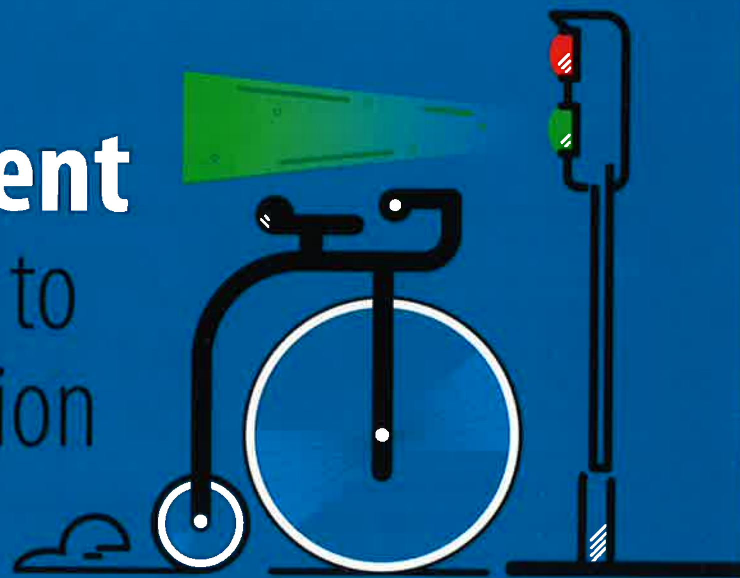
Improving **Bicycle Detection Pavement Marking Symbols** to Increase Comprehension at Traffic Signals



By Jesse Boudart, P.E., Nick Foster, AICP, Peter Koonce, P. E., Juli Maus, and Lisa Okimoto

To help bicyclists identify where they should wait at a signalized intersection to be detected by an inductive loop detection system, the standard bicycle detector pavement marking is used, as shown in Figure 9C-7, in the current *Manual on Uniform Traffic Control Devices* (MUTCD).[1] Previous research has indicated that 55 percent of the general population does not intuitively understand what this symbol means and as a result do not position themselves over it.[2,3] Cyclists not properly dwelling over the detection loop will not receive a green indication to proceed through the intersection until another bicycle or automobile arrives at the intersection and stops over the loop, or until someone pushes a pedestrian/bicycle pushbutton. Receiving no green indication results in excessive delay and bicyclist frustration, which is one of many reasons leading to risky red light running behavior.[4-6] Furthermore, bicycles and motor vehicles typically use the same traffic signal detector loop in the center of the travel lane. This location may not be an intuitive or comfortable place for many cyclists to stop and wait, which has subsequently resulted in research dealing with how to better accommodate cyclists at signalized intersections with loop detection.[7-9]

Consequently, there is interest in improving cyclist positioning over loop detectors. Previous research has shown that providing additional information (e.g., a blue light feedback device adjacent to the signal head, the MUTCD R10-22 sign, and a descriptive bicycle detection informational sandwich board sign) can improve cyclist understanding and positioning.[10]

Building on this previous research of various feedback devices, the City of Portland, OR, USA undertook a project to determine whether a more descriptive pavement marking may be more intuitive to cyclists, and as a result, increase the proportion of cyclists to properly dwell over inductive loops.

The Manual on Uniform Traffic Control Devices R10-22 Sign.

Site Selection

Two intersections in Portland, OR were chosen for this study: NE Tillamook Street/NE Martin Luther King Jr. Boulevard and SE Division Street/SE 21st Avenue (referred to as the Tillamook Street and 21st Avenue sites from now on). Figures 1 and 2 illustrate that the study intersections feature inductive loop bicycle detection with a blue light feedback indication on the side street approaches. Figure 3 provides a close-up of the traffic signal and blue light feedback indication assembly. These two study sites were chosen to test out two different situations. Tillamook Street is a shared street where cyclists must stop near the center of the shared travel lane in order to position themselves over the detector. 21st Avenue features a green bike box at the intersection, bicycle symbol in the center of the bike box, and a curb tight bicycle stencil in the natural continuation of the bike lane.

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Figure 1: The Tillamook Street site Westbound approach.

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Figure 2: The 21st Avenue site Northbound approach with an inset image of the Modified Columbia Experiment Marking.

Postcard Intercept Survey

Survey Administration

Survey administrators handed out postcards to people bicycling through the Tillamook Street and 21st Avenue sites on May 7, 2015. The postcards provided a brief introduction to the survey's purpose and included a link to the online survey, which was tailored to each location. There were a total of 213 responses out of 446 distributed postcards resulting in a response rate of 48 percent.

Intercept Survey Findings

Blue Light Indication

The first question to the study group was, "what does the blue light feedback device mean?" accompanied by the picture of the device shown in Figure 3. Figure 4 indicates the responses to the question.

Eighty-six percent of the respondents at the Tillamook Street survey provided the correct response of the blue light as compared to 58 percent of the respondents at the 21st Avenue survey. One possibility to the variance of correct responses is that the blue light has been active longer at the Tillamook location, or it is also feasible that the 21st Avenue location generally has more pavement markings, which may dilute the meaning of the feedback devices. In general, Figure 4 indicates that most respondents correctly identified the meaning of the blue light.

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Figure 3: A close-up of a traffic signal with a blue light feedback device in the upper right corner.

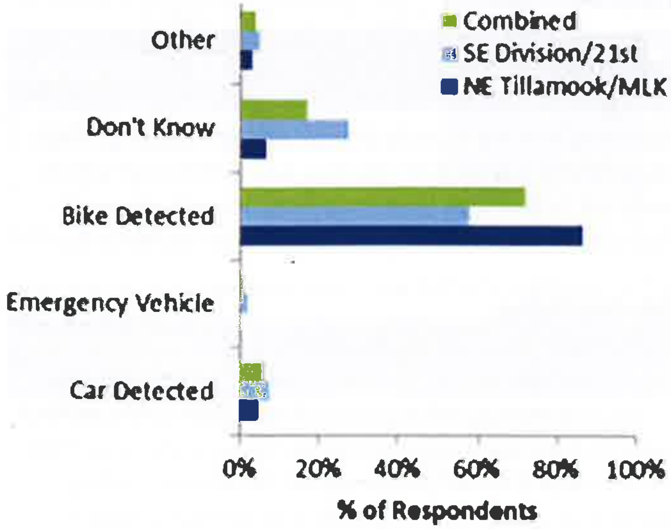

Figure 4: Responses to the survey question, "What does the Blue Light Feedback Device in Figure 3. mean?"

What Does the Blue Light Feedback Device Mean?

The blue light feedback device is a blue light mounted adjacent to the red signal indication (shown in Figure 3) which illuminates when a metallic object (bicycle or automobile) dwells on top of the inductive loop detector. This light notifies the user that they are being detected and will soon receive a green light. More details about this device may be found in previous research.[10]

Bicycle Detector Pavement Marking

Survey respondents were presented with seven different pavement markings and asked to choose from a set of responses that best described what that marking would mean to them if they saw it at the approach to a signalized intersection. As shown in Figure 5, the markings include:

- 9C-7 marking (9C-7);
- 9C-7 with a red-yellow-green signal (9C-7 + RYG);
- Bicycle lane pavement marking (Bike Lane);
- Bicycle route pavement marking used by the Portland Bureau of Transportation (PBOT) in certain locations (Bike Route);
- A green-backed version of the 9C-7 (Greenback 9C-7);
- A modified version of the 9C-7 (Developed by Alta Planning + Design) approved for experimentation by the Federal Highway Administration (FHWA) in Columbia, Missouri (Columbia Experiment);[11] and
- The 9C-7 plus the text "Wait on Lines for Green" (9C-7 + Text).

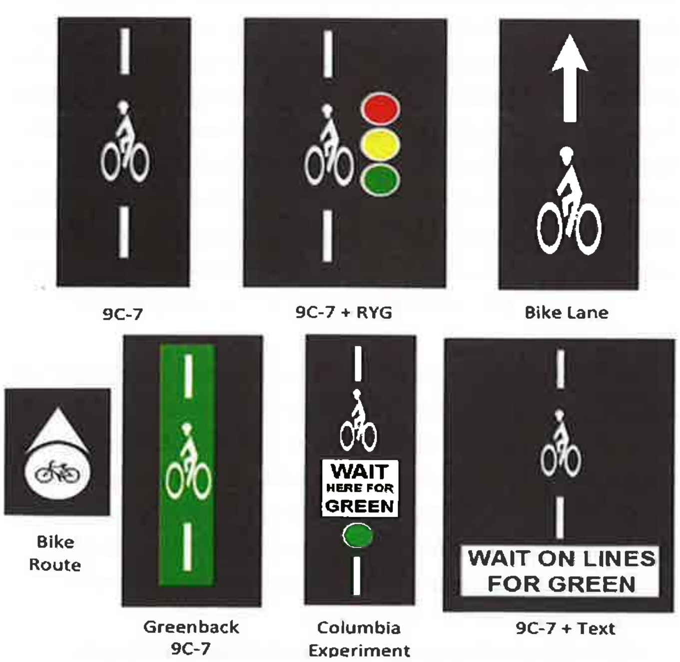

Figure 5: Pavement markings shown to survey participants.

The 9C-7 was always shown first to avoid other designs with more information influencing responses to the marking. The bike lane and bike route markings were included to avoid respondents figuring out that the response to every marking should be the same. The markings including text were shown last because they were the most descriptive. Other symbols were shown in a randomized order. Finally, the respondents were presented a list of seven possible responses to choose from including an open-ended option. Figure 6 summarizes the respondents' perceived meaning of each marking.

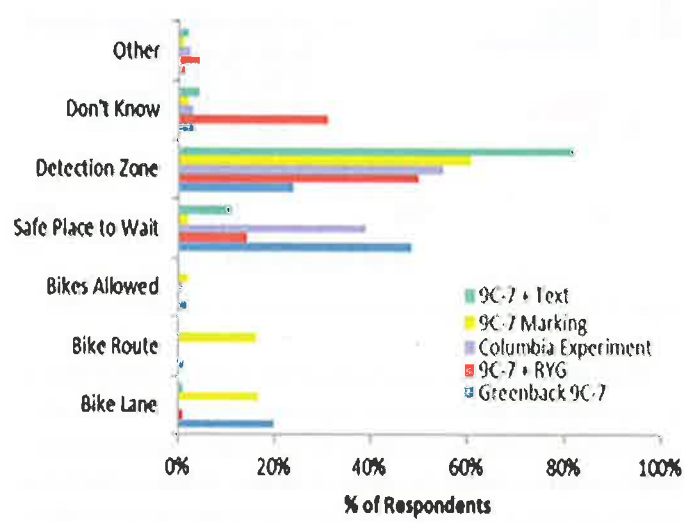

Figure 6: Survey responses to the meaning of each pavement marking.

The 9C-7 + Text, 9C-7, and Columbia Experiment had the highest percentage of comprehension, with more than half of respondents selecting that the marking means "where a bicyclist should wait to be detected by the signal." Notably, a majority of respondents identified the Columbia Experiment and the Greenback 9C-7 markings as a "safe place for a bicyclist to wait on a red light," with 39 percent and 48 percent, respectively. While not necessarily the correct response, this interpretation of the marking should produce a similar practical effect (i.e., people stopping their bikes on top of the marking, thereby being detected by the inductive loop). If both the "safe place to wait" and "detection zone" responses are considered acceptable, then the Columbia Experiment and 9C-7 + Text have the highest level of comprehension, approximately 94 and 93 percent, followed by the Greenback 9C-7 (72 percent) and the 9C-7 + RYG (64 percent) and existing 9C-7 markings (63 percent). Of note, the 9C-7 + RYG marking had the highest "don't know" response of 32 percent. In any case, this level of understanding of the 9C-7 marking is roughly similar to previous research on the marking.[12]

After selecting the meaning for each marking individually, respondents were asked to rank how well each marking performs in communicating the correct location a bicyclist should wait in order to become detected. Figure 7 summarizes the overall rankings for the markings.

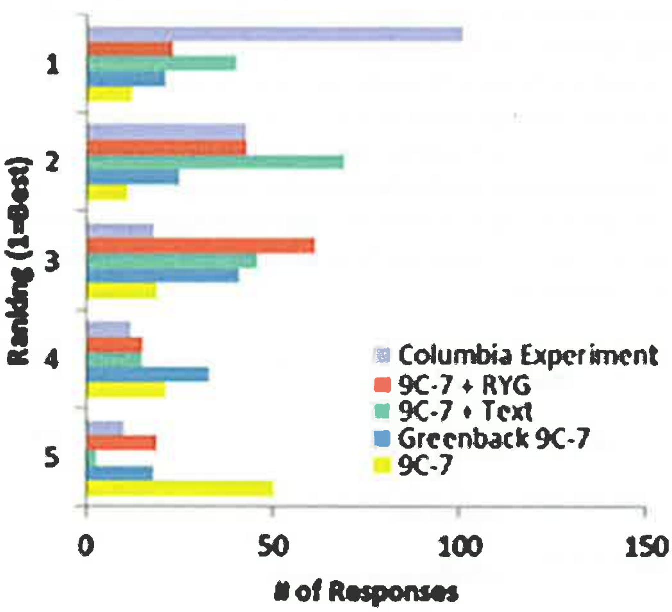

Figure 7: Ranking of detector pavement markings responses.

The Columbia Experiment received the greatest number of best (i.e. #1) rankings. Based on these responses and that it is currently undergoing an official experiment, the Columbia Experiment was chosen to be installed at the two test locations. However, due to cost constructability, a modified Columbia Experiment was used which will be shown later in this study.

Video Observations

Field Testing

Video data was collected and reduced in order to observe cyclist positioning with respect to the detector pavement markings. Table 1 describes the dates of data collection, postcard intercept surveys dates, and the Columbia Experiment installation date. Figure 2 illustrates the final design of the stencil as it was installed in the field.

Video Data Findings

Tables 2 and 3 shows the results of the video observations for the Tillamook Street and 21st sites, respectively.

Cyclist positioning before and after the installation of the modified Columbia Experiment was essentially unchanged at Tillamook Street. The percentage of cyclists positioning over the detection marking slightly decreased with the installation of the modified Columbia Experiment; however, this result is not statistically significant.

In contrast, the proportion of cyclists positioning themselves over the detection pavement marking at 21st Avenue increased after the intercept survey was conducted and also after the Columbia Experiment was installed. While the impact of the postcard intercept survey to bicyclist behavior was not statistically significant, the installation of the Columbia Experiment was statistically significant with more than 95 percent confidence using a chi-squared statistics test. Also, there is a notable decrease of bicyclists running the red light from before the survey and after the new stencil installation, but these results are not statistically significant.

There was a noticeable difference in cyclist positioning between the two sites. Observations and conversations with cyclists at 21st Avenue indicate that this may be because many cyclists are turning left at this location. As a result, they are positioning themselves to the left-hand side of the bike box, as opposed to the right-hand side where the detection marking is located. Also, 21st Avenue contains a green bicycle box and other markings, which may muddle the message to "wait here for green." The Tillamook blue light and stencil were installed two years prior to 21st Avenue, indicating that bicyclists were already familiar with the features of Tillamook Street.

Conclusion

Based on the results of this postcard intercept survey and video observations, the addition of text explaining the purpose of the 9C-7 marking positively influences how well the 9C-7 marking is understood. Furthermore, the Columbia Experiment marking approved for use in Columbia, Missouri appears to have the best potential for being intuitively understood by bicyclists. The 9C-7 + Text marking also appears to better inform roadway users on its purpose.

This study provides further evidence that improved bicycle markings and blue light feedback devices impact bicyclist dwelling

Table 1: Dates of video data collection.

Information	Before		Postcard Intercept Survey	After Postcard Intercept Survey	Columbia Experiment Install	After Columbia Experiment Install	
	Video Data Collection			Video Data Collection		Video Data Collection	
Tillamook Street	May 4, 2015		May 7, 2015	N/A	June 22, 2015	June 29, 2015	
21st Avenue		May 6, 2015		May 8, 2015			July 7, 2015

Table 2: Bicyclist behavior observations from 7:30 a.m. to 6:00 p.m. at Tillamook Street.

Observation Type	Before Columbia Experiment	Percentage of Behavior Observations	After Columbia Experiment	Percentage of Behavior Observations
Total Number of Behavior Observations	168		188	
User Waits on Marking Only	145	86.3%	155	82.4%
Pushes Button	7	4.2%	14	7.4%
Other Location	13	7.7%	17	9.0%
Runs Red Light	3	1.8%	2	1.1%

Table 3: Bicyclist behavior observations from 7:30 a.m. to 6:00 p.m. at 21st Avenue.

Observation Type	Before Columbia Experiment & Survey	Percentage of Behavior Observations	After Survey, but Before Columbia Experiment	Percentage of Behavior Observations	After Columbia Experiment & Survey	Percentage of Behavior Observations
Total Number of Behavior Observations	228		250		231	
User Waits on Marking Only	107	46.9%	135	59.2%	144	63.2%
User Waits Elsewhere Off Stencil	97	42.5%	86	37.7%	69	30.3%
Pushes Button	4	1.8%	3	1.3%	3	1.3%
Runs Red Light	20	8.8%	26	11.4%	15	6.6%

behavior at traffic signals. While these devices didn't have a statistically significant impact on red light running behavior, the data from this study provides an indication that improved roadway information may influence their decision to disobey the red light indication. More research on optimizing bicyclist position at a traffic signal and red light running behavior is needed to improve the cycling experience for an increasing number of American bicyclists. **itej**

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Jesse Boudart, P.E. *is a multidisciplinary transportation professional who straddles the line between engineering and planning. With more than four years in the industry, he has experience with big picture transportation planning and even very detailed engineering design. In particular, Jesse has aptitude in Active Transportation planning/design and has been fortunate to work on the Federal Highway Administration's* Separated Bike Lane Planning and Design Guide. *He has also worked on multi-modal traffic analysis issues with various jurisdictions in New England and helps communities think differently about how people should be moved throughout a city and region. Creating an easy to understand transportation solution with a solid a technical foundation is his forte.*

Nick Foster, AICP *is a senior planner in the Boise, ID, USA office of Kittelson & Associates, Inc. He is a member of the Transportation Research Board's Bicycle Transportation Committee. His experience includes metropolitan transportation plans, corridor studies, non-motorized transportation plans, traffic impact analyses, safety analyses and plans, microsimulation analyses, road safety audits, and spatial analyses using geographic information systems (GIS) software. Nick works with a range of agencies, including state departments of transportation, metropolitan planning organizations, highway districts, and local government agencies. His project experience includes work in large metropolitan areas, as well as small rural towns. Nick is an active member of the Institute of Transportation Engineers, American Planning Association, and Association of Pedestrian and Bicycle Professionals, having presented at several of their conferences and webinars and volunteered for local chapter projects.*

Juli Maus *joined the street light team at the City of Portland, OR, USA in 2015. She brings more than 20 years of city biking experience from racing to riding around town with her family and three kids. Multimodal transportation is not only a career interest, but a hobby and a family business.*

Peter Koonce, P.E. *manages the City of Portland, OR, USA Bureau of Transportation's Signals, Street Lighting, & ITS Division. He has served as an adjunct professor at Portland State University teaching graduate level courses in transportation engineering. He is a voting member of the National Committee on Uniform Traffic Control Devices and also serves as Chair of the Transportation Research Board's Committee on Traffic Signal Systems. He is a member of ITE.*

Lisa Okimoto *has an avid interest in the improvement and innovation of transportation infrastructure. She graduated from Portland State University in 2014 earning a bachelor's degree in civil engineering, with a focus on transportation. While studying at Portland State, she worked as an undergraduate research assistant under Dr. Chris Monsere, where she studied bicyclist behavior and their comprehension of green bike boxes and bike ways. Now working as an engineering associate in the Portland Bureau of Transportation Signals and Street Lighting Division, she has been involved in the study and research of various bicycle detection devices as well as the design of bicycle infrastructure.*