MEMORANDUM

State of Alaska

Department of Transportation & Public Facilities
Design and Engineering Services – Central Region
Traffic Safety & Utilities Section

ACCEPTED: Luke Bowland, P.E.
Acting Regional
Preconstrucion Engineer

DATE: 4/8/21

THRU: Cynthia L. Ferguson, P.E.
Chief, TS&U

TELEPHONE NO: 269-0639
FAX NUMBER:

FROM: Scott E. Thomas, P.E.
Central Region Traffic
Engineer

Digitally signed by Scott Thomas
Date: 2021.04.08 14:59:03 -08'00'

SUBJECT: Left Turn Signalization Guidance for Design & Operations

With the advent of Flashing Yellow Arrow (FYA) left turn (LT) indications, protected vs permissive LT operation can now be considered for any hour of the day, not just the peak. Designers should install a 4 section FYA head at locations that require protected-only (PO) phasing during peak periods. Four (4) section FYA heads allow us the flexibility to operate permissive phasing during off-peak times of day when protected-only (PO) criteria is not met.

The following criteria indicate when a design engineering study of protected-only (PO) phasing should be documented for a signalized intersection. One or more of these criteria do not require protected-only (PO) phasing, but do require further study:

1) horizontal or vertical stopping sight distance restrictions are below minimum when adjusted for grade, or
2) left turns must cross four or more lanes, or
3) left turns operate as dual left turns or greater, or
4) for any 3 years, during an average 4 hour period having the lowest number of crashes, the permissive left turn crash rate:
    a. exceeds 0.26 crashes per 1,000 hours of protected-permissive (P/P) or permissive operation, or
    b. any individual hour exceeds 0.77 crashes per 1,000 hours of operation, or
5) Other site factors (such as local lead-lag procedures), gap observations, and the engineering judgement of the maintaining agency document the desirability of protected-only (PO) phasing at the site.

Guidance for the engineering study may be found in: Chapter 4, Left Turn Phasing Mode, "Decision-Making Guide for Traffic Signal Phasing (2020)", NCHRP 25905.

https://www.nap.edu/catalog/25905/decision-making-guide-for-traffic-signal-phasing

FYA heads and FYA hours of use are selected by the maintaining agency with supporting documentation from the designer. FYA is intended to be used where lower volumes and traffic gaps allow, with site specific judgment. Unless otherwise indicated by history or analysis, standard FYA operational hours would be during those hours of the day which satisfy the Left Turn Volume criteria of NCHRP 25905 on pages 26-27.

These guidelines should be used when the project scope allows the reconstruction of existing protected-only (PO) installations. Locations with a previous history of permissive crashes leading to 24/7 protected-only (PO) installation should be re-evaluated for selected hours of protected-only (PO) operation to be implemented upon FYA conversion.

The operations and maintenance agency, as well as field staff, should be consulted early in the engineering study phase.

Background:

This memo supersedes the "Left Turn Signalization Guidance for Design" Memo of Feb. 6, 2017. This new memo replaces the speed and lane configuration criteria of the previous memo and substitutes a sight distance requirement, based on recent NCHRP 25905 guidance.

Before the advent of FYA LT equipment, all LT treatment decisions were based on the worst case scenario, the peak hour. Because FYA can be used selectively by time of day (TOD), using the worst case scenario is no longer a limitation. In addition, unlike the 5 Section P/P head, the operators of FYA heads have the option of omitting the permissive phase entirely, without expensive hardware modifications. The additional cost of a 4 section P/P FYA head, wiring, and electronics, is minimal when compared to a 3 section protected-only (PO) installation. Because of these considerations, some additional flexibility in favor of P/P FYA LT is recommended.

Crash rate guidelines are established based upon a sampling of average rates of "left turn failure to yield" crashes at Alaska intersections through HSIP Program analysis.

Distribution:

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MEMORANDUM STATE OF ALASKA

Department of Transportation & Public Facilities
Design and Engineering Services – Central Region
Highway Design Section - Traffic and Safety

ACCEPTED: Wolfgang Junge, P.E.
Regional Preconstruction Engineer

DATE: February 6, 2017

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FROM: Scott E. Thomas, P.E.
Central Region Traffic Engineer

SUBJECT: Left Turn Signalization Guidance for Design

With the advent of Flashing Yellow Arrow (FYA) left turn (LT) indications protected vs permissive LT operation can now be considered for all hours of the day, not just the peak. Designers should install a 4 section FYA head at locations that require protected phasing only during peak periods. This permits permissive phasing during off-peak times of the day when protected-only criteria is not met. (For example, hours judged as likely to be level of service LOS A or B may be good candidates for permissive turns).

The following criteria indicate when a design engineering study of Protected-only (PO) phasing should be documented for a signalized intersection. One or more of these critera do not require PO phasing, but do require further study:

1) horizontal or vertical stopping sight distance restrictions are below minimum when adjusted for grade, or
2) left turns must cross four or more lanes, or
3) left turns operate as dual left turns or greater, or
4) there are three opposing-conflicting traffic lanes (thru+RT) and the opposing speed limit is 45 mph or greater, or
5) for any 3 year period during the 4 hour period with the lowest number of crashes, the permissive left turn crash rate:
    a. exceeds 0.26 per 1,000 hours of protected-permissive (P/P) or permissive operation, or
    b. any individual hour exceeds 0.77 per 1,000 hours of operation, or
6) Other site factors (such as local lead-lag procedures), gap observations, and the engineering judgement of the maintaining agency document the desirability of protected-only (PO) phasing at the site.

FYA heads and FYA hours of use are selected by the maintaining agency with supporting documentation from the designer. FYA is intended to be used where lower

4 Left-Turn Phasing Mode

Left-turn phasing mode is a key component of the design and operation of a traffic signal, with impacts on safety and delay for all users of an intersection.

This chapter of the Guide is intended to address accommodations for left turns from two-way streets as well as U-turns to the left. For left turns from one-way streets, the right-turn phasing chapter of the Guide (Chapter 5) may provide more relevant guidance.

4.1 Left-Turn Phasing Mode

Left turns can operate using one of the following phasing modes, as shown in Figures 7 through 10:

- ***Permissive-Only***, where left turns are usually served by a circular green or flashing yellow left arrow signal indication. Permissive left turns may only be made after yielding to opposing traffic and conflicting pedestrians. During a permissive left-turn movement, a pedestrian phase can be served across the left-turn movement's departing lanes. Left-turning drivers are required to yield to pedestrians in the parallel crosswalk when making a permissive left turn. A flashing red left arrow may also be used to indicate permissive left turns. Such a display communicates to motorists that they must stop prior to making a permissive left turn, unlike a circular green or flashing yellow arrow, which require motorists to yield.
- ***Protected-Only***, where left turns can be made only on a green left arrow indication. During a protected left-turn movement, no conflicting traffic or pedestrian phases may be served, and no phases may be served that use the same departing lanes (unless sufficiently channelized).
- ***Protected-Permissive***, where both modes may be used on the same approach during the same signal cycle.

Split Phasing is a special case of protected-only phasing mode in which the green indications for all movements on a single approach always start and end at the same time. On approaches where split phasing is used, a yellow left arrow is not required as it is in all other protected-only or protected-permissive configurations. The circular yellow indication serves all movements on the approach.

The left-turn mode may change by time of day or in response to changing traffic conditions.

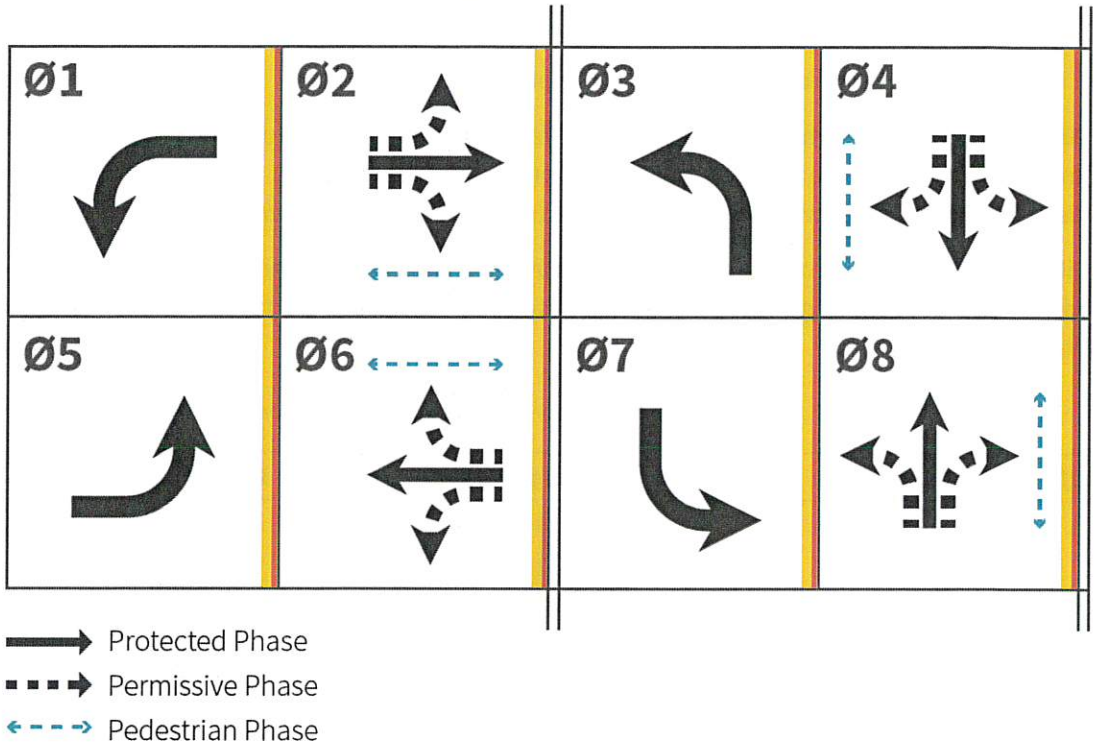


Figure 9 - Typical Phasing Diagram for Protected-Permissive Phasing (Adapted from NCHRP 2015)

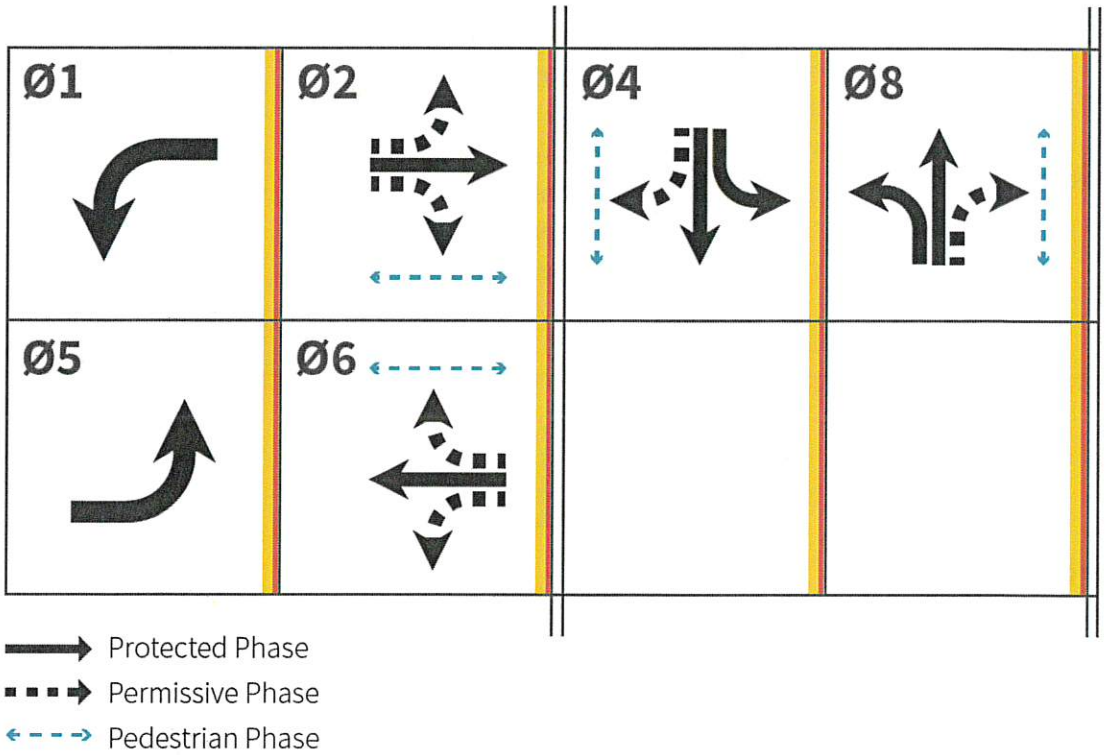


Figure 10 - Typical Phasing Diagram for Split Phasing on the Minor Street (Adapted from NCHRP 2015)

4.2 Left-Turn Phasing Mode Considerations

Typically, protected-only phasing mode is operationally less efficient than permissive-only and protected-permissive modes in most cases because motorists cannot use available gaps to turn left. Rather, green time must be allocated to the left-turn movement, which reduces the time available for other movements, increasing delay for all movements. Protected-only phasing mode often requires a longer cycle length, compounding the inefficiency. Because of this inherent inefficiency, protected-only mode should be used only where permissive left turns are determined to be inappropriate.

A two-step process is recommended to select a left-turn phasing mode:

1. Determine if permissive left turns can be allowed for safety reasons.
2. If so, determine if protected left turns are needed for operational reasons.

The steps should be repeated for every left-turn movement at a signalized intersection.

This Guide considers each of these two steps separately. Since the second step may not be necessary depending on the outcome of the first step, it is important to consider the steps in this order.

4.2.1 Safety Impacts of Permissive Left Turns

A designer should consider the following features of an intersection approach to determine whether permissive left turns are appropriate for safety reasons:

- Sight Distance
- Lane Configuration
- Crash History

If any of these factors indicate that permissive left turns are not appropriate, protected-only phasing mode is often recommended, and further evaluation of that approach may not be necessary.

Sight Distance

Sight Distance	To allow permissive left turns, **left-turning drivers must have a clear view of opposing traffic, including bicyclists.**	Insufficient line of sight between left-turning drivers and opposing vehicles, as discussed below	Protected-Only **recommended**
	To allow permissive left turns, **left-turning drivers must have a clear view of pedestrians** in the conflicting parallel crosswalk.	Blocked line of sight between drivers and pedestrians	Protected-Only **recommended**

Intersection sight distance should be determined according to *A Policy on Geometric Design of Highways and Streets*, also known as the Green Book (AASHTO 2018). The Green Book assumes that drivers of passenger cars crossing one opposing lane need a gap in opposing traffic 5.5 seconds long to make a permissive left turn. As such, drivers must be able to see oncoming traffic at least 5.5 seconds away. For

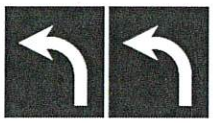
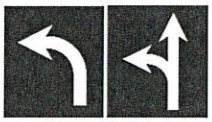
point may also be desirable if drivers tend to wait at a different point, but the left-turn signal face should be visible from any point where a measurement is made. For adequate sight distance to exist, **an opposing vehicle must be continuously visible in any approach lane** for the distance specified in the Green Book. For intersections not yet constructed, it may be necessary to estimate sight distance using design plans.

- ***Opposing Left Turns.*** Vehicles waiting to make a left turn in opposite directions sometimes obstruct each other's sight distance. Opposing left-turning vehicles should be considered where they are a persistent visibility obstruction on an approach.

Because protected-only phasing mode is almost always less efficient than allowing permissive left turns, agencies should evaluate intersections lacking sufficient sight distance to determine if the line of sight could be improved by measures such as the following:

- Trimming or removing vegetation
- Providing a positive geometric offset or improving the geometric offset of opposing left-turn lanes

Lane Configuration

Lane Configuration	On an approach where **left turns are permitted from more than one lane**, most agencies use protected-only phasing mode.[3] Some agencies allow permissive left turns from dual left-turn lanes, but these applications are uncommon.		Protected-Only **recommended**
	On an approach where **left turns and through traffic share a lane**, it is undesirable to give green indications to the two movements at different times of the signal cycle. However, permissive left turns may be acceptable where one of the two movements has very low volume or conflicting opposing traffic is very low. The MUTCD prohibits protected-only mode on approaches without an exclusive left-turn lane.	 or 	Protected-Only **not permitted**[4] Split Phasing **recommended**
	Where the **paths of opposing left-turning vehicles overlap**, these left turns are required not to be served at the same time. If both directions of through traffic are served concurrently, then permissive-only phasing must not be used on at least one of the conflicting left-turn paths.	Overlapping opposing left-turn paths	Protected-Only **required** for at least one of the two overlapping paths

count from published industry state of the practice. Chapter 11 provides more information about combining the impacts of safety and operations at individual intersections.

Table 3 - Critical Correctable Left-Turn Crash Counts (Adapted from FHWA 2009d; NCHRP 2015)

Number of left-turn movements on subject road	Period during which crashes are considered (years)	Critical correctable left-turn crash count
One	1	6
	2	11
	3	14
Both	1	11
	2	18
	3	26

The cross-sectional research conducted as part of this Guide's development determined that protected-permissive phasing mode was not associated with significantly fewer left-turn crashes than permissive-only mode. However, significantly fewer left-turn crashes were observed at intersections using protected-only mode. This study's research shows that adding protected-only phasing mode to opposing major road approaches is associated with a left-turn CMF of 0.507, indicating a crash reduction of 49.3 percent, and adding protected-only to the minor road approaches has a CMF of 0.702, a crash reduction of 29.8 percent. More details about this safety research can be found in Chapter 9.

A safety review to determine left-turn phasing mode usually focuses on correctable left-turn crashes. However, at congested intersections, particularly where left-turn bays are short, a different safety problem may emerge if a queue of left-turning vehicles extends out of the left-turn bay and blocks a through travel lane. In this case, the presence of stopped vehicles in a through lane may result in rear-end crashes. If so, protected-only left-turn phasing mode may aggravate the problem because of the less efficient operation. In these circumstances, the frequency and severity of rear-end or sideswipe crashes under protected-only conditions should be weighed against the frequency and severity of correctable left-turn crashes under permissive left-turn conditions. Chapters 9 - 11 provide additional information on comparing safety and operational impacts of phasing alternatives.

For intersections without a crash history, such as those under design or recently built, it may be possible to use a SPF to evaluate the likelihood of crashes. Chapter 9 provides more information on using SPFs to estimate expected safety performance.

4.2.2 Operational Impacts of Permissive Left Turns

If any of the previous factors recommend against the use of permissive left turns, it is usually not necessary to evaluate the operational impacts. However, where it has been determined that permissive left turns can operate safely, the following factors should be evaluated to determine if permissive-only phasing mode is sufficient or if protected-permissive phasing mode should be used for operational reasons:

- Left-Turn Volume
- Left-Turn Delay

Left-Turn Volume (Continued)	$$L_{CP} = \frac{V_{LT} * V_{OT}}{N_L}$$ where: V_{LT} = number of vehicles turning left during the intersection's peak hour V_{OT} = number of opposing through vehicles during the same hour N_L = number of opposing through lanes It may be desirable to include opposing right-turn volume in V_{OT} and opposing right-turn lanes in N_L where right-turn volume is heavy or where conflicts with left turns are unusually high, such as where dual right-turn lanes exist.	LCP <= 50,000	Permissive-Only recommended

4.2.3 Other Considerations

At intersections with a high volume of pedestrians, conflicts between permissive left turns and crossing pedestrians may make protected-only left-turn phasing mode desirable.

Some intersection configurations may require protected-only phasing mode for reasons not already indicated here. Examples of these conditions include the following:

- Streets with center-running or left-side exclusive transitways. At intersections on these streets, transit vehicles pass to the left of left-turning vehicles. Left-turning drivers cannot be expected to see and yield to transit vehicles approaching from behind, so in these cases protected-only left-turn phasing mode is normally used.
- Streets with median or left-side two-way separated bike lanes. Where a left turn conflicts with a two-way separated bike lane, left-turning motorists may not expect through cyclists coming from behind, so protected-only left-turn phasing mode, or another method of serving bicycle traffic and conflicting left turns at different times, can be appropriate.

Some agencies require the same left-turn phasing mode to be used on opposing approaches. In practice, this often results in use of protected-only phasing mode where permissive turns would otherwise be allowed. No known research indicates any safety or operational benefit to matching the left-turn phasing mode on opposing approaches.

The impacts of an intersection's left-turn phasing mode should be reviewed for possible adverse effects at adjacent intersections. One phasing mode may be best for a signal in isolation, but if it causes queues to spill back to surrounding intersections, its left-turn phasing mode may need to be reviewed to mitigate negative network impacts.

For example, the closely spaced intersections at a diamond interchange may require careful review to ensure that their phasing modes contribute to effective overall operation of the interchange as a whole. Phasing should not contribute to excessive queues formed at one intersection that extend into a nearby intersection.

At unsignalized intersections, all uncontrolled left turns are permissive. If permissive left turns are operating safely and effectively at unsignalized intersections along a corridor, drivers may not understand the rationale if permissive left turns are disallowed at one or more signalized intersections with similar characteristics on the same corridor. However, unsignalized intersections may operate differently because, for instance, nearby signals may create gaps that facilitate left turns from the major street.

When permissive left turns are not appropriate because of a temporary condition, it may be desirable to consider using a variable left-turn phasing mode. A variable mode can change by time of day, week, or year, such as when opposing left-turning vehicles frequently obstruct sight distance during peak hours, but not during off-peak hours. A variable mode can also change dynamically in response to intersection conditions, such as using protected-only phasing mode only when a parallel pedestrian crossing has been actuated. Following are two examples where variable phasing mode may be appropriate:

configuration is more intuitive to drivers than an MUT because left turns are served from their typical position in the left lane.

- ***Jughandle*** configurations typically route left-turning vehicles onto the side street, where they join the stream of side street through traffic. A jughandle helps eliminate signal phases and can improve safety by avoiding left-turn crash conflicts.

More information about these and other alternative intersection treatments, including potential disadvantages, can be found FHWA's Alternative Intersections/Interchanges Informational Report (FHWA 2009a).

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[1] The Green Book suggests that wide medians "should be converted to an equivalent number of lanes; for example, an 18-ft median would be equivalent to one and a half lanes."

[2] On an approach without a stop line, the measurement can be made from the near-side crosswalk line or drivers' normal stopping point, which may need to be determined from a field assessment of driver behavior.

[3] The research conducted as part of this Guide's development was not able to model impacts on crashes where varied left-turn phasing modes are used on approaches with multiple left-turn lanes.

[4] On an approach without an exclusive left-turn lane, Protected-Only left-turn phasing mode is only acceptable when the left-turn movement begins and ends at the same time as the adjacent through movement (i.e., split phasing), per MUTCD Sec. 4D.17, para. 06.

[5] Interim Approval IA-17 from the Federal Highway Administration (2014) allows optional use of a three-section flashing yellow arrow signal face where the flashing and solid yellow arrows are combined in a single section. Agencies using this option must comply with the terms of IA-17.