TRAFFIC SIGNALS

A GUIDE FOR THEIR PROPER USE

MICHIGAN DEPARTMENT OF TRANSPORTATION

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Foreword

Intersection traffic control is a very controversial subject. In particular, when discussion turns to the merits of traffic signals, emotion frequently hinders an accurate evaluation of the need for these devices. In order to ensure signalization will provide the best available solution to existing problems, experienced personnel trained in traffic engineering principles should be consulted.

Properly used, the traffic signal can be an effective tool for providing safe and orderly traffic flow through an intersection. Indiscriminate traffic signal installation may result in more crashes, greater traffic congestion, or both.

This booklet has been prepared to explain and illustrate considerations and procedures the Michigan Department of Transportation (MDOT) follows when analyzing the need for changing from "STOP" sign control to "**stop and go**" traffic signal control at an intersection. We hope a "behind the scenes" picture will clear up many popular misconceptions and bring the importance of having such decisions based on nationally recognized engineering criteria into sharper focus.

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Introduction

In Michigan, responsibility for traffic signal installation at all intersections involving state trunklines (Interstate, US, and M routes) rests with the Department of Transportation (MDOT). Requests are received and analyzed, and decisions are made by Traffic and Safety Division engineers whose principle function is to review and evaluate traffic data and provide traffic control on the trunkline system where necessary.

The basic criteria for solutions to traffic control problems are contained in the *Michigan Manual of Uniform Traffic Control Devices* (MMUTCD). This book, based on standards approved by the Federal Highway Administration (FHWA), contains the lessons and experiences of a whole range of engineering disciplines. These standards were developed through the recommendations of a National Committee on Uniform Traffic Control Devices which is comprised by more than 20 organizations. Some of these organizations are:

American Automobile Association
American Association of Motor Vehicle Administrators
Association of American Railroads
American Association of State Highway and Transportation Officials
Advocates for Highway and Auto Safety
American Highway Users Alliance
American Pubic Transportation Association
American Public Works Association
American Railway Engineering and Maintenance of Way Association
American Road and Transportation Builders Association
American Traffic Safety Services Association
Human Factors Resources
Governors Highway Safety Association
International Association of Chiefs of Police
International Bridge, Tunnel and Turnpike Association
International Municipal Signal Association
Institute of Transportation Engineers
League of American Bicyclists
National Association of County Engineers
National Committee on Uniform Traffic Laws and Ordinances
National Safety Council

The intent of the manual is to establish uniform national standards for traffic control devices based on the experience of these groups, which will provide the safest and most efficient operation of our highway systems.

Why Uniform Standards?

Do you know what the color red signifies? A yellow painted line? An eight-sided traffic sign?

A study of driver observance of a standard red octagonal sign with the letters "SOTP" painted on it was conducted. It was found practically no one noticed the misspelled legend but everyone obeyed the sign. This exemplified the value of a uniform standard – the red octagonal "STOP" sign. Imagine the resulting confusion and chaos if there were no uniformity, if every political unit arbitrarily established its own rules and standards governing the operation of its streets, roads, and highways. It is through years of effort that organizations concerned with highway operations have succeeded in standardizing many of the well-accepted traffic control devices in use on our highways today.

Another important aspect of uniformity concerns the application of a device or "when and where" each will be used. This is very important to ensure uniform driver respect and response to a sign or device message. Uniformity is a critical factor relative to signalization because of the serious consequences which may result from installation of an unwarranted signal.

Properly used, traffic signals help reduce a certain type of crash, provide gaps in the traffic stream benefiting other access points further "downstream," and provide right-of-way changes for traffic at intersections.

However poorly designed, ineffectively placed, or improperly operated, signals perform just the opposite of what is expected of them. Intersections become clogged with cars, and motorist delay and crash potential is increased. Entire street systems can become creeping parking lots, particularly during rush hours.

Traffic engineers know there are reasons why some signals work while others do not. They are aware a set of guidelines, based on these experiences, has been developed to aid in deciding whether to signalize or seek other measures to alleviate intersection problems.

These guidelines were formulated into a set of "warrants," a list of circumstances under which signals may function properly and provide the motoring public and pedestrians the most benefit. The "warrants" are used by traffic engineers nationally to evaluate the need for stop and go traffic signals.

Warrants – Guidelines for Traffic Signal Installation

Signal warrants are a set of guidelines or conditions which can be applied equally to various traffic situations. Administered by experienced professional engineers skilled at applying them in an objective manner, they provide useful "tools" which allow careful assessment of the need for signalization.

Warrant 1 – EIGHT-HOUR VEHICULAR VOLUME

This warrant requires one of two conditions to be satisfied. The Minimum Vehicular Volume, Condition A, is intended for application at locations where a large volume of intersecting traffic is the principal reason to consider installing a traffic control signal. The minimum vehicular volume condition for rural environments and/or smaller municipalities is 70 percent of the requirement for urban conditions. The Interruption of Continuous Traffic, Condition B, is intended for application at locations where Condition A is not satisfied and where a very high volume of major street traffic restricts entry of cross-street traffic, causing excessive delay.

If neither condition is satisfied, a combination of Conditions A and B can be applied, but only after an adequate trial of other alternatives that could cause less delay and inconvenience to traffic has failed to solve the traffic problems.

Warrant 2 – FOUR-HOUR VEHICULAR VOLUME

This warrant is intended to be used where the volumes of intersecting traffic is the principal reason to consider signalization.

Warrant 3 - PEAK HOUR

This warrant is intended for application where traffic conditions are such that, for a minimum of one hour of the day, minor street traffic suffers excessive delay entering or crossing the major street.

Warrant 4 - PEDESTRIAN VOLUME

Occasionally, a situation arises where very high pedestrian activity conflicts with high traffic volumes on a major street. Warrant 4 provides for these instances.

Warrant 5 - SCHOOL CROSSING

Warrant 5 provides minimum installation guidelines for traffic signals at established school crossing locations based on the number of children utilizing the crossing and the availability of adequate gaps in the traffic stream during crossing periods.

Warrant 6 – COORDINATED SIGNAL SYSTEM

Between two widely spaced signals in a system, an intermediate traffic signal, properly located, may serve to regulate the size and speed of the traffic "platoon." A signal may be installed under this warrant if vehicle speeds vary and volumes are high.

Warrant 7 - CRASH EXPERIENCE

Certain conditions at an intersection may result in a high incidence of crashes. This warrant provides for a reduction in the number of vehicles required under other warrants.

Warrant 8 – ROADWAY NETWORK

This allows installation of traffic signals at some intersections to encourage concentration and organization of traffic flow networks.

These warrants have one common point: *they all require certain minimum vehicular volumes*. Other modifying circumstances are considered; gaps in traffic, presence of pedestrians and school children, proximity of the proposed signal to existing signals, and, of course, crashes. The basic criterion, however, is traffic volumes. MDOT traffic engineers utilize these warrants as a first step in evaluating all signal requests.

The warrants for signal installation represent years of exhaustive documentation, analysis, and review. They provide the traffic engineer with a good “tool” to aid his decision if, when, and where to install a signal. It must be remembered, these standards only establish minimum criteria for signalization. Satisfaction of a warrant does not necessarily indicate a traffic signal should be installed. Extensive study prior to final approval of a traffic signal is necessary to ensure the proposed signal provides the best solution to the problem at hand. Alternate solutions, such as changes in signs, lane markings, minor design revisions, etc., may “work” better.

Without knowledge of these guidelines, signal requests are often tinged with emotion. Traffic engineers and others at MDOT are as vitally concerned as anyone about the safety and well-being of all road users. If signals were a general solution to all intersection crash problems, traffic engineers would advocate a program to install signals at intersections throughout the state.

A signal request often results when people feel inconvenienced waiting to enter a highway at “their” access point. Naturally, once they are “on” and moving, they do not want to be delayed by a signal along the route. A very chaotic situation would result on our roadways if signals were installed at all of the locations where signalization requests are received. It is for this reason their use must be carefully considered by traffic engineers who have the data necessary to determine exactly what the problem is, along with the most desirable solution at their disposal.

Effects of Traffic Signals

What, then, are the effects of traffic signals? Do they improve intersection operation? Are intersections safer after their installation? When located properly and operated correctly, signals offer the following advantages:

1. They can provide orderly traffic movement.

2. Where proper physical design and control measures are used, they can increase the traffic-handling capacity of the intersection.

3. They can reduce the frequency of certain crash types, especially right-angle collisions.

4. Under favorable conditions, they can be coordinated to provide continuous or nearly continuous movement of traffic along a given route.

5. They can be used to interrupt heavy traffic at intervals to permit other traffic, vehicular or pedestrian, to cross.

Many believe traffic signals provide the solution to all intersection traffic problems. This has led to their installation at a large number of locations where no legitimate, factual need or warrant exists.

Traffic signal installation, even though warranted by traffic and roadway conditions, can be poorly-designed, ineffectively placed, improperly operated, or poorly maintained. The following factors can result from improper or unwarranted signal installation:

1. Excessive delay may be caused.

2. Disobedience of signal indications is encouraged.

3. The use of less adequate routes may be induced in an attempt to avoid the signal.

4. Crash frequency (especially rear-end crashes) can be significantly increased.

Improper Location

Some signals fail to provide expected benefits because they are incorrectly spaced along a roadway. Who hasn't experienced the utter frustration of plodding along in a long, slow-moving, overheated stream of cars through a signal clogged area? Stop and go, sit and wait, late to work, late to dinner. Another signal? It would only add to the congestion; it would only add to the crash potential. Alternate solutions are usually the only answer in situations of this type.

For sake of emphasis, put yourself in the driver's seat. Have you ever sat 40 or 50 seconds at a signal waiting for "your" green light with little or no cross street traffic? In most instances, delay at signalized intersections is greater than those with "STOP" sign control.

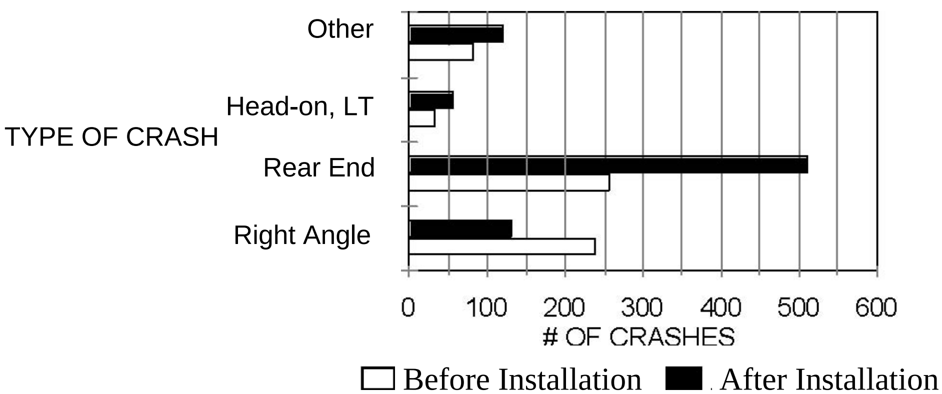
In summary, if warranting conditions are exceeded, a properly engineered signal installation may reduce certain types of crashes and, in general, lend organization to the flow of traffic from lesser volume cross streets. If improperly used, however, just the opposite may occur.

Signals and Safety

Remember the primary function of a signal. It stops traffic! Just as stopping for repairs or "turning off" a highway may create a crash potential, so, too, does stopping cars at a traffic signal.

Have you ever been confronted by the "yellow dilemma?" Close to a signal, sudden yellow: "Stop?" "Go through?" Have you always made the right decision? A wrong decision at this point can, at one time or another, result in a serious crash. The figure below illustrates the crash record at several locations throughout the State of Michigan one year before signalization and one year after.

Figure 1: Before and After Crash Studies of Traffic Signals

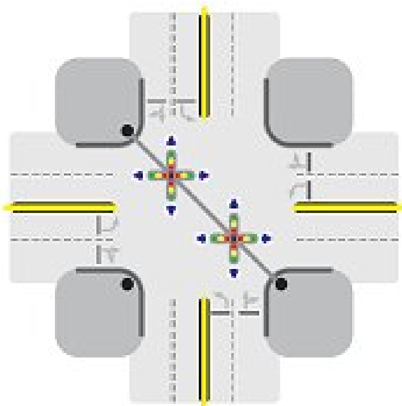


Left turns at signalized intersections frequently cause serious problems. Safe gaps for left-turning vehicles are often difficult to obtain at a signal. In addition, one left-turning vehicle can effectively block a whole lane of traffic, adding to intersection congestion. For these reasons, it is often necessary to prohibit left turns to insure the safest, most efficiently operating intersection.

When left-turn prohibition is not possible, MDOT has sometimes elected to provide a separate left-turn signal operation. Left turns can be "permissive" or "protected." "Permissive" left turn means left-turning traffic has permission to turn when a suitable gap is available. A flashing red ball is one way Michigan has denoted this permission; the new flashing yellow left-turn arrow is another. "Protected" left-turn phasing is provided with a left-turn green arrow and means left-turning traffic can turn without conflict because opposing traffic is stopped.

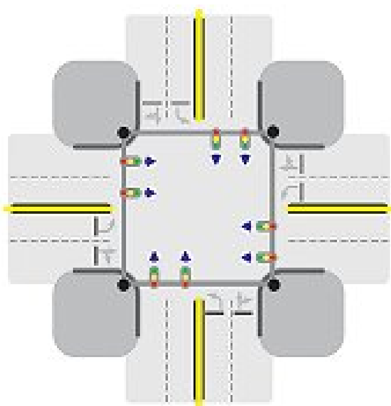
The New Box Span Traffic Signal

Box span signal design is a new method for positioning traffic signals in an intersection. In the course of projects that require upgrading an intersection and/or signal, MDOT will be replacing the traditional signal configuration with the box span design.



Traditional signal design

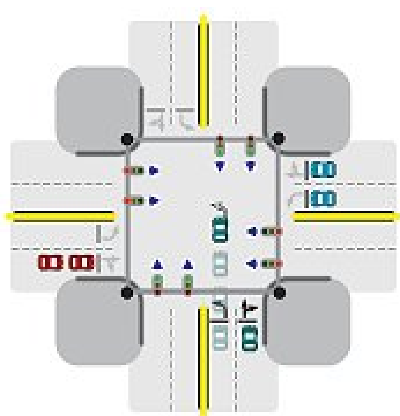
With the traditional signal design, two traffic signals are located in the middle of an intersection. They are suspended on wires secured to two poles placed opposite each other in the intersection.



New box span signal configuration

With the new box span configuration, signals are located near each corner of the intersection (thus, the "box" design).

Advantages of this design include increased safety for maintenance workers who no longer need to be stationed in the middle of a busy intersection to make repairs, and placement of the signal head over each lane which makes it easier for drivers to see the signals.



How a box span signal works

This diagram shows how the new signal configuration works. Motorists will continue to pull up to the stop line and proceed according to the signal directly opposite them at the far side of the intersection. Once this signal turns green, a motorist could go straight or turn, depending on their lane of travel. Motorists turning left need to follow through with the left-turn regardless of what the other traffic signals show; drivers should NOT stop in an intersection for any reason.

Understanding the New Flashing Yellow Left-Turn Signal

Motorists in the state may have begun to notice a new style of left-turn signals on Michigan's roads. The new signals are known as "flashing yellow arrow left-turn signals," and offer a safer, more efficient way to handle traffic turning left at busy intersections. The signals are being introduced nationwide and ultimately will be required at intersections where there is a separate left-turn-arrow signal. This change is the result of a national study conducted for the Federal Highway Administration, which demonstrated the new signals help prevent crashes, move more traffic through an intersection, and provide additional traffic management flexibility for road agencies.

What is a Flashing Yellow Arrow Left-Turn Signal?

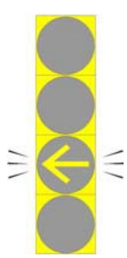
It's a new type of signal placed OVER the left-turn lane at a signalized intersection. The signal display includes a flashing yellow arrow. Other displays on the signal are a steady green arrow, steady yellow arrow, and steady red arrow. In coming years, this type of signal will be used by Michigan's roadway agencies in place of the flashing-red, left-turn signals that are now common.

What is the purpose of the new signal?

The new signals will make intersections safer while reducing traffic delay. While the flashing-yellow arrow is displayed, motorists are allowed to turn left when available gaps in oncoming traffic are present. Motorists may also turn left when a green arrow is displayed and oncoming traffic has stopped. You should not turn left when the red left-turn arrow is displayed.

How will the new signals operate?

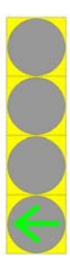
In most locations, the flashing yellow arrow display will be part of a four-arrow display. In areas where a total signal replacement is not possible, a three-section signal would be used where the bottom display will display either the flashing yellow arrow or steady green arrow. For the four-arrow display, the flashing yellow arrow operation will typically be:



Interval 1

Flashing Yellow Arrow

The flashing yellow arrow display allows you to turn left when oncoming traffic is clear (oncoming traffic has a green light). You must carefully determine there is an adequate gap in the oncoming traffic, and ensure there are no pedestrian conflicts, before making the turn.



Interval 2

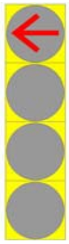
Steady Green Arrow

A steady green arrow allows you to turn left. You should proceed with caution. At intersections equipped with vehicle detection cameras or in-pavement sensors, this sequence may be skipped if there are no left-turning vehicles.

Steady Yellow Arrow

A steady yellow arrow display warns you the left-turn signal is about to go to red and you should prepare to stop, or prepare to complete your left turn if you are legally within the intersection and no conflicting traffic is present.

Interval 3



Steady Red Arrow

A steady red arrow display requires you to stop and wait during this interval. This interval will be followed by Interval 1.

Interval 4

Why is this a better left-turn signal?

It's safer

The national study demonstrated that drivers made fewer mistakes with the new signals than with traditional left-turn arrow signals. While the flashing red allows motorists to turn left when opposing traffic clears, it requires a complete stop under state law. Many times a complete stop is not necessary, which explains why the flashing red is so often violated. Further, most road agencies choose to follow the flashing red with a green arrow even if it is not needed. The reason for this is to avoid going from a flashing red arrow to a solid red and potentially trapping vehicles within the intersection.

It's more efficient

The new signals provide traffic engineers with more options to handle variable traffic volumes. Because the flashing yellow arrow signals utilize a solid yellow arrow display immediately above the flashing yellow arrow display, the green arrow phase may be skipped when left-turn vehicles are not detected (at locations equipped with video detection or in-pavement sensors). This reduces intersection delay by shortening the time it takes for the signal to go through all phases or allowing more green time to be added to the through traffic phases.

It's more consistent

The new signals will be mandated throughout the U.S.; you'll see the same signals in every state.

Where will these signals be installed?

In coming years, MDOT will be converting signals with a flashing red ball for left-turns to the flashing yellow arrow. Motorists will begin to see flashing yellow arrow left-turn signals at intersections across the United States. The FHWA has begun the process of making these signals the standard for signalized left-turns. It will, however, take a number of years for the standard to be adopted and implemented by all road agencies and municipalities nationwide.

Traffic Controls for School Areas

Need for Standards

Traffic control in school areas is a highly sensitive subject. If all the demands of parents and others were met, there would have to be many more police and adult guards for school duty as well as many more traffic signals, signs, and markings. But such demands are not always in line with actual needs.

Analyses show that at many locations, school crossing controls requested by parents, teachers, and other citizens are unnecessary, costly, and tend to lessen respect for warranted controls. Therefore, it is important to point out that, regardless of the school location, safe and effective traffic control can best be obtained through uniform application of realistic policy, practices, and standards developed through engineering studies.

Pedestrian safety depends in large measure upon public understanding of accepted methods for efficient traffic control. This principle is never more important than in pedestrian and vehicle control in the vicinity of schools. Neither school children nor motorists can be expected to move safely in school zones unless they understand both the need for traffic controls and the way these controls function for their benefit.

Non-uniform procedures and devices cause confusion among pedestrians and motorists, prompt wrong decisions, and can contribute to crashes. In order to achieve traffic control uniformity in school areas, comparable traffic situations must be treated in the same manner.

The type of school area traffic control used, either warning or regulatory, must be related to traffic volume and speed, street width, and the number of children crossing. For this reason, the traffic control necessary in a school area located on a major highway would not be needed on a residential street away from heavy traffic. Yet, the important point is a uniform approach to school-area traffic control must be developed to assure use of similar controls for similar situations (which promotes uniform behavior on the part of both motorists and pedestrians).

A school route plan is useful to develop uniform use of school-area traffic controls. The plan, developed by the school and traffic officials responsible for school pedestrian safety, consists of a simple map showing streets, school facilities, school entrances, existing traffic controls, established school routes, established school crossings, sidewalks, adult crossing guards, and student patrols.

The plan permits orderly review of school area traffic control needs, coordination of school pedestrian safety education, and engineering activities.

Signs, Marking, and Alternate Measures

There are various steps which can be taken to provide maximum safety in school zones. The traffic engineer or professional trained in this field can conduct studies and recommend a program designed to suit the needs and resources of the particular school in question. These recommendations could include crosswalks at selected points where vehicle-pedestrian conflicts are at a minimum, the use of “SCHOOL ADVANCE” and/or “SCHOOL CROSSING” signs, or perhaps adult crossing supervision. Also, the school symbol signs may be equipped with a flashing yellow beacon to further alert motorists in rural areas. In urban areas where speeds are lower, “SCHOOL SPEED LIMIT” signs are operable only during specified school hours.

A pedestrian overpass may provide the ultimate in student safety across heavily traveled roadways, particularly when very large numbers of children are crossing. However, the most practical solution in a great many cases is adult supervision by a crossing guard. Adult guards do not direct traffic in the usual police regulatory sense. Their function is to select opportune times when gaps are available or to create safe gaps in the traffic flow. Usually, it is not necessary for them to actually stop a large amount of traffic.

Signal Control

The department annually receives many requests for signals at school crossings. Experience has shown effective traffic signal control can only be realized when a detailed traffic engineering study shows such a need. In most circumstances, the school signal control requires supplemental control by an adult guard or student patrol. It should be realized; however, that crash rates will generally increase following signalization at locations where vehicular or pedestrian cross traffic is relatively light.

The Michigan manual states a school signal may be warranted at an established school crossing when a traffic engineering study (of pedestrian group size and available gaps in the vehicular traffic stream) indicates the number of adequate gaps in the traffic stream during the period the children are using the crossing is less than the number of minutes in that same time period.

Protection of the school child pedestrian is a complex and vital issue. All those concerned with this matter must work together to develop proper study procedures and sound, uniform methods of traffic and pedestrian control.

Additional information concerning school safety is contained in the booklet "Guidelines for Traffic Safety Planning and Traffic Control in School Areas" published by MDOT.

Understanding Pedestrian Signals and How They Work

Pedestrian signals assign right-of-way to pedestrians in much the same way vehicular signals do for vehicular traffic. Listed below are descriptions of the three indications shown on pedestrian signals:

- A steady, illuminated symbol of a walking person, or a steady, illuminated WALK display, means a pedestrian may enter the roadway and proceed in the direction of the indication.
- A flashing, illuminated symbol of an upraised hand, or a flashing, illuminated DON'T WALK display, means a pedestrian may not start to cross the roadway in the direction of the indication, but any pedestrian who has partly completed his crossing during the steady WALK indication may continue across.
- A steady, illuminated symbol of an upraised hand, or a steady, illuminated DON'T WALK display, means that a pedestrian cannot legally enter the roadway.

How do pedestrian signals work?

When you press the pushbutton, a call is put into the signal controller to let it know a pedestrian is waiting. The signal controller does not count how many times the button is pushed, it only registers the first time and remembers it until the walk comes on. The call lets the controller know it must allow enough time for a pedestrian to safely cross the street.

The signal may not change immediately, sometimes when the button is pushed there is not enough time for the signal controller to activate the walk phase. When this happens, you may need to wait one more cycle for the WALK display. If the WALK indication doesn't come on the second time around, the signal is probably not working properly. You must use extreme caution when crossing under these conditions.

Countdown Pedestrian Signals

Countdown pedestrian signals inform pedestrians of the number of seconds remaining to safely complete their crossing. The number of remaining seconds display begins at the start of the flashing upraised hand (DON'T WALK) pedestrian signal indication and counts down to zero at the end of the pedestrian clearance phase. After the countdown displays zero, the number part of the indication goes dark until the beginning of the next countdown phase.

Pedestrian countdown signals will be placed at signalized intersections equipped with pedestrian signals in central business districts, at established school routes, and other high pedestrian volume locations. Unless there is a documented safety or operational concern that can be addressed by this device, pedestrian countdown signals will not be added to an existing signalized location until it is being modernized.

Safety Tips

The following suggestions are offered in the interest of safety:

- Cross only at intersections. If the intersection is signalized, ALWAYS press the pushbutton if one is present. This will guarantee adequate crossing time.
- Make eye contact with drivers before you step in front of their vehicle. By law, vehicles have to yield to pedestrians lawfully within the intersection. However, in any contest of right-of-way between pedestrians and vehicles the pedestrian will ALWAYS lose.
- Always watch for turning vehicles. Drivers may not see you.
- Cross quickly and be alert. Minimize your time in the roadway.
- Hold small children by the hand when crossing.

Remember, although pedestrian signals assign your legal right in the intersection, always use caution when crossing the street. Crosswalks do not stop cars. Responsible pedestrians are involved in fewer crashes.

How a Signal Request is Evaluated

A signal request usually begins with an inquiry from an individual to local government officials. These people, being familiar with the area, can better evaluate the request in light of previous complaints, crash records, future development, and related background information. If a preliminary review indicates the proposal should be studied in greater depth, they will contact one of the MDOT traffic and safety engineers located throughout the state (addresses included in this booklet). If the regional traffic and safety engineer review finds merit in the request, it is forwarded to Lansing Traffic and Safety.

Upon receipt of the request, a traffic engineer is assigned to study the location in detail and collect the data necessary for analysis. This involves reviewing history files of the location for available information collected during previous investigations. Then the engineer determines what additional data may aid the investigation.

There are a number of studies utilized by MDOT engineers which enable a decision to be made about a traffic concern.

Traffic Counts

This survey consists of "machine counts" (the "boxes" and rubber hoses frequently seen along state highways) taken of all vehicles entering the intersection on a typical weekday. In conjunction with the machine counts, an eight-hour "turning count" is conducted during peak traffic hours in which all incoming vehicles are tabulated according to the direction they leave the intersection.

The results of the 24-hour machine counts are plotted on a "warrant graph" and the turning counts are pictorially represented on a "summary sheet." If there is an indication a problem finding "safe gaps" in the traffic stream exists, a gap study which counts the number and size of gaps during peak traffic hours may be taken. Additional surveys, such as vehicle backups and delays, pedestrian volumes, speed checks, and law observance studies may be ordered to provide further material to aid the engineer's analysis.

Crash Records

A record of all traffic crashes reported to the Michigan Department of State Police is forwarded to MDOT Traffic and Safety. The traffic engineer uses these crash reports to study the problems at the subject location and determine which crash patterns are susceptible to correction through application of various measures, including traffic signals.

Right-angle crashes are the type which a traffic signal will generally reduce. Other patterns will dictate use of different techniques which may involve turn prohibitions, skid proofing, pavement widening, or the addition of special turning lanes. Careful analysis of crashes is one of the most important considerations involved in a signal study.

Field Investigations

In addition, the engineer also conducts an on-site investigation to observe the intersection and its operating characteristics. Some of the points the traffic engineer looks for are type and condition of the road; presence of curves and hills; schools and school crossings; large traffic generators, such as shopping centers; existence of parking and bus stops; and the proximity of other traffic signals.

From the preceding study data, the engineer must determine if traffic signal installation or some other traffic control device will provide increased benefits to the motoring public. These benefits are essentially a decrease in delay to the motorist on the cross street or a decrease in numbers or severity of certain types of crashes.

Installing and Maintaining Traffic Signals

If, after study and analysis of the data, a traffic signal is approved, MDOT personnel specializing in the physical engineering of such installation prepare a design plan of the proposed signal installation. This phase of the operation requires careful planning to insure optimum operation.

Field Layout

Initially, technicians visit the site and prepare a plan which shows the existing physical features of the subject intersection. The actual "signal layout" is then incorporated into this drawing in a manner conforming with the *Michigan Manual on Uniform Traffic Control Devices*. This work is done in cooperation with representatives of the electric power company, the local traffic engineer, and other members of the Traffic and Safety Division. Occasionally, minor changes in the existing intersection design may be necessary. In this case, additional plans must be prepared by the Traffic and Safety Division's geometric design engineers.

Processing

Upon completion of the "field work," a bill of materials and a cost estimate are prepared. With the estimate, formal cost agreement forms (legal documents establishing a contractual relationship between MDOT and a local governmental unit and/or corporation) are submitted to proper officials for their approval and signature. Upon receipt of the properly signed documents and copies of a formal resolution from the local governing body agreeing to the costs, a work authorization is prepared by department engineers. The cost sharing, as outlined on the agreement forms, is determined by the number of signalized directions and the jurisdictional responsibility for each. The procedure for determining these costs can be fully explained by Traffic and Safety Division personnel.

Along with the "work order," the engineer will include a timing permit for the intersection. This permit sets forth the hours the signal will operate "stop-and-go," the hours it will "flash," and the time intervals allotted to different traffic movements. The previously mentioned traffic survey data is used to establish signal timing.

Installation

The work order and timing permit are forwarded to the MDOT Maintenance Division's Signal Unit. Scheduling of various signal installations is necessary to allow crews to complete their work in an economical and efficient manner. The actual traffic signal installation takes place according to this schedule.

In some cases, MDOT crews will install the signal. In other cases, local contractual agencies such as a city or county will be assigned to perform the work. Also, MDOT awards contracts to private companies with the ability and expertise to install traffic signals.

Maintenance of Traffic Signals

The *Michigan Manual on Uniform Traffic Control Devices* recommends once a traffic signal has been approved for installation, responsibility for its maintenance should be clearly established. This is very important because it helps insure the signal will operate the way it was designed.

The maintaining agency should:

1. Provide for alternate operation of the signal during a period of failure, either on flash or manually, or by having manual traffic direction by proper authorities as may be warranted by traffic volumes or congestion, or by erecting other traffic control devices.

2. Have properly skilled maintenance available without undue delay for all emergency calls, including lamp failures.

3. Provide properly skilled maintenance for all components.

4. Maintain the appearance of the installation in a manner consistent with the manual's intention.

5. Service equipment and lamps as frequently as experience proves necessary to prevent undue failures.

6. Provide adequate stand-by equipment to minimize interruption of signal operation due to equipment failure.

Every signal timing controller should be kept in effective operation in strict accordance with its predetermined timing schedule.

A careful check of the correctness of time operation of the controller should be made frequently enough to ensure it is operating in accordance with the planned timing schedule. Timing changes should be made only by authorized persons. A written record of all timing changes should be kept.

Controllers should be carefully cleaned and serviced at least as frequently as specified by the manufacturer and more frequently if experience proves it necessary.

Uniform Flow of Traffic

When signalized intersections are in close proximity (a half mile or less), the goal is to install signal timing so a vehicle traveling straight through those intersections would not be required to stop. This is called progression. Determining necessary timing involves analysis of vehicle volumes, travel speeds, turning movements, and spacing between intersections. With this information and use of a variety of computer programs, an analysis will supply accurate timing for each signal in the system.

Sometimes it is not possible to progress traffic completely through all signals along a route. Most often this is because of unsatisfactory intersection spacing. Therefore, it is not unusual to require at least one stop along a route to allow traffic to queue up before it is allowed to proceed through the rest of the system unencumbered. Sometimes traffic is progressed inbound in the morning and outbound in the afternoon to match traffic patterns.

Also, there may be instances when a set of signals do not operate as they had previously. You may have to stop at an intersection when most other days you were able to get through on a green indication. If you have not altered your driving speed or turned onto the system from a side street, it may be that an equipment adjustment is necessary. Notifying the local maintaining agency can address this problem.

Computer Control

MDOT continually strives to incorporate traffic control advancements into our signal systems. One method in use is computer control centers in metropolitan areas which “supervise” all traffic signals in the surrounding area. This type of system can be a powerful tool by providing immediate response to actual traffic demands, thus adding efficiency.

Other methods are being used more and more. Often traffic volumes increase to the point where normal fixed-time traffic signals become “bogged down.” Drivers become frustrated when they must wait for their green time while the opposing street may have little or no traffic. To address this problem, technology has provided what have been called “smart” signals.

Several methods developed for “detecting” traffic are being used on the street systems. Examples of detectors include wire loops imbedded in the street and video cameras mounted on adjacent poles. The detector notifies the signal controller of traffic conditions and which street needs more or less green time. The smart controller then reallocates time to address the changing traffic needs. The timing change is done instantaneously and eliminates the need for an external monitoring system. This type of traffic signal is increasingly being applied because of its diversity in signal timing and flexibility.

Conclusion

We hope the preceding explanation gives you a better understanding of the complexities involved in signal evaluation from first request to actual installation. The decision-making process is lengthy, though justified, since a professional traffic engineer must make decisions based on engineering studies, not snap judgements resulting from opinion. The necessary data requires time to collect. It may take four to six months to gather and analyze traffic counts and crash records. After approval, signal installation must be engineered, estimates prepared, contractual agreements negotiated, material requisitioned, and installation crews scheduled. Actual installation proceeds quickly, often within a week, but the preliminary steps must be followed in a smooth, coordinated fashion.

Traffic signals are never denied on the basis of cost. Our primary concern is the public's well-being. Safe and efficient operation of our state roadways concerns our engineers as much as the proper design of the middle span of a bridge. Michigan is proud of its highway system. Its many dedicated employees constantly strive to maintain goals in construction and operation necessary to be ranked a leader among the nation's transportation departments.

APPENDICES

GLOSSARY OF TERMS	
Conflict	A situation where a crash would occur if evasive action were not taken.
Continuous traffic flow	A steady, unbroken stream of traffic.
Controller	A complete electrical mechanism for controlling traffic signal operation which is mounted in a cabinet.
Crash potential	The relative degree of safety of a location or area.
Downstream	Points on a route further ahead in the direction of traffic flow.
Driver response	The reaction of a driver to some message or condition on a highway, such as signs or traffic signals.
Efficient systems	A route or network of routes on which traffic flows with a minimum of delay and congestion.
Gaps	Breaks in the traffic stream long enough to permit vehicles or pedestrians access across or into the traffic stream.
Law observance study	Surveys designed to check effectiveness of various traffic control devices.
Platoon	A group of vehicles moving, more or less as a unit, along a signalized roadway system.
Progressive movement	Traffic moving at a constant speed with a minimum number of stops.
Right-of-way assignment	The "green" phase of a stop-and-go signal when a certain movement of traffic is permitted to flow.
Signal cycle	The time required for all phases of a signal to take place beginning of green to beginning of green.
Speed checks	Radar studies conducted to obtain information concerning the distribution of vehicle speeds through an area.
Timing permit	A form indicating/authorizing how a traffic signal will operate; when it will flash, how much "green time" will be allotted to each leg of the intersection, how it will operate in relation to adjacent signals, and what special provisions will be made for high-volume, peak-hour traffic.
Traffic engineer	An experienced engineer specializing in problems associated with the safe and efficient operation of roadway facilities.

GLOSSARY OF TERMS	
Traffic volumes	The actual number of vehicles passing a given point.
Uniform standards	A policy of consistent traffic control devices on all roadway systems throughout the nation.
Signal Warrants	A set of guidelines designed to provide justification for installation of stop-and-go traffic signals.

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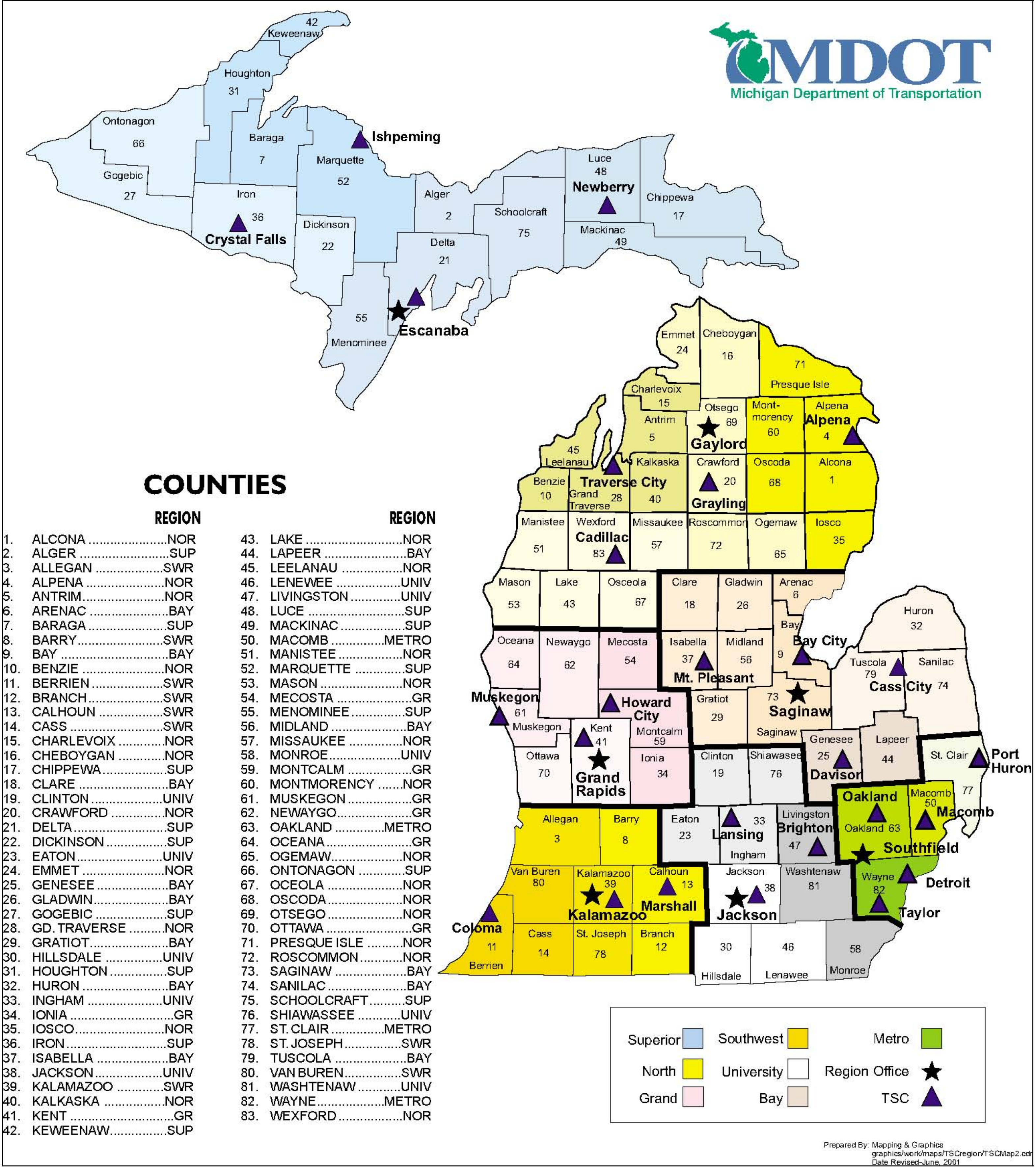
MDOT Regions and Transportation Service Centers



COUNTIES

		Region			Region
1.	ALCONA	NOR	43.	LAKE	NOR
2.	ALGER	SUP	44.	LAPEER	BAY
3.	ALLEGAN	SWR	45.	LEELANAU	NOR
4.	ALPENA	NOR	46.	LENEWEE	UNIV
5.	ANTRIM	NOR	47.	LIVINGSTON	UNIV
6.	ARENAC	BAY	48.	LUCE	SUP
7.	BARAGA	SUP	49.	MACKINAC	SUP
8.	BARRY	SWR	50.	MACOMB	METRO
9.	BAY	BAY	51.	MANISTEE	NOR
10.	BENZIE	NOR	52.	MARQUETTE	SUP
11.	BERRIEN	SWR	53.	MASON	NOR
12.	BRANCH	SWR	54.	MECOSTA	GR
13.	CALHOUN	SWR	55.	MENOMINEE	SUP
14.	CASS	SWR	56.	MIDLAND	BAY
15.	CHARLEVOIX	NOR	57.	MISSAUKEE	NOR
16.	CHEBOYGAN	NOR	58.	MONROE	UNIV
17.	CHIPPEWA	SUP	59.	MONTCALM	GR
18.	CLARE	BAY	60.	MONTMORENCY	NOR
19.	CLINTON	UNIV	61.	MUSKEGON	GR
20.	CRAWFORD	NOR	62.	NEWAYGO	GR
21.	DELTA	SUP	63.	OAKLAND	METRO
22.	DICKINSON	SUP	64.	OCEANA	GR
23.	EATON	UNIV	65.	OGEMAW	NOR
24.	EMMET	NOR	66.	ONTONAGON	SUP
25.	GENESEE	BAY	67.	OCEOLA	NOR
26.	GLADWIN	BAY	68.	OSCODA	NOR
27.	GOGEBIC	SUP	69.	OTSEGO	NOR
28.	GD. TRAVERSE	NOR	70.	OTTAWA	GR
29.	GRATIOT	BAY	71.	PRESQUE ISLE	NOR
30.	HILLSDALE	UNIV	72.	ROSCOMMON	NOR
31.	HOUGHTON	SUP	73.	SAGINAW	BAY
32.	HURON	BAY	74.	SANILAC	BAY
33.	INGHAM	UNIV	75.	SCHOOLCRAFT	SUP
34.	IONIA	GR	76.	SHIAWASSEE	UNIV
35.	IOSCO	NOR	77.	ST. CLAIR	METRO
36.	IRON	SUP	78.	ST. JOSEPH	SWR
37.	ISABELLA	BAY	79.	TUSCOLA	BAY
38.	JACKSON	UNIV	80.	VAN BUREN	SWR
39.	KALAMAZOO	SWR	81.	WASHTENAW	UNIV
40.	KALKASKA	NOR	82.	WAYNE	METRO
41.	KENT	GR	83.	WEXFORD	NOR
42.	KEWEENAW	SUP			