Title: Procedure for Traffic Signal Design and Operation	Issue Date: February 2, 2018 Revised Date: October 4, 2018 February 10, 2022
Discipline: Traffic Signals and Beacons	
Originators: Traffic Engineering	
Approved By:	

Procedure for Traffic Signal Design and Operation

A. Warrants

- A traffic signal can only be installed if it meets a traffic signal warrant as indicated in the latest edition of the Manual on Uniform Traffic Control Devices (MUTCD)
- Meeting one or more warrants does not necessarily mandate a signal installation. The installation should rely on an engineering study or engineer's judgement
- Peak hour warrant should only be used for locations where there is a true peak hour discrepancy in the side road/entrance traffic.
- A 12-hour seasonally adjusted count of traffic on all intersection approaches is required.
- The higher volume approach will be defined as the major approach, and the lesser volumes approaches will be defined as the minor approaches.
- Where appropriate, the left turn on the major road can be used as the minor approach. When doing so, the major approach would be defined as only the conflicting approaching vehicles.
- When determining a warrant, major and minor approaches will be singularly defined for all time periods.
- Right turning vehicles shall be discounted as indicated in the attached method from the state of Oregon. See Appendix A

B. Functionality

- Fully-Actuated – All new or retrofitted traffic signals shall be fully actuated.
- Coordinated – All new signals should be coordinated with adjacent signals if within 1200 feet +/-.
    1. Time of Day – coordination in which the time of day determines the cycle length for the coordination program.

2. Adaptive – Adaptive signal technology is a tool that continually adjusts splits, cycle length and offsets based on effective use of green time. The type of adaptive system to be installed is decided through FHWA's systems engineering process (FHWA-HOP-11-027 or as most recently amended). MaineDOT will determine intersections appropriate for adaptive signal technology.

- Interconnection – required on all new or retrofit signal installations with adjacent intersections within 1200 feet +/-, and should be considered if within 2600 feet at MaineDOT's discretion.
    1. Hardwire
        a. Fiber Optic – can carry a lot of information at high speed, expensive, specialized equipment needed to repair. Fiber will be considered the preferred connection between traffic signals.
    2. Spread spectrum radio – only to be used for connection when there are no utility poles in the area to attach to. Need clear line of sight between radios to work, communications can suffer from interference from outside entities.
- Phasing
    1. Protected left turn phases in a shared left/through lane are not allowed.
    2. Permitted left turn phases across two through movement lanes are not allowed.
    3. Overlaps – Overlap phases shall be used where possible as appropriate.
    4. NEMA compliant phasing is required.
    5. Consultants shall avoid yellow traps when using protected-permissive phasing. Use of FYA, clearance to all-red or traffic signal controller logic processing are accepted means to avoid a yellow trap condition.
- Timings
    1. Consultant is responsible for coordination timing.
    2. Consultant should be retained after new signal installation or modification to monitor delay at the intersection for at least six months to adjust timing and/or develop additional coordination plans.
- Battery Back-up –MaineDOT at its discretion will determine where the Department will participate in the installation of battery back-up on any given project.
- Pre-emption
    1. Railroad – Battery back-up at a signalized intersection shall be required when railroad tracks are within 200 feet of an approach, where the maximum queue length of an approach will conflict with a railroad crossing, or if railroad tracks are

in a position that allowing certain phases will cause vehicular back-up into the intersection.

2. Emergency Vehicle – If a municipality does not have existing emergency pre-emption, the MaineDOT will only consider installation of emergency pre-emption if the municipality also furnishes and installs emitters in the emergency vehicles. When designing the preemption system for approaches with permissive only or protected-permissive phasing, the preemption shall be constructed so that yellow traps are not provided. Under certain conditions this may require clearance to an all-red condition prior to preemption of the affected approach.
3. Bus Route Priority – The Department will only install transit preemption in areas where there are existing fixed route transit service and only if the municipality or transit line furnishes and installs emitter on their busses. School busses are not to be considered for transit preemption.
4. Freight Priority – As of 2021, freight priority is under a pilot program status until MaineDOT authorizes widespread implementation after a period of data collection and analysis.

- Dilemma Zone

  Advance detectors shall be used on approaches with speed limits equal to or greater than 35 MPH, or as needed based on site conditions. Dilemma zone protection shall operate up to the programmed MAX green by extension of the current green phase. Once MAX green time is reached the controller shall switch to extending the all red phase of the cycle. Dilemma zone protection that operates by switching to a different phase number will not be allowed requiring use of a modern ATC controller (see Section C) in lieu of any pre-existing legacy traffic signal controller, where applicable.
- Roadside Units (RSU) – Each new or modified traffic signal shall be outfitted with a hybrid (DSRC/C-V2X) RSU to communicate with Connected and Autonomous Vehicles (CAV).
- Clearance Intervals

  Use of ITE equations will be required for determining clearance intervals for yellow and red. Max clearance times may be capped by MaineDOT to 4 seconds for yellow and 5 seconds for all red unless at a Single Point Urban Interchange (SPUI) where all red clearances may be up to 8 seconds depending on geometry. Calculated clearance times should be rounded up to the nearest ½ second
- Pedestrian Phase – Pedestrian phases and pedestrian signal indication shall be installed on all new designs where there is an existing crosswalk or pedestrian facilities on both sides of the roadway. Care should be taken not to put the pedestrian crossings in locations that

may run across heavy turn volumes if another alternative is available. All new or retrofitted signal projects shall be equipped with Accessible Pedestrian Signals (APS). APS devices communicate information about the WALK and DON'T WALK intervals at signalized intersections audibly to vision impaired pedestrians.

1. Concurrent – This type of phasing allows pedestrians to cross with adjacent parallel vehicle green phase. Concurrent pedestrian crossings should be the preferred method for signalized crosswalks. The use of "No Turn on Red" and/or "Turning Traffic Yield to Pedestrian" dynamic blank out signs should be considered for use in high traffic locations.
2. Exclusive – This type of phasing stops all traffic to allow the pedestrians to cross roadway Exclusive pedestrian crossings should be discouraged for signalized crosswalks. This type of crossing can create congestion and should be weighed against potential safety, "No Turn on Red" dynamic blank out signs shall be used on all proposed exclusive phase and installed on existing exclusive pedestrian phases when a traffic signal is modified in any matter.
3. Leading Pedestrian Interval – A type of pedestrian phasing that gives pedestrians a head start when entering an intersection with a corresponding green signal in the same direction of travel by extending the all red time. LPIs enhance the visibility of pedestrians in the intersection and reinforce their right-of-way over left-turning vehicles. LPI's should be looked at where there are heavy left-turning vehicle movements. Leading Pedestrian Intervals can only be used on traffic signals with APS.
4. Clearance Times
    - **a.** Walk - Walk time is set that a typical user can notice the indication change and start their crossing. The Walk time is set between 4 and 7 seconds. A 5 second time is typically used. If additional time is required, moving the pedestrian button should be considered.
    - **b.** Flashing Don't Walk (FDW) - FDW time is set as the time to use the crosswalk across the vehicle travel way at a speed of 3.0 ft/sec. The speed can be reduced further in a location that has a significant number of mobility impaired users. MaineDOT allows yellow and red clearance intervals to be included as part of the FDW time.

C. Equipment – Care shall be taken in the placement of poles and controller cabinets so that they do not impede sight distance for turning vehicles and

pedestrians crossing at the crosswalk. The distance from signal face to stop bar shall be between 40 and 180 feet and the angle between the signal heads as measured from the driver's eye at the stop bar shall not exceed 40 degrees, unless additional near/far side heads are installed.

- Controllers – all new controllers shall be Advance Transportation Controllers (ATC) type controllers. Each signal shall have a separate controller unless the Department determines that use of a single controller for multiple intersections would provide mobility benefits.
- Cabinets – On all new installations or modifications to existing signals, controller cabinets shall be ground-mounted unless the Department deems that a ground mounted installation is not feasible. All Cabinets shall be ATC type Cabinets (dual doors front and back), aluminum and unpainted. Painted cabinets will be allowed on a case-by-case basis.
- Field Monitoring Unit (FMU) – Each cabinet shall have a field monitoring unit installed. A field Monitoring unit uses an onboard cellular modem to transmit and receive data from the devices inside the cabinet.
- Span Wires and Poles – Signal heads mounted on span wire with a tether is the most common installation Structural mounting of span wire shall be by wood pole (preferred) or strain pole. Care should be taken that the minimum 40 foot setback to the stop bar is attained and that signal heads from one direction do not block a signal indication from another direction. On larger intersections, the designer shall ensure that the maximum distance of 180 feet from stop bar to signal heads is not violated. When the distance is between 120 and 180, a supplemental near side signal head shall be installed.
- Mast Arms – Mast arms shall be installed in downtown/historic settings where there may be issues with installation of span wires. Foundation designs need to meet the Load Resistance Factor Design (LRFD) design standards which require foundation designs to be much larger than they were in the past, though this has caused issues in some downtown settings. Foundations cannot extend into the sidewalk area so that ADA standards are violated.
- Strain Poles – Strain Poles can be used where right of way is tight and guying poles would cause right of way issues. The LRFD design standards have also impacted the size of strain pole designs. Designers need to ensure that these also do not interfere with ADA standards.
- Detection – (Stop bar and Advance) All new detection shall be able to detect vehicles and provide traffic counts. Currently the accepted stop bar detection is: Thermal FLIR cameras, Gridsmart 360 cameras, Mio-vision cameras and Wavetronix matrix. Accepted Advance detection is the Wavetronix Advance.
- Signal Heads – all signal heads shall be 12-inch LED with back-plates with3-inch wide yellow TYPE XI retroreflective sheeting.

1. "Doghouse" configurations will be used for new 5-section heads, including back-plates and 3-inch wide yellow TYPE XI retro-reflective tape along all borders.
2. May use bi-modal section in ***retrofits***, provided there is proper clearance.
3. May use flashing yellow arrow for permissive left turns (and right turns where applicable if approved by MaineDOT).

- Pedestrian Heads – LED countdown heads shall be used in all new installations or upgrades.
- Conduit
    1. Metallic conduit or concrete encased PVC shall be used for power supply to controller.
    2. PVC may be used for field wiring and interconnect.
- Junction Boxes – Placed behind sidewalk or seven feet from the travel way and the cover shall be labeled "traffic signal". Junction Boxes and their covers shall be rated for 2200 lbs.
- Taper Lengths – When two through lanes cross through a signalized intersection, the two lanes shall be carried beyond the intersection for a minimum of 12 times the maximum green time and then taper back into 1 lane at a rate of $WS^2/60$ (for 40 mph and under) and WS for 45 mph and greater (where W is the width being tapered from and S is the posted speed). In an alternate merge situation, where you are tapering in from both sides at an equal length, you need to double the taper length to get the proper transition length. See MaineDOT Traffic Engineering Striping & Stenciling Handbook for additional information.
- Use of overhead lane use signs is encouraged where there are multiple lanes in each direction. The bottom of all signs shall be a minimum of 16 ½ feet from the pavement.
    1. Lane usage signs
    2. Left Turn Yield on Green Ball
    3. Left Turn Yield on Flashing Yellow Arrow

D. ADA Consideration – any new or modified signal project shall check to determine which ADA issues need to be addressed.

- Audible Indications – APS shall be installed anytime a new signal or signal modification are proposed.
- As per the MUTCD:
    1. Percussive tones to be used when pedestrian crossing buttons are at least 10' apart.
    2. Speech message to be used when pedestrian crossing buttons are less than 10' apart.
- Truncated Domes – Truncated domes are required on all new signal installations where necessary to meet ADA accessible ramps.

- Landings areas shall be constructed to allow for level landings at the top, bottom, or change in direction of a run. Changes in level greater than 1:48 are not permitted on landings.
- Crosswalk Location – crosswalk locations should be installed to minimize pedestrian/vehicle conflicts.

E. Notes

- Eliminate redundant notes (such as information already called out in MaineDOT standard specs or MUTCD) on plans.
- Signal contractors are not traffic engineers and should not be tasked with determining timing or design changes.

F. Traffic Signals required through the Traffic Movement Permit (TMP) process or Developer review process.

- A traffic signal may be required through the TMP process based on information presented to MaineDOT by the applicant. The signal can be installed in full color mode for up to 6 weeks. The applicant will perform warrant analysis using counts from the first 6 weeks. Only if the intersection meets a warrant can remain in full colors. If it does not meet a warrant then the signal must revert to flash mode until such time as it does meet a warrant.
- When a permit is written to perform a warrant analysis at a certain percentage of the full build out of the permitted facility(this is usually done when the numbers or reliability of those numbers come into question) the applicant will perform a warrant analysis and shall install a traffic signal at the intersection within 12 months of meeting the signal warrant.

G. Plan Layout

- Show lane markings on the signal plan sheet.
- Where there are left-turn only lanes, either a 3-section (R Y Y, see MUTCD Figure 4D-7) for permissive only or 4-section (R Y Y G, see MUTCD Figure 4D-12) for protected-permissive FYA's shall be positioned and centered on the left-turn lane approach.

H. FAQ

- Driveways approaches within a signalized intersection must be signalized.
- Flash Operation is not recommended but may be used if vehicle detection is not working and should be quickly returned to full color operation after repairs.
- Any and all timing or phasing changes must be approved by a MaineDOT Traffic Engineer before implementation.

Appendix A

Preliminary Signal Warrants

Introduction

The single most important criterion for preliminary signal warrant analysis is engineering judgment. In the following procedures only the fundamental parameters of volumes and approach lanes are provided.

Background

There are 8 traffic signal warrants found in the Manual on Uniform Traffic Control Devices (MUTCD), Page 4C-1. The signal warrants are:

Warrant 1, Eight-Hour Vehicular Volume.
- Case A – Minimum Vehicular Volume.
- Case B – Interruption of Continuous Traffic.

Warrant 2, Four-Hour Vehicular Volume.
Warrant 3, Peak Hour.
Warrant 4, Pedestrian Volume.
Warrant 5, School Crossing.
Warrant 6, Coordinated Signal System.
Warrant 7, Crash Experience.
Warrant 8, Roadway Network.

OAR 734-020-0460 (1) stipulates that only MUTCD warrant 1 Case A and Case B may be used to project a future need for a traffic signal. (Corrected to reflect numbering used in the Millennium Edition of the MUTCD.) In the Transportation Planning Analysis Unit (TPAU), we are typically projecting traffic into the future and analyzing future years, so we consider warrants 1, Case A and Case B. Case A deals primarily with high volumes on the intersecting minor street. Case B addresses high volumes on the major street and the delays and hazards to vehicles on the minor street trying to either access or cross the major street.

Analysis

In MUTCD warrant 1 the eighth highest hour of an average day is used to determine whether a warrant is met. At the analysis stage in TPAU, Average Daily Traffic (ADT) is used for preliminary signal warrant analysis. We apply a conversion factor of 5.65% to the ADT to reach the eighth highest hour. The conversion factor of 5.65% is acceptable as shown using 1991 to 1994 manual counts and as agreed on by TPAU and Traffic Management Section. To convert MUTCD hourly volumes to ADT volumes, divide the MUTCD volume by the factor .0565, this equals the target ADT volume to meet MUTCD warrant 1.

If the "85 percentile speed of major street traffic exceeds 40 mph in either an urban or rural area, or when the intersection lies within the built-up area of an isolated community having a population of less that 10,000" (MUTCD), reduce the target volume for the warrants to 70 percent of the normal requirements. The warrant volumes, along with the number of lanes, are shown in the preliminary traffic signal warrant analysis sheet on the following page.

Oregon Department of Transportation

Transportation Development Branch

Transportation Planning Analysis Unit

Preliminary Traffic Signal Warrant Analysis[1]

Major Street:	**Minor Street:**
Project:	**City/County:**
Year:	**Alternative:**

Preliminary Signal Warrant Volumes

Number of Approach lanes		ADT on major street approaching from both directions		ADT on minor street, highest approaching volume	
Major Street	Minor Street	Percent of standard warrants 100	70	percent of standard warrants 100	70
Case A: Minimum Vehicular Traffic					
1	1	8,850	6,200	2,650	1,850
2 or more	1	10,600	7,400	2,650	1,850
2 or more	2 or more	10,600	7,400	3,550	2,500
1	2 or more	8,850	6,200	3,550	2,500
Case B: Interruption of Continuous Traffic					
1	1	13,300	9,300	1,350	950
2 or more	1	15,900	11,100	1,350	950
2 or more	2 or more	15,900	11,100	1,750	1,250
1	2 or more	13,300	9,300	1,750	1,250

5.65% of the above ADT volumes is equal to the MUTCD vehicles per hour (vph)

	100 percent of standard warrants
	70 percent of standard warrants[2]

Preliminary Signal Warrant Calculation

	Street	Number of Lanes	Warrant Volumes	Approach Volumes	Warrant Met
Case A	Major				
	Minor				
Case B	Major				
	Minor				

Analyst and Date:	Reviewer and Date:

[1] Meeting preliminary signal warrants does **not** guarantee that a signal will be installed. Before a signal can be installed a traffic signal investigation must be conducted or reviewed by the Region Traffic Manager. Traffic signal warrants must be met and the State Traffic Engineer's approval obtained before a traffic signal can be installed on a state highway.

[2] Used due to 85th percentile speed in excess of 40 mph or isolated community with population of less than 10,000.

Determining the number of approach lanes and determining the approach volumes to use in the warrant analysis requires knowledge of the involved intersection.

1. Major Street (higher volume street)
   - Include only the through and through/turn lanes in the number of approach lanes.
   - For the ADT, count total volume approaching from both directions, **including** all turn movements.

2. Minor Street (lower volume street)
   - Include only the through, through/turn, and left turn lanes in the number of approach lanes.
   - For the ADT, count the highest approaching volume (one direction only, do not include the ADT approaching from both directions) including some or none of the right turn volume as discussed in the following scenarios:

     - ***Scenario # 1 – Shared left-through-right lane:*** Some of the right turns are included in the minor street approach ADT if the right turn demand is greater than 85% of the capacity of the shared lane. Use UNSIG10 or HCS to calculate the capacity of the shared lane. The right turn discount is 85% of the shared lane capacity (85% of the capacity is used because once the v/c exceeds 0.85, drivers suffer longer delay and begin to take unsafe gaps). Subtract the right-turn discount from the total right turn volume to determine the number of right turns in the warrant. If the remainder is less than or equal to zero, do not include any of the right turns in the approach ADT.

     - ***Scenario # 2 – Exclusive right-turn lane:*** Some of the right turns are included in the approach ADT if the right turn lane demand is greater than 85% of the capacity of the right turn lane. Use UNSIG10 or HCS to calculate the capacity of the right turn lane. The right turn discount is 85% of the right turn lane capacity. Subtract the right turn discount from the total right turning volume to determine the number of right turns that will be included in the warrant. If the remainder is less than or equal to zero, do not include any of the right turns in the approach ADT.

     - ***Scenario # 3 – Shared through-right lane:*** Some of the right turns are included in the approach ADT if the right turn demand is greater than 85% of the capacity of the shared through-right lane. Use UNSIG10 or HCS to calculate the capacity of the through-right shared lane. The right turn discount is 85 % of the shared lane capacity. Subtract the right turn discount from the total right turn volume to determine the number of right turns in the warrant. If the remainder is less than or equal to zero, do not include any of the right turns in the approach ADT.

- ***Scenario # 4 – Double right-turn lane:*** Include all of the right turning volume in the approach ADT if a double right turn lane is required. If such is the case, the number of approach lanes for warrant analysis is 2 or more.

The above information is meant to serve as general guidelines only, engineering judgment may be required when one or both of the streets are one way, the intersection is not a typical four legged design, or the highest volume is associated with a turn movement. Engineering judgment must be the deciding factor in preliminary warrant analysis.

Example Application: Right Turn Discounts (Only for the minor road)

Example # 1: Figure 1 shows a typical unsignalized intersection, the peak hour volumes, the ADT volumes, and lane configurations. The peak hour volumes are 10% of the ADT. The 85th percentile speed is 35 mph and the intersection is located in a city with a population of 60,000.

a) **Determining the number of right-turns to include in the warrant:** using the HCS unsignalized intersection methodology it was determined that the eastbound shared lane capacity is 120 vph. The right-turn discount is 85% of the shared lane capacity, 120 x 0.85 = 102 right turns. The number of right turns included in the warrant would be 180 – 102 = 78.

b) **Determine the minor approach ADT:** the minor street approach peak hour volume used in the warrant is 90+50+78 = 218. Since the peak hour volume is 10% of the ADT, the minor approach ADT is (218 / 0.10) = 2,180.

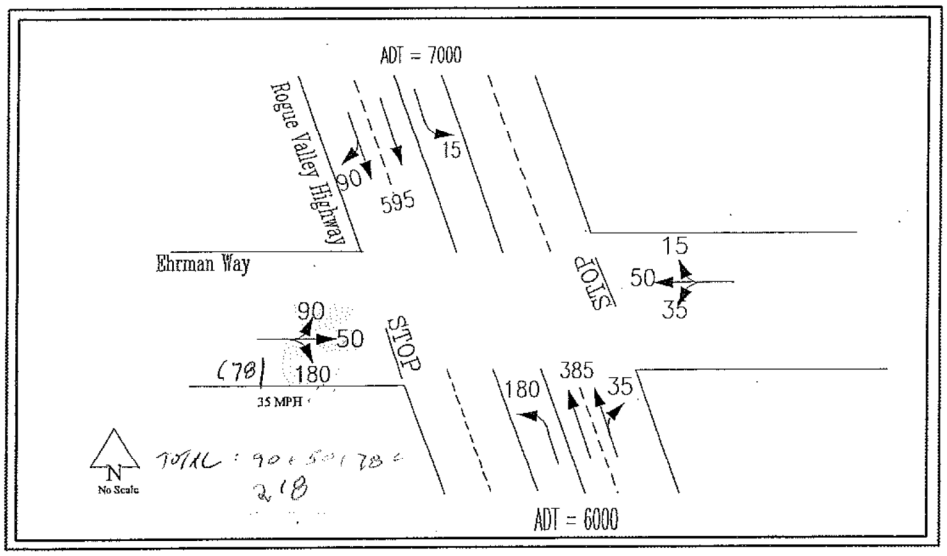

Figure 1

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Transportation Development Branch
Transportation Planning Analysis Unit

Preliminary Traffic Signal Warrant Analysis[1]

Major Street:	Rogue Valley Highway	**Minor Street:**	Ehrman Way
Project:	Ehrman Way	**City/County:**	Medford
Year:	1995	**Alternative:**	No Build

Preliminary Signal Warrant Volumes

Number of approach lanes		ADT on major street approaching from both directions		ADT on minor street, highest approaching volume	
Major Street	Minor Street	Percent of standard warrants 100	70	percent of standard warrants 100	70
Case A: Minimum Vehicular Traffic					
1	1	8,850	6,200	2,650	1,850
2 or more	1	10,600	7,400	2,650	1,850
2 or more	2 or more	10,600	7,400	3,550	2,500
1	2 or more	8,850	6,200	3,550	2,500
Case B: Interruption of Continuous Traffic					
1	1	13,300	9,300	1,350	950
2 or more	1	15,900	11,100	1,350	950
2 or more	2 or more	15,900	11,100	1,750	1,250
1	2 or more	13,300	9,300	1,750	1,250

5.65% of the above ADT volumes is equal to the MUTCD vehicles per hour (vph)

x	100 percent of standard warrants
	70 percent of standard warrants[2]

Preliminary Signal Warrant Calculation

	Street	Number of Lanes	Warrant Volumes	Approach Volumes	Warrant Met
Case A	Major	2+	10,600	13,000	N
	Minor	1	2,650	2,180	
Case B	Major	2+	15,900	13,000	N
	Minor	1	1,350	2,180	

Analyst and Date: Reviewer and Date:

Figure 2

[1] Meeting preliminary signal warrants does **not** guarantee that a signal will be installed. Before a signal can be installed a traffic signal investigation must be conducted or reviewed by the Region Traffic Manager. Traffic signal warrants must be met and the State Traffic Engineer's approval obtained before a traffic signal can be installed on a state highway.

[2] Used due to 85th percentile speed in excess of 40 mph or isolated community with population of less than 10,000.

Figure 2 shows the Preliminary Signal Warrant Analysis for example #1. The preliminary signal warrant is not met because the Minor Street ADT is less than the warrant volume in Case A and the Major Street ADT is less than the warrant volume in Case B.

Example # 2: Figure 3 shows a typical unsignalized intersection with a shared through-right lane on the eastbound, the peak hour volumes, the ADT volumes, and lane configurations. The peak hour volumes are 10% of the ADT. The 85th percentile speed is 35 mph and the intersection is located in a city with a population of 60,000.

a) **Determining the number of right-turns to include in the warrant:** using the HCS unsignalized intersection methodology it was determined that the eastbound shared lane capacity is 277 vph. The right turn discount is 85% of the shared lane capacity, 0.85 x 277 = 235 right turns. The number of right turns included in the warrant is 180 – 235= -55 = 0 (if the number is less than or greater to zero, do not include any right turns in the warrant).
b) **Determine the minor approach ADT:** the minor approach peak hour volume used in the warrant is 90+50+0= 140. Since the peak hour volume is 10% of the ADT, the minor approach ADT is (140 / 0.10) = 1,400.

Figure 4 shows a the Preliminary Signal Warrant Analysis for example #2. The warrant # 1 is not met since the Minor Street ADT is less than the Warrant Volume in Case A and the Major/Minor Street ADT's are both less than the warrant volumes in Case B.

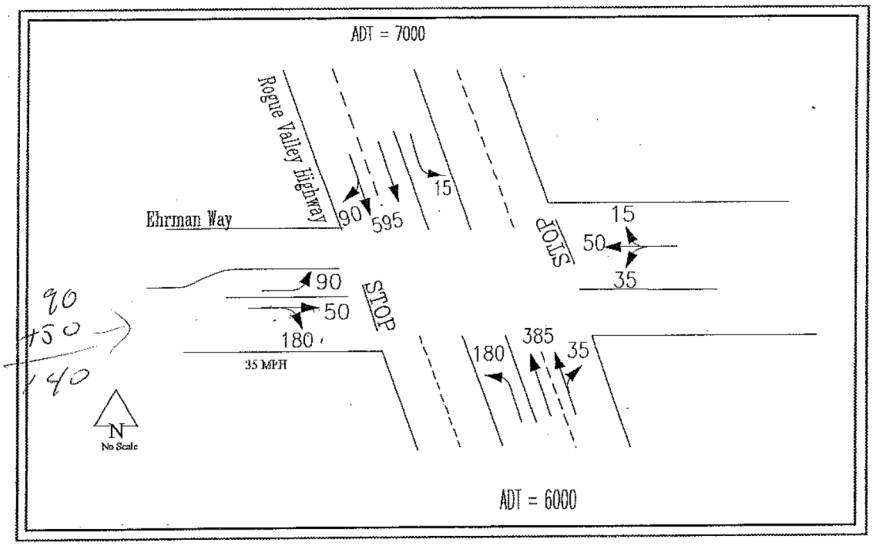

Figure 3

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Transportation Planning Analysis Unit

Preliminary Traffic Signal Warrant Analysis[1]

Major Street:	Rogue Valley Highway	**Minor Street:**	Ehrman Way
Project:	Ehrman Way	**City/County:**	Medford
Year:	1995	**Alternative:**	No Build

Preliminary Signal Warrant Volumes

Number of approach lanes		ADT on major street approaching from both directions		ADT on minor street, highest approaching volume	
Major Street	Minor Street	Percent of standard warrants 100	70	percent of standard warrants 100	70
Case A: Minimum Vehicular Traffic					
1	1	8,850	6,200	2,650	1,850
2 or more	1	10,600	7,400	2,650	1,850
2 or more	2 or more	10,600	7,400	3,550	2,500
1	2 or more	8,850	6,200	3,550	2,500
Case B: Interruption of Continuous Traffic					
1	1	13,300	9,300	1,350	950
2 or more	1	15,900	11,100	1,350	950
2 or more	2 or more	15,900	11,100	1,750	1,250
1	2 or more	13,300	9,300	1,750	1,250

5.65% of the above ADT volumes is equal to the MUTCD vehicles per hour (vph)

x	100 percent of standard warrants
	70 percent of standard warrants[2]

Preliminary Signal Warrant Calculation

	Street	Number of Lanes	Warrant Volumes	Approach Volumes	Warrant Met
Case A	Major	2+	10,600	13,000	
	Minor	2	3,550	1,400	N
Case B	Major	2+	15,900	13,000	
	Minor	2	1,750	1,400	N

Analyst and Date: Reviewer and Date:

Figure 4

[1] Meeting preliminary signal warrants does **not** guarantee that a signal will be installed. Before a signal can be installed a traffic signal investigation must be conducted or reviewed by the Region Traffic Manager. Traffic signal warrants must be met and the State Traffic Engineer's approval obtained before a traffic signal can be installed on a state highway.

[2] Used due to 85th percentile speed in excess of 40 mph or isolated community with population of less than 10,000.

Example # 3: Figure 5 shows a typical unsignalized intersection with a separate right turn lane on the eastbound, the peak hour volumes, the ADT volumes, and lane configurations. . The peak hour volumes are 10% of the ADT. The 85th percentile speed is 35 mph and the intersection is located in a city with a population of 60,000.

a) **Determining the number of right-turns to include in the warrant:** using the HCS unsignalized intersection methodology it was determined that the eastbound right turn lane capacity is 639 vph. The right turn discount is 85% of the shared lane capacity, 0.85 x 639 = 543 right turns. The number of right turns included in the warrant is 180 – 543= -363 = 0 (if the number is less than or greater to zero, do not include any right turns in the warrant).
b) **Determine the minor approach ADT:** the minor approach peak hour volume used in the warrant is 90+50+0= 140. Since the peak hour volume is 10% of the ADT, the minor approach ADT is (140 / 0.10) = 1,400.

Figure 6 shows the Preliminary Signal Warrant Analysis for example #3. Warrant # 1 is not met since the Minor Street ADT is less than the Warrant Volume in Case A and the Major Street ADT is less than the warrant volume in Case B.

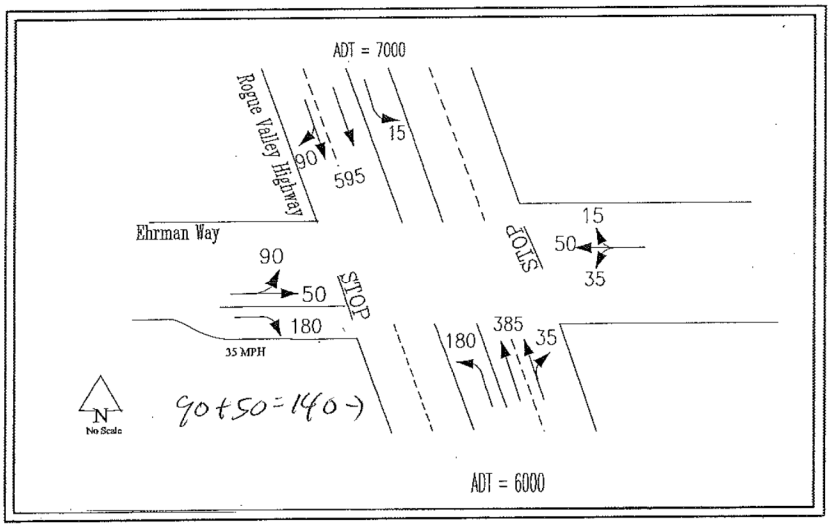

Figure 5

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Preliminary Traffic Signal Warrant Analysis[1]

Major Street:	Rogue Valley Highway	**Minor Street:**	Ehrman Way
Project:	Ehrman Way	**City/County:**	Medford
Year:	1995	**Alternative:**	No Build

Preliminary Signal Warrant Volumes

Number of approach lanes		ADT on major street approaching from both directions		ADT on minor street, highest approaching volume	
Major Street	Minor Street	Percent of standard warrants 100	70	percent of standard warrants 100	70
Case A: Minimum Vehicular Traffic					
1	1	8,850	6,200	2,650	1,850
2 or more	1	10,600	7,400	2,650	1,850
2 or more	2 or more	10,600	7,400	3,550	2,500
1	2 or more	8,850	6,200	3,550	2,500
Case B: Interruption of Continuous Traffic					
1	1	13,300	9,300	1,350	950
2 or more	1	15,900	11,100	1,350	950
2 or more	2 or more	15,900	11,100	1,750	1,250
1	2 or more	13,300	9,300	1,750	1,250

5.65% of the above ADT volumes is equal to the MUTCD vehicles per hour (vph)

x	100 percent of standard warrants
	70 percent of standard warrants[2]

Preliminary Signal Warrant Calculation

	Street	Number of Lanes	Warrant Volumes	Approach Volumes	Warrant Met
Case A	Major	2+	10,600	13,000	
	Minor	1	2,650	1,400	N
Case B	Major	2+	15,900	13,000	
	Minor	1	1,350	1,400	N

Analyst and Date:	Reviewer and Date:

Figure 6

[1] Meeting preliminary signal warrants does **not** guarantee that a signal will be installed. Before a signal can be installed a traffic signal investigation must be conducted or reviewed by the Region Traffic Manager. Traffic signal warrants must be met and the State Traffic Engineer's approval obtained before a traffic signal can be installed on a state highway.

[2] Used due to 85th percentile speed in excess of 40 mph or isolated community with population of less than 10,000.

Information for Narrative:

The following statement should be included in the Analysis Methodology section of the Narrative: The Transportation Planning Analysis Unit (TPAU) uses Signal Warrants 1, Case A and Case B (Manual on Uniform Traffic Control Devices) which deal primarily with high volumes on the intersecting minor street, and high volumes on the major-street. Meeting preliminary signal warrants does **not** guarantee that a signal will be installed. Before a signal can be installed a field warrant analysis is conducted by the Region. If warrants are met, the ODOT Traffic Management Section will make the final decision on the installation of a signal.

Resources

- Manual on Uniform Traffic Control Devices, Section 4C.
- 1999 Traffic Signal Guidelines, ODOT Traffic Management Section (see appendix A)
- OAR 734-020

Conclusion:

The Transportation Planning Analysis Unit (TPAU) uses Signal Warrants 1, Case A and Case B, found in the Millennium Edition of the Manual on Uniform Traffic Control Devices. This traffic signal warrant deals primarily with high volumes on the intersecting minor street, and high volumes on the major-street. Meeting preliminary signal warrants does **not** guarantee that a signal will be installed. Before a signal can be installed, a field warrant analysis is conducted by the Region. If warrants are met, the ODOT Traffic Management Section will make the final decision on the installation of a signal.

HCM Unsignalized Intersection Capacity Analysis
3: Int 12/17/2002

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Volume (veh/h)	90	50	180	35	50	15	180	385	35	15	595	90
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (veh/h)	95	53	189	37	53	16	189	405	37	16	626	95
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	1329	1526	361	1363	1555	221	721			442		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1329	1526	361	1363	1555	221	721			442		
tC, single (s)	7.5	6.5	6.9	7.5	6.5	6.9	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	0	42	70	0	39	98	78			99		
cM capacity (veh/h)	48	90	636	34	86	783	877			1114		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2	SB 3
Volume Total	337	105	189	270	172	16	418	304
Volume Left	95	37	189	0	0	16	0	0
Volume Right	189	16	0	0	37	0	0	95
cSH (120)	118	61	877	1700	1700	1114	1700	1700
Volume to Capacity	2.85	1.72	0.22	0.16	0.10	0.01	0.25	0.18
Queue Length (ft)	784	240	20	0	0	1	0	0
Control Delay (s)	912.3	492.6	10.2	0.0	0.0	8.3	0.0	0.0
Lane LOS	F	F	B			A		
Approach Delay (s)	912.3	492.6	3.1			0.2		
Approach LOS	F	F						

Intersection Summary			
Average Delay	199.5		
Intersection Capacity Utilization	67.1%	ICU Level of Service	B

Example #1

EXAMPLE 2
3: Int 12/17/2002

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Volume (veh/h)	90	50	180	35	50	15	180	385	35	15	595	90
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (veh/h)	95	53	189	37	53	16	189	405	37	16	626	95
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	1329	1526	361	1363	1555	221	721			442		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1329	1526	361	1363	1555	221	721			442		
tC, single (s)	7.5	6.5	6.9	7.5	6.5	6.9	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	0	42	70	0	39	98	78			99		
cM capacity (veh/h)	48	90	636	34	86	783	877			1114		

Direction, Lane #	EB 1	EB 2	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2	SB 3
Volume Total	95	242	105	189	270	172	16	418	304
Volume Left	95	0	37	189	0	0	16	0	0
Volume Right	0	189	16	0	0	37	0	0	95
cSH (227)	48	274	61	877	1700	1700	1114	1700	1700
Volume to Capacity	1.97	0.88	1.72	0.22	0.16	0.10	0.01	0.25	0.18
Queue Length (ft)	239	193	240	20	0	0	1	0	0
Control Delay (s)	634.5	68.5	492.6	10.2	0.0	0.0	8.3	0.0	0.0
Lane LOS	F	F	F	B			A		
Approach Delay (s)	227.7		492.6	3.1			0.2		
Approach LOS	F		F						

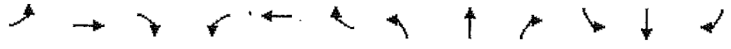
Intersection Summary			
Average Delay	72.1		
Intersection Capacity Utilization	55.3%	ICU Level of Service	A

$(634.5\text{sec})(90) = 15.86$ Veh·Hr

$(68.5\text{sec}) \times 180 = \frac{12,330}{360.} = \frac{4.37}{3.42}$ Veh·Hr

$20.2 > 5$ Veh·Hr

EXAMPLE 3
3: Int 12/17/2002



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Volume (veh/h)	90	50	180	35	50	15	180	385	35	15	595	90
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (veh/h)	95	53	189	37	53	16	189	405	37	16	626	95
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	1329	1526	361	1363	1555	221	721			442		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1329	1526	361	1363	1555	221	721			442		
tC, single (s)	7.5	6.5	6.9	7.5	6.5	6.9	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	0	42	70	0	39	98	78			99		
cM capacity (veh/h)	48	90	636	34	86	783	877			1114		

Direction, Lane #	EB 1	EB 2	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2	SB 3
Volume Total	147	189	105	189	270	172	16	418	304
Volume Left	95	0	37	189	0	0	16	0	0
Volume Right	0	189	16	0	0	37	0	0	95
cSH (639)	58	636	61	877	1700	1700	1114	1700	1700
Volume to Capacity	2.55	0.30	1.72	0.22	0.16	0.10	0.01	0.25	0.18
Queue Length (ft)	373	31	240	20	0	0	1	0	0
Control Delay (s)	856.4	13.0	492.6	10.2	0.0	0.0	8.3	0.0	0.0
Lane LOS	F	B	F	B			A		
Approach Delay (s)	382.0		492.6	3.1			0.2		
Approach LOS	F		F						

Intersection Summary			
Average Delay	100.9		
Intersection Capacity Utilization	55.5%	ICU Level of Service	A