Revision 03/27/24

Electronic Traffic Control Device Guidelines

MDOT

Michigan Department of Transportation

Revision Date: Issue Addressed

8-4-15: Original posting to website

11-30-16: Corrected missing hyperlink to section 1.7.1 on pg. 10

Page 101 section 7.4.1 C under REST IN WALK: Added reference to section **7.5** E for Coordination Mode

Page 12 section 1.7 Devices in School Zones: Added verbiage that requests should be documented by a letter from the Superintendent, especially when school costs will be incurred with the installation

Page 16 Figure 1-2: Corrected step 4B verbiage

Pages 116-117 SECTION B – PREEMPT TIMES: SEL Ped Cl, SEL Yellow, SEL Red Cl: When replacing existing controllers (having EPAC Software versions prior to 3.56) with new controllers (using EPAC Software version 3.56 or greater), it is imperative that any existing settings of SEL PED CLR = "0" be changed to SEL PED CLR = "1" to avoid long transition times.

11-29-17: Page 8 Section 1.3: Added text "including aligned left turn only lanes" when discussing the need to widen to obtain two approach lanes to accommodate a new traffic signal

Page 55 Section 5.2.1 Cycle Length Selection added: "The network cycle optimization option should be selected, and the resulting performance indices reviewed and reported as part of cycle length evaluation and selection."

Section 1.2.6 Signals for Private development: Added typical data requirements for traffic impact studies

Added verbiage about the purpose of this document immediately below this update list

05-07-21: Notification of Installation of New Traffic Signals (Formerly T&S Note224a) was added as Section 1.3

Financial Participation in Traffic Signals Due to Operational Changes (Formerly T&S Note 262A) was added as Section 1.5

Pedestrian Activated Devices information updated in Section 1.6 in regards to Rectangular Rapid Flashing Beacons.

Additional references to Form 1597 (1597 Form Signal Study Screening) and Pedestrian Crosswalk Guide were added in Section 3.1.

Section 7 was rearranged in descending order starting with the most commonly used Timing Permit. The NTCIP Permit was discussed in Section 7.1. Sections discussing the same timing permit were also combined.

Reference to the EPAC timing parameters spreadsheet was added to Section 7.2.

03-27-24: All links to MDOT forms and other internet resources were verified and updated where needed.

Modified guidance for accessible pushbuttons, use of leading pedestrian intervals, clearance interval calculations, and extended pedestrian clearance typical preference (end of green).

Updated Warrant Analysis supporting text about right turn reduction percentages.

NTCIP Permit images and supporting text updated.

Ring and Barrier phasing diagram and language updated to clarify MDOT standard: Coordinated Phase 2 is NB or EB, then assign phases clockwise with 4 EB or SB, 6 is SB or WB, and 8 is WB or NB.

The purpose of the *Electronic Traffic Control Device Guidelines* is to provide guidelines and recommendations for the use and operation of electronic traffic control devices in the state of Michigan. This manual provides guidance to administrative, engineering, and technical staff. Engineering practice requires that professionals use a combination of technical skills and judgment in decision making. Engineering judgment is necessary to allow decisions to account for unique site-specific conditions and considerations to provide high quality products, within budget, and to protect the public health, safety, and welfare. This manual provides the general operational guidelines; however, it is understood that adaptation, adjustments, and deviations are sometimes necessary. Innovation is a key foundational element to advance the state of engineering practice and develop more effective and efficient engineering solutions and materials. As such, it is essential that our engineering manuals provide a vehicle to promote, pilot, or implement technologies or practices that provide efficiencies and quality products, while maintaining the safety, health, and welfare of the public. It is expected when making significant or impactful deviations from the technical information from these guidance materials, that reasonable consultations with experts, technical committees, and/or policy setting bodies occur prior to actions within the timeframes allowed. It is also expected that these consultations will eliminate any potential conflicts of interest, perceived or otherwise. MDOT Leadership is committed to a culture of innovation to optimize engineering solutions.

The National Society of Professional Engineers Code of Ethics for Engineering is founded on six fundamental canons. Those canons are provided below.

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform Services only in areas of their competence.
3. Issue public statement only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.

Conduct themselves honorably, reasonably, ethically and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

To provide comments, please contact the MDOT Signals Unit at 517-488-7413.

This document was prepared by:

WSP USA

500 Griswold Street, Suite 2600
Detroit, MI 48226

In cooperation with:

Michigan Department of Transportation

Operations and Field Services Division
Traffic Signal Operations
6333 Lansing Rd
Lansing, MI 48917

TABLE OF CONTENTS

List of Appendices

List of Figures

List of Tables

1 STUDY AND APPROVAL PROCESS FOR DEVICES

This chapter provides guidance for evaluating various electrical devices proposed for use as traffic control devices or as warning devices on State of Michigan highways.

The following *MDOT Traffic & Safety Notes* have been incorporated into this chapter:

- Note 201A: Traffic Signal Warrant Analysis
- Note 201B: Requesting an Electronic Traffic Control Device
- Note 202A: Required Intersection Widening to Accommodate New Signals
- Note 204A: Guidelines for Installation of Emergency Vehicle Traffic Signals
- Note 205B: Guidelines for Installation of Emergency Vehicle Advance Warning Signs Supplemented with Flashers or Pre-empt of Existing Traffic Signals.
- Note 210A: Application of the MMUTCD Traffic Signal Warrants
- Note 211A: Procedure for Installing a Pedestrian Hybrid Beacon
- Note 212B: Signs with Rectangular Flashing Beacons
- Note 224A: Notification of Installation of New Traffic Signals
- Note 262A: Financial Participation in Traffic Signals Due to Operational Changes
- Note 405B: School Traffic Signals

Consideration of all transportation modes, and advances in technology, have resulted in more devices being requested to assist pedestrians, cyclists, bus, and transit, in addition to automobile drivers. When evaluating a proposed device for the benefit of one of these modes of transportation, consideration must be given to potential adverse impacts to the other modes. A comprehensive traffic engineering study is required to evaluate requests for new devices and for the modification of existing devices.

The process for approving or modifying an existing electronic traffic control device on the state trunkline highway system can be broken down into two major parts, the study and the design. This chapter will focus on the Signal Study with emphasis on the approval process. In addition to standard traffic signals, these devices include overhead flashing beacons, sign mounted flashers, and various devices to assist pedestrians and emergency vehicles

1.1 REQUESTING AN ELECTRONIC TRAFFIC CONTROL DEVICE (FORMERLY T&S NOTE 201B)

Some requests for new electronic traffic control devices can be addressed by a preliminary review of existing data and roadway characteristics without ordering a traffic survey and a full traffic engineering study. To assist in this preliminary review of data, the online ***SIGNAL STUDY SCREENING FORM*** has been developed. To ensure the proper use of electronic traffic control devices, MDOT has a process for studying and approving these devices outlined as follows:

1. The Region/TSC Traffic and Safety Representative receives a request to review a location for an electrical device.

2. The Region/TSC Traffic and Safety Representative reviews the existing files and conducts a field review. The Region/TSC Traffic and Safety Representative completes the online ***SIGNAL STUDY SCREENING FORM*** (1597) and submits it to the MDOT Signals Unit. Some preliminary counts may be required to complete this form. Although the title of this form refers to “Signal”, this form should be used for requests for all electronic traffic control devices. The comments section of this form should be used to clearly state the request and to include any detailed information pertinent to the issue.

3. The MDOT Signals Unit will review the form and decide if a formal study is required, if more information is needed, or if the request can be denied based on the information in the Signal Study Screening form.

4. If a formal study is needed, the MDOT Signals Unit will typically order a full survey of the intersection to be completed typically by Transportation Planning Staff. For a new signal study, the full survey includes 24-hour machine counts, 8-hour manual turning movement counts, a gap study, and a delay study. In addition, they will provide a drawing of the intersection showing laneage and any other unusual conditions.

5. The MDOT Signals Unit will also review the crash data for the intersection and if appropriate conduct a field review.

6. Upon completion of the full survey, review of the crash data, and if appropriate a field review of the location, the MDOT Signals Unit will determine if a signal should be installed. The Region/TSC Traffic and Safety Representative is asked for input on the draft memo and will receive the final memo of the results. The Region/TSC Traffic and Safety Representative then notifies the local agency involved of the results.

7. The Region/TSC Traffic and Safety Representative then notifies any affected local or private agency of the results. Because traffic signal maintenance (and sometimes installation) costs are split among any agencies having jurisdiction of an approach to the intersection, The Region/TSC Traffic and Safety Representative must provide written approval from any agencies ensuring that the estimated signal costs will be paid.

8. For permit based requests, the developer shall hire a consultant pre-qualified in traffic signal operations to perform the analysis. MDOT reserves the right to make the final determination if electronic traffic control devices are justified. If a device is approved as part of a permit, a minimum $2000.00 fee (per signal location) must be included in the permit to cover MDOT’s cost to set up the controller and perform

inspections on the installation. The permitee is typically responsible for the installation costs and for obtaining approvals from any other agencies involved.

1.2 TRAFFIC SIGNAL WARRANT ANALYSIS (FORMERLY T&S NOTE 201A)

This section provides information and guidance on the use of traffic signal warrants. MDOT has an online spreadsheet ***SIGNAL WARRANTS*** to assist in summarizing the necessary data and performing signal warrant analysis.

The online MDOT document ***TRAFFIC SIGNALS - A GUIDE FOR THEIR PROPER USE*** explains the need to use uniform standards when evaluating the need for a traffic signal and the potential negative impacts of installing a traffic signal.

The *Michigan Manual on Uniform Traffic Control Devices* (MMUTCD) contains a number of "warrants" of which at least one must be met prior to installing a traffic signal. A significant amount of data must be gathered and evaluated to properly determine if a traffic signal is appropriate. Even if one of the warrants is met, engineering judgment is required to determine if the benefits of the installation of a traffic signal will outweigh the negative impacts. It is also important to review the traffic signal warrants for existing traffic signals periodically to determine if a traffic signal is still justified. Unwarranted signals can actually increase both delay and crashes.

For a more detailed description of each signal warrant see Chapter 4C: Traffic Control Signal Needs Studies in the current version of the MMUTCD. MDOT primarily focuses on the eight hour Warrant 1, but all appropriate warrants should be evaluated to ensure a comprehensive review of site conditions.

An engineering study focusing on traffic conditions, non-motorized characteristics, and physical characteristics of the location should be performed before determining the justification of a particular signal. Compliance with (or lack of) the traffic signal warrants does not in itself require the installation (or removal) of a traffic control signal.

A warrant analysis for a new signal requires the following data:

- Peak eight hour turning movement volume
- A backup delay study per MDOT standards
- A gap study per MDOT standards
- Twenty four hour volumes on all approaches
- An intersection diagram showing all pertinent geometric information and speed limits
- Crash data from the most recent 3 to 5 years
- If appropriate, pedestrian and school crossing data

- If appropriate, a capacity analysis comparing the existing operation and potential signalized operation

It is important to review all criteria in each warrant. Some require trial of other remedial measures, and several have delay or crash data requirements. Optimization projects will typically provide all the required data as part of the project.

1.2.1 *ITEMS FOR CONSIDERATION REGARDING VOLUME INFORMATION*

- The MMUTCD states, "The study should consider the effects of the right-turn vehicles from the minor-street approaches." This addresses the "right turn on red" phenomena. Effects of left turning vehicles on one-way roads (boulevards and cross-overs) can be considered for reducing approach volumes.
    - The intent is to identify how many vehicles are experiencing very little delay under the unsignalized operation. This reduction in volume, which is ultimately removed from consideration of signal warrants, is determined and applied within the warrant analysis tool, ***SIGNAL WARRANTS***. Typical candidates for reduction are right turning vehicles at a standard intersection and left turning vehicles at a crossover.
- The MMUTCD allows for consideration of crashes, speed limits and area population for reducing volume requirements. While the MMUTCD allows for it, the reductions are not typically treated as additive for typical warrant analyses. Whichever situation creates a larger reduction in the warranting volumes is typically used.
    - If a situation arises where the engineer feels that it is appropriate to use multiple reductions in an additive fashion, she or he should consult with the Signals Unit for agreement and approval prior to submitting a recommendation.
- All warrants will be analyzed based on two lane approaches in all directions. A minimum of two approach lanes is typically required prior to installing a traffic signal to ensure efficient signal operations

1.2.2 *ITEMS FOR CONSIDERATION REGARDING DELAY INFORMATION*

- When reviewing delay information at an intersection, patterns of delay in excess of one minute experienced by any particular approach may be a potential cause for concern.
    - When reviewing delay for left-turn phasing studies, the delay is partially dictated by the existing cycle length. For example, a 120 second cycle length could consistently provide the major road with 90 seconds out of the cycle. A driver on the minor road that arrives just after their signal turns red will have to wait 90 seconds until they get the green. If that driver doesn't get through the intersection on the green, they experience what is called a cycle failure. Cycle failures may be a potential cause for concern.
- Field measured delay is the preferred data to be used for analysis. Locations where projected volumes are used have delay information calculated from simulation models. The simulation models must be reviewed carefully due to the speculative nature of volume projections.

1.2.3 *ITEMS FOR CONSIDERATION REGARDING CRASH INFORMATION*

- Crashes considered correctable by signalization are typically right angle type crashes. Research has shown that total crashes typically increase when a signal is installed, particularly rear end type crashes on the major road. Locations that experience a pattern of right angle type crashes of at least 5 per year on average may be a cause for concern and further review should be done to identify potential causes of the crashes. Also, crash trends over time and crash severity should be considered in determining if the number of crashes per year is a concern.

- Crashes considered correctable by left-turn phasing are typically head on-left turn type crashes. Crash thresholds are established for one and two approaches for one and two years.

1.2.4 *MISCELLANEOUS ITEMS*

- The MMUTCD states, **"The satisfaction of a warrant or warrants shall not in itself require the installation of a traffic control signal."** A traffic signal should not be installed unless an identifiable concern exists, regardless of any warrants that are met. The most important concerns are excessive delays or crash patterns susceptible to correction by signalization.

- The MMUTCD is referenced by the Michigan Vehicle Code and has the force of law. It states, "A traffic control signal should not be installed unless one or more of the factors described in this Chapter are met." Federal funds cannot be used unless a warrant is met. Therefore, a thorough signal warrant analysis must be completed before a traffic signal will be approved.

- The MDOT Signals Unit considers Warrant #1 (Condition A) as the major component for traffic signalization analysis. This warrant is an eight hour volume warrant. The remaining warrants were developed to address situations when a location experiences a delay or crash pattern so serious that a traffic signal may be an appropriate solution even though the intersection does not meet the minimum volumes required by Warrant #1 (Condition A). In those situations, other warrants may be considered.

- Many of the warrants have multiple requirements that must be met before that warrant can be applied to a location. Some [#1 (Condition B) and #3] require excessive delay be experienced on the minor road approaches and Warrant #1 (Combination of A & B) requires trial of other remedial measures first. If these initial requirements are not met, it is inappropriate to review the remainder of the warrant.

- Even if an intersection meets one of the warrants based on traffic data, engineering judgement is required to determine if a new traffic signal is the best solution. Considerations should include:
    - Evaluation of other alternatives including roundabouts, pedestrian devices, improved access management, and roadway geometric improvements that may provide a better solution.
    - Assessing if the benefits of a traffic signal will outweigh any potential negative impacts including increased delay and frequency of rear end crashes.

- Determine the impact to any nearby signals. Signal spacing has significant impacts to traffic operations along a corridor. Allowing a signal to be installed too close to an existing signal can result in queues that may block all traffic movement at an intersection. Allowing a signal to be installed too close to existing signals along a corridor can interrupt two-way progression and significantly increase delay along the corridor. Minimum desirable signal spacing to provide two-way progression (for cycle length of 90 s and 40 Mph speed) is approximately 1/2 mile.
- Evaluate existing roadway geometry that might preclude the installation of a traffic signal including horizontal and vertical curvature and skew.

1.2.5 *SIGNAL WARRANT FILE NAMING CONVENTION*

Each signal warrant analysis spreadsheet ***(SIGNAL WARRANTS.XLS)*** should adhere to a standard naming convention unless otherwise discussed in advance with the MDOT project manager. The following is the standard file naming convention:

Control Section # - Spot # -"Signal Warrant" – Month-Day-Year.xls

Example: The Woodward Avenue (M-1) corridor within the city of Detroit (Control Section 82400) is being reviewed. The spot number in this case is 025. The date is May 6th, 2015.

File Name = ***82400-025-Signal Warrant – 05-06-2015.xls***

1.2.6 *SIGNALS FOR PRIVATE DEVELOPMENT*

If a traffic impact study is required per latest version of ***GEOMETRIC DESIGN GUIDANCE***. It is strongly suggested that a traffic volume assumptions memo be approved very early in the study. This memo would include assumptions regarding traffic growth, future year(s) to be evaluated, trip generation rates, percent bypass trips, and percent internal trips.

The scope and detailed requirements of any required traffic impact study will be determined by a cooperative effort between MDOT (including specialty units) and the developer after a preliminary site plan has been submitted. Typical data requirements include the following:

- Traffic data should have been collected within the last 3 years
- Traffic data should be collected during the peak season (especially important if location is recreational in nature). If not, contact MDOT planning to determine if counts can be adjusted using seasonal day of week (DOW) factors
- The raw traffic counts should be included in the appendix
- Growth rates should come from the urban travel demand model or statewide model. If not, the annual growth rate selected for use shall be subject to approval by MDOT staff

- Pass-by and internal linked trips should be based on guidelines from the latest edition of the ITE Trip Generation Manual
- If development is anticipated to occur in phases, then the first phase (opening day) must be analyzed in addition to total build out. If there are other intermediate phases prior to total build out, these may also require separate analyses
- If development generates 500 or more trips in the peak hour, a minimum 5-year horizon forecast must be included. This means total traffic (background + development) forecasted at least 5 years beyond opening year.
  - 500 peak hour trips (In+Out) after reductions for by-pass trips
  - If development has an opening day and a future buildout, then the future buildout can serve as the 5 year horizon forecast (only if the future buildout is at least 5 years after opening day)

To assist in determining the need for and the scope of traffic impact studies, the following online document was prepared in 1994 for the Tri-County Regional Planning Commission in cooperation with the Michigan Department of Transportation and the Southeast Michigan Council of Governments (SEMCOG): "***EVALUATING TRAFFIC IMPACT STUDIES***".

A signal is often requested prior to the opening day of a private development. Use of the ITE trip generation manual is the common method used to estimate peak hour development traffic. Often, the permit applicant will justify a new signal using warrant #3 which is a peak hour warrant. Due to the speculative nature of these volume estimates, they must be reviewed closely. There are a few things that can be done to ensure a signal is only installed if appropriate:

- If it is a development where data could be collected at a similar installation (similar community and similar size development), have the development provide volume information from the existing open development. With that information, Warrant #1 (Condition A) may be reviewed.
- For MDOT to consider approving a new signal prior to opening day of a development, one of the 8 hour warrants must typically be shown to be met using volumes from a similar development.
- Projected volumes are very speculative and it is not unusual for the projected and actual volumes to vary widely. As a result, the preferred option is to put language in the permit that requires the development to open and then a study be conducted with actual field data. Include time frames for when the study will be conducted and clearly state the developer will be responsible for all costs to design and install the traffic signal if it is approved. The MDOT Signals Unit will still make the final determination if a signal should be installed.

- The peak hours can be modeled such that the operation can be reviewed with and without a signal in place. It is preferred that the modeling be done with Synchro and electronic copies of the model be supplied to streamline the review process.
- Contact MDOT Signal Operations to confirm the scope of data collection and signal modeling including gap study, 8 hour turning movement counts, and 24 hr road tube counts.
- Use and provide appropriate MDOT online spreadsheets for analysis and evaluation.

1.3 NOTIFICATION OF INSTALLATION OF NEW TRAFFIC SIGNALS (FORMERLY T&S NOTE 224A)

This section provides information and guidance to alert motorists on the installation of new traffic signals. New traffic signals are typically operated in a flashing mode for approximately one week before beginning "Stop-and-Go" operation. Exceptions include major geometric changes which require the signal to be operational immediately upon opening of the new roadway for traffic.

To publicize the new traffic signal, a note will be included in all new "Stop-and-Go" traffic signal work authorizations, requesting the installing agency to inform the Region/TSC Traffic and Safety Representative at least two weeks in advance of installation. The Region/TSC Traffic and Safety Representative will then issue an announcement to the appropriate people. (City Manager, Police Chief, State Police, newspaper, radio station, etc.)

Sample Announcement:

> ***NOTIFICATION OF INSTALLATION OF NEW TRAFFIC SIGNAL***
>
> *The MDOT will be installing a new stop-and-go traffic signal at <u>intersection</u> in <u>city/township/county</u> during the week of <u>month, Monday date and year</u>. The signal will operate in a flashing mode for approximately one week before beginning STOP-AND-GO operation. For further information, please call the MDOT Region Office in <u>city</u> at <u>Phone number</u>.*

The conditions below, for isolated and non-isolated traffic signals, apply only to the roadways that did not stop prior to signalization. W3-3 signs may be erected on the minor legs if deemed appropriate.

1.3.1 *ISOLATED OR OUTSKIRTS TRAFFIC SIGNALS*

Traffic signals that are more than one mile from any other traffic signal or are the first traffic signal encountered when entering an area with signals spaced closer than one mile.

- SIGNAL AHEAD symbol signs (W3-3) should be considered at the appropriate distance in advance of the intersection as determined by the Michigan Manual of Uniform Traffic Control Devices (MMUTCD) or at a greater distance as determined by engineering judgment. A permanent panel with the name of the crossroad may be attached under the W3-3 sign.

- NEW SIGNAL AHEAD signs with a supplemental panel, ½ MILE (or other distance if appropriate), should be considered in advance of the W3-3 sign. This sign should be removed approximately 90 days after the signal is installed.
- All signing should be supplemented with fluorescent orange flags to be removed after 90 days.
- Battery operated flashers may be considered to supplement the signs. All supplemental devices should be removed after approximately 90 days.

1.3.2 *NON-ISOLATED TRAFFIC SIGNALS*

Traffic signals along a corridor where the spacing is less than one mile.

- If visibility limited or the signal is not expected some or all of the signing for Isolated Traffic Signals should be considered.
- W3-3 signs with fluorescent flags should be erected. If visibility is not limited, this signing should be removed after 90 days.

1.4 REQUIRED INTERSECTION WIDENING TO ACCOMMODATE NEW SIGNALS (FORMERLY T&S NOTE 202A)

When a “Stop-and-Go” traffic signal is installed at an intersection, the capacity of the through roadway is reduced by about half. In addition, left turning traffic can interlock, effectively stopping all through traffic. As a result, prior to the installation of a “Stop-and-Go” traffic signal, all legs of the intersection should have a minimum of two approach lanes. Additional widening may be required to provide for capacity. An alternative to widening would be to prohibit left turns or provide for one way streets.

If widening is required, it shall be done in accordance with MDOT Geometric Design Guides, and the crossroad shall provide a minimum of two approach lanes. The crossroad widening shall be the responsibility of and financed by the roadway authority.

At locations with a single approach lane, intersection widening will typically be required in order to obtain two approach lanes, including aligned left turn only lanes, as required to accommodate a new traffic signal.

1.5 FINANCIAL PARTICIPATION IN TRAFFIC SIGNALS DUE TO OPERATIONAL CHANGES (FORMERLY T&S NOTE 262A)

When an operational change to a traffic signal is required due a project not initiated by the department, such as widening of a local road crossing a trunkline or signal modifications due to a development, all costs associated with the modifications shall be at the cost of the local governmental agency or the developer.

If the controller is not adequate to handle the new operation or if the controller is 10 years old or older, the controller along with the cabinet will be replaced at no cost to the department.

All requests of this type should be processed as a permit to work within MDOT Right-of-Way.

The Traffic Signals Unit will assign costs due to operation changes.

1.6 PEDESTRIAN ACTIVATED DEVICES (FORMERLY T&S NOTE 210A)

This section provides information and guidance on the use of pedestrian activated electronic devices including the Rectangular Rapid Flashing Beacon (RRFB) and the pedestrian hybrid beacon (PHB). The PHB is often referred to as a HAWK signal and is intended as an alternative when the warrants for a full pedestrian traffic signal are not met, but additional traffic control beyond signing and pavement markings are desirable. The PHB signal provides a protected walk movement but during the Flashing Don't Walk, the vehicle traffic is shown a flashing red to minimize delay.

Relevant documents include the MMUTCD, which has a chapter for PHB's, and MDOT's online document: ***GUIDANCE FOR INSTALLATION OF PEDESTRIAN CROSSWALKS ON MICHIGAN STATE TRUNKLINE HIGHWAYS***, which establishes minimum criteria for the consideration of a PHB or an RRFB. The criteria include pedestrian and vehicular volumes, the number of multiple threat lanes, the width of the crossing, and the traffic speed.

If minimum criteria are met for consideration of a PHB or an RRFB, then a signal study screening form can be sent to the signals unit to initiate an engineering study per Section 1.1

MDOT's online spreadsheet, ***SIGNAL WARRANTS.XLS*** contains tabs for evaluating thresholds (not warrants) for both RRFB's and PHB's.

1.6.1 *RECTANGULAR RAPID FLASHING BEACONS (RRFB) (FORMERLY T&S NOTE 212B)*

Rectangular rapid flashing beacons (RRFB) used in conjunction with pedestrian crossing or school crossing signs can alert drivers that a pedestrian may be entering the crosswalk. The RRFB is intended to provide emphasis to the crossing signs where drivers may not be expecting pedestrians, or where special emphasis is required. The RRFB is a pedestrian actuated device, which is an essential aspect of its effectiveness.

Figure 1-1: Example of RRFB with W11-2 sign and W16-7p plaque at unsignalized crosswalk.
[Photo courtesy of City of St. Petersburg, Florida]

The decision to use an RRFB must be based on engineering analysis of the site conditions. MDOT guidance establishing pedestrian crossings and determining appropriate treatments can be found in ***GUIDANCE FOR INSTALLATION OF PEDESTRIAN CROSSWALKS ON MICHIGAN STATE TRUNKLINE HIGHWAYS*** . This MDOT guideline follows and uses text directly from ***FHWA Interim Approval 21 – Rectangular Rapid-Flashing Beacons at Crosswalks.***

APPLICATION

1. An RRFB shall only be installed to function as a pedestrian-actuated conspicuity enhancement.
2. An RRFB shall only be used to supplement a post-mounted W11-2 (Pedestrian), S1-1 (School), or W11-15 (Trail) crossing warning sign with a diagonal downward arrow (W16-7p) plaque, or an overhead-mounted W11-2, S1-1, or W11-15 crossing warning sign, located at or immediately adjacent to an uncontrolled marked crosswalk.
3. The RRFB is to be used at mid-block pedestrian crossings or pedestrian crossings at intersection approaches that are not controlled by another traffic control device (e.g. YIELD signs, STOP signs, Pedestrian Hybrid Beacon or traffic control signals). The RRFB may be applicable to a crosswalk across the approach to, or egress from, a roundabout.
4. If sight distance approaching the crosswalk at which RRFBs are used is less than deemed necessary, an additional RRFB may be installed in advance of the crosswalk to supplement a W11-2, S1-1, or W11-15 crossing warning sign with an AHEAD (W16-9P) or distance (W16-2P or W16-2aP) plaque.

DESIGN

1. For design details please see MDOT's online ***RECTANGULAR RAPID FLASHING BEACON*** special detail.
2. The outside edges of the RRFB indications, including any housings, shall not project beyond the outside edges of the W11-2, S1-1, or W11-15 sign.
3. As a specific exception to MMUTCD Section 4L.01 guidance, the RRFB unit associated with a post-mounted sign and plaque may be located between the bottom of the crossing warning sign and the top of the supplemental downward diagonal arrow plaque (or, in the case of a supplemental advance sign, the AHEAD or distance plaque) or within 12 inches above the crossing warning sign, rather than 12 inches minimum above or below the sign assembly.
4. For any approach on which RRFBs are used, two W11-2, S1-1, or W11-15 crossing warning signs (each with RRFB and W16-7p plaque) shall be installed at the crosswalk, one on the right-hand side of the roadway and one on the left-hand side of the roadway. On a divided highway, the left-hand side assembly should be installed on the median, if practical, rather than on the far left side of the highway.
5. An RRFB shall not be installed independent of the crossing signs for the approach the RRFB faces. The RRFB shall be installed on the same support as the associated W11-2 (Pedestrian), S1-1 (School), or W11-15 (Trail) crossing warning sign and plaque. If the RRFB unit is supplementing an overhead-mounted sign, the RRFB unit shall be mounted directly below the bottom of the sign.

OPERATION

1. The RRFB shall be normally dark, shall initiate operation only upon pedestrian actuation, and shall cease operation at a predetermined time after the pedestrian actuation or, with passive detection, after the pedestrian clears the crosswalk.

2. All RRFBs associated with a given crosswalk shall, when activated, simultaneously commence operation of their alternating rapid flashing indications and shall cease operation simultaneously.

3. If pedestrian pushbuttons (rather than passive detection) are used to actuate the RRFBs, a pedestrian instruction sign with the legend PUSH BUTTON TO TURN ON WARNING LIGHTS should be mounted adjacent to or integral with each pedestrian pushbutton.

4. The duration of a predetermined period of operation of the RRFBs following each actuation should be based on the MMUTCD procedures for timing of pedestrian clearance times for pedestrian signals.

5. As a specific exception to MMUTCD requirements for the flash rate of beacons, RRFBs shall use a much faster flash rate and shall provide 75 flashing sequences per minute. Except as provided in Condition 8 below, during each 800-millisecond flashing sequence, the left and right RRFB indications shall operate using the following sequence:
    - **a. The RRFB indication on the left-hand side shall be illuminated for approximately 50 milliseconds.**
    - b. Both RRFB indications shall be dark for approximately 50 milliseconds.
    - **c. The RRFB indication on the right-hand side shall be illuminated for approximately 50 milliseconds.**
    - d. Both RRFB indications shall be dark for approximately 50 milliseconds.
    - **e. The RRFB indication on the left-hand side shall be illuminated for approximately 50 milliseconds.**
    - f. Both RRFB indications shall be dark for approximately 50 milliseconds.
    - **g. The RRFB indication on the right-hand side shall be illuminated for approximately 50 milliseconds.**
    - h. Both RRFB indications shall be dark for approximately 50 milliseconds.
    - **i. Both RRFB indications shall be illuminated for approximately 50 milliseconds.**
    - j. Both RRFB indications shall be dark for approximately 50 milliseconds.
    - **k. Both RRFB indications shall be illuminated for approximately 50 milliseconds.**
    - l. Both RRFB indications shall be dark for approximately 250 milliseconds.

6. The flash rate of each individual yellow indication, as applied over the full on-off sequence of a flashing period of the indication, shall not be between 5 and 30 flashes per second, to avoid frequencies that might cause seizures.

7. The light intensity of the yellow indications shall meet the minimum specifications of Society of Automotive Engineers (SAE) standard J595 (Directional Flashing Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles) dated January 2005.

8. Existing RRFB units that use the flashing sequence that was specified in the Interim Approval 11 memorandum and a subsequent interpretation (the RRFB indication on the left-hand side emits two slow pulses of light after which the RRFB indication on the right-hand side emits four rapid pulses of light followed by one long pulse of light) should be reprogrammed to the flash pattern specified above in Condition 5 as part of a systematic upgrading process, such as when the units are serviced or when the existing signs are replaced.

9. If a speech pushbutton information message is used in conjunction with an RRFB, a locator tone shall be provided, the audible information device shall not use vibrotactile indications or percussive indications, and the message should say twice, "Yellow lights are flashing".

1.6.2 *PEDESTRIAN HYBRID BEACON*

A Pedestrian Hybrid Beacon (PHB), often referred to as a HAWK signal, is intended as an alternative when the warrants for a full pedestrian traffic signal are not met but additional traffic control beyond signing and pavement markings are desirable.

The PHB signal provides a protected walk movement but during the Flashing Don't Walk, the vehicle traffic is shown a flashing red to minimize delay.

When a requested, a screening is completed similar to requests for traffic signals. If deemed appropriate, a full study is conducted. The Alternative Pedestrian Devices tabs of the ***SIGNAL WARRANTS*** spreadsheet provide for PHB signals. An important distinction is these are minimum thresholds not "warrants".

PHBs should only be considered if the crosswalk is at least 100' away from an intersecting street or driveway. A sample plan and operation sequence can be found in MDOT's online ***HAWK SIGNAL SAMPLE PLAN***.

1.7 SIGN MOUNTED FLASHING BEACONS (FORMERLY T&S NOTE 208B)

Flashing beacons used in conjunction with sign messages may attract a driver's attention in unusual situations (e.g., where a driver may not be expecting a warning or regulation, or where special emphasis is required). Most traffic engineers are concerned that extensive use of flashing beacons will reduce their overall effectiveness. Thus, flashing beacons on advance warning signs and/or regulatory signs are used sparingly and only when there is a true need for additional emphasis. (U. S. Department of Transportation, Federal Highway Administration, Traffic Control Devices Handbook, Washington, D.C., 1983, p. 4-142).

The decision to use a flashing beacon in conjunction with a sign must be based on engineering judgment after analysis of conditions at the field location. Further discussion pertaining to flashing beacons used with signs can be found in Parts 4 and 7 of the MMUTCD.

- NOTE: See Section 1.6.2 for Installation of Emergency Vehicle Advance Warning Signs Supplemented with Flashers or Pre-Empt of Existing Signals.

- NOTE: See Section 1.7.1 for installation of sign mounted flashing beacons at school crossings.

1.8 DEVICES FOR EMERGENCY VEHICLES (FORMERLY T&S NOTES 204A AND 205B)

This section provides minimum criteria to consider installation of devices intended to improve the safety when emergency vehicles exit their driveway onto a State Highway. MDOT's online spreadsheet ***SIGNAL WARRANTS*** includes an "Emergency Signals" tab to assist in evaluating thresholds for these devices.

1.8.1 *TRAFFIC SIGNAL FOR EMERGENCY VEHICLE ACCESS*

The following guidelines will be used when analyzing requests for the installation of EMERGENCY VEHICLE TRAFFIC SIGNALS. These are based on guidelines similar to those in the MMUTCD for warranting traffic signals at similar low volume type generators. Each of the following sections must be met:

- For at least eight hours of an average day, the major street volumes are at least:

No. of Lanes for Each Direction	Vehicles Per Hour (Total Both Directions)
1	750
2 or more	900

  - If sight distance is less than eight seconds, the warrant is 80 percent of the requirements above.
  - If one or more reported crashes (of a type susceptible to correction by traffic signal control) involving emergency vehicle equipment occur within the most recent two year period, the warrant is 80 percent of the requirements above.
  - The percent reductions are not additive. If more than one is applicable, choose the one that reduces the volumes the most.

- There are a minimum of 300 emergency runs per year from the emergency vehicle station onto or across the major street.

- The number of adequate gaps in the major street traffic stream during the peak traffic periods is consistently less than the number of minutes in the same period.
  - Adequate gap length should be calculated using emergency vehicle accelerating characteristics and the number of lanes to be crossed to enter the major street

- All parking must be prohibited on both sides of the major street 150 feet in advance of and beyond the projected stop bar location to assist major street visibility for emergency equipment.

No emergency vehicle traffic signal shall be located within 500 feet of an existing traffic signal. If an emergency vehicle driveway is located within 500 feet of an existing traffic signal, consideration should be given to installing a preemption control in the existing traffic signal to assist emergency vehicles in gaining access to the major street.

The Emergency Signals tab on the ***SIGNAL WARRANTS*** spreadsheet provides for this review.

1.8.2 *AUXILIARY DEVICES FOR EMERGENCY VEHICLE ACCESS*

The following guideline will be used when analyzing requests for the installation of EMERGENCY VEHICLE ADVANCE WARNING SIGNS SUPPLEMENTED WITH FLASHERS OR PRE-EMPT OF EXISTING TRAFFIC SIGNALS. Each of the following sections must be met:

- For at least eight hours of an average day, the major street volumes are at least:

No. of Lanes for Each Direction	Vehicles Per Hour (Total Both Directions)
1	375
2 or more	450

  - If sight distance is less than eight seconds, the warrant is 80 percent of the requirements above.
  - If one or more reported crashes (of a type susceptible to correction by traffic signal control) involving emergency vehicle equipment occur within the most recent two year period, the warrant is 80 percent of the requirements above.
  - The percent reductions are not additive. If more than one is applicable, choose the one that reduces the volumes the most.

- There are a minimum of 50 emergency runs per year from the emergency vehicle station onto or across the major street.

- All parking must be prohibited on both sides of the major street within 150 feet of the access point to assist major street visibility for emergency equipment.

No emergency vehicle advance flashers shall be located within 400 feet of an existing traffic signal. If an emergency vehicle driveway is located within 400 feet of an existing traffic signal, consideration should be given to installing a preemption control in the existing traffic signal to assist emergency vehicles in gaining access to the major street.

1.9 DEVICES IN SCHOOL ZONES

This section highlights special considerations for electronic traffic control devices in school zones. Requests for these devices should be documented by a letter from the Superintendent. This is especially important if the school will incur costs with the installation. The school will incur costs if any installation is required outside MDOT right-of-way (for example if the school requests pushbutton activation from inside the school).

Relevant documents include the MMUTCD, which has a chapter for Traffic Control for School Areas in addition to the School Crossing Warrant, and MDOT's online document: ***SCHOOL AREA TRAFFIC CONTROL GUIDELINES***.

1.9.1 *SCHOOL SIGN MOUNTED FLASHING BEACONS (FORMERLY T&S NOTE 404C)*

The decision to use a flashing beacon in conjunction with a sign should be based on engineering judgment after analysis of site conditions. All of the following criteria should be met prior to the consideration of a flashing beacon on the School Advance Warning Assembly (S1-1 with supplemental plaque):

- Presence of established school crosswalk
- Use of an adult crossing guard
- Majority of the students using school crosswalk in Grades 5 and lower

The decision to use a flashing beacon on a school speed limit sign should be based on a review of the existing speed limits, the actual speeds, and any safety benefits anticipated by installing a flashing beacon. Adding flashing beacons to existing school speed limit zone signs will require replacement of signs and determination of how to operate the device. For guidance on establishing a new school speed limit zone with flashing beacons please see the following link: ***SCHOOL AREA TRAFFIC CONTROL GUIDELINES***.

OPERATION

Electronic devices warning drivers of school crossings should be operated by the adult crossing guard during their shifts. They should also be activated during unplanned crossing periods, such as school closure due to inclement weather. Electronic devices warning drivers of a school speed limit zone shall be in operation when the school speed limit is in effect. School zone speed limit flashing beacons are typically activated by a button inside the school. The School Superintendent is responsible for designating the person to operate the device. A second responsible person shall be designated in the event the main person is unavailable to operate the system.

To derive the greatest benefit from these devices, they must operate only during periods when they are applicable. Only by pushing the push button may the devices be turned on. They will turn off automatically in accordance with the programmed operating schedule. A small light at the controls will be lit whenever the devices are operating.

A fully automatic system for operating school flashers will not be allowed. There have been issues with this type of system operating during the summer or during the next school year when classes start at a different time. A manual start ensures that the devices operate only when they are applicable..

OPERATION SCHEDULE

The school zone speed limit operation schedule shall be in accordance with Section 257.627a of the Michigan Vehicle Code. A typical schedule would be as follows:

Time of Day	Flashing Beacon Operation
Morning	Start 30 minutes before classes convene. End when classes convene
Noon	During any lunch period when students are permitted to leave the school property or to accommodate half day kindergarteners who walk to school.
Afternoon	Start at the time classes let out. End 30 minutes after classes let out.

Once a schedule is approved and the devices erected, the Region/TSC Traffic and Safety Representative should make periodic checks of the operation to ensure adherence to the approved schedule. Proposed changes in a schedule shall be approved by the Region Traffic and Safety Representative.

COST PARTICIPATION

The Michigan Department of Transportation does not require local cost participation for installation, maintenance, and power consumption of signs with flashers within the Right-of-Way. All work conducted outside of the Right-of-Way shall be at the cost of the local agency or school.

PROCESSING

1. The MDOT publication "***SCHOOL AREA TRAFFIC CONTROL GUIDELINES***" provides detailed guidelines for determining appropriate school related traffic control devices. If the Region/TSC Traffic and Safety Representative determines that a sign with a flashing beacon is justified, they recommend to MDOT Safety Programs and the Signals Unit the type of device to be erected and the approximate locations for the required signs. The request should be provided on a "Traffic Signal Screening" form and should include the name of the school, the distance from the signs to the nearest road and distances to other landmarks as needed. If a school speed limit zone is to be established, the Michigan State Police should be included in the establishment of the speed limit.

2. The Region/TSC Traffic and Safety Representative should provide the speed limit to be established (if a speed limit sign is to be erected) and an operation schedule for the devices. If there is a flasher on other school signs, the school speed limit operation should be coordinated with them. In addition, the

Region/TSC Traffic and Safety Representative must furnish the title of the responsible person appointed by the school to operate the flashing beacon.

3. If approved by MDOT Safety Programs and the Region Operations Engineer, the MDOT Signals Unit will then investigate the school locale to determine the design and operation details. The MDOT Signals Unit will issue the work authorization (unless installed by contract) for the installation of the required signs and flashing beacons.

REMOVAL OF FLASHER

For the removal of a school sign flashing beacon, a letter needs to be obtained from the school with a signature of the superintendent that reflects the school's desire to remove the existing flashing beacon. Once this letter has been received, a work authorization needs to be issued for the removal of the electrical device(s) and a second work authorization issued, if necessary, for the removal of the sign. The sign inventory should be amended to reflect this change.

1.10 MANUAL TRAFFIC SIGNAL OPERATION USING THE *POLICE CONTROL BOX*

This section provides guidance on how to use the police control box when it is desired to change the operation of a traffic signal as a result of a traffic incident. The Police Department should have an existing key to open the control box. If not, one can be obtained from MDOT by calling the appropriate phone number listed by region on the map at the end of this section and asking for the contact information for the MDOT Region Electrician. For use of the police control box during planned events, please use the same contact information to provide advanced notification to MDOT.

1.10.1 TO HAND DIRECT TRAFFIC WITHOUT THE TRAFFIC SIGNAL:

1. Stop all traffic approaching the intersection by hand
2. Open police control box
    a. Flip switch from “normal” to “flash”
    b. Flip switch from “signal” to “off”
    c. The traffic signal is dark now
3. Direct traffic by hand
4. When ready to return to traffic signal control, stop all traffic approaching the intersection by hand
    a. Flip switch from “flash” to “normal”
    b. Flip switch from “off” to “signal”
    c. Hold traffic until visible confirmation of signal cycling
        i. This may take up to 30 seconds for the controller to power up and to cycle
    d. Cease hand direction of traffic and close police control box

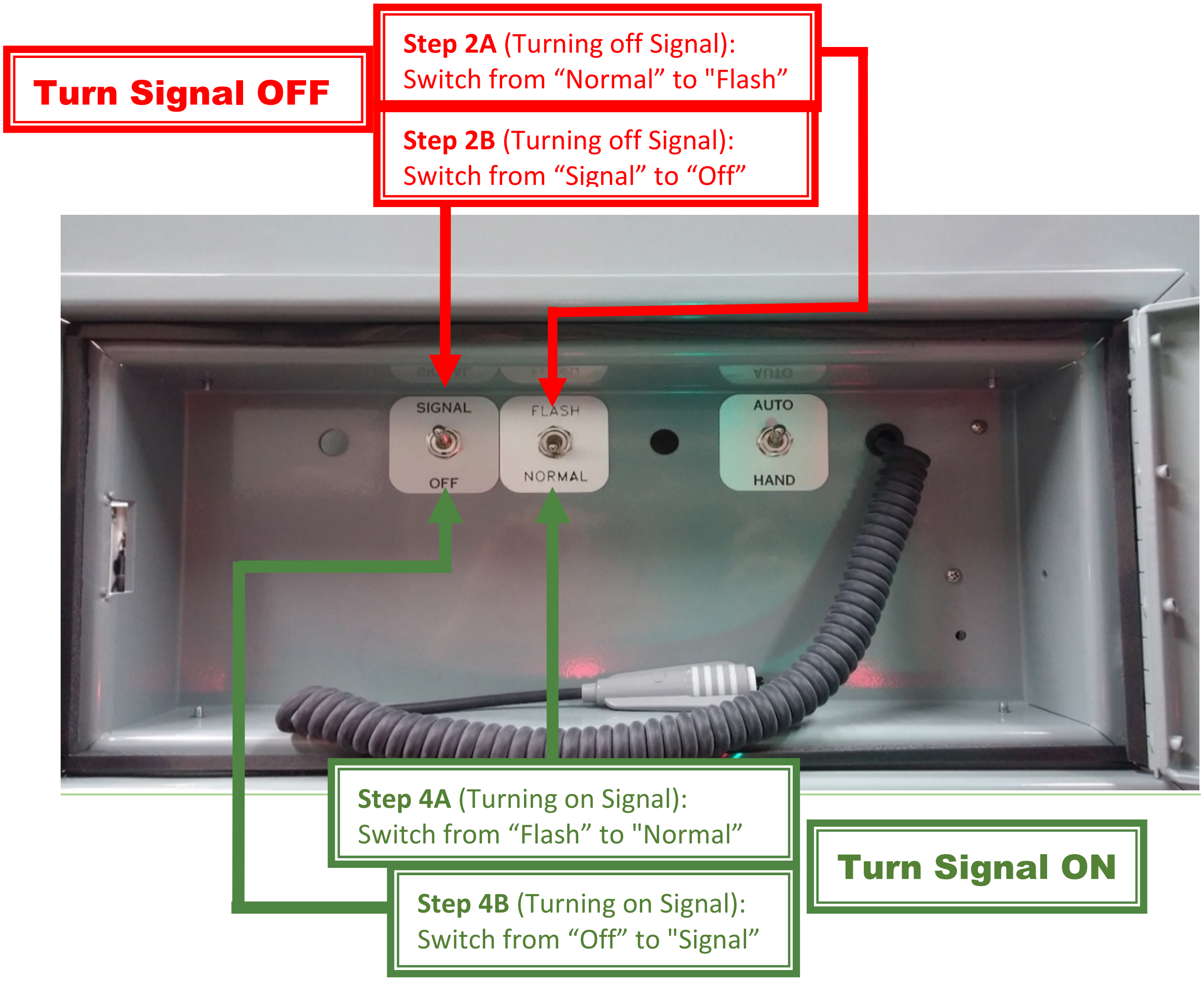


Figure 1-2: Hand Direct Traffic Without The Traffic Signal

These photos are representative of new traffic signal cabinet installations. The police box on existing traffic signal cabinets may vary significantly

1.10.2 *TO GIVE ADDITIONAL GREEN TIME TO ONE MOVEMENT:*

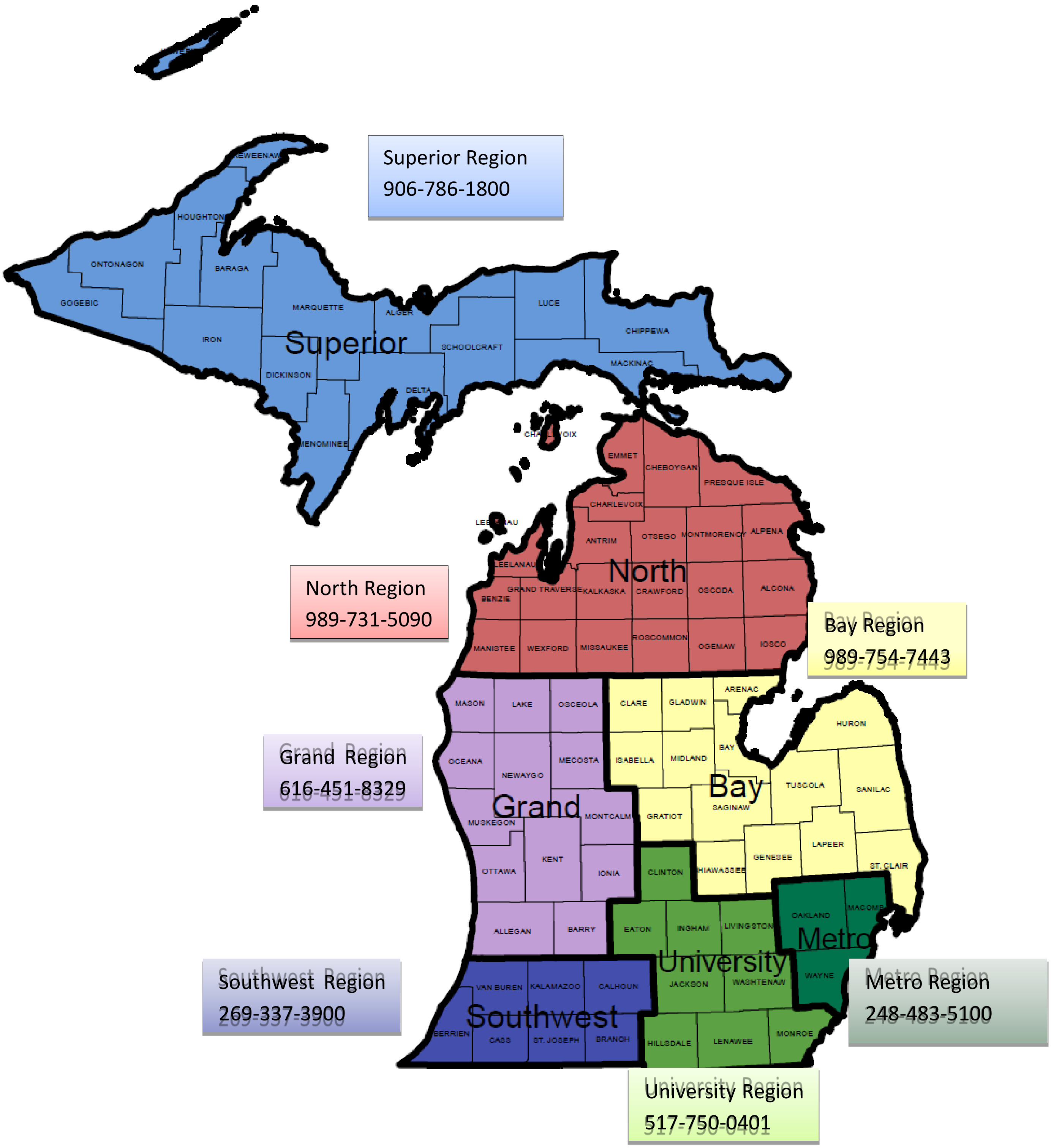
Notes: This option is not available for any location that has a flashing red ball for left turns. This option may not be available depending on the age and condition of the signal controller

1. Open police control box
   a. Flip switch from “auto” to “hand”
   b. The traffic signal is now able to receive input from the hand button
   c. The traffic signal will rest in the traffic movement which was green at the time the switch was flipped from “auto” to “hand”
   d. To go to another traffic movement, push the button ***once*** and wait
      i. The traffic signal will complete the current traffic movement as quickly as possible without violating minimum green, yellow, and red times
      (Note: The minimum times are pre-programmed times that limit how fast the signal changes in order to avoid causing traffic conflict)
      ii. The traffic signal will rest in green for the next available traffic movement
      iii. Depending on the intersection and the point at which you flipped the switch from “auto” to “hand”, you may need to cycle thru several traffic movements. Push the button once each time you want to advance to the next movement.
   e. When the green is displayed for the direction you want additional green time, do nothing and the signal will rest in green for this traffic movement.
2. When ready to return to normal traffic signal operation
   a. **Flip switch from “hand” to “auto”**
   b. Visually confirm signal returns to normal operations
   c. If signal does not return to normal operations, call MDOT at the numbers listed at the end of this document.

NOTE: If you forget to flip the switch back to “auto”, the signal will rest in green in this last movement and will not cycle to serve any other movement

Figure 1-3: Give Additional Green Time to One Movement

Figure 1-4: Contact Information for each MDOT Region



1.11 TEMPORARY TRAFFIC SIGNALS

Temporary traffic signals are often requested as part of construction projects. They can generally be broken down into two types: Signals at crossroads and signals to alternate traffic in a single lane.

1.11.1 *TEMPORARY TRAFFIC SIGNALS AT CROSSROADS*

Traffic patterns caused by construction closures will sometimes create the need for a temporary traffic signal at an intersection. It is still necessary that a warrant be met if a signal is installed and the signal request must be reviewed and approved by the MDOT Signals Unit. Because the determination to install a temporary signal must be made prior to the start of construction, estimated volumes and delays must be used in the analysis.

While design should include initial signal timings, due to the variability in construction volumes, it is often desirable to make provisions to review the operations and update the timings during construction to account for actual traffic volumes.

Particular attention should be given to the temporary nature of the traffic signal. Once installed, there is often considerable resistance to the removal of the temporary traffic signal by the local community. Unless there is intent to leave the signal as a permanent installation, there should be clear written confirmation from the local governmental agencies that they understand and agree that the temporary traffic signal will be removed at the end of the project.

1.11.2 *TEMPORARY TRAFFIC SIGNALS TO ALTERNATE TRAFFIC IN A SINGLE LANE (FORMERLY T&S NOTE 906A)*

Temporary traffic signals and street lighting become necessary on bridge deck repair or improvement projects when only one lane of traffic can be maintained at a time on a two way roadway. The Signals Unit maintains typical installation plans for such work.

No roads or driveways may be between the temporary signal heads. In the event a side road or driveway is within 200 feet (60 meters) of the stop bar, a custom signal design will be required or a detour should be considered. The busier the side road, the greater the distance should be between the stop bar and the side road. Contact the MDOT Signals Unit on any projects requiring temporary traffic signals.

Temporary portable traffic signals are only for use on projects with a short duration. The MDOT Signals Unit does not typically provide timing permits for temporary portable traffic signals. The following all red intervals (per direction) are based on assumed speeds of 25 MPH as a function of distance between stop bars.

All-Red Intervals for Temporary Traffic Signals

Distance Between Stop Bars Feet (meters)	All Red Interval Seconds (per Direction)
200 (60)	5
250 (75)	7
300 (90)	8
350 (105)	10
400 (120)	11
450 (135)	12
500 (150)	14
550 (165)	15
600 (180)	16
650 (200)	18
700 (215)	19
750 (230)	20
800 (245)	22
850 (260)	23
900 (275)	25
950 (290)	26
1000 (305)	27
1050 (320)	29
1100 (335)	30
1150 (350)	31
1200 (365)	33

Assumptions:

- A 25 MPH speed limit through work zone.
- Distances should be rounded up to the nearest 50 feet.
- Typically stop bars are 50 feet from the signal heads.
- Green time should be adjusted to match traffic demand.
- Yellow interval should be 5.0 seconds.

1.12 REMOVAL OF EXISTING TRAFFIC SIGNALS

Traffic control devices are used at intersections to regulate the flow of conflicting traffic streams. Over time, traffic patterns and land uses can change and a signal at a particular intersection may no longer be justified.

Federal funding cannot be used to modernize an unwarranted signal. Prior to modernizing a signal, warrants must be verified. If a signal appears to be unwarranted, a thorough review is required to determine if the signal is warranted. If warranted, modernization can proceed. If unwarranted, coordination with any affected local agency is required to establish an appropriate course of action.

MDOT has a procedure to analyze existing signalized intersections to determine if a traffic signal is warranted and to assist the Region/Transportation Service Center (TSC) in interacting with local agencies where traffic signal removal may be indicated. This process only applies to intersections where signalization is already in place and should not be used for installation of a new signal.

2 LEFT-TURN PHASING GUIDELINES

This chapter documents the different types of left-turn phasing used in the State of Michigan and provides guidance for determining when to consider the use of left-turn phasing as well as which type of left-turn phasing would be appropriate. Additional guidance is provided on when to consider the removal of left-turn phasing.

MDOT has an online spreadsheet ***LEFT TURN PHASING*** to perform left-turn phasing threshold analysis. Instructions can be found in a tab of the online spreadsheet.

2.1 TYPES OF LEFT-TURN PHASING

There are three types of left-turn phasing currently in use in the State of Michigan:

1. Permissive-Protected (lagging) left-turn phasing is when the left-turn movement is permissive during a portion of the cycle length (must yield to opposing traffic) and protected during a portion of the cycle length (exclusive signal phase).
2. Protected-Permissive (leading) left-turn phasing is when the left-turn movement is protected during a portion of the cycle length (exclusive signal phase) and permissive during a portion of the cycle length (must yield to opposing traffic).
3. Protected-Only left-turn phasing is when the left-turn movement can only be made during an exclusive left-turn phase.

In some situations, it may be advantageous to corridor progression for the left-turn phase to lead the adjacent through movement and the opposite phase will lag the adjacent thru movement (often referred to as Lead/Lag phasing).

- *Note: Opposing left-turn phases generally should match left-turn phasing type for consistent driver expectations*.

The signal head displays used during the permissive operation are the flashing yellow arrow (in a four- section head) or the green ball (in a four or five-section head). The flashing red ball in a three-section left-turn signal head is being phased out. The display used for the Protected-Only operation is a steady green arrow.

2.2 WHEN TO CONSIDER LEFT-TURN PHASING

While left-turn phasing generally will improve the capacity and level of service for the left-turn traffic, it typically, reduces the overall intersection capacity and level of service. Left-turn phasing should only be considered where the benefits outweigh the costs. Left-turn phasing should be considered at signalized intersections when the thresholds below are met:

- The left-turn peak hour volume exceeds 90 vehicles per hour (VPH)[1], and
- The product of opposing through hourly volume (VHP) and left-turn hourly volumes (VHP) exceeds 50,000 (if there is one opposing through[2] lane) or 100,000 (if there are two or more opposing through[2] lanes), or
- A crash pattern that could be corrected with left-turn phasing is evident, or
- Left-turn delay is greater than or equal to 2.0 vehicle-hours AND greater than 35 seconds per vehicle during a peak hour.

Meeting the thresholds should not be considered a requirement to install left-turn phasing. Left-turn phasing should only be approved and installed after a comprehensive engineering study indicates this is necessary for the safe and efficient operation of an intersection. The type of left-turn phasing will be determined based on data from the engineering study which includes the amount of delay experienced by left-turning traffic, crash patterns that may be occurring and available capacity of the intersection.

2.3 DETERMINING LEFT-TURN PHASING TYPE

After a comprehensive engineering study indicates left-turn phasing is necessary for the safe and efficient operation of an intersection, it must be determined whether the left-turn phase will be "Protected-only" or if there will also be a permissive portion of the left-turn phase. Generally, an incremental approach is preferred with Permissive-Protected (or Protected-Permissive) left-turn phasing being utilized before moving to Protected-Only left-turn phasing. Including a permissive portion in the left turn phase typically results in higher capacity and a better level of service for the left-turn movement(s) and for the overall intersection. The following guidelines are to be considered for the determination of the left-turn phasing type.

2.3.1 *PERMISSIVE-PROTECTED AND PROTECTED-PERMISSIVE LEFT-TURN PHASING*

Permissive-Protected and Protected-Permissive left-turn phasing may be considered under the following conditions:

- Adequate sight distance for left-turning vehicles and opposing through traffic is available or can be made available by implementing geometric or pavement marking improvements.

---

[1] *A 90 vehicle/hour threshold is based on typical cycle length in which 2 veh/cycle can clear during the phase change. If the traffic signal being evaluated has a higher cycle length then engineering judgment should be provided on consideration of a lower threshold.*

[2] *Through lanes include combination lanes such as through/right turn or through/left-turn. Exclusive turn lanes are NOT counted in this opposing calculation.*

- There are no more than three (3) lanes of opposing through traffic (including shared through lanes).
- Intersection geometrics do not promote hazardous conditions.
- A crash pattern is evident which could be corrected with left-turn phasing. A crash pattern[3] exists if:
  - By approach, there are **four (4)** correctable left-turn crashes in one consecutive 12 month period OR **six (6)** correctable crashes in a 24 month period.
  - For a pair of opposing left turn lanes, there are **six (6)** correctable crashes in one consecutive 12 month period OR **nine (9)** correctable crashes in a 24 month period.

    When these crash thresholds are met, additional accident analysis should be conducted to determine if there are any causes, such as insufficient sight distance, that could be mitigated to eliminate the need for left-turn phasing.

2.3.2 *PROTECTED-ONLY LEFT-TURN PHASING*

Protected-Only left-turn phasing may be considered under the following conditions:

- Sight distance to opposing traffic is inadequate due to geometry or opposing left-turn vehicles and where offsetting the left-turn lanes is not feasible or will not provide the required minimum sight distance.
  - MDOT'S online "***SIGHT DISTANCE GUIDELINES***" provide details for the determination and measurement of intersection sight distance.
- Left-turn traffic must cross four or more lanes of opposing through traffic[2].
- There are dual left-turn lanes on the approach. (Permissive-Protected and Protected-Permissive left-turn phasing should not be used with dual turn lanes)
- Left-turn phasing is existing and a correctable crash pattern exists. A crash pattern[3] exists if:

[3] *Left-Turn Phasing Thresholds are based on the following documents:*

Traffic Signal Timing Manual, USDOT, Federal Highway Administration Publication Number: FHWA-HOP-08-024, June 2008: Pg 4-13; Figure 4-11: "Guidelines for determining the potential need for a left-turn phase"

"Guidelines for the Installation of Left-Turn Phasing", Research Report KTC-95-23, K.R. Agent, Nikiforos Stamatiadis, and Bryan Dye, December, 1995

  - By approach, there are **four (4)** correctable left-turn crashes in a 12 month period OR **six (6)** correctable left-turn crashes in a 24 month period.

  - For a pair of opposing left turn lanes, there are **six (6)** correctable left-turn crashes in a 12 month period OR **nine (9)** correctable left-turn crashes in a 24 month period.

- No previous left-turn phasing exists and when one the following correctable crash patterns[3] exist:

  - By approach, there are **six (6)** correctable crashes in one consecutive 12 month period OR **eleven (11)** correctable crashes in a 24 month period.

  - For a pair of opposing left turn lanes, there are **eleven (11)** correctable crashes in one consecutive 12 month period OR **eighteen (18)** correctable crashes in a 24 month period.

  When these crash thresholds are met, additional accident analysis should be conducted to determine if there are any causes, such as insufficient sight distance, that could be mitigated to eliminate the need for left-turn phasing.

- The posted speed limit of opposing traffic is greater than 45 mph.

- The product of left-turn and opposing through traffic hourly volumes (VPH) exceeds 150,000 for one opposing lane or 300,000 for two or more opposing lanes. The number of hours the cross product meets thresholds should also be considered in determining protected phasing.

2.4 REMOVAL OF EXISTING LEFT-TURN SIGNAL PHASING

Removal of left-turn phasing or changing from a Protected-Only left-turn phasing to Permissive/Protected or Protected/Permissive left-turn phasing requires the completion of an engineering study. The engineering study should consider the following:

- Crash history prior to the installation of the protected left-turn phasing. If the signal was installed due to left-turn crashes, Protected-Only phasing should be maintained unless the engineering study indicates a reduction in potential vehicle conflicts.

- The recent crash history to determine if there is evidence that a reduction in rear-end crashes may be achieved.

- Evaluation to ensure adequate sight distance for left-turning drivers

- Evaluation of the overall impact to intersection operations if the phasing change were implemented including an estimate of the expected reduction in delay per vehicle entering the intersection and the anticipated benefit from left-turn lane queue reduction.

- Additional factors such as high pedestrian volumes, traffic signal progression, geometric design, maneuverability of particular classes of vehicles, adequacy of gaps, or operational requirements unique to pre-emption systems.

- Follow up crash evaluation after the implementation of the less restrictive form of left-turn phasing, to determine if a correctable crash pattern develops. If a correctable crash pattern does develop, then the prior left-turn phasing should be reinstalled.

3 PEDESTRIAN SIGNAL GUIDELINES

This chapter details the requirements associated with the use of pedestrian traffic signal indications. While pedestrians can generally observe the vehicular traffic signals to determine when it is safe to cross, separate pedestrian signal indications provide direction that is clearer and aids pedestrians in determining if there is sufficient time remaining in the phase to safely cross the roadway.

In addition, with the utilization of more complex signal phasing and adaptive signal operations, it may not be clear to pedestrians when conflicting traffic streams will be stopped even if they are familiar with the operations. Pedestrian traffic signal indications reduce the potential for confusion.

3.1 WHEN TO INSTALL PEDESTRIAN SIGNAL INDICATIONS

Pedestrian signal indications are installed at locations where pedestrian activity is clearly evident. Evidence may include the following:

- Sidewalks crossing the intersection.
- Well-worn paths near the intersection.
- Counts indicating pedestrian activity
- Proposed projects involving new sidewalks or non-motorized path crossings should include any signal related work required to accommodate pedestrians and path users.

Depending on the equipment, the addition of pedestrian facilities to an existing traffic signal may require complete modernization of the signal. Unless there is a safety or operational concern, pedestrian signal indications will typically not be able to be added to an existing signalized location until it can be modernized.

There may be situations in which it is desirable to prohibit pedestrians from crossing certain legs of an intersection. For example: at an intersection with dual left turns and split phase signal operations, it is undesirable to allow pedestrians to cross the path of the protected, left turning vehicular movement.

Furthermore, the ***GUIDANCE FOR INSTALLATION OF PEDESTRIAN CROSSWALKS ON MICHIGAN STATE TRUNKLINE HIGHWAYS*** is available as a reference. This guidance document provides a step-by-step procedure to identify the appropriate location for a crosswalk and selection of appropriate crossing treatments on state trunklines. Where the installation of Pedestrian Hybrid Beacon, Pedestrian Signals, or Rectangular Rapid Flashing Beacon Signs are deemed appropriate, a request for a study of an electronic pedestrian device is submitted to MDOT Signal Operations by using the ***SIGNAL STUDY SCREENING FORM*** (1597).

3.2 HOW TO OPERATE PEDESTRIAN SIGNALS

The timing of pedestrian signals is described in Chapter 4, including the meaning of the indications, when they should be displayed, and how to calculate the time intervals.

Pedestrian signals are typically operated in one of two ways:

- The pedestrian signals provide a walk interval every signal timing cycle
- The pedestrian signals only provide a walk interval if a pushbutton is activated

Pushbuttons should be located so they are clearly visible to pedestrians approaching the intersection, and should be signed so it is clear which crossing the pushbutton is associated with. The pushbuttons should be located adjacent to the sidewalk and accessible to disabled persons in accordance with the MMUTCD and MDOT's online ***PUSHBUTTON DESIGN*** details and construction ***PEDESTRIAN PUSHBUTTON DETAILS***.

3.3 COUNTDOWN PEDESTRIAN SIGNALS

Pedestrian countdown displays are mandatory for new installations. These devices inform pedestrians of the number of seconds remaining to safely complete their crossing. The display of the number of remaining seconds is concurrent with the flashing UPRAISED HAND indication and counts down to zero at the end of the flashing UPRAISED HAND. After the countdown displays zero the number part of the indication goes dark and a steady UPRAISED HAND is displayed.

3.4 ACCESSIBLE PEDESTRIAN SIGNALS

Accessible pedestrian signals and detectors provide information in non-visual formats (such as audible tones, speech messages, and/or vibrating surfaces). These devices provide additional information to visually impaired individuals. MDOT will install them where determined appropriate by engineering judgement.

If a leading pedestrian interval (LPI) is implemented without accessible pushbuttons, then the LPI time should be added to the calculated walk time.

4 SIGNAL TIMING CALCULATIONS

This chapter provides guidance on the calculation of vehicle change and clearance intervals, pedestrian clearance intervals, and minimum splits. MDOT has a standard online spreadsheet (***Y & R & PED TIMING.XLS***) that should be used to determine these intervals.

The timing of traffic signals requires the consideration of a number of interrelated variables. These are used as the basis for setting the overall framework for timings at traffic signals. A Yellow change interval and an All-Red clearance interval are provided for vehicular phases. The Yellow Change interval includes perception reaction time and the time it takes to decelerate the vehicle to a stop. The All-Red clearance interval is the time it takes a vehicle to completely clear the intersection at the approach speed.

Walk, Flashing Don't Walk (FDW), and Steady Don't Walk Buffer Intervals are provided for pedestrian crossings. The Walk interval is intended to give the pedestrian sufficient time to travel from the pedestrian detector (or from behind the curb if there is no pedestrian detector) to a point just beyond the near face of curb to begin their crossing. The FDW interval (combined with the buffer interval) is intended to provide the pedestrian with the time necessary to walk from the near curb (or shoulder) to the far side of the traveled way (or to a median of sufficient width for pedestrians to wait). The Steady Don't Walk Buffer Interval (BI) provides a buffer between the end of the FDW interval and the release of conflicting traffic.

Clearance intervals for both vehicles and pedestrians must provide sufficient notice to either avoid entering an intersection if there is insufficient time or to clear the intersection safely. In addition to clearance intervals, if a Green or Walk interval is too short, drivers or pedestrians may miss their opportunity or out of frustration may choose to enter when there is insufficient time to clear the intersection safely. Where vehicle and pedestrian detection systems are available, the traffic signal controller must be programmed properly to avoid wasting time unnecessarily while still servicing all traffic as efficiently as possible.

4.1 VEHICULAR CLEARANCE INTERVAL CALCULATIONS

When calculating change and clearance intervals, opposing directions (northbound and southbound for example) of traffic should be calculated separately, and the larger of the calculated Yellow and All-Red values should be applied to both paired approaches. However, if opposing directions of traffic are operating as split phased, they should be calculated independent of each other. The Yellow and All-Red times calculated for the through movements of an approach are typically also used for any adjacent left turn phasing unless engineering judgment indicates otherwise.

4.1.1 *YELLOW CHANGE INTERVALS*

Calculation of Yellow change intervals shall adhere to the following methodology:

- The following formula shall be used to calculate the Yellow interval:

$$Y = t + \frac{v}{2(a + 32.2G)}$$

Where: **Y** = Yellow change interval (seconds)
t = Driver perception-reaction time for stopping (seconds)
v = Approach speed (feet/second)
a = Deceleration rate for stopping (feet/sec^2)
G = Grade of approach, with uphill positive and downhill negative (percent grade/100)

Use the following predetermined values in the above formula when calculating the Yellow change interval:

t = 1.0 second
a = 10 feet/sec^2
v = Measured 85th percentile speed is preferred, but if not available use posted speed (for driveways/malls, freeway ramps and crossovers use 25 mph)

- The range of the Yellow interval shall be between 3.0 seconds to a maximum value calculated by the formula above. Calculated intervals less than 3.0 seconds shall be increased to 3.0 seconds.
- If the calculated value exceeds 6.0 seconds, confirm with the MDOT Signals Unit prior to use.
- Yellow intervals shall be rounded to the nearest 1/10th of a second.
- The grade of the roadway should be estimated or measured. 0% should generally be used unless the grade is estimated to be greater than 2%. If a grade other than 0% is used, it should be noted in the remarks section of the timing permit.

4.1.2 *ALL-RED CLEARANCE INTERVALS*

Calculation of All-Red clearance intervals shall adhere to the following methodology:

- The following formula shall be used to calculate the All-Red clearance interval:

$$AR = \frac{w + L}{\mathrm{v}}$$

Where: **AR** = All-Red interval (seconds)

w = Distance to clear the intersection, measured from the near-side stop bar to the farthest conflicting movement, measured along the actual vehicle path (feet). The farthest conflicting movement should consider right turn lanes and pedestrian movements that begin with the next phase. At “T” intersections, “w” is measured along the turning path or can be estimated from the near-side stop bar to the opposing curb along the path a through vehicle would travel. Figure 4-1 illustrates how “w” is measured.

L = Length of vehicle (feet)

v = Approach speed (feet/second)

The following values are typically used in the above formula when calculating the All-Red interval:

L = 20 feet

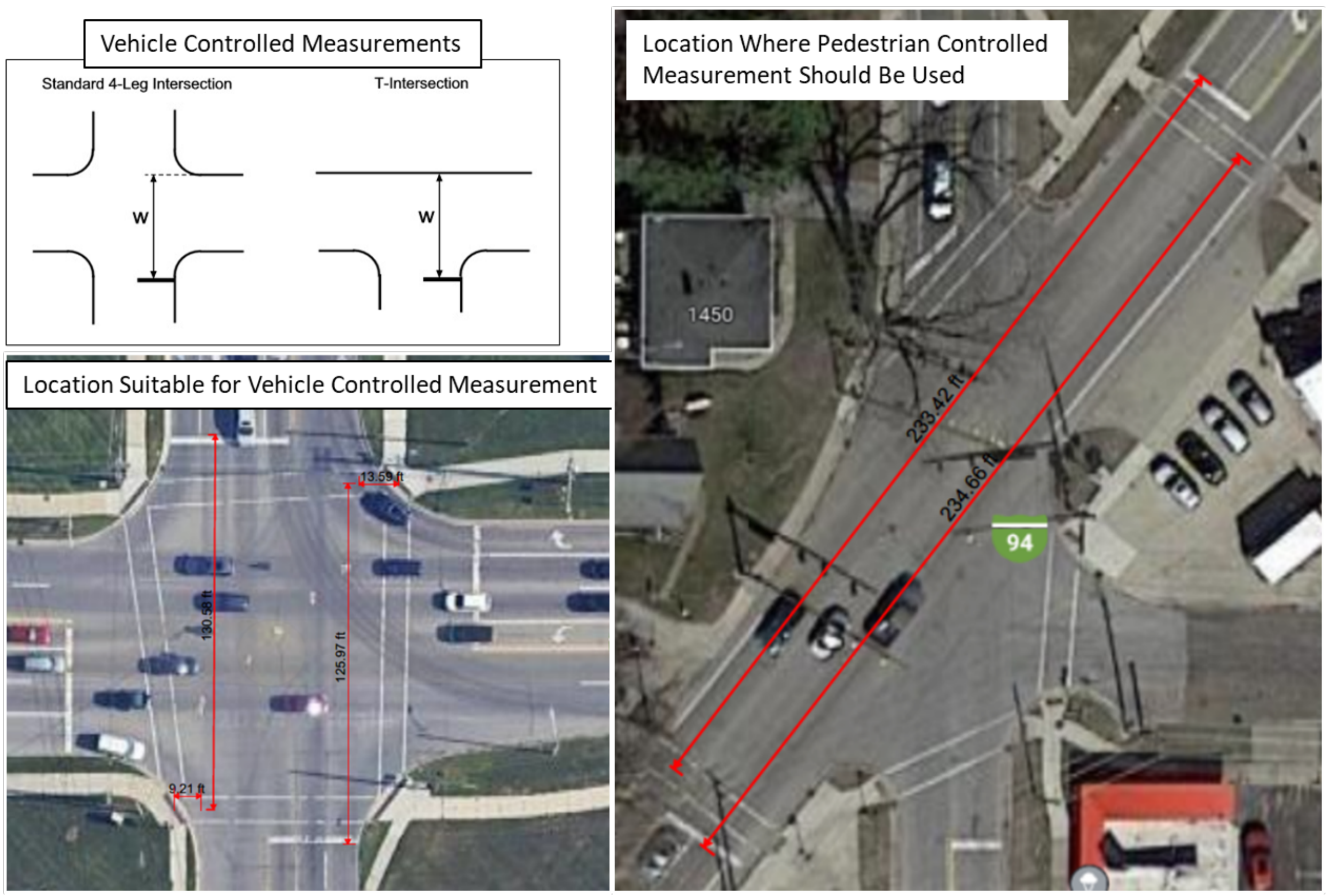
v = Measured 85th percentile speed is preferred, but if not available use posted speed unless site conditions indicate otherwise. For T intersections use 25 Mph for the traffic approaching the intersection along the stem of the T (the traffic that must turn). For private driveways or local streets with no posted speed, use 25 Mph unless site conditions indicate otherwise.

- As determined using engineering judgement, it may be appropriate (particularly on high-speed approaches) to calculate the All-Red using a left turning vehicle speed of 25 Mph and the distance left turning traffic must travel to clear conflicting movements.

- Conflicting pedestrian movements should be considered to determine if they control the All-Red time. Engineering judgement should be used evaluating how long it would take for a conflicting pedestrian to walk into the vehicle travel lane. This time will depend on how close the pedestrian is to the travel lane. When the sidewalk ramp is on a large radius, this time will typically be much longer than if the sidewalk ramp is on the curb tangent immediately adjacent to the travel lane. Measure to the center of the crosswalk when considering conflicting pedestrian movements.

- The All-Red interval cannot be less than 1 second or greater than the calculated value using the formula above.
- If the calculated value exceeds 4.0 seconds, confirm with the **MDOT Signals Unit** prior to use.

Figure 4-1: Measuring Intersection Width



4.1.3 *BOULEVARD CLEARANCE INTERVALS*

For boulevard crossings, the following method shall be applied to determine clearance and trail green intervals:

- **Step 1**: Determine the clearance intervals for each side of the boulevard separately using the methods shown in sections 4.1.1 and 4.1.2. Take the longer of the two intervals and apply it to both sides of the boulevard.
- **Step 2**: To determine the trail green (tg), use the following formula:
- The minimum tg value is 2 seconds. Values shall be rounded up to the next whole second. If there is no median stop bar, estimate where the front of a vehicle would stop in the median and measure to that location.

$$tg = \frac{ds}{\mathrm{v}}$$

Where: **tg** = Trail Green interval (seconds)

ds = Distance from near side stop bar to median stop bar (feet)

v = Measured 85th percentile speed is preferred, but if not available use posted speed unless site conditions indicate otherwise (feet/second)

4.2 PEDESTRIAN CLEARANCE INTERVAL CALCULATIONS

4.2.1 *WALK INTERVALS*

For locations with pedestrian signals, the pedestrian walk interval should generally be ***7.0 seconds or greater***. Walk intervals less than 7.0 seconds will be considered if the pedestrian time requirements exceed the vehicular time requirements for that particular movement, and if pedestrian volumes, characteristics, and pedestrian detector locations do not require a 7.0 second walk interval. The walk interval shall be no less than 4.0 seconds.

The walk interval may need to be more than 7.0 seconds based on the location of pedestrian detectors and the length of the crossing: The sum of the walk interval plus the FDW interval plus the buffer interval should be sufficient to allow a pedestrian to travel from the pedestrian detector (if no pedestrian detector then use 6' behind curb) to the far curb at a speed of 3.0 feet per second. Any additional time that is required to satisfy the conditions of this paragraph should be added to the walk interval. The online spreadsheet (***Y & R & PED TIMING***) accounts for this and will increase the minimum walk interval accordingly. Set the minimum walk interval to 4.0 seconds in the spreadsheet to see if this calculation is controlling the minimum walk time.

If an LPI is implemented without accessible pushbuttons, then the LPI time should be manually added to the calculated walk interval.

4.2.2 *PEDESTRIAN CLEARANCE TIME*

The MMUTCD requires a clear distinction between the pedestrian clearance time and the FDW interval. The calculated pedestrian clearance time (CPCT) is the time calculated for a pedestrian to walk (assumed walking speed of 3.5 feet per second) from the near curb (or shoulder) to the far side of the traveled way (or to a median of sufficient width for pedestrians to wait).

$$CPCT = \frac{d}{\mathrm{v}}$$

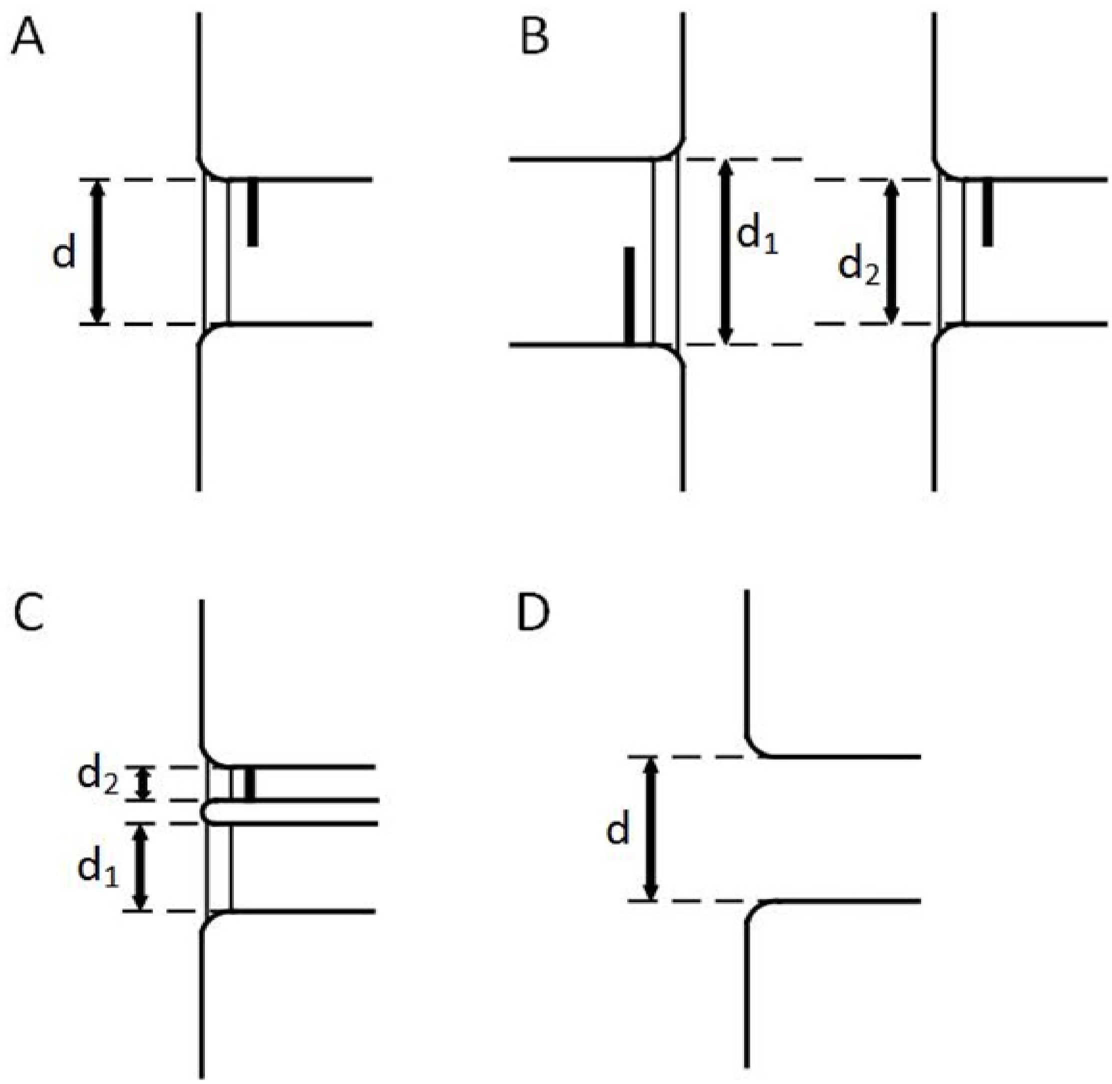
Where: **CPCT** = Calculated Pedestrian Clearance Time (seconds)
d = Distance from curb to curb (feet)
v = Walking speed of 3.5 feet/second

The CPCT is calculated as follows:

- If a crosswalk exists, distance is measured along the center of the crosswalk. If the crosswalk is on a radius and is significantly impacting the CPCT, the MDOT Signals Unit may authorize a measurement along the crosswalk line closest to the stop bar from near curb to far curb. (see Figure 4-2 scenario A).

- If there are two concurrent crosswalks, then use the longer crosswalk distance (see Figure 4-2 scenario B).
- If there is a median refuge that is clearly designed and designated for pedestrians to wait to cross in two stages, then use the longer crosswalk distance (see Figure 4-2 scenario C)
- If there is a median that is NOT clearly designed and designated as a refuge for pedestrians to wait to cross in two stages, then use the complete crossing distance similar to Figure 4-2 scenario A or B)
- If there is no crosswalk and/or no stop bar, measure the distance from near curb to edge of furthest travel lane extended (see Figure 4-2 scenario D).

Figure 4-2: Measuring Pedestrian Crossing Distances



The actual pedestrian clearance time (APCT) is the time provided between the end of the walk interval and the end of the all red clearance interval. The APCT consists of the FDW time plus the Steady Don't Walk Buffer Interval (BI). The APCT (FDW + BI) must equal or exceed the CPCT:

$$FDW + BI \geq \mathrm{CPCT}$$

Where: **FDW** = Flash Don't Walk time (seconds)
BI = Steady Don't Walk buffer interval (seconds)
CPCT = Calculated Pedestrian Clearance Time (seconds)

- Steady Don't Walk Buffer Interval (BI):
  - The Buffer Interval must be at least 3.0 seconds long and may be longer depending on controller setting chosen for when to end the FDW interval. Chapter 7, Table 7-2 includes controller settings specific to EPAC controllers.
    - If the signal controller limits the end of the FDW to the end of green, yellow, or All-Red, then use the setting to end the FDW at the end of green
      - The BI will then equal the sum of Yellow + All-Red
    - If the All-Red time is 3 seconds or greater, then it is also acceptable to use the setting to end the FDW at the end of yellow
      - The BI will then equal the All-Red
    - Newer signal controllers have a setting for the FDW interval to end exactly 3.0 seconds prior to the end of the All-Red clearance interval. This setting can ONLY be used if the All-Red is 3.0 seconds or less.
    - Typical MDOT preference is to end the FDW at the end of green. This eliminates the potential need to change this setting if the All-Red is changed.
- FDW Interval:
  - The FDW interval equals the CPCT minus the Buffer Interval

    - On short crosswalks, the calculated FDW time may be very short. While there is sufficient time to safely cross, this may be confusing for pedestrians. In order to avoid this, the FDW should be adjusted to always be equal to at least 75% of the CPCT.

    - Round up the FDW value to the next whole number for controller programming

4.3 MINIMUM SPLITS

4.3.1 *MINIMUM GREEN INTERVALS*

Minimum green (minimum initial) intervals are provided to ensure drivers do not miss their green phase and more importantly, if they are approaching at speed, they are not taken by surprise when a signal turns to green and then almost immediately turns to Yellow. Minimum green intervals should be determined for each signal phase for the purposes of calculating a minimum split. This applies to both fixed time signals, as well as for any actuated or semi-actuated signals. Minimum green intervals should be applied as follows:

- ***10.0 seconds*** should be used for all major street through movements, including:
  - State trunklines
  - Major arterial roadways
- ***7.0 seconds*** should be used for the following:
  - Minor cross-street movements (i.e. subdivision entrances, driveways, secondary roadways)
  - All left-turn phasing with the exception of actuated permitted-protected left-turn phasing
  - At locations with low turning volumes, the minimum green for left-turn phases may be reduced to 5.0 seconds with approval of the MDOT project manager.
- ***5.0 seconds*** should be used for actuated permitted-protected left-turn phasing. A minimum vehicle recall should always be set for actuated permitted-protected left-turn phasing where a flashing red is used. Locations with a 5 section (dog house) or the flashing Yellow left-turn operation do not require the minimum vehicle recall for permitted-protected left-turn phasing

4.3.2 *MINIMUM SPLIT CALCULATIONS*

The minimum split is the minimum time that must be provided for each vehicular phase or concurrent pedestrian movement to enable vehicles and pedestrians to safely enter and clear the intersection.

The time required to clear pedestrians often exceeds the time allotted for vehicular traffic on the concurrent phase, particularly for side street traffic with concurrent pedestrians crossing the major street. Pushbuttons should be considered for this situation. Pushbuttons must be provided for all pedestrian approaches in which the concurrent vehicular phase is actuated. Pushbuttons should be considered at intersections that otherwise operate fixed time.

If pedestrian signals are provided, but no pushbuttons, then the minimum split must accommodate the required pedestrian crossing times.

If pedestrian signals and pushbuttons are provided, then the minimum split can be based on the vehicular phase, but the pedestrian crossing times must still be calculated and programmed to run upon pushbutton activation.

If a pedestrian movement is equipped with pushbuttons, the minimum split based on vehicular movement can be programmed for the controller to run in the absence of any pushbutton activations, allowing for a shorter cycle length. When a pushbutton is activated, it overrides the vehicular phase timing to provide additional time for pedestrians to cross. If the signal is running in coordination mode, this additional time may cause the signal to be bumped out of coordination for multiple cycle lengths (depending on correction mode and timing).

Depending on the number of pushbutton actuations, especially during peak traffic, the timing plan may need to accommodate the pedestrian timing within the split and cycle length.

Minimum splits for each phase must be calculated. The **minimum vehicle split** is calculated with the following equation:

$$SPLIT_{min(vehicle)} = \mathrm{G_{min}} + \mathrm{Y} + \mathrm{AR} + 1\ \mathrm{second}$$

Where: **$SPLIT_{min(vehicle)}$** = Minimum vehicle split (seconds)

G_{min} = Minimum green interval (seconds)

Y = Yellow change interval (seconds)

AR = All-Red clearance interval (seconds)

The **minimum pedestrians split** is calculated with the following equation:

$$SPLIT_{min(pedestrian)} = \mathrm{W_{min}} + \mathrm{FDW} + \mathrm{BI}$$

Where: **$SPLIT_{min(pedestrian)}$** = Minimum pedestrian split (seconds)

W_{min} = Minimum walk interval (7 seconds typical)

FDW = Flash Don't Walk time (seconds)

BI = Steady Don't Walk buffer interval (minimum of 3.0 seconds)

The following shall be true regarding the minimum Walk time used in the previous equation:

$$W_{min} \geq \frac{\mathrm{dp}}{3.0} - \mathrm{FDW} - \mathrm{BI}$$

Where: $\mathbf{W_{min}}$ = Minimum walk interval
dp = Distance from pushbutton to far curb
FDW = Flash Don't Walk time (seconds)
BI = Steady Don't Walk buffer interval (minimum of 3.0 seconds)

5 TRAFFIC MODELING

This chapter details methods for consistently developing traffic models in SYNCHRO/SimTraffic. The models developed are often used as the basis for future studies, so it is important to follow the guidelines even if certain aspects are not directly required for the current project. SYNCHRO/SimTraffic is the preferred software package for developing optimized traffic signal timings by MDOT. If a SYNCHRO/SimTraffic cannot model a particular operation, consult with the MDOT project manager prior to selecting an alternative software package.

Traffic modeling is a valuable tool in developing optimized traffic signal timings, but the results are only as good as the input data. Models should represent realistic operations and they must be calibrated to local conditions. MDOT, in order to provide consistent, quality traffic models, has standardized much of the model development process.

5.1 MAP AND NETWORK SET-UP

SYNCHRO networks should be developed to replicate existing conditions during the periods to be analyzed, including the current geometric configuration, existing signal timing parameters (including existing clearance intervals, minimum times, etc.), and traffic volumes. The existing conditions analysis serves both as a point of comparison for the optimized timings, and as a means to calibrate and validate the SimTraffic model (see Section 5.3.2). The following sections detail the standards and conventions to be used in developing the SYNCHRO models.

5.1.1 *FILE STRUCTURE AND NAMING CONVENTION*

SYNCHRO network files should adhere to a standard naming convention unless otherwise discussed in advance with the MDOT project manager. The following is the standard file naming convention:

Route # - Control Section # - Zone # - Condition – Time Period.syn

The following abbreviations should be used in file naming:

- Zone Number:
  - Numeric designation (1, 2, 3…)
  - "A" for all (the entire control section if no zone breakdown is used, or if multiple zones are included in the same file)
- Condition:
  - "EX" for existing condition
  - "OPT" for optimized condition
  - "MIT" for optimized condition with geometric or operational mitigation.
- Time Period:
  - "AM" for AM peak period
  - "PM" for PM peak period
  - "OP" for mid-day/off-peak period
  - "NT" for nighttime period (if required due to special circumstances)
  - "WE" for weekend period (if required due to special circumstances)
  - "SP-IN" for an inbound special event timing plan
  - "SP-OUT" for an outbound special event timing plan
  - "EM-XX" for emergency signal timing plan. XX will indicate the direction of travel as follows:
    - NB – Northbound
    - SB – Southbound
    - EB – Eastbound
    - WB – Westbound

- BI – Bi-directional

Example: The Woodward Avenue (M-1) corridor within the city of Detroit (Control Section 82400) is being divided into two zones, or segments, for optimization – Zone 1 and Zone 2. The file being named represents the optimized condition for Zone 1 during the AM peak period.

File Name = ***M1-82400-1-OPT-AM.syn***

Once a model contains more than one corridor the naming convention may become too large. For isolated intersections use one SYNCHRO file and place the intersections adjacent to each other but unconnected. Spacing the intersections out geographically causes problems during review as these intersections are easily missed. If more than one corridor is present use different control section numbers in the file name to differentiate between models.

File Name = ***82300–82400–83500-OPT-AM.syn***

5.1.2 MAP SET-UP

A background image of the study area should be inserted in each SYNCHRO model. The background image can be toggled on/off for ease of loading and navigation. All maps should be imported under the File -> Select Backgrounds interface. SYNCHRO also allows users to import a background map using Bing maps. Follow the instructions provided within the software for up-to-date procedures. Once the map is inserted into the file be sure that it is scaled properly before beginning to construct the model. If using an imported map, the map needs to be scaled to correct proportions manually.

5.1.3 BASIC CODING PARAMETERS

The following procedures and values should be used when coding the basic SYNCHRO network:

LINK NAMING

Link names along a single corridor should be as consistent as possible so that the corridor will be recognized as a single arterial and be displayed properly in the time-space diagram.

Road names should match the names on the permit. For trunklines, it should start with the route number followed by the local name if there is one.

Dummy nodes should be named alphabetically without duplicates. They should also be consistent between time periods.

For intersections utilizing SCATS, the crossroad name should be followed by, “(SCATS)” in order to clarify operational questions.

LINK SPEED

The link speed coded in SYNCHRO provides the basis for evaluating progressive movement between signalized intersections. Where 85th percentile speeds are available, they should be used. If not available, set the speeds based on the posted speed limit. A speed limit of 25 MPH should be used for all ramps unless there is a through movement, in which case the speed limit should be set to the speed limit (or estimated prevailing speed) of the receiving lanes. In the event the 85th percentile speeds exceed the posted speed limit, consult with the MDOT project manager to determine the appropriate speed to use in the models.

IDEAL SATURATED FLOW RATE

The default ideal saturated flow rate for a movement at an intersection should be ***2,000 vehicles/hour*** for projects in the Metro Region. ***1,900 vehicles/hour*** should be used for all other regions of the State, or as directed by the MDOT project manager.

VOLUME INPUT

Pedestrian counts and pedestrian push button data should be entered in two different areas. Under the Volume Settings window, the number of pedestrians counted should be entered under the Conflicting Pedestrians per hour. When inputting pedestrian data into the Phasing Settings window, the data is entered as Pedestrian Calls per hour. It is important to differentiate between the number of pedestrians and the number of actuations/calls when collecting pedestrian data. Multiple pedestrians may cross under one (1) actuation.

Actual pushbutton actuations per hour can sometimes be determined by reviewing the existing controller's local alarms report. If not, then review the pedestrian counts in 15 minute time periods and estimate the number of pushbutton actuations per hour using engineering judgment.

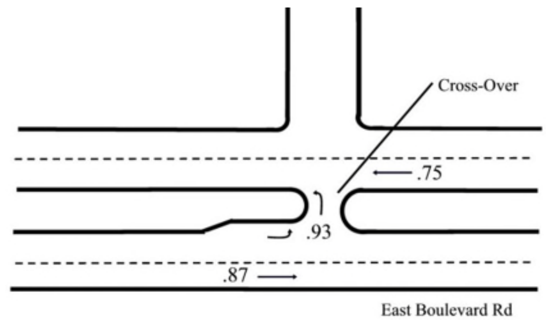
For simplicity, the number of pedestrian calls can be calculated as follows:

- Up to 5 pedestrians/hour – Pedestrian calls should equal the number of pedestrians.
- From 5 to 10 pedestrians/hour: 5 calls should be used.
- For 10 or more pedestrians/hour: Half of the pedestrian volume up to the number of cycles per hour
- If there are more than 30 pedestrians/hour – Engineering judgment should be used to determine if there is a traffic generator such as a school or factory concentrating the pedestrians into a short time period.

To determine which volumes should be entered into the SYNCHRO models, select the Peak Hour for each intersection and input the corresponding volumes. Once these volumes have been entered, volume balancing between the intersections should be completed. Volume balancing can occur through one of two methods.

- If intersections are spaced far enough apart to allow for the insertion of dummy intersections this method should be adopted. Use the dummy intersections to balance the volumes between the study intersections, regardless of calibration. Thru volumes should always be carried thru first before adding or subtracting volumes from the minor dummy road.
    - ➢ The surrounding area should be reviewed to determine if the volumes added or subtracted at the dummy node are reasonable.

Figure 5-1: Crossover Peak Hour Factor



- For locations with no access between intersections volumes should be balanced in a manner similar to that of calibration. Anything greater than 10% of the existing volume or 20 vehicles difference between the existing volumes should not be accepted. The intersections should always balance up to the higher volume intersection with the additional volume dropped at the next available dummy node.

PEAK HOUR FACTOR

Peak hour factors should be applied by intersection approach, and the peak hour factor for the approach as a whole should be entered for all movements on that approach. For example, if the total approach volume (L + T + R) over the study hour is 1000, and the peak 15-minute approach volume (L + T + R) is 300, the peak hour factor applied to all movements for that approach is 1000/(4*300) = 0.83.

Peak hour factors lower than 0.60 or greater than 0.95 should not be used. Should the calculated peak hour factors fall out of this range, the minimum or maximum range value should be applied. Exceptions may be made for locations where the turning movement peak hour factors should be calculated separately from the overall approach peak hour factor. This may occur at schools or factories where an approach may have steady overall volumes thru the peak hour, but the turning movement going to or from the traffic generator may have strong peaking characteristics. An exception should also be made for peak hour factor associated with crossovers contained with a boulevard intersection.

Example: For a eastbound to westbound crossover the eastbound left turn lane feeding into the crossover should have a peak hour factor that reflects the crossover volumes. See Figure 5-1 for example.

RIGHT AND LEFT-TURN LANE STORAGE DISTANCES

Right and left-turn lane storage lengths should be coded in SYNCHRO as the distance from the stop bar to the beginning of the taper, or the end of the full-lane width. Figure 5-2 provides an example of the turn lane storage length to code in SYNCHRO.

For intersections with continuous two-way left-turn lanes, the left-turn lane storage length should typically be coded as 500 feet as a default value. However, care should be taken to consider the impact of opposing driveways and nearby intersections on the practical storage length available. The following issues should be considered in determining storage length in the case of continuous two-way center left-turn lanes:

- Observed queues exceeding 500 feet contained within the left-turn lane
- Observed queues of less than 500 feet which overflows from the left-turn lane
- Closely-spaced driveways or intersections, the location of which reduces the practical available left-turn storage at the signalized intersection.

Typically, taper lengths should not be measured. However, if an intersection has a long taper length and vehicles are using the taper length as additional storage the portion of the taper being used as storage should be measured and coded as part of the storage distance. This should be noted on the inventory sheet.

MINIMUM SPLITS AND CLEARANCE INTERVALS

This section provides an overview of the SYNCHRO inputs for minimum split times and pedestrian and vehicular clearance intervals. For evaluating SYNCHRO outputs, including optimizing signal timings, see Section 5.2.

Figure 5-2: Turn Lane Distances

Minimum split definitions and calculations can be found in Section 4.3. Controller settings determining splits and pedestrian timings can be found in Section 7.4.

- **Yellow and All-Red Time:**

  These values should be taken directly from MDOT's online spreadsheet ***Y & R & PED TIMING*** noting that Yellow intervals greater than 6 seconds and All-Red intervals greater than 4 seconds must be confirmed with MDOT Lansing Signal Operations.

- **Walk and Flash Don't Walk Time:**

  These values should be taken directly from MDOT's online spreadsheet ***Y & R & PED TIMING*** making sure to use the column labeled "FDW Interval-Synchro". There is also a column labeled "FLASH DON'T WALK (CONTROLLER)".

These two values may not be the same since SYNCHRO always assumes the FDW ends at the end of green. SYNCHRO may overestimate the required split time if the FDW time is entered incorrectly.

- **Minimum Split:**

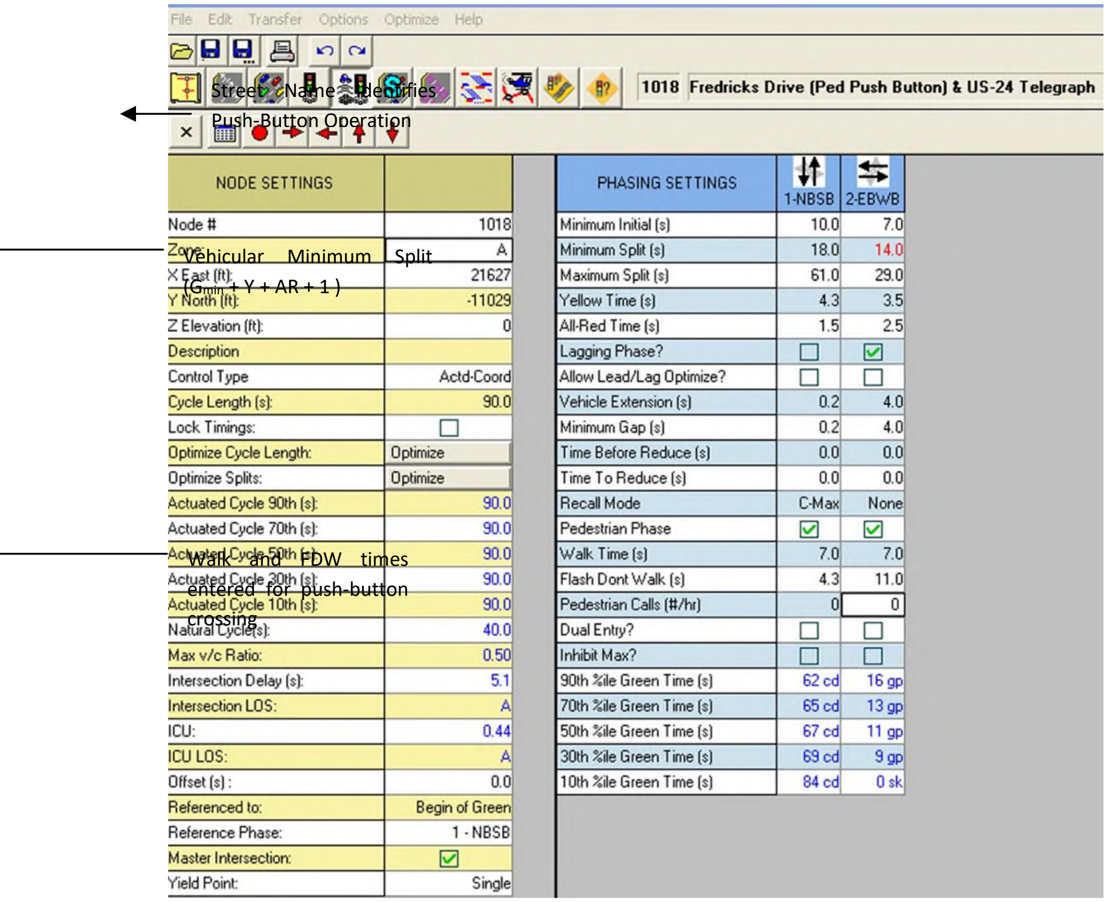
  MDOT's online spreadsheet ***Y & R & PED TIMING*** has a column labeled "Min. Split (larger of vehicle or pedestrian)". The spreadsheet calculations take into account whether or not the pedestrian movement is equipped with pushbuttons. If no pushbuttons, this minimum split will be the greater of the vehicle or pedestrian split. If a pedestrian movement is equipped with pushbuttons, this minimum split will be the vehicle split.

  When a pedestrian movement is equipped with pushbuttons, the vehicle split can be entered as the minimum split in SYNCHRO as a starting point. Significant engineering judgment must be used before choosing a cycle length that does not accommodate pedestrian split times (See Section 5.2 Optimization).

If a street has parallel pedestrian pushbuttons, then rename the street in SYNCHRO to indicate the pedestrian pushbuttons, e.g. "Elm Street (Pushbuttons)." Always enter the pedestrian Walk and FDW times for any movement with pedestrian indications, even if the vehicle split is entered as the minimum split. SYNCHRO may provide a minimum split error warning in the signal timing window. This is a reminder to include pedestrian considerations when evaluating the proposed cycle length and splits. Figure 5-3 illustrates the phasing window in SYNCHRO for this situation.

NOTE: SYNCHRO assumes that the Flash Don't Walk phase and the Yellow vehicle phase are sequential and not concurrent. In other words, SYNCHRO assumes that the pedestrian indication will stop flashing and enter a steady Don't Walk as vehicles receive the Yellow indication.

Figure 5-3: Phasing Window for Signal with Pedestrian Push-Buttons and No Ped-Calls



For the Existing Conditions models with EPIC or EF-140 controllers, the clearance intervals (Flash Don't Walk, Yellow and All-Red intervals) should match the value actually running. Normally the minimum interval and the dial/split interval times should be identical for clearance intervals, but occasionally they are not. Minimum Green/Walk intervals are highly variable ranging from the typical 7 to 10 seconds down to 0 seconds and up to the actual interval time. As these controllers typically run fixed time operation, the minimum green/walk times do not impact the existing splits. For simplicity, they should be based on the typical 7 to 10 second times for optimization unless that will cause the operation to violate the existing split, in which case they should be adjusted to allow for the existing split.

ACTUATED SIGNAL SETTINGS

The following values should serve as default settings for actuated signals. Exceptions for the vehicle extension and minimum gap may occur:

- Vehicle Extension = 3.0 seconds

- Minimum Gap = 3.0 seconds
- Time Before Reduce = 0.0 seconds
- Time to Reduce = 0.0 seconds

For Actuated locations, extra attention should be paid to make sure that phases are on the correct side of the barrier so the signal will operate correctly when simulated in SIMTRAFFIC.

Detectors should be coded utilizing SYNCHRO's default size and position unless there is a non-typical operation such as a second set of advance detection zones well away from the intersection. Default detector setting should be left in the models for consistency purposes.

INHIBIT MAX SETTING

For actuated coordinated signals, the inhibit max setting in SYNCHRO is used to designate whether unused time from a phase that is skipped or gaps out early is given to other uncoordinated phases so that they exceed their maximum split or if all unused time should be given to coordinated phases.

- An inhibit max setting of "YES" allows unused or extra time to be given to uncoordinated phases and should be used if the mode setting of 7-Dual Coordinated is used on the timing permit.
- An inhibit max setting of "NO" means all unused time will go to the coordinated phases and should be used in most other situations.

The Inhibit Max setting in EPAC controller is unrelated to the SYNCHRO setting. In an EPAC controller, setting the Inhibit Max to "YES" implies that the signal is running coordinated and the dial/split times should override the Max time settings.

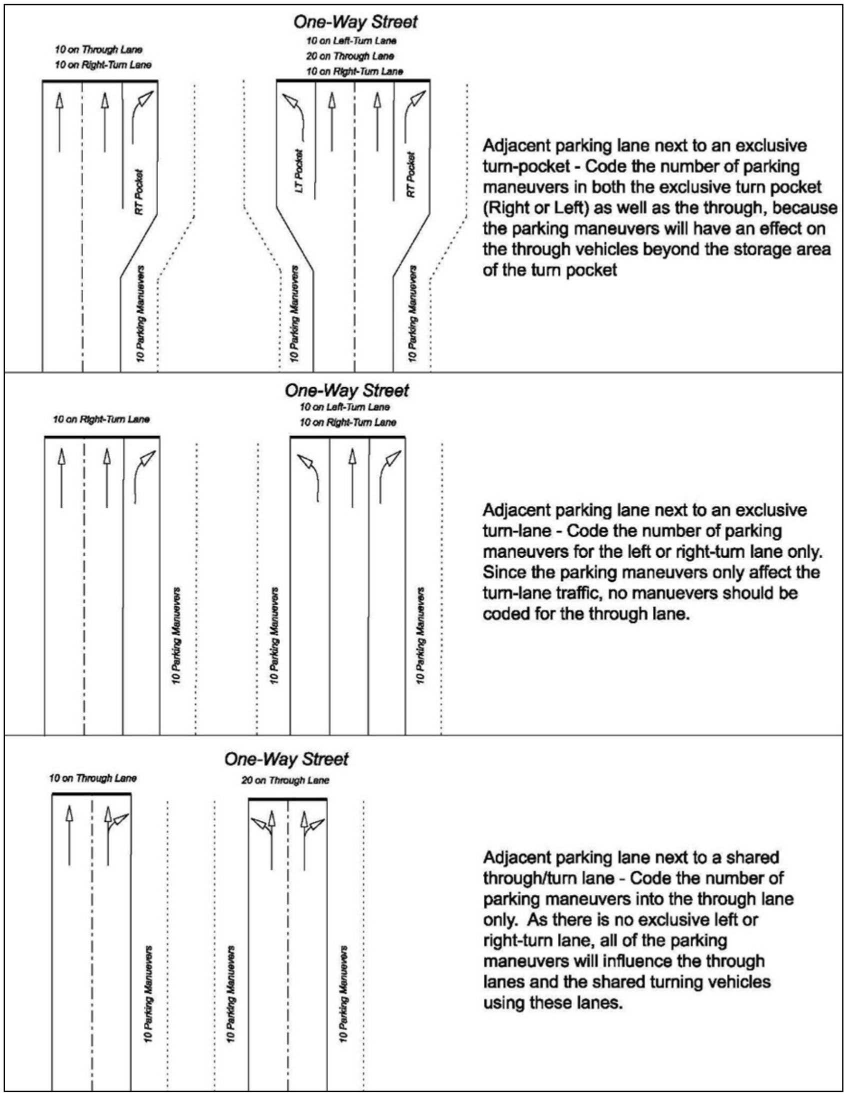
INTERCHANGES

If an interchange lies within the corridor (signalized or unsignalized), the ramps should be modeled within the SYNCHRO model.

PARKING MANEUVERS

Parking maneuvers adjacent to the travel lanes should be estimated based on number of spaces, nearby land use composition, and parking time and duration restrictions (where applicable). A default of 10 maneuvers/hour should be assumed under typical conditions with an adjacent parking lane. On-Street parking should be coded as shown in Figure 5-4.

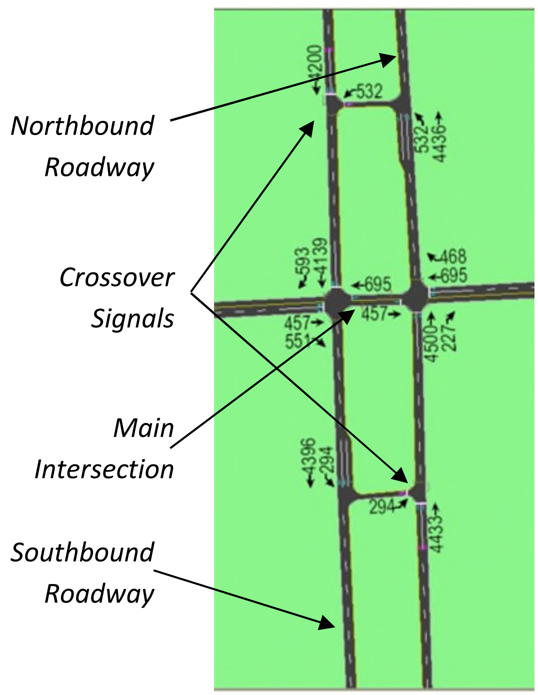
Figure 5-4: Parking Maneuvers Coding Examples



MICHIGAN BOULEVARD

Michigan boulevards should be coded as parallel, one-way links, connected by crossing streets and crossover lanes within the median space, in order to appropriately replicate field operations. An example boulevard layout is depicted in Figure 5-5.

Figure 5-5: Typical Boulevard Configuration



Crossover lanes should be coded as short links connecting both directions of the divided roadway. Crossover lanes typically function as a short two-lane segment, as the width of the lane at the point of u-turn accommodates wide truck movements, and often serves simultaneous turns for smaller vehicles.

The origin-destination feature should be used wherever possible to properly proportion movements at the crossover locations.

Modeling of boulevards in another manner must be submitted and approved by MDOT Lansing Signal Operations before proceeding.

TRAVEL TIME

SYNCHRO provides a calculation of link travel time, shown in the link settings window. This travel time is based solely on the link distance and speed provided by the user, and should not be adjusted from the default setting.

5.1.4 *INTERSECTION NUMBERING*

Because SYNCHRO limits intersection numbers to four numeric digits (no symbols or letters), MDOT numbering standards using the control section and spot number cannot be followed. In addition, boulevard intersections, represented by more than one node in SYNCHRO, only have one unique spot number in the MDOT system.

Figure 5-6: Boulevard Node Numbering

The following node numbering guidelines have been developed to match MDOT's numbering system as much as possible, while accommodating multi-node intersections and projects that span multiple control sections. Node numbering should follow these guidelines except as otherwise directed MDOT.

Signalized nodes for projects with one Control Section:

Node Number = 1 + Spot Number

- *Example: Spot #034*
    - *Node #1034*

Signalized nodes for projects with multiple Control Sections:

1. Each Control Section included in the project should each be given a unique number 1-8, in order along a corridor (if applicable)

2. Node number = Control Section # + Spot Number

- *Example: Control Section 80000 = #2 (the second control section included in the project)*
    - *Control Section 80000, Spot Number 034 = Node # 2034*

Signalized nodes for boulevard intersections (more than one SYNCHRO node representing a single spot number):

1. The Northwest-most node should be numbered based on the standard numbering system above

2. Additional nodes should be numbered by varying the hundreds digit of the node number, counting back from “9” going counterclockwise.

- *Example (See Figure 5-6 on the previous page): Control Section 80000 (#2), Spot Number 034 is a boulevard/boulevard intersection (represented by four SYNCHRO nodes):*
    - *Northwest-most Node = Node #2034*
    - *Southwest-most Node = Node #2934*
    - *Southeast-most Node = Node #2834*
    - *Northeast-most Node = Node #2734*

Unsignalized Nodes:

Unsignalized nodes (including sign-controlled intersections, bend nodes, external nodes, etc.) should be numbered in the 9000’s for ease of segregating during the reporting process. If the node is directly associated with an adjacent signal, such as the unsignalized node at a crossover, it should be numbered in association with the signalized node similar to the way boulevard intersections are numbered.

5.1.5 *STANDARD INTERSECTION PHASING SET-UP*

The signal phasing used in SYNCHRO modeling should follow the phasing as documented on the timing permit wherever possible. In cases where the timing permit phasing is unclear, NEMA standard phasing sequence should be used. Since phases greater than eight (8) are rarely used, overlaps can be distinguished by coding them as phase number 9 or higher.

When coding intersection phasing, it is imperative that the offset is referenced properly to the initial phase (or start-up phase) in the controller. While maintaining agencies differ in their assignment of the initial controller phase (based on major street, cardinal direction, etc.), the following standard should be applied to assure SYNCHRO network consistency.

Offsets should always be set to match the existing permit if possible, if this is not possible reference the beginning of the green indication for phases 2+6.

Right turn movements should typically be coded as permissive unless there is a green arrow and no conflicting pedestrian movement.

Where there are unsignalized approaches, SYNCHRO does not directly model the operation. They should generally be coded as a channelized right turn with stop control and all traffic turning right. Engineering judgment should be used if this creates operational issues, in which case the project engineer should be consulted to determine how it should be coded.

5.1.6 *BOULEVARD PHASING SET-UP*

Boulevard signals are represented by two or more individual signalized intersections in SYNCHRO – one for each direction of travel of each divided roadway. The intersections must therefore be grouped using the cluster function, as they functionally operate using the same controller.

Boulevard signal phasing must be coded to replicate the trail green (TG) for traffic crossing the divided roadway. Because SYNCHRO does not replicate the controller logic of the trail green sequence, the length of the trail green for the far-side signal must instead be represented by an extension of the all-red time for the near-side signal. In order for this trail green sequence to be coded appropriately, the near- and far-side signals must be coded as independent phases. .

For each crossing, there is typically only one set of pedestrian timings associated. The pedestrian timing is typically associated with the near signals and the pedestrian clearance intervals should be associated with the phases, not both the near and far indications.

Example: The through movements of an east-west minor roadway at an intersection with a major roadway would typically be served by phases 4+8, phase 4 representing one direction of traffic, and phase 8 representing the other. If the minor roadway is intersecting a divided roadway, phase 4 would represent both directions of travel at the near-side signal, and phase 8 would represent both directions of travel at the far-side signal. Phase 4 would have an extended all-red time equal to the calculated all-red time plus the trail green time to allow the median space to clear at the end of the phase. Figure 5-7 and Figure 5-8 illustrate this example.

Figure 5-7: Standard Boulevard Phasing Assignments

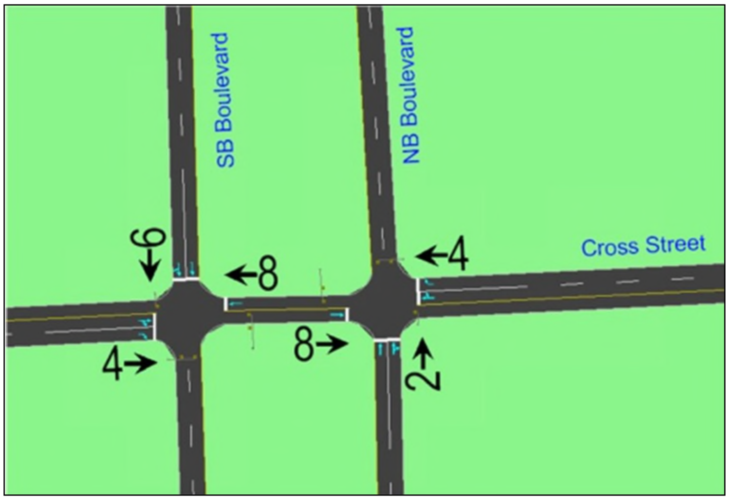


Figure 5-8: Trail Green Sequence

5.2 OPTIMIZATION

The automated optimization functions in SYNCHRO do not typically provide timings consistent with MDOT's preferences. SYNCHRO output should be considered as a starting point for the optimization process. Care must be taken by the engineer to evaluate the SYNCHRO results and manually adjust the timings in the model based on the following general guidelines.

5.2.1 *SPLIT, CYCLE LENGTH, AND OFFSET SELECTION*

- **Splits**

  When a pedestrian movement is equipped with pushbuttons, the vehicle split is typically entered as the minimum split in SYNCHRO as a starting point. Depending on the cycle length selected after evaluating the output of the SYNCHRO optimization, the minimum split in SYNCHRO may be increased to accommodate the pedestrian split.

  Generally, signal phase splits should be manually adjusted to favor the trunkline corridor (typically the higher volume roadway), while maintaining acceptable LOS on the intersecting roadways. Special attention should be paid to locations where a major arterial crosses the trunkline. In addition, signalized crossovers should generally be timed as an extension of the main intersection, with identical splits.

- **Cycle Lengths**

  MDOT signals typically operate on cycle lengths ranging from 60 seconds to 120 seconds, in 10 second increments.

  The progression bands and phase splits must be reviewed during the process of selecting a cycle length as the splits and offsets that SYNCHRO provides are often impractical and/or provide excessive time to minor movements and thus may result in a less than ideal cycle length.

  The network cycle optimization option should be selected, and the resulting performance indices reviewed and reported as part of cycle length evaluation and selection.

  Cycle lengths should generally be evaluated first based on the quality of progression for the trunkline corridor, and secondly based on the resulting local intersection delay. Typically, cycle lengths that provide optimum progression for a high-volume trunkline will yield the best overall network performance.

  Before choosing a cycle length that does not accommodate pedestrian split times, the following data must be evaluated:

  - Number of pedestrian pushbutton actuations during the 15 minute periods in the peak hours
  - Amount of time differential between minimum splits and programmed splits for all phases

- Correction mode being used for signals in coordination
- Number of cycles required for traffic signal controller to get back in step (correction)
- Impact to corridor traffic operations during correction time

Evaluation results may indicate that the peak period cycle length must accommodate the pedestrian split time, but the off peak cycle length can be shorter based on vehicle split times, providing the longer pedestrian split times only upon pushbutton activation.

When considering a cycle length that does not accommodate the pedestrian split time, it is highly recommended to bench test a controller with anticipated pedestrian calls to ensure it gets back into step as anticipated.

- **Offsets**

Offsets obtained from traffic models should be considered as a starting point for signal retiming projects. Field observation of the implemented offsets is critical to verify the efficacy of the proposed timing. Offset adjustments may be needed due to slower traffic speeds or excessive queues.

Offsets should generally be adjusted to provide optimal progression for the predominant peak direction, while maintaining the best possible progression in the off-peak direction. If the cycle length remains the same in optimized conditions as in existing conditions, a common reference point should be established for ease of comparing the existing and optimized offset plan. A reference intersection should be selected (typically a major crossroad or a signal at one end of the corridor) and the existing offset at that location held constant for the optimized condition, with all other offsets developed around it.

Selecting offsets for traffic signals with side-street vehicle detection requires engineering judgment. When an actuated side street phase gaps out, the coordinated main street phase will be serviced earlier than planned. This early return to green may result in undesirable queuing and inefficient flow at a critical intersection or along the corridor. Early return to green is most likely to occur when side street volumes are low or sporadic. Adverse impacts from early return to green can sometimes be identified by observing the simulation, or by viewing the time space diagram using 50% flows compared to 90% flows.

Techniques to mitigate early return to green include:

- Not allowing the early return to green if it will cause excessive queuing or adversely impact progression at downstream intersection(s)
- Starting the green earlier on downstream intersection(s) to accommodate the early arrivals.
    - The more this adjustment is made, both in magnitude and the number of signals down the corridor, the more potential adverse impact to the bandwidth, especially for two-way progression along a corridor.

- If a particular intersection is known to have consistently low side street volumes, consideration should be given to starting the green earlier at the next downstream signal. A general rule, based on driver expectation, is to avoid having drivers stop at two consecutive signals.

Offset selection may depend on the type of controller in use for the particular corridor being retimed. The following considerations are specific to the controller type:

- ***EPAC Controller***
  - Side street with vehicle detection:
    - Select offsets using engineering judgment described above to address impacts of early return to green as required based on directional, flows, progression bandwidths, time of day plan, and any critical intersections.
    - The offsets on the timing permit should match the offsets shown in SYNCHRO.
- ***EPIC Controller***
    - If the controller loses step when the push button is activated (This will occur if the side street split is less than the minimum pedestrian split): EPIC controllers won't accommodate this type of operation. Adjust the splits to accommodate the pedestrian timings while staying within the cycle length.
  - If the controller does not lose step when the push button is activated (The start of mainline green for EPIC controllers with push buttons will vary depending on if the push button is activated. This will result in variable early greens depending on vehicle volumes):
    - If pedestrian actuations are infrequent, the SYNCHRO model and permit should be based on not having pedestrian actuation. Typically, the start of the mainline green will be at the beginning of the last interval and the SYNCHRO offset will correspond with the mainline green starting at the beginning of the last interval. However, the offset on the timing permit is based on the start of the first interval. The offset on the timing permit will need to be adjusted from what is shown in SYNCHRO to account for the early mainline green.
    - If pedestrian actuations are frequent, the SYNCHRO model and permit should be based on having pedestrian actuation. Typically, the start of the mainline green will be the start of the first interval and the SYNCHRO offset will correspond with the mainline green starting at the beginning of the first interval. The offset on the timing permit should match the offset shown in SYNCHRO.

5.2.2 *ZONE ASSIGNMENT*

In many cases it may be necessary or desirable to divide a project area into smaller signal zones in order to accommodate different cycle lengths. Zone assignments must be approved by the MDOT project manager before proceeding with the optimization process. Proposed zone assignments are typically submitted in the form of a memo including a summary of the cycle length selection process. For larger projects, a meeting is typically held to discuss the zone assignments in the cycle length selection memo.

The following are examples of where separate zones should be considered:

- Where differing volumes, speeds, or signal spacing indicate different cycle lengths would reduce overall network delay.
- Where a coupling index calculation indicates low benefit of coordinating two signals or zones.
- Where a transition occurs from a median-divided to undivided roadway.
- At a highly-congested intersection where congestion prevents progressive movement, even when a common cycle length is used.
- Where unique geometric conditions necessitate signal phasing not consistent with other intersections within the project area.
- Where a natural break in progression occurs, such as at a “T” intersection, the crossing of a freeway, or a long segment of roadway (greater than 1.5 miles) without a signalized intersection.

5.2.3 *COORDINATION WITH ADJACENT SIGNALS*

Coordination with adjacent signals should be investigated under certain conditions so that the optimization project causes the least possible disruption to the surrounding signal network. The following are examples of when coordination with adjacent signals should be investigated:

- When a signal is closely adjacent (less than ¼ mile) to the project area/corridor.
- When the optimized cycle length for the project area/zone is the same as the surrounding signal network, and cross-progression could be accommodated.
- When single intersections adjacent to the project area are left isolated (not functioning with any system) by the optimization project.

The extent of coordination may vary, from proposed changes in offsets to a complete re-timing. Every effort should be made to determine coordination requirements in advance of proceeding with an optimization project. The extent of coordination should be discussed and determined in conjunction with the MDOT project manager.

5.2.4 *PHASING*

MDOT applies a standard phasing sequence wherever possible in order to remain consistent with driver expectations. Signal phasing should not be changed unless special conditions exist where other phasing strategies are required, or would result in a substantial improvement over standard phasing.

The following phasing sequences are typically used:

- Left-turns <u>must</u> ***LAG*** the through movement where a flashing red ball or 4th level left-turn arrow permissive-protected phasing is used.
- Left-turns <u>should</u> ***LAG*** the through movement where a flashing yellow arrow or 5 section permissive-protected phasing is used.
  - Where there is significant benefit, the MDOT project manager may approve having the left turn phase ***LEAD***.
- Left-turns <u>should</u> ***LEAD*** the through movement where protected-only phasing is used.

5.2.5 *MEASURES OF EFFECTIVENESS*

Measures of Effectiveness (MOEs) should be evaluated to determine the effectiveness of the optimization process. MOEs to be considered vary between the local intersection and network levels:

- **Local Intersections**

  Intersection ***control delay*** and ***level of service*** (Highway Capacity Manual method) should be evaluated as the primary MOE at the local intersection level. Wherever possible, Level of Service (LOS) C or better should be achieved for all approaches. However, judgment should be used to balance approach levels of service based on relative traffic demand. Where an intersection is running at or above theoretical capacity, the volume/capacity ratio should also be considered.

- **Network/System**

  Progression ***bandwidth*** should be evaluated as the primary MOE at the network/system level. The optimization should aim not only to provide the maximum bandwidth along major corridors, but to position the band to provide progression for the leading vehicles in the platoon (leading edge bandwidth) wherever possible.

While other MOEs should be evaluated as part of the optimization and reporting process (see Section 5.3.3), the above MOEs should be considered the most important when making optimization decisions and adjustments.

5.2.6 *TIME-OF-DAY SCHEDULES*

The time-of-day schedule for the project area/zone should be updated as part of the optimization process to designate when the various timing plans should be in operation. The following guidelines should be followed in determining the time-of-day schedule:

- Signals typically operate under three timing plans: AM peak period, PM peak period, and a mid-day/off-peak/weekend plan.
- 24-hour counts should be used to determine when timing plan changes should occur based on the traffic flow pattern. Figure 5-9 presents an example of a typical 24-hour traffic flow pattern of an average weekday, and illustrates where timing plan changes may be appropriate.
- The time-of-day schedule should be the same for all signals within a zone in order to maintain coordination, except when signals change in and out of flash operation.
- Certain locations may require special mid-day, night, or weekend timing plans to accommodate unique conditions, such as school dismissal or shift changes. In such cases, coordination should be maintained whenever possible with adjacent signals operating on a standard schedule.
- When a signal comes out of flash mode or changes dial/splits, it must go thru a period of correction where the controller adjusts the timings to move the offset to the desired time. During this correction the offsets tend to be random and progression will often be poor. Depending on the cycle length, how much the offset needs to be adjusted and how much correction the controller can make per cycle, this can take multiple cycles and last for as much as 10-15 minutes. In the AM time period, it is often beneficial to start the timing plan while volumes are still relatively low but growing quickly. This allows all the controllers to be coordinated when the peak volumes arrive. There may be situations where this is beneficial for the PM time period, but the midday volumes are typically substantially higher than the early morning volumes and the PM peak is typically more of a gradual increase in volumes as opposed to the sharp spike typically seen in the AM time period.

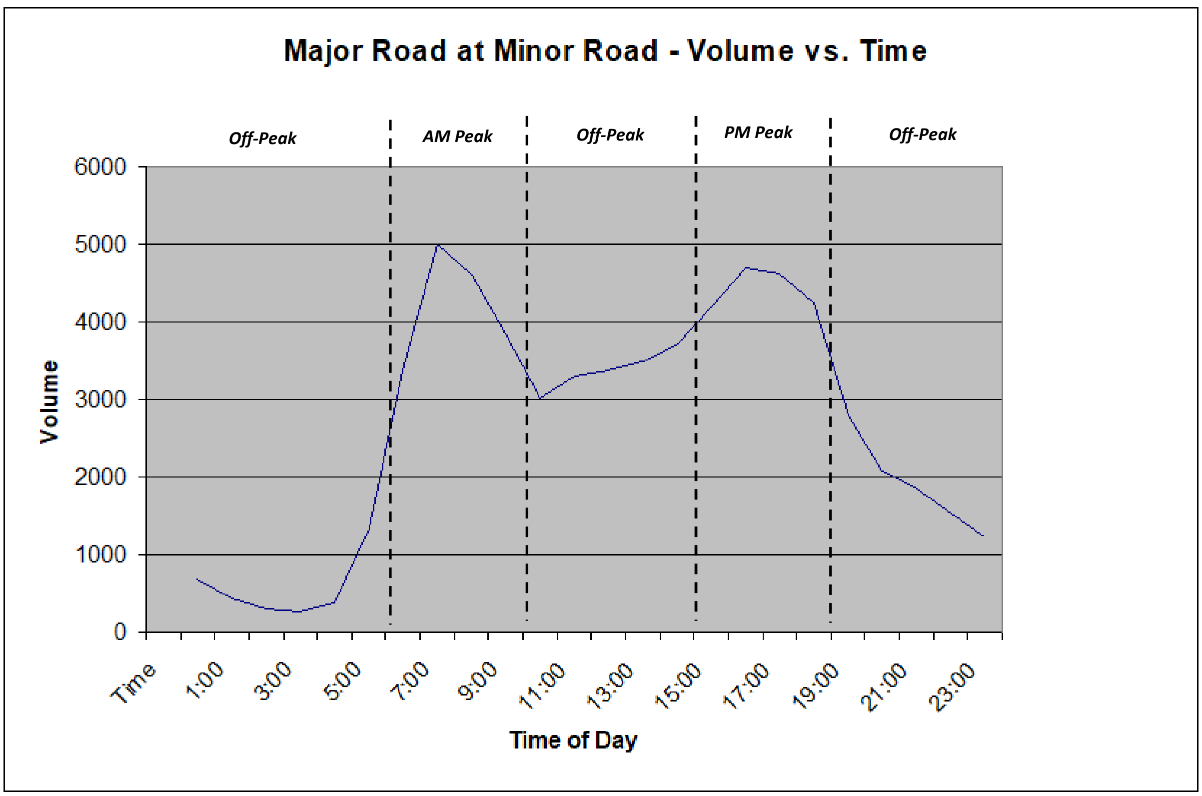
At locations with current flash schedules, the period(s) of flash operation should be reviewed based on 24-hour volume data. *While flash schedule is not explicitly addressed in the current edition of the Michigan Manual of Uniform Traffic Control Devices (MMUTCD), MDOT's internal guideline on setting flash schedule, consistent with direction set forth in the 1994 MMUTCD, which follows:*

> *"When for a period of four or more consecutive hours any traffic volume drops to 50 percent or less of the stated volume warrants, it is desirable that flashing operation be substituted for conventional operation for the duration of such periods. However, such flashing operation should be restricted to no more than three separate periods during each day."*

An exception to the 1994 MMUTCD guidelines as stated previously is as follows. Flashing operation should only be considered during time periods where **the minor road** traffic volume drops to 50 percent or less of the volume warrants for Warrant 1 (Minimum Vehicular Volume). Also, engineering judgment should be used in cases when unique intersection characteristics may warrant deviation from this guideline, such as locations where major road volumes are exceptionally high or there are sight restrictions. Intersection flash schedules should be evaluated and updated based on these criteria.

Flash schedules should generally be kept consistent along a corridor. To do this, flash schedules at individual intersections may be shortened, but they should not be extended beyond what the volume criteria allows. If the signals can be grouped into major and minor intersections or separate segments that would have significantly different flash schedules, utilizing two flash schedules may be considered. Utilizing more than three flash schedules on a corridor should generally be avoided.

Figure 5-9: Example Timing Plan Changes by Time-of-Day



5.2.7 *FLASH SCHEDULES*

Based on engineering study or engineering judgment, traffic control signals may be operated in the flashing mode on a scheduled basis during one or more periods of the day rather than operated continuously in the regular mode (running colors). Generally flashing operation should be considered only during time periods when the minor road traffic volume drops to 50% or less of the volume warrants for Warrant 1 (Minimum Vehicular Volume) as shown in Table 5.1. There are a number of items to consider to determine if and when flashing operation is appropriate including:

- Crash analysis during hours of any existing flash operation
- If there is no existing side street detection, then try to implement flash operation during as many hours as appropriate using engineering judgement.
- If there is existing side street detection, then allow the signal to operate in regular mode for as many hours as appropriate using engineering judgement.
- If the major street has significant volume that would make it difficult for minor road traffic to enter the intersection, a flash schedule may not be desirable.
- For signals in residential areas or with evening pedestrian activity, consider delaying the beginning of the flash schedule until at least 10:00 PM, especially for roadways having more than 3 lanes and speeds greater than 35 Mph.
- Consideration should be given to vehicle and pedestrian volume characteristics on the weekend.
- If the major road volume is below 50% of the warranting volumes but the minor road volume is not, consideration of utilizing a flash schedule may be considered if it would allow for a more consistent flash schedule along the corridor.
- Flash operation should generally be avoided in cases when unique intersection characteristics may make it undesirable, such as locations where there are sight distance restrictions.

Table 5-1: Warrant 1 (Minimum Vehicular Volume)

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

[a] *Basic minimum hourly volume.*

[c] *May be used when the major-street speed exceeds 70 km/h or exceeds 40 mph or in an isolated community with a population of less than 10,000.*

For determination of Flash Schedules, MDOT will typically consider left-turn and right-turn lanes as individual lanes for moving traffic. Therefore, if an approach has 1 through lane and 1 left-turn lane, it is considered a 2-lane approach for the purposes of determining flash schedules.

Even though it is allowable for an intersection to be in flash based on the volume criteria, it is generally desirable to keep the entire corridor on the same flash schedule. This may reduce the duration of the flash schedule at some locations. This should not be used to justify putting a signal into flash when it does not meet the 50% of the warranting volumes criteria.

It sometimes is beneficial to provide two schedules such as a corridor where there are a small number of busy intersections that allow for a relatively short flash schedule and the remainder could have a longer flash schedule.

Any locations where the flash schedule is increased beyond the existing should be highlighted so the project manager can verify if the change is acceptable.

- Set all flash schedules beginning at midnight to 00:01 so as not to interfere with a midnight sync pulse or recovery from a power outage.

5.3 MICROSIMULATION

Microsimulation should be conducted using SimTraffic to further evaluate the network performance both before and after optimization. This evaluation should focus on the effectiveness of progression along major corridors and identification of potential storage issues. The following sections document specific procedures to be followed when conducting microsimulation.

5.3.1 *SIMULATION TIMEFRAME*

A full hour of analysis is typically used for all microsimulation analyses, in addition to an adequate period for network seeding. However, duration may be evaluated and determined on a project-by-project basis, as simulation of large networks may become prohibitively long.

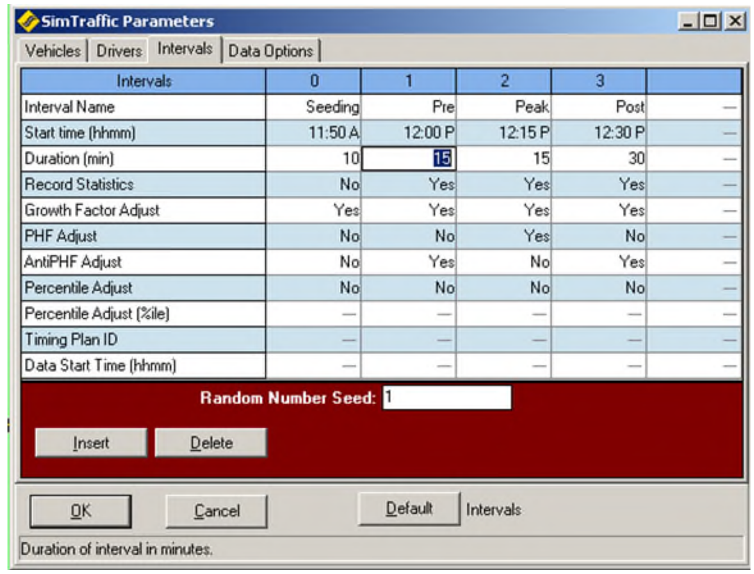
NETWORK SEEDING PERIOD

The network seeding period must at a minimum be long enough for one vehicle to travel from one entry point of the network to the farthest exit point of the network. This length of time should be approximated based on distance, speed limits and consideration of signal density and congestion within the network. No data should be recorded during the seeding interval.

ANALYSIS PERIOD

The analysis hour should reflect fluctuations in traffic flow over an hour period, as represented by the Peak Hour Factor (PHF). The PHF defines the intensity of traffic flow during the peak 15-minutes of the hour period, relative to the remainder of the hour. The location of the peak 15-minute period within the peak hour may vary, even within a single corridor. However, under normal conditions, the peak 15-minute period may be estimated to occur within the middle two 15-minute intervals of the hour.

Figure 5-10: Example SimTraffic Time Interval Setup



In order to reflect this variation in traffic flow over the hour, the analysis hour should be divided into three distinct intervals – a 15-minute pre-peak interval, a peak 15-minute interval, and a 30-minute recovery interval. The PHF should be applied during the peak 15-minute interval only. An anti-PHF (an inverse of the PHF used to reduce volume levels during the off-peak intervals) should be applied during the pre-peak and recovery intervals. Figure 5-10 illustrates this interval set-up.

5.3.2 *CALIBRATION AND VALIDATION*

The SimTraffic model of the existing conditions must be calibrated and validated to actual field conditions before further analysis is conducted. In addition to performing adjustments to the simulation parameters to better reflect nuances experienced in the field, this process serves as an opportunity to validate the accuracy of the SYNCHRO model inputs.

SimTraffic model outputs should be compared against any available and comparable field data to determine the validity of the model results. On a typical project, this would be traffic volumes served. A comparison of actual turning-movement counts that were input into SYNCHRO and the SimTraffic model results can be done using the SimTraffic VOLUME EXITED report. This report should be conducted to assure that the actual volume levels observed in the field are being replicated by the SimTraffic model. The greater of ±10 percent or ±20 vehicles is considered a reasonable threshold for model validation. Figure 5-11 illustrates an example report to be included in the final report (see Section 5.4.2). The report shows the volume exited, the volume input, as well as the percent of volume exited. If volume on a certain approach is very low, usually the ±20 vehicle rule will apply.

Once calibrated and validated, any adjusted parameters are stored in a SimTraffic configuration file (extension .sim for SimTraffic version 7). If the SYNCHRO file is modeled in SimTraffic without the appropriate configuration file in the same directory, SimTraffic will use default parameters, thereby negating the calibration and validation process. Therefore, appropriate .st7 files, representing the calibration of existing conditions, should be used when modeling optimized conditions, and should accompany all file transmittals.

Figure 5-11: Sample Model Validation Log

Volume Comparison
AM Existing
7/17/2008

1002: Newport & US-24 Performance by movement

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vehicles Exited	9	55	19	73	67	103	19	533	77	51	341	3
Hourly Exit Rate	9	55	19	73	67	103	19	533	77	51	341	3
Input Volume	11	49	18	69	62	84	18	528	76	59	324	2
% of Volume	82	113	107	106	108	123	104	101	102	86	105	150

1002: Newport & US-24 Performance by movement

Movement	All
Vehicles Exited	1350
Hourly Exit Rate	1350
Input Volume	1300
% of Volume	104

5.3.3 *MEASURES OF EFFECTIVENESS*

SimTraffic Measures of Effectiveness (MOEs) should be collected and evaluated as a means of further assessing the results of the optimization process. The following MOEs should be reviewed during the analysis process, and should be included in the final report (see Section 5.4.2):

- Total Network Delay
- Average Network Speed
- Total Network Travel Time
- Total Network Stops

5.4 DOCUMENTATION

5.4.1 *PROJECT BENEFITS ANALYSIS*

A project benefits analysis should be performed for each project, quantitatively evaluating conditions both before and after the new timings are in place. This analysis will typically require collection of travel time or other data both before and after implementation. Specific procedures, however, will vary by project, and will be determined in conjunction with the MDOT project manager at the beginning of the project.

The benefit analysis can be performed using two different methodologies:

- The preferred method for corridors is to utilize *PC-Travel* data from before- and after-travel time runs. MDOT provides a *Signal Optimization Benefit/Cost Analysis Spreadsheet*. Data from *PC-Travel* reports can be quickly entered into this spreadsheet along with traffic volume information to generate a benefit/cost summary for the project.

- A second benefit analysis can be performed using results from SimTraffic. This method should be used when studying isolated intersections, small groupings of signals (typically 5 or fewer), or any other situation where before or after travel time runs are unavailable. The benefit analysis uses the following MOE's from SimTraffic:

    - Stop Delay (sec/veh)
    - Travel Time (hr)
    - Average Speed (mph)
    - Fuel used (gal)
    - HC Emissions (g)
    - CO Emissions (g)
    - NOx Emissions (g)
    - Vehicles Exited

Several assumptions regarding average values have been made. These values are as follows:

- Average Cost of Fuel: Obtain an average annual fuel cost from a reliable source such as http://www.bls.gov/regions/midwest/news-release/averageenergyprices_detroit.htm and confirm with MDOT Signals Unit

- Average Number of Work days per Year: 250

- Average Vehicle Occupancy: 1.1

- Average Value of Time per Individual: Should be an average based on the Federal Highway Administration (FHWA) publication number FHWA-SA-98-079, "Life-Cycle Cost Analysis in Pavement Design." Currently, MDOT updates these costs yearly using the Consumer Price Index (CPI).

These values should be verified with the MDOT PM prior to completing the analysis. Volume counts for each peak hour should also be input into the analysis.

5.4.2 *PROJECT REPORT*

Each optimization project should include a final report documenting the project process and results, as well as all data collected for the signal timing effort. The following sections describe the required documentation.

MEASURES OF EFFECTIVENESS DOCUMENTATION

All Measures of Effectiveness (MOEs) should be summarized in a tabular format within the project report for ease of review. The summary of MOEs prepared for the optimization analysis should include a comparison between existing and optimized conditions results. Following are sample formats for MOE summary tables:

Table 5-2: Comparison of Optimized and Existing Intersection Operations - Zone 1, PM Peak Hour

Intersection	Existing Condition		Optimized Condition		Change (sec/veh)
	Delay (sec/veh)	**LOS**	**Delay (sec/veh)**	**LOS**	
Main Street/Elm Street	47.6	D	41.3	D	**-6.3**
Main Street/Walnut Street	**24.9**	**C**	**18.2**	**B**	**-6.7**

Source: SYNCHRO

Table 5-3: Comparison of Optimized and Existing Network Operations - Zone 1, PM Peak Hour

MOE	Existing Condition	Optimized Condition	Change (%)
Total Delay (hours)	370	320	**-14%**
Total Stops	15000	13000	**-13%**
Total Travel Time (hours)	600	500	**-17%**
Average Speed (mph)	27	34	**+26%**

Source: SimTraffic

REPORT ORGANIZATION

Optimization project reports should generally be organized into the following sections:

Project Summary

The first page of the report should provide a one-page summary table detailing pertinent project scope and results information. The summary should include the following information:

SIGNAL OPTIMIZATION PROJECT SUMMARY				
MDOT Job Number		**JN 50000C**		
Route Number and Name		**M-1000 Elm Avenue**		
Control Section(s)		**CS 90000**		
Location (City/Township, County)		**Anywhere Twp, Michigan County**		
Project Limits (Cross-Streets)		**Main Street to Oak Street**		
Project Limits (Mileposts)		**10.2 to 16.7**		
Field Study Results		**AM Peak**	**Mid-Day**	**PM Peak**
Travel Time Reduced by (minutes):	Northbound	1.2	0.4	**2.2**
	Southbound	1.0	0.1	**3.1**
Stopped Time Reduced by (minutes):	Northbound	0.8	0.2	**1.6**
	Southbound	0.6	0.2	**2.7**
Speed Increased by (mph):	Northbound	5.0	2.0	**6.0**
	Southbound	4.0	1.0	**5.0**
Daily Vehicle-Hours of Travel Reduced by:		500	***Vehicle-Hours***	
Daily Fuel Consumption Reduced by:		300	***Gallons***	
Daily Pollutant Emissions Reduced by:		1000	***Pounds VOC, NOx***	
Daily Time and Fuel Savings:		$1,400	***Dollars***	
Annual Time and Fuel Savings:		$350,000	***Dollars***	
Project Cost:		$100,000	***Dollars***	
Funding Source:		**CMAQ**		
Average Daily Traffic:		20,000	***Vehicles per Day***	
Annual Benefit/Cost Ratio:		**3.5**		

If the project incorporates multiple corridors, a summary for the entire project should be incorporated. The Field Study Results would not be listed. The summary for the individual corridors should be included in an appendix separate for each corridor.

Table of Contents

Following the Project Summary, provide a table of contents detailing page numbers of report sections, tables and figures.

1.0 Introduction

The Introduction section should include a brief description of the project area, including a map, and a list of intersections included in the analysis.

2.0 Data Collection

The Data Collection section should include a description of the data collected, including dates. Any unusual circumstances surrounding the data collection effort should be identified, such as construction, weather conditions, etc.

3.0 Existing Operations Analysis

The Existing Operations Analysis section should document the following:

- SYNCHRO analysis results in tabular form
- The SimTraffic model calibration and validation process
- SimTraffic analysis reports in tabular form

4.0 Crash Analysis

The Crash Analysis section should identify critical crash locations and discernable crash patterns at critical locations.

5.0 Optimization Analysis

The Optimization Analysis and Results section should document the following:

- A brief description of the optimization process, including cycle length selection (Maps should be provided in cases where multiple cycle lengths are employed during the same time period).
- Discussion of any proposed phasing modifications
- SYNCHRO analysis results in tabular form
- SimTraffic analysis results in tabular form

7.0 Project Implementation and Benefits

The Project Implementation and Benefits section should document the following:

- A discussion of the implementation process, including field review and necessary timing modifications.
- Project benefits analysis summary that includes a comparison of before and after travel time runs.
- Identification of any items for consideration that were mitigated (or may potentially be mitigated) as a result of this project.

8.0 Items for Further Consideration

Include any recommendations to further improve operations or safety, including equipment upgrades, geometric or striping reconfiguration, addition or deletion of signal phases, removal of signals due to lack of warrant, or other modifications. Also make a note where further study would be required to determine the exact scope or effectiveness of potential improvements.

Potential items to identify for improvement may include:

- Operations and safety, i.e. signal timing/phasing, turn restrictions, lane assignment, adjacent parking.
- Geometry that impacts both traffic operations and safety, i.e. lane geometry, sight distance issues, offset vehicle paths.

NOTE: An advanced submittal regarding items for consideration should only be submitted if there is a critical item that needs to be addressed through the retiming of the signal.

Appendix A: Traffic Volume and Travel Time Data

- A sample MDOT formatted traffic volume data submittal and guidelines for the submittal of MDOT formatted traffic volume data is included in Appendix A of this document.

Appendix B: Intersection Inventory and Condition Reports

- A sample inventory form and instructions for data collection are provided in Appendix B of this document.

Appendix C: Timing Permits

Appendix D: SYNCHRO and SimTraffic Reports

- A sample SYNCHRO analysis report format is included in Appendix D of this document, including HCM reports.
  - For models containing two or more coordinated signals, include 90%tile bandwidth and 90%tile flow printouts.
- A sample SimTraffic analysis report format is included in Appendix D of this document.

Appendix E: Project Benefits Analysis Spreadsheet

The report should be prepared in a concise manner, using maps, figures and tables where appropriate to best convey the information.

6 DATA COLLECTION

Data collection includes traffic counts, intersection geometry, speed, and crash data. High quality data is critical to effective traffic signal timing.

Data collection procedures for signal retiming should be documented in a data collection plan, including types of information to be collected, acceptable collection timeframes, and other procedures as required by the specific project.

The data collection processes and procedures presented herein are based on procedures outlined in the *ITE Manual of Transportation Engineering Studies*. The ITE manual should be consulted in the event that additional data collection is required beyond what is outlined in this chapter.

6.1 TRAFFIC COUNTS AND PEAKING CHARACTERISTICS

Peak period, off-peak, and daily traffic counts are all necessary in order to fully understand the traffic characteristics of an intersection. The following presents guidelines for the conduct of these counts, including when and where they are required, and interpretation and processing of the data.

6.1.1 *GENERAL GUIDELINES*

Traffic volume data can vary significantly based on day of the week, and is often highly sensitive to holidays and special events. In order to maintain consistency and to assure counts are reflective of typical conditions, traffic volume data collection should adhere to the following general guidelines:

- Counts should be taken on Tuesdays, Wednesdays and Thursdays only, unless special circumstances require data for another day of the week.
- Counts should not be taken during periods of inclement weather (rain, snow or fog events) that may result in atypical traffic flow conditions.
- Counts should not be taken at any time during a week that includes one of the following holidays:
  - Martin Luther King Jr. Day
  - Presidents Day
  - Good Friday
  - Easter Sunday
  - Memorial Day
  - Independence Day
  - Labor Day
  - Thanksgiving
  - Christmas
  - New Years Eve/Day
- Counts should not be taken on the day of the above holidays or any other national holidays.
- Whenever possible, counts should be taken while schools are in session.

- In tourist areas, the seasonal variation should be discussed with the Project Manager when setting up the data collection schedule.

- Consideration should be given to the two-week summer "shut-down" period observed by major automakers and suppliers in the state. Shut-down may lead to lower than normal traffic volumes in high employment areas, or higher than normal volumes in recreational areas. Depending on the project location, data collection during the shut-down period should be avoided whenever possible.

6.1.2 24-HOUR VOLUME COUNTS

24-hour volume counts provide the basis with which to understand the changes in traffic flow over the course of a typical weekday. They will be used to determine when changes in timing programs should occur throughout the day, and to identify if and when a flash operation is appropriate. The following guidelines should be applied when conducting 24-hour approach counts:

- Counts should be taken at all intersection approaches for a period of two weekdays within a typical Monday through Thursday period.

- Counts should be taken on all approaches at locations that currently operate under flash control at any time or currently operate with a special weekend timing plan for a period of seven (7) days, including all days of the week.

- If an interchange lies within the corridor, machine counts should be taken on the ramps (signalized and unsignalized).

- Counts should be provided in 15 minute intervals.

- Additional counts may be performed at the suggestion of the Engineer as warranted by field conditions.

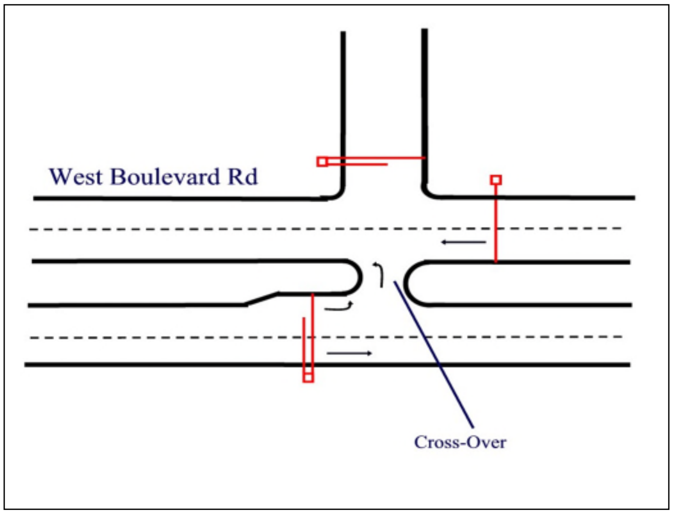
On roadways that utilize directional crossovers, machine counts may be utilized in lieu of manual counts. Recognizing that the timing at crossovers is often a direct reflection of the timing at the nearest major intersection, machine counts can often collect all of the necessary data. A cost savings may be achieved by utilizing machine counts without manual counts at some crossovers. See Figure 6-1 for placement of tube counters.

- Machine counts are typically higher than manual counts since machines count axles not vehicles. As a result, the machine counts and the manual counts should be compared by time period at the primary intersection to determine the variance between them. The machine counts at the crossover should be adjusted accordingly to balance with the main intersection.

- At locations where there is no driveway or minor road coming into the crossover, machine counts will typically provide sufficient data for the analysis. At locations where the crossover turns into a driveway or minor road, a judgment should be made regarding the likelihood that it will control the signal timings or have timings independent of adjacent signals. If likely to control the timings, full manual counts should be taken.

- It is preferable to measure the crossover traffic in the left turn lane as opposed to the crossover itself. Tubes typically count axels and convert the results into the number of vehicles. This is best accomplished by placing the tube at a right angle to the direction of traffic. If placed in the crossover, vehicles may cross at an angle and individual wheels may be counted substantially increasing the measured volume.

Figure 6-1: Tube Counters on Boulevards



6.1.3 *TURNING MOVEMENT COUNTS*

Turning-movement counts should be collected during the following periods, unless special circumstances exist that warrant additional counting periods:

- AM Peak Period: 7:00AM – 9:00AM
- Mid-Day Period: 11:00AM – 1:00PM
- PM Peak Period: 2:00PM – 6:00PM

For the AM and PM peak periods where multiple hours of data are collected, each intersection will have a unique peak hour within the multi-hour count period. To determine which volumes should be used, evaluate the Peak Hour for each intersection and use the volumes that correspond to this hour.

Peak hour factors should be calculated by intersection approach. For example, if the total approach volume (L + T + R) over the study hour is 1000, and the peak 15-minute approach volume (L + T + R) is 300, the peak hour factor applied to all movements for that approach is 1000/(4*300) = 0.83. For Dummy nodes, the PHF should be set based on the average of the upstream and downstream PHF.

Truck counts should be included in the total with the main counts when reporting, even though they have a separate tab on the traffic counts spreadsheet.

6.1.4 *PEDESTRIAN COUNTS*

Pedestrian counts should be included as part of intersection turning movement counts. Pedestrian counts are of particular importance at locations where pedestrian volumes play a significant role in intersection operation. Pedestrian counts should be taken during time periods as the turning-movement counts and recorded in 15 minute increments. Additional notes should be taken if multiple pedestrians are seen crossing in groups.

When reported, pedestrian movements are categorized under the vehicular movement that they are in conflict with. For example, a pedestrian that crosses the south leg of an intersection will be counted as a northbound pedestrian. Similarly, a pedestrian that crosses the east leg is considered a westbound pedestrian

6.2 GAP STUDIES

Gap studies are typically conducted to get a better idea of how vehicles react when faced with an unprotected movement or to determine if pedestrians can safely cross a roadway. In order to make an unprotected movement, vehicles and pedestrians must find a "gap" in the conflicting traffic. Two factors are important in determining if there are enough gaps in traffic:

1. The minimum acceptable gap, otherwise known as the critical gap.
2. The actual gap that is present in opposing traffic.

To measure vehicle gaps in the field, a reference point is selected near the intersection, and the time is recorded every time the front bumper of a car hits that same point. This allows a time in seconds to be calculated between each vehicle. The data is then grouped into bins such that the engineer can see how many gaps were available from 0 to 2 seconds, 2 to 4 seconds, and so on.

If there is an existing or planned pedestrian refuge island in the median, then gaps for pedestrians should be measured for each direction separately, and the critical gaps calculated for each direction separately as required. For pedestrian crossings, Warrant 5 (School Crossing) in the MMUTCD provides guidance on acceptable gaps.

6.3 DELAY/QUEUING

Comprehensive delay and queue measurement is a time consuming and expensive process. A simplified method used by MDOT is as follows:

Every five minutes an observer records how many cars are in the queue and starts the stop watch. When the last car from the queue clears the intersection, the observer stops the watch and records its time. This will provide two sets of data points. The length of the queue in number of vehicles, and the time in seconds it takes for that last vehicle to clear the intersection.

6.4 SPEED STUDIES

Speed is an important factor in determining signal progression. Spot speed studies are the easiest to conduct. They should generally be taken away from intersection approaches so that traffic is free flowing and not impacted by intersection control. There are many ways to measure speed but the most common are radar (or laser) units or pneumatic tubes. Measuring with radar can be accurate, but generally hose counts are preferred as drivers tend to react to an observer with a radar unit by slowing down.

6.5 TRAVEL TIME DATA

While simulation models predict the impacts of optimization, there are often situations where field conditions do not match the predictions. Field reviews including travel time runs are useful to calibrate the existing conditions models and to verify the improvements due to optimized signal timings.

Travel time data will typically be required to support the evaluation of before- and after-conditions. The extent of study and data to be collected will be determined at the beginning of a project in conjunction with the MDOT project manager. Travel time runs should be performed when six or more signals are being coordinated and are no more than 80 seconds travel time apart. Additional corridors may require travel time runs as requested by the MDOT project manager. There are various methods in which travel time data can be collected, including GPS tracking software, Bluetooth/Wi-Fi receivers and detectors, and other software capable of monitoring real-time and historical travel times. All are acceptable methods, however the method used on each project must be approved by the MDOT PM prior to collection. Travel time data collection should follow the procedures outlined in the *ITE Manual of Transportation Engineering Studies*, unless otherwise directed by the MDOT project manager. An average of the data must be obtained per time period (i.e. 5 runs in each direction or multiple times of day for alternative methods).

6.6 INTERSECTION GEOMETRY AND EQUIPMENT

A field inventory of intersection geometry and equipment should be conducted at each study intersection. Whenever possible, MDOT or the maintaining agency will provide available as-built drawings for use in verifying field data. MDOT has developed a standardized inventory form that includes the information required to develop accurate models.

Intersection inventory forms should adhere to a standard naming convention unless otherwise discussed in advance with the MDOT project manager. The following is the standard file naming convention:

Control Section # - Spot # -" Inventory" - Month-Day-Year–Vx.pdf

Example: The Woodward Avenue (M-1) corridor within the city of Detroit (Control Section 82400) is being inventoried. The spot number in this case is 025. The date should be the date the inventory data was collected. If minor updates are made the version number should be updated.

File Name = ***82400-025-Inventory - 01-01-2001-V1.pdf***

6.6.1 *INTERSECTION INVENTORY AND CONDITION FORM*

A sample inventory form is included in Appendix B along with instructions for data collection. In general, the inventory should include the following information:

- Intersection Location and Number
- Street Naming
- Geometry
- Operations
- Equipment
- Signal Phasing
- Intersection Layout Diagram
- General Comments

6.6.2 *INTERSECTION PHOTOGRAPHS*

Photographs of each intersection should be taken to ensure the accuracy of recordings on the Inventory Form and as a source of additional information. The approach photo should be taken from a position where all approach and departure lanes and signal equipment is visible. If this cannot be done with one photo or there are unusual features, additional photos should be taken to capture pertinent data.

Intersection photographs should be taken in all approach directions (If there is a one way road or departing ramp include the opposite approach also) and labeled accordingly in the Approach Direction (Northbound, Southbound, Eastbound, Westbound, etc). When submitting intersection photographs, all photographs for a single intersection should be contained within one file. A PDF form has been developed for consistency. Within the document, photographs are to be labeled with their corresponding directional approach and inserted into the document as follows:

- Major Approach Photographs
- Minor Approach Photographs
- Miscellaneous Approach Photographs

If the intersection is a boulevard take separate photos for both the "near" and "far" approaches. Place the "near" intersection photographs first and the "far" intersection photographs second in the PDF document.

Intersection photographs should adhere to a standard naming convention unless otherwise discussed in advance with the MDOT project manager. The following is the standard file naming convention:

Control Section # - Spot # - "Photo" - Month-Day-Year.pdf

Example: The Woodward Avenue (M-1) corridor within the city of Detroit (Control Section 82400) is being inventoried. The spot number in this case is 025. The date that the photo was taken will also be included in the file name.

File Name = ***82400 – 025 – Photo – 01-01-2008.pdf***

6.7 HEAVY VEHICLE VOLUME

While it is preferable to collect actual heavy vehicle counts, MDOT's Average Daily Traffic (ADT) Map and Commercial Vehicle ADT Map can be used to verify the heavy vehicle counts. Both are available on the MDOT website at ***WWW.MICHIGAN.GOV/MDOT*** under "Reports, Publications, and Specs." A default value of two-percent heavy vehicles should be assumed for other intersection movements where data is not available.

The heavy vehicle percentage (HV%) is typically calculated by approach and not for an individual movement. An exception to this can be made if a particular movement has a higher percentage of truck traffic than the others in the approach (e.g., near the Ambassador Bridge there are certain turning movements that feed into the freeway system and thus have very high truck volumes associated with them).

6.8 BUS BLOCKAGES

Bus blockages can have a measurable impact on intersection performance along corridors with high transit use. A number of bus blockages per hour should be determined or estimated at intersections with bus stops in the near upstream or downstream vicinity. Local transit providers should be contacted when possible to determine bus routing and headways during analysis hours.

6.9 PARKING MANEUVERS

Parking maneuvers adjacent to the travel lanes should be estimated based on number of spaces, nearby land use composition, and parking time and duration restrictions (where applicable). A default of 10 maneuvers/hour should be assumed under typical conditions with an adjacent parking lane.

6.10 CRASH DATA

Crash data, if available, should be collected for study intersections in order to identify any crash patterns that may be correctable through signal timing or equipment modifications. While most data will be available through MDOT, the assistance of local agencies may be required in some cases. Crash data should be obtained for the last three consecutive years of complete crash data. Locations where fatal crashes have occurred may justify additional years of analysis and should be verified with the MDOT project manager.

It will be at the discretion of the MDOT project manager to determine whether a crash analysis is warranted and should be conducted.

7 TIMING PLAN PREPARATION

Modern traffic signal controllers are capable of a wide variety of operations and functions. The core of a timing plan is clearance intervals, cycle lengths, splits, offsets and time of day schedule, but there are a variety of other entries that impact the resulting timings sometimes in subtle and other times dramatic ways. While many controller entries can be left with default values, there are many entries that need to be determined in order for the timings to operate as intended.

The vast majority of traffic signal controllers in Michigan until 2021 have been Siemens EPIC (**E**agle **P**roducts **I**nterval **C**ontroller) and EPAC (**E**agle **P**roducts **A**ctuated **C**ontroller) controllers. The major exceptions were:

- Oakland County: many signals operating under SCATS (Sydney Coordinated Adaptive Traffic System) controllers.
- Macomb County: many signals will be operating under D4 controllers.
- There are some older EF-140 controllers still in use. They are an older version of an EPIC controller with key limitations which must be accounted for when developing the timing permit.

Going forward, new controllers will typically be National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) compatible. These controllers will be manufactured by various developers including but not limited to Siemens and Econolite.

There are separate timing permit forms for NTCIP, EPAC, and EPIC/EF-140 controllers that contain the pertinent information to run timing plans. Occasionally, entries not on the permit will be needed and those should be noted in the remarks section of the permit. Alternative signal systems such as SCATS can generally be coded on the NTCIP or EPAC timing permit form, though it is important to highlight the controller type and entries should be verified with MDOT to ensure they are consistent with the individual controller operations.

A timing permit should be prepared documenting the timing parameters to be entered into a controller. MDOT maintains timing permit forms for NTCIP compatible, EPAC, and EPIC/EF-140 controller types in fillable PDF format. Sample forms are included in Appendix B.

Timing permits should be prepared in accordance with these *Guidelines,* which documents procedures for completing timing permits. Timing permit files should be named with the control section spot number and the prepared by date.

Timing Permit File Name = 55555-01-555_05-29-08.pdf

The rest of this chapter focuses on the different timing permit forms used by MDOT and describing the various fields on each of these forms.

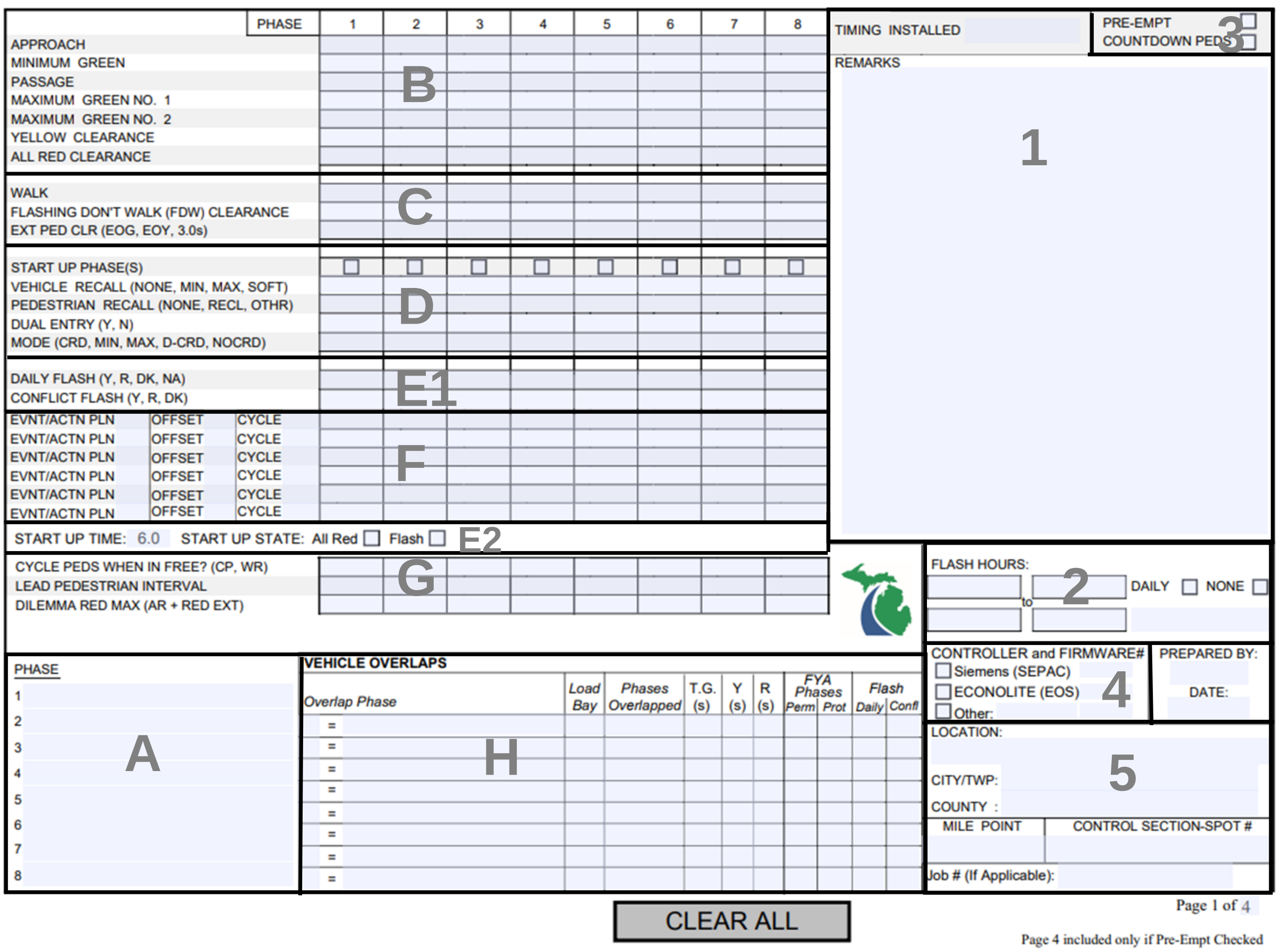
7.1 NTCIP TRAFFIC SIGNAL TIMING PERMIT FORM

The ***NTCIP PERMIT*** consists of four pages which are each independently detailed in the following four sub-sections. Additionally, the ***NTCIP TIMING PARAMETERS*** spreadsheet may be used as a quick reference tool as it details the possible inputs and descriptions.

7.1.1 *BASIC NTCIP TIMING PARAMETERS*

Figure 7-1 illustrates the basic parameters for the NTCIP Traffic Signal. A description of each section (A – H) of the signal timing permit and how to properly complete each section is provided in the text that follows. All of the general information (1-5) is presented under Section 4 Standard Information: Page 1. The ranges and increments for the timed values entered into the timing permit are provided in Table 7-1.

Figure 7-1: NTCIP Timing Permit



SECTION A – PHASE DESCRIPTION

Section A lists the phases that are utilized for the timing plan. The eight phases typically correspond to the standard eight phases used in a NEMA dual-ring controller. Unless a new controller is being installed as part of the project, the phase numbering should not be changed. Should more than the eight phases provided on the permit be needed, a second sheet should be attached. The second sheet should note in the Remarks Section that phase one of that sheet is actually phase nine.

SECTION B – BASIC VEHICLE TIMINGS

Section B is where much of the basic data is entered for the signal. This information provides basic assumptions the controller uses when determining interval times. Some data such as the Maximums are required in case the signal is operating as a free actuated signal with no dial information, or if for some reason the dial information is lost.

The phases one through eight listed along the top row of Section B correspond to the eight phases listed in Section A.

- ***APPROACH*** – An abbreviated description of the corresponding information from Section A.
- ***MINIMUM GREEN*** – The minimum amount of initial green time, in seconds, that must be given to each phase in use. This value must be a whole number, and the MDOT minimum is 10 seconds for the major road, 7 seconds for the minor road/cross street and all non-actuated left-turn phases. For actuated left-turn phases, 7 seconds is the minimum green for protected-only left-turn phasing, and 5 seconds for all permitted-protected left-turn phasing. A minimum vehicle recall will always be set for actuated permitted-protected left-turn phasing where a flashing red is used. Locations with a "doghouse" or a flashing yellow left turn indication do not require the minimum vehicle recall for permitted-protected left-turn phasing. 5 seconds may be used for a non-actuated and/or protected-only left-turn phase with MDOT approval. This would be considered when the left-turn volume is extremely low and the additional 2 seconds taken from the left-turn would provide a significant benefit to the other phases of the signal.
- ***PASSAGE*** – The extended portion of the green time for an actuated approach is a function of vehicle actuations that occur after the minimum green is served. The phase remains green after the minimum green has been served until no additional calls are received and the passage timer has timed out, or until the maximum green time is reached. The passage timer is reset with each subsequent vehicle actuation and begins timing again when the actuation is removed. The typical passage time is 3.0 seconds.
    - *While uncommon, it is possible for an actuated phase to have a passage time equal to zero. This is sometime used where there are multiple lanes of detection for an approach or a particularly long detection zone. Unusual operations such as this should be noted in the remarks section.*
- ***MAXIMUM GREEN NO. 1*** – The maximum length of time this phase may be held green in the presence of a serviceable conflicting call. In the absence of a serviceable conflicting call, the maximum green timer is held reset. The value is to be entered in whole seconds and typically matches the highest split entered in Section F for that particular phase.

- ***MAXIMUM GREEN NO. 2*** – This time setting serves the same function as *MAXIMUM NO. 1.* This is most commonly used at intersections that run free where the volumes change significantly over the course of a day and require different maximum times at different times of the day. To achieve this, MAXIMUM NO. 2 can be designated to run at certain times of the day.
  - There are 3 additional Maximum times available, but they are very rarely used as they require special programming techniques in the controller*.* The *MAXIMUM NO.2* data is typically left with a default value of zero entered.
- ***YELLOW CHANGE*** – The yellow change interval time for each phase. The value is entered in seconds in 0.1 second increments. Per MDOT policy, the yellow change interval must be at least 3.0 seconds. The typical range is 3.0 to 6.0 seconds. Yellow change intervals greater than 6.0 seconds may be used with MDOT approval.
- ***ALL RED CLEARANCE*** – The all-red clearance interval time for each phase. The value is entered in seconds in 0.1 second increments. Per MDOT policy, the red clearance interval must be at least 1.0 second. The typical range is from 1.5 to 4.0 seconds. Red clearance intervals greater than 4.0 seconds may be used with MDOT approval. Situations that may require longer all red times include locations with a trail green, single-point urban interchanges, and diverging diamond interchanges.

SECTION C – PEDESTRIAN TIMING

Pedestrian timing data is entered in Section C. The *WALK* time, *FLASHING DON'T' WALK CLEARANCE* time, and *EXTENDED PEDESTRIAN CLEARANCE* are entered here for each phase.

- ***WALK*** – The minimum time, in seconds, that the walk display must be displayed for this phase. The value must be entered in whole seconds. Per MDOT policy, the typical minimum *WALK* time is 7.0 seconds. A minimum *WALK* time of 4.0 seconds may be used, where deemed appropriate based on pedestrian characteristics, volumes, and timing requirements, with approval of MDOT. In some situations, the minimum walk time will be greater than 7.0 seconds (see Section 4.3.2)
- ***FLASHING DON'T WALK CLEARANCE*** – The time in seconds that the "Flash Don't Walk" indication, is displayed during each phase. This value must be entered in whole seconds. This is different from the calculated pedestrian clearance which includes a buffer interval after the Flash Don't Walk.
- ***EXTENDED PED. CLEARANCE*** – Defines when the Flash Don't Walk indication terminates. The *EXTENDED PED. CLEARANCE* entries are as follows:
  - EOG = The pedestrian clearance only flashes thru green.
  - EOY = The pedestrian clearance flashes thru yellow.
  - 3.0s = The pedestrian clearance flashes to exactly 3.0 seconds before the end of the All Red. This is the preferred entry.

SECTION D – INITIALIZATION AND ACTUATION

This section contains the information for *START UP PHASE(S), VEHICLE RECALL*, *PEDESTRIAN RECALL, DUAL ENTRY,* and *MODE.*

- ***START UP PHASE(S)*** – Check the mainline thru phases that start in green after the initialization process.

- ***VEHICLE RECALL*** – This row defines the *VEHICLE RECALL* mode for each phase previously defined in Section A. The *VEHICLE RECALL* entries are as follows:

    - NONE = Fully Actuated Phase
    - MIN = Actuated with Minimum Green
    - MAX = Maximum Green (not actuated)
    - SOFT = "Soft Recall" recalls a phase if no calls are being made.
    - OTHR = other to be described in the REMARKS Section 1

- ***PEDESTRIAN RECALL*** – This row defines the *PEDESTRIAN RECALL* mode for each phase previously defined in Section A. The *PEDESTRIAN RECALL* entries are as follows:

    - NONE = pedestrian push buttons are present, or no pedestrian signals are provided.
    - RECL = pedestrian signals are provided, but no pedestrian push buttons are present.
    - OTHR = other to be described in the REMARKS Section 1

- ***DUAL ENTRY*** – *DUAL ENTRY* is a mode of operation (in multiple ring controllers) in which one phase in each ring must be in service, subject to compatibility, at all times. If a call does not exist in a ring when it is committed to cross a barrier, a phase is selected in that ring to be activated by the controller unit that will be compatible. *DUAL ENTRY* is entered either as "Y" for yes, or "N" for no. A NO represents *SINGLE ENTRY*. *SINGLE ENTRY* is a mode of operation (in multiple ring controllers) in which a phase in one ring can be selected and timed alone if there is no demand for service in a non-conflicting phase in a parallel ring.

Minor St thru phases are typically entered as Dual entry, all left turn phases are typically entered as Single entry.

- ***MODE*** – This row represents the *Phase Mode* for each respective phase defined in Section A. The phase mode combines with the *VEHICLE* and *PEDESTRIAN RECALL* codes entered in Section D. The controller may be capable of having different Mode settings for each Dial-Split combination, but typically the mode will be the same for all time periods. The Phase Mode entries are as follows:

    - CRD = will operate as the Coordinated Phase for the ring. The trunkline thru movement will typically be set as the coordinated phase.

- MIN = will operate as the actuated phase with a Minimum Recall.
- MAX = will operate as an actuated phase with a Maximum Recall.
- D-CRD = will operate as the Dual Coordinated phase for the ring. Dual coordination should not be used with actuated operations unless the intent is to provide coordination for the crossroad in addition to the trunkline. For consistency, if the controller is running fixed time, set the side road mode to dual coordination (code = 7).
- NOCRD = will operate as a non-coordinated phase.

SECTION E (E1&E2) – DAILY FLASH, CONFLICT FLASH, START UP TIME AND START UP STATE

The *DAILY FLASH, CONFLICT FLASH, START UP TIME, and START UP STATE* information are entered in these areas. This section is a supplement to the Flash Hours entered in the Standard Information Section 2.

- ***DAILY FLASH*** – If there is no flash schedule, enter "NA" for Not Applicable. If the signal flashes daily, enter "Y" for Yellow, "R" for Red, or "DK" for Dark.
- ***CONFLICT FLASH*** – Enter conflict flash information as follows: "Y" for Yellow, "R" for Red, or "DK" for Dark.
- ***START UP TIME*** – The standard start up period to transition to regular operations is 6 seconds.
- ***START UP STATE*** – Conflict flash state determines start up state. Check "All Red" if conflict flash state for all phases and overlaps is either R or DK. Check "Flash" if yellow flash is used in conflict.

SECTION F – EVENT/ACTION PLAN SET-UP

Section F is the Event/Action Plan Set-Up section. It establishes the cycle lengths, splits, and offsets for the Event/Action Plan. Event/Action Plan numbering fitting with MDOT standard assignment is entered in the left most box of Section F. Under typical conditions, MDOT's standard convention is to use Event/Action Plan 1 for normal "off-peak" operation, Event/Action Plan 2 for the AM peak period, and Event/Action Plan 3 for the PM peak period. However, assignment of dials may vary depending on maintaining agency and should therefore be determined in advance of preparing a timing permit. If needed, additional dial and split information can be entered on page 2 (see Section 7.1.2).

- ***OFFSETS*** – The offsets, in seconds, for each Event/Action Plan in operation are entered in the second column of Section F.
- ***CYCLE*** – The cycle length, in seconds, for each Event/Action Plan in operation are entered in the third column of Section F.
- ***PHASE TIME*** – The phase time for each phase is entered for each Event/Action Plan in operation. The phase time includes the green time, yellow time, and all-red time for that phase. Phase time data supersedes the values entered in *MAXIMUM GREEN NO.1* and *NO.2*. The Phase Times are often referred to as Splits.

SECTION G – LESS FREQUENTLY USED FEATURES

Less frequently used features are entered in Section G. These features include *CYCLE PEDS WHEN FREE?*, *LEAD PEDESTRIAN INTERVAL*, and *DILEMMA RED MAX*. It is acceptable to leave these blank on permits where they don't apply.

- ***CYCLE PEDS WHEN FREE?*** – This entry is applicable only for signals that are running in Free Mode with peds but no pushbuttons with the major street phase. Enter "Y" for pedestrian signals that cycle in Free Mode, and enter "N" for pedestrian signals that do not cycle in Free Mode. Cycling peds allows a side street call to be serviced more quickly. Not cycling peds will result in a side street call being serviced less quickly. Typically cycle peds if FDW time is approximately 20 seconds or greater.

- ***LEAD PEDESTRIAN INTERVAL*** – This entry is the number of seconds before starting the phase vehicles in order to allow pedestrians to establish a presence in the street. This value is typically 3.0 to 5.0 seconds.

- ***DILEMMA RED MAX*** – This entry is for dilemma zone mitigation. This is the All-Red time plus the length in time to extend the red clearance based on a late vehicle detection. This value is typically equal to Phase AR time + 5.0 seconds.

SECTION H – VEHICLE OVERLAPS

Section H contains the *VEHICLE OVERLAP* information. Overlaps are similar to phases except they are set up to specifically run concurrently with other phases.

- ***OVERLAP PHASE*** – The letter and description of the *Overlap Phase* is entered in the first column.

- ***LOAD BAY*** – The load switch position that it is associated with is entered in the next column. This will be on the existing timing permit or it must be obtained from the controller cabinet.

- ***PHASES OVERLAPPED*** – The phases overlapped are entered in the third column. The phase numbers entered in the *Phases Overlapped* section should correspond to the phases entered in Section A.

- ***T.G.*** – Trail Green in seconds. This is typically used to clear the space between two sets of signal indications (one near and one far) servicing the same approaches of a median-divided roadway or other offset intersection. Details for determining this time are found in Section 4.1.3.

    - For locations with a trail green, set the near signal's all-red equal to the calculated all-red plus the trail green value (this will typically exceed 2.5 seconds). The splits entered in Section F should add up to the cycle length and not be adjusted for the trail green (i.e. do not subtract the trail green from the split times).

- ***Y & R*** – The Yellow and All-Red times typically correspond to the values calculated for the associated phases.

- ***FYA PHASES*** – This entry is used for a Flashing Yellow Arrow operation. Indicate the permissive and protected phase numbers in their respective column. Leave blank the "Phases Overlapped", "T.G.", "Y", and "R" columns.

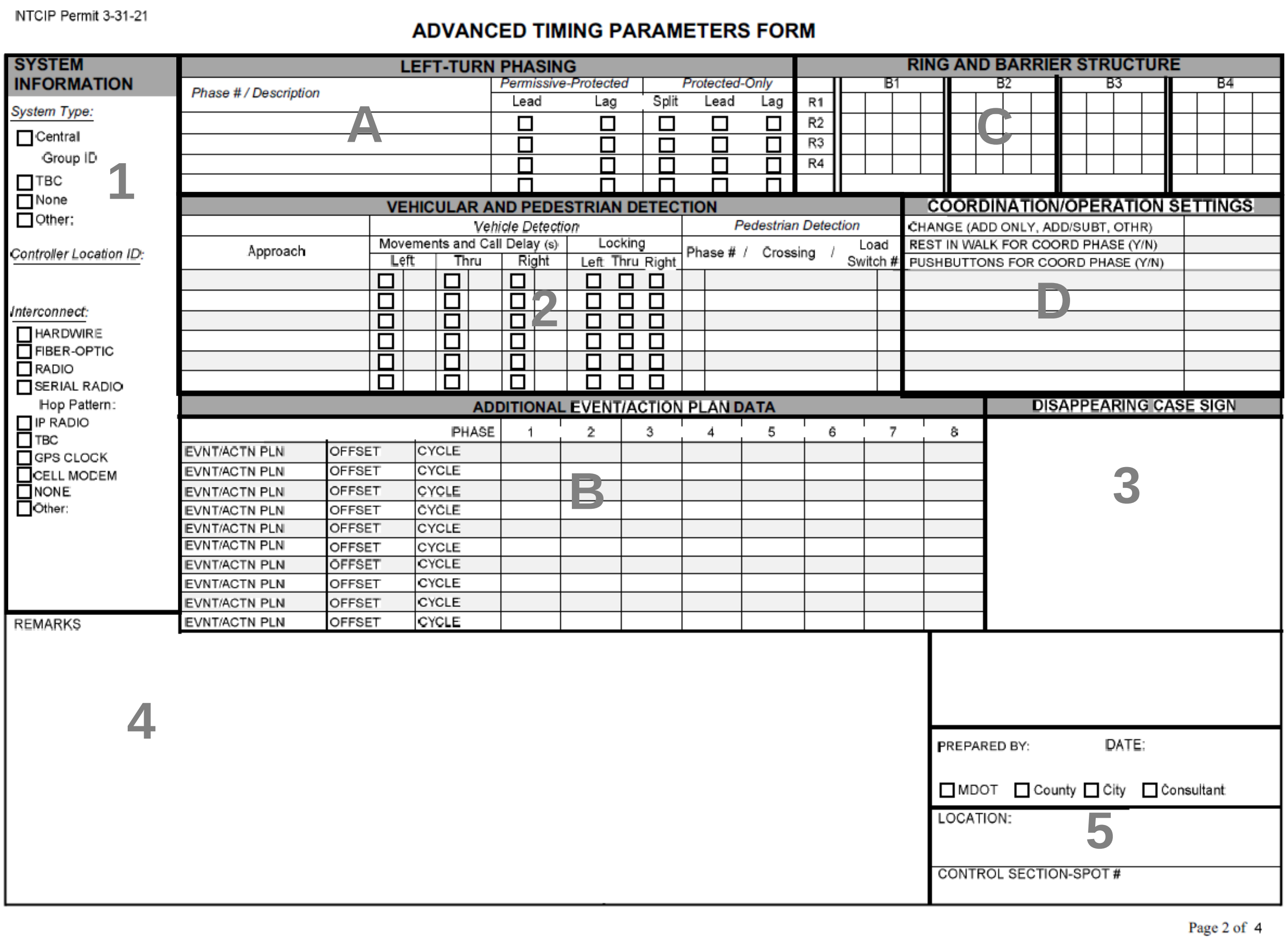
- ***FLASH*** – This entry is used to indicate the daily and/or conflict flash for the overlap phase. For entry information, refer to Section E – Daily Flash and Conflict Flash.

7.1.2 *ADVANCED TIMING PARAMETERS FORM – NTCIP PERMIT*

The Advanced Timing Parameters form (page 2) provides the system data and signal operation parameters. This form should accompany the signal timing permit form on all occasions.

Figure 7-2 illustrates a sample Advanced Timing Parameters form. A description of each section (A – D) of the Advanced Timing Parameters form and how to properly fill in these sections is provided in the text that follows. All of the general information (1-5) is presented under 7.5 Standard Information: Page 2.

Figure 7-2: Advanced Timing Parameters Form (NTCIP)



SECTION A – LEFT-TURN PHASING

The *LEFT-TURN PHASING* information is entered in Section A. The left-turn *Phase # / Phase Description* information as well as *Permissive-Protected* and *Protected Only* information are entered in this section.

- ***Phase # / Phase Description*** – The left-turn phase number, followed by a description of the phase are entered in this area. This information must match the left-turn information found in Section A of the *Basic NTCIP Timing Parameters*.

- ***Permissive-Protected and Protected-Only Phasing*** – In this section, the left-turn operation should be defined as either a “leading,” “lagging,” or “split” phase (relative to the parallel through movement), and whether permissive left-turns are allowed during the companion through phase. Only one box should be checked for each phase.

- *Note*: If a lagging left-turn phase is selected, the electrician will input an "alt sequence" into the controller. Do not reverse the phase sequence in the Ring and Barrier Structure if lagging left turn phase has already been selected

SECTION B – ADDITIONAL DIAL SPLIT DATA

Additional Dial Split Data may be entered on page 2. Refer to Section 7.1.1 (Section F) of the *Basic NTCIP Timing Parameters* for more detail.

SECTION C – RING AND BARRIER STRUCTURE

The *RING and BARRIER STRUCTURE* entered in Section C defines and illustrates the phase operations of a controller.

- A *Ring* is a series of conflicting phases that occur in an established order and never at the same time.
- A *Barrier* is a compatibility line in the sequence of a multi-ring controller that interlocks the *Rings*. A *Barrier* assures there will be no concurrent selection and timing of conflicting phases for traffic movements in different *Rings*. All *Rings* cross the *barrier* simultaneously to select and time phases on the other side.

Section C is set up with four *Barriers* and four *Rings* (the current constraints of an NTCIP controller). The phase numbers should be entered in their corresponding areas and match the phases identified in Section A of the *Basic NTCIP Timing Parameters.*

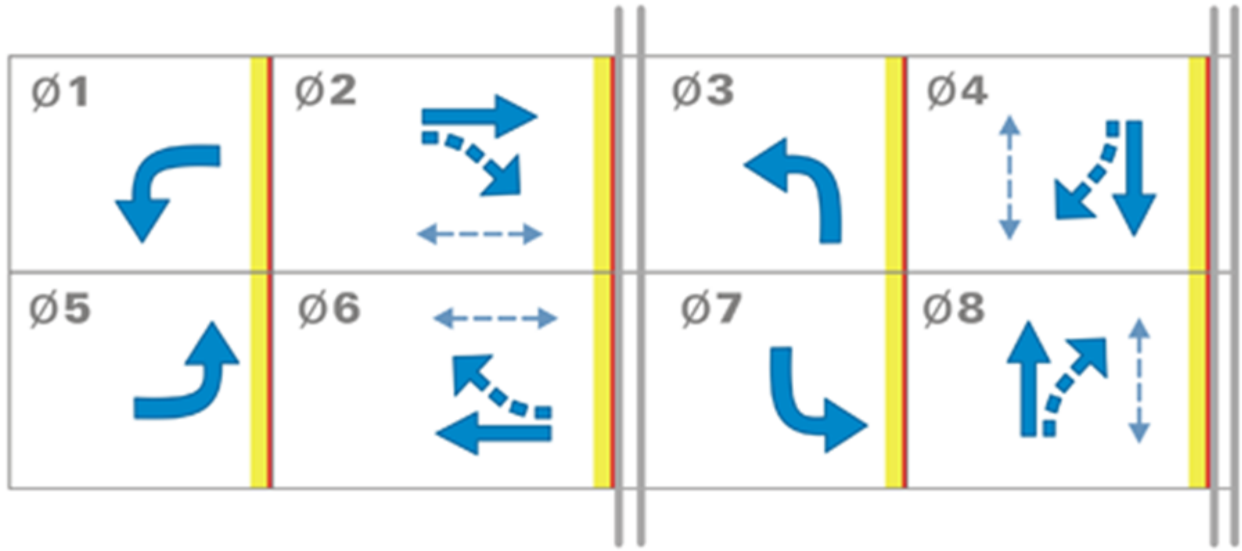
Typically, an eight-phase dual-ring controller is utilized in the field. Figure 7-3 illustrates this controller configuration based on the National Electrical Manufacturers Association (NEMA) standard, which is as follows:

- Phases 2 and 6 are the main street through movements
- Phases 1 and 5 are the main street left-turn movements
- Phases 4 and 8 are the minor street through movements
- Phases 3 and 7 are the minor street left-turn movements

MDOT standard practice is to first apply phase 2 to a main street approach, using the main street's NB or EB approach if there is one, and sequence the remaining phases in a clockwise manor. The two most common phase 1-8 configurations will be 1-WBL, 2-EBT, 3-NBL, 4-SBT, 5-EBL, 6-WBT, 7-SBL, 8-NBT and 1-SBL, 2-NBT, 3-WBL, 4-EBT, 5-NBL, 6-SBT, 7-EBL, 8-WBT. Four boxes are provided in each *Ring* per *Barrier* for more complicated and non-standard phasing schemes, such as split-phasing or sequential phasing.

When filling out the *Advanced Timing Parameters Form* for new signal installations, the NEMA standard should be adhered to whenever possible when filling out the ring and barrier structure

Figure 7-3: Dual-Ring Controller (NEMA Standard)



SECTION D – COORDINATION DATA

This section provides information for *COORDINATION/OPERATION SETTINGS*. The values will typically need to be obtained from the controller.

- ***CHANGE* –** The Change Setting establishes how the controller corrects to get to the offset. If at any time the offset for the signal does not match the offset programmed, the Change setting determines how the signal will adjust the timing in order to move the offset to the programmed value. It will not violate the minimum times. The offset may be off for a variety of common reasons (When the signal changes timing plans throughout the day, when it comes out of night time flash mode, when an actuation calls for a phase length longer than the regular phase split, etc.). The Change settings may have various names and minor controller specific differences that put them into the following three categories:
    - ADD ONLY = allows the signal to find its coordination point only through the use of extending green lengths, and therefore phase lengths, on one or more phases. This entry is often used when programmed splits are relatively short with green times near the minimum values such that not much time can be subtracted each cycle from correcting phases.
    - ADD/SUBT = sometimes referred to as short way, but may be called different names by different controller types. ADD/SUBT correction allows the signal to either add or subtract green time to or from acceptable phases as defined by controller specific parameters in order to reach the programmed offset as quickly as it is able.
    - OTHR = use this entry if a Change setting not clearly identified by one of the explicitly listed labels is used. Explain the setting in the Remarks Section.

- ***REST IN WALK FOR COORD PHASE*** – This entry is applicable only for signals that are running coordinated. For intersections that are coordinated, the signal can dwell in *WALK* at the end of the *WALK* timing when there is no serviceable conflicting call. Enter "Y" for yes, coordinated phase will rest in walk, meaning FDW will not come on until a conflicting call comes in. Enter "N" for no, coordinated phase will not rest in walk, meaning there will be an automatic transition from walk; therefore, walk must cycle or be actuated.

- ***PUSHBUTTONS FOR COORD PHASE*** – This entry is applicable only for signals that are running coordinated. Enter "Y" for yes, pushbuttons are present for the coordinated phase. Enter "N" for no, pushbuttons are not present for the coordinated phase.

- ***OTHER COORDINATION FIELDS*** – Default values need not be called out on the permit. Use for site specific settings (e.g. start of yellow offset, transition %, and slack time distribution). Describe settings in the Remarks section on page 2 as needed.

7.1.3 *SCHEDULING INFORMATION – NTCIP PERMIT*

The Scheduling Information form (page 3) should accompany the signal timing permit form on all occasions. Figure 7-4 illustrates a sample Advanced Timing Parameters form. A description of each section (A – C) of the Scheduling Information form and how to properly fill in these sections is provided in the text that follows.

Figure 7-4: Scheduling Information Form (NTCIP)

NTCIP Permit 3-31-21

SCHEDULING INFORMATION

Typical Schedule

Schedule #	Days of Week	Start Date	End Date	Day Plan #	Events
1	Saturday and Sunday	January 1st	December 31st	1	#1 - NORMAL 06:00-23:00 #4 - 00:00-06:00; 23:00-24:00
2	Monday thru Friday	January 1st	December 31st	2	#1 - NORMAL 00:00-06:00; 10:00-14:00; 18:00-24:00 #2 - AM PEAK 06:00-10:00 #3 - PM PEAK 14:00-18:00
3	A			3	
4				4	

Special Schedules — Schedule remarks including floating holiday schedules

Day Plan #	Events	Day Plan #	Events	Day Plan #	Events	Day Plan #	Events
5	B	6		7		8	

Schedule	Day Plan #	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D	DAY OF WEEK S	M	T	W	T	F	S	DAY OF MONTH 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	REMARKS : dfdsf
11																																																				
12						C																																														
13																																																				
14																																																				
15																																																				
16																																																				
17																																																				
18																																																				
19																																																				
20																																																				
21																																																				
22																																																				
23																																																				
24																																																				

PREPARED BY:	DATE:	LOCATION:	CONTROL SECTION-SPOT #

Page 3 of 4

SECTION A – TYPICAL SCHEDULE

Section A provides space for four schedules and their associated day plans, which should cover the typical schedules for most. The first two rows in Section A of Figure 7-4 have been filled out as an example. As shown, this information consists of six columns detailing *Schedule #, Days of Week, Start Date, End Date, Day Plan #,* and *Events.* The Event # corresponds to the EVNT/ACTN PLN # provided on page 1 as detailed in Section F in 7.1.1 Basic NTCIP Timing Parameters.

SECTION B – SPECIAL SCHEDULES

Section B provides space for four additional day plans. If additional day plans are needed, use remarks or additional Scheduling pages. Each day plan will have a specific set of events/action plans associated with it.

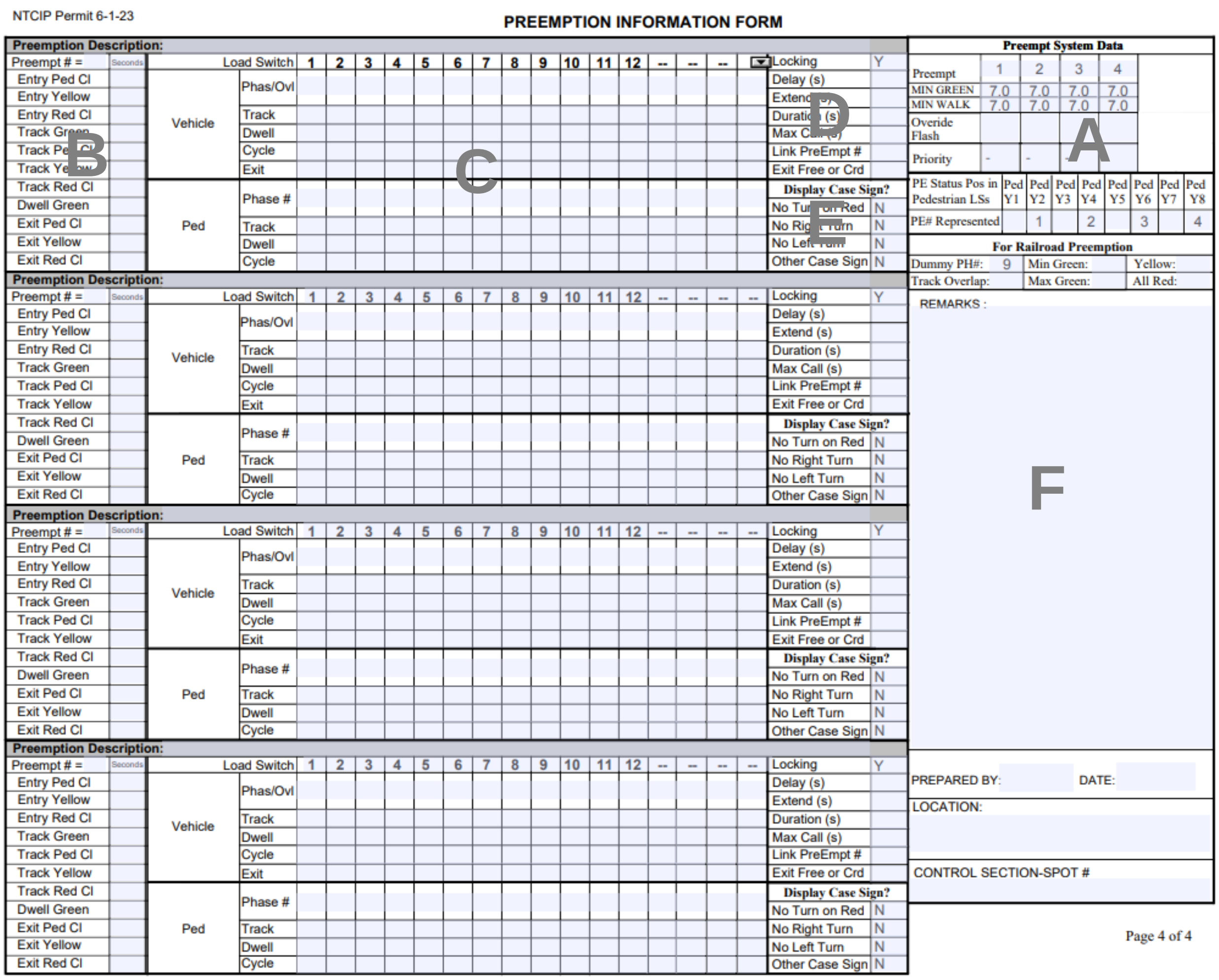
SECTION C – SPECIAL SCHEDULES GRID

Section C provides a grid that allows for identification of specific days of the month or days of each week within any month. In the special schedule grid, next to the appropriate schedule number indicate the Day Plan to be run and X mark the months, days of the week, and specific days of the month that it may run. Day plans will not run during any month, any day of the week, or any day of the month that is not checked. Day plans will be frequently associated with multiple schedules, either out of necessity or clarity of design intent. Schedule numbers for special schedules start at 11 to avoid confusion between typical schedules and special schedules.

7.1.4 *PREEMPTION INFORMATION FORM – NTCIP PERMIT*

PREEMPTION INFORMATION is entered on page 4 of the timing permit (see Figure 7-5). This page only needs to be included if preemption information exists. Four preemption plans may be entered on this form. If additional preemption plans are needed an additional sheet may be attached.

Figure 7-5: NTCIP Preemption Information Form



NTCIP Permit 6-1-23

PREEMPTION INFORMATION FORM

Preemption Description: (four identical blocks)

Preempt # =	Seconds		Load Switch	1	2	3	4	5	6	7	8	9	10	11	12	--	--	--	--	Locking	Y
Entry Ped Cl		Vehicle	Phas/Ovl																	Delay (s)	
Entry Yellow																				Extend (s)	
Entry Red Cl			Track																	Duration (s)	
Track Green			Dwell																	Max Call (s)	
Track Ped Cl			Cycle																	Link PreEmpt #	
Track Yellow			Exit																	Exit Free or Crd	
Track Red Cl		Ped	Phase #																	Display Case Sign?	
Dwell Green																				No Turn on Red	N
Exit Ped Cl			Track																	No Right Turn	N
Exit Yellow			Dwell																	No Left Turn	N
Exit Red Cl			Cycle																	Other Case Sign	N

Preempt System Data

Preempt	1	2	3	4
MIN GREEN	7.0	7.0	7.0	7.0
MIN WALK	7.0	7.0	7.0	7.0
Overide Flash				
Priority	-	-	-	

PE Status Pos in Pedestrian LSs	Ped Y1	Ped Y2	Ped Y3	Ped Y4	Ped Y5	Ped Y6	Ped Y7	Ped Y8
PE# Represented		1		2		3		4

For Railroad Preemption

Dummy PH#: 9	Min Green:	Yellow:
Track Overlap:	Max Green:	All Red:

REMARKS :

PREPARED BY: DATE:

LOCATION:

CONTROL SECTION-SPOT #

Page 4 of 4

SECTION A – PREEMPT SYSTEM DATA

The preempt system data allows the user to include parameters that are common to all six preempts.

- ***Min Grn/Wlk*** – This establishes the time in seconds which any Green and or Walk interval must have been displayed prior to its termination for a transition to Preempt. Space is provided for an independent setting for each of the four rings in the ring and barrier structure.

- ***Preempt Overrides Flash*** – Check box if preemption overrides flash.
- ***Order of Priority*** – The entry identifies which preemption call will be serviced in the event of multiple simultaneous calls. Once the call with priority completes then a lower priority call may run if there is still an actuation.
- ***PE Status Pos in Pedestrian LSs*** – The entry identifies where each preempt status light is located in the cabinet. These will be located in the otherwise unused yellow positions, typically in the phase 2, 4, 6, and 8 pedestrian load switches. Default values place PE status 1, 2, 3, 4 in Pedestrian load switches 2, 4, 6, and 8
- ***For Railroad Preemption*** – Railroad preemption uses a dummy phase (phase 9) for track clearance and all of the following information needs to be filled in for that dummy phase: Min Green, Max Green, Yellow, and All Red. When there is a railroad preemption the dummy phase must also be included in the ring structure on page 2.

SECTION B – PREEMPT TIMES

- ***Preemption Description*** – Enter a description of the preemption here.
- ***Preempt Number*** - Indicate which of the 6 available preempts is being defined. If more than four preempt plans exist, then an additional form should be attached for the additional preempts.
- ***Entry Ped Cl*** – The Entry Ped clearance interval is provided to transition from a ped movement into a preempt. The proper pedestrian clearance time can be terminated early if necessary, by using the “Entry Ped Cl”. The type of preemption typically determines how much transition time is feasible.
  - The MDOT project manager must be consulted prior to changing any of these values. Railroads are required to provide a minimum amount of time prior to the train entering the intersection. Railroad preemption can be reduced as necessary to 1. If this minimum time is not sufficient, the required amount of time must be calculated and provided to the MDOT project manager and to the railroad.
  - For emergency vehicle preemption, the Entry Ped Cl is typically set to the largest of the “Pedestrian Clearance” values from the various phases in operation. For example, at a two-phase signal where the normal pedestrian clearance is 12 seconds for one phase and 14 seconds for the second phase, 14 seconds would be entered for the *Entry Ped Cl* as it is the larger of the two phases. The phase that it is transitioning to generally does not need to be considered unless there is a track green being utilized.
- ***Entry Yellow, Entry Red Cl*** – The “*Entry*” clearance intervals are provided to transition from normal operation into Track Green. Proper values for “Entry Yellow” and “Entry Red Cl” cannot be terminated early during this transition. The type of preemption typically determines how much transition time is feasible. Railroad preemption will typically require minimal transition time. Emergency vehicle preemption will typically allow for the full more transition time.

- For rail preemption, use the highest Yellow Clearance and All Red Clearance values from page 1 phase information.

- For Emergency Vehicle preemption, use highest Yellow and Red Clearance values that are not on a phase that is being transition to.

- ***Track Green, Track Ped Cl, Track Yellow, Track Red Cl*** – The "*Track"* intervals are provided when a railroad track is located close to the intersection and they are intended to keep vehicles from queuing across the track. The intervals provide a short period of green as well as clearance intervals at the intersection while the pre-signal at the tracks stays red. Doing this clears vehicles that were stopped on the tracks while not allowing more vehicles on to the tracks. The "*Track*" intervals are typically used when there are near and far signal heads at an intersection. The "*Track*" intervals clear vehicles between the near and far signal head to avoid vehicle trapping.

  - ***TRACK GREEN*** interval provides the time for the *TRACK Green*. If no time is entered for the *TRACK Green* interval, the "*Track"* intervals will be skipped (*Track Green, Track Ped Clear, Track Yellow,* and *Track Red Clear*).

    - ***If the signal utilizes a flashing red ball for left turns, the track green must provide a minimum of 1.0 seconds in order to operate correctly.***

  - The ***TRACK Ped Clear*** interval is the time provided to clear a terminating Walk during the transition to *DWELL Green*.

  - The ***TRACK Yellow*** interval is the time provided to clear a terminating Green during the transition to *DWELL Green*.

  - The ***TRACK Red Clear*** interval is the time provided to clear a terminating Yellow during the transition to *DWELL Green*.

- ***Dwell Green, Exit Ped Cl, Exit Yellow, Exit Red Cl*** – The *Dwell Green* interval is the time that the intersection will dwell in green for the allowed phases during the preempt. The "*Exit*" clearance intervals are provided to transition from preempt operation into normal operation. These values should be set to the normal clearance intervals for the respective approach.

For railroad preempts the amount of fixed time the railroad gives the traffic signal prior to the train entering the intersection is 20 seconds unless otherwise specified in writing from the railroad owner. Therefore, the sum of the **Min Grn/Wlk, *Entry Ped Cl, Entry Yellow, Entry Red Cl,*** and ***TRACK GREEN*** times shall not typically exceed 20 seconds. In any cases where it is unclear whether the railroad owner has provided notices of a period less than 20 seconds, extreme caution should be exercised to make sure that a dangerous timing is not put in place. If there is an existing timing then the new time to clear the tracks should not be increased without verification.

SECTION C – PREEMPT STATUS

- ***Vehicle*** – Identify the Phase or Overlap that corresponds with each of the load switches in use. This is entered in the first Vehicle row and only needs to be done for one preempt as it auto populates the others.

The vehicle signal head displays for the *TRACK Green* and *DWELL Green* for each phase are entered in this area. Possible entries for these phases include:

R	Red
G	Green
FR	Flashing Red
FY	Flashing Yellow
Blank	Dark

The phases that are permitted to *"Cycle"* during the *DWELL Green* are also entered in this area in the *Cycle row* denoted by "X". The phases that are permitted to *"Exit"* in after return yellow and red are also entered in this area in the *Exit row* denoted by "X". If Dwelling in FY, make sure to exit in that phase.

- ***Pedestrian*** – The pedestrian signal head displays for the *TRACK Green* and *DWELL Green* for each phase/interval are entered in this area. Possible entries for these phases/intervals include:

DW	Don't Walk
W	Walk
Blank	Dark

The phases that are permitted to *"Cycle"* during the *DWELL Green* are also entered in this area in the *Cycle row* denoted by "X".

SECTION D – MISCELLANEOUS PREEMPT PARAMETERS

- ***Locking*** – The default entry is "Y" for yes, meaning once a preempt detector gets a call, this call is "locked" in and remains a constant call until the preempt routine is serviced using a defined service duration. An entry of "N" for no means that the preempt detector will time out and transition back to regular operation as soon as it loses the call for service.

- ***Delay*** – This denotes the number of seconds (0-999) that the Preempt actuation must be active before normal controller operations are interrupted for the Preempt routine.

- ***Extend*** – This denotes the number of seconds (0-999) that each Preempt actuation shall be extended from the point the actuation terminates.

- ***Duration*** – This denotes the number of seconds (0-999) which a Preempt requires prior to a transition back to normal traffic operations can occur.

- ***Max Call*** – This establishes the number of seconds (0-999) which a Preempt call may remain active and be considered valid.

- ***Link PreEmpt #*** – This establishes the higher priority Preempt routine which is to be linked to this Preempt routine.

- ***Exit Free or Crd*** – This identifies whether the initial transition out of the preemption is to free mode or coordinated mode. This option may not be available on all controllers.

SECTION E –DISPLAY CASE SIGNS

Section E lists four types of Display Case Signs. The default value is “N” for each of the Display Case Signs, meaning the case sign is not provided. If the Display Case Sign is present, this value can be overridden with “Y” for yes. The following four types of Display Case Signs can be denoted in Section E:

- No Turn on Red – enter “Y” if No Turn on Red case sign is present.
- No Right Turn – enter “Y” if No Right Turn case sign is present.
- No Left Turn – enter “Y” if No Left Turn case sign is present.
- Other Case Sign – enter “Y” if other case sign is present. Describe in the REMARKS section on the same page.

SECTION F – REMARKS & LOCATION

Section F provides space for *REMARKS* and general information about the signalized location. Any information that is necessary for the proper installation of the signal timing permit that was not captured by the fields of the signal timing permit should be entered in this section. If all of the remarks do not fit into the space provided, do not change the font size as MDOT will lose all of this information in their database when the font is changed.

If a timing permit is prepared by a consultant, the consultant name should be included in the remarks section. For example:

“OPTIMIZED BY (Insert Organization Name)”

The general information about the signalized location auto populates from the entries made on the first page. This information includes:

- Who prepared the timing permit and the date
- The location and control section-spot number

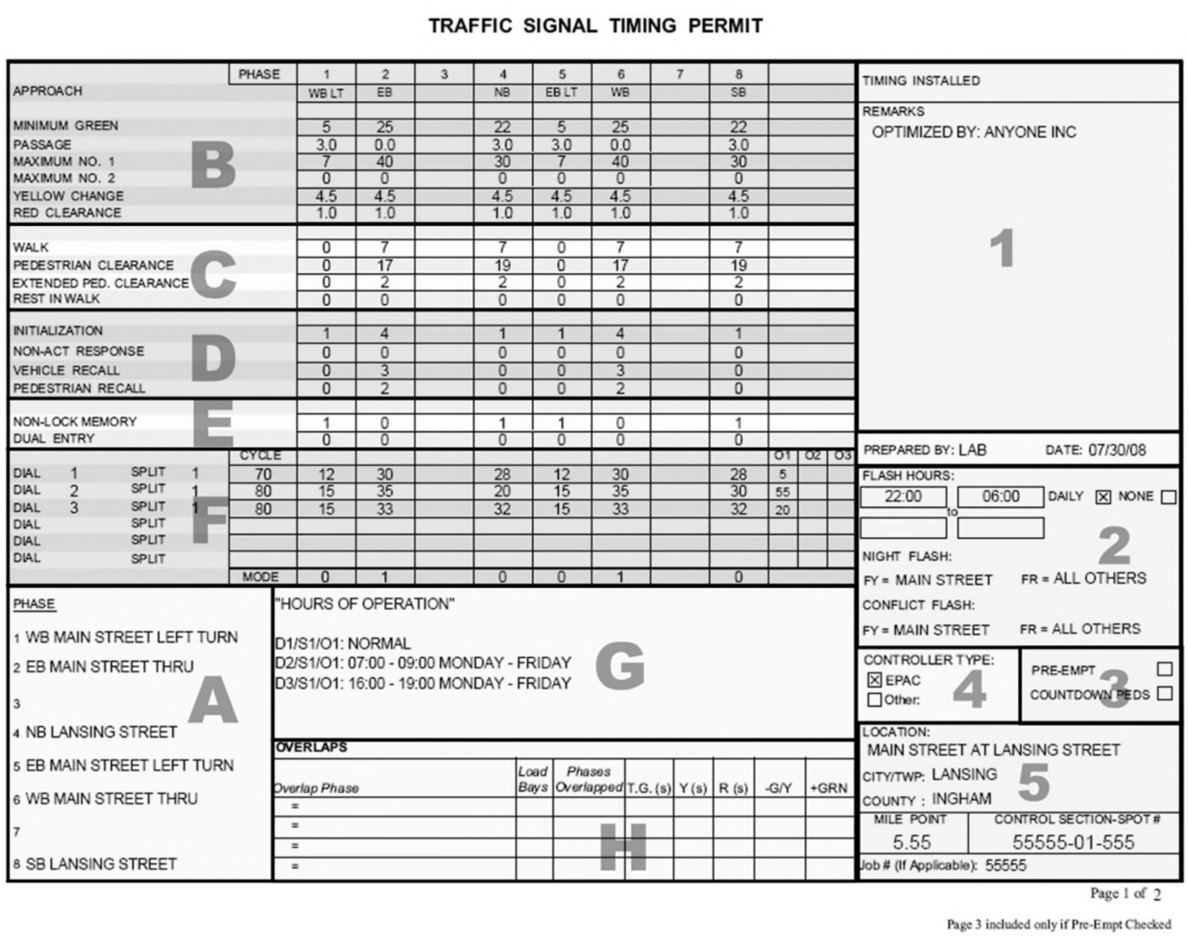
7.2 EPAC CONTROLLER UNIT

The ***EPAC PERMIT*** is described below and in the ***EPAC TIMING PARAMETERS*** spreadsheet.

7.2.1 *BASIC TIMING PARAMETERS FORM - EPAC CONTROLLER UNIT*

The EPAC controller unit offers pre-timed, semi-actuated, and fully-actuated operation. Up to 16 phases in four rings can be entered into the EPAC controller. Figure 7-6 illustrates a sample signal timing permit for an EPAC controller unit. A description of each section (A – H) of the signal timing permit and how to properly complete each section is provided in the text that follows. All of the general information (1-5) is presented under Section 7.4 Standard Information: Page 1. The ranges and increments for the timed values entered into the timing permit are provided in Table 7-1.

Figure 7-6: EPAC Timing Permit Example



TRAFFIC SIGNAL TIMING PERMIT

PHASE	1	2	3	4	5	6	7	8		O1	O2	O3
APPROACH	WB LT	EB		NB	EB LT	WB		SB				
B												
MINIMUM GREEN	5	25		22	5	25		22				
PASSAGE	3.0	0.0		3.0	3.0	0.0		3.0				
MAXIMUM NO. 1	7	40		30	7	40		30				
MAXIMUM NO. 2	0	0		0	0	0		0				
YELLOW CHANGE	4.5	4.5		4.5	4.5	4.5		4.5				
RED CLEARANCE	1.0	1.0		1.0	1.0	1.0		1.0				
C												
WALK	0	7		7	0	7		7				
PEDESTRIAN CLEARANCE	0	17		19	0	17		19				
EXTENDED PED. CLEARANCE	0	2		2	0	2		2				
REST IN WALK	0	0		0	0	0		0				
D												
INITIALIZATION	1	4		1	1	4		1				
NON-ACT RESPONSE	0	0		0	0	0		0				
VEHICLE RECALL	0	3		0	0	3		0				
PEDESTRIAN RECALL	0	2		0	0	2		0				
E												
NON-LOCK MEMORY	1	0		1	1	0		1				
DUAL ENTRY	0	0		0	0	0		0				

F	CYCLE	1	2	3	4	5	6	7	8	O1	O2	O3
DIAL 1 SPLIT 1	70	12	30		28	12	30		28	5		
DIAL 2 SPLIT 1	80	15	35		20	15	35		30	55		
DIAL 3 SPLIT 1	80	15	33		32	15	33		32	20		
DIAL SPLIT												
DIAL SPLIT												
DIAL SPLIT												
MODE		0	1		0	0	1		0			

A

PHASE

1 WB MAIN STREET LEFT TURN
2 EB MAIN STREET THRU
3
4 NB LANSING STREET
5 EB MAIN STREET LEFT TURN
6 WB MAIN STREET THRU
7
8 SB LANSING STREET

G

"HOURS OF OPERATION"

D1/S1/O1: NORMAL
D2/S1/O1: 07:00 - 09:00 MONDAY - FRIDAY
D3/S1/O1: 16:00 - 19:00 MONDAY - FRIDAY

H

OVERLAPS

Overlap Phase	Load Bays	Phases Overlapped	T.G. (s)	Y (s)	R (s)	-G/Y	+GRN
=							
=							
=							
=							

1

TIMING INSTALLED

REMARKS
OPTIMIZED BY: ANYONE INC

PREPARED BY: LAB DATE: 07/30/08

2

FLASH HOURS: 22:00 to 06:00 DAILY ☒ NONE ☐

NIGHT FLASH:
FY = MAIN STREET FR = ALL OTHERS
CONFLICT FLASH:
FY = MAIN STREET FR = ALL OTHERS

4

CONTROLLER TYPE:
☒ EPAC
☐ Other:

3

PRE-EMPT ☐
COUNTDOWN PEDS ☐

5

LOCATION:
MAIN STREET AT LANSING STREET
CITY/TWP: LANSING
COUNTY : INGHAM

MILE POINT	CONTROL SECTION-SPOT #
5.55	55555-01-555

Job # (If Applicable): 55555

Page 1 of 2

Page 3 included only if Pre-Empt Checked

Table 7-1: Signal Timing Permit Ranges and Increments

Function	Controller Range (seconds)	*MDOT Range (seconds)	Increments (seconds)
MINIMUM GREEN	0-999	5-10	**1**
PASSAGE	0-99.9	-	**0.1**
MAXIMUM NO. 1 & NO.2	1-999	-	**1**
YELLOW CHANGE	3.0-99.9	3.0-6.0**	**0.1**
RED CLEARANCE	0.0-99.9	1.0-4.0**	**0.1**
WALK	0-999	4-999	**1**
PEDESTRIAN CLEARANCE	0-999	-	**1**
CYCLE	30-999	60-999***	**1**
PHASE TIME (Split Time)	0-400	-	**1**
OFFSET	**0-999**	**-**	**1**

*MDOT Range is listed only if different than the actual Controller Range

** See Section B below for more details on yellow and red change interval ranges.

***60 seconds minimum is MDOT's typical restriction; cycle lengths less than 60 seconds require MDOT approval.

Source: *EPAC300 Actuated Signal Control Manual (2002)*

SECTION A – PHASE DESCRIPTION

Section A lists the phases that are utilized for the timing plan. The eight phases typically correspond to the standard eight phases used in a NEMA dual-ring controller. Unless a new controller is being installed as part of the project, the phase numbering should not be changed. Should more than the eight phases provided on the permit be needed, a second sheet should be attached. The second sheet should note in the Remarks Section (Section G1) that phase one of that sheet is actually phase nine.

SECTION B – BASIC VEHICLE TIMINGS

Section B is where much of the basic data is entered for the signal. This information provides basic assumptions the controller uses when determining interval times. Some data such as the Maximums are required in case the signal is operating as a free actuated signal with no dial information, or for some reason the dial information is lost.

The phases one through eight listed along the top row of Section B correspond to the eight phases listed in Section A.

- ***APPROACH*** – An abbreviated description of the corresponding information from Section A.
- ***MINIMUM GREEN*** – The minimum amount of initial green time, in seconds, that must be given to each phase in use. This value must be a whole number, and the MDOT minimum is 10 seconds for the major road, 7 seconds for the minor road/cross street and all non-actuated left-turn phases. For actuated left-turn phases, 7 seconds is the minimum green for protected-only left-turn phasing, and 5 seconds for all permitted-protected left-turn phasing. A minimum vehicle recall will always be set for actuated permitted-protected left-turn phasing where a flashing red is used. Locations with a "doghouse" or a flashing yellow left turn indication do not require the minimum vehicle recall for permitted-protected left-turn phasing. 5 seconds may be used for a non-actuated and/or protected-only left-turn phase with

MDOT approval. This would be considered when the left-turn volume is extremely low and the additional 2 seconds taken from the left-turn would provide a significant benefit to the other phases of the signal.

- ***PASSAGE*** – The extended portion of the green time for an actuated approach is a function of vehicle actuations that occur after the minimum green is served. The phase remains green after the minimum green has been served until no additional calls are received and the passage timer has timed out, or until the maximum green time is reached. The passage timer is reset with each subsequent vehicle actuation and begins timing again when the actuation is removed. The typical passage time is 3.0 seconds.
    - *While uncommon, it is possible for an actuated phase to have a passage time equal to zero. This is sometime used where there are multiple lanes of detection for an approach or a particularly long detection zone. Unusual operations such as this should be noted in the remarks section.*
- ***MAXIMUM NO. 1*** – The maximum length of time this phase may be held green in the presence of a serviceable conflicting call. In the absence of a serviceable conflicting call, the maximum green timer is held reset. The value is to be entered in whole seconds and typically matches the highest split entered in Section F for that particular phase.
- ***MAXIMUM NO. 2*** – This time setting serves the same function as *MAXIMUM NO. 1.* This is most commonly used at intersections that run free where the volumes change significantly over the course of a day and require different maximum times at different times of the day. To achieve this, MAXIMUM NO. 2 can be designated to run at certain times of the day.
    - There are 3 additional Maximum times available, but they are very rarely used as they require special programming techniques in the controller. The *MAXIMUM NO.2* data is typically left with a default value of zero entered.
- ***YELLOW CHANGE*** – The yellow change interval time for each phase. The value is entered in seconds in 0.1 second increments. Per MDOT policy, the yellow change interval must be at least 3.0 seconds. The typical range is 3.0 to 6.0 seconds. Yellow change intervals greater than 6.0 seconds may be used with MDOT approval.
- ***RED CLEARANCE*** – The all-red clearance interval time for each phase. The value is entered in seconds in 0.1 second increments. Per MDOT policy, the red clearance interval must be at least 1.0 second. The typical range is from 1.5 to 4.0 seconds. Red clearance intervals greater than 4.0 seconds may be used with MDOT approval. Situations that may require longer all red times include locations with a trail green, single-point urban interchanges, and diverging diamond interchanges.

SECTION C – PEDESTRIAN TIMING

Pedestrian timing data is entered in Section C. The *WALK* time, *PEDESTRIAN CLEARANCE* time, *EXTENDED PEDESTRIAN CLEARANCE* code, and *REST IN WALK* code are entered here for each phase.

- ***WALK*** – The minimum time, in seconds, that the walk display must be displayed for this phase. The value must be entered in whole seconds. Per MDOT policy, the typical minimum *WALK* time is 7.0 seconds. A minimum *WALK* time of 4.0 seconds may be used, where deemed appropriate based on pedestrian characteristics, volumes, and timing requirements, with approval of MDOT. In some situations, the minimum walk time will be greater than 7.0 seconds (see Section 4.3.2)

- ***PEDESTRIAN CLEARANCE*** – The time in seconds that the "Flash Don't Walk" indication, is displayed during each phase. This value must be entered in whole seconds. This is different from the calculated pedestrian clearance which includes a buffer interval after the Flash Don't Walk.

- ***EXTENDED PED. CLEARANCE*** – Defines when the Flash Don't Walk indication terminates. The codes are found in Table 7-2. Code 0 is most typically required to meet the 3 s minimum buffer requirement. If the All-Red time is 3 s or greater, then code 2 may be used (Note that MOD 10 controllers and older do not have the code 2 option). If the controller has the option to terminate the Flash Don't Walk at exactly 3 s before the end of All-Red, then this option can only be used if the All-Red is 3 s or less.

- ***REST IN WALK*** – This entry is applicable only for signals that are running uncoordinated. For signals running in coordinated mode, this entry is overridden by the coordination mode (see section 7.5 E). For intersections that are actuated and uncoordinated, the signal can dwell in *DON'T WALK* (Mode 0) or *WALK* (Mode 1) at the end of the *WALK* timing when there is no serviceable conflicting call. If there is a pedestrian push-button available, having the signal dwell in DON'T WALK is preferable as it can transition to a conflicting phase more quickly if a call comes in. If there is not a pedestrian push button, the signal should be set up to dwell in WALK with locking side street vehicle detection. Otherwise, if there are no conflicting calls, the signal will continue to dwell in DON'T WALK and a pedestrian will never have an opportunity to cross. It is preferred that logic common be jumpered to the walk rest modifier input on the controller back panel. Then set ped recall to code 3 which is "non-actuated". This allows walk cycling to occur when side street vehicle detection is non-locking. This will override the entry for rest in walk.

Table 7-2: Extended Pedestrian Clearance Codes and Descriptions

Code	Description
0 **(Normal)**	Flash Don't Walk ends at the end of Green
1 **(Extended Ped. Clear)***	Flash Don't Walk ends at the end of All-Red
2 **(Extended Ped. Clear)**	Flash Don't Walk ends at the end of Yellow
3 **(Extended Ped. Clear)****	Flash Don't Walk ends at 3.0s before the end of All-Red

*Extended Pedestrian Clearance code 1 is no longer acceptable if it does not allow the minimum 3 second pedestrian clearance buffer interval required per the MMUTCD.

**Extended Pedestrian Clearance code 3 is only acceptable when concurrent vehicle phase All-Red intervals are no more than 3.0s long to ensure that the Flashing Don't Walk interval is not active after the All-Red interval has begun.

Source: *EPAC300 Actuated Signal Control Manual (2002)*

SECTION D – INITIALIZATION AND ACTUATION

This section contains the information for *INITIALIZATION*, *NON-ACT RESPONSE*, *VEHICLE RECALL*, and *PEDESTRIAN RECALL*.

- ***INITIALIZATION*** – *INITIALIZATION* occurs when there is a restoration of power after a defined power interruption, or the activation of External Start input is entered. An entry for *INITIALIZATION* is provided to cause the controller unit to start at the beginning of the Green, Yellow, or Red interval of any phase or non-conflicting phase pair. The *INITIALIZATION* codes are shown in Table 7-3. The typical values used are 4 for the major movement and 1 for the minor movements.

- ***NON-ACT RESPONSE*** – Two inputs are provided which when activated causes any phase(s) appropriately programmed to operate in the Non-Actuated Mode. These inputs are CALL TO NAI and CALL TO NAII. The *NON-ACT RESPONSE* codes are shown in Table 7-4.

- ***VEHICLE RECALL*** – This row defines the *VEHICLE RECALL* mode for each phase previously defined in Section A. The *VEHICLE RECALL* codes are shown in Table 7-5.

- ***PEDESTRIAN RECALL*** – This row defines the *PEDESTRIAN RECALL* mode for each phase previously defined in Section A. The *PEDESTRIAN RECALL* codes are shown in Table 7-6. Code 0 is typically used with pedestrian push-buttons, and Code 2 is typically used if there are no pedestrian push-buttons.

Table 7-3: Initialization Codes and Descriptions

Code	Description
0 (No Phase)	Phase is not used and will not appear in the sequence.
1 (Phase Not On)	Phase will not be active. No intervals will be timing and the outputs will be Red and Don't Walk.
2 (Phase On in Red Clear)	Phase starts timing at the beginning of its Red Clearance interval and the outputs will be Red and Don't Walk.
3 (Phase On in Yellow Change)	Phase starts timing at the beginning of its Yellow Change interval and the outputs will be Yellow and Don't Walk.
4 (Phase On in Green/Walk)	Phase starts timing at the beginning of its Minimum Green and Walk intervals and the outputs will be Green and Walk.
5 (Phase Dark & Omitted)	Phase will not be active and will not normally appear in the sequence. No intervals will be timing and the outputs will be dark. The state is similar to Code "0" but enables a distinction and currently is the only way a user can get a dummy (dark) phase time to run in Coordination.

Source: *EPAC300 Actuated Signal Control Manual (2002)*

Table 7-4: Non-Actuated Response Codes and Descriptions

Code	Description
0 (None)	Phase will not respond to the activation of either of the Call To Non-Actuated Mode inputs.
1 (Responds to NA1)	Phase will respond to the activation of the Call To Non-Actuated Mode I input but not to the activation of the Call To Non-Actuated II input.
2 (Responds to NA2)	Phase will respond to the Call To Non-Actuated II input but not to the activation of the Call To Non-Actuated I input.
3 (Responds to NA1 & NA2)	Phase will respond to the activation of either of the Call To Non-Actuated Mode inputs.

Source: *EPAC300 Actuated Signal Control Manual (2002)*

Table 7-5: Vehicle Recall Codes and Descriptions

Code	Description
0 (None)	Phase will operate as actuated.
2 (Min Vehicle Recall)	Phase will continually demand at least a Minimum Green service even in the absence of actual vehicle or pedestrian calls. The Green interval may then be extended by vehicle

	actuations during the Green interval in the usual manner. Pedestrian service will not be provided in the absence of pedestrian actuations.
3 (Max Vehicle Recall)	Phase will continually demand the Maximum Green setting. The Green interval will not terminate on the basis of the Max setting, but will continue until there is an actual serviceable conflicting call. Pedestrian service is not provided in the absence of pedestrian actuations.
4 (Soft Vehicle Recall)	Places a demand for vehicle service in memory when a conflicting phase is in Green or Red dwell and there are no serviceable conflicting calls. This provides the capability to recall a phase in the absence of serviceable calls (light traffic conditions).

Source: *EPAC300 Actuated Signal Control Manual (2002)*

Table 7-6: Pedestrian Recall Codes and Descriptions

Code	Description
0 (None)	Phase will operate as actuated.
2 (Pedestrian Recall)	Phase will continually demand pedestrian service even in the absence of actual pedestrian calls, but an actual pedestrian call is required to recycle pedestrian service during the pedestrian service interval.
3 (Non-Actuated)	Phase will operate as a Non-Actuated phase. (See discussion under REST IN WALK)
4 (Non-Actuated Plus)	Phase will operate as a Non-Actuated phase. On initial entry to a phase, the WALK time will be set equal to the longer of the WALK time parameter or the called MAXIMUM time parameter (MAX 1 or 2). A recycle of the pedestrian within the phase will result in the WALK time being set equal to the WALK time parameter. An active Call to Non-Actuated input, for which the phase is programmed to respond, will result in the WALK time being set equal to the WALK time parameter. Running Internal Coordination will result in WALK time being set equal to the WALK time parameter.

Source: *EPAC300 Actuated Signal Control Manual (2002)*

SECTION E – NON-LOCK MEMORY/DUAL ENTRY

The *NON-LOCK MEMORY* and *DUAL ENTRY* information for each phase are entered in this area.

- ***NON-LOCK MEMORY*** – Code “0” represents locking vehicle memory. This means that once a vehicle detector gets a call, this call is “locked” in and remains a constant call until the phase is serviced. Code “1” represents non-locking vehicle memory. This means that there is no memory storage of a vehicle call on a detector. The detector must be continuously occupied in order to maintain a vehicle call for service in this mode.

- ***DUAL ENTRY*** – *DUAL ENTRY* is a mode of operation (in multiple ring controllers) in which one phase in each ring must be in service, subject to compatibility, at all times. If a call does not exist in a ring when it is committed to cross a barrier, a phase is selected in that ring to be activated by the controller unit that will be compatible. *DUAL ENTRY* is entered either as YES (1), or NO (0). A NO (0) represents *SINGLE ENTRY*. *SINGLE ENTRY* is a mode of operation (in multiple ring controllers) in which a phase in one ring can be selected and timed alone if there is no demand for service in a non-conflicting phase in a parallel ring.

For a typical 2-phase semi-actuated signal with actuation assigned to phase 4 and 8 (side streets), dual entry shall be entered for both phases.

SECTION F – DIAL-SPLIT SET-UP

Section F is the Dial-Split data section. It establishes the cycle lengths, splits, offsets, and actuation modes for the Dial-Split Combinations if a defined cycle length is being used. Dial and split information is entered in the left most box of Section F. There are four dials (1-4) and each dial has four splits (1-4) available for a total of 16 Dial-Split Combinations. Each Dial-Split Combination can have up to 3 offsets. Under typical conditions, MDOT's standard convention is to use Dial 1 Split 1 Offset 1 for normal "off-peak" operation, Dial 2 Split 1 Offset 1 for the AM peak period, and Dial 3 Split 1 Offset 1 for the PM peak period. However, assignment of dials may vary depending on maintaining agency and should therefore be determined in advance of preparing a timing permit. If needed, additional dial and split information can be entered on page 2 (see Section 7.2.2).

- ***CYCLE*** – The cycle length, in seconds, for each dial in operation.
- ***PHASE TIME*** – The phase time for each phase is entered for each dial in operation. The phase time includes the green time, yellow time, and all-red time for that phase. Phase time data supersedes the values entered in *MAXIMUM NO.1* and *NO.2*. The Phase Times are often referred to as Splits.
- ***OFFSETS*** – The offsets for each dial in operation are entered, in seconds, in the last three columns of Section F. Up to three offsets may be entered for each dial split.
    - ***If the offset is set to the cycle length, the Phase Time values become maximum green times with the yellow and all red times being timed separately. In addition the controller unit will be running free (un-coordinated). But the splits entered cannot violate the minimum split time. This can be problematic with short left turn phases.***
- ***MODE*** – This row represents the *Phase Mode* for each respective phase defined in Section A. The phase mode combines with the *VEHICLE* and *PEDESTRIAN RECALL* codes entered in Section E. The codes representing the different Phase Modes are shown in Table 7-7. The controller is capable of having different Mode settings for each Dial-Split combination, but typically the mode will be the same for all time periods. The trunkline through movement will typically be set as the coordinated phase.
    - For consistency, if the controller is running fixed time, set the side road mode to dual coordination (code = 7).
    - Dual coordination should not be used with actuated operations unless the intent is to provide coordination for the crossroad in addition to the trunkline.

For information on minimum split times see Section 4.3.

Table 7-7: Phase Mode Codes and Descriptions

Code	Description
0 (Actuated)	Phase will operate as actuated.
1 (Coordinated Phase)	Phase will operate as the Coordinated Phase for the ring.
2 (Minimum Recall)	Phase will operate as an actuated phase with a Minimum Recall.
3 (Maximum Recall)	Phase will operate as an actuated phase with a Maximum Recall.

4 (Pedestrian Recall)	Phase will operate as an actuated phase with a Pedestrian Recall.
5 (Max + Ped Recall)	Phase will operate as an actuated phase with a Maximum and Pedestrian Recall.
6 (Phase Omit)	Phase will operate as an actuated phase with a Phase Omit.
7 (Dual-Coordinated Phase)	Phase will operate as the Dual-Coordinated phase for the ring.

Source: *EPAC300 Actuated Signal Control Manual (2002)*

SECTION G – HOURS OF OPERATION AND ADDITIONAL REMARKS

Section G is where the hours of operation data should be entered. If there are any additional remarks that did not fit in Section H, they can be written in Section 1.

SECTION H – PHASE OVERLAPS

Section H contains the *PHASE OVERLAP* information. Overlaps are similar to phases except they are set up to specifically run concurrently with other phases.

- The letter and description of the *Overlap Phase* is entered in the first column.
- The load switch position that it is associated with is entered in the next column. This will be on the existing timing permit or it must be obtained from the controller cabinet.
- The phases overlapped are entered in the third column. The phase numbers entered in the *Phases Overlapped* section should correspond to the phases entered in Section A.
- T.G.s is the Trail Green. This is typically used to clear the space between two sets of signal indications (one near and one far) servicing the same approaches of a median-divided roadway or other offset intersection. Details for determining this time are found in Section 4.1.3.
  - For locations with a trail green, set the near signal's all-red equal to the calculated all-red plus the trail green value (this will typically exceed 2.5 seconds). The splits entered in Section F should add up to the cycle length and not be adjusted for the trail green (i.e. do not subtract the trail green from the split times).
- The Yellow and All-Red times typically correspond to the values calculated for the associated phases.
- -G/Y is used to specify the phase when the protected green arrow is displayed.
- +GRN is used to specify the phase when the flashing yellow arrow is displayed, which is typically the opposing through phase.

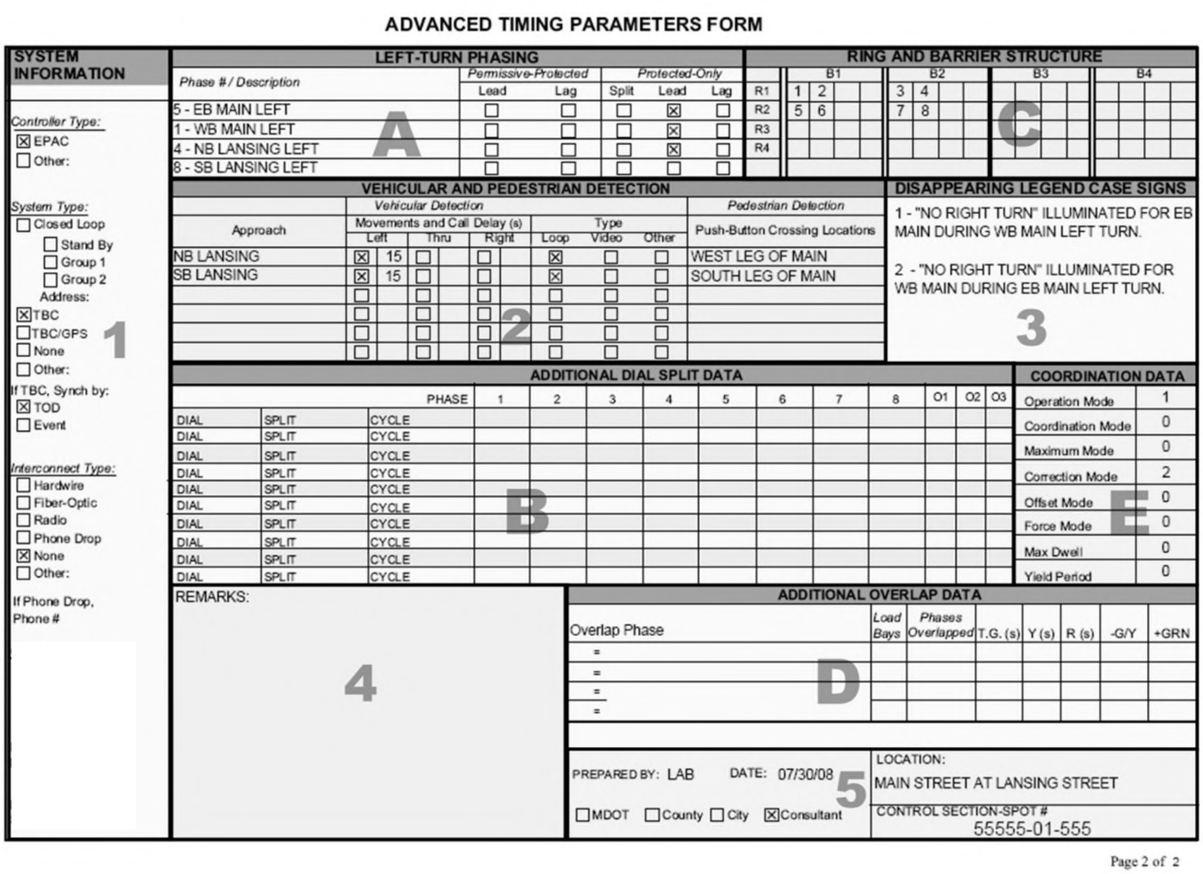
Note: When using a flashing yellow arrow operation, a zero should be entered for the phase overlaps. Additional overlaps can be entered on Page 2, *Advanced Timing Parameters Form*.

7.2.2 *ADVANCED TIMING PARAMETERS FORM – EPAC CONTROLLER*

The Advanced Timing Parameters form (page 2) provides the system data, signal operation parameters, and space to provide additional dial, split, and overlap information. This form should accompany the signal timing permit form on all occasions.

Figure 7-7 illustrates a sample Advanced Timing Parameters form filled out in completion. A description of each section (A – E) of the signal timing permit and how to properly fill in these sections is provided in the text that follows. All of the general information (1-5) is presented under the General Permit Guidelines in Section 7.8. Table 7-8 provides the ranges and increments for the numerical values included on this form.

Figure 7-7: Advanced Timing Parameters Form (EPAC) Example


ADVANCED TIMING PARAMETERS FORM

SYSTEM INFORMATION (1)

Controller Type: ☒ EPAC ☐ Other:

System Type: ☐ Closed Loop ☐ Stand By ☐ Group 1 ☐ Group 2 Address: ☒ TBC ☐ TBC/GPS ☐ None ☐ Other:

If TBC, Synch by: ☒ TOD ☐ Event

Interconnect Type: ☐ Hardwire ☐ Fiber-Optic ☐ Radio ☐ Phone Drop ☒ None ☐ Other:

If Phone Drop, Phone #

LEFT-TURN PHASING (A)

Phase # / Description	Permissive-Protected Lead	Permissive-Protected Lag	Protected-Only Split	Protected-Only Lead	Protected-Only Lag
5 - EB MAIN LEFT	☐	☐	☐	☒	☐
1 - WB MAIN LEFT	☐	☐	☐	☒	☐
4 - NB LANSING LEFT	☐	☐	☐	☒	☐
8 - SB LANSING LEFT	☐	☐	☐	☐	☐

RING AND BARRIER STRUCTURE (C)

	B1		B2		B3	B4
R1	1	2	3	4		
R2	5	6	7	8		
R3						
R4						

VEHICULAR AND PEDESTRIAN DETECTION (2)

Approach	Left	Delay (s)	Thru	Right	Loop	Video	Other	Push-Button Crossing Locations
NB LANSING	☒	15	☐	☐	☒	☐	☐	WEST LEG OF MAIN
SB LANSING	☒	15	☐	☐	☒	☐	☐	SOUTH LEG OF MAIN

DISAPPEARING LEGEND CASE SIGNS (3)

1 - "NO RIGHT TURN" ILLUMINATED FOR EB MAIN DURING WB MAIN LEFT TURN.

2 - "NO RIGHT TURN" ILLUMINATED FOR WB MAIN DURING EB MAIN LEFT TURN.

ADDITIONAL DIAL SPLIT DATA (B)

PHASE 1 2 3 4 5 6 7 8 O1 O2 O3 — DIAL / SPLIT / CYCLE (10 blank rows)

COORDINATION DATA (E)

Operation Mode	1
Coordination Mode	0
Maximum Mode	0
Correction Mode	2
Offset Mode	0
Force Mode	0
Max Dwell	0
Yield Period	0

REMARKS: (4)

ADDITIONAL OVERLAP DATA (D)

Overlap Phase | Load Bays | Phases Overlapped | T.G. (s) | Y (s) | R (s) | -G/Y | +GRN

PREPARED BY: LAB DATE: 07/30/08 (5)

☐ MDOT ☐ County ☐ City ☒ Consultant

LOCATION: MAIN STREET AT LANSING STREET

CONTROL SECTION-SPOT # 55555-01-555

Page 2 of 2

Table 7-8: Advanced Timing Parameters Ranges and Increments

Function	Controller Range (seconds)	*MDOT Range (seconds)	Increments (seconds)
Phase Overlap Trail Green	0-99.9	-	0.1
Phase Overlap Yellow	3.0-99.9	3.0-6.0**	0.1
Phase Overlap Red	0-99.9	1.0-4.0**	0.1
Call Delay (Vehicular Detection)	0-999	-	1
Max Dwell	0-999	-	1
Yield Period	0-999	-	1

*MDOT Range is listed only if different than the actual Controller Range

**See 4.1, for details on yellow and red clearance intervals.

Source: *EPAC300 Actuated Signal Control Manual (2002)*

SECTION A – LEFT-TURN PHASING

The *LEFT-TURN PHASING* information is entered in Section A. The left-turn *Phase # / Phase Description* information as well as *Permissive-Protected* and *Protected Only* information are entered in this section.

- ***Phase # / Phase Description*** – The left-turn phase number, followed by a description of the phase are entered in this area. This information must match the left-turn information found in Section A of the *Basic Timing Parameters Form for EPAC Controllers*.

- ***Permissive-Protected and Protected-Only Phasing*** – In this section, the left-turn operation should be defined as either a "leading," "lagging," or "split" phase (relative to the parallel through movement), and whether permissive left-turns are allowed during the companion through phase. Only one box should be checked for each phase.

    - *Note*: If a lagging left-turn phase is selected, the electrician will input an "alt sequence" into the controller. Do not reverse the phase sequence in the Ring and Barrier Structure if lagging left turn phase has already been selected

SECTION B – ADDITIONAL DIAL SPLIT DATA

Additional Dial Split Data may be entered on page 2. Refer to Section 7.4.1 (Section F) of the *EPAC Basic Timing Parameters Form* for more detail.

SECTION C – RING AND BARRIER STRUCTURE

The *RING and BARRIER STRUCTURE* entered in Section C defines and illustrates the phase operations of a controller.

- A *Ring* is a series of conflicting phases that occur in an established order and never at the same time.

- A *Barrier* is a compatibility line in the sequence of a multi-ring controller that interlocks the *Rings*. A *Barrier* assures there will be no concurrent selection and timing of conflicting phases for traffic movements in different *Rings*. All *Rings* cross the *barrier* simultaneously to select and time phases on the other side.

Section C is set up with four *Barriers* and four *Rings* (the current constraints of an EPAC controller). The phase numbers should be entered in their corresponding areas and match the phases identified in Section A of the *Basic Timing Parameters Form for EPAC Controllers.*

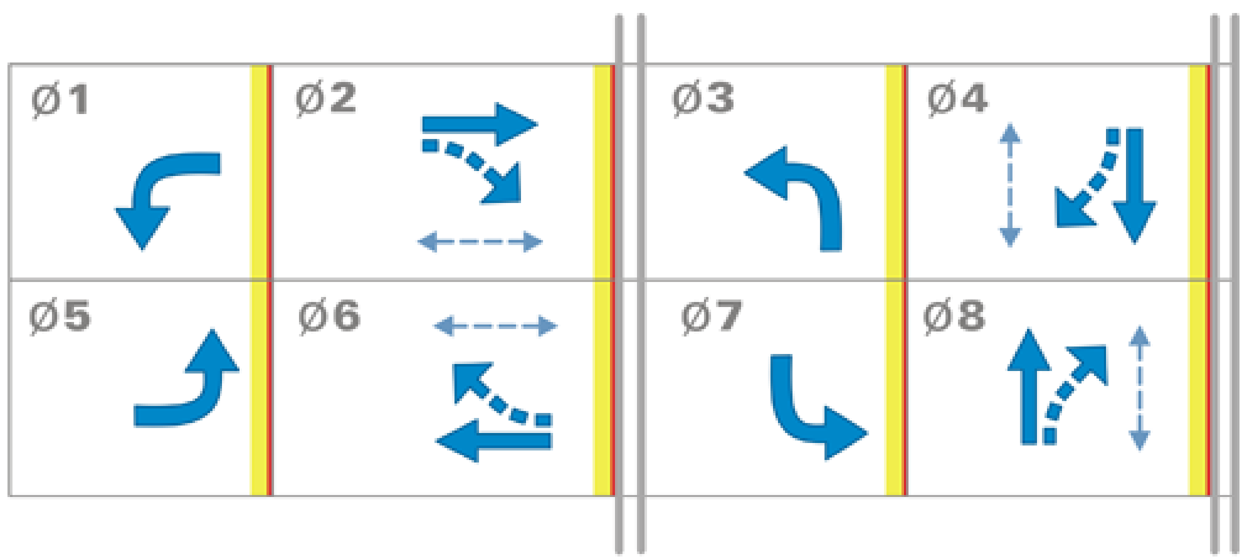
Typically, an eight-phase dual-ring controller is utilized in the field. Figure 7-8 illustrates this controller configuration based on the National Electrical Manufacturers Association (NEMA) standard, which is as follows:

- Phases 2 and 6 are the main street through movements
- Phases 1 and 5 are the main street left-turn movements
- Phases 4 and 8 are the minor street through movements
- Phases 3 and 7 are the minor street left-turn movements

MDOT standard practice is to first apply phase 2 to a main street approach, using the main street's NB or EB approach if there is one, and sequence the remaining phases in a clockwise manor. The two most common phase 1-8 configurations will be 1-WBL, 2-EBT, 3-NBL, 4-SBT, 5-EBL, 6-WBT, 7-SBL, 8-NBT and 1-SBL, 2-NBT, 3-WBL, 4-EBT, 5-NBL, 6-SBT, 7-EBL, 8-WBT. Four boxes are provided in each *Ring* per *Barrier* for more complicated and non-standard phasing schemes, such as split-phasing or sequential phasing.

When filling out the *Advanced Timing Parameters Form* for new signal installations, the NEMA standard should be adhered to whenever possible when filling out the ring and barrier structure.

Figure 7-8: Dual-Ring Controller (NEMA Standard)



SECTION D – PHASE OVERLAPS

See Section 7.4.1 Section H of the EPAC Basic Timing Parameters form for more details.

SECTION E – COORDINATION DATA

This section provides information for *OPERATION MODE, COORDINATION MODE, MAXIMUM MODE, CORRECTION MODE, OFFSET MODE, FORCE MODE, MAX DWELL,* and *YIELD PERIOD*. The values will typically need to be obtained from the controller.

- ***Operation Mode*** – The Operation Mode establishes whether the signal operates as Free or Coordinated.
  - **0** - provides **Non-Coordinated (Free)** operation. This is the typical setting for signals that are not coordinated and are not locked down to a particular cycle length.
    - If the signal is Non-coordinated and is running Max 1 and Max 2 times depending on the time of day it is suggested that if the signal is running free, fill in all zeros for the Operation Mode. If the signal is running dial/splits part of the day and free the remainder, fill in the Operation Mode based on the dial/split operation.
  - **1** - Provides for **Coordination** operation to be automatically determined by interconnect, time base, or system commands. This is the typical setting for a coordinated system.
  - **2** - Provides for **Manual Coordination** operation. This option allows for a single dial/split/offset combination to run always. This is not typically used as a permanent setting.
- ***Coordination Mode*** **–** The Coordination Mode establishes the type of coordination. The following provides descriptions of each mode. See Table 7-9 for codes and brief descriptions.
  - **0 = Permissive (Typical Value)**: Under permissive coordination the controller will transition to the coordinated phase(s), and upon completion of the coordinated phase(s) split time rest in the Green/Don't Walk state,. Because the controller is already in a state (Green/DW) where it can readily exit the coordinated phase(s), this allows a relatively large time window to transition from the coordinated phase(s) to the actuated non-coordinated phase(s). After the transition time window closes, and there is no call placed from the non-coordinated phase(s), the controller will cycle back to Green/Walk for the coordinated phase(s). When multiple non-coordinated phases are present, the coordinator provides sequential releases, based on the order of the ring structure, to the non-coordinated phases
  - **1 = Yield:** Under yield coordination the controller will rest in the Green/Walk state if there is an absence of call from the actuated non-coordinated phases. This allows a relatively short time window to transition from the coordinated phase(s) to the actuated non-coordinated phase(s), potentially increasing the worst case delay time to service non-coordinated actuated phases. When multiple non-coordinated phases are present, the coordinator provides a single release to the non-coordinated phases.

- **2 = Permissive Yield:** Permissive Yield is similar to Permissive mode except for the coordinated phase(s) pedestrian movement(s) are actuated. This mode is useful when pedestrian push buttons are provided for the coordinated phase(s).

- **3 = Permissive Omit:** Permissive Omit is similar to Permissive Yield except for once terminated, the coordinated phase(s) are omitted. This prevents the controller from exiting the non-coordinated phase(s) early to return to the coordinated phase(s).

- **4 = Sequential Omit:** Sequential Omit is similar to the Permissive Yield mode except it provides a phase by phase sliding window of service (omit lifted), resulting in one and only one phase in a ring having the omit lifted at any time.

- **5=Fully Actuated:** Fully Actuated coordinated is similar to Permissive mode except for the coordinated phase(s) will act as an actuated phase. This is useful if vehicle detection is used on the coordinated phase(s).

Table 7-9: Coordination Mode Codes and Descriptions

Code	Description
0 (Permissive)	Provides Permissive Coordination operation (typical value)
1 (Yield)	Provides Yield Coordination operation
2 (Permissive Yield)	Provides Permissive Yield Coordination (use if push buttons for coordinated phase pedestrian signals are present)
3 (Permissive Omit)	Provides Permissive Omit Coordination operation
4 (Sequential Omit)	Provides Sequential Omit Coordination operation
5 (Fully Actuated)	Provides Full Actuated Coordination operation

EPAC300 Actuated Signal Control Manual (2002)

<u>Example of Permissive and Yield coordination modes:</u>

Assumptions:

- Assume a two-phase semi-actuated signal.
- Coordinated phase: 30 second split, 7 second walk, 20 second APCT*, 5 second yellow & all red
- Actuated phase: 30 second split 7 second walk, 20 second APCT*, 5 second yellow & all red

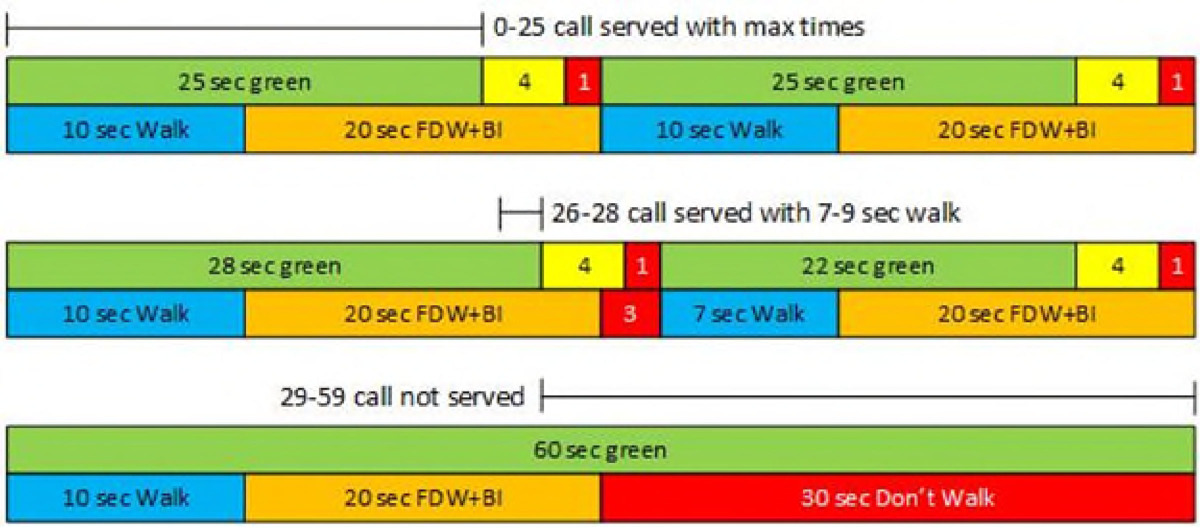
*APCT is actual pedestrian clearance time which consists of the FDW time plus the Steady Don't Walk Buffer Interval (BI).

When a call arrives, will the actuated phase be serviced (times are from start of coordinated green)?

Permissive (Figure 7-9):

- Call during 0-10 - **serviced** (walk will automatically be extended to 10 seconds since there will always be at least 3 extra seconds in the coordinated phase split available. There is time to run all the clearance intervals plus the actuated phase min split.)
- Call during 11-25 - **serviced** (it always runs the Green/FDW so there is no effect on the window, similar to previous in that there should be time to run the remaining clearance intervals plus the actuated minimum split)
- Call during 26-28 - **serviced** (there are 32 or more seconds remaining in the cycle. 5 seconds are needed for the coordinated yellow/all red, and 27 seconds are needed for the actuated phase min split)
- Call during 29-59 - **not serviced** (there is not enough time to run both coordinated yellow/all-red plus the actuated min split)

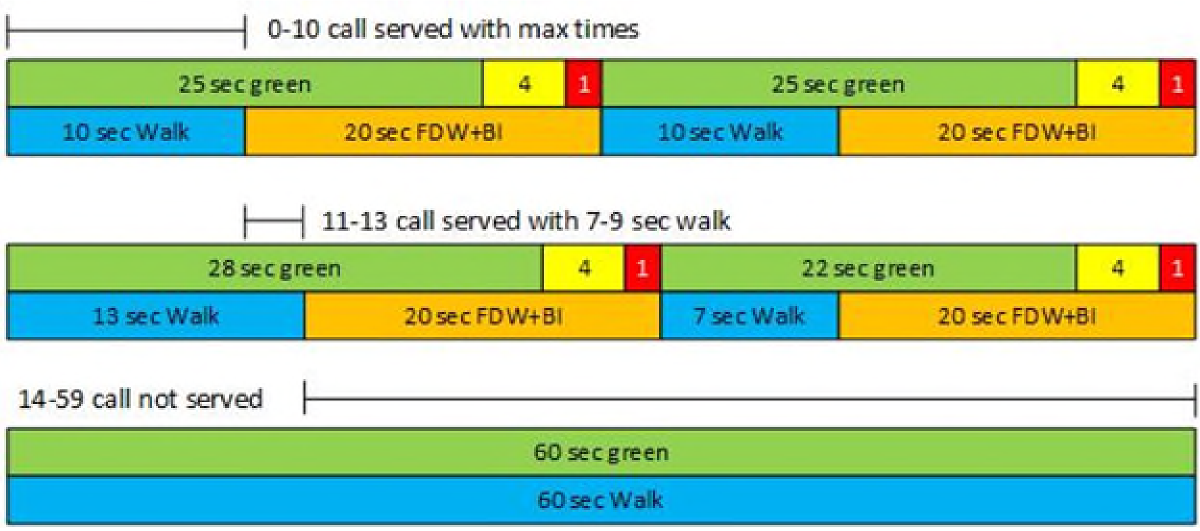
Figure 7-9: Permissive Coordination Mode Example



Yield (Figure 7-10**):**

- Call during 0-10 - **serviced** (walk will automatically be extended to 10 seconds since there will always be at least 3 extra seconds in the coordinated phase split available. There is time to run all the clearance intervals plus the actuated phase min split.)
- Call during 11-13 - **serviced** (FDW would not start until a call came in for the actuated phase. There is enough time to run 20 seconds FDW including yellow/all red and the 27 second min split for actuated phase)
- Call during 14-59 - **not serviced** (there is not enough time to run the FDW and the actuated min split)

Figure 7-10: Yield Coordination Mode Example



- ***Maximum Mode*** **–** The Maximum Mode determines the Maximum time that will be used. See Table 7-11 for codes and descriptions.

Table 7-11: Maximum Mode Codes and Descriptions

Code	Description
0 (Inhibit)	Provides for internal Maximum Timing to be inhibited while coordination is running
1 (Maximum 1)	Provides for Maximum 1 Timing to be effective while coordination is running
2 (Maximum 2)	Provides for Maximum 2 timing to be effective while coordination is running

EPAC300 Actuated Signal Control Manual (2002)

- ***Correction Mode*** **–** The Correction Mode establishes the mode used for offset correction. See Table 7-11 for codes and descriptions. If for some reason, the offset for the signal does not match the offset programmed, the correction mode determines how the signal will adjust the timing in order to move the offset to the correct value. It will typically not violate the minimum times. The offset may be off for a variety of common reasons (When the signal changes timing plans throughout the day, when it comes out of night time flash mode, after a power outage, etc.). The correction mode will typically be found in the controller. It should be noted for EPAC MOD 30 and newer controller models, correction modes can be assigned by individual dials. Therefore, multiple correction modes can be assigned to one controller. This is useful in the event that the preferred Short Way mode can be operated for a dial(s) but cannot function properly with an additional dial that the controller may run daily. In that event, it may be a good opportunity to assigned correction modes to the individual dials.

    - **0** – **Dwell**: causes the signal to dwell in green interval beyond the time defined for the phase until the correction has been accomplished. This correction mode is not typically used. Especially at locations with high cycle lengths, it can cause the signal to dwell in one phase for an inordinate length of time.

- **1** – **Max Dwell**: causes the signal to dwell in the same manner as Dwell, but limits the maximum amount of time the signal can dwell per cycle. If the correction cannot be completed in one cycle, the signal will continue to correct in future cycles until the offset is correct. If they cycle length is 90 seconds or less, Max Dwell may be a good alternative to Short Way +.

- **2** – **Short Way**: allows the signal to dwell or if it can correct the offset faster by reducing the time provided for the phases, it will do that. Correction will not exceed 19% in a cycle and will automatically take into consideration minimum times.

  - With Short Way correction, it is important that the phasing have enough time beyond the minimum times to allow for a reduction in the split time. If this is not accounted for, it is possible for the signal to get caught in an endless loop as it tries to subtract time from a phase and the minimum times don't allow for it. If this happens, the signal will never be able to correct the offset.

  - The requirement to use Short Way is that the sum of the difference between the phase split times and the respective phase minimum split times must exceed at least 19% of the cycle length.

  - If the Short Way method does not meet the requirements stated above, consider Short Way + or Max Dwell Mode.

- **3** – **Short Way+**: this correction mode is identical to Max Dwell except correction will not exceed 20% in a cycle. This mode does not reduce interval times to adjust the offset.

  - If a larger Max Dwell time is entered, it will override the 20% default value. To avoid confusion, if a maximum dwell time other than 20% of the cycle length is desired, use Max Dwell as the correction type. With Short Way+, the Max Dwell should be set to zero.

  - **Short Way is t**he preferred method, but as mentioned above it requires splits beyond what is required for the minimum times.

  - If the intersection contains push buttons this may also affect the decision between **Short Way** and **Short Way+**.

    - The difference between the proposed splits and the minimum times should be looked at to see how much time can be subtracted from the split times (keeping in mind the 20% maximum correction per cycle). Also the difference between the proposed split times and the minimum pedestrian split should be compared (this assume the proposed splits with push buttons are less than the minimum pedestrian split). If based on the differences, the controller will be back in step after one cycle, shortway is likely a good option. I.e. If a push button is utilized and the pedestrian times force the cycle length beyond the split by 5 seconds ("out of step") and the controller is able to subtract 5 or more seconds in the next cycle, its next operation **Short Way** should be applied. If a push button pushes the controller out of step by 15 seconds, but the controller is only able to subtract

2 seconds **Short Way+** should be considered since it would take 8 cycles of reducing time for the controller to get into step.

- **4** – **Short Way2**: this correction mode operates the same as Short Way except when going long will add to all phases proportional to their split time.

Table 7-11: Correction Mode Codes and Descriptions

Code	Description
0 (Dwell)	Provides an offset dwell until correction has been accomplished
1 (Maximum Dwell)	Provides an offset dwell until correction has been accomplished with Max Dwell time establishing the dwell limit for a single cycle.
2 (SWY)	Provides an offset correction by dwelling based on a shortest way calculation. Correction will not exceed 20% in a cycle
3 (SW+)	Provides offset dwell similar to Max dwell except the max dwell time will be the larger of 20% of the cycle OR the entered Max Dwell Time
4 (SW2)	Provides offset dwell similar to SW except when going long will add to all phases proportional to their split time

EPAC300 Actuated Signal Control Manual (2002)

- ***Offset Mode*** **–** The offset mode establishes whether the offset is based on the beginning of the first coordination phase green, Code “0-BEG”, or if the offset is based on the end of the first coordination phase green, Code “1-END”. The typical value is 0.

- ***Force Mode*** **–** The force mode establishes whether the force is based upon the plan timing, Code “0-PLN” or if he force mode is based on the cycle timing, code “1-CYCLE”. The typical value is 0.

- ***Max Dwell*** **–** The Max Dwell establishes the number in seconds (0-999) that the unit may dwell for offset correction in a single cycle if Max Dwell correction is used.

- ***Yield Period*** **–** The Yield Period establishes the number in seconds (0-999) of the yield period for Yield and Permissive Yield coordination modes.

7.2.3 *PREEMPTION INFORMATION FORM – EPAC CONTROLLER*

PREEMPTION INFORMATION is entered on page 3 of the timing permit (see Figure 7-11). This page only needs to be included if preemption information exists. Four preemption plans may be entered on this form. If additional preemption plans are needed an additional sheet may be attached. Up to six preemption plans may be entered into the signal controller, as well as six low-priority preemption plans.

Figure 7-11: EPAC Preemption Information Form

PREEMPTION INFORMATION FORM

Preemption Description:

Preempt # =	Time (s)	Phases		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
SEL Ped Cl	16	Vehicle	Track	R	R	R	R	R	R	R	R									☒ Locking	
SEL Yellow	4.5		Dwell	R	G	R	R	G	R	R	R										
SEL Red Cl	2.0		Cycle	0	0	0	0	0	0	0	0									☐ Non-Locking	
TRACK Green	0		Exit		X				X												
TRACK Ped Cl	0	Ped	Track		D		D		D		D									Delay (s)	0
TRACK Yellow	0.0		Dwell		D		D		D		D									Extend (s)	0
TRACK Red CL	0.0		Cycle		0		0		0		0									Duration (s)	20
DWELL Green	10	Overlap Vehicle	Overlap	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Max Call (s)	60
RET Ped Cl	14		Track	R	R															Lockout (s)	0
RET Yellow	5.0		Dwell	R	R															Link PE #	0
RET Red Cl	2.5		Cycle	0	0																

Preemption Description:

Preempt # =	Time (s)	Phases		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
SEL Ped Cl		Vehicle	Track																	☐ Locking	
SEL Yellow			Dwell																		
SEL Red Cl			Cycle																	☐ Non-Locking	
TRACK Green			Exit																		
TRACK Ped Cl		Ped	Track																	Delay (s)	
TRACK Yellow			Dwell																	Extend (s)	
TRACK Red CL			Cycle																	Duration (s)	
DWELL Green		Overlap Vehicle	Overlap	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Max Call (s)	
RET Ped Cl			Track																	Lockout (s)	
RET Yellow			Dwell																	Link PE #	
RET Red Cl			Cycle																		

Preemption Description:

Preempt # =	Time (s)	Phases		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
SEL Ped Cl		Vehicle	Track																	☐ Locking	
SEL Yellow			Dwell																		
SEL Red Cl			Cycle																	☐ Non-Locking	
TRACK Green			Exit																		
TRACK Ped Cl		Ped	Track																	Delay (s)	
TRACK Yellow			Dwell																	Extend (s)	
TRACK Red CL			Cycle																	Duration (s)	
DWELL Green		Overlap Vehicle	Overlap	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Max Call (s)	
RET Ped Cl			Track																	Lockout (s)	
RET Yellow			Dwell																	Link PE #	
RET Red Cl			Cycle																		

Preemption Description:

Preempt # =	Time (s)	Phases		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
SEL Ped Cl		Vehicle	Track																	☐ Locking	
SEL Yellow			Dwell																		
SEL Red Cl			Cycle																	☐ Non-Locking	
TRACK Green			Exit																		
TRACK Ped Cl		Ped	Track																	Delay (s)	
TRACK Yellow			Dwell																	Extend (s)	
TRACK Red CL			Cycle																	Duration (s)	
DWELL Green		Overlap Vehicle	Overlap	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Max Call (s)	
RET Ped Cl			Track																	Lockout (s)	
RET Yellow			Dwell																	Link PE #	
RET Red Cl			Cycle																		

Preempt System Data

Ring	1	2	3	4		
MIN GRN/WLK (s)	7.0	7.0	7.0	7.0		
Priority	PE/FL	PE1/2	PE2/3	PE3/4	PE4/5	PE5/6
Status	1	0	0	0	0	0

REMARKS :
OPTIMIZED BY: ANYONE INC.

PREPARED BY: LAB DATE: 07/30/08

LOCATION:
MAIN STREET AT LANSING STREET

CONTROL SECTION-SPOT #
55555-01-555

Page 3 of 3

SECTION A – PREEMPT SYSTEM DATA

The preempt system data allows the user to include parameters that are common to all six preempts.

- ***Min Grn/Wlk*** – This establishes the time in seconds which any Green and or Walk interval must have been displayed prior to it's termination for a transition to Preempt. This may be set independently for each of the four rings in the ring and barrier structure.

- ***Priority and Status*** – The entry (Code "0" = NO and Code "1" = YES) establishes whether the first function has priority over the second. An entry of "0" indicates no priority between the two. When a function has priority over another, the function of lower priority will terminate and the higher priority will assume control.

  PE/FL – Preemption to Remote Flash

  PE1/2 – Preempt 1 over Preempt 2

  PE2/3 – Preempt 2 over Preempt 3

  PE3/4 – Preempt 3 over Preempt 4

  PE4/5 – Preempt 4 over Preempt 5

  PE5/6 – Preempt 5 over Preempt 6

SECTION B – PREEMPT TIMES

- ***Preemption Description*** – Enter a description of the preemption here.

- ***Preempt Number*** - Indicate which of the 6 available preempts is being defined. If more than four preempt plans exist, then an additional form should be attached for the additional preempts.

- ***SEL Ped Cl, SEL Yellow, SEL Red Cl*** – The "*Selective*" clearance intervals are provided to transition from normal operation into a preempt. Proper values for "SEL Yellow" and "SEL Red Cl" cannot be terminated early during this transition. The proper pedestrian clearance time can be terminated early if necessary by using the "SEL Ped Cl". The type of preemption typically determines how much transition time is feasible. Railroad preemption will typically require minimal transition time. Emergency vehicle preemption will typically allow for the full more transition time.

  - With EPAC Software versions prior to 3.56, setting the SEL PED CLR to "0" seconds results in the controller immediately terminating a timing ped clearance (or skipping the ped clearance if the Walk was timing) upon activation of the preempt input.

  - With EPAC Software version 3.56 or greater, a SEL PED CLR setting of "0" results in the use of the Ped Clearance setting that is in Phase Data for timing the pedestrian clearance upon activation of the preempt input.

  NOTE: **When replacing existing controllers (having EPAC Software versions prior to 3.56) with new controllers (using EPAC Software version 3.56 or greater), it is imperative that any existing settings of SEL PED CLR = "0" be changed to SEL PED CLR = "1" to avoid long transition times.**

- With EPAC Software version 3.56 or greater, a value of "1" second for SEL PED CLR will transition to preempt operation as quickly as possible.

- With EPAC Software versions prior to 3.56 for railroad preemption, the SEL PED CLR was typically set to "0" to transition to preempt as quickly as possible. Due to the potential for this setting to be a problem with newer controller software, the SEL PED CLR should be set to "1" to transition to preempt as quickly as possible.

- For emergency vehicle preemption, the SEL PED CLR is typically set to the largest of the "Pedestrian Clearance" values from the various phases in operation. For example, at a two-phase signal where the normal pedestrian clearance is 12-seconds for one phase and 14-seconds for the second phase, 14-seconds would be entered for the *SEL Ped CL* as it is the larger of the two phases. The phase that it is transitioning to generally does not need to be considered unless there is a track green being utilized.

- The MDOT project manager must be consulted prior to changing any of these values. Railroads are required to provide a minimum amount of time prior to the train entering the intersection. If this minimum time is not sufficient, the required amount of time must be calculated and provided to the MDOT project manager and to the railroad.

- ***TRK Green, TRK Ped Cl, TRK Yellow, TRK Red Cl*** – The "*Track"* intervals are provided when a railroad track is located close to the intersection and they are intended to keep vehicles from queuing across the track. The intervals provide a short period of green as well as clearance intervals at the intersection while the pre-signal at the tracks stays red. Doing this clears vehicles that were stopped on the tracks while not allowing more vehicles on to the tracks. The "*Track*" intervals are typically used when there are near and far signal heads at an intersection. The "*Track*" intervals clear vehicles between the near and far signal head to avoid vehicle trapping.

  - ***TRACK GREEN*** interval provides the time for the *TRACK Green*. If no time is entered for the *TRACK Green* interval, the "*Track"* intervals will be skipped (*Track Green, Track Ped Clear, Track Yellow,* and *Track Red Clear*).

    - ***If the signal utilizes a flashing red ball for left turns, the track green must provide a minimum of 1.0 seconds in order to operate correctly.***

  - The ***TRACK Ped Clear*** interval is the time provided to clear a terminating Walk during the transition to *DWELL Green*.

  - The ***TRACK Yellow*** interval is the time provided to clear a terminating Green during the transition to *DWELL Green*.

  - The ***TRACK Red Clear*** interval is the time provided to clear a terminating Yellow during the transition to *DWELL Green*.

- ***DWELL Green, RET Ped Cl, RET Yellow, RET Red Cl*** – The *DWELL Green* interval is the time that the intersection will dwell in green for the allowed phases during the preempt. The "*Return*" clearance intervals are provided to transition from preempt operation into normal operation. These values should be set to the normal clearance intervals for the respective approach.

- When the signal exits out of preempt operation the signal will run the MAX 1 times for one cycle before returning into normal coordinated operation.

  - If queuing is a concern after the pre-emption event is completed, a simple method to address the queuing by simply increasing the MAX 1 times for the phase that has backed up. This will provide one cycle where the queued approach receives a substantial increase in green time and then the controller reverts to normal operation. This is the minimum time; if more time is needed, due to substantial queuing, the extra time can be added to the lockout time as described on page 35.

  - A more complicated method, involves setting up a second preempt utilizing the Link to PE # function. This option provides more flexibility but requires setting up an additional pre-empt that is automatically called up at the end of the primary pre-empt and runs for a predetermined time frame.

  - If any of these options are utilized, a note should be included on the permit.

For railroad preempts the amount of fixed time the railroad gives the traffic signal prior to the train entering the intersection is 20 seconds unless otherwise specified in writing from the railroad owner. Therefore, the sum of the **Min Grn/Wlk, *SEL Ped Cl, SEL Yellow, SEL Red Cl,*** and ***TRACK GREEN*** times shall not typically exceed 20 seconds.

SECTION C – PREEMPT STATUS

- ***Vehicle*** – The vehicle signal head displays for the *TRACK Green* and *DWELL Green* for each phase are entered in this area. Possible entries for these phases include:

R	Red
G	Green
FR	Flashing Red
FY	Flashing Yellow
Blank	Dark

The phases that are permitted to "*Cycle"* during the *DWELL Green* are also entered in this area in the *Cycle* row. Possible entries for **EPAC** phases include:

0	*Vehicle Phase* will not cycle
1	*Vehicle Phase* will cycle based on demand
2	*Vehicle Phase* will cycle on Min Recall

3	*Vehicle Phase* will cycle on Max Recall

- ***Pedestrian*** – The pedestrian signal head displays for the *TRACK Green* and *DWELL Green* for each phase/interval are entered in this area. Possible entries for these phases/intervals include:

DW	Don't Walk
W	Walk
Blank	Dark

The pedestrian phases that are permitted to "*Cycle*" during the *DWELL Green* are also entered in this area in the *Cycle* row. Possible entries for **EPAC** phases include:

0	*Pedestrian Phase* will not cycle
1	*Pedestrian Phase* will cycle based on demand
2	*Pedestrian Phase* will cycle on Recall

- ***Overlap Vehicle*** - The vehicle signal head displays for the *TRACK Green* and *DWELL Green* for each phase/interval are entered in this area for overlap vehicles. Possible entries for these phases/intervals include:

R	Red
G	Green
FR	Flash Red
FY	Flash Yellow

The overlaps that are permitted to "*Cycle*" during the *DWELL Green* are also entered in this area in the *Cycle* row. Possible entries for **EPAC** phases include:

0	*Overlap Vehicle* will not cycle
1	*Overlap Vehicle* will cycle based on service to included phases

SECTION D – MISCELLANEOUS PREEMPT PARAMETERS

- ***Locking / Non-Locking***

  - ***Non-Locking*** preempt memory: there is no memory storage of a preempt call. The preempt detector must have a continuous call in order to maintain a call for service of the preempt routine.

  - ***Locking*** preempt memory: once a preempt detector gets a call, this call is "locked" in and remains a constant call until the preempt routine is serviced.

- ***Delay*** – This denotes the number of seconds (0-999) that the Preempt actuation must be active before normal controller operations are interrupted for the Preempt routine.

- ***Extend*** – This denotes the number of seconds (0-999) that each Preempt actuation shall be extended from the point the actuation terminates.

- ***Duration*** – This denotes the number of seconds (0-999) which a Preempt requires prior to a transition back to normal traffic operations can occur.

- ***Max Call*** – This establishes the number of seconds (0-999) which a Preempt call may remain active and be considered valid.

- ***Lockout*** – This establishes the number of seconds (0-999) following the exit from the Preempt Routine that will occur prior to entering a Low Priority Routine.

  - When this value is "0", Lockout will be in effect until:

    - No serviceable Conflicting Call Exists or

    - Any phase is re-serviced following the exit.

- ***Link PE #*** - This establishes the higher priority Preempt routine which is to be linked to this Preempt routine.

SECTION E – REMARKS

Section E is the *REMARKS* section. Any information that is necessary for the proper installation of the signal timing permit that was not captured by the fields of the signal timing permit should be entered in this section. If all of the remarks do not fit into the space provided, do not change the font size as MDOT will lose all of this information in their database when the font is changed.

If a timing permit is prepared by a consultant, the consultant name should be included in the remarks section. For example:

"OPTIMIZED BY (Insert Organization Name)"

SECTION F – LOCATION

Section F provides general information about the signalized location including:

- Who prepared the timing permit and the date
- The location and control section-spot number

This data automatically transfers from the first page.

7.3 EPIC/EF-140 CONTROLLER UNITS

7.3.1 *BASIC TIMING PARAMETERS FORM – EPIC/EF-140 CONTROLLER UNITS*

The EPIC and EF-140 controller units are interval–based pre-timed traffic controller units. Limited vehicle and pedestrian actuation can be accommodated through the use of detectors and alternate pre-timed paths entered into the interval sequences. The procedures for completing timing permits for pre-timed and actuated (alternate path) formats are detailed below, respectively.

PRE-TIMED EPIC/EF-140 CONTROLLER TIMING PERMIT

Figure 7-12 represents a sample signal timing permit sheet for an EPIC or EF-140 controller operating in pre-timed mode. The sample illustrates a signal with lagging permitted-protected left-turns on Main Street, and pedestrian crosswalks provided on both Main Street and Lansing Street. A description of each section (A – E) of the signal timing permit, and how to properly fill in these sections, is provided in the text that follows. All of the general information (Sections 1-5) is presented under Section 7.4 Standard Information: Page 1. The ranges and increments for the timed values entered into the timing permit are provided in Table 7-12.

Figure 7-12: EPIC/EF-140 Pre-Timed Permit Example

P1500D (R4/88)

SOLID STATE TRAFFIC SIGNAL TIMING PERMIT

CYCLE LENGTH	OFF-SET	HOURS OF OPERATION	INTERVAL TIMING (SECONDS) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SEC	SEC	MINIMUM TIME °	7.0	3.0	6.5	6.0	4.5	1.0	3.0	4.0	4.5	1.0	7.0	15.0	4.5	1.0										
70	5	NORMAL D 1 S 1 SPLITS 28/14/28	7.0	3.0	6.5	6.0	4.5	1.0	4.5	4.0	4.5	1.0	7.5	15.0	4.5	1.0										
80	55	AM PEAK 07:00 - 09:30 D 2 S 1 SPLITS 32/15/33	10.0	4.0	6.5	6.0	4.5	1.0	5.5	4.0	4.5	1.0	12.5	15.0	4.5	1.0										
80	20	PM PEAK 16:00 - 19:00 D 3 S 1 SPLITS 34/14/32	12.0	4.0	6.5	6.0	4.5	1.0	4.5	4.0	4.5	1.0	11.5	15.0	4.5	1.0										
		C D S SPLITS												D												

LOAD SWITCH	DESCRIPTION	SIGNAL PLAN -- CYCLE SEQUENCE CHART 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	FLASH
V1	MAIN STREET THRU (EB & WB)	G	G	G	G	Y	R	R	R	R	R	R	R	R	R											Y
P1	MAIN STREET LT (EB & WB)	FR	FR	FR	FR	FR	FR	GL	Y	R	R	R	R	R	R											R
V2	LANSING STREET (NB & SB)	R	R	R	R	R	R	R	R	R	R	G	G	Y	R											R
V3	MAIN STREET PED	W	W	FD	FD	D	D	D	D	D	D	D	D	D	D											
V4	LANSING STREET PED	D	D	D	D	D	D	D	D	D	D	W	FD	FD	D											
	A												B													
	C=Correction, I=Enter Flash, O=Exit Flash	CO						C				C			I											

REMARKS MAIN STREET CORRIDOR OPTIMIZATION PROJECT OPTIMIZED BY: ANYONE INC 1	Controller Type: ☒EPIC ☐EF140 4 ☐Other:	FLASH HOURS: 22:00 to 06:00 E DAILY ☒ NONE 2 ☐	PRE-EMPT 3 ☐ COUNTDOWN PEDS ☐
	DATE TIMING INSTALLED	LOCATION: MAIN STREET AT LANSING STREET	
	JOB # (IF APPLICABLE): 55555	5 CITY/TWP.: LANSING	COUNTY: INGHAM
	PREPARED BY: LAB DATE: 07/30/08	MILE POINT: 5.55	CONTROL SECTION - SPOT # 55555-01-555

Page 1 of 2
Page 3 included only if Pre-Empt is Checked

Table 7-12: EPIC and EF-140 Signal Timing Permit Ranges and Increments

Function	Range (seconds)	Increments (seconds)
Cycle Length	*60-999	**1**
Offset	0-999	**1**
Interval Timing	**0-99.9**	****0.1**

*60 seconds minimum is MDOT's typical restriction; cycle lengths less than 60 seconds require MDOT approval Actual controller range is 0-999 seconds
**Restrictions exist for the EF-140 Controller (see Section D)
Source: *EPIC140 Pre-timed Controller Unit Manual (1997)*

SECTION A – PHASE DESCRIPTIONS

Section A establishes the phases that will occur in the signal timing plan.

The Description is a text description of the vehicle or pedestrian movement linked to the signal head indications entered for that row in the cycle sequence chart (see Section B). The permit form allows for 11 rows. If more than 11 vehicle and pedestrian phases are in use, a second form with the additional movements should be provided.

There is a corresponding load switch (LS) wired into the controller that corresponds to each movement described as well. The Load Switch values range from (V-1 to V-4, P-1 to P-4 and V-A to V-D). *Load switches* are devices that switch the load current to the appropriate indication (phase red, green or yellow). Each load switch consists of three outputs into the field load bay which connect to a field terminal. These load switches allow a low voltage signal from the Controller Unit to control the delivery of high current and voltage to the traffic signal load.

Standard load switch assignments for a cabinet with 8 load switches are as follows:

LS1(V-1) and LS2(V-2) are typically used for vehicle movements and LS3(V-3) and LS4(V-4) are used for the pedestrian signals associated with LS1 and LS2, respectively. LS5(P-1) and LS6(P-2) are typically used for vehicle movements and LS7(P-3) and LS8(P-4) are used for the pedestrian signals associated with LS6 and LS5, respectively.

Standard load switch assignments for a cabinet with 12 load switches are as follows:

LS1(V-1) through LS4(V-4) and LS5(P-1) through LS8(P-4) are used for vehicle movements. LS9(V-A), LS10(V-B), LS11(V-C), and LS12(V-D) are used for pedestrian signals associated with vehicle movements LS2, LS4, LS6, and LS8 respectively.

While these are the typical convention, individual intersections may utilize them differently. The value for the load switch will typically need to be obtained from the existing timing permit or from the controller cabinet.

SECTION B – CYCLE SEQUENCE CHART

The cycle sequence chart in Section B is where the signal indication is entered for each interval. Each row corresponds to the phase defined in Section A. Possible entries for these intervals include:

G	Green
GL	Green Left Arrow
GR	Green Right Arrow
R	Red (used for ball or arrow)
FR	Flashing Red
Y	Yellow (used for ball or arrow)
FY	Flashing Yellow
W	Walk
D	Don't Walk
FD	Flash Don't Walk

Some indications for turning movement simply go dark during parts of the cycle. When the indication is dark, simply leave those intervals blank.

Twenty-four (24) intervals are provided on the signal timing permit to enter the signal indication for each phase description. The EPIC and EF-140 controllers allow for up to 32 intervals of data entry. Should more than the 24 intervals be needed, a second sheet may be attached. The second sheet should note in the Remarks Section (Section G1) that interval one of that sheet is actually interval 25. Interval eight (8) on the second sheet will be the last interval possible for data entry, as it represents interval 32 in the controller unit.

At signalized locations with no pedestrian signals, it was common for the green-time of individual splits to be divided into more than one interval to accommodate for potential future pedestrian signal intervals. This is a remnant of the EF-140 controllers that required a permanently burnt in PROM chip, which limited the ability to add intervals at a later date without burning a new PROM chip. With the advent of EPIC controllers the duplicate intervals were often still utilized even though they were not necessary. The duplicate intervals should not be removed when updating the permit. This is intended to minimize the potential for errors during the programming of the controllers. If the controller is being modernized, all interval information will need to be entered regardless and the unnecessary intervals should be eliminated. Duplicate intervals can be eliminated only if the intervals are forced to be redone, such as adding an all red or trail green to the signal.

Where duplicate intervals do exist, the minimum green time should be split roughly equally between them and the interval time for the second interval should be set equal to the minimum time for all dial/split combinations. This will cause all changes in splits along with correction to occur in the first of the duplicate intervals. In addition, if a pedestrian crossing is present at the intersection duplicate intervals for the vehicle phase are needed to accommodate the walk time and all or a portion of the pedestrian clearance interval. It is typical to have the minimum time for the second interval of a phased be governed by all or a portion of the pedestrian clearance time.

The last column in Section B denotes the state of the signal indication for each respective vehicle phase when the controller is in Flash Mode. Entries here should be **Y** (yellow), **R** (red) or Blank (dark). In the event conflict flash and scheduled flash operations are different, the remarks section should be updated to clarify.

Into and Out of Flash

The last row in Section B denotes the entry/exit interval for the flash mode and the intervals that can be used for offset correction operation. The entry interval should be designated with an "I" for **I**nto Flash, and the exit interval should be designated with an "O" for **O**ut of Flash. The Into Flash transition will occur at the end of the specified interval. The Out of Flash transition will occur at the beginning of the specified interval. The signal will typically enter Into Flash at the end of the side road's All Red interval. The signal will typically come Out of Flash at the beginning of interval 1, or the main street's green. If pedestrian push buttons are present and the last interval is a main street green, do not exit Out of Flash in this interval. If there is no flash schedule the Into and Out of Flash intervals should still be entered to account for power outages.

Correction Intervals

The intervals used for offset correction operation should be designated with a "C". Correction is allowed in intervals that are not timing a clearance interval (Yellow, All Red or Flashing Don't Walk). Typically these will be green/walk intervals. Multiple intervals can and should be coded for correction if the minimum times allow for it. With multiple correction intervals the coordinator will split the correction time for each cycle proportionally among the correction intervals based on the difference in the correction intervals between the Min time and interval time provided in the Dial/Split data. This is true for all correction modes including Dwell, Dwell with Interrupt, Short Way, and Short Way +. If there are multiple green/walk intervals for a phase, set one interval to be the same for all dial/split combinations and make changes to the other interval. For the interval that does not change, try to set the minimum time equal to the interval time. This will ensure that the correction does not occur during this interval.

- Before allowing correction in an interval, it should be verified that the interval times **EXCEED** the minimum time for the interval or Short Way correction should not be used (see Section D for more details on minimum times and Section 7.2 for details on Correction Mode).

- For an interval in which correction is being considered, if some Dials allow for correction but others don't, code it to provide correction. For the dials in which there is no additional time beyond the minimum time, the controller will correct in other intervals.

- If the signal is an EF-140, leave the Correction and Into/Out of Flash off of the permit because what is currently in operation is unknown and is permanently burned into the PROM.

SECTION C – DIAL SET-UP

Section C is the dial data section. It establishes the pre-timed cycle lengths, offsets, and hours of operation for up to four timing plans. A controller can accommodate up to four dials, and each dial can accommodate up to four different splits, allowing a controller to accommodate up to 16 different timing plans total. Each dial/split combination can accommodate up to 3 offsets. Under typical conditions, MDOT's standard convention is to use Dial 1, Split 1, Offset 1 for normal "off-peak" operation, Dial 2, Split 1, Offset 1 for the AM peak period, and Dial 3, Split 1, Offset 1 for the PM peak period. Construction and special event timing plans should be placed in Dial 4. However, assignment of dials may vary depending on maintaining agency and should therefore be determined in advance of preparing a timing permit. If more than the four timing plans provided on the first page of the permit are needed, there are spots for up to four additional timing plans available on the second page (see Section 7.2).

- ***CYCLE LENGTH*** – The first column is where the cycle length is entered, in seconds, for each dial in operation.

- ***OFFSET*** – The second column is where the offset is entered, in seconds, from the system zero time for each dial in operation. Up to three offsets can be entered for each split. For uncoordinated locations, enter zero.

- ***HOURS OF OPERATION*** – The hours and days of the week of operation for each dial in operation are entered here. A timing plan must be designated for all time periods 24-hours a day, seven days a week, except for the hours where the signal is designated to operate in flash mode (see Section F). Dial 1, Split 1, Offset 1 is often simply designated as "Normal." This implies that for any time period in which another dial-split combination is not called out and the signal is not in nighttime flash mode, the signal will run this plan.

- ***Dial Split Designation*** – The dial and split number are entered below the Hours of Operation. Both the dial and split can range from (1-4). Default values of (D1/S1, D2/S1, and D3/S1) have been entered in the first three timing plans. If necessary, these values may be overridden.

- ***Phase Split Times*** – The split times, in seconds, for each phase can be entered in the box provided for splits. For example, the splits in the example for D1/S1 are 28/14/28. If the splits are variable due to vehicle detection or pedestrian push buttons, this entry may be left blank.

Valid offset entries for EF-140 controllers range from zero to the cycle length minus one second. An offset equal to the cycle length will make the controller run free on that particular dial. An offset greater than the cycle length is invalid and the dial will not run.

Valid offset entries for EPIC controllers range from zero to the cycle length minus one second. An offset greater than or equal to the cycle length will make the controller run free on that particular dial.

For an EF-140 controller, the *OFFSET* time, when subtracted from the end of the cycle, should not occur during a yellow or all-red interval when used in a coordinated system. During dial changes or other synchronization periods, the controller will dwell at the offset point until the clock reaches synchronization with the system time. If the offset point occurs within a yellow or all-red interval, the signal will dwell in that interval, leading to lengthened clearance interval that may confuse drivers. Offsets should therefore always be designated to fall within a green interval.

SECTION D – INTERVAL TIMING

The interval timing section is where the length of the intervals is entered for each dial in operation as well as the minimum times for each interval (Minimum Time row is above the first Dial-Split row). The interval lengths entered in Section D correspond to the length of the signal indications entered in Section B.

Minimum times should reflect the minimum Yellow, All-Red, or Flash Don't Walk intervals, as calculated per MDOT's clearance interval methodology (See chapter 4.0 for details). In addition, minimum Walk and Initial Green intervals should be entered based on MDOT standards wherever possible. The minimum standards are as follows:

- *Minimum Green* for major roadway – 10.0 seconds
- *Minimum Green* for minor roadway/cross-street – 7.0 seconds
- *Minimum Green* for all left-turn phasing with the exception of actuated permitted-protected left-turn phasing – 7.0 seconds
- *Minimum Green* for actuated permitted-protected left-turn phasing – 5.0 seconds
- Minimum *WALK* time – 7.0 seconds

A *Minimum Green* of 5.0 seconds may be used for a protected left-turn phase with MDOT approval. This would be considered when the left-turn volume is extremely low and the additional 2.0 seconds taken from the left-turn would provide a significant benefit to the other phases of the signal. A minimum WALK time of 4.0 seconds may be used, where deemed appropriate based on pedestrian volumes and timing requirements, with approval of MDOT.

If there are duplicate green/walk intervals, the minimum times should be set such that the total of the two intervals is equal to the minimum times above.

For an EF-140 controller, the interval time may only be entered with a decimal place up to 12.7 seconds. Any interval time above 12.7 seconds must be entered as a whole number.

For an EF-140 controller, the minimum times are fixed (burned) into the controller and are not easily adjustable. Typically, these minimum times will be left alone and not adjusted. If there is a need to adjust the minimum times, the MDOT project manager will need to approve.

Interval times should always equal or exceed the minimum times. If the minimum time for an interval exceeds the interval time for a Dial-Split, the minimum time will be run and the signal will not stay in coordination.

SECTION E – FLASH SCHEDULE

Information for determining an appropriate flash schedule can be found in Section 5.2.7.

ACTUATED EPIC/EF-140 CONTROLLER TIMING PERMIT

The EPIC and EF-140 controller units do have limited actuation capabilities through the use of multiple pre-timed paths. The pre-timed path to be followed is determined by calls (or the absence of calls) placed by vehicle and pedestrian detectors. For the EPIC controller unit, there are two detector groups; Detector A and Detector B. Each detector group allows for a pedestrian and vehicle call.

The majority of the timing permit for operation in actuated mode is completed similarly to that of pre-timed control (see Section 7.1) However, multiple paths must be established in the Cycle Sequence Chart and Interval Timing Chart, corresponding to the various timing sequences, should detector calls occur. Figure 7-13 illustrates a sample signal timing permit for an EPIC or EF-140 controller operating in actuated mode, with multiple pre-timed paths. A description of how to complete each affected section of the signal timing permit to reflect operation in actuated mode follows.

Figure 7-13: EPIC/EF-140 Actuated Timing Permit Example

P1500D (R4/88)

SOLID STATE TRAFFIC SIGNAL TIMING PERMIT

CYCLE LENGTH	OFF-SET	HOURS OF OPERATION	INTERVAL TIMING (SECONDS) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SEC	SEC	MINIMUM TIME*	7.0	8.0	3.5	2.5	7.0	10.0	3.5	2.5	7.0	3.5	2.5	1.0												
70	5	Normal D 1 S 1 SPLITS 30/14/26	16.0	8.0	3.5	2.5	10.0	10.0	3.5	2.5	8.0	3.5	2.5	14.0												
80	55	AM Peak 07:00-09:00 D 2 S 1 SPLITS 43/14/26	26.0	8.0	3.5	2.5	10.0	10.0	3.5	2.5	8.0	3.5	2.5	14.0												
80	66	PM Peak 15:00-18:30 D 3 S 1 SPLITS 43/14/26	26.0	8.0	3.5	2.5	10.0	10.0	3.5	2.5	8.0	3.5	3.5	14.0												
		D S SPLITS																								

LOAD SWITCH	DESCRIPTION	SIGNAL PLAN -- CYCLE SEQUENCE CHART 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	FLASH
V1	Matin Street Thru	G	G	Y	R	R	R	R	R	R	R	R	G													Y
V2	Lansing street	R	R	R	R	G	G	Y	R	R	R	R	R													R
V3	Main Street LT	R	R	R	R	R	R	R	R	G	Y	R	R													R
P1	Main Street Ped	W	FD	FD	D	D	D	D	D	D	D	D	W													
P2	Lansing Street Ped	D	D	D	D	W	FD	FD	D	D	D	D	D													
	Actuation	0	0	0	0	0	0	0	0	5	5	5	6													
C=Correction, I=Enter Flash, O=Exit Flash		CO				C				C		I	C													

REMARKS
Main Street Corridor Optimization Project

Optimized by Anyone Inc.

Controller Type: ☒ EPIC ☐ EF140 ☐ Other:

DATE TIMING INSTALLED

JOB # (IF APPLICABLE): 55555

PREPARED BY: LAB DATE: 05/05/05

FLASH HOURS: 22:00 to 06:00 DAILY ☒ NONE ☐

PRE-EMPT ☐
COUNTDOWN PEDS ☐

LOCATION: Main Street at Lansing Street

CITY/TWP.: Lansing COUNTY: Ingham

MILE POINT: 5.55

CONTROL SECTION - SPOT # 55555-01-555

CLEAR PAGE 1 CLEAR ALL

Page 1 of 3
Page 3 included only if Pre-Empt is Checked

SECTION A – CYCLE SEQUENCE CHART

The cycle sequence chart is used to define the signal indications throughout a series of actuated "paths". The various signal paths are denoted with actuation codes. The actuation codes and their descriptions are shown in Table 7-13. Typical multi-path sequences are illustrated in Figure 7-14.

Table 7-13: Actuation Codes and Descriptions

Code	Description	Sequence Restrictions
0 **(Non-Actuated)**	Interval is not actuated and will always run. An interval with code "0" also serves as a choice interval during which the controller unit determines which interval to run next, given two or more branches in the interval path. This is the only interval during which the controller accepts detector calls.	Must be included in all actuated timing plans and will precede all other codes used.
1 **(Either)**	Indicates that a call on either one of the two detector groups will provide the same signal displays in response to detector actuations regardless of which detector calls are received on.	Code "1" (if used) must follow Code "0". Must precede Codes "2", "3" or "4" (if used), or Codes "6" and "7" (if used).
2 **(A Only)**	Interval is actuated by calls on Detector A only and no calls on Detector B. This code is used in conjunction with code "3" and code "4" to provide differing signal sequences depending on whether there are calls on Detector A only, Detector B only, or both Detector A and Detector B. Generally if one of these codes, 2, 3, or 4 is employed, paths should be provided for all three possibilities.	Must follow Code "0" or "1". Must precede Codes "3" or "4" (if used).
3 **(B Only)**	Interval is actuated by calls on Detector B only and no calls on Detector A. See comments in code "2."	Must follow Code "0" or "1". Must follow Code "2" (if used). Must precede Code "4" (if used).
4 **(Both)**	Interval is actuated only if both Detector A and Detector B both have calls.	Must follow Code "0" or "1". Must follow Codes "2" or "3" (if used).
5 **(Default)**	Interval is a default interval. If none of the alternate paths are taken because of no calls on Detector A or B, the default path will be taken. Default (code 5) intervals must constitute the last alternate path in a set of intervals.	Must be the last alternate path of any sequence. All other codes used must precede Code "5". Code "5" cannot be used elsewhere in the sequence.
6 **(A)**	Indicates that a call on Detector A, regardless of whether there are any calls on Detector B, will select the alternate path of intervals.	Must follow Code "0" or "1". Must precede Code "7" (if used).
7 **(B)**	Indicates that a call on Detector B, regardless of whether there are any calls on Detector A, will select the alternate path of intervals.	Must follow Code "0" or "1". Must follow Code "6" (if used).

Source: *EPIC140 Pre-timed Controller Unit Manual (1997)*

Additional constraints on the use of actuation codes are as follows:

- The lowest numbered interval to run MUST BE non-actuated. Generally this is interval one.
- The controller unit determines the alternate path to serve based on detector call status only in non-actuated (Code 0) and Either (Code 1) intervals.
- Primary branches in the interval path (branches from the main interval path) must be immediately preceded by a non-actuated (Code 0) interval. Secondary branches to Codes 2, 3, and 4 may follow Code 1 intervals.

- All actuated intervals, except those with Code 1, in a set of alternate paths must be assigned to consecutive intervals, with no Code 0 or Code 5 intervals intervening, and those with the same code must be grouped together.
- Code 1 intervals may immediately precede or follow any group of actuated alternate paths.
- In a set of alternate paths, there may be one or more Default (Code 5) intervals, which will then be serviced if none of the other alternatives is met; these Default interval(s) must also be consecutive, and must immediately follow the last actuated interval of that set of alternate paths.
- It is possible to have more than one set of primary branches in a cycle, if there is at least one non-actuated (Code 0) interval in between.
- In branches with alternate paths Codes 6 and 7, if there are calls on both detectors, the path with the LOWER-numbered intervals will be serviced.

Figure 7-14: Typical Multi-Path Operation Sequence

SECTION B – INTERVAL TIMING

Timings for each interval in actuated mode are governed by the same restrictions as those of pre-timed locations as discussed in Section 7.1. However, care must be taken to assure that timings for each path equal the defined cycle length for each dial. The following is an example taken from the sample permit illustrated in Figure 7-13:

Example: The intersection of Main Street and Lansing Road operates with two paths: the default path (if no detector calls are received), and the actuated path (if a call is received on Detector A).

- **Default Path (0→5):** The default path is comprised of intervals with actuation codes "0" and "5". In this case, this includes Interval 1-8, and Intervals 9-11. Therefore, the sum of timings for Dial 1, intervals 1-8 and 9-11must equal the cycle length of 70 seconds.

- **Actuated Path (0→6):** The actuated path is comprised of intervals with actuation codes "0" and "6". In this case, this includes Intervals 1-8, and Interval 12. Therefore, the sum of timings for Dial 1, intervals 1-8 and 12 must equal the cycle length of 70 seconds.

EPIC/EF-140 controllers are not capable of extending a cycle length based on detector calls received. All alternative path intervals must independently sum to the assigned cycle length for that dial.

MISCELLANEOUS ACTUATED OPTIONS

EXTEND and *DELAY* times can also be used in association with actuated intervals.

- ***EXTEND*** – When in the actuated intervals associated with the detector, an actuation (input duration) shall be extended from the point of termination by the *EXTEND* time entered (0-99.9 seconds). *EXTEND* times and the intervals they pertain to should be described in the *REMARKS* section (Section G1).

- ***DELAY*** – When not in the actuated intervals associated with the detector, a detector actuation shall be delayed by the *DELAY* time. Once the actuation has been present for the *DELAY* time, it shall be continued for as long as it is present (0-99.9 seconds). *DELAY* times and the intervals they pertain to should be described in the *REMARKS* section (Section G1).

EXTEND timings do not apply to "Either" or "Default" path intervals in regard to *FORCE INTERVALS* and extend/gap operation. *DELAY* is operational in "Either" or "Default" path intervals and disabled in other path intervals.

FORCE INTERVALS

Though not commonly used, the EPIC/EF-140 controllers have the capability of variable time intervals called ***FORCE INTERVALS***. A *FORCE INTERVAL* is an actuated interval with the capability to terminate early if there are no detector calls. The remaining time from the actuated interval is then distributed to a non-actuated interval so that the cycle length remains unchanged.

Any actuated green interval can be specified as a *FORCE INTERVAL.* If there are no calls currently present on a detector when an actuated path is used, a *FORCE INTERVAL* will terminate early with at least the *MINIMUM TIME* for the actuated interval in use. The remaining time from the *FORCE INTERVAL* that was unused is distributed to the next non-actuated interval in the controller path (this is typically a main street green interval). If there are constant calls on the detector, the *FORCE INTERVAL* will run the full interval time listed for the timing plan.

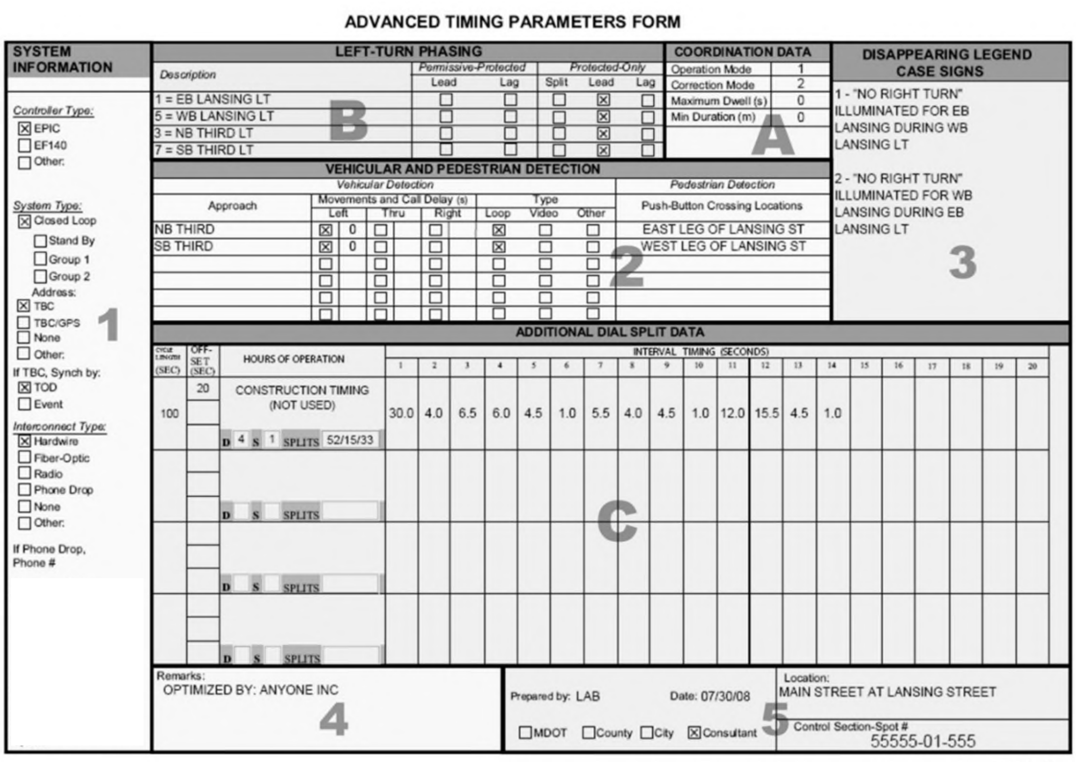
Because it is not common for EPIC/EF-140 controllers to use FORCE INTERVALS, the current timing permit does not provide areas for the specification of FORCE INTERVALS or the EXTEND/DELAY times. If FORCE INTERVALS or EXTEND/DELAY times are used, this information should be described in the REMARKS section (Section G1) after consulting the EPIC controller manual for more detail.

7.3.2 *ADVANCED TIMING PARAMETERS FORM – EPIC/EF-140 CONTROLLER*

The Advanced Timing Parameters form (page 2) provides the system data, signal operation parameters, and space to provide additional dial and split information. This form is meant to be used for EPIC/EF-140 signal controllers and should always be included as part of the signal timing permit.

Figure 7-15 illustrates a sample *Advanced Timing Parameters* form filled out. A description of each section (A – C) of the signal timing permit and how to properly fill in these sections is provided in the text that follows. All of the general information (sections 1 - 5) is presented under the *General Permit Guidelines* in Section 7.8. Table 7-14 provides the ranges and increments for the numerical values included on this form.

Figure 7-15: Advanced Timing Parameters Form (EPIC) Example



ADVANCED TIMING PARAMETERS FORM

SYSTEM INFORMATION

Controller Type: ☒ EPIC ☐ EF140 ☐ Other:

System Type: ☒ Closed Loop ☐ Stand By ☐ Group 1 ☐ Group 2

Address: ☒ TBC ☐ TBC/GPS ☐ None ☐ Other:

If TBC, Synch by: ☒ TOD ☐ Event

Interconnect Type: ☒ Hardwire ☐ Fiber-Optic ☐ Radio ☐ Phone Drop ☐ None ☐ Other:

If Phone Drop, Phone #

1

LEFT-TURN PHASING

Description	Permissive-Protected Lead	Permissive-Protected Lag	Protected-Only Split	Protected-Only Lead	Protected-Only Lag
1 = EB LANSING LT	☐	☐	☐	☒	☐
5 = WB LANSING LT	☐	☐	☐	☒	☐
3 = NB THIRD LT	☐	☐	☐	☒	☐
7 = SB THIRD LT	☐	☐	☐	☒	☐

B

COORDINATION DATA

Operation Mode	1
Correction Mode	2
Maximum Dwell (s)	0
Min Duration (m)	0

A

DISAPPEARING LEGEND CASE SIGNS

1 - "NO RIGHT TURN" ILLUMINATED FOR EB LANSING DURING WB LANSING LT

2 - "NO RIGHT TURN" ILLUMINATED FOR WB LANSING DURING EB LANSING LT

3

VEHICULAR AND PEDESTRIAN DETECTION

Approach	Left	Call Delay (s)	Thru	Right	Loop	Video	Other	Push-Button Crossing Locations
NB THIRD	☒	0	☐	☐	☒	☐	☐	EAST LEG OF LANSING ST
SB THIRD	☒	0	☐	☐	☒	☐	☐	WEST LEG OF LANSING ST

2

ADDITIONAL DIAL SPLIT DATA

Cycle Length (sec)	Offset (sec)	Hours of Operation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
100	20	CONSTRUCTION TIMING (NOT USED) D 4 S 1 SPLITS 52/15/33	30.0	4.0	6.5	6.0	4.5	1.0	5.5	4.0	4.5	1.0	12.0	15.5	4.5	1.0						
		D S SPLITS																				
		D S SPLITS																				
		D S SPLITS																				

C

Remarks: OPTIMIZED BY: ANYONE INC 4

Prepared by: LAB Date: 07/30/08 ☐ MDOT ☐ County ☐ City ☒ Consultant 5

Location: MAIN STREET AT LANSING STREET

Control Section-Spot #: 55555-01-555

Page 2 of 2

Table 7-14: Advanced Timing Parameters Ranges and Increments

Function	Controller Range	*MDOT Range	Increments
Delay (seconds)	000-999	-	**1**
Maximum Dwell (seconds)	000-999	-	**1**
Minimum Duration (minutes)	**00-99**	**-**	**1**

*MDOT Range is listed only if different than the actual Controller Range
Source: *EPIC140 Pre-timed Controller Unit Manual (1997)*

SECTION A – COORDINATION DATA

The coordination information is entered in Section A.

- **Operation Mode**
  - **0** - provides **Non-Coordinated** operation. This is the typical setting for signals that are not coordinated.
  - **1** - provides for **Coordination** operation to be automatically determined by interconnect, time base, or system commands. This is the typical setting for a coordinated system.
  - **2** - provides for **Manual Coordination** operation. This option allows for a single dial/split/offset combination to run always. This is not typically used as a permanent setting.
- **Correction Mode** – The correction mode determines how the signal will adjust the timing in order to move the offset to the correct value. It will typically not violate the minimum interval times. The offset may be off for a variety of common reasons (when the signal changes timing plans throughout the day, when it comes out of night time flash mode, after a power outage, etc.). The correction mode will typically be found in the controller.
  - **0** – **Dwell**: causes the signal to dwell in a compatible interval beyond the time defined for the interval until the correction has been accomplished. This correction mode is not typically used. Especially at locations with high cycle lengths, it can cause the signal to dwell in one phase for an excessive length of time.
  - **1** – **Max Dwell**: causes the signal to dwell in the same manner, but limits the maximum amount of time the signal can dwell per cycle. If the correction cannot be completed in one cycle, the signal will continue to correct in future cycles until the offset is correct.
  - **2** – **Short Way**: allows the signal to dwell or if it can correct the offset faster by reducing the time provided for intervals it will do that. Correction will not exceed 20% in a cycle and will automatically take into consideration minimum times.
    - **Short Way** correction is the preferred correction, but it requires the sum of the difference between the interval times (that the correction is applied to) and the respective interval minimum times to exceed at least 19% of the cycle length.

- **3** – **Short Way+**: this correction mode is identical to Max Dwell except the Maximum Correction will not exceed 20% in a cycle. This mode does **not** reduce interval times to adjust the offset.

- **Maximum Dwell** – This value establishes the maximum time the unit may dwell for offset correction in a single cycle when the correction mode is set to Max Dwell. This value may range from (0-999 seconds).

- **Minimum Duration** – This value establishes the minimum time a dial/spit/offset pattern will run. This value may range from (0-99 minutes). This is typically only a concern for closed loops running Traffic Responsive. Depending on the timing, it can take upwards of 10 minutes for a system to get in step after a dial/split/offset change. If the system changes dial-splits too often, it will spend a large percentage of time correcting rather than running the plan. While correcting, progression is typically disrupted.

If the controller is an EF-140 controller, leave the coordination data blank as what is currently running is unknown and the data may be burnt into the PROM.

With **Short Way** correction, it is important that the correction intervals have interval times that **EXCEED** the minimum time. If this is not accounted for, it is possible for the signal to get caught in an endless loop as it tries to subtract time from an interval and the minimum times do not allow for it. If this happens, the signal will never be able to correct the offset.

SECTION B – LEFT-TURN PHASING

The *LEFT-TURN PHASING* information is entered in Section B. The left-turn *Phase # / Phase Description* information as well as *Permissive-Protected* and *Protected Only* information are entered in this section.

- ***Load Switch # / Phase Description*** – The load switch number, followed by a description of the phase are entered in this area.

- ***Permissive-Protected and Protected-Only Phasing*** – In this section, the left-turn operation should be defined as either a “leading,” “lagging,” or “split” phase (relative to the parallel through movement), and whether permissive movement of that phase is allowed during the companion through phase. Only one box should be checked for each phase.

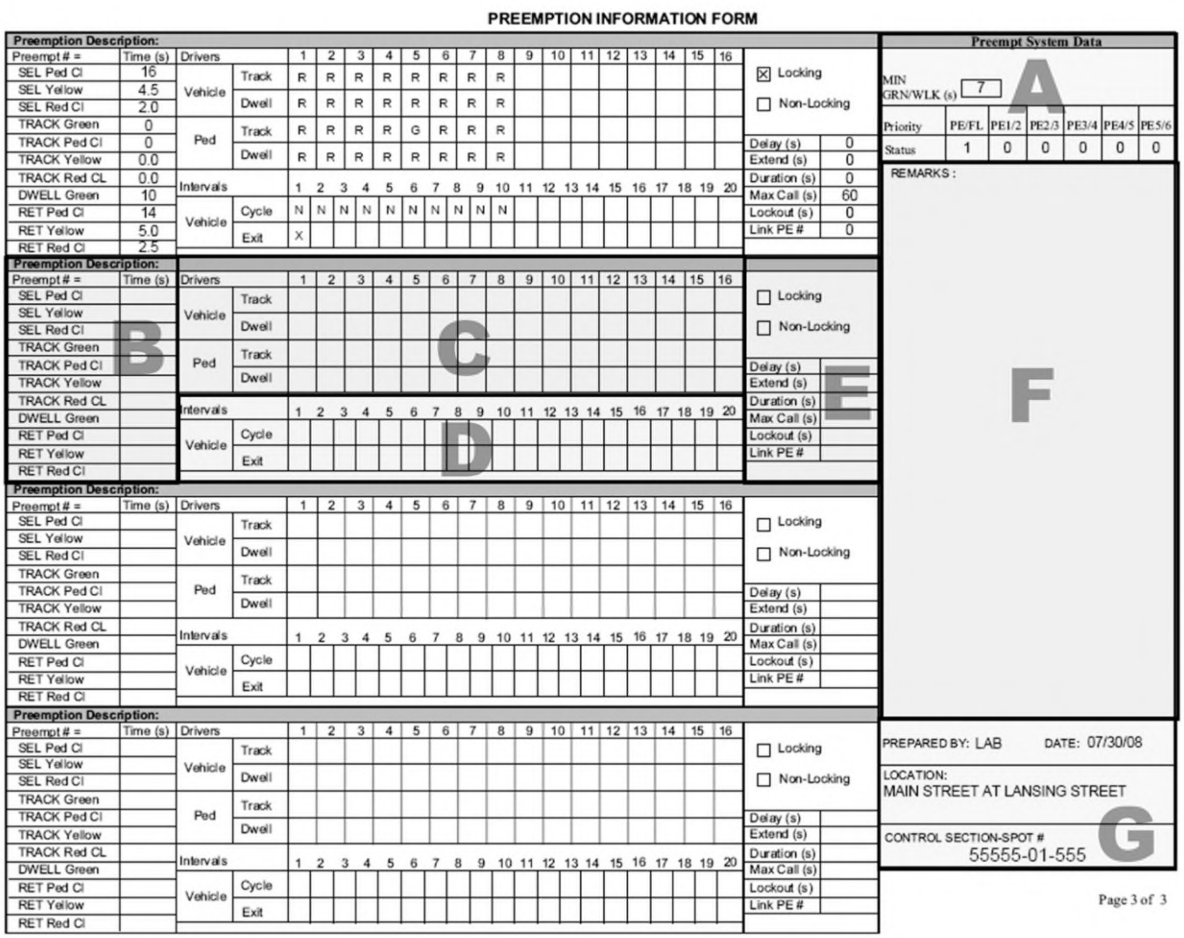
SECTION C – ADDITIONAL DIAL AND SPLIT DATA

There are four additional timing plans that may be entered in this section. See section D of the Basic Timing Parameters Form (Section 7.1.1) for more information.

7.3.3 *PREEMPTION INFORMATION FORM – EPIC/EF-140 CONTROLLER*

PREEMPTION INFORMATION is entered on page 3 of the timing permit see Figure 7-16. This page is only included if preemption exists, otherwise this page should be deleted from the file. Four preemption plans may be entered on this form, if additional preemption plans are needed, an additional sheet may be attached. Up to six preemption plans may be entered into the signal controller, as well as six low-priority preemption plans.

Figure 7-16: EPIC/EF-140 Preemption Information Form


PREEMPTION INFORMATION FORM

Preemption Description:

Preempt # =	Time (s)
SEL Ped Cl	16
SEL Yellow	4.5
SEL Red Cl	2.0
TRACK Green	0
TRACK Ped Cl	0
TRACK Yellow	0.0
TRACK Red CL	0.0
DWELL Green	10
RET Ped Cl	14
RET Yellow	5.0
RET Red Cl	2.5

Drivers		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Vehicle	Track	R	R	R	R	R	R	R	R								
	Dwell	R	R	R	R	R	R	R	R								
Ped	Track	R	R	R	R	G	R	R	R								
	Dwell	R	R	R	R	R	R	R	R								

Intervals		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Vehicle	Cycle	N	N	N	N	N	N	N	N	N	N										
	Exit	X																			

☒ Locking
☐ Non-Locking

Delay (s)	0
Extend (s)	0
Duration (s)	0
Max Call (s)	60
Lockout (s)	0
Link PE #	0

Preemption Description: B C D E

Preempt # =	Time (s)
SEL Ped Cl	
SEL Yellow	
SEL Red Cl	
TRACK Green	
TRACK Ped Cl	
TRACK Yellow	
TRACK Red CL	
DWELL Green	
RET Ped Cl	
RET Yellow	
RET Red Cl	

Drivers		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Vehicle	Track																
	Dwell																
Ped	Track																
	Dwell																

Intervals		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Vehicle	Cycle																				
	Exit																				

☐ Locking
☐ Non-Locking

Delay (s)	
Extend (s)	
Duration (s)	
Max Call (s)	
Lockout (s)	
Link PE #	

Preemption Description:

Preempt # =	Time (s)
SEL Ped Cl	
SEL Yellow	
SEL Red Cl	
TRACK Green	
TRACK Ped Cl	
TRACK Yellow	
TRACK Red CL	
DWELL Green	
RET Ped Cl	
RET Yellow	
RET Red Cl	

Drivers		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Vehicle	Track																
	Dwell																
Ped	Track																
	Dwell																

Intervals		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Vehicle	Cycle																				
	Exit																				

☐ Locking
☐ Non-Locking

Delay (s)	
Extend (s)	
Duration (s)	
Max Call (s)	
Lockout (s)	
Link PE #	

Preemption Description:

Preempt # =	Time (s)
SEL Ped Cl	
SEL Yellow	
SEL Red Cl	
TRACK Green	
TRACK Ped Cl	
TRACK Yellow	
TRACK Red CL	
DWELL Green	
RET Ped Cl	
RET Yellow	
RET Red Cl	

Drivers		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Vehicle	Track																
	Dwell																
Ped	Track																
	Dwell																

Intervals		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Vehicle	Cycle																				
	Exit																				

☐ Locking
☐ Non-Locking

Delay (s)	
Extend (s)	
Duration (s)	
Max Call (s)	
Lockout (s)	
Link PE #	

Preempt System Data A

MIN GRN/WLK (s) 7

Priority	PE/FL	PE1/2	PE2/3	PE3/4	PE4/5	PE5/6
Status	1	0	0	0	0	0

REMARKS : F

PREPARED BY: LAB DATE: 07/30/08

LOCATION:
MAIN STREET AT LANSING STREET

CONTROL SECTION-SPOT # 55555-01-555 G

Page 3 of 3

SECTION A – PREEMPT SYSTEM DATA

The preempt system data allows the user to include parameters that are common to all six preempts.

- ***Min Grn/Wlk*** – This establishes the time in seconds which any Green and or Walk interval must have been displayed prior to its termination for a transition to Preempt.

- ***Priority and Status*** – The entry (Code "0" = NO and Code "1" = YES) establishes whether the first function has priority over the second. An entry of "0" indicates no priority between the two. When a function has priority over another, the function of lower priority will terminate and the higher priority will assume control.

  PE/FL – Preemption over Remote Flash

  PE1/2 – Preempt 1 over Preempt 2

  PE2/3 – Preempt 2 over Preempt 3

  PE3/4 – Preempt 3 over Preempt 4

  PE4/5 – Preempt 4 over Preempt 5

  PE5/6 – Preempt 5 over Preempt 6

SECTION B – PREEMPT INTERVAL TIMES

- ***Preemption Description*** – Enter a description of the preemption here.

- ***Preempt Number*** – Indicate which of the 6 available preempts is being defined. If more than four preempt plans exist, then an additional form should be attached for the additional preempts.

- ***SEL Ped Cl, SEL Yellow, SEL Red Cl*** – The "*Selective*" clearance intervals are provided to transition from normal operation into a preempt. These values should typically be set to the highest value from the various phases in operation. For example, at a two-phase signal where the normal pedestrian clearance is 12-seconds for one phase and 14-seconds for the second phase, 14-seconds would be entered for the *SEL Ped CL* as it is the larger of the two phases. The phase that it is transitioning to generally does not need to be considered unless there is a track green being utilized.

  - The exception to this is at some rail road crossings, the signal from the train does not trigger the preempt soon enough to run all of the clearance intervals prior to the train arriving. When setting minimum times within preempts do not increase the SEL Ped Clearance without verifying that the increase can be accommodated. During preempts, the railroad will provide a fixed amount of time prior to the train entering the intersection. Often it is impractical to provide additional advance notice. In the event this situation arises, the MDOT project manager should be consulted prior to changing any of these values.

- ***TRK Green, TRK Ped Cl, TRK Yellow, TRK Red Cl*** – The "*Track*" intervals are provided when a railroad track is located close to the intersection and they are intended to keep vehicles from queuing across the track. The intervals provide a short period of green as well as clearance intervals at the intersection while the pre-signal at the tracks stays red. Doing this clears vehicles that were stopped on the tracks while not allowing more vehicles on to the tracks. The "*Track*" intervals are typically used when there are near and far signal heads at an intersection. The "*Track*" intervals clear vehicles between the near and far signal head to avoid vehicle trapping.

- ***TRACK GREEN*** interval provides the time for the *TRACK Green*. If no time is entered for the *TRACK Green* interval, the "*Track"* intervals will be skipped (*Track Green, Track Ped Clear, Track Yellow,* and *Track Red Clear*).

- The ***TRACK Ped Clear*** interval is the time provided to clear a terminating Walk during the transition to *DWELL Green*.

- The ***TRACK Yellow*** interval is the time provided to clear a terminating Green during the transition to *DWELL Green*.

- The ***TRACK Red Clear*** interval is the time provided to clear a terminating Yellow during the transition to *DWELL Green*.

- ***DWELL Green, RET Ped Cl, RET Yellow, RET Red Cl*** – The *DWELL Green* interval is the time that the intersection will dwell in green for the allowed phases during the preempt. The "*Return*" clearance intervals are provided to transition from preempt operation into normal operation. These values should be set to the normal clearance intervals for the respective approach.

For railroad preempts the amount of fixed time the railroad gives the traffic signal prior to the train entering the intersection is 20 seconds unless otherwise specified in writing from the railroad owner. Therefore, the sum of the **Min Grn/Wlk, *SEL Ped Cl, SEL Yellow, SEL Red Cl,*** and ***TRACK GREEN*** times shall not typically exceed 20 seconds.

SECTION C – PREEMPT SIGNAL DRIVERS

- ***Vehicle*** – The vehicle signal head displays for the *TRACK Green* and *DWELL Green* for each driver are entered in this area. Possible entries for these drivers include:

R	Red
G	Green
Y	Yellow
FR	Flashing Red
FG	Flashing Green
FY	Flashing Yellow
RG	Red and Green
Blank	Dark

- ***Pedestrian*** – The pedestrian signal head displays for the *TRACK Green* and *DWELL Green* for each driver are entered in this area. Possible entries for these drivers include:

DW	Solid Don't Walk
W	Walk
FDW	Flashing Don't Walk

SECTION D – PREEMPTION CYCLING INTERVALS

- If the signal cycles during preempt, the **EPIC** controller needs only to specify whether or not an interval will cycle. This can be done by placing a "Y" in the intervals that will cycle, and an "N" in those that will not. A row is also provided for the *Exit* interval information. This information specifies the interval the preemption routine will transition to following the *RET Red Cl* interval in order to start Normal Operation. Mark this interval with an "X."

- EF-140 preempt timings are substantially different and will not typically be changed. The MDOT project manager should be consulted on how to address the preempt if necessary.

SECTION E – MISCELLANEOUS PREEMPT PARAMETERS

- ***Locking / Non-Locking***

  - ***Non-Locking*** preempt memory: there is no memory storage of a preempt call. The preempt detector must have a continuous call in order to maintain a call for service of the preempt routine.

    - ***Often used at Railroad or Draw Bridge locations where the length of the disruption is not known.***

  - ***Locking*** preempt memory: once a preempt detector gets a call, this call is "locked" in and remains a constant call until the preempt routine is serviced.

    - ***Often used for fire stations where a button is pushed once and the preemption runs for a predetermined time.***

- ***Delay*** – This denotes the number of seconds (0-999) that the Preempt actuation must be active before normal controller operations are interrupted for the Preempt.

- ***Extend*** – This denotes the number of seconds (0-999) that each Preempt actuation shall be extended from the point the actuation terminates.

- ***Duration*** – This denotes the number of seconds (0-999) which a Preempt requires prior to a transition back to normal traffic operations can occur.

- ***Max Call*** – This establishes the number of seconds (0-999) which a Preempt call may remain active. When the preempt call has been active for this time period, the controller shall return to normal operation.

- ***Lockout*** – This establishes the number of seconds (0-999) following the exit from the Preempt Routine that will occur prior to entering a Low Priority Routine.

  - When this value is "0", Lockout will be in effect until:

    - No serviceable Conflicting Call Exists or

    - Any phase is re-serviced following the exit.

- ***Link PE #*** - This establishes the higher priority Preempt routine which is to be linked to this Preempt routine.

SECTION F – REMARKS

Section F is the *REMARKS* section. Any information that is necessary for the proper installation of the signal timing permit that was not captured by the fields of the signal timing permit should be entered in this section. If all of the remarks do not fit into the space provided, do not change the font size as MDOT will lose all of this information in their database when the font is changed.

SECTION G – LOCATION

Section G provides general information about the signalized location including:

- Who prepared the timing permit and the date.

- The location and control section-spot number.

This data automatically transfers from the first page.

7.4 STANDARD INFORMATION: PAGE 1

The EPIC/EF-140, EPAC, and NTCIP permits have areas that provide similar information. The following section will detail information that is common between these permits. The following section numbers match the corresponding sections in Figure 7-1, Figure 7-6, and Figure 7-12 for reference.

SECTION 1 – REMARKS

Section 1 is reserved for *REMARKS*.

- Any information that is necessary for the proper installation of the signal timing permit that was not captured by the fields of the signal timing permit should be entered in this section.

- Notes regarding the changes when compared to the previous permit should be included.
- If all of the remarks cannot fit on the first page, do not change the font size as MDOT's database will not download the information and it will be lost if the font is changed. Carry additional comments to Page 2 or utilize abbreviations.
- If the timing permit is prepared by a consultant, a comment should also be added in the *REMARKS* section that states what company/organization prepared the permit (see Figure 7-6 or Figure 7-12). For example:
    - "OPTIMIZED BY: (Insert Organization Name)"

SECTION 2 – FLASH OPERATION

The flash mode hours of operation are entered in Section 2. If there is no flash schedule, the check box for *NONE* should be checked. If there is a daily flash schedule, the *DAILY* check box should be checked with the times of flash operation entered in military time. The sample signal timing permit sheet shown in Figure 7-12 shows a flash schedule that occurs daily from the hours of 22:00 to 06:00. If the weekend flash schedule differs from the daily flash schedule, it should be entered beneath the daily flash schedule. A description of the weekend flash should be entered to the right of the flash schedule times. If more space is needed the description should be entered in the remarks section.

See Section 5.2.7 for details on selecting a flash schedule.

EF-140 controllers only: For non-harmonic cycle lengths (cycle lengths that do not divide evenly into 3600 seconds), a signal that comes out of flash at a different time than the rest of the corridor should come out at the beginning of a cycle. This assumes that the "time of day" changes occur on the hour. If they change on the half or quarter hour it should be verified if the cycle length is harmonic for that time period.

On the EPAC permit the NIGHT FLASH and CONFLICT FLASH section specifies what the state of the signal indications should be for each approach during flash modes.

SECTION 3 – PREEMPTION

Section 3 is where preemptions and countdown pedestrian signals are specified.

- ***PRE-EMPT*** – This box should be checked if a preemption sequence exists at the location.
- ***COUNTDOWN PEDS*** – This box should be checked if there are countdown pedestrian signal heads.

SECTION 4 – CONTROLLER TYPE

Section 4 is where the controller type is specified. This is typically set as EPIC, EF-140, EPAC, Siemens (SEPAC), or ECONOLITE (EOS). The other box should be check if the controller is not one of the common types and a description should be written in next to the box

- 2070 is a relatively common alternative controller that would also utilize the EPAC form.
- NEMA style and SCATs controllers should use the EPAC form.
- Electromechanical controllers should utilize the EPIC form, but the interval times should be shown as percentages with a note in the remarks section indicating this.

SECTION 5 – LOCATION INFORMATION

Section 5 provides general information about the signalized location including: intersecting roads, city and county location, mile point, control section-spot number, who prepared the timing plan, when the timing plan was developed and when it was installed, and the controller type. The initials of the actual person who prepared the timing plan permit should be entered in the *PREPARED BY* portion of Section 5. If the permit is prepared by a consultant, the MDOT job number should be entered in the *Job #* field. The page number information should also be verified just below where the control section-spot number information is entered. The second number can be overridden if necessary.

The spot numbers and mile point will generally be provided, but if they are not, do not assume or use measurements from a map as the MDOT system already has defined spot numbers and mile points for all signalized locations.

If a timing permit is prepared by a consultant, the consultant name should be included in the remarks section (see Section 1).

7.5 STANDARD INFORMATION: PAGE 2

SECTION 1 – SIGNAL SYSTEM INFORMATION

The *SIGNAL SYSTEM INFORMATION* is entered in Section 1, including the *Controller Type*, *System Type*, *Interconnect Type*, and *Controller Status*.

- ***Controller Type*** – The choices that may be checked are: EPIC, EF140, EPAC, and OTHER. If OTHER is checked, a description of the controller type should also be entered.
- ***System Type*** – The *System Type* can be:
    - *Central*
        - If the signal is connected to the *Central System* then it will have a *Group ID* number that is common for nearby signals that to are intended to operate in a coordinated system.
    - *Closed Loop*

- If the signal is part of a *Closed Loop,* a specification as to whether the signal operates on *Stand By, Group 1,* or *Group 2* must be entered. Setting *Closed Loop* systems to *Stand By* is preferred, unless there are special event or traffic responsive operations. All signals in the same Group must have identical time of day and flash schedules. Special event plans and traffic responsive plans are called up by Group Number, but for other situations, there is no need. Standby allows individual signals to have different time of day and flash schedules.

- For *Closed Loop* intersections, the intersection will have an *Address* number (ranging from 1-32). The value is typically obtained from the Primary Controller.

➢ *Time Base Coordinated (TBC)*

- The clocks at each location are set to the exact same time by the electrician (down to the second). As long as the clocks keep time accurately, the signals will remain coordinated.

➢ *Time Base Coordinated with Global Positioning System (TBC/GPS)*

- This is the same as TBC except each signal has a GPS unit that reads the time signature from the GPS satellites rather than having the electrician manually set the clocks.

➢ *None*

➢ *Other* - If *Other* is checked, a description of the system should follow. Other systems that may be present:

- *Hardwire* – There is a wire connection between a group of signals and one controller is selected as Primary, and it sends a synch pulse over the wire every cycle.

- *SCATS* – This is a central computer system. Currently it is only in use in Oakland County, but not on all signals within the county. It typically communicates via an independent phone drop at each location or wireless radio.

- *TACTICS (Formerly ACTRA)* – This is the next step up from a closed loop. It is a central computer system that is capable of controlling a large number of closed loops and/or individual signals.

    - If the location is part of a closed loop, controlled by TACTICS, code it as a closed loop, but include a note in the remarks that the closed loop is on an TACTICS system.

    - Some signals in the Ann Arbor area are on a SCOOT system. SCOOT runs in conjunction with TACTICS. Again include a note in the remarks indicating that it is running SCOOT.

- Centracs – This is a system similar to TACTICS used for some locations in Macomb County

  - If the *System Type* is *TBC, Closed Loop or TACTICS*, a specification as to whether the signal is synched by *Time of Day (TOD)* or *Event* must be made.

    - All signals along a corridor should synch in the same manner
    - Most newer signals should be set to synch by TOD.

- ***Interconnect Type*** – The *Interconnect Type* can be *Cell Modem, Hardwire*, *Fiber-Optic*, *Radio*, *Phone Drop*, *None*, or *Other*. If *Phone Drop* is checked, the phone number should be included. .

  - Controllers connected to the *Central System* are routinely connected via cellular modem.
  - For closed loop systems, the Primary will typically be equipped with a cellular modem for communications along the corridor. Other should be checked in addition to the general closed loop interconnect type (hardwire, fiber-optic or radio).
  - In some cases individual intersections may be equipped with a cellular modem or a phone drop (those signals in Oakland County on the SCATS system will typically have a phone drop at each intersection).

- ***Controller Status***

  - If the signal is part of a *Closed Loop* or other interconnected system, the controller should be identified as either the Primary or a Secondary (controlled by the Primary controller).
  - If a signal doesn't have an interconnect system, but it is coordinated with adjacent signals, it will typically be set to TBC.
  - If the signal is not intended to be coordinated with nearby signals, the status should be set to Isolated.

If the signal controller is secondary to a Primary (typically a closed loop, but not always), the location of the Primary should be entered along with the Primary's Control Section-Spot Number.

SECTION 2 – VEHICULAR AND PEDESTRIAN DETECTION

Section 2 is for entering information pertaining to *VEHICULAR AND PEDESTRIAN DETECTION* for actuated approaches. Each line should represent one approach with both the vehicle and pedestrian data. They should be entered in order corresponding with the order of the through phases listed on page 1. This routinely means that line one corresponds with the approach represented by phase 2, followed on line two by phase 4, then phase 6, and finally phase 8.

Vehicular Detection

- ***Approach*** – The vehicle approach description is entered in this column.
- ***Movements and Call Delay*** – This column defines what *Movements* are detected by the vehicle detector(s) for the corresponding approach. The turn movements should not be checked unless there is a separate dedicated turning lane. A shared thru/right or shared thru/left lane, should be coded as Thru.
    - If there is a *Call Delay* on the detector, this time (in seconds) should be entered in the corresponding column. A Call Delay is the amount of time a vehicle call must be present at a detector before the controller acknowledges the call as needing to be serviced. If a call leaves before the *Call Delay* time is satisfied, there will be no service call placed on the controller for that movement. Call Delay is most commonly used to account for right-turn-on-red traffic. If they clear on red, the phase they would use does not need to be triggered.
- ***Locking*** – On NTCIP permits the detection locking entry has been shifted to page 2 with options to enter any movement that has locking detection right next to the listing of the movements that have detectors.
- ***Type*** – On older permits this column defines the *Type* of vehicle detection used for the corresponding approach. It has been phased out with the updated NTCIP permit. *Loop, Video,* and *Other* are the choices that can be checked for Type of Vehicular Detection. The use of Wireless detection is becoming more popular; if Wireless is used check the *Other* box. If *Other* is checked under the "Remarks" section indicate which type of detection is being used.

Pedestrian Detection

- ***Push-Button Crossing Locations*** – The intersection legs where there are pedestrian push-buttons are identified in this section. If there is no push button for an approach it should be left blank. The approach entered into this section is the approach the pedestrian will be crossing. Phrasing should be as shown below:
    - North Leg of Main Street
    - East Leg of Elm Street
    - South Leg of Main Street
    - West Leg of Elm Street

SECTION 3 – DISAPPEARING LEGEND CASE SIGNS

The *DISAPPEARING LEGEND CASE SIGNS* information is entered in Section 3. If a disappearing legend case sign is in use at the location, a complete description should be provided, including sign indication, dials in which it operates and coinciding vehicular phases.

SECTION 4 – REMARKS

Section 4 is the *REMARKS* section. Any information that is necessary for the proper installation of the signal timing permit that was not captured by the other fields of the signal timing permit should be entered in this section. If all the remarks do not fit into the space provided, do not change the font size. MDOT's database will lose all of this information if the font is changed. Utilize abbreviations or any additional space on Page 1.

If a timing permit is prepared by a consultant, the consultant name should be included in the remarks section. For example:

"OPTIMIZED BY (Insert Organization Name)"

SECTION 5 – LOCATION

Section 5 provides general information about the signalized location including:

- Who prepared the timing permit and date
- What type of organization prepared the timing permit
- The location and control section-spot number

This data automatically transfers from the first page. The page number information should also be verified just below where the control section-spot number information is entered. If there is no pre-empt sequence, the third page should be deleted and the page numbering adjusted to reflect 2 pages.

8 TIMING PLAN IMPLEMENTATION

While most of the work in optimizing traffic signal timings is in the data collection, modeling and development of timing permits, the field implementation is the critical final step to ensure that all of the work culminates in better traffic operations. This requires field observation, and where necessary, adjustment of the timings to improve operations relative to actual traffic conditions. Timing changes are to be made by MDOT electrician or designated maintaining agent only.

8.1 FIELD ADJUSTMENTS

A field review of implemented timings is required for all projects in order to assure that timings have been implemented properly, and that the signal timings are facilitating traffic as they were designed. The field review of implemented timings should include the following steps:

- Coordinate date of field implementation with MDOT signal operations engineer and MDOT electrician or designated maintaining agent.
- Verification that individual signal controller clocks are synchronized.
- Verification of offsets should be conducted by performing a driving check of the corridor to verify progression.

- Any observed and unexpected conditions, such as cycle failures, extensive queuing or spillbacks, should be noted and further reviewed to determine whether reallocation of green time is required or appropriate.

- The speed and platooning of vehicles should be critically reviewed to determine whether progression is maintained as intended, and whether adjustments should be made to better facilitate coordinated traffic flow.

Any recommended adjustments after implementation should be documented in a brief memo, along with updated signal timing permits reflecting the proposed adjustments.

Outside of optimization projects, it is sometimes necessary to make on the spot minor changes in the traffic signal timing. This may be due to construction activities, special events or changes in traffic patterns. It is imperative that any changes be recorded and a copy provided to the MDOT Signals Unit. Timing changes initiated in the field must be compatible with the signal system. If time allows, the change should be reviewed by the MDOT Signals Unit prior to implementing the change. If an immediate response is required, the changes should be done under the guidance of the MDOT Region/TSC Traffic and Safety Representative with documented changes provided to the MDOT Signals Unit after the fact.

Prior to any adjustments, the location should be thoroughly reviewed in the field. Particular attention should be paid to the times when a problem may exist. Any changes should be implemented by the Region/TSC electrician or the maintaining agency.

8.2 VERIFICATION THAT SIGNAL TIMING HAS BEEN INSTALLED

Traffic Signal Timing Permits are issued with one copy placed in the controller cabinet for ready reference. A second copy is kept in the Region/TSC Traffic and Safety files. A third copy is kept in the Lansing Traffic Signal spot files.

When new timing (or a timing modification) is installed in a controller, the MDOT electrician or maintaining agent shall provide documentation to the MDOT Signals Unit including the date of installation, and any modifications. The preferred method of documentation is attaching an electronic copy of the timing permit to a work order in MDOT's asset management program (SigAM) as required. Alternatively, an electronic copy of the timing permit, including any modifications, may be emailed to the MDOT Signals Unit.

APPENDIX A

MDOT Traffic Volume Data Submittal Format

Michigan Department of Transportation

MDOT Traffic Volume Data Submittal Format

The following are guidelines for the submittal of traffic volume data (manual and machine counts) to MDOT for signal optimization projects:

- *File Format* - All manual and machine counts should be exported into a **Microsoft Excel** format (.xls).

- *File Name* – The file name will be the Control Section/Spot # followed by the date of the manual traffic count. The following is an example:

  77091-01-012_Jan27-2005_Counts.xls

- *Worksheet Arrangement* – The Excel file will contain one worksheet for the manual traffic counts, and separate worksheets for each of the machine counts with the worksheet tabs named accordingly (NB Machine Counts, SB Machine Counts, etc.).

- *Manual Traffic Counts General Info* – The manual traffic counts worksheet will contain the following info at the top of the worksheet:
  Control Section/Spot #
  - Location (the MDOT name for the intersection)
  - City/Township
  - Date (the date the manual traffic count was collected)
  - Weather (weather conditions if applicable)
  - Collected By (a note about who collected the counts)

  Example:

Control Section/Spot #	**77091-01-012**
Location:	**M-25 Pine Grove at Hancock**
City/Twp:	**Port Huron**
Date:	**1/27/2005 (Thursday)**
Weather	**Clear, Dry 20 Deg's**
Collected By:	**MDOT**

- *Machine Counts General Info* – The machine counts worksheet(s) will contain the following info at the top of the worksheet:
  - Type of Count (direction of count taken and any pertinent information)

- Location (where on the roadway was the count taken)
- City/Township
- Start Date (date the machine count was started)
- Collected By (a note about who collected the counts)

Example:

Type of Count:	**NB M-25 24-Hour Vehicle Count**
Location:	**M-25 (210' South of Hancock St.)**
City/Twp:	**Port Huron**
Start Date:	**2/1/2005 (Tuesday)**
Collected By:	**MDOT**

- *Offset Intersections* – If the offset intersections are on the same controller, the counts should be summarized in one Excel file. If the offset intersections are on separate controllers, the counts should be summarized in separate Excel files.

- *Multi-Approach Intersections* – There will occasionally be situations where there are more than four approaches at an intersection. On the *Manual Counts* worksheet, simply add these additional approaches to the right of usual four approaches and label accordingly. For the machine counts, insert additional worksheets and name accordingly for the additional approaches.

- *Boulevard Intersections* – Boulevard roadway intersections are to be treated as one intersection and summarized in one Excel file. Crossovers adjacent to the boulevard intersection are to be summarized in separate Excel files (a different file for each crossover).

- *Closely Spaced Intersections* – For closely spaced intersections, such as those near highway on/off ramps, locations that are on the same controller should be summarized in the same Excel file. Care must be taken in the naming of the Manual Count approaches and Machine Count locations so that it is easily understood what approach is being described.

Sample Turning Movement Count Submittal Format

Microsoft Excel - 61022-01-013_Mar22-2006_Counts.xls

Control Section/Spot # **61022-01-013**
Location: **Main Street at Elm Street**
City/Twp: **Muskegon**
Date: **3/22/2006 (Wednesday)**
Weather **Clear**
Collected By: **PB**

	Elm St From South				Main St From West				Elm St From North				Main St From East			
Start Time	Rgt	Thru	Left	Ped	Rgt	Thru	Left	Ped	Rgt	Thru	Left	Ped	Rgt	Thru	Left	Ped
7:00 AM	2	0	1	0	0	48	0	0	0	0	0	0	0	77	1	0
7:15 AM	2	0	0	2	0	59	0	0	0	0	0	0	1	126	0	0
7:30 AM	0	0	1	0	1	87	0	0	0	0	0	0	0	154	0	0
7:45 AM	1	0	0	0	0	78	0	0	0	0	0	0	0	146	0	0
8:00 AM	0	0	1	0	1	57	0	0	0	0	0	0	1	116	0	0
8:15 AM	0	0	1	0	2	58	0	0	0	0	0	0	0	121	0	0
8:30 AM	3	0	4	0	0	82	0	0	0	0	0	0	0	85	1	0
8:45 AM	1	0	1	0	0	83	1	0	0	0	0	0	1	93	0	0
11:00 AM	0	0	0	0	0	108	0	0	0	0	0	0	0	94	0	0
11:15 AM	3	2	0	0	0	119	0	0	0	0	0	0	1	94	0	0
11:30 AM	1	0	0	0	3	111	0	0	0	0	0	0	0	98	0	0
11:45 AM	2	0	1	0	0	136	0	0	0	0	0	0	0	125	0	0
12:00 PM	3	0	0	0	1	163	1	0	0	0	0	0	3	93	0	0
12:15 PM	3	0	0	0	0	143	0	0	0	0	0	0	2	123	0	0
12:30 PM	0	0	0	0	0	122	0	0	0	0	0	0	0	133	0	0
12:45 PM	2	0	1	0	0	123	0	0	0	0	0	0	2	144	0	0
2:00 PM	1	0	1	0	0	127	0	0	1	0	1	0	2	104	0	0
2:15 PM	3	0	1	0	0	110	1	0	0	0	0	0	1	113	0	0
2:30 PM	1	0	0	0	1	121	0	0	0	1	0	0	0	128	0	0
2:45 PM	3	0	1	0	2	146	0	0	0	0	0	0	2	125	1	0
3:00 PM	2	1	1	0	2	166	0	0	0	0	0	0	3	137	2	0
3:15 PM	2	0	1	0	3	137	0	0	0	0	0	0	0	102	0	0
3:30 PM	2	0	1	0	5	184	0	0	0	0	0	0	2	116	1	0
3:45 PM	4	0	0	0	3	151	0	0	0	0	0	0	2	139	0	0
4:00 PM	4	2	0	0	0	167	0	0	0	0	0	0	1	128	1	0
4:15 PM	1	0	1	0	3	133	0	0	0	0	0	0	1	125	0	0
4:30 PM	1	0	0	0	1	173	1	0	0	0	0	0	2	108	0	0
4:45 PM	2	0	0	0	0	159	0	0	0	0	0	0	1	109	1	0
5:00 PM	0	0	0	0	2	245	0	0	0	0	0	0	2	105	0	0
5:15 PM	2	1	1	0	1	170	1	0	0	0	0	0	0	111	0	0
5:30 PM	2	0	0	0	2	115	0	0	0	0	0	0	1	108	0	0
5:45 PM	2	0	0	0	1	115	1	0	0	0	0	0	1	100	0	0

Manual Counts / Manual Counts - Trucks / NB Machine Counts / WB Machine Counts / EB Machine Counts

Sample Machine Count Submittal Format

Microsoft Excel - 61022-01-013_Mar22-2006_Counts.xls

	Type of Count:	WB Main St 24-Hour Vehicle Count	
	Location:	Main St East of Elm St	
	City/Twp:	Muskegon	
	Start Date:	4/12/2006 (Wednesday)	
	Collected By:	PB	
Number	Date	Time	WB
1	4/12/2006	1:00 PM	531
2	4/12/2006	2:00 PM	558
3	4/12/2006	3:00 PM	588
4	4/12/2006	4:00 PM	476
5	4/12/2006	5:00 PM	397
6	4/12/2006	6:00 PM	346
7	4/12/2006	7:00 PM	282
8	4/12/2006	8:00 PM	222
9	4/12/2006	9:00 PM	228
10	4/12/2006	10:00 PM	139
11	4/12/2006	11:00 PM	79
12	4/13/2006	12:00 AM	47
13	4/13/2006	1:00 AM	32
14	4/13/2006	2:00 AM	23
15	4/13/2006	3:00 AM	25
16	4/13/2006	4:00 AM	23
17	4/13/2006	5:00 AM	72
18	4/13/2006	6:00 AM	162
19	4/13/2006	7:00 AM	462
20	4/13/2006	8:00 AM	505
21	4/13/2006	9:00 AM	387
22	4/13/2006	10:00 AM	413
23	4/13/2006	11:00 AM	455
24	4/13/2006	12:00 PM	551

Manual Counts / Manual Counts - Trucks / NB Machine Counts / **WB Machine Counts** / EB Machine Counts

APPENDIX B

INTERSECTION INVENTORY AND CONDITION FORM

MDOT Inventory Form

The following are guidelines for the data collection of intersection geometry and equipment as related to MDOT signal optimization projects. The two-pages of the Intersection *Inventory and Condition Form* are illustrated next, with a detailed description of the information filled into each section following.

MDOT
Michigan Department of Transportation

MDOT Intersection Inventory and Condition Form

Sheet 1 of 2

A

Main Street Name:
Cross Street Name:
City/Township:
County:
GPS Coordinates: Latitude (N) Longitude (W)

Intersection Number: *Control Section # / Spot #* *Mile Post #*
Prime Number: *PR Mile Point*
MDOT Project Number:

Observer:
Date:

B

					ADD'L APPROACH
APPROACH (DIRECTION OF TRAVEL):					
STREET NAME:					

C

GEOMETRY					
Thru Lanes (#)					
Left Turn Lanes (#/Length in ft)					
Right Turn Lanes (#/Length in ft)					
Intersection Width*					
Near Button/Pedestrian Crossing Distance/Far Button**					
Adjacent Pkg Approach Lane (Y/N)					
Adjacent Pkg Departure Lane (Y/N)					
Approach Grade (±%)					

D

OPERATIONS					
Approach Speed Limit (MPH)					
Departure Speed Limit (MPH)					
Right Turn On Red (Y/N)					
Turn Restrictions (Y/N)					
If Yes, describe:					

E

EQUIPMENT					
Pedestrian Signal (Y/N)					
Pedestrian Push Button (Y/N)					
Left Turn Head Type***					
Right Turn Green Arrow (Y/N)					
Ambient Lighting (Y/N)					

* Width of intersection, measured from the near-side stop bar to the far edge of the conflicting extended travel lane along the actual vehicle path of a thru vehicle (feet).
** Pedestrian crossing distance is measured near push button to the curb, along the crosswalk line closest to the stop bar from near curb to extended edge of furthest travel lane, and from the far curb to the far push button.
*** Left turn signal head type should be indicated as *3-Level Arrow*, *4-Level Green Arrow*, *4-Level Yellow Arrow Flash*, or *Dog House-Type*.

MDOT
Michigan Department of Transportation

Intersection Inventory and Condition Form

Main Street Name:
Cross Street Name:

H

Intersection Number:

Control Section # / Spot #

Mile Post #:

Sheet 2 of 2

SIGNAL PHASING

Phase 1

Phase 2

F

Phase 3

Phase 4

Phase 5

Phase 6

GENERAL COMMENTS:

INTERSECTION LAYOUT DIAGRAM

Indicate North

Not to Scale

Data to be Included:

Lane Layout

- Thru Lane
- Left Turn lane
- Right Turn Lane
- Lane Width
- Intersection Width*
- Crosswalk/Length**
- Stop Bar Location
- pkg — Parking Lane
- bus — Bus Stops

Signal Layout

- Span Wire/Pole
- Mast Arm/Pole
- Pedestal
- Ped. Signal
- Controller
- Vehicle Detection
- Ped. Push Button
- *Signal Heads:*
  - One-Way
  - Two-Way
  - Three-Way
  - Four-Way

G

* Width of intersection, measured from the near-side stop bar to the far edge of the conflicting extended travel lane along the actual vehicle path of a thru vehicle (feet).
** Pedestrian crossing distance is measured along the crosswalk line closest to the stop bar from near curb to extended edge of furthest travel lane.

I

Reset Form

Section A – Intersection Location and Number

Section A provides the general information about the intersections location including:

- Main and Cross Street Name
- City/Township, County
- Latitude & Longitude Coordinates: the coordinates should be as close to the center of where the roads cross as possible. For Boulevards it should be the center of the combined intersection. The standard format should be as shown (Latitude/Longitude) and the last two digits should be decimals. Utilization of Google Earth is acceptable for obtaining the coordinates. If an existing inventory form is available and includes the GPS coordinates they should not be changed unless a review shows them to be incorrect.

Example: DD-MM-SS.SS

- Intersection Number and Mile Post Number. These are the Control Section, Spot number and Mile Post number provided by MDOT.
- Prime Number
- MDOT Project Number
- The observer who performed the inventory and the date in which it was completed on should also be entered.

Section B – Street Naming

Section B provides the names for each approach as indicated by the direction above. If there is no approach in a particular direction, leave this street name blank.

Section C – Geometry

Section C provides information regarding approach lanes, intersection measurements, parking lanes, and grades.

- **Through Lanes:** The number of through lanes present in each direction.
- **Left and Right Turn Lanes:** Indicates the number of right and left turn lanes and their corresponding lengths. If a turn lane is shared with a through lane movement, count it as a through lane. If a two-way left-turn lane (TWLTL) is present, indicate this on the inventory form using the abbreviation TWLTL next to the left turn lane. In Synchro this length should be coded as a TWLTL with a 500 foot storage length unless a field review shows that as unreasonable (ie: queuing observed to be longer than 500 feet or it would extend back beyond a major intersection limiting drivers ability to utilize a full 500 feet).

- If adjacent parking is present and ends before the intersection, thus leaving room for a vehicle to make a right turn, indicate this as an available right turn lane, with storage distance. Observations should be made to determine if traffic is utilizing this space as a right turn lane. Include a note in the comments section indicating this is the case. If the parking ends at the intersection, as can be seen in Figure 1 on the southbound approach, then there is no exclusive right turn lane.

- Turn lane lengths should be measured based on the length of full width pavement, not where the pavement markings stop. If congestion is significant, part of the taper length may be coded as storage. If this is done a remark should be included in the comments section that the operation was being used based on field observation.

- Some approaches will be marked as a single lane but may be wide enough to accommodate multiple lanes of traffic. In this case the operation should be observed and the lanes shown as they function along with a note in the comments section explaining this.

- **Intersection Width:** See Section 4.1 for details on measuring intersection widths. If it is a boulevard the near/far stop bar distance should be entered in parentheses after the intersection width.

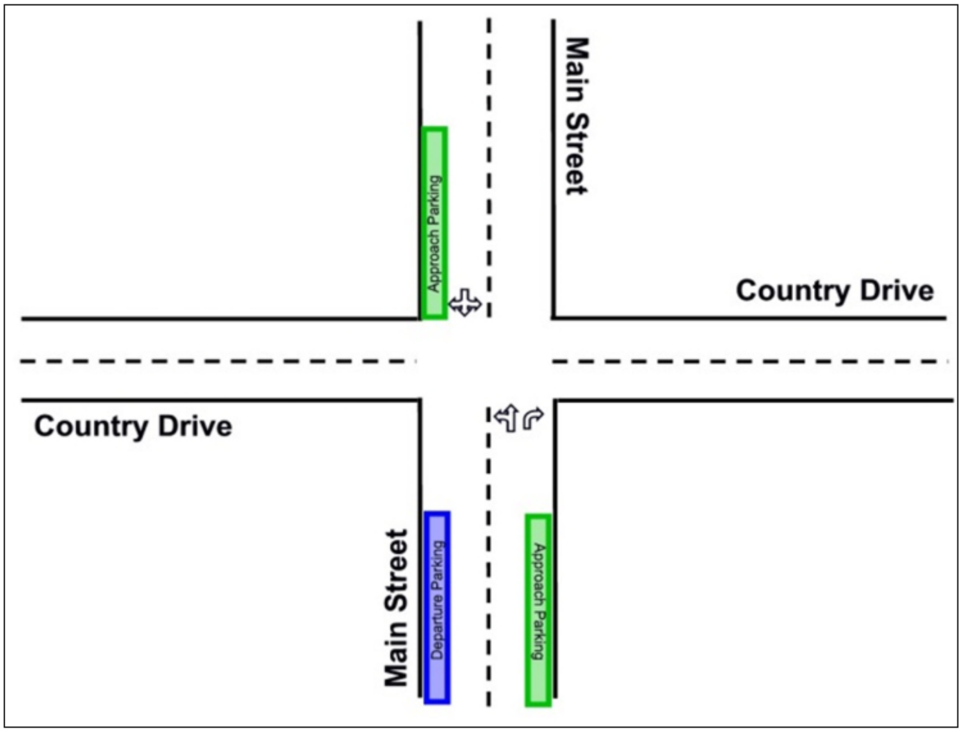
- **Pedestrian Crossing Length / Button Distance:** See Section 4.2 for details on measuring the pedestrian crossing length. The first and third entry for each approach are the distances from the curb to the pushbuttons, if present. The middle entry is the actual crossing distance. This is most helpful when reducing the walk time from 7.0 sec to 4.0 sec, if this distance is more than the recommended 10 feet and the pedestrian waits near the push button and not the curb, the walk time should be increased.

- **Adjacent Parking Lane Approach and Departure:** Indicates with a yes, "Y", or a no, "N" whether a parking lane is present. If a parking lane is present on the near side of the intersection this would be labeled as an Approach Parking Lane, whereas if the parking lane is located on the far side of the intersection it should be labeled as a Departure Parking Lane.

  - See Figure 1 for a visual. There is parking available on Main Street only. For the northbound lane Approach Parking should be indicated, whereas for the southbound lane both Approach and Departure Parking should be indicated.

- **Approach Grade:** Grades are indicated as either positive or negative. If the approach is uphill this would be positive, if the approach is downhill it would be negative. A visual estimate of the grade should be entered on the inventory form. For any grade perceived as 2% or less, leave as 0% on the clearance interval calculation spreadsheet (Section 4.1). For any grade perceived as 3% or higher, enter these values on the clearance interval calculation spreadsheet. Also note the grades in the *REMARKS* section of the timing permit. (i.e. EB M-55 approach grade 5%). Leave all grades out of the Synchro files.

Figure 1: Approach and Departure Parking Lanes



<u>Section D – Operations</u>

Section D provides information regarding intersection speed limit and operations.

- **Approach and Departure Speed Limit:** Indicates the speed limit in mph for the approach and departure lanes. Make sure that if the speed limit changes at the intersection it is accurately recorded.

  - The official location where a speed limit changes is typically at an intersection. Often the sign is placed a few hundred feet past the intersection to avoid the congested area near the intersection. If the sign is placed a short distance past the intersection, the models should reflect a change at the intersection.

  - See Figure 2 for a visual. The speed limit on Main Street is consistently 25 mph, therefore the approach and departure speed limit is the same. On Country Drive the speed limit changes as a vehicle approaches town entering westerly, dropping from 50 mph to 30 mph. Similarly the speed increases as the vehicle leaves town (easterly), increasing from 30 mph to 50 mph. Therefore the EB approach speed limit should be recorded as 30 mph while the departure speed would be recorded as 50 mph.

  - At ramps and driveways, a default value of 25 mph should be utilized unless posted otherwise. On the inventory form it should be noted as "unposted - 25 mph".

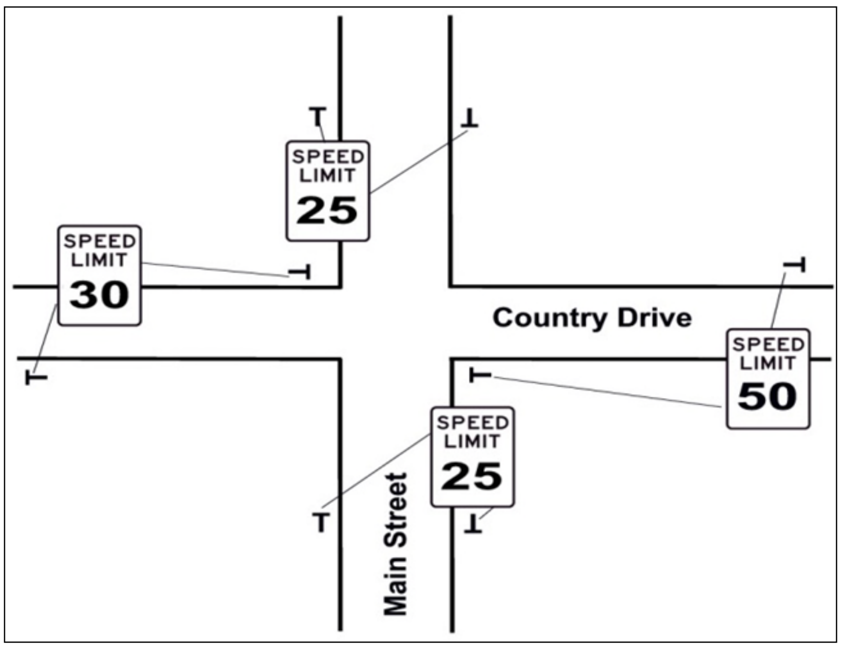
- For other roads with no posted speed limit, the nature of the road should be noted and assigned a speed limit, typically 25 mph or 55 mph, unless there is reason to recommend a different speed limit. As with ramps and driveways, utilize the format "unposted – XX mph".

- **Right Turn on Red:** Indicates any prohibitions/restrictions

  - If Left Turn on Red is allowed at a crossover or one way street, this should be noted in the comments section.

- **Turn Restrictions:** A turning restriction should be indicated when right or left turns are not allowed. This is common on boulevards where the left turn is achieved through crossovers.

Figure 2: Approach and Departure Speed Limits



Section E – Equipment

- **Pedestrian Signal:** Indicate with a yes, "Y", or a no, "N" whether a pedestrian signal is present.

  - Pedestrian indications should reflect the crossing that would be in operation with the adjacent vehicle signal. Example: The Northbound approach should include pedestrian information for the east leg of the intersection.

  - If countdown signals are present enter: "Y – Countdown"

- **Pedestrian Push Button:** Indicate with a yes, "Y", or a no, "N" whether a push button is present.

- **Left Turn Head Type:** The left turn signal head type should be indicated as:

- 3 - Level Arrow
- 4 - Level Green Arrow
- 4 - Level Yellow Arrow Flash
- Dog-House

- **Right Turn Green Arrow:** Indicates with a yes, "Y", or a no, "N" whether a right turn green arrow is present.
- **Ambient Light:** MDOT is moving away from internally lighted case signs if there is ambient lighting within the area. Ambient lighting can be provided from an overhead streetlight or from an adjacent parking lot. Any reasonable amount of lighting should be coded as yes. This is a judgment determination. A separate night review is not required.

Section F – Signal Phasing

Section F provides a drawing of each phase for which the signal operates. A solid line indicates that the movement is "Protected", a dashed line indicates that the movement is "Permitted". Provided in each of the phases are four arrows:

- Permitted Left Arrow
- Protected Left Arrow
- Protected Through Arrow
- Protected Right Arrow: The protected right turn should only be checked if there is a right turn arrow and it is on during that phase.

For each phase, indicate which movements are allowed, leaving blank those movements that are not stopped. In the case where a signal has more than six phases attach a third page and provide an explanation in the general comments section (I).

For T intersections for the movement coming from the bottom of the T, the through movement should be checked if there are no turn arrows. If there are green arrows, the turning movements should be checked. This is primarily to differentiate between a protected turning movement and one with the potential for conflicting pedestrians.

Section G – Intersection Layout Diagram

In the space provided for drawing, a clean hand sketch or an electronic version of the intersection should be provided. Data to be included are as follows:

- Through Lanes
- Turn Lanes
- Signal Poles
- Pedestrian Signal/Push Button

- Width/Measurements
- Crosswalk Length
- Parking Lanes
- Bus Stops
- Controller
- Detection
- Signal Head Direction
- Directional North Arrow: to be indicated via radio button.

To add an electronic version of the intersection layout start by left-clicking anywhere within the gridded-box area. This will bring up a “Select Image File” box. From here route the browser to the correct image file. Click on intersection layout and choose “Select,” this will add the layout to the Inventory form.

Section I – General Comments

Section I provides extra space for anything that is not contained within the Inventory form. A possible item to include is if the layout should be modeled differently in Synchro than from what is shown. This case is most common when an approach lane is marked as a single lane but is wide enough that it is being used as two approach lanes.

Section H – Intersection Location and Number

The information contained within Section H carries over from Page 1 when inserted.

APPENDIX C

SAMPLE TIMING PERMIT FORMS

MDOT
Michigan Department of Transportation

NTCIP Permit 6-22-23

NTCIP TRAFFIC SIGNAL TIMING PERMIT

PHASE	1	2	3	4	5	6	7	8
APPROACH								
MINIMUM GREEN								
PASSAGE								
MAXIMUM GREEN NO. 1								
MAXIMUM GREEN NO. 2								
YELLOW CLEARANCE								
ALL RED CLEARANCE								
WALK								
FLASHING DON'T WALK (FDW) CLEARANCE								
EXT PED CLR (EOG, EOY, 3.0s)								
START UP PHASE(S)	☐	☐	☐	☐	☐	☐	☐	☐
VEHICLE RECALL (NONE, MIN, MAX, SOFT)								
PEDESTRIAN RECALL (NONE, RECL, OTHR)								
DUAL ENTRY (Y, N)								
MODE (CRD, MIN, MAX, D-CRD, NOCRD)								
DAILY FLASH (Y, R, DK, NA)								
CONFLICT FLASH (Y, R, DK)								
EVNT/ACTN PLN OFFSET CYCLE								
EVNT/ACTN PLN OFFSET CYCLE								
EVNT/ACTN PLN OFFSET CYCLE								
EVNT/ACTN PLN OFFSET CYCLE								
EVNT/ACTN PLN OFFSET CYCLE								
EVNT/ACTN PLN OFFSET CYCLE								

START UP TIME: 6.0 START UP STATE: All Red ☐ Flash ☐

	1	2	3	4	5	6	7	8
CYCLE PEDS WHEN IN FREE? (CP, WR)								
LEAD PEDESTRIAN INTERVAL								
DILEMMA RED MAX (AR + RED EXT)								

TIMING INSTALLED

PRE-EMPT ☐
COUNTDOWN PEDS ☐

REMARKS

FLASH HOURS: ______ to ______ DAILY ☐ NONE ☐

PHASE
1
2
3
4
5
6
7
8

VEHICLE OVERLAPS

Overlap Phase	*Load Bay*	*Phases Overlapped*	T.G. (s)	Y (s)	R (s)	*FYA Phases Perm*	*FYA Phases Prot*	*Flash Daily*	*Flash Confl*
=									
=									
=									
=									
=									
=									
=									
=									

CONTROLLER and FIRMWARE#
☐ Siemens (SEPAC)
☐ ECONOLITE (EOS)
☐ Other:

PREPARED BY:

DATE:

LOCATION:

CITY/TWP:

COUNTY :

MILE POINT	CONTROL SECTION-SPOT #

Job # (If Applicable):

CLEAR ALL

Page 1 of 4

Page 4 included only if Pre-Empt Checked

Michigan Department of Transportation

NTCIP Permit 6-1-23

ADVANCED TIMING PARAMETERS FORM

SYSTEM INFORMATION

System Type:

- ☐ Central
  - Group ID
- ☐ TBC
- ☐ None
- ☐ Other:

Controller Location ID:

Interconnect:

- ☐ HARDWIRE
- ☐ FIBER-OPTIC
- ☐ RADIO
- ☐ SERIAL RADIO
  - Hop Pattern:
- ☐ IP RADIO
- ☐ TBC
- ☐ GPS CLOCK
- ☐ CELL MODEM
- ☐ NONE
- ☐ Other:

LEFT-TURN PHASING

Phase # / Description	*Permissive-Protected* Lead	*Permissive-Protected* Lag	*Protected-Only* Split	*Protected-Only* Lead	*Protected-Only* Lag
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

RING AND BARRIER STRUCTURE

	B1	B2	B3	B4
R1				
R2				
R3				
R4				

VEHICULAR AND PEDESTRIAN DETECTION

Approach	*Vehicle Detection* Movements and Call Delay (s) Left	Thru	Right	Locking Left	Thru	Right	*Pedestrian Detection* Phase # /	Crossing /	Load Switch #
	☐	☐	☐	☐	☐	☐			
	☐	☐	☐	☐	☐	☐			
	☐	☐	☐	☐	☐	☐			
	☐	☐	☐	☐	☐	☐			
	☐	☐	☐	☐	☐	☐			
	☐	☐	☐	☐	☐	☐			

COORDINATION/OPERATION SETTINGS

CHANGE (ADD ONLY, ADD/SUBT, OTHR)	
REST IN WALK FOR COORD PHASE (Y/N)	
PUSHBUTTONS FOR COORD PHASE (Y/N)	

ADDITIONAL EVENT/ACTION PLAN DATA

		PHASE	1	2	3	4	5	6	7	8
EVNT/ACTN PLN	OFFSET	CYCLE								
EVNT/ACTN PLN	OFFSET	CYCLE								
EVNT/ACTN PLN	OFFSET	CYCLE								
EVNT/ACTN PLN	OFFSET	CYCLE								
EVNT/ACTN PLN	OFFSET	CYCLE								
EVNT/ACTN PLN	OFFSET	CYCLE								
EVNT/ACTN PLN	OFFSET	CYCLE								
EVNT/ACTN PLN	OFFSET	CYCLE								
EVNT/ACTN PLN	OFFSET	CYCLE								
EVNT/ACTN PLN	OFFSET	CYCLE								

DISAPPEARING CASE SIGN

REMARKS

PREPARED BY: DATE:

☐ MDOT ☐ County ☐ City ☐ Consultant

LOCATION:

CONTROL SECTION-SPOT #

NTCIP Permit 6-1-23

SCHEDULING INFORMATION

Default Weekly Schedule

Schedule #	Days of Week	Start Date	End Date	Day Plan #	Events
1		January 1st	December 31st	1	
2				2	
3				3	
4				4	

Special Schedules

Schedule remarks including floating holiday schedules

Day Plan #	Events	Day Plan #	Events	Day Plan #	Events	Day Plan #	Events
5		6		7		8	

MONTH OF YEAR / DAY OF WEEK / DAY OF MONTH

Schedule	Day Plan #	J	F	M	A	M	J	J	A	S	O	N	D	S	M	T	W	T	F	S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
11																																																			
12																																																			
13																																																			
14																																																			
15																																																			
16																																																			
17																																																			
18																																																			
19																																																			
20																																																			
21																																																			
22																																																			
23																																																			
24																																																			

REMARKS :

PREPARED BY: | DATE: | LOCATION: | CONTROL SECTION-SPOT #

NTCIP Permit 6-1-23

PREEMPTION INFORMATION FORM

Preemption Description:

Preempt # =	Seconds		Load Switch	1	2	3	4	5	6	7	8	9	10	11	12	--	--	--	--	Locking	Y
Entry Ped Cl			Phas/Ovl																	Delay (s)	
Entry Yellow																				Extend (s)	
Entry Red Cl		Vehicle	Track																	Duration (s)	
Track Green			Dwell																	Max Call (s)	
Track Ped Cl			Cycle																	Link PreEmpt #	
Track Yellow			Exit																	Exit Free or Crd	
Track Red Cl			Phase #																	**Display Case Sign?**	
Dwell Green																				No Turn on Red	N
Exit Ped Cl		Ped	Track																	No Right Turn	N
Exit Yellow			Dwell																	No Left Turn	N
Exit Red Cl			Cycle																	Other Case Sign	N

Preemption Description:

Preempt # =	Seconds		Load Switch	1	2	3	4	5	6	7	8	9	10	11	12	--	--	--	--	Locking	Y
Entry Ped Cl			Phas/Ovl																	Delay (s)	
Entry Yellow																				Extend (s)	
Entry Red Cl		Vehicle	Track																	Duration (s)	
Track Green			Dwell																	Max Call (s)	
Track Ped Cl			Cycle																	Link PreEmpt #	
Track Yellow			Exit																	Exit Free or Crd	
Track Red Cl			Phase #																	**Display Case Sign?**	
Dwell Green																				No Turn on Red	N
Exit Ped Cl		Ped	Track																	No Right Turn	N
Exit Yellow			Dwell																	No Left Turn	N
Exit Red Cl			Cycle																	Other Case Sign	N

Preemption Description:

Preempt # =	Seconds		Load Switch	1	2	3	4	5	6	7	8	9	10	11	12	--	--	--	--	Locking	Y
Entry Ped Cl			Phas/Ovl																	Delay (s)	
Entry Yellow																				Extend (s)	
Entry Red Cl		Vehicle	Track																	Duration (s)	
Track Green			Dwell																	Max Call (s)	
Track Ped Cl			Cycle																	Link PreEmpt #	
Track Yellow			Exit																	Exit Free or Crd	
Track Red Cl			Phase #																	**Display Case Sign?**	
Dwell Green																				No Turn on Red	N
Exit Ped Cl		Ped	Track																	No Right Turn	N
Exit Yellow			Dwell																	No Left Turn	N
Exit Red Cl			Cycle																	Other Case Sign	N

Preemption Description:

Preempt # =	Seconds		Load Switch	1	2	3	4	5	6	7	8	9	10	11	12	--	--	--	--	Locking	Y
Entry Ped Cl			Phas/Ovl																	Delay (s)	
Entry Yellow																				Extend (s)	
Entry Red Cl		Vehicle	Track																	Duration (s)	
Track Green			Dwell																	Max Call (s)	
Track Ped Cl			Cycle																	Link PreEmpt #	
Track Yellow			Exit																	Exit Free or Crd	
Track Red Cl			Phase #																	**Display Case Sign?**	
Dwell Green																				No Turn on Red	N
Exit Ped Cl		Ped	Track																	No Right Turn	N
Exit Yellow			Dwell																	No Left Turn	N
Exit Red Cl			Cycle																	Other Case Sign	N

Preempt System Data

Preempt	1	2	3	4
MIN GREEN	7.0	7.0	7.0	7.0
MIN WALK	7.0	7.0	7.0	7.0
Overide Flash				
Priority	-	-	-	-

PE Status Pos in Pedestrian LSs	Ped Y1	Ped Y2	Ped Y3	Ped Y4	Ped Y5	Ped Y6	Ped Y7	Ped Y8
PE# Represented		1		2		3		4

For Railroad Preemption

Dummy PH#:	9	Min Green:		Yellow:	
Track Overlap:		Max Green:		All Red:	

REMARKS :

PREPARED BY: DATE:

LOCATION:

CONTROL SECTION-SPOT #

MDOT
Michigan Department of Transportation

EPAC Permit 4-2-21

TRAFFIC SIGNAL TIMING PERMIT

	PHASE	1	2	3	4	5	6	7	8	
APPROACH										
MINIMUM GREEN										
PASSAGE										
MAXIMUM NO. 1										
MAXIMUM NO. 2										
YELLOW CHANGE										
RED CLEARANCE										
WALK										
PEDESTRIAN CLEARANCE										
EXTENDED PED. CLEARANCE										
REST IN WALK										
INITIALIZATION										
NON-ACT RESPONSE										
VEHICLE RECALL										
PEDESTRIAN RECALL										
NON-LOCK MEMORY										
DUAL ENTRY										

DIAL		SPLIT		CYCLE	1	2	3	4	5	6	7	8	O1	O2	O3
DIAL	1	SPLIT	1												
DIAL	2	SPLIT	1												
DIAL	3	SPLIT	1												
DIAL		SPLIT													
DIAL		SPLIT													
DIAL		SPLIT													
				MODE											

PHASE

1

2

3

4

5

6

7

8

OVERLAPS

Overlap Phase	*Load Bays*	*Phases Overlapped*	T.G. (s)	Y (s)	R (s)	-G/Y	+GRN
=							
=							
=							
=							

TIMING INSTALLED

REMARKS

PREPARED BY: DATE:

FLATH HOURS:

to DAILY ☐ NONE ☐

NIGHT FLASH:

FY = FR =

CONFLICT FLASH:

FY = FR =

CONTROLLER TYPE:
☐ EPAC
☐ Other:

PRE-EMPT ☐
COUNTDOWN PEDS ☐

LOCATION:

CITY/TWP:

COUNTY :

MILE POINT	CONTROL SECTION-SPOT #

Job # (If Applicable):

CLEAR PAGE 1 CLEAR ALL

Page 1 of 3

Page 3 included only if Pre-Empt Checked

MDOT
Michigan Department of Transportation

EPAC Permit 4-2-21

ADVANCED TIMING PARAMETERS FORM

SYSTEM INFORMATION

Controller Type:
- ☐ EPAC
- ☐ Other:

System Type:
- ☐ Closed Loop
  - ☐ Stand By
  - ☐ Group 1
  - ☐ Group 2
  - Address:
- ☐ TBC
- ☐ TBC/GPS
- ☐ None
- ☐ Other:

If TBC, Sync by:
- ☐ TOD
- ☐ Event

Interconnect Type:
- ☐ Hardwire
- ☐ Fiber-Optic
- ☐ Radio
- ☐ Cell Modem
- ☐ None
- ☐ Other:

If Cell Modem:
Phone #

Controller Status:
- ☐ Primary
- ☐ Secondary
- ☐ Isolated
- ☐ TBC

If Secondary, Primary Location:

Primary Spot # :

LEFT-TURN PHASING

Phase # / Description	*Permissive-Protected* Lead	*Permissive-Protected* Lag	*Protected-Only* Split	*Protected-Only* Lead	*Protected-Only* Lag
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

RING AND BARRIER STRUCTURE

	B1	B2	B3	B4
R1				
R2				
R3				
R4				

VEHICULAR AND PEDESTRIAN DETECTION

Approach	*Vehicular Detection* Movements and Call Delay (s) Left	Thru	Right	Type Loop	Video	Other	*Pedestrian Detection* Push-Button Crossing Locations
	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	

DISAPPEARING LEGEND CASE SIGNS

ADDITIONAL DIAL SPLIT DATA

						PHASE	1	2	3	4	5	6	7	8	O1	O2	O3
DIAL		SPLIT		CYCLE													
DIAL		SPLIT		CYCLE													
DIAL		SPLIT		CYCLE													
DIAL		SPLIT		CYCLE													
DIAL		SPLIT		CYCLE													
DIAL		SPLIT		CYCLE													
DIAL		SPLIT		CYCLE													
DIAL		SPLIT		CYCLE													
DIAL		SPLIT		CYCLE													
DIAL		SPLIT		CYCLE													

COORDINATION DATA

Operation Mode	
Coordination Mode	
Maximum Mode	
Correction Mode	
Offset Mode	
Force Mode	
Max Dwell	
Yield Period	

REMARKS:

ADDITIONAL OVERLAP DATA

Overlap Phase		*Load Bays*	*Phases Overlapped*	T.G. (s)	Y (s)	R (s)	-G/Y	+GRN
	=							
	=							
	=							
	=							

PREPARED BY: DATE:

☐ MDOT ☐ County ☐ City ☐ Consultant

LOCATION:

CONTROL SECTION-SPOT #

CLEAR PAGE 2

MDOT
Michigan Department of Transportation

EPAC Permit 4-2-21

PREEMPTION INFORMATION FORM

Preemption Description:																				
Preempt # =	Time (s)	Phases		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
SEL Ped Cl		Vehicle	Track																	☐ Locking
SEL Yellow			Dwell																	
SEL Red Cl			Cycle																	☐ Non-Locking
TRACK Green			Exit																	
TRACK Ped Cl		Ped	Track																	Delay (s)
TRACK Yellow			Dwell																	Extend (s)
TRACK Red CL			Cycle																	Duration (s)
DWELL Green		Overlap Vehicle	Overlap	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Max Call (s)
RET Ped Cl			Track																	Lockout (s)
RET Yellow			Dwell																	Link PE #
RET Red Cl			Cycle																	

Preemption Description:																				
Preempt # =	Time (s)	Phases		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
SEL Ped Cl		Vehicle	Track																	☐ Locking
SEL Yellow			Dwell																	
SEL Red Cl			Cycle																	☐ Non-Locking
TRACK Green			Exit																	
TRACK Ped Cl		Ped	Track																	Delay (s)
TRACK Yellow			Dwell																	Extend (s)
TRACK Red CL			Cycle																	Duration (s)
DWELL Green		Overlap Vehicle	Overlap	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Max Call (s)
RET Ped Cl			Track																	Lockout (s)
RET Yellow			Dwell																	Link PE #
RET Red Cl			Cycle																	

Preemption Description:																				
Preempt # =	Time (s)	Phases		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
SEL Ped Cl		Vehicle	Track																	☐ Locking
SEL Yellow			Dwell																	
SEL Red Cl			Cycle																	☐ Non-Locking
TRACK Green			Exit																	
TRACK Ped Cl		Ped	Track																	Delay (s)
TRACK Yellow			Dwell																	Extend (s)
TRACK Red CL			Cycle																	Duration (s)
DWELL Green		Overlap Vehicle	Overlap	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Max Call (s)
RET Ped Cl			Track																	Lockout (s)
RET Yellow			Dwell																	Link PE #
RET Red Cl			Cycle																	

Preemption Description:																				
Preempt # =	Time (s)	Phases		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
SEL Ped Cl		Vehicle	Track																	☐ Locking
SEL Yellow			Dwell																	
SEL Red Cl			Cycle																	☐ Non-Locking
TRACK Green			Exit																	
TRACK Ped Cl		Ped	Track																	Delay (s)
TRACK Yellow			Dwell																	Extend (s)
TRACK Red CL			Cycle																	Duration (s)
DWELL Green		Overlap Vehicle	Overlap	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Max Call (s)
RET Ped Cl			Track																	Lockout (s)
RET Yellow			Dwell																	Link PE #
RET Red Cl			Cycle																	

Preempt System Data						
Ring	1	2	3	4		
MIN GRN/WLK (s)						
Priority	PE/FL	PE1/2	PE2/3	PE3/4	PE4/5	PE5/6
Status						

REMARKS :

PREPARED BY: DATE:

LOCATION:

CONTROL SECTION-SPOT #

CLEAR PAGE 3

Michigan Department of Transportation

P1500D (R4/88)

SOLID STATE TRAFFIC SIGNAL TIMING PERMIT

CYCLE LENGTH	OFF-SET	HOURS OF OPERATION	INTERVAL TIMING (SECONDS) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SEC	SEC	MINIMUM TIME °																								
		D 1 S 1 SPLITS																								
		D 2 S 1 SPLITS																								
		D 3 S 1 SPLITS																								
		D S SPLITS																								

LOAD SWITCH	DESCRIPTION	SIGNAL PLAN -- CYCLE SEQUENCE CHART 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	FLASH
C=Correction, I=Enter Flash, O=Exit Flash																										

REMARKS

Controller Type: ☐ EPIC ☐ EF140 ☐ Other:

DATE TIMING INSTALLED

JOB # (IF APPLICABLE):

PREPARED BY: DATE:

FLASH HOURS: to DAILY ☐ NONE ☐

PRE-EMPT ☐

COUNTDOWN PEDS ☐

LOCATION:

CITY/TWP.: COUNTY:

MILE POINT: CONTROL SECTION - SPOT #

CLEAR PAGE 1

CLEAR ALL

Page 1 of 3

Page 3 included only if Pre-Empt is Checked

MDOT
Michigan Department of Transportation

ADVANCED TIMING PARAMETERS FORM

SYSTEM INFORMATION

Controller Type:
- ☐ EPIC
- ☐ EF140
- ☐ Other:

System Type:
- ☐ Closed Loop
  - ☐ Stand By
  - ☐ Group 1
  - ☐ Group 2
  - Address:
- ☐ TBC
- ☐ TBC/GPS
- ☐ None
- ☐ Other:

If TBC, Synch by:
- ☐ TOD
- ☐ Event

Interconnect Type:
- ☐ Hardwire
- ☐ Fiber-Optic
- ☐ Radio
- ☐ Phone Drop
- ☐ None
- ☐ Other:

If Phone Drop, Phone #

LEFT-TURN PHASING

Description	*Permissive-Protected*		*Protected-Only*		
	Lead	Lag	Split	Lead	Lag
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

COORDINATION DATA

Operation Mode	
Correction Mode	
Maximum Dwell (s)	
Min Duration (m)	

DISAPPEARING LEGEND CASE SIGNS

VEHICULAR AND PEDESTRIAN DETECTION

Approach	*Vehicular Detection* Movements and Call Delay (s)			Type			*Pedestrian Detection*
	Left	Thru	Right	Loop	Video	Other	Push-Button Crossing Locations
	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	

ADDITIONAL DIAL SPLIT DATA

CYCLE LENGTH (SEC)	OFF-SET (SEC)	HOURS OF OPERATION	INTERVAL TIMING (SECONDS) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		D S SPLITS																				
		D S SPLITS																				
		D S SPLITS																				
		D S SPLITS																				

Remarks:

Prepared by: Date:

☐ MDOT ☐ County ☐ City ☐ Consultant

Location:

Control Section-Spot #

CLEAR PAGE 2

\

PREEMPTION INFORMATION FORM

Preemption Description:

Preempt # =	Time (s)
SEL Ped Cl	
SEL Yellow	
SEL Red Cl	
TRACK Green	
TRACK Ped Cl	
TRACK Yellow	
TRACK Red CL	
DWELL Green	
RET Ped Cl	
RET Yellow	
RET Red Cl	

Drivers		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Vehicle	Track																
	Dwell																
Ped	Track																
	Dwell																

Intervals		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Vehicle	Cycle																				
	Exit																				

☐ Locking

☐ Non-Locking

Delay (s)	
Extend (s)	
Duration (s)	
Max Call (s)	
Lockout (s)	
Link PE #	

Preemption Description:

Preempt # =	Time (s)
SEL Ped Cl	
SEL Yellow	
SEL Red Cl	
TRACK Green	
TRACK Ped Cl	
TRACK Yellow	
TRACK Red CL	
DWELL Green	
RET Ped Cl	
RET Yellow	
RET Red Cl	

Drivers		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Vehicle	Track																
	Dwell																
Ped	Track																
	Dwell																

Intervals		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Vehicle	Cycle																				
	Exit																				

☐ Locking

☐ Non-Locking

Delay (s)	
Extend (s)	
Duration (s)	
Max Call (s)	
Lockout (s)	
Link PE #	

Preemption Description:

Preempt # =	Time (s)
SEL Ped Cl	
SEL Yellow	
SEL Red Cl	
TRACK Green	
TRACK Ped Cl	
TRACK Yellow	
TRACK Red CL	
DWELL Green	
RET Ped Cl	
RET Yellow	
RET Red Cl	

Drivers		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Vehicle	Track																
	Dwell																
Ped	Track																
	Dwell																

Intervals		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Vehicle	Cycle																				
	Exit																				

☐ Locking

☐ Non-Locking

Delay (s)	
Extend (s)	
Duration (s)	
Max Call (s)	
Lockout (s)	
Link PE #	

Preemption Description:

Preempt # =	Time (s)
SEL Ped Cl	
SEL Yellow	
SEL Red Cl	
TRACK Green	
TRACK Ped Cl	
TRACK Yellow	
TRACK Red CL	
DWELL Green	
RET Ped Cl	
RET Yellow	
RET Red Cl	

Drivers		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Vehicle	Track																
	Dwell																
Ped	Track																
	Dwell																

Intervals		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Vehicle	Cycle																				
	Exit																				

☐ Locking

☐ Non-Locking

Delay (s)	
Extend (s)	
Duration (s)	
Max Call (s)	
Lockout (s)	
Link PE #	

Preempt System Data

MIN GRN/WLK (s) ☐

Priority	PE/FL	PE1/2	PE2/3	PE3/4	PE4/5	PE5/6
Status						

REMARKS :

PREPARED BY: DATE:

LOCATION:

CONTROL SECTION-SPOT #

CLEAR PAGE 3

Page 3 of 3

Michigan Department of Transportation

APPENDIX D

SYNCHRO AND SIMTRAFFIC
SAMPLE ANALYSIS REPORT FORMATS

Sample SYNCHRO HCM Analysis Report Format

HCM Signalized Intersection Capacity Analysis
1035: M-3 (Gratiot) & 7 Mile 5/4/2015

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↱			↑↱			↑↑↱			↑↑↱	
Volume (vph)	0	557	45	0	514	238	0	1327	108	0	900	96
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Lane Width	12	10	12	12	12	12	10	10	12	10	10	12
Total Lost time (s)		4.0			4.0			4.0			4.0	
Lane Util. Factor		0.95			0.95			0.91			0.91	
Frt		0.99			0.95			0.99			0.99	
Flt Protected		1.00			1.00			1.00			1.00	
Satd. Flow (prot)		3424			3549			4479			4544	
Flt Permitted		1.00			1.00			1.00			1.00	
Satd. Flow (perm)		3424			3549			4479			4544	
Peak-hour factor, PHF	0.92	0.92	0.92	0.81	0.81	0.81	0.88	0.88	0.88	0.85	0.85	0.85
Adj. Flow (vph)	0	605	49	0	635	294	0	1508	123	0	1059	113
RTOR Reduction (vph)	0	5	0	0	22	0	0	8	0	0	12	0
Lane Group Flow (vph)	0	649	0	0	907	0	0	1623	0	0	1160	0
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	5%	5%	5%	5%	5%	5%
Bus Blockages (#/hr)	0	2	2	0	0	0	0	13	13	0	0	0
Parking (#/hr)								10			10	
Turn Type		NA			NA			NA			NA	
Protected Phases		4			8			2			6	
Permitted Phases												
Actuated Green, G (s)		36.0			36.0			62.2			62.2	
Effective Green, g (s)		38.0			38.0			64.0			64.0	
Actuated g/C Ratio		0.35			0.35			0.58			0.58	
Clearance Time (s)		6.0			6.0			5.8			5.8	
Lane Grp Cap (vph)		1182			1226			2605			2643	
v/s Ratio Prot		0.19			c0.26			c0.36			0.26	
v/s Ratio Perm												
v/c Ratio		0.55			0.74			0.62			0.44	
Uniform Delay, d1		29.1			31.7			15.1			12.9	
Progression Factor		1.00			1.00			0.24			0.54	
Incremental Delay, d2		1.8			4.0			1.0			0.5	
Delay (s)		30.9			35.7			4.6			7.4	
Level of Service		C			D			A			A	
Approach Delay (s)		30.9			35.7			4.6			7.4	
Approach LOS		C			D			A			A	

Intersection Summary			
HCM 2000 Control Delay	15.9	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	54.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

M-3 (Gratiot) - State Fair to I-75 1/4/2005 Optimized Conditions (PM Peak) Synchro 8 Report
IA Page 1

SimTraffic Performance Report
PM PEAK HOUR

ZONE 1
OPTIMIZED

Total Network Performance

	All
Total Delay (hr)	390.7
Total Stops	23745
Travel Time (hr)	542.1
Avg Speed (mph)	10

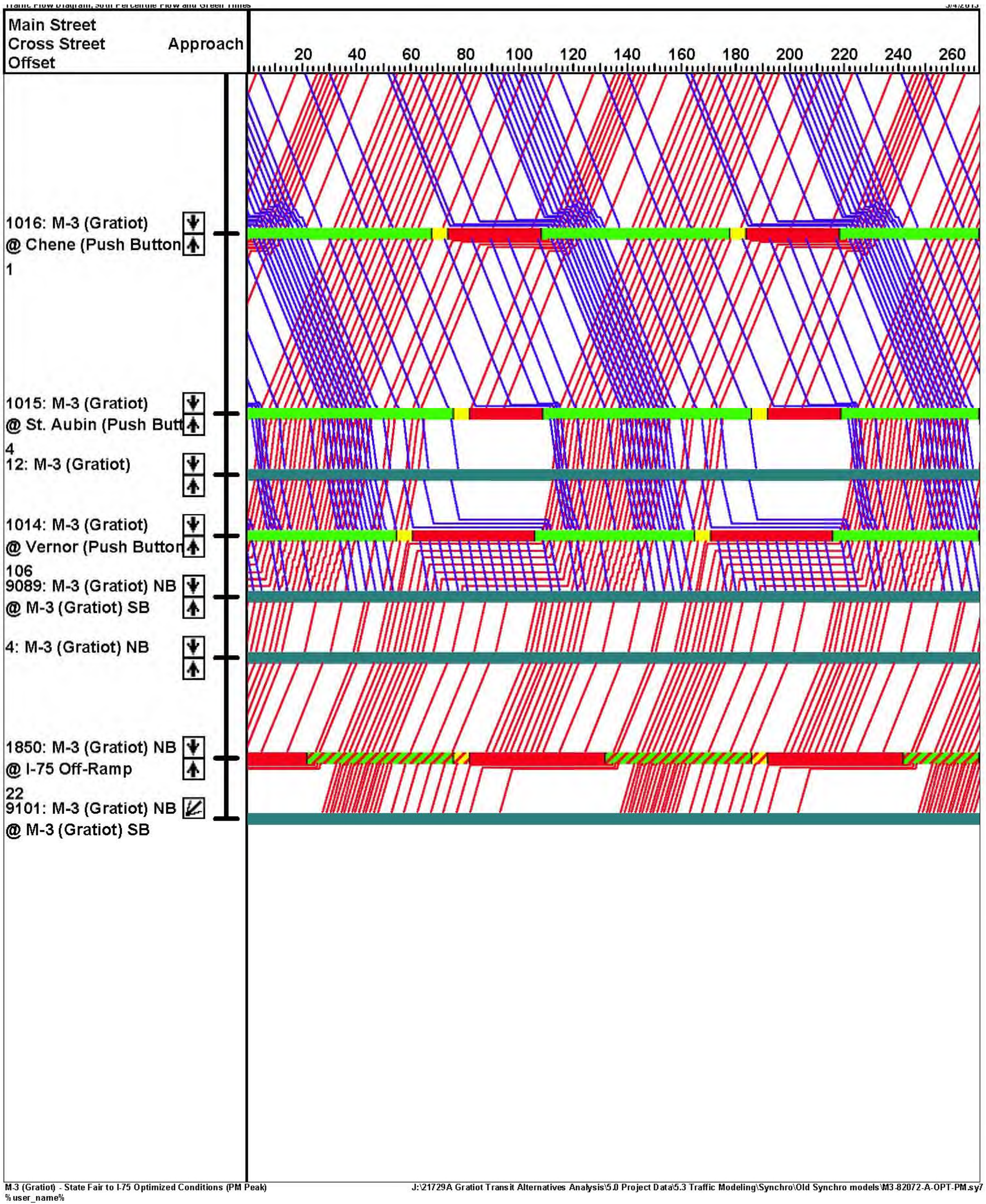
8/27/2003

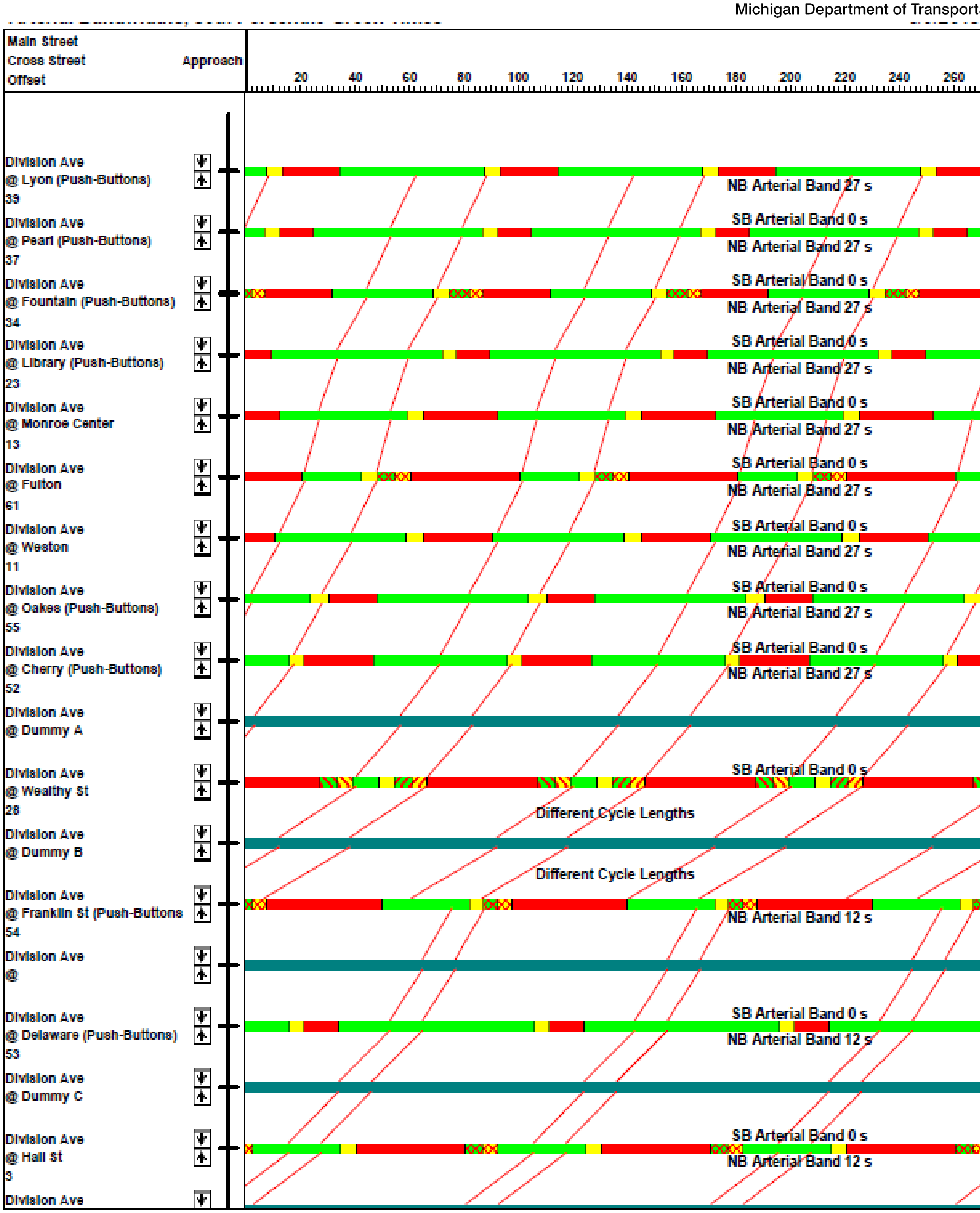
SimTraffic Report
Page 1

PARSONLVL7-FF51

Sample SIMTRAFFIC Network MOE Output Report

Sample SYNCHRO 90th percentile flow diagram





Sample SYNCHRO 90th percentile bandwidth diagram

APPENDIX E

SAMPLE BENEFIT COST ANALYSIS SPREADSHEET

PEAK HOUR SUMMARY STATISTICS

		Average Travel Time (sec)	Average Stopped Time (sec)	Average Travel Speed (mph)	Fuel Consumption (gal)	Pollutant Emissions CO (lbs)	Pollutant Emissions HC (lbs)	Pollutant Emissions NOx (lbs)	Total Travel Time (veh*hrs)
7:45 AM - 8:45 AM									
WB	Before	382.7	29.0	34.3	76.6	179.4	14.8	9.3	39.66
	After	372.0	24.8	35.2	78.1	158.5	13.6	8.2	38.81
	Change	-10.7	-4.2	0.9	1.5	-20.9	-1.2	-1.0	-0.84
EB	Before	373.3	26.0	35.2	109.0	233.4	19.7	12.6	51.46
	After	360.0	23.1	36.8	96.4	170.9	14.1	6.9	51.06
	Change	-13.3	-2.9	1.6	-12.6	-62.5	-5.6	-5.7	-0.40
12:00 PM - 1:00 PM									
WB	Before	410.4	36.8	31.7	144.3	356.2	29.4	18.5	78.56
	After	400.8	38.5	32.6	151.4	344.1	29.0	18.6	75.64
	Change	-9.6	1.7	0.9	7.1	-12.1	-0.4	0.1	-2.92
EB	Before	417.8	59.2	31.4	158.9	342.0	29.8	18.4	84.64
	After	376.5	23.5	35.2	145.9	299.4	24.6	14.1	75.59
	Change	-41.3	-35.7	3.8	-12.9	-42.6	-5.2	-4.3	-9.04
3:45 PM - 4:45PM									
WB	Before	426.0	62.6	30.5	160.0	373.8	31.1	20.1	94.89
	After	410.9	48.7	31.9	172.0	395.5	32.9	20.2	91.29
	Change	-15.1	-13.9	1.4	12.0	21.8	1.7	0.1	-3.60
EB	Before	416.8	57.0	31.5	157.7	341.1	29.5	18.3	83.31
	After	372.6	34.7	35.6	142.1	237.3	20.4	10.2	74.83
	Change	-44.2	-22.3	4.1	-15.6	-103.9	-9.0	-8.1	-8.48

PEAK PERIOD SUMMARY STATISTICS

		Fuel Consumption (gal)	Pollutant Emissions CO (lbs)	Pollutant Emissions HC (lbs)	Pollutant Emissions NOx (lbs)	Total Travel Time (veh*hrs)
AM Peak Period (6:00 AM - 9:00 AM)						
WB	Before	183.7	430.3	35.4	22.2	95.14
	After	187.2	380.2	32.6	19.8	93.11
	Change	3.5	-50.0	-2.8	-2.5	-2.02
EB	Before	244.2	522.9	44.1	28.2	115.29
	After	216.0	382.9	31.5	15.5	114.40
	Change	-28.2	-140.0	-12.6	-12.8	-0.89
Off-Peak Periods (9:00 AM - 3:00 PM; 7:00 PM - 10:00 PM)						
WB	Before	913.9	2227.5	185.9	116.7	504.99
	After	966.6	2180.4	186.8	120.3	491.77
	Change	52.7	-47.1	0.8	3.7	-13.22
EB	Before	1040.4	2283.6	198.9	125.2	549.50
	After	950.7	1978.1	162.1	94.1	489.51
	Change	-89.7	-305.5	-36.8	-31.1	-59.99
PM Peak Period (3:00 PM - 7:00 PM)						
WB	Before	544.1	1270.8	105.9	68.2	322.64
	After	584.8	1344.7	111.8	68.7	310.38
	Change	40.7	74.0	5.9	0.5	-12.26
EB	Before	535.0	1157.1	100.0	62.0	282.59
	After	482.1	804.8	69.3	34.5	253.82
	Change	-52.9	-352.3	-30.7	-27.5	-28.77

DAILY SUMMARY STATISTICS

	Fuel Consumption (gal/day)	Pollutant Emissions CO (lbs/day)	Pollutant Emissions HC (lbs/day)	Pollutant Emissions NOx (lbs/day)	Total Travel Time (veh*hrs)
Before	3461.4	7892.1	670.2	422.5	1870.14
After	3387.5	7071.2	594.0	352.8	1752.98
Change	-73.8	-821.0	-76.2	-69.7	-117.2
% Change	-2.1%	-10.4%	-11.4%	-16.5%	-6.3%

BENEFIT/COST EVALUATION

	Fuel Savings (gal/day)	Fuel Savings $	Travel Time Savings veh*hrs	Travel Time Savings Person - $
Daily Savings	73.8	$155	117.16	$1,772
Yearly Savings	18457	$38,759	29289	$443,001

[1-Year B/C Analysis]	Total Yearly Savings:	$481,760
	Total Project Cost:	$58,985
	Benefit/Cost:	**8.17**
[3-Year B/C Analysis]	Total Savings:	1,445,279.11
	Benefit/Cost:	**24.50**

Assumptions

Avg. Cost of Fuel ($/gal)	$2.10
Avg. # of Workdays/Year	250
Avg. Vehicle Occupancy	1.1
Avg. Value of Time/Individual ($/hr)	$13.75