The intent of this section is to present considerations the proposing entity should address in the safety analysis. Details of specific analysis tools and technical guidance can be found in Appendix B.

The safety analysis in the IJR should address the following:

- Establish safety area of influence.
- Collect traffic, geometric, and crash data.
- Analyze crash data.
- Identify safety considerations in design alternatives.
- Document the current and anticipated safety performance.

### **A. Establish Safety Area of Influence**

The IJR should include an area of influence that addresses the safety concerns for the proposal and includes at least the adjacent interchanges along the freeway including the roads in the area of influence. For most cases, this will be the same area as the operational analysis (see Figure 2). The area of influence can and should be expanded where crash data suggests the need to do so, such as for high crash locations adjacent to the area.

### **B. Collect Traffic, Geometric, and Crash Data**

Crash data for an appropriate safety analysis as part of the IJR should include at least the three most recent years data is available. The proposing entity should request this data from the AHTD. The type of information that is typically relevant to the safety analysis includes crash location, crash frequency, crash type, crash severity, work zone related, time of day, and weather conditions.

Currently, crash data on non-State Highways in Arkansas is normally not locatable in the crash database. There is currently a statewide effort through the Arkansas State Police to require the location coding of crashes on functionally classified non-State Highways. Once this effort is complete, crashes on non-State Highways within the safety influence area of interchanges should be locatable. Until then, if the crossroad or frontage road is a non-State Highway or not maintained by the AHTD, reliable and useful crash data may not be available.

### **C. Analyze Crash Data**

Once at least three years of crash data is obtained from the AHTD, a cursory analysis of the data should follow. Crash rates may be calculated and then compared to statewide average rates for similar facilities (which can also be obtained from the AHTD). However, in many cases—particularly in congested urban areas—the crash rates within the study area will almost always be higher than the statewide average due to more congestion and more conflicts in and around interchanges. Therefore, an objective analysis using crash rates alone may not be appropriate.

Once crash rates are calculated, further investigation into the crashes is appropriate, particularly if the crash rates are higher than the statewide average. The following issues should be considered in this analysis:

- Driver workload and decision making.
- Consistency in geometric design.
- Number of lane changes required by drivers.
- Number of conflicts for drivers.
- Operational consistency along a system of interchanges.
- Flexible design solutions that can work in a variety of traffic flow volumes and patterns.

Currently, the location information for crashes on freeways, ramps, or frontage roads is normally not adequate to determine the lane in which the collision occurred. In other words, the location of a crash may be listed on a freeway as route, section, and log mile, but not list the direction of travel or lane where the collision occurred. Consequently, it may be appropriate to conduct an in-depth crash analysis by examining all possible crash records to determine the location and characteristics of individual crashes. This additional analysis can be requested from the AHTD, or the records can be requested from the AHTD and provided to the proposing entity, and should be discussed during early coordination. Also, coordination with emergency management personnel may be appropriate if further investigation is needed.

### **D. Identify Safety Considerations in Design Alternatives**

Once the safety analysis is complete in the purpose and need, safety issues and considerations in the evaluation of conceptual design alternatives should be identified. The IJR should demonstrate that the proposed alternatives will not have significant or adverse impact on the safe operation of the freeway system. The IJR should also identify any design features that may result in a higher risk of safety impacts. Figure 6 shows a table of safety impacts of not implementing certain design features.

Some safety impacts of alternatives are highly dependent on traffic forecasts, such as inadequate turn lane storage or inadequate weaving length. It is therefore crucial that a sensitivity analysis as outlined in Section 5 should be considered to determine the risk of such impacts. Conflict areas with significant traffic volumes on the crossroad (such as busy driveways near the ramp terminal intersection) or on the freeway main lanes (such as closely spaced ramps), particularly that can result in a high speed differential, should be identified and considered in the analysis.

<b>Geometric Feature</b>	<b>Operational Effect</b>	<b>Safety Impact</b>
Lack of route continuity	Excessive lane changing Violate driver expectations Increased signing requirements	Moderate
No lane continuity (basic lanes)	Excessive lane changing	Moderate
No lane balance (exit entrances)	Increased lane changing	Moderate
Inadequate application of auxiliary lanes	Capacity reduction Increased lane changing	Moderate
Left exits/entrances	Increased lane changing Two-sided weaving (across all lanes) Increased signing requirements	High
Two exits/interchanges	Increased signing requirements Potential driver confusion	Moderate
Exit beyond crossroad	Reduce exit visibility Driver comfort/convenience	Moderate
Inadequate exit/entrance design Short taper/parallel Small radius at exit/entrance gore	Inadequate merge/diverge opportunities Inadequate speed for entering vehicles Exiting vehicles slow on main lanes-speed differential	Moderate
Inadequate exit ramp length	Queuing onto main lanes	High
Inadequate weaving sections Short weaving section Two-sided weaving section	Capacity reduction Excessive lane changing Lane changing across all lanes Speed differential between vehicles-all lanes	High
Inadequate decision sight distance	Driver confusion/indecision Driver comfort/convenience	Moderate

Source: *Freeway and Interchange Geometric Design Handbook*, 2005, ITE

**Figure 6.** Freeway and Interchange Geometric Features Impacting Operations and Safety

Other safety impacts of alternatives are highly dependent on geometric design, such as the use of a low-speed exit loop ramp that may meet geometric standards but may not be consistent with driver expectations. Any design exceptions for any alternative that may have a safety impact should be identified in the IJR.

Currently, there is little in the way of widely accepted safety guidance and tools available for agencies to use in the analysis of safety performance of highways. As a result, safety considerations often carry little weight in the project development process. However, with continued emphasis being placed on reducing the numbers of fatal and serious crashes on the highway system, new approaches and tools for the quantitative analysis of safety performance are being developed. For instance, two new tools for the analysis of safety performance that will have a large impact on the development of highway projects will be the *Highway Safety Manual* and the *Interchange Safety Analysis Tool (ISAT)*. The *FHWA Interstate System Access Informational Guide* provides additional guidance regarding safety analyses that may be appropriate in an IJR.

## **E. Document the Current and Anticipated Safety Performance**

The documentation related to the safety analysis in the IJR should provide sufficient information for an independent review and usually contains the following.

- The safety analysis of existing conditions as related to the purpose and need.
  - A description of the performance measures.
  - The crash data used in the safety analysis.
  - The type of safety analysis.
  - The results of the safety analysis.
- The safety issues and considerations in the alternatives analysis.
  - Identification of any potential significant safety issues or considerations.
  - Documentation of any design exceptions.

## APPENDIX A: DEFINITIONS

A **request** for new or revised freeway access is the process of asking the FHWA for granting approval. If the proposing entity is other than the AHTD, the request goes to the AHTD first. The request for a finding of engineering and operational acceptability is typically stated in a letter that accompanies the Interchange Justification Report (IJR). The request for final approval is a separate letter.

A **review** is the process the AHTD and the FHWA follow to determine whether the request meets the eight FHWA Policy requirements. This occurs by reviewing the IJR during the engineering and operational acceptability review step, and later during the final approval step.

The **Interchange Justification Report (IJR)** is the document that is transmitted to FHWA along with the request for new or revised freeway access. The IJR supports the request and is the document that is reviewed by the AHTD and FHWA.

**Locked gate access for right-of-way maintenance** refers to access granted by the Department to the adjacent property owner for access to the highway right-of-way, but not the main lanes, for the purpose of mowing the part of the right-of-way that is outside the area that is typically mowed.

**Locked gate access to/from the main lanes** refers to specific access rights granted by the Department, with FHWA approval, to allow non-AHTD personnel access to an adjacent property.

**Urban area** refers to an urbanized area or an urban place as designated by the Bureau of the Census having a population of 5,000 or more and not within any urbanized area, within boundaries to be fixed by responsible State and local officials in cooperation with each other, subject to approval by the Secretary. Such boundaries shall encompass, at a minimum, the entire urban place designated by the Bureau of the Census.

**Urbanized area** means an area with a population of 50,000 or more designated by the Bureau of the Census, within boundaries to be fixed by responsible State and local officials in cooperation with each other, subject to approval by the Secretary. Such Boundaries shall encompass, at a minimum, the entire urbanized area as designated by the Bureau of the Census.

A **transportation management area (TMA)** is defined as an urbanized area with a current population more than 200,000 as determined by the latest census, or other area when the TMA designation is requested by the Governor and the MPO, and officially designated by the Administrators of the FHWA and FTA.



## **APPENDIX B: TECHNICAL RESOURCES**

- Interstate System Access Informational Guide, FHWA
- A Policy on Design Standards – Interstate System, AASHTO
- A Policy on Geometric Design of Highways and Streets, AASHTO
- Manual on Uniform Traffic Control Devices, FHWA
- Roadside Design Guide, AASHTO
- Access Management Manual, TRB
- Freeway Management and Operations Handbook, FHWA
- Signalized Intersections: Informational Guide, FHWA
- Traffic Analysis Tools Program (Toolbox), FHWA
- Highway Capacity Manual, TRB
- Highway Safety Manual, AASHTO
- Freeway and Interchange Geometric Design Handbook, ITE