Traffic and Safety Engineering
25% Design Submission Guidelines

As noted in Section 2.4.3 of MassDOT’s Project Development & Design Guide, the following guidelines provide additional information related to the traffic and safety engineering elements of a project. These guidelines contain detailed descriptions and requirements of the report and plans to be included with the 25% Design Submission. A functional design report (FDR), preliminary design plans, and the completed 25% Traffic and Safety Engineering Review Checklist are necessary components for all Transportation and Safety Improvement Projects submitted to the Massachusetts Department of Transportation (MassDOT), including mitigation projects (referred to as “private development”) permitted through the Massachusetts Environmental Policy Act (MEPA) process. These guidelines standardize the preparation of Functional Design Reports and streamline the MassDOT review process.

I. Functional Design Report

A. Existing Conditions

1. Study Area – Description of the study area including, but not limited to: project length, roadway jurisdiction and classification, roadway geometry (i.e. lane layouts, usage, and width, shoulder widths, location of crosswalks, guardrail etc.), pavement conditions, vehicular, bicycle and pedestrian traffic control, posted speed limits as compared to the Speed Regulations, adjacent land use, number and operation of existing adjacent driveways, transit stations/stops, and on-street parking conditions. Include a project locus map.

2. Existing Conditions – Discussion of any deficiencies or problem areas with the existing design (e.g. poor sight distance, high speeds, inefficient signal operation, lack of turn storage, etc.). Evaluate the condition of the existing signals, signage and pavement markings for potential repair or replacement. Document any field specific areas of concern.

B. Traffic Volumes

1. Traffic Count Data – Traffic count data should be current and is preferred to be less than 2 years old from the date of submission of the FDR. Data between 2 and 4 years old may be acceptable if a low growth rate factor can be documented and approved by the State Traffic Engineer (include approval in the submission). When considering volume warrants for a traffic control signal, traffic count data shall be less than 2 years old from the date of submission of the FDR. The traffic count data should be collected on an average Tuesday through Thursday when schools are in session, if possible, and exclude weeks with a holiday. The timeframe for conducting traffic counts may be altered based on land use or seasonal variations. Additional traffic count data may be required for the preparation of the Construction Management Outline (refer to Section I.G. Traffic Management for details).
a. *Automatic Traffic Recorder (ATR) Counts* – Counts should be conducted on the major roadway (both directions) for construction and safety improvement projects and on the roadway providing primary access to private development projects. The counts shall be continuous and completed over a minimum of 48 weekday-hours. The counts should be summarized in 15-minute, hourly, and daily intervals. If the project includes potential installation/modification of a traffic signal, ATR counts for the side street approaches shall be collected for a minimum of 24 continuous weekday-hours.

b. *Turning Movement Counts (TMC)* – Manual turning movement counts shall be collected in 15-minute intervals on all approaches of study area intersections, generally for a minimum of 2 hours during both the morning and afternoon roadway peak periods. However, additional peak hours shall be counted if the Private Development project trips peak at a time different from the roadway peaks. 8-hour turning movement count data is required for justification of warrant analysis for proposed signal installation. It may be necessary to review the ATR counts to determine the morning, afternoon, and 8-hour peak periods. The number of heavy vehicles, bicyclists, and pedestrians shall be collected as part of the TMC.

2. *Base Year Traffic Volumes* – Base year traffic volumes should represent an average month during the year the FDR is submitted. If the traffic count data were not collected during the FDR submission year, the data shall be factored by a seasonal/growth rate and increased by any new traffic from developments that have been completed since the time of the original count as necessary. In the case of a private development project permitted through MEPA, the base year traffic should represent an average month no more than 2 years from the date of the FDR submission. Traffic network figures that show the base year volumes shall be provided for reference.

a. Seasonal Factors – Base year volumes should be adjusted, in addition to the above, if the project is located in a region that experiences a notable seasonal variation or is primarily retail. A seasonal factor should be based primarily upon a relevant permanent count station noted in MassDOT’s *Monthly ADT Comparisons Report*. If a relevant permanent count station data is unavailable, a seasonal factor may be obtained from the appropriate Regional Planning Agency (RPA). If the above mentioned data is unavailable, MassDOT’s *Weekday Seasonal Factors Report* may be used.

b. Annual Background Growth Rate - Background growth rate, associated with region-wide population and employment trends, can be developed from documented historical data, or be directly supplied by the Office of Transportation Planning or the RPA. Justification of the background growth rate used shall be documented.

3. *Future Year Traffic Volumes* – All projects shall be evaluated with future year volumes. The future year is defined as 7 years, as a minimum, from the base year. In the case of private development projects, a timeframe of 7 years is recommended as the future year to allow for 2 years for the permitting process and a mandatory 5 years from occupancy. The volumes are typically comprised of the base year
volumes, factored by the compounded annual background growth rate (refer to Section I.B.2.b Annual Background Growth Rate for details), and estimated vehicle trips for other specific development within the study area. Traffic network figures that show the future year volumes shall be provided for reference.

a. Other Specific Development – Vehicle trips for other specific development should be included as identified by a MEPA filing or discussions with local and regional planning agencies or MassDOT.

b. Private Development Trips – All private development projects should show new trip generation estimates and calculations. The method used for distributing trips should be documented and shown graphically, this includes pass-by and diverted link trips. Pass-by rates should be consistent with the EOEA/EOT Guidelines for EIR/EIS Traffic Impact Assessment. Theoretical reductions in trip generation due to Transportation Demand Management (TDM) may be quantified in tabular format; however, full trip generation shall be used to provide a conservative analysis. Traffic network figures that show the base year volumes, the future year volumes without the project, the new trip generation/distribution, the future year project trip assignment (to study area intersections), and the future year volumes with the project trips should be provided for reference.

C. Safety Analysis

1. Crash Analysis – Collection and analysis of crash records for all corridors and intersections within the study area is required. The crash data should be based on the latest 5 years of data available (preferred) or the latest 3 years of data available (minimum) and can be requested through the Traffic and Safety Engineering Section of the MassDOT Highway Division. Crash data should be compiled in tabular format and analysis of the data shall include, but not be limited to: discussion of trends, probable causes, and geometric shortfalls (e.g. stopping and intersection sight distance) based on all collected data.

2. Crash Rate Worksheets – Calculation of the study area intersection(s) and segment(s) crash rates, as applicable, using the standard MassDOT Crash Rate Worksheet are required. Discussion shall be provided noting how the intersection(s) and segment(s) calculated rates for the project compare to the District and State-wide average crash rates.

3. Collision Diagrams – Collision diagrams are a helpful tool used to examine crash patterns at intersections and determine where improvements should be considered. Collision diagrams shall be based on the Massachusetts State Police or local police reports with crash diagrams and narratives and shall be completed for all study area intersections with more than 3 crashes per year. Back-up data to support the collision diagrams shall be provided.

4. Collision Mapping – Collision mapping is also a helpful tool used to examine patterns of crashes along a corridor. A collision map shall be created for study area corridors noting the number, type, and location of crashes.

5. Safety Review – Consideration shall be given to (but not limited to) the items listed in the Safety Review Prompt List during a site visit. Discussion shall be included in the FDR regarding the safety evaluation. If all or a portion of the project area is...
considered HSIP-eligible, the Safety Review shall be replaced with a Road Safety Audit (RSA) for the specific area. The Road Safety Audit shall be conducted in accordance with MassDOT Road Safety Audit Guidelines and shall be conducted prior to developing the 25% Design Plans. A HSIP-Eligible location is a high crash location, designated by region, which is highlighted on the map contained in the following website link: http://services.massdot.state.ma.us/maptemplate/TopCrashLocations and identified as the latest year HSIP cluster (including Bicycle, Pedestrian, etc.).

D. MUTCD Signal Warrants

1. Traffic Data – The traffic count data for the major-street and the minor-street approaches shall be collected and analyzed for a minimum of the highest 8 hours of the day. The minor-street volume shall be conducted by manual turning movement count method. The volume data should be shown in tabular form for review.

2. Warrant Analysis – MUTCD Chapter 4C: Traffic Control Signal Needs (Warrants) should be reviewed in conjunction with the prevailing geometric and speed conditions to determine if signal installation should be considered or if an existing signal remains warranted. Note: MassDOT prefers that the data satisfy an “Eight-Hour Vehicular Volume Warrant” for signal installation justification.

E. Operational Analysis

1. Capacity Analysis – Capacity analysis should be conducted for all study area intersections using an approved traffic analysis tool as noted in MassDOT’s A Guide on Traffic Analysis Tools. Capacity analysis results, including volume-to-capacity ratio, vehicle delay, and level of service (as available) should be shown in tabular format by lane group and overall intersection (as available). Where appropriate, short lane segments that operate effectively in the field as turning pockets, without being striped or signed as such, can be included in the capacity analyses. Engineering judgment shall be used in making this adjustment. All assumptions should be field verified and documented in the report text, and, to the extent possible, reviewed with MassDOT prior to conduct of the work. All analyses shall be included in the appendix; electronic files of these analyses shall be made available to MassDOT upon request.

   a. Peak Hour Factor (PHF) – All intersection approaches shall be evaluated based on the peak 15 minutes of data collected during the peak hour. The PHF shall be applied on an approach-by-approach basis for analysis of base year traffic volumes. For future year traffic volumes, the PHF shall be 0.88 for rural areas and 0.92 for urban areas.

   b. Heavy Vehicle Percentage – The traffic volume data used in the analysis shall include the percentage of heavy vehicles reflected in the actual TMC data. The percentage may be applied on an approach-by-approach basis, or by lane group as necessary.

   c. Pedestrian Phase - If applicable, a pedestrian phase should be incorporated into the analysis based on field review and engineering judgment.

   d. Analysis Scenarios - The following cases should be reviewed:

      1. Base Year Traffic Volumes with Existing Geometry
2. Future Year Traffic Volumes with Existing Geometry
3. Future Year Traffic Volumes with Proposed Geometry

For Private Development Projects, scenarios 1 and 2 above shall be considered in addition to the following two scenarios:

- Future Year Traffic Volumes including full build development trips with Existing Geometry
- Future Year Traffic Volumes including full build development trips with Mitigated Geometry

2. Systems Analysis – A systems analysis shall be completed for closely spaced intersections and/or coordinated signal systems, using an approved traffic analysis tool. The systems analysis can be either arterial or network format. The scope for systems analysis shall be defined by the designer and approved by the Boston Traffic and Safety Engineering Section or the designer shall justify why a systems analysis is not needed. Areas of influence beyond the project limits may be included in the simulation if determined necessary by MassDOT. The most appropriate modeling software for the simulation shall be determined by the designer and also approved by the Boston Traffic and Safety Engineering Section. The system model shall appropriately simulate the existing conditions before modeling alternative scenarios. Electronic files of these analyses shall be submitted to MassDOT for review.

3. Queue Length Analysis – Both 50th (average) and 95th Percentile Back of Queue calculation results should be depicted graphically as well as summarized in tabular format for the analysis scenarios listed above. The approved software programs provide vehicle queue results as part of the analysis and should be used for all situations. Queues calculated as part of a coordinated systems analysis are preferred over the isolated intersection results. A standard vehicle length of 25 feet should be used unless data can be provided to support an alternate length.

4. Basic Signal Strategy – The capacity analyses evaluating the existing condition should accurately reflect the existing conditions such as timing and phasing, as determined by a field visit. The capacity analyses evaluating the Build condition shall replicate what is depicted in the plans.

F. Proposed Design

1. Modified Geometry – The report shall include discussion of the alternative designs considered, if any, and the proposed geometric changes associated with the preferred alternative. List out the strengths and weaknesses of each alternative and how a preferred alternative was determined. Discussion shall include the rationale for selecting the design criteria for the project.

2. Bicycle and Pedestrian Accommodation – A narrative describing how the project improves or addresses bicycle and pedestrian accommodation shall be included. This narrative should also include impacts associated with meeting design requirements (i.e. ROW, environmental impacts, change in scope, construction costs).
3. **Proposed Traffic Control Modifications** – Modifications to the existing traffic control should be documented, including specific details regarding the layout and intended operation of any new equipment.

4. **Roundabouts** – A roundabout should be considered, when feasible, to address intersection traffic control. When a roundabout intersection is proposed for a project, we recommend reviewing the latest edition of the Federal Highway Administration’s publication, *Roundabouts: an Informational Guide* for design assistance. Design criteria are explained in depth with detailed explanations of the characteristics of the modern roundabout vs. the traditional rotary that is common in Massachusetts. If feasible, the offset left geometry should be proposed.

5. **Mitigation Requirements** – For all Private Development projects the proposed mitigation requirements (Section 61 Finding, if applicable) should be clearly defined and a copy shall be included in the Appendix. This includes all phased work up to full build-out (mitigation phases based on occupancy, trip generation or other means). The schedule for improvements should be clearly defined in the document.

6. **Traffic Calming** – If a project is submitted to MassDOT for review that includes any form of traffic calming, it should follow the “Traffic Calming Guidelines” as developed by the New England Section of the Institute of Transportation Engineers on behalf of MassHighway. Traffic Calming is primarily intended for functionally classified local roads.

7. **Safety Enhancements** – All study area intersections shall include corrective design measures based on the safety analysis. Discussion shall include all detailed recommendations to reduce the severity and number of crashes and enhance the overall safety condition of the roadway based on the field visit, collision diagrams/mapping and engineering judgment. In addition, all potential enhancements identified in the RSA report should be included in the proposed design, or justified in the FDR why they are not feasible or appropriate.

8. **Work by Others** – The project shall document the “work to be done by others” and how the schedule for this work impacts the proposed project. Lapses in construction sequencing should be addressed with temporary improvements as necessary.

### G. Traffic Management

1. **Construction Management Outline** – Provide a description of all major construction components of the project (utilities, culverts, sidewalks, roadway grading, etc.) and how vehicle, pedestrian, and bicycle accommodations will be maintained during that construction component (lane closures, pedestrian routes, detours and detour route descriptions, etc). The description should be detailed and include at a minimum: the number and width of available travel lanes for each direction of travel and proposed work hours. The traffic management approach selected for each component should result in the least adverse impact possible to all facility users. All temporary facilities shall be handicap accessible as directed by the Massachusetts Architectural Access Board (MAAB) and the Federal Americans with Disabilities Act Accessibility Guidelines (ADAAG).

   a. **Traffic Count Data** – Traffic count data will be necessary for all construction projects that impact the roadways. In general, the criteria set forth in the
I.B.1 Traffic Count Data section shall apply in addition to the following statement: Friday through Monday (weekend) counts will be necessary if construction will occur on those days given the difference in traffic patterns and time of day volumes when compared to a typical weekday. Traffic count data shall consist of 48-hour (minimum) ATR data for all roadways impacted by construction within the project limits. The ATR data shall include vehicle classification and speed information. If there is an existing or proposed traffic signal, existing designated turn lane(s), or multiple lanes approaching an unsignalized intersection, peak hour (based on the ATR data collected) Turning Movement Counts (TMCs) shall be submitted in addition to the ATRs. The TMCs shall provide classification by vehicle, bicycle and pedestrians. If the traffic signal is part of a coordinated system of signals additional TMCs and ATRs are required at the adjacent intersections both upstream and downstream of the project location. If construction impacts are such that they may have corridor or regional impacts additional count data may also be required as directed by the State Traffic Engineer.

b. Capacity Analysis – Roadway capacity shall be evaluated using the required ATR data and the Measured Work Zone Capacities table provided on Figure Gen-1 of the Standard Details and Drawings for the Development of Temporary Traffic Control Plans. If the analysis shows traffic impacts, and backups are expected, additional mitigation may be required.

II. Preliminary Design Plans

A. Basic Design Plan Set


2. Dimensions – All projects shall be designed using English Units.

3. Roadway Cross-Section – The typical cross-section for the roadway segments included in the project should be developed in accordance with MassDOT’s Project Development & Design Guide to ensure a context-sensitive design that accommodates all users safely. This includes, but is not limited to, the provision for bicycle accommodation. Right-of-Way, environmental, historic and other constraints may influence the development of the roadway cross-section. The Designer is responsible for obtaining any necessary design exceptions at this stage of the design process.

4. Additional Detail – It is recommended to supply additional details on the preliminary plans, including but not limited to: lane and shoulder pavement markings, sign locations, crosswalk and wheelchair ramp placements, location of sidewalk facilities, and other bicycle and pedestrian accommodations.
B. Traffic Signal Plans

1. **Signal Head Placement** – All existing and proposed traffic signal heads shall be identified on the plans and positioned at their intended angle of sight. Heads shall be located within the cone of vision as specified by the MUTCD.

2. **Signal Head Data** – The type and quantity of each signal head configuration shall be noted on the plans and in accordance with the MUTCD. The signal head configuration detailed on the plans shall be consistent with the text and analysis in the Functional Design Report.

3. **Pavement Markings** – The pavement markings necessary to the operation of the traffic signals (e.g. lane layouts, stop lines, dedicated turn lanes) should be included on the traffic signal layout plans.

4. **Sequence and Timing Chart** – Each signalized location shall have the appropriate sequence and timing chart included with the plan set. The sequence and timing chart detailed on the plans shall be consistent with the text and analysis in the Functional Design Report.

5. **Preferential Phasing Diagram** – A preferential phasing diagram shall be shown for each signalized location and should include concurrent or actuated pedestrian phases and emergency vehicle preemption phases as necessary. The phasing sequence detailed on the plans shall be consistent with the text and analysis in the Functional Design Report.

6. **Coordinated System** – A proposed method of coordination shall be noted for new coordinated traffic signal systems. If modification of an existing coordinated system is proposed, then the additional components shall be noted. A Time-Space Diagram for the interconnected signals is recommended at the 25% submission, although not required until the 75% submission stage.

7. **Signal Detectors** – Although this is not a requirement at the 25% design stage, it is recommended that traffic signal detector information be included in the signal plans. Location and detector type information is more important than specifics on hardwiring and geometrics. Bicycle accommodation is required at all signal installations, except on approaches to and from limited access highways.

8. **Miscellaneous** – Early coordination is helpful when considering the pre-emption needs of the municipality, the ownership and maintenance of signal equipment, and the payment of utility expenses.

C. Traffic Management Plans (TMP) - For significant projects, a TMP consists of a Temporary Traffic Control Plan (TTCP) and addresses the Intelligent Transportation System Monitoring Plan (IMP) and the Public Information Plan (PIP) aspects of the project.

1. **Basic TTCPs** – While it is not a requirement at the 25% design level, it is recommended that some preliminary temporary traffic control plans (TTCP) be provided at this stage. At a minimum, construction staging for bridge work shall be submitted at this stage if not sooner (pre-25%).

2. **Typical Layouts** – Each project shall, at a minimum, include a typical TTCP layout as provided in the MUTCD or as provided in MassDOT’s Standard Details and
Drawings for the Development of Temporary Traffic Control Plans, however, modifications are usually necessary.

3. *Detour Routes* – All proposed detour routes should be clearly marked out and be “user friendly” to the general public. If a detour route uses roads under local jurisdiction then the plan shall be reviewed by the local community.

4. *Pedestrian and Bicycle Accommodations* – All TTCPs shall address pedestrian and bicycle accommodation. If bicycle or pedestrian facilities are temporarily closed due to construction then alternate routes shall be provided and clearly marked. All temporary facilities shall be handicap accessible as directed by the MAAB and the ADAAG.