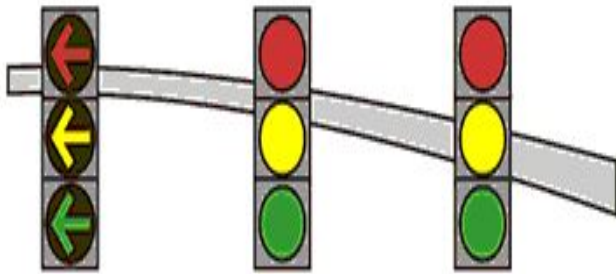


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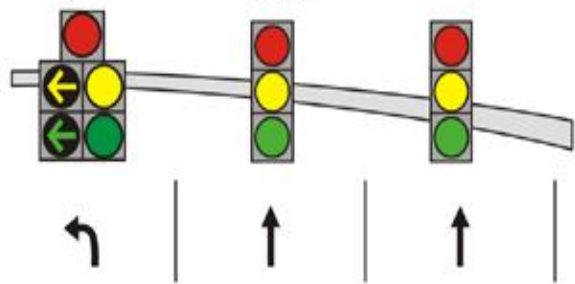
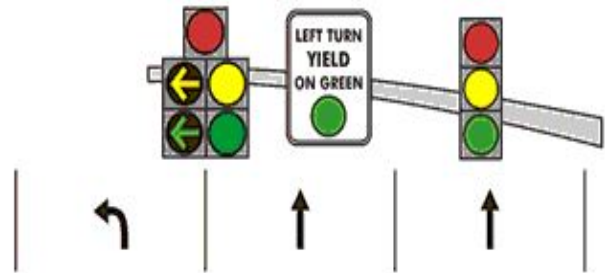
Advantages of Protected and Protected/Permissive Left-Turn Phasing

City of Beaumont, CA

Protected Left-Turn Phasing



Protected/Permissive Left-Turn Phasing



PREPARED FOR:



City of Beaumont

Department of Public Works
550 E. 6th Street
Beaumont, CA 92223



PREPARED BY:



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TECHNICAL MEMORANDUM

To: Jeff Hart, PE
Public Works Director/City Engineer, City of Beaumont

From: Fred Minagar, MS, PE, RCE, FITE
City Traffic Engineer, Principal, Minagar & Associates, Inc.

Date: May 19, 2021

Re: Advantages of Protected or Protected/Permissive Left-Turn Signal Phasing

Executive Summary:

The City of Beaumont requested that Minagar & Associates, Inc. provide the advantages of protected and protected/permissive left turn signal phasing for an existing or proposed signalized intersection. Listed below are the stated advantages of left-turn phasing according to the following traffic manuals:

- *Federal Highway Administration (FHWA)*
- *National Cooperative Highway Research Program (NCHRP)*

Federal Highway Administration (FHWA)

Advantages of Protected Left-Turn Phasing:

- Higher capacity due to fewer conflicts.
- Conflicts between left-turning and opposing vehicles and pedestrians are eliminated.
- Lowest rate of left-turn-related vehicle crashes.

Disadvantages:

- None

Advantages of Protected/Permissive Left-Turn Phasing:

- Average delay per left-turn vehicle is reduced.
- Protected green arrow time is reduced.
- There is a potential to omit a protected left-turn phase.
- Arterial progression can be improved particularly when special signal head treatments are used to allow lead-lag phasing.

Disadvantages of Protected/Permissive Left-Turn Phasing:

- The permissive phase increases the potential for vehicle-vehicle and vehicle-pedestrian conflicts.
- There is a limited ability to use lead-lag phase sequences unless special signal head treatments are used.



National Cooperative Highway Research Program (NCHRP)

Advantages of Protected Left-Turn Phasing:

- No conflicting traffic or pedestrian phases may be served.
- Driver executes a left-turn safely.

Advantages of Protected/Permissive Left-Turn Phasing:

- Increases traffic efficiency by allowing both protected and permissive movements during a signal cycle.
- Increase left-turn capacity and reduce delay at intersections.

Disadvantages of Protected/Permissive Left-Turn Phasing:

- Increased exposure of left-turning and opposing through vehicles to conflicts with each other during the permitted phase.

Discussion

Federal Highway Administration (FHWA)

“Left-Turn movements with "protected-only" phasing have a higher capacity than those with "permissive-only" phasing due to fewer conflicts”. (FHWA, 2004)

“Under protected left-turn phasing (i.e., steady green arrow), conflicts between left-turning and opposing through vehicles and between left-turning vehicles and pedestrians are eliminated”. (FHWA, 2018, p. 5)

“Prior studies have found that protected-only left-turn phasing is associated with the lowest rate or frequency of left-turn-related vehicle crashes”. (FHWA, 2018, p. 5)

“The controller phasing for protected-permissive mode is the most complicated phasing because of the safety implications created by the potential of what is known as the “yellow trap.” In a permissive-mode operation, the left-turning driver must obey the green display for the adjacent through movement, which also gives permission for the permissive left turn. When the yellow display for the adjacent through movement appears, the left-turning driver ordinarily expects the opposing through display to be yellow as well. The driver may now mistakenly believe that the left turn can be completed on the yellow display or immediately thereafter when the opposing through display will be red”. (FHWA 2004).

National Cooperative Highway Research Program (NCHRP):

“The increase in traffic volume on urban roadways has led engineers to develop innovative means to control traffic. With an increase in traffic volume, a driver has fewer available gaps in the opposing through traffic to execute a left-turn maneuver safely. To alleviate this situation, signal phasing was designed to provide a protected left-turn phase for part of the signal cycle. The resulting increase in safety came at the expense of operational efficiency. To regain some of the lost efficiency, traffic signals were designed to protect the left-turn movement during a

portion of the signal cycle and to allow a permissive movement during the remainder of the signal cycle, resulting in left-turn control that is commonly known as protected-permissive left-turn control, or simply PPLT control (or phasing). If a protected movement is warranted, PPLT control has been shown to increase left-turn capacity and reduce delay at intersections (as compared with protected-only control) by providing an exclusive turn phase for left turns as well as a permissive phase during which left turns can be made if gaps in opposing through traffic will allow, all within the same cycle. The left-turn phase (interval) can precede (lead) or follow (lag) the through phase". (NCHRP, 2003, p. 2)

"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)". (NCHRP, 2020, p. 17)

"The safety problems that left-turning vehicles encounter arise from three sources of conflict:

- Opposing through traffic,
- Through traffic in the same direction, and
- Crossing vehicular and pedestrian traffic.

These conflict types often produce angle, sideswipe same direction, and rear-end crashes. There are several treatments that could alleviate operational and safety impacts of—and on—left-turn traffic. Protected left-turn phases are warranted based on such factors as turning volumes, delay, visibility, opposing vehicle speed, distance to travel through the intersection, and safety experience of the intersections". (NCHRP, 2004, V-7)

"The use of "protected/permitted" phasing represents a compromise between fully protected phasing and permitted-only phasing. This operational strategy has several advantages, the most important being the reduction in delay for left-turning vehicles achieved by permitting left turns while the opposing through movement has a green indication. Other benefits include less green time needed for protected left turns (and hence more time for other high priority movements) and the potential for improved arterial progression. The safety performance of protected/permitted left-turn phases is not as good as that of protected-only phases, due to the increased exposure of left-turning and opposing through vehicles to conflicts with each other during the permitted phase. Dual or triple left-turn lanes should only operate with protected turn phases". (NCHRP, 2004, V-7)

Respectfully submitted,

MINAGAR & ASSOCIATES, INC.
(A California Corporation)

A handwritten signature in black ink, appearing to read "Fred Minagar", written in a cursive style.

Fred Minagar, MS, RCE, PE, FITE
Principal



References

1. Federal Highway Administration (2004). Signalized Intersections: Informational Guide Chapter 4.2.2.
2. Federal Highway Administration (2018). Safety Evaluation of Protected Left-Turn Phasing and Leading Pedestrian Intervals on Pedestrian Safety.
3. National Cooperative Highway Research Program (NCHRP), (2003). Report 493, Evaluation of Traffic Signal Displays for Protected/Permissive Left-Turn Control, 2.
4. National Cooperative Highway Research Program (NCHRP), (2020). Web-Only Document 284, Decision-Making Guide for Traffic Signal Phasing, 17.
5. National Cooperative Highway Research Program (NCHRP), (2004). Report 500, Volume 12: A guide for Reducing Collisions at Signalized Intersections, V-7.