

Ada County Highway District's Flashing Yellow Arrow Initiative

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Abstract

In 2010 the Ada County Highway District (ACHD) began replacing protected only and protected/permissive signals with flashing yellow arrow (FYA) permissive left-turn indications. The initiative began due to the understanding that FYA indications are generally better understood by the majority of drivers than the circular green indication and that FYA's provide operational flexibility that cannot be achieved with other left-turn displays. Favorable public feedback led to a 2013 directive from the ACHD Commission to install FYA's at all feasible intersections. ACHD currently operates 148 intersections with FYA out of 427 countywide signalized intersections, with plans to continue converting more. ACHD's experience with FYA's has generally been good; however, ACHD has learned much along the way and been reminded about efficiency and safety trade-offs. This paper highlights national research and guidelines regarding FYA's, criteria used to assess FYA feasibility, the conversion prioritization process, design and operational details, before-after crash comparisons, and possible future FYA applications.

Background

Ada County, population 416,000, is the most populous county in Idaho and includes the capitol city of Boise. ACHD is a countywide highway district that builds, maintains, and operates all public roadways within Ada County and the incorporated cities within it except for the state highways and interstate freeway. This is a unique situation that results in the cities and counties not being responsible for the roadways within their boundaries and ACHD overseeing a wide spectrum of facilities ranging from very urban to rural high-speed environments. One of ACHD's many responsibilities is to operate and maintain the signalized intersections within the county. In addition to all the local street intersections, ACHD also maintains and operates all traffic signals on state highways within the county.

In 1989 ACHD started implementing protected/permissive left-turn signal phasing with 5-section, "doghouse" style signals in situations that previously only used protected-only left-turn signal phasing. Federal Highway Administration's *Traffic Signal Timing Manual* and the Institute of Transportation Engineers *Traffic Engineering Handbook* were used to develop criteria and thresholds to assist in determining whether a protected-only left-turn signal could be converted to protected/permissive operation.

Figure 1 – ACHD's First Doghouse Intersection



Source: Google Streetview, Fairview/Orchard intersection

Although current versions of documents like the *Traffic Engineering Handbook* provide general considerations, previous versions provided specific thresholds that ACHD utilized as a part of the screening process. Table 1 summarizes the general criteria that were considered when evaluating the merits of installing doghouse signals.

Table 1 – Past ACHD Criteria for Doghouse Installations

Design	Safety	Volume
<ul style="list-style-type: none"> • Geometric constraints/movement conflicts • Number and configuration of left-turn lanes • Number of opposing lanes • Posted speed limit 	<ul style="list-style-type: none"> • Crash history • Sight distance measurements • School and/or pedestrian activity 	<ul style="list-style-type: none"> • Left-turn volume • Gaps in conflicting traffic • The cross product of left-turn and oncoming traffic volumes

The protected/permissive, five-section doghouse left-turn signals provided some benefits and flexibility that did not exist with protected-only and permissive-only signal phasing; however, significant limitations with this menu of devices still remained. If protected-only phasing was required at an intersection for a relatively short period (i.e. school times or rush hour), a three-section, protected-only signal had to be used. As a result, during off peak times drivers felt the wait for a green indication was excessive and frequently ran the red light to take advantage of large gaps in opposing traffic. Other intersections with the five-section doghouse left-turn signals frequently appeared on the High Crash Location reports and review of the police investigations frequently found that drivers commonly failed to yield when making left-turns when presented with a green, circular indication. Additionally, other concerns were voiced by pedestrians and other users who could not understand why some drivers had green indications that conflicted with their “Walk” signals.

Initial Implementation

The National Cooperative Highway Research Program published *NCHRP Report 493 - Evaluation of Traffic Signal Displays for Protected/Permissive Left-turn Control* in 2003 highlighting a new option for the left-turn signal display. The findings provided in the report showed that drivers are more likely to correctly understand the meaning of a FYA for permissive left turns than the traditional circular green indication. Following the NCHRP report, in 2009 the *Manual on Uniform Traffic Control Devices (MUTCD)* officially adopted the FYA as a left-turn signal display option and provided guidance on display configurations.

The ACHD works to be among the industry leaders and stay on the cutting edge of traffic engineering tools and practices; however, ACHD is not typically the first jurisdiction to implement new practices. Although the 2009 MUTCD included the FYA as an optional indication, ACHD was cautious to begin conversions of existing signals. Prior to implementing FYA, staff coordinated with other jurisdictions and listened to technical presentations to learn about how they use FYA signals and any benefits or

drawbacks they experienced with them. Many publications like the *Traffic Engineering Handbook*, *Traffic Signal Timing Manual*, and American Association of State Highway and Transportation Official's *A Policy on Geometric Design of Highways and Streets* (The Green Book) are valuable for assessing the left turn control that should be employed at an intersection; however, these resources still have generally not yet been updated to reflect FYA operation.

In 2010 the ACHD Commission was preferential to protected/permissive phasing over protected only operations wherever feasible, so with the information from NCHRP 493, the adoption of FYA in the 2009 MUTCD, and helpful information from jurisdictions with FYA, ACHD installed FYA's on the first test corridor. The test corridor selected was State Street, a principal arterial and gateway to the Downtown Boise Central Business District. The average daily traffic for State Street is approximately 40,000 vehicles per day; it has a five-lane cross section, and a 35-45 mph speed limit. Six local and collector street intersections along State Street were converted from five-section and three-section (protected only) signal heads to four-section heads displaying FYA's. Left turning sight distance and volume cross products were first checked to verify that protected/permissive phasing was appropriate. Based upon field observations and cross products, some signals were programmed to run protected only phasing during peak hours due to lack of acceptable gaps in traffic. Table 2 summarizes a before-after comparison of the State Street FYA test corridor.

Table 2 – State Street FYA Before-After Comparison

Previous Left-Turn Phasing	Number of Intersections	Average Number of Crashes/Year/Intersection					
		Before (2005-2009)		After (2010-2014)		Change	
		Total	Left-Turn Only	Total	Left-Turn Only	Total	Left-Turn Only
Protected Only	3	5.5	0.6	3.5	0.5	-37%	-11%
Protected/Permissive (Doghouse)	3	4.6	0.7	2.8	0.3	-39%	-60%

As summarized in Table 2, a reduction in crashes was realized after the installation of FYA's on the State Street test corridor. As expected, the reduction in left turn crashes was greater for intersections that previously had protected/permissive (doghouse) operations than for protected only locations. An overall reduction in the number of injury crashes was also realized. The reduction in crashes at intersections previously with protected only operation could have been an anomaly or could be due to less red light running activity.

Commission Directed Priority Initiative

Initial feedback from citizens and the ACHD Commission was overwhelmingly positive. At the end of the second year, staff presented the State Street conversion to the Commission and was directed to continue with FYA conversions with a goal of 50 intersections in one year. As a result, 2012 saw the conversion of 50 intersections to have FYA's, part by contract and part with in-house crews. The strategy

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was to install FYA's by corridor for the sake of consistency to help drivers get comfortable with the new display and maximize their exposure on high volume facilities. Cross products and sight distance were checked at each location to verify protected/permissive phasing was appropriate. These intersections were the "easier" locations to convert and generally had approaches with straight alignments, well aligned single left turn lanes, adequate mast arm lengths, and modern traffic signal controllers capable of operating the FYA phasing. Contracting most of the conversions was seen as a way to address the limited manpower of Highway District crews. This proved to be fairly inefficient, though, with the contractor needing frequent input to complete the work. The experience led to the decision to do all future conversions in-house.

Following the first large-scale conversion effort, the focus turned to prioritizing the conversion of intersections with protected-only phasing and signalized intersections with frequent left-turn crash patterns. This new focus ended the by corridor conversion effort to visibly maximize public benefit (e.g., reduce delay). After many of the protected-only left-turn signals were converted the focus again shifted to the more difficult locations. In order to achieve necessary sight distance, some turn lanes required modifications to striping, generally, blocking out the right lane (#2) of double left turn bays or shifting single turn lanes closer to through traffic. An analysis was performed beforehand to determine if a single turn lane with FYA would function with less delay than dual turn lanes with protected only phasing. In some cases, delay was comparable for either option during peak hours, but the delay reduction during off peak times lead to the decision to convert to FYA.

High speed (45 mph or higher) were not initially converted to FYA given the concern about reaction time for drivers and the increased severity of injuries from high speed angle type crashes. In 2013, after consulting with other jurisdictions, ACHD implemented 6 high speed locations on suburban, 55 mph, 5-lane highways as a test. Warning signs reading "New Traffic Signal Operation" were placed on tall stands in advance of the signal for two weeks after installation to inform drivers (these signs are also placed on shorter sandwich board stands at locations with approach speeds between 40 and 55 mph for two weeks after installation). To date, the test locations average 1 left turning crash per intersection and none of these were fatality or severe injury type crashes.

Conversions of doghouse signals are currently the focus, in an effort to achieve uniformity in protected/permissive signal displays countywide. Approximately 57 intersections remain to be converted with a goal of 15 conversions this year. In addition to uniformity, the ability to implement time of day suppression of the FYA are seen as very valuable for addressing crash and pedestrian conflict issues as they arise. The use of lag operation is a valuable tool for signal coordination.

FYA operation is not utilized at signalized intersection approaches with dual-left turn lanes, inadequate intersection sight distance, three or more opposing through lanes, and geometric constraints that create movement conflicts.

ACHD Flashing Yellow Operation

The MUTCD provides guidance for the operation of FYA's and signal head configuration, however, there are still many operational choices a practitioner can employ. One example is the option of using a 4-

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section head (red arrow, yellow arrow, flashing yellow arrow, green arrow), a 3-section head (red arrow, yellow arrow, flashing yellow arrow), or a 3-section, bi-modal head. Early on, ACHD made the decision to use only 4-section heads for FYA, even if permissive only operation is intended. This provides flexibility should future conditions change and the need for a protected phase arise, either temporarily or permanently. The down side is that citizens sometimes wonder why the green arrow is never displayed and report a signal malfunction.

FYA signals also allow for operational strategies such as time of day prohibitions. ACHD uses these to balance safety and mobility. The signal controller is programmed to “suppress” the FYA during a certain time period, in effect running protected only during a short time frame and then running protected/permissive or even permissive only during the remainder of the day. This strategy is generally employed either during peak times when acceptable gaps are few, or during the release of an adjacent school where high numbers of students are crossing through an intersection.



Conflicts between left turning vehicles and pedestrians have long been a concern with permissive signal indications. ACHD programs all signal controllers running FYAs to hold the red arrow and delay the onset of the FYA by 5 seconds following the end of the green and solid yellow phases to stop vehicles and allow pedestrians to enter the intersection. This operation is very similar to a typical leading pedestrian interval and allows the pedestrians to be more visible to drivers. In the future, ACHD hopes to have the signal controller capability to delay or prohibit the onset of the FYA when a pedestrian call is received. In some higher pedestrian activity areas or at skew intersections, the R10-15 “Left Turn Yield to Pedestrians” sign is installed on the mast arm to the right of the 4-section head.

Signal preemption is also a concern with permissive left turn operations, due to the possibility of a “yellow trap”. In the case of a FYA, an oncoming emergency vehicle could preempt the signal, turn the indication for a conflicting vehicle from FYA to red, but leave the conflicting vehicle to think that oncoming traffic also now has a red indication and will stop. To prevent this, ACHD programs controllers to continue to display the FYA opposite a preempting emergency vehicle.

Crash Evaluation

Table 3 provides a summary of crash data for all intersections converted to FYA that have at least 1 year of ‘after’ crash data. Many of these locations only have a year or two of crash data post conversion and staff availability limited the ability to account for traffic volumes and other control measures at this time.

Table 3 – Countywide Before-After Comparison

Previous Left-Turn Phasing	Number of Intersections	Average Number of Crashes/Year/Intersection					
		Before		After		Change	
		Total	Left-Turn Only	Total	Left-Turn Only	Total	Left-Turn Only
Protected Only	68	4.7	0.7	5.5	1.0	17%	67%
Protected/Permissive (Doghouse)	47	6.7	2.2	6.3	2.0	-8%	-6%

As summarized in Table 3, FYA installations achieved a reduction in crashes over the traditional doghouse protected/permissive display type. However, ACHD experienced an increase in crashes at locations converted from a protected only signal to protected/permissive phasing with a FYA. This increase is a tradeoff for increased signal efficiency that is highly valued by the constituents of Ada County. That tragedy reinforced the importance of carefully vetting locations for the appropriateness of FYA but also the public's desire for efficiency as staff received requests to maintain the FYA operation at that location for fear it may be removed in response to the fatal crash.

Conclusions

ACHD is expanding their use of FYA to allow for additional operational benefits in response to the significant amount of favorable public comments and staff's experience to date. Thus far, intersections with three opposing lanes have been ruled out for FYA installations due to initial concerns of increased crash risk. After further consideration and positive feedback from other agencies, ACHD is now considering such applications. Along those lines, high speed locations (greater than 45 mph speeds) were also an area of concern that are now being reevaluated for possible inclusion of FYA's. Looking into the future, ACHD is also starting to discuss the application of FYA for right turn movements. This could offer improved driver understanding and decreased pedestrian conflicts.

ACHD is an agency that strives to stay on top of many of the national traffic engineering trends. For example, no traffic signals in Ada County have late-night flash operation and none have for a long time. As a result, only a few out of town visitors submitted concerns over their misunderstanding of a flashing yellow signal display. If late night flash was more common in the area, supplemental signage may have had a greater need. Additionally, ACHD tried to install two signal heads for the left-turn movements. This setup provides a FYA display in the movements far left corner and may help focus drivers' attention to the pedestrian conflict areas.

ACHD is continuing to expand the system for increased uniformity and greater benefit to users. ACHD's experience suggests there are some safety tradeoffs with FYA operation, but additional research and analysis is necessary. Many national publications and research efforts need to still be updated to reflect the use of FYA.