

Request to the Federal Highway Administration for Experimentation by Implementation of the Flashing Yellow Arrow Display

By Ali Eghtedari, Ph.D., P.E.
City of Vancouver
Transportation Services
PO Box 1995
Vancouver, WA 98668-1995

May 13, 2005

FHWA Operations
Attention: Regina S. McElroy Director
Office of Transportation Operations
HOTO Room 3401
400 76 Street, S.W.
Washington, D.C. 20590

Request to Experiment by Implementation of the Flashing Yellow Arrow Display

Preface

The research project, NCHRP 3-54, Evaluation of Traffic Signal Displays for Protected Permitted Left Turn Control, conducted by Kittelson and Associates, Inc. (KAI) as the prime contractor, has completed the field implementation of the flashing yellow arrow display for the permissive indication at protected/permitted left turns. The flashing yellow arrow has shown good results for driver understanding and safety. The implementation of the flashing yellow arrow display should continue in order to collect additional field data even though the NCHRP 3-54 research project will not be conducting any analysis of this field data under the current contract. To that regard, the City of Vancouver, Washington is submitting to FHWA for approval for experimental use of this test display.

Statement of the problem

The NCHRP 3-54 project evaluated the safety and effectiveness of different signal displays and phasing for protected/permissive left-turn control (PPLT). Many agencies have sought alternatives to the green ball indication used in PPLT since the green ball can produce yellow trap situations if not used properly (i.e., lead/lag phasing schemes). NCHRP 3-54 has conducted several studies of both the green ball permissive display and several other displays. The flashing yellow arrow has been shown to be the most promising alternative display to the green ball display.

Description of the Proposed Change

The proposed change would allow the use of a flashing yellow arrow indication as the permissive interval associated with the protected/permissive left-turn control. The

proposed flashing yellow display is recommended for experimental testing based upon the results of several studies conducted within the NCHRP 3-54 project. Research has demonstrated that driver understanding is lower with the green ball permitted display as compared to other permitted displays being used in various parts of the country. The flashing yellow arrow display is better understood than the green ball display and has few fail critical errors (drivers turning left without the right-of-way). The flashing yellow arrow provides versatility in application. The flashing yellow arrow display enables all of the following turning movement modes of operation:

- Protected/permissive
- Protected only
- Permissive only
- Prohibited (No Left Turn)

The flashing yellow arrow can be used for left- or right-turn treatments; although it is recognized that the left-turn treatment will be the most predominant use. The flashing yellow arrow display eliminates the left turn "trap". The protected phase can operate as a leading or lagging movement without regard for the type of operation and phase sequence in the other direction, and can change between leading and lagging sequences during the day. Side street phases can be skipped and a leading left turn safely re-introduced (sometimes called "backing up"). The protected turn phase can be vehicle actuated and skipped in the absence of demand, regardless of the phase sequence.

Proposed Flashing Yellow Arrow Display Arrangements

The research team, in partnership with project panel and technical advisory group members, has identified several display arrangements that demonstrate good motorist understanding. Different display arrangements are recommended for an exclusive leftturn display and shared display.

Exclusive Display Arrangements

There are at least four possible PPLT signal displays that are recommended for installation of the flashing yellow arrow display at a location where there is an exclusive left-turn lane and the left-turn display is a separate display (not used by the adjacent through movements).

It is noted that the basic signal arrangement is a four-section arrangement. However, if bimodal lens is employed (bottom or far right section), then a three-section arrangement can be used. The three-section arrangement may be desired for clearance purposes or for ease of implementation if an existing three-section arrangement is available. The signal arrangement can be mounted either vertically or horizontally. One, and only one, of the four arrows are illuminated at all times. The flashing yellow arrow is illuminated when traffic can safely turn by yielding to opposing through traffic and/or pedestrians (permissive operation). The other three arrows are used as in the normal three-color exclusive left turn display. The red arrow is displayed when it is unsafe to make a left turn movement. The green arrow is displayed when the left turn movement can be made with no conflicting simultaneous vehicle or pedestrian movement (protected operation).

The steady yellow arrow is illuminated for a few seconds as a clearance indication following both the green arrow and the flashing yellow arrow.

Proposed Work Plan

The City of Vancouver will install the flashing yellow arrow display on the two major street approaches to a planned new traffic signal installation. The intersection approaches are considered to be typical and contain no unique geometric or operational features. The proposed PPLT intersection has approximately a 70-degree angle relationship to the minor street approaches. The approach for which the FYA will be installed has an exclusive left-turn lane. The horizontal grade is relatively flat. All lanes meet current design standards. The subject intersection is currently two-way stop controlled and the existing major street left-turn treatment (before implementation of the FYA) is uncontrolled.

Anticipated Changeover Implementation Issues

Past experience with implementing flashing indications has identified various obstacles or issues that may be a factor in future implementations. The City of Vancouver will be installing the FYA at two locations along SE Mill Plain Blvd.; at the intersections of SE 168th Avenue, and at the intersection of 190th Avenue. These intersections are currently un-signalized and both are part of a new road construction. All of the traffic signal equipment will be new and designed to accommodate the FYA display and thus will not pose any retrofit issues related to head size/mounting, additional cabling, or mast arm requirements.

Controller logic issues

In a typical PPLT situation, it is possible for the green ball display and green arrow display to illuminate simultaneously. However, by converting to the flashing yellow arrow display, the flashing yellow arrow and green arrow displays cannot illuminate simultaneously. Further, in a shared-head arrangement there could be an issue related to an agency's requirement of a red clearance interval following the protected interval display (the green arrow followed by steady yellow arrow). In a shared-head arrangement, a leading green arrow could be illuminated concurrently with a green ball for parallel through traffic. With such a display, a red ball can not be illuminated for clearing the protected left turn movements as it would conflict with the green ball. In unusual situations, additional or different phases could serve as parent phases to drive the flashing yellow arrow overlap. The same overlap logic can also be used to drive right turn arrows where appropriate. If existing controller software cannot be modified to provide this functionality, the same effect can be achieved using external logic, although with less flexibility. It is assumed that new controller software and any significant upgrade of existing controller software will include this functionality, so that over time, external logic will no longer be needed.

Conflict monitor issues

Past applications of flashing indications have required the use of special external logic units to prevent the conflict monitor from detecting a signal malfunction.

Evaluation Plan

The City of Vancouver will collect "after" crash data along with data from similar PPLT instillation in the city but without FYA as control cases, and send that data to FHWA for later follow-up analysis. Volunteering agencies responsibilities are:

- Install the FYA display.
- Make the necessary modifications, if any, to the signal controller and controller conflict monitor to accommodate the FYA.
- Provide intersection data sheets for each FYA location, which includes geometrics, and traffic volumes for all movements, approach posted speed limit, and pertinent operational data.
- Provide three years of "after" crash data along with data from similar PPLT instillation in the city but without FYA as control cases, directly to FHWA for further study at a later date.
- Track and report any implementation issues.
- Submit overall qualitative statement on the flashing yellow arrow operation.

Site Restoration

Each participating agency will agree to restore the experiment site to a state complying with the provisions of the MUTCD:

- within 3 months following the end of the time period of the experiment, or
- at any time that the participating agency determines that significant hazards are directly or indirectly attributable to the experimentation, or
- if requested to do so by the Office of Traffic Operations.

If, as a result of experimentation, a request is made that the Manual be changed to include flashing yellow arrow permissive indications, then the experimental device may remain in place until an official rulemaking action has occurred.

Reporting

The City of Vancouver will provide semi-annual progress reports until the experiment is completed. A copy of the final results will be sent to FHWA, HHS-10, within 3 months following completion of experimentation.. All reports will be submitted to:

Regina S. McElroy
Director
Office of Transportation
Operations HOTO Room 3401
400 7th Street, S.W.
Washington, D.C. 20590

Project Administration

The City of Vancouver will be responsible for administering this experiment under the direction of Ali Eghtedari, P.E., with an office located at Transportation Services, 1300 Franklin Street, Fourth Floor, PO Box 1995, Vancouver, Washington, 98668-1995.

U.S. Department of Transportation
Federal Highway Administration
400 Seventh St., S.W.
Washington, D.C. 20590

Refer to: HOTO-1
May 27, 2005

Mr. Ali Eghtedari
City of Vancouver Transportation Services
P.O. Box 1995
Vancouver, WA 98668-1995

Dear Mr. Eghtedari:

Thank you for your May 13 letter requesting permission to experiment with the flashing yellow arrow display for protected-permissive left-turn (PPLT) movements at two intersections that will be newly signalized on SE Mill Plain Boulevard in the city of Vancouver.

We approve your request to experiment with the flashing yellow arrow for PPLT at these two intersections in Vancouver, as per your proposal, using the four-section "all arrows" signal head display. This approval is granted for a period not to exceed 4 years, on the condition that Snohomish County will collect and summarize crash data annually over a 3-year period following implementation of the flashing yellow arrows. (Please note that only the "after" data is required for locations where the flashing yellow arrow is being implemented at a newly signalized intersection.)

We very much appreciate the willingness of the city of Vancouver to participate in the continuing evaluations of the flashing yellow arrow display. We look forward to the results. If you have any questions, please email Mr. Scott Wainwright at scott.wainwright@fhwa.dot.gov or call him at 202-366-0857. Please note that your request has been assigned the following official experimentation number and title: "4-219(Ex)-NCHRP 3-54, Flashing Yellow Arrow." Please refer to this number in future correspondence.

Sincerely yours,

Regina S. McElroy
Director, Office of Transportation Operations

cc: Mr. Roger Wentz, ATSSA

PUBLIC WORKS

Paul A. Roberts, Director
80 Columbia Avenue
Marysville, Washington 98270
Phone (360) 363-8100
Fax (360) 363-8284
ci.marysville.wa.us

April 14, 2005

Office of Transportation Operations
Attention: Regina S. McElroy, Director
HOTO Room 3401
400-7 th Street, S.W.
Washington, D.C. 20590

Subject: Request to FHWA for Experimentation by Implementation of the Flashing Yellow Arrow Display

Dear Ms. McElroy:

Please find the enclosed request correspondence for the subject Request for Experimentation. The five selected signal locations are as follows:

- 92nd Street and State Avenue
- 99th Place and State Avenue

In accordance with the Reporting section on page 6 of the request correspondence, we are to send you a semi-annual progress reports. You can therefore expect the first report to be sent October of 2005. Please contact Tom King, Traffic Control System Technician, or myself at (360) 363-8262 and 363-8280, respectively, should you have any questions or concerns.

With best regards,

Jeffrey D. Massie, P.E.
Assistant City Engineer

Enclosure

Copies: Kevin Nielsen, City Engineer
Burt Gunderson,
Street Maintenance Supervisor
Tom King,
Traffic Control System Technician

Sandra Gruber,
GIS/CAD Technician

Request to the Federal Highway Administration for Experimentation by Implementation
of the Flashing Yellow Arrow Display

By Jeffrey Massie
CITY OF MARYSVILLE, WASHINGTON

April 20, 2005

Request to Experiment by Implementation of the Flashing Yellow Arrow Display

Preface

The research project, NCHRP 3-54, Evaluation of Traffic Signal Displays for Protected Permitted Left Turn Control, conducted by Kittelson and Associates, Inc. (KAI) as the prime contractor, has completed the field implementation of the flashing yellow arrow display for the permissive indication at protected/permitted left turns. The flashing yellow arrow has shown good results for driver understanding and safety. The implementation of the flashing yellow arrow display should continue in order to collect additional field data even though the NCHRP 3-54 research project will not be conducting any analysis of this field data under the current contract. To that regard, City of Marysville Public Works is submitting to FHWA for approval for experimental use of this test display.

Statement of the problem

The NCHRP 3-54 project evaluated the safety and effectiveness of different signal displays and phasing for protected/permissive left-turn control (PPLT). Many agencies have sought alternatives to the green ball indication used in PPLT since the green ball can produce yellow trap situations if not used properly (i.e., lead/lag phasing schemes). NCHRP 3-54 has conducted several studies of both the green ball permissive display and several other displays. The flashing yellow arrow has been shown to be the most promising alternative display to the green ball display.

Description of the Proposed Change

The proposed change would allow the use of a flashing yellow arrow indication as the permissive interval associated with the protected/permissive left-turn control. The proposed flashing yellow display is recommended for experimental testing based upon the results of several studies conducted within the NCHRP 3-54 project. Research has demonstrated that driver understanding is lower with the green ball permitted display as compared to other permitted displays being used in various parts of the country. The flashing yellow arrow display is better understood than the green ball display and has few fail critical errors (drivers turning left without the right-of-way). The flashing yellow arrow provides versatility in application. The flashing yellow arrow display enables all of the following turning movement modes of operation:

- Protected/ permissive

- Protected only
- Permissive only
- Prohibited (No Left Turn)

The flashing yellow arrow can be used for left- or right-turn treatments; although it is recognized that the left-turn treatment will be the most predominant use. The flashing yellow arrow display eliminates the left turn "trap". The protected phase can operate as a leading or lagging movement without regard for the type of operation and phase sequence in the other direction, and can change between leading and lagging sequences during the day. Side street phases can be skipped and a leading left turn safely re-introduced (sometimes called "backing up"). The protected turn phase can be vehicle actuated and skipped in the absence of demand, regardless of the phase sequence.

Proposed Flashing Yellow Arrow Display Arrangements

The research team, in partnership with project panel and technical advisory group members, has identified several display arrangements that demonstrate good motorist understanding. Different display arrangements are recommended for an exclusive left-turn display and shared display.

Exclusive Display Arrangements

There are at least four possible PPLT signal displays that are recommended for installation of the flashing yellow arrow display at a location where there is an exclusive left-turn lane and the left-turn display is a separate display (not used by the adjacent through movements). Those alternative displays are shown in Figure 1 below. City of Marysville Public Works request FHWA approval to test display number 1 shown in Figure 1. Figure 1. Exclusive FYA Display Arrangements

[Image not shown: Proposed flashing arrow display arrangements. Figure 1: Four vertically stacked arrows pointing left. Top arrow is red, second arrow is yellow, third is flashing yellow, bottom is green. Figure 2 is three vertically stacked arrows pointing left. Top arrow is red, middle is yellow and bottom is flashing yellow. (See the PDF version to view images)]

It is noted that the basic signal arrangement is a four-section arrangement. However, if bimodal lens is employed (bottom or far right section), then a three-section arrangement can be used. The three-section arrangement may be desired for clearance purposes or for ease of implementation if an existing three-section arrangement is available. The signal arrangement can be mounted either vertically or horizontally. One, and only one, of the four arrows are illuminated at all times. The flashing yellow arrow is illuminated when traffic can safely turn by yielding to opposing through traffic and/or pedestrians (permissive operation). The other three arrows are used as in the normal three-color exclusive left turn display. The red arrow is displayed when it is unsafe to make a left turn movement. The green arrow is displayed when the left turn movement can be made with no conflicting simultaneous vehicle or pedestrian movement (protected operation). The steady yellow arrow is illuminated for a few seconds as a clearance indication following both the green arrow and the flashing yellow arrow.

Proposed Work Plan

The City of Marysville Public Works Department will install the flashing yellow arrow display at four (4) signal approaches. Each location is considered to be a typical intersection containing no unique geometric or operational features. The proposed PPLT intersection has a right angle relationship to all intersecting approaches. The approach for which the FYA will be installed has an exclusive left-turn lane. The horizontal grade is relatively flat. All lanes meet current design standards, as much as possible (12-foot travel lanes). The existing left-turn treatment (before implementation of the FYA) is protected-permitted (or permitted-protected) using the green ball permissive display. The implementing agency has identified two (2) intersections that will not receive any improvements during the study period and will be used as control site intersections.

Anticipated Changeover Implementation Issues

THE CITY OF MARYSVILLE IS AWARE OF THE FOLLOWING ISSUES AND CAN ADDRESS THEM. Past experience with implementing flashing indications has identified various obstacles or issues that may be a factor in future implementations.

Issues with replacement head size / mounting

The implementation of the flashing yellow arrow will require a 12-inch lens, therefore if the current green ball display has an 8-inch lens replacement of the complete head will likely be necessary.

Potential need for additional cabling

A common installation of PPLT using the green ball for the permissive interval makes use of the through phase green to illuminate the green ball. Due to the flashing indication, additional cabling may be necessary in order for the flashing display to be controlled by its own circuit.

Controller logic issues

In a typical PPLT situation, it is possible for the green ball display and green arrow display to illuminate simultaneously. However, by converting to the flashing yellow arrow display, the flashing yellow arrow and green arrow displays cannot illuminate simultaneously. Further, in a shared-head arrangement there could be an issue related to an agency's requirement of a red clearance interval following the protected interval display (the green arrow followed by steady yellow arrow). In a shared-head arrangement, a leading green arrow could be illuminated concurrently with a green ball for parallel through traffic. With such a display, a red ball can not be illuminated for clearing the protected left turn movements as it would conflict with the green ball. In unusual situations, additional or different phases could serve as parent phases to drive the flashing yellow arrow overlap. The same overlap logic can also be used to drive right turn arrows where appropriate. If existing controller software cannot be modified to provide this functionality, the same effect can be achieved using external logic, although with less flexibility. It is assumed that new controller software and any significant upgrade of existing controller software will include this functionality, so that over time, external logic will no longer be needed.

Conflict monitor issues

Past applications of flashing indications have required the use of special external logic units to prevent the conflict monitor from detecting a signal malfunction.

Evaluation Plan

The City of Marysville Public Works will obtain the most recent 3 years of "before" crash data and will send that data to FHWA for later analysis. "after" crash data will be collected and sent to FHWA for later follow up analysis. Volunteering agencies responsibilities are:

- Identifying intersections for installing the flashing yellow display on at least one intersection approach.
- Install or retrofit the appropriate signal arrangements (head).
- Make the necessary modifications, if any, to the existing signal controller and controller conflict monitor.
- Provide intersection data sheets for each location, which includes geometrics, and traffic volumes for all movements, approach posted speed limit, and pertinent operational data.
- Provide three years of before crash data and three years after crash data. It is requested that volunteer agency supply a total of three years of after data and this data would be forwarded directly to FHWA for further study at a later date.
- Track and report change over costs and implementation issues.
- Submit overall qualitative statement on the flashing yellow arrow operation. Site Restoration

Each participating agency will agree to restore the experiment site to a state complying with the provisions of the MUTCD:

- within 3 months following the end of the time period of the experiment, or
- at any time that the participating agency determines that significant hazards are directly or indirectly attributable to the experimentation, or
- if requested to do so by the Office of Traffic Operations.

If, as a result of experimentation, a request is made that the Manual be changed to include flashing yellow arrow permissive indications, then the experimental device may remain in place until an official rulemaking action has occurred.

Reporting

City of Marysville Public Works will provide semi-annual progress reports until the experiment is completed. A copy of the final results will be sent to FHWA, HHS-10, within 3 months following completion of experimentation. All reports will be submitted to:

Regina S. McElroy
Director
Office of Transportation Operations

HOTO Room 3401
400 7' Street, S.W.
Washington, D.C. 20590

Project Administration

City of Marysville will be responsible for administering this experiment under the direction of Jeffrey Massie located at Department of Public Works, 80 Columbia Avenue, Marysville, WA 98270.

U.S. Department of Transportation
Federal Highway Administration
400 Seventh St., S.W.
Washington, D.C. 20590

May 27, 2005
Refer to: HOTO-1

Mr. Jeffrey D. Massie
Assistant City Engineer City of Marysville
Department of Public Works
80 Columbia Avenue
Marysville, WA 98270

Dear Mr. Massie:

Thank you for your April 14 letter requesting permission to experiment with the flashing yellow arrow display for a total of four existing protected-permissive left-turn (PPLT) movements at two intersections in the city of Marysville.

We approve your request to experiment with the flashing yellow arrow for PPLT at the two intersections in Marysville, as per your proposal, using the four-section "all arrows" signal head display. This approval is granted for a period not to exceed 4 years, on the condition that Marysville will collect and summarize crash data annually over a 3-year period both before and following implementation of the flashing yellow arrows.

We very much appreciate the willingness of Marysville to participate in the continuing evaluations of the flashing yellow arrow display. We look forward to the results. If you have any questions, please email Mr. Scott Wainwright at scot.wainwright@fhwa.dot.gov or call him at 202-366-0857. Please note that we have assigned your request the following official experimentation number and title: "4-219(Ex)-NCHRP 3-54, Flashing Yellow Arrow." Please refer to this number in future correspondence.

Sincerely yours,

Regina S. McElroy
Director, Office of Transportation Operations

cc: Mr. Roger Wentz, ATSSA

Request to the Federal Highway Administration for Experimentation by Implementation of the Flashing Yellow Arrow Display On Columbia Center Boulevard at:

Clearwater Avenue
Deschutes Avenue
Grandridge Boulevard
and
Okanogan Avenue

By the City of Kennewick, Washington

A participant in -the NCHRP Project 3-54 Project, Evaluation of Traffic Signal Displays for Protected Permitted Left Turn Control

February 25, 2005

Request for Experimental Implementation of the FYA Display on Columbia Center Boulevard at Clearwater Ave, Deschutes Ave, Grandridge Blvd, and Okanogan, Ave, City of Kennewick, Washington Request to Experiment by Implementation of the Flashing Yellow Arrow Display

Preface

The research project, NCHRP 3-54, Evaluation of Traffic Signal Displays for Protected Permitted Left Turn Control, conducted by Kittelson and Associates, Inc. (KAI) as the prime contractor, has completed the field implementation of the flashing yellow arrow display for the permissive indication at protected/permitted left turns. The flashing yellow arrow has shown good results for driver understanding and safety. The implementation of the flashing yellow arrow display should continue in order to collect additional field data even though the NCHRP 3-54 research project will not be conducting any analysis of this field data under the current contract. To that end, The City of Kennewick, Washington (herein after referred to as "Kennewick") is submitting to FHWA for approval for experimental use of this test display.

Statement of the Problem

The objective of the NCHRP 3-54 project is to evaluate the safety and effectiveness of different signal displays and phasing for protected/permissive left-turn control (PPLT). Many agencies have sought alternatives to the green ball indication used in PPLT since the green ball can produce yellow trap situations if not used properly (i.e., lead/lag phasing schemes). NCHRP 3-54 has conducted several studies of both the green ball permissive display and several other displays. The flashing yellow arrow appears to be the most promising alternative display to the green ball display. The NCHRP 3-54 Project

Panel has asked that additional field data on flashing yellow arrow installations be obtained. That data is needed to further evaluate the effectiveness of the flashing yellow arrow and to confirm results of earlier tests.

Description of the Proposed Change

The proposed change would allow the use of a flashing yellow arrow indication as the permissive interval associated with the protected/permissive left-turn control. The proposed flashing yellow display is recommended for experimental testing based upon the results of several studies conducted within the NCHRP 3-54 project. Research has demonstrated that driver understanding is lower with the green ball permitted display as compared to other permitted displays being used in various parts of the country. The flashing yellow arrow display is better understood than the green ball display and has few fail critical errors (drivers turning left without the right-of-way). The flashing yellow arrow provides versatility in application. The flashing yellow arrow display enables all of the following turning movement modes of operation:

- Protected/permissive
- Protected only
- Permissive only
- Prohibited (No Left Turn)

The flashing yellow arrow can be used for left- or right-turn treatments; although it is recognized that the left-turn treatment will be the most predominant use. The flashing yellow arrow display eliminates the left turn "trap". The protected phase can operate as a leading or lagging movement without regard for the type of operation and phase sequence in the other direction, and can change between leading and lagging sequences during the day. Side street phases can be skipped and a leading left turn safely re-introduced (sometimes called "backing up"). The protected turn phase can be vehicle actuated and skipped in the absence of demand, regardless of the phase sequence.

Proposed Flashing Yellow Arrow Display Arrangements The research team, in partnership with project panel and technical advisory group members, has identified several display arrangements that demonstrate good motorist understanding. Different display arrangements are recommended for an exclusive leftturn display and shared display.

Exclusive Display Arrangement There are several recommended PPLT signal displays for installation of the flashing yellow arrow display at a location where there is an exclusive left-turn lane and the leftturn display is a separate display (not used by the adjacent through movements). Kennewick requests FHWA approval to test the display shown in Figure 1.

[Image not shown: Proposed flashing arrow display arrangements. Figure 1: Four vertically stacked arrows pointing left. Top arrow is red, second arrow is yellow, bottom is flashing yellow. (See the PDF version to view images)]

Figure 1. Exclusive FYA Display Arrangement

It is noted that the basic signal arrangement is recommended to be a four-section arrangement. However, if bi-modal lens is employed (bottom or far right section), then a three-section arrangement can be used. The three-section arrangement is desired for clearance purposes and for ease of implementation if an existing three-section arrangement is available. One, and only one, of the four arrows are illuminated at all times. The flashing yellow arrow is illuminated when traffic can safely turn by yielding to opposing through traffic and/or pedestrians (permissive operation). The other three arrows are used as in the normal three-color exclusive left turn display. The red arrow is displayed when it is unsafe to make a left turn movement. The green arrow is displayed when the left turn movement can be made with no conflicting simultaneous vehicle or pedestrian movement (protected operation). The steady yellow arrow is illuminated for a few seconds as a clearance indication following the green arrow. The steady yellow arrow is also illuminated for a few seconds as a clearance indication following the flashing yellow arrow, but only when the flashing, yellow arrow terminates and the next phase to be serviced is NOT the protected left turn in the same display. When the next phase to be serviced IS the protected left turn in the same display, the flashing yellow arrow terminates and is immediately followed by the green arrow.

Proposed Work Plan

Columbia Center Boulevard & Clearwater Avenue

The intersection of Columbia Center Boulevard and Clearwater Avenue will be modified in the next six months due to a railroad grade separation project currently under construction. Both directions on east/west Clearwater Avenue (a typical five-lane arterial) currently have protected-permitted left-turn phasing while the north/south directions on Columbia Center Boulevard are split phase. Changes due to construction will be an increase from one to two westbound right-turn lanes, and an increase from two to three northbound lanes. The intersection should operate more or less the same after installation of the Flashing Yellow Arrow display. The posted speed limit on both Clearwater Avenue and Columbia Center Boulevard is 35 mph. Sight distance is excellent with no significant vertical or horizontal curves in the vicinity of the intersection. This location is considered to be a typical intersection containing no unique geometric or operational features and it has a right angle relationship to the intersecting approaches. The approaches for which the flashing yellow arrow displays will be installed will have exclusive left-turn lanes. All lanes meet current design standards, including the use of 11 and 12-foot travel lanes.

Columbia Center Boulevard and Deschutes Avenue

The intersection of Columbia Center Boulevard and Deschutes Avenue will be modified in the next six months due to a railroad grade separation project currently under construction. The intersection currently operates as a typical 8-phase intersection with all four approaches having protected-permitted left-turn control. The only significant change due to construction will be addition of a northbound right-turn lane. The intersection should operate more or less the same after installation of the Flashing Yellow Arrow display. The posted speed limit along Columbia Center Boulevard, a standard five lane

arterial, is 35 mph and along Deschutes Avenue, a three-lane arterial is 30 mph. Sight distance is adequate with no significant vertical or horizontal curves in the vicinity of the intersection. This location is considered to be a typical intersection containing no unique geometric or operational features and it has a right angle relationship to the intersecting approaches. The approaches for which the flashing yellow arrow displays will be installed will have exclusive left-turn lanes. All lanes meet current design standards, including the use of 11 and 12-foot travel lanes.

Columbia Center Boulevard and Grandridge Boulevard

The intersection of Columbia Center Boulevard and Grandridge Boulevard currently has protected-permitted left-turn phasing both north and south on Columbia Center Boulevard, while the east and west approaches on Grandridge are split phased. There are no other changes planned for this intersection other than installation of the Flashing Yellow Arrow display. Therefore, this location will be the best comparison location for before and after statistics. The posted speed limit along Columbia Center Boulevard is 35 mph and 30 mph along Grandridge Boulevard. Sight distance is adequate with no significant vertical or horizontal curves in the vicinity of the intersection. This location is considered to be a typical intersection containing no unique geometric or operational features and it has a right angle relationship to the intersecting approaches. The approaches for which the flashing yellow arrow displays will be installed will have exclusive left-turn lanes. All lanes meet current design standards, including the use of 11 and 12-foot travel lanes.

Columbia Center Boulevard and Okanogan Avenue

The intersection of Columbia Center Boulevard and Okanogan Avenue currently has protected-permitted left-turn phasing both north and south on Columbia Center Boulevard, while the east and west approaches on Okanogan are a single concurrent phase where left-turns yield. A minor striping change is planned just prior to installation to help correct an existing accident problem. This change will probably skew the before and after results. The posted speed limit along Columbia Center Boulevard is 35 mph and 25 mph along Okanogan Avenue. Sight distance is adequate with no significant vertical or horizontal curves in the vicinity of the intersection. This location is considered to be a typical intersection containing no unique geometric or operational features and it has a right angle relationship to the intersecting approaches. The approaches for which the flashing yellow arrow displays will be installed will have exclusive left-turn lanes. All lanes meet current design standards, including the use of 11 and 12-foot travel lanes.

Anticipated Changeover Implementation Issues

Kennewick has identified the following implementation issues relevant to its participation in the research project:

- The City intends to use two different controllers to accomplish the Flashing Yellow Arrow Display. They are:
 1. 2070 ATC controller configured with 2070-2N Field I/O Module, allowing it to operate in the City's existing NEMA TS2 Type 1 cabinets. The software in the 2070 ATC will be the WA03 software package from

Northwest Signal Supply, and will use standard overlaps and internal logic to omit overlap displays when necessary.

2. The Econolite ASC/3 NEMA TS2 Type 1 controller using standard overlaps and internal logic to omit overlap displays when necessary.
- Standard overlap programming will be used in the software to provide the flashing yellow indication. The overlap will have a separate output for the solid yellow arrow, thus necessitating the use of a bi-modal, yellow/yellow section in the center of the three-section display.

Length of Experimentation

The experiment is proposed to last until Kennewick has access to three years of reported crash data after implementation.

Evaluation Plan

Kennewick ' will collect 3 years of "before" and "after" crash data and will forward to FHWA for later follow up analysis. Volunteering agencies responsibilities are:

- Identifying intersections for installing the flashing yellow arrow display on at least one intersection approach.
- Install or retrofit the appropriate signal arrangements (head).
- Make the necessary modifications, if any, to the existing signal controller and controller conflict monitor.
- Provide intersection data sheets for each location, which includes geometrics, and traffic volumes for all movements, approach posted speed limit, and pertinent operational data.
- Provide three years of "before" and "after" crash data. It is requested that volunteer agency supply a total of three years of after data and this data would be forwarded directly to FHWA for further study at a later date.
- Track and report change over costs and implementation issues.
- Submit overall qualitative statement on the flashing yellow arrow operation.

Site Restoration

Kennewick agrees to restore the experiment site to a state complying with the provisions of the MUTCD as adopted by the Washington State Department of Transportation:

- within 3 months following the end of the time period of the experiment, or
- at any time that the participating agency determines that significant hazards are directly or indirectly attributable to the experimentation, or
- if requested to do so by the Office of Traffic Operations.

If, as a result of experimentation, a request is made that the MUTCD be changed to include flashing yellow arrow permissive indications, then the experimental device may remain in place until an official rulemaking action has occurred.

Reporting

Reporting will be done by Kennewick following the collection of three years of "after" crash data. A copy of the final results will be sent to FHWA, HHS-10, within 3 months of this time. All reports will be submitted to:

Ms. Regina S. McElroy Director
Office of Transportation Operations
HOTO Room 3401
400 7th Street, S.W.
Washington, D.C. 20590

Project Administration

Kennewick will be responsible for administering this experiment under the direction of:
John R.F. Deskins, P.E., P.T.O.E. Traffic Engineer City of Kennewick 210 W. 6th
Avenue P.O. Box 6108 Kennewick, Washington 99336-0108
john.deskins@ci.kennewick.wa.us

U.S. Department of Transportation
Federal Highway Administration
400 Seventh St., S.W.
Washington, D.C. 20590

March 9, 2005
Refer to: HOTO-1

Mr. John R.F. Deskins
Traffic Engineer
City of Kennewick
210 West 6th Avenue
Kennewick, WA 99336-0108

Dear Mr. Deskins:

Thank you for your February 25 letter, sent by email to Mr. Scott Wainwright of our staff, requesting permission to experiment with the flashing yellow arrow for protected-permissive left-turn (PPLT) movements at four additional intersections in the city of Kennewick. These locations are in addition to the locations previously approved for Kennewick in 2001 and in 2004.

We approve your request to experiment with the flashing yellow arrow for PPLT at the four additional intersections, as per your proposal. This approval is granted for a period not to exceed 4 years, on the condition that the city of Kennewick collect and summarize crash data for the 3-year periods both before and after implementation of the flashing yellow arrows at these four locations. It is our understanding that all four of these intersections involve existing PPLT phases, and that the flashing yellow arrow display will be provided via a 3-section all-arrows left-turn signal face utilizing a dual arrow for the bottom section. Please note that we are requesting regular progress reports upon

completion of each year of data availability and a copy of the final results within 3 months following availability of the third year of "after" data.

We very much appreciate the willingness of the city of Kennewick to continue participating in the evaluations of the flashing yellow arrow display. We look forward to the results. Please note that your approved request continues to have the following official experimentation number and title: "4-219(Ex)--NCHRP 3-54, Flashing Yellow Arrow."

Please refer to this number in future correspondence. If you have any questions, please email Mr. Wainwright at scott.wainwright@fhwa.dot.gov or call him at 202-366-0857. Thank you again for your interest in traffic operations and safety.

Sincerely yours,

Regina S. McElroy
Director, Office of Transportation Operations

cc: Mr. Jim Baron, ATSSA

Snohomish County
Public Works Aaron Reardon
County Executive
2930 Wetmore Avenue
Everett, WA 98201
(425) 388-3488
FAX (425) 388-6494

April 18, 2005

Regina S. McElroy, Director
Office of Transportation
Operations HOTO Room 3401
U.S. DOT - Federal Highway Administration
400 7th Street SW
Washington, D.C. 20590

Refer to: NCHRP 3-54, Flashing Yellow Arrow

Dear Ms. McElroy:

This letter is to request a Flashing Yellow Arrow Display at Beverly Park Road and 112th Street SW, Everett, Washington, 98204. This is an existing signal and is to be modified with new mast arms and signal heads. The signal currently operates with Protected/Permitted phasing for the NB approach and we would like to install a Flashing Yellow Arrow Display for the new head at this location. Enclosed is the "Request to the

Federal Highway Administration for Experimentation by Implementation of the Flashing Yellow Arrow Display" application with further descriptions of the signal and study area.

Jim Bloodgood, P.E.
COUNTY TRAFFIC ENGINEER

Attachment

Request to the Federal Highway Administration for Experimentation by Implementation of the Flashing Yellow Arrow Display

By Snohomish County
Attention: Jim Bloodgood
2930 Wetmore Ave
Everett, WA 98201
425-388-6419

DATE: April 15, 2005

Request to Experiment by Implementation of the Flashing Yellow Arrow Display Preface

The research project, NCHRP 3-54, Evaluation of Traffic Signal Displays for Protected Permitted Left Turn Control, conducted by Kittelson and Associates, Inc. (KAI) as the prime contractor, has completed the field implementation of the flashing yellow arrow display for the permissive indication at protected/permitted left turns. The flashing yellow arrow has shown good results for driver understanding and safety. The implementation of the flashing yellow arrow display should continue in order to collect additional field data even though the NCHRP 3-54 research project will not be conducting any analysis of this field data under the current contract. To that regard, Snohomish County is submitting to FHWA for approval for experimental use of this test display.

Statement of the problem

The NCHRP 3-54 project evaluated the safety and effectiveness of different signal displays and phasing for protected/permissive left-turn control (PPLT). Many agencies have sought alternatives to the green ball indication used in PPLT since the green ball can produce yellow trap situations if not used properly (i.e., lead/lag phasing schemes). NCHRP 3-54 has conducted several studies of both the green ball permissive display and several other displays. The flashing yellow arrow has been shown to be the most promising alternative display to the green ball display.

Description of the Proposed Change

The proposed change would allow the use of a flashing yellow arrow indication as the permissive interval associated with the protected/permissive left-turn control. The proposed flashing yellow display is recommended for experimental testing based upon

the results of several studies conducted within the NCHRP 3-54 project. Research has demonstrated that driver understanding is lower with the green ball permitted display as compared to other permitted displays being used in various parts of the country. The flashing yellow arrow display is better understood than the green ball display and has few fail critical errors (drivers turning left without the right-of-way). The flashing yellow arrow provides versatility in application. The flashing yellow arrow display enables all of the following turning movement modes of operation:

- Protected/permissive
- Protected only
- Permissive only
- Prohibited (No Left Turn)

The flashing yellow arrow can be used for left- or right-turn treatments; although it is recognized that the left-turn treatment will be the most predominant use. The flashing yellow arrow display eliminates the left turn "trap". The protected phase can operate as a leading or lagging movement without regard for the type of operation and phase sequence in the other direction, and can change between leading and lagging sequences during the day. Side street phases can be skipped and a leading left turn safely re-introduced (sometimes called "backing up"). The protected turn phase can be vehicle actuated and skipped in the absence of demand, regardless of the phase sequence.

Proposed Flashing Yellow Arrow Display Arrangements

The research team, in partnership with project panel and technical advisory group members, has identified several display arrangements that demonstrate good motorist understanding. Different display arrangements are recommended for an exclusive left turn display and shared display.

Exclusive Display Arrangements

There are at least four possible PPLT signal displays that are recommended for installation of the flashing yellow arrow display at a location where there is an exclusive left-turn lane and the left-turn display is a separate display (not used by the adjacent through movements). Those alternative displays are shown in Figure 1 below. Snohomish County request FHWA approval to test display number 1 shown in Figure 1.

[Image not shown: Proposed flashing arrow display arrangements. Figure 1: Four vertically stacked arrows pointing left. Top arrow is red, second arrow is yellow, third is flashing yellow, bottom is green. Figure 2 is three vertically stacked arrows pointing left. Top arrow is red, middle is yellow and bottom is flashing yellow. Figure 3 is four horizontal arrows pointing left. From left to right the arrows are red, yellow, flashing yellow, and green. Figure 4 is three horizontal arrows pointing left. From left to right the arrows are red, yellow, and flashing yellow. (See the PDF version to view images)]

Figure 1. Exclusive FYA Display Arrangements

It is noted that the basic signal arrangement is a four-section arrangement. However, if bi-modal lens is employed (bottom or far right section), then a three-section arrangement can be used. The three-section arrangement may be desired for clearance purposes or for ease of implementation if an existing three-section arrangement is available. The signal arrangement can be mounted either vertically or horizontally. One, and only one, of the four arrows are illuminated at all times. The flashing yellow arrow is illuminated when traffic can safely turn by yielding to opposing through traffic and/or pedestrians (permissive operation). The other three arrows are used as in the normal three-color exclusive left turn display. The red arrow is displayed when it is unsafe to make a left turn movement. The green arrow is displayed when the left turn movement can be made with no conflicting simultaneous vehicle or pedestrian movement (protected operation). The steady yellow arrow is illuminated for a few seconds as a clearance indication following both the green arrow and the flashing yellow arrow.

Proposed Work Plan

Snohomish County will install the flashing yellow arrow display at 1 signal approach at Beverly Park Road and 112th Street SW, Everett, Washington, 98204. The intersection to be studied has a substantial geometric skew (130 degrees). With the skew and associated stop bar placement, the primary left turn display will be greater than 150 feet from its stop bar. The beneficial use of the FYA display for supplemental far left displays for left turn movements is cited in chapter 4 of the project final report. The approach for which the FYA will be installed has an exclusive left-turn lane. The horizontal grade is relatively flat. All lanes meet current design standards, as much as possible (12-foot travel lanes). The existing left-turn treatment (before implementation of the FYA) is protected-permitted (or permitted-protected) using the green ball permissive display. The implementing agency has identified 25 intersections that will not receive any improvements during the study period and will be used as control site intersections.

Anticipated Changeover Implementation Issues

Past experience with implementing flashing indications has identified various obstacles or issues that may be a factor in future implementations.

Issues with replacement head size / mounting

The implementation of the flashing yellow arrow will require a 12-inch lens, therefore if the current green ball display has an 8-inch lens replacement of the complete head will likely be necessary.

Potential need for additional cabling

A common installation of PPLT using the green ball for the permissive interval makes use of the through phase green to illuminate the green ball. Due to the flashing indication, additional cabling may be necessary in order for the flashing display to be controlled by its own circuit.

Controller logic issues

In a typical PPLT situation, it is possible for the green ball display and green arrow display to illuminate simultaneously. However, by converting to the flashing yellow

arrow display, the flashing yellow arrow and green arrow displays cannot illuminate simultaneously. Further, in a shared-head arrangement there could be an issue related to an agency's requirement of a red clearance interval following the protected interval display (the green arrow followed by steady yellow arrow). In a shared-head arrangement, a leading green arrow could be illuminated concurrently with a green ball for parallel through traffic. With such a display, a red ball can not be illuminated for clearing the protected left turn movements as it would conflict with the green ball. In unusual situations, additional or different phases could serve as parent phases to drive the flashing yellow arrow overlap. The same overlap logic can also be used to drive right turn arrows where appropriate. If existing controller software cannot be modified to provide this functionality, the same effect can be achieved using external logic, although with less flexibility. It is assumed that new controller software and any significant upgrade of existing controller software will include this functionality, so that over time, external logic will no longer be needed.

Conflict monitor issues

Past applications of flashing indications have required the use of special external logic units to prevent the conflict monitor from detecting a signal malfunction.

Evaluation Plan

Snohomish County will obtain the most recent 3 years of "before" crash data and will send that data to FHWA for later analysis. "after" crash data will be collected and sent to FHWA for later follow up analysis. Volunteering agencies responsibilities are:

- Identifying intersections for installing the flashing yellow arrow display on at least one intersection approach.
- Install or retrofit the appropriate signal arrangements (head).
- Make the necessary modifications, if any, to the existing signal controller and controller conflict monitor.
- Provide intersection data sheets for each location, which includes geometrics, and traffic volumes for all movements, approach posted speed limit, and pertinent operational data.
- Provide three years of before crash data and three years after crash data. It is requested that volunteer agency supply a total of three years of after data and this data would be forwarded directly to FHWA for further study at a later date.
- Track and report change over costs and implementation issues.
- Submit overall qualitative statement on the flashing yellow arrow operation.

Site Restoration

Each participating agency will agree to restore the experiment site to a state complying with the provisions of the MUTCD:

- within 3 months following the end of the time period of the experiment, or
- at any time that the participating agency determines that significant hazards are directly or indirectly attributable to the experimentation, or
- if requested to do so by the Office of Traffic Operations.

If, as a result of experimentation, a request is made that the Manual be changed to include flashing yellow arrow permissive indications, then the experimental device may remain in place until an official rulemaking action has occurred.

Reporting

Snohomish County will provide semi-annual progress reports until the experiment is completed. A copy of the final results will be sent to FHWA, HHS-10, within 3 months following completion of experimentation. All reports will be submitted to:

Regina S. McElroy
Director
Office of Transportation Operations
HOTO Room 3401
400 7th Street, S.W.
Washington, D.C. 20590

Project Administration

Snohomish County will be responsible for administering this experiment under the direction of Jim Bloodgood, P.E. located at Snohomish County Public Works, Traffic Operations, 2930 Wetmore Avenue, Suite 700, Everett, Washington, 98201, Phone 425388-6419. Snohomish County

Aaron Reardon County Executive

Public Works
(425) 388-3488
FAX (425) 388-6494 2930
Wetmore Avenue Everett, WA 98201

May 9, 2005

Regina S. McElroy, Director
Office of Transportation
Operations HOTO Room 3401
U.S. DOT - Federal Highway Administration
400 7th Street SW
Washington, D.C. 20590

Refer to: NCHRP 3-54, Flashing Yellow Arrow

Dear Ms. McElroy:

This letter is to request a Flashing Yellow Arrow Display at Woodinville-Snohomish Rd and 240th St SE, in the Woodinville area, Washington, 98072. This is a new signal with protected/permitted operations. Woodinville-Snohomish Road runs parallel to a railroad.

The railroad crosses 240th Street within 25 feet of the intersection and will require railroad preemption. There is a need for separate left turn displays from through displays during railroad pre-emption. A separate flashing yellow arrow display will provide a clear indication of the allowed left-turn movements. Enclosed is the "Request to the Federal Highway Administration for Experimentation by Implementation of the Flashing Yellow Arrow Display" application with further descriptions of the signal and study area.

Request to the Federal Highway Administration for Experimentation by Implementation of the Flashing Yellow Arrow Display By Snohomish County

Attention: Jim Bloodgood

2930 Wetmore Ave

Everett, WA 98201

425-388-6419

DATE: May 9, 2005

Request to Experiment by Implementation of the Flashing Yellow Arrow Display

Preface The research project, NCHRP 3-54, Evaluation of Traffic Signal Displays for Protected Permitted Left Turn Control, conducted by Kittelson and Associates, Inc. (KAI) as the prime contractor, has completed the field implementation of the flashing yellow arrow display for the permissive indication at protected/permitted left turns. The flashing yellow arrow has shown good results for driver understanding and safety. The implementation of the flashing yellow arrow display should continue in order to collect additional field data even though the NCHRP 3-54 research project will not be conducting any analysis of this field data under the current contract. To that regard, Snohomish County is submitting to FHWA for approval for experimental use of this test display. Statement of the problem The NCHRP 3-54 project evaluated the safety and effectiveness of different signal displays and phasing for protected/permissive left-turn control (PPLT). Many agencies have sought alternatives to the green ball indication used in PPLT since the green ball can produce yellow trap situations if not used properly (i.e., lead/lag phasing schemes). NCHRP 3-54 has conducted several studies of both the green ball permissive display and several other displays. The flashing yellow arrow has been shown to be the most promising alternative display to the green ball display.

Description of the Proposed Change The proposed change would allow the use of a flashing yellow arrow indication as the permissive interval associated with the protected/permissive left-turn control. The proposed flashing yellow display is recommended for experimental testing based upon the results of several studies conducted within the NCHRP 3-54 project. Research has demonstrated that driver understanding is lower with the green ball permitted display as compared to other permitted displays being used in various parts of the country. The flashing yellow arrow display is better understood than the green ball display and has few fail critical errors (drivers turning left without the right-of-way). The flashing yellow arrow provides

versatility in application. The flashing yellow arrow display enables all of the following turning movement modes of operation:

- Protected/permissive
- Protected only
- Permissive only
- Prohibited (No Left Turn)

The flashing yellow arrow can be used for left- or right-turn treatments; although it is recognized that the left-turn treatment will be the most predominant use. The flashing yellow arrow display eliminates the left turn "trap". The protected phase can operate as a leading or lagging movement without regard for the type of operation and phase sequence in the other direction, and can change between leading and lagging sequences during the day. Side street phases can be skipped and a leading left turn safely re-introduced (sometimes called "backing up"). The protected turn phase can be vehicle actuated and skipped in the absence of demand, regardless of the phase sequence.

Proposed Flashing Yellow Arrow Display Arrangements The research team, in partnership with project panel and technical advisory group members, has identified several display arrangements that demonstrate good motorist understanding. Different display arrangements are recommended for an exclusive leftturn display and shared display.

Exclusive Display Arrangements There are at least four possible PPLT signal displays that are recommended for installation of the flashing yellow arrow display at a location where there is an exclusive left-turn lane and the left-turn display is a separate display (not used by the adjacent through movements). Those alternative displays are shown in Figure 1 below. Snohomish County request FHWA approval to test display number 1 shown in Figure 1.

[Image not shown: Proposed flashing arrow display arrangements. Figure 1: Four vertically stacked arrows pointing left. Top arrow is red, second arrow is yellow, third is flashing yellow, bottom is green. Figure 2 is three vertically stacked arrows pointing left. Top arrow is red, middle is yellow and bottom is flashing yellow. Figure 3 is four horizontal arrows pointing left. From left to right the arrows are red, yellow, flashing yellow, and green. Figure 4 is three horizontal arrows pointing left. From left to right the arrows are red, yellow, and flashing yellow. (See the PDF version to view images)]

Figure 1. Exclusive FYA Display Arrangements

It is noted that the basic signal arrangement is a four-section arrangement. However, if bi-modal lens is employed (bottom or far right section), then a three-section arrangement can be used. The three-section arrangement may be desired for clearance purposes or for ease of implementation if an existing three-section arrangement is available. The signal arrangement can be mounted either

vertically or horizontally. One, and only one, of the four arrows are illuminated at all times. The flashing yellow arrow is illuminated when traffic can safely turn by yielding to opposing through traffic and/or pedestrians (permissive operation). The other three arrows are used as in the normal three-color exclusive left turn display. The red arrow is displayed when it is unsafe to make a left turn movement. The green arrow is displayed when the left turn movement can be made with no conflicting simultaneous vehicle or pedestrian movement (protected operation). The steady yellow arrow is illuminated for a few seconds as a clearance indication following both the green arrow and the flashing yellow arrow.

Proposed Work Plan Snohomish County will install the flashing yellow arrow display at 2 signal approaches at the intersection of Snohomish-Woodinville Road (SR9) and 240th St SE, in Snohomish County near Woodinville, WA 98072. This intersection is currently unsignalized and a new leg of the intersection is being installed and warrants signalization. SnohomishWoodinville Road (North/South) runs parallel to a railroad. The railroad crosses 240th St. within 25 feet of the stop bar for the intersection and requires railroad pre-emption of the traffic signal for trains crossing 240th St. There is a need for separate left-turn displays from the thru display during railroad pre-emption. An all arrow 4-section head with a Flashing Yellow Arrow would provide clarity by separating the left turn display from the thru display. The horizontal grade is relatively flat. All lanes meet current design standards, as much as possible (12-foot travel lanes). The implementing agency has identified 25 intersections that will not receive any improvements during the study period and will be used as control site intersections.

Anticipated Changeover Implementation Issues Past experience with implementing flashing indications has identified various obstacles or issues that may be a factor in future implementations. I

Issues with replacement head size / mounting

The implementation of the flashing yellow arrow will require a 12-inch lens, therefore if the current green ball display has an 8-inch lens replacement of the complete head will likely be necessary.

Potential need-for additional cabling

A common installation of PPLT using the green ball for the permissive interval makes use of the through phase green to illuminate the green ball. Due to the flashing indication, additional cabling may be necessary in order for the flashing display to be controlled by its own circuit.

Controller logic issues

In a typical PPLT situation, it is possible for the green ball display and green arrow display to illuminate simultaneously. However, by converting to the flashing yellow arrow display, the flashing yellow arrow and green arrow displays cannot

illuminate simultaneously. Further, in a shared-head arrangement there could be an issue related to an agency's requirement of a red clearance interval following the protected interval display (the green arrow followed by steady yellow arrow). In a shared-head arrangement, a leading green arrow could be illuminated concurrently with a green ball for parallel through traffic. With such a display, a red ball can not be illuminated for clearing the protected left turn movements as it would conflict with the green ball. In unusual situations, additional or different phases could serve as parent phases to drive the flashing yellow arrow overlap. The same overlap logic can also be used to drive right turn arrows where appropriate. If existing controller software cannot be modified to provide this functionality, the same effect can be achieved using external logic, although with less flexibility. It is assumed that new controller software and any significant upgrade of existing controller software will include this functionality, so that over time, external logic will no longer be needed.

Conflict monitor issues

Past applications of flashing indications have required the use of special external logic units to prevent the conflict monitor from detecting a signal malfunction.

Evaluation Plan Snohomish County will obtain the most recent 3 years of "before" crash data and will send that data to FHWA for later analysis. "after" crash data will be collected and sent to FHWA for later follow up analysis. Volunteering agencies responsibilities are:

- Identifying intersections for installing the flashing yellow arrow display on at least one intersection approach.
- Install or retrofit the appropriate signal arrangements (head).
- Make the necessary modifications, if any, to the existing signal controller and controller conflict monitor.
- Provide intersection data sheets for each location, which includes geometrics, and traffic volumes for all movements, approach posted speed limit, and pertinent operational data.
- Provide three years of before crash data and three years after crash data. It is requested that volunteer agency supply a total of three years of after data and this data would be forwarded directly to FHWA for further study at a later date.
- Track and report change over costs and implementation issues.
- Submit overall qualitative statement on the flashing yellow, arrow operation.

Site Restoration Each participating agency will agree to restore the experiment site to a state complying with the provisions of the MUTCD:

- within 3 months following the end of the time period of the experiment
-

Snohomish County

Public Works

Aaron Reardon County Executive
2930 Wetmore Avenue
Everett, WA 98201
(425) 388-3488
FAX (425) 388-6494

August 5, 2005

Regina S. McElroy, Director
Office of Transportation
Operations HOTO Room 3401
U.S. DOT - Federal Highway Administration
400 7th Street SW
Washington, D.C. 20590

Refer to: NCHRP 3-54, Flashing Yellow Arrow

Dear Ms. McElroy:

This letter is to request a Flashing Yellow Arrow Display at three intersections located in Snohomish County, Everett, WA 98204. These three intersections are interconnected and located in a corridor of 5 intersections, with the remaining two intersections to remain as a protected/permitted operation. The three intersections to have flashing yellow arrow displays installed are: Airport Road and Admiralty Way, Airport Road and Gibson Road, and 128th St SE and 8th Ave W. The intersections at Airport Road and Admiralty Way and Airport Road and Gibson Road are currently operating with protected left-turns. These will be converted to protected/permitted with a 3-section flashing yellow arrows from Airport Road. The intersection at 128th St. SE and 8th Ave W is currently operating with protected/permitted left turns from 128th St. SE. These will be converted to a 4-section flashing yellow arrow. The rest of the corridor is operating at a protected/permitted operation and is much more efficient. In addition, a separate flashing yellow arrow display will provide a clear indication of the allowed left-turn movements.

Enclosed are the "Request to the Federal Highway Administration for Experimentation by Implementation of the Flashing Yellow Arrow Display" applications with farther descriptions of the signals and study area.

Sincerely,

Jim Bloodgood , P.E.
COUNTY TRAFFIC ENGINEER

Request to the Federal Highway Administration For Experimentation by Implementation of the Flashing Yellow Arrow Display

By

Snohomish County
Attention: Jim Bloodgood
2930 Wetmore Ave
Everett, WA 98201
425-388-6419
DATE: August 4, 2005

Request to Experiment by Implementation of the Flashing Yellow Arrow Display

Preface

The research project, NCHRP 3-54, Evaluation of Traffic Signal Displays for Protected Permitted Left Turn Control, conducted by Kittelson and Associates, Inc. (KAI) as the prime contractor, has completed the field implementation of the flashing yellow arrow display for the permissive indication at protected/permitted left turns. The flashing yellow arrow has shown good results for driver understanding and safety. The implementation of the flashing yellow arrow display should continue in order to collect additional field data even though the NCHRP 3-54 research project will not be conducting any analysis of this field data under the current contract. To that regard, Snohomish County is submitting to FHWA for approval for experimental use of this test display.

Statement of the problem

The NCHRP 3-54 project evaluated the safety and effectiveness of different signal displays and phasing for protected/permissive left-turn control (PPLT). Many agencies have sought alternatives to the green ball indication used in PPLT since the green ball can produce yellow trap situations if not used properly (i.e., lead/lag phasing schemes). NCHRP 3-54 has conducted several studies of both the green ball permissive display and several other displays. The flashing yellow arrow has been shown to be the most promising alternative display to the green ball display.

Description of the Proposed Change

The proposed change would allow the use of a flashing yellow arrow indication as the permissive interval associated with the protected/permissive left-turn

control. The proposed flashing yellow display is recommended for experimental testing based upon the results of several studies conducted within the NCHRP 3-54 project. Research has demonstrated that driver understanding is lower with the green ball permitted display as compared to other permitted displays being used in various parts of the country. The flashing yellow arrow display is better understood than the green ball display and has few fail critical errors (drivers turning left without the right-of-way).

The flashing yellow arrow provides versatility in application. The flashing yellow arrow display enables all of the following turning movement modes of operation:

- Protected/permissive
- Protected only
- Permissive only
- Prohibited (No Left Turn)

The flashing yellow arrow can be used for left- or right-turn treatments; although it is recognized that the left-turn treatment will be the most predominant use.

The flashing yellow arrow display eliminates the left turn "trap". The protected phase can operate as a leading or lagging movement without regard for the type of operation and phase sequence in the other direction, and can change between leading and lagging sequences during the day. Side street phases can be skipped and a leading left turn safely re-introduced (sometimes called "backing up"). The protected turn phase can be vehicle actuated and skipped in the absence of demand, regardless of the phase sequence.

Proposed Flashing Yellow Arrow Display Arrangements

The research team, in partnership with project panel and technical advisory group members, has identified several display arrangements that demonstrate good motorist understanding. Different display arrangements are recommended for an exclusive left turn display and shared display.

Exclusive Display Arrangements

There are at least four possible PPLT signal displays that are recommended for installation of the flashing yellow arrow display at a location where there is an exclusive left-turn lane and the left-turn display is a separate display (not used by the adjacent through movements). Those alternative displays are shown in Figure 1 below. Snohomish County request FHWA approval to test display number 1 shown in Figure 1.

[Image not shown: Proposed flashing arrow display arrangements. Figure 1: Four vertically stacked arrows pointing left. Top arrow is red, second arrow is yellow, third is flashing yellow, bottom is green. Figure 2 is three vertically stacked

arrows pointing left. Top arrow is red, middle is yellow and bottom is flashing yellow. Figure 3 is four horizontal arrows pointing left. From left to right the arrows are red, yellow, flashing yellow, and green. Figure 4 is three horizontal arrows pointing left. From left to right the arrows are red, yellow, and flashing yellow. *(See the PDF version to view images)*
Figure I. Exclusive FYA Display Arrangements

It is noted that the basic signal arrangement is a four-section arrangement. However, if bi-modal lens is employed (bottom or far right section), then a three-section arrangement can be used. The three-section arrangement may be desired for clearance purposes or for case of implementation if an existing three-section arrangement is available. The signal arrangement can be mounted either vertically or horizontally.

One, and only one, of the four arrows are illuminated at all times. The flashing yellow arrow is illuminated when traffic can safely turn by yielding to opposing through traffic and/or pedestrians (permissive operation). The other three arrows are used as in the normal three-color exclusive left turn display. The red arrow is displayed when it is unsafe to make a left turn movement. The green arrow is displayed when the left turn movement can be made with no conflicting simultaneous vehicle or pedestrian movement (protected operation). The steady yellow arrow is illuminated for a few seconds as a clearance indication following both the green arrow and the flashing yellow arrow.

Proposed Work Plan

Snohomish County will install the flashing yellow arrow display at 2 signal approaches at the intersection of 128th Street SW and 8 Avenue W. in Snohomish County, Everett, WA 98204. This signalized intersection currently operates with 6 phases and protected/permitted left-turns. The east and westbound approaches are to be converted to the 4 section flashing yellow arrow operation. There are separate left-turn pockets and all the lanes meet current design standards, as much as possible (12-foot travel lanes).

This intersection is part of a 5 intersection corridor that is being converted to have protected/permitted mainline left-turns. Currently 3 of the intersections operate as protected/permitted left-turns with one operating as a flashing yellow arrow. The implementing agency has identified 23 intersections that will not receive any improvements during the study period and will be used as control site intersections.

Anticipated Changeover Implementation Issues

Past experience with implementing flashing indications has identified various obstacles or issues that may be a factor in future implementation.

Issues with replacement head size / mounting

The implementation of the flashing yellow arrow will require a 12-inch lens; therefore if the current green ball display has an 8-inch lens replacement of the complete head will likely be necessary.

Potential need for additional cabling

A common installation of PPLT using the green ball for the permissive interval makes use of the through phase green to illuminate the green ball. Due to the flashing indication, additional cabling may be necessary in order for the flashing display to be controlled by its own circuit.

Controller logic issues

In a typical PPLT situation, it is possible for the green ball display and green arrow display to illuminate simultaneously. However, by converting to the flashing yellow arrow display, the flashing yellow arrow and green arrow displays cannot illuminate simultaneously.

Further, in a shared-head arrangement there could be an issue related to an agency's requirement of a red clearance interval following the protected interval display (the green arrow followed by steady yellow arrow). In a shared-head arrangement, a leading green arrow could be illuminated concurrently with a green ball for parallel through traffic. With such a display, a red ball cannot be illuminated for clearing the protected left turn movements, as it would conflict with the green ball. In unusual situations, additional or different phases could serve as parent phases to drive the flashing yellow arrow overlap. The same overlap logic can also be used to drive right turn arrows where appropriate.

If existing controller software cannot be modified to provide this functionality, the same effect can be achieved using external logic, although with less flexibility. It is assumed that new controller software and any significant upgrade of existing controller software will include this functionality, so that over time, external logic will no longer be needed.

Conflict monitor issues

Past applications of flashing indications have required the use of special external logic units to prevent the conflict monitor from detecting a signal malfunction.

Evaluation Plan

Snohomish County will obtain the most recent 3 years of "before" crash data and will send that data to FHWA for later analysis. "after" crash data will be collected and sent to FHWA for later follow up analysis.

Volunteering agencies responsibilities are:

- Identifying intersection for installing the flashing yellow arrow display on at least one intersection approach.
- Install or retrofit the appropriate signal arrangements (head).
- Make the necessary modifications, if any, to the existing signal controller and controller conflict monitor.
- Provide intersection data sheets for each location, which includes geometrics, and traffic volumes for all movements, approach posted speed limit, and pertinent operational data.
- Provide three years of before crash data and three years after crash data. It is requested that volunteer agency supply a total of three years of after data and this data would be forwarded directly to FHWA for further study at a later date.
- Track and report change over costs and implementation issues.
- Submit overall qualitative statement on the flashing yellow arrow operation.

Site Restoration

Each participating agency will agree to restore the experiment site to a state complying with the provisions of the MUTCD:

- Within 3 months following the end of the time period of the experiment, or
- at any time that the participating agency determines that significant hazards are directly or indirectly attributable to the experimentation, or
- if requested to do so by the Office of Traffic Operations.

If, as a result of experimentation, a request is made that the Manual be changed to include flashing yellow arrow permissive indications, then the experimental device may remain in place until an official rulemaking action has occurred.

Reporting

Snohomish County will provide semi-annual progress reports until the experiment is completed. A copy of the final results will be sent to FHWA, HHS-10, within 3 months following completion of experimentation. All reports will be submitted to:

Regina S. McElroy
 Director
 Office of Transportation
 Operations HOTO Room 3401
 400 7th Street, S.W.
 Washington, D.C. 20590

Project Administration

Snohomish County will be responsible for administering this experiment under the direction of Jim Bloodgood, P.E. located at Snohomish County Public Works, Traffic Operations, 2930 Wetmore Avenue, Suite 70C, Everett, Washington, 98201, Phone 425-388-6419.

Request to the Federal Highway Administration for Experimentation by Implementation of the Flashing Yellow Arrow Display

By

Snohomish County
Attention: Jim Bloodgood
2930 Wetmore Ave
Everett, WA 98201
425-388-6419
DATE: August 5, 2005

Request to Experiment by Implementation of the Flashing Yellow Arrow Display

Preface

The research project, NCHRP 3-54, Evaluation of Traffic Signal Displays for Protected Permitted Left Turn Control, conducted by Kittelson and Associates, Inc. (KAI) as the prime contractor, has completed the field implementation of the flashing yellow arrow display for the permissive indication at protected/permitted left turns. The flashing yellow arrow has shown good results for driver understanding and safety. The implementation of the flashing yellow arrow display should continue in order to collect additional field data even though the NCHRP 3-54 research project will not be conducting any analysis of this field data under the current contract. To that regard, Snohomish County is submitting to FHWA for approval for experimental use of this test display.

Statement of the problem

The NCHRP 3-54 project evaluated the safety and effectiveness of different signal displays and phasing for protected/permissive left-turn control (PPLT). Many agencies have sought alternatives to the green ball indication used in PPLT since the green ball can produce yellow trap situations if not used properly (i.e., lead/lag phasing schemes). NCHRP 3-54 has conducted several studies of both the green ball permissive display and several other displays. The flashing yellow arrow has been shown to be the most promising alternative display to the green ball display.

Description of the Proposed Change

The proposed change would allow the use of a flashing yellow arrow indication as the permissive interval associated with the protected/permissive left-turn control. The proposed flashing yellow display is recommended for experimental testing based upon the results of several studies conducted within the NCHRP 3-54 project. Research has demonstrated that driver understanding is lower with the green ball permitted display as compared to other permitted displays being used in various parts of the country. The flashing yellow arrow display is better understood than the green ball display and has few fail critical errors (drivers turning left without the right-of-way).

The flashing yellow arrow provides versatility in application. The flashing yellow arrow display enables all of the following turning movement modes of operation:

- Protected/permissive
- Protected only
- Permissive only
- Prohibited (No Left Turn)

The flashing yellow arrow can be used for left- or right-turn treatments; although it is recognized that the left-turn treatment will be the most predominant use.

The flashing yellow arrow display eliminates the left turn "trap". The protected phase can operate as a leading or lagging movement without regard for the type of operation and phase sequence in the other direction, and can change between leading and lagging sequences during the day. Side street phases can be skipped and a leading left turn safely re-introduced (sometimes called "backing up"). The protected turn phase can be vehicle actuated and skipped in the absence of demand, regardless of the phase sequence.

Proposed Flashing Yellow Arrow Display Arrangements

The research team, in partnership with project panel and technical advisory group members, has identified several display arrangements that demonstrate good motorist understanding. Different display arrangements are recommended for an exclusive leftturn display and shared display.

Exclusive Display Arrangements

There are at least four possible PPLT signal displays that are recommended for installation of the flashing yellow arrow display at a location where there is an exclusive left-turn lane and the left-turn display is a separate display (not used by the adjacent through movements). Those alternative displays are shown in Figure 1 below. Snohomish County request FHWA approval to test display number 2 shown in Figure 1.

[Image not shown: Proposed flashing arrow display arrangements. Figure 1: Four vertically stacked arrows pointing left. Top arrow is red, second arrow is yellow, third is flashing yellow, bottom is green. Figure 2 is three vertically stacked arrows pointing left. Top arrow is red, middle is yellow and bottom is flashing yellow. Figure 3 is four horizontal arrows pointing left. From left to right the arrows are red, yellow, flashing yellow, and green. Figure 4 is three horizontal arrows pointing left. From left to right the arrows are red, yellow, and flashing yellow. (See the PDF version to view images)]

Figure I. Exclusive FYA Display Arrangements

It is noted that the basic signal arrangement is a four-section arrangement. However, if bi-modal lens is employed (bottom or far right section), then a three-section arrangement can be used. The three-section arrangement may be desired for clearance purposes or for ease of implementation if an existing three-section arrangement is available. The signal arrangement can be mounted either vertically or horizontally.

One, and only one, of the four arrows are illuminated at all times. The flashing yellow arrow is illuminated when traffic can safely turn by yielding to opposing through traffic and/or pedestrians (permissive operation). The other three arrows are used as in the normal three-color exclusive left turn display. The red arrow is displayed when it is unsafe to make a left turn movement. The green arrow is displayed when the left turn movement can be made with no conflicting simultaneous vehicle or pedestrian movement (protected operation). The steady yellow arrow is illuminated for a few seconds as a clearance indication following both the green arrow and the flashing yellow arrow.

Proposed Work Plan

Snohomish County will install 3-section flashing yellow arrow display at 2 signal approaches at the intersection of Airport Road and Gibson Road in Snohomish County, Everett, WA 98204. This intersection is currently signalized with an 8 phase, protected left-turn operation. The left-turn demand at the east and westbound approaches are minor and will operate more efficiently with a protected/permitted left-turn operation. For the permitted left-turns at this intersection, there are adequate sight distances with the 85% speeds of 45 mph. There are left-turn pockets and all lanes meet current design standards, as much as possible (12-foot travel lanes).

This intersection is part of a corridor of 5 interconnected intersections. This corridor of intersections is being converted to protected/permitted left-turns. Currently 3 intersections have been converted, one operating with a flashing yellow arrow. The implementing agency has identified 23 intersections that will not receive any improvements during the study period and will be used as control site intersections.

Anticipated Changeover Implementation Issues

Past experience with implementing flashing indications has identified various obstacles or issues that may be a factor in future implementations.

Issues with replacement head size / mounting

The implementation of the flashing yellow arrow will require a 12-inch lens, therefore if the current green ball display has an 8-inch lens, replacement of the complete head will likely be necessary.

Potential need for additional cabling

A common installation of PPLT using the green ball for the permissive interval makes use of the through phase green to illuminate the green ball. Due to the flashing indication, additional cabling may be necessary in order for the flashing display to be controlled by its own circuit.

Controller logic issues

In a typical PPLT situation, it is possible for the green ball display and green arrow display to illuminate simultaneously. However, by converting to the flashing yellow arrow display, the flashing yellow arrow and green arrow displays cannot illuminate simultaneously.

Further, in a shared-head arrangement there could be an issue related to an agency's requirement of a red clearance interval following the protected interval display (the green arrow followed by steady yellow arrow). In a shared-head arrangement, a leading green arrow could be illuminated concurrently with a green ball for parallel through traffic. With such a display, a red ball can not be illuminated for clearing the protected left turn movements as it would conflict with the green ball.

In unusual situations, additional or different phases could serve as parent phases to drive the flashing yellow arrow overlap. The same overlap logic can also be used to drive right turn arrows where appropriate.

If existing controller software cannot be modified to provide this functionality, the same effect can be achieved using external logic, although with less flexibility. It is assumed that new controller software and any significant upgrade of existing controller software will include this functionality, so that over time, external logic will no longer be needed.

Conflict monitor issues

Past applications of flashing indications have required the use of special external logic units to prevent the conflict monitor from detecting a signal malfunction.

Evaluation Plan

Snohomish County will obtain the_ most recent 3 years of "before" crash data and will send that data to FHWA for later analysis. "after" crash data will be collected and sent to FHWA for later follow up analysis.

Volunteering agencies responsibilities are:

- Identifying intersections for installing the flashing yellow arrow display on at least one intersection approach.
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Regina S. McElroy
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400 7th Street, S.W.
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Request to the Federal Highway Administration for Experimentation by
Implementation of the Flashing Yellow Arrow Display

By

Snohomish County
Attention: Jim Bloodgood
2930 Wetmore Ave
Everett, WA 98201
425-2008-6419
DATE: August 4, 2005

Request to Experiment by Implementation of the Flashing Yellow Arrow Display

Preface

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The corridor to the east of this intersection will also be converted to protected/permitted left-turns. Currently there are 3 intersections that operate with protected/permitted leftturns including one operating with a flashing yellow arrow. The implementing agency has identified 23 intersections that will not receive any improvements during the study period and will be used as control site intersections.

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Reporting

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Regina S. McElroy Director
Office of Transportation
Operations HOTO Room 3401
400 7" Street, S.W.
Washington, D.C. 20590

Project Administration

Snohomish County will be responsible for administering this experiment under the direction of Jim Bloodgood, P.E. located at Snohomish County Public Works, Traffic Operations, 2930 Wetmore Avenue, Suite 700, Everett, Washington, 98201, Phone 425388-6419.

U.S. Department of Transportation
Federal Highway Administration
400 Seventh St., S.W.
Washington, D.C. 20590

June 10, 2005
Refer to: HOTO-1

Mr. Jim Bloodgood
County Traffic Engineer
Snohomish County Public Works
2930 Wetmore Avenue
Everett, WA 98201

Dear Mr. Bloodgood:

Thank you for your April 18 and May 9 letters requesting permission to experiment with the flashing yellow arrow display for two protected-permissive left-turn (PPLT) movements at two intersections in Snohomish County. These two intersections would be in addition to the other previously approved experimentations with flashing yellow arrow in Snohomish County:

1. Beverly Park Road and 112th Street, SW. -modification of existing PPLT
2. Woodinville-Snohomish Road and 240th Street, SE. - installation of new signal

We approve your request to experiment with the flashing yellow arrow for PPLT at these two additional intersections in Snohomish County, as per your two proposals, using the four-section "all arrows" signal head display. This approval is granted for a period not to exceed 4 years, on the condition that Snohomish County will collect and summarize crash data annually over a 3-year period both before and following implementation of the flashing yellow arrows. (Please note that only the "after" data will be required for the location where the flashing yellow arrow is being implemented at a newly signalized intersection.)

We very much appreciate the willingness of Snohomish County to expand its participation in the continuing evaluations of the flashing yellow arrow display. We look forward to the results. If you have any questions, please email Mr. Scott Wainwright at scott.wainwright@fhwa.dot.gov or call him at 202-366-0857. Please note that your request continues to have the following official experimentation number and title: "4-219(Ex)-NCHRP 3-54, Flashing Yellow Arrow." Please refer to this number in future correspondence.

Sincerely yours,

Regina S. McElroy
Director, Office of Transportation Operations
cc: Mr. Roger Wentz, ATSSA

U.S. Department of Transportation
Federal Highway Administration
400 Seventh St., S.W.
Washington, D.C. 20590

September 29, 2005
Refer to: HOTO-1

Mr. Jim Bloodgood
County Traffic Engineer
Snohomish County Public Works
2930 Wetmore Avenue
Everett, WA 98201

Dear Mr. Bloodgood:

Thank you for your August 5 letter requesting permission to experiment with the flashing yellow arrow display for six protected-permissive left-turn (PPLT) movements at three intersections in Snohomish County. These three

intersections would be in addition to the other previously approved experimentations with flashing yellow arrow displays in Snohomish County:

1. 128th Street SE and 8th Avenue W - modification of existing PPLT
2. Airport Road and Gibson Road - conversion from protected only mode to PPLT
3. Airport Road and Admiralty Way - conversion of protected only mode to PPLT

We approve your request to experiment with the flashing yellow arrow for PPLT at these three additional intersections in Snohomish County, as per your proposals, using the four-section all arrows signal head display at the first location and the three-section all arrows/dual arrow display at the other two locations. This approval is granted for a period not to exceed 4 years, on the condition that Snohomish County will collect and summarize crash data annually over a 3-year period both before and following implementation of the flashing yellow arrows. (Please note that only the "after" data will be required for the two locations where the flashing yellow arrow is being implemented in conjunction with a conversion from protected only mode to PPLT).

We very much appreciate the willingness of Snohomish County to expand its participation in the continuing evaluations of the flashing yellow arrow display. We look forward to the results. If you have any questions, please email Mr. Scott Wainwright at scott.wainwright@fhwa.dot.gov or call him at 202-366-0857. Please note that your request continues to have the following official experimentation number and title: "4-219(Ex)-NCHRP 3-54, Flashing Yellow Arrow." Please refer to this number in future correspondence.

Sincerely yours,

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Director, Office of Transportation Operations

cc: Mr. Roger Wentz, ATSSA