

**City of Columbia, Missouri  
Request to Experiment:  
Alternate Pavement Markings for Bicycle  
Route Wayfinding**



U.S. Department of Transportation  
Federal Highway Administration

**Prepared by:** City of Columbia, Missouri Non-Motorized  
Transportation Pilot Program (NMTTPP)

**Approved:**

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## BACKGROUND

The City of Columbia, Missouri has a growing network of bicycle and pedestrian facilities including bike lanes, shared roadways, shared use paths, greenways, sidewalks and side paths (or pedways). The City is also home to the University of Missouri at Columbia that includes internal campus paths that are interconnected to the City's non-motorized network. These facilities serve a wide geographic area within the city and are intended to both encourage bicycling and pedestrian activity and increase motorist awareness of the presence of bicyclists and pedestrians.

Columbia was designated as one of four Federal Non-Motorized Transportation Pilot Program (NTPP) communities. These funds have been used to plan, design and construct additional bicycle and pedestrian facilities in an effort to encourage a modal shift to non-motorized transportation. With Columbia's population growth and modal shift that has taken place since the beginning of the pilot program, the potential exists to incorporate additional experimental facilities to address specific issues that arise from implementation. This document is a request to the Federal Highway Administration to experiment with the use of alternative wayfinding pavement marking treatments for existing and planned on-street bikeways, bicycle boulevards and side paths that will guide users between and through the non-motorized network of facilities.

## NATURE OF THE PROBLEM

The nature of the problem is that the confidence and comfort of a bicyclist is compromised when they have difficulty following a designated bicycle route. While wayfinding signage is one method of guiding bicyclists through the non-motorized network, pavement markings are another feature that will improve navigation through confirmation of the street as an element of the network as well as directing the bicyclist when there is a turn needed to follow a specific route. In Columbia, a specific designated route is often a combination of shared use paths, bicycle boulevards, streets with shared lane markings, and streets with bike lanes. There is a critical need to inform unfamiliar cyclists, as well as those who use the network on a somewhat regular basis, of the integrated network that exists. Sign clutter is also an issue in many cities and in Columbia, so the marking of bike routes using pavement markings can help to eliminate sign clutter in residential areas or where there are other signs that are critical for the operation of vehicles on and along the roadway, such as a campus environment. Even with wayfinding signs along a route, because of the physical position on a bike (leaning forward) and the need to avoid hazards, a bicyclist may be looking down and not see the signs. The City of Columbia intends to use wayfinding markings and signage on two key spines of the network in the city, one east-west, and one north-south.



Figure 1 - Route Markings can encourage bicyclists to ride on a facility

### **Problem 1: Route Identification for On-Street bicycle facilities**

The MUTCD provides limited pavement marking applications for unambiguous guidance of users through bikeway networks that consist of a variety of facilities. Currently in the MUTCD, there are only two types of pavement markings used, Shared Lane Markings (SLM) and Bike Lane Markings (BLM). While both can effectively be used to guide bicyclists along routes including

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shared streets and bicycle boulevards, these markings are misleading when a route turns onto another facility and are not recommended for use on side paths. Since both markings imply direction, it is easy for a bicyclist to infer the designated route continues straight ahead, when it actually makes a turn onto a connecting street. This can be particularly confusing to individuals who also participate in organized recreational rides, where the road is typically marked with arrows that direct the participant where to turn and when to proceed straight. Included in this is marking the transition from On-Street bikeways to Off-Street Bicycle Facilities.

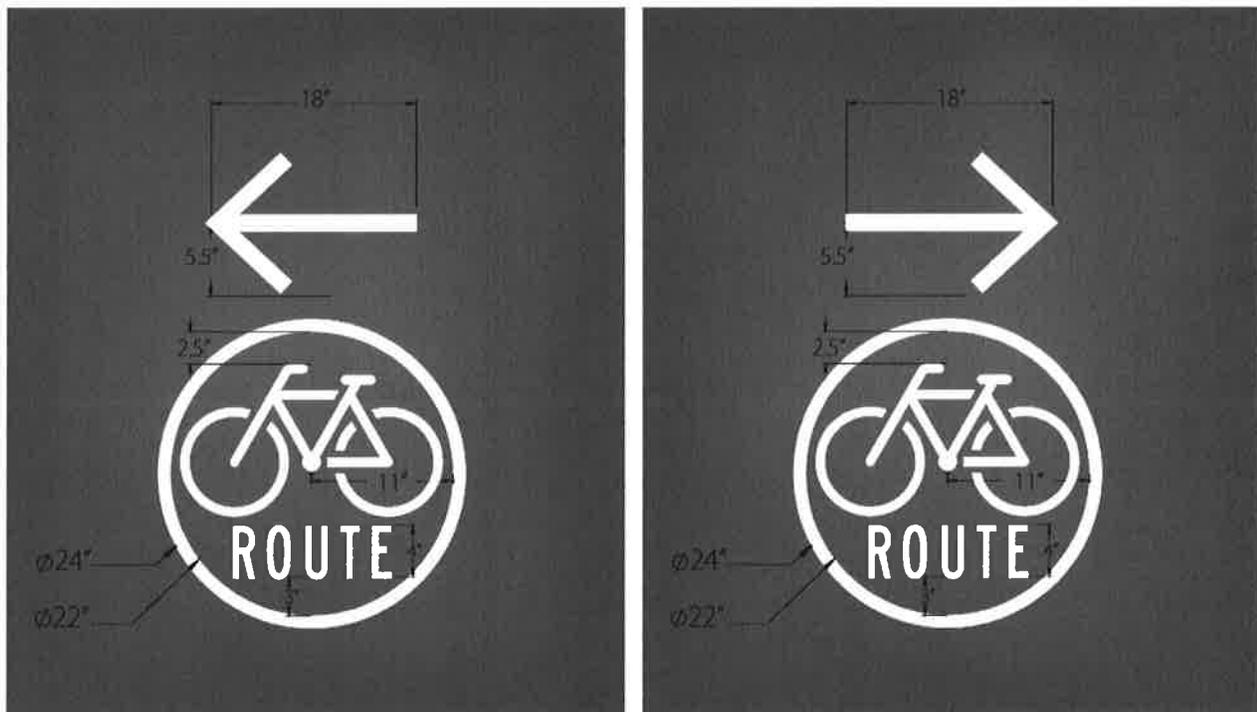
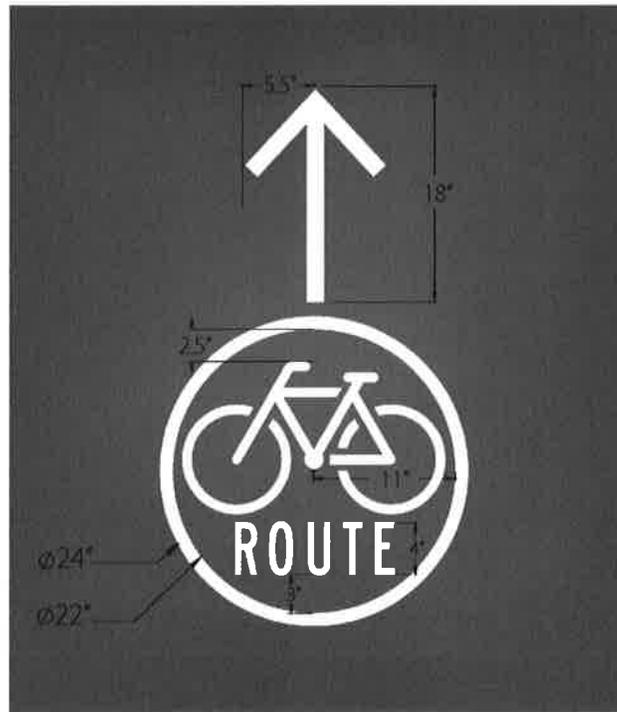
**Problem 2: Wayfinding on Sidepaths and other Off-Street Bicycle Facilities** When a network transitions from an On-Street bikeway to a side path or other Off-Street bicycle facility that is intended for use by both bicyclists and pedestrians, it is critical to confirm that the bike network intends to utilize the Off-Street facility because of potential dangerous situations ahead or to support non-vehicular cyclists. Without wayfinding and verification of the correct route a bicyclist should take, a bicyclist may use a sidewalk where it is not planned or may miss turns or transitions that are part of the designated bicycle route. The experience of unintentionally finding one's self in an area or on a roadway they are not comfortable riding on, can discourage future riding. Rather than being supplemental, these marking would be "stand-alone" wayfinding markings and could also apply to campus "sidewalk" networks which often function similar to shared use paths.

## **DESCRIPTION OF PROPOSED EXPERIMENT**

The Manual on Uniform Traffic Control Devices (MUTCD) includes guidance on the use of bike lane markings, shared lane markings and wayfinding signage on bicycling routes. Many cities have utilized these in combination with supplemental on-street markings to define an existing on-street bikeway network. The intent of this experiment is to test wayfinding pavement markings that can be applied to a range of bikeway types such as bicycle boulevards, shared use paths, sidepaths, bike lanes or combinations of these facilities

This experiment will test two types of markings. Type 1 will be On-Street markings that will supplement SLM's and BLM's. Two options will be tested: 1) a white bicycle marking and the word "Route" underneath it in a 24" circle with a directional symbol (arrow) pointing to the direction of the route change (Figure 2), and 2) a white bicycle marking and the word "Route" underneath it in a 24" circle with a directional symbol (arrow) pointing to the direction of the route change, with green color behind the 24" circle and marking in the circle (Figure 3). The symbols will be installed before the route change for transitions in direction or between on-road bikeways and shared use paths. The symbols can also be used as verification after the route change. These symbols were selected based on feedback received on symbols that have been used in other cities, but not officially tested.

A second test will be completed on paved off-street facilities such as sidepaths or Shared Use Paths. Again, two alternate options will be tested: 1) half size white bicycle marking and the word "Route" underneath it in a 12" circle with a directional symbol (arrow) pointing to the direction of the route change (Figure 4), and 2) a white bicycle marking with the word "Route" underneath in a 12" circle with a directional symbol (arrow) pointing to the direction of the route change, with green color behind the 12" circle and marking in the circle (Figure 5). These will also be used as verification after the route change.



**Figure 2. Proposed Type 1 pavement marking symbols**



Figure 3. Proposed Type 2 pavement marking symbols

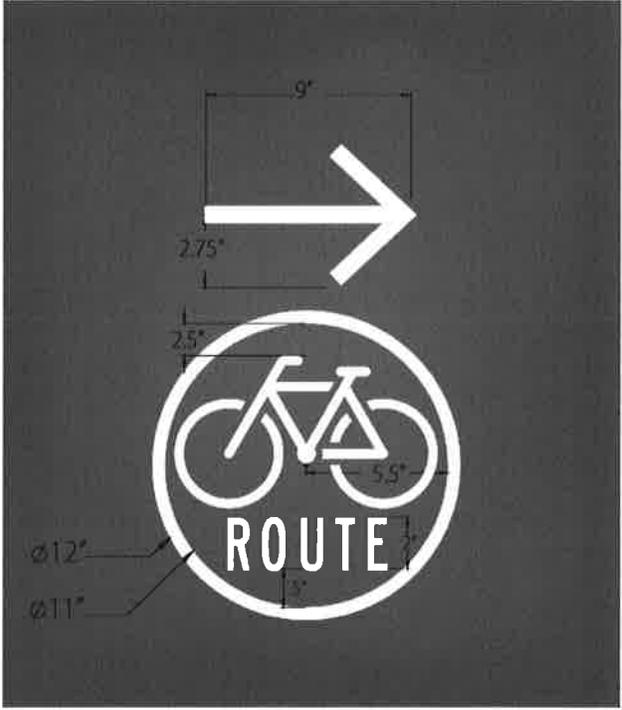
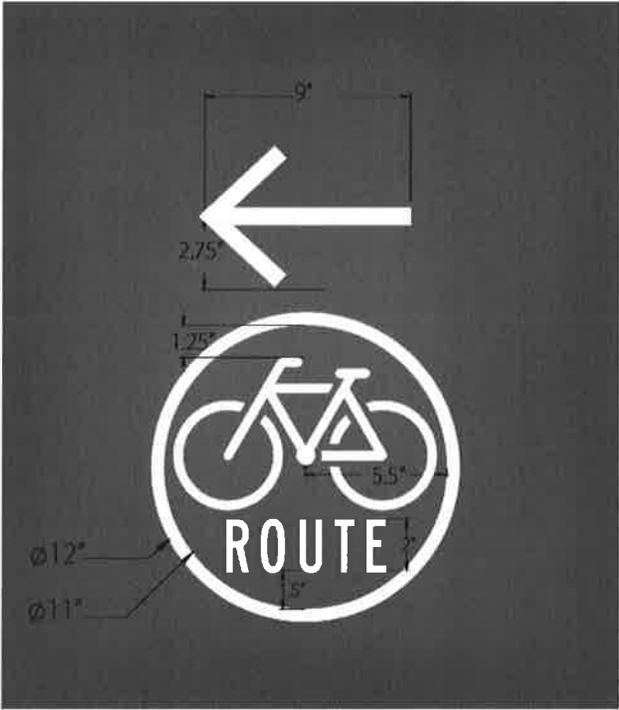
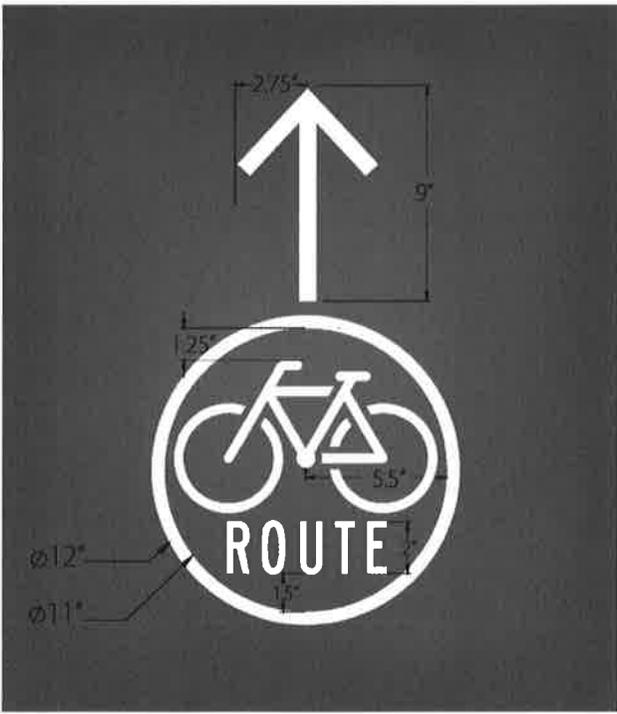


Figure 4. Proposed half-size Type 1 pavement marking symbols for off-street facilities

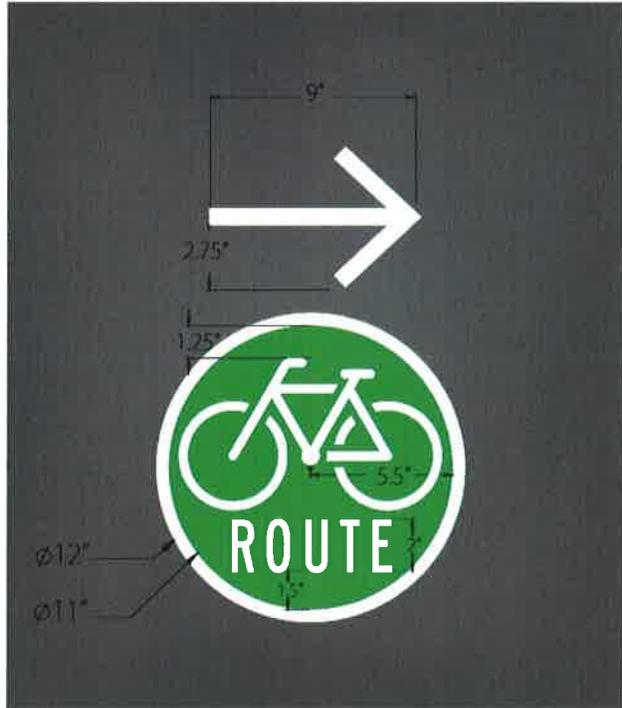
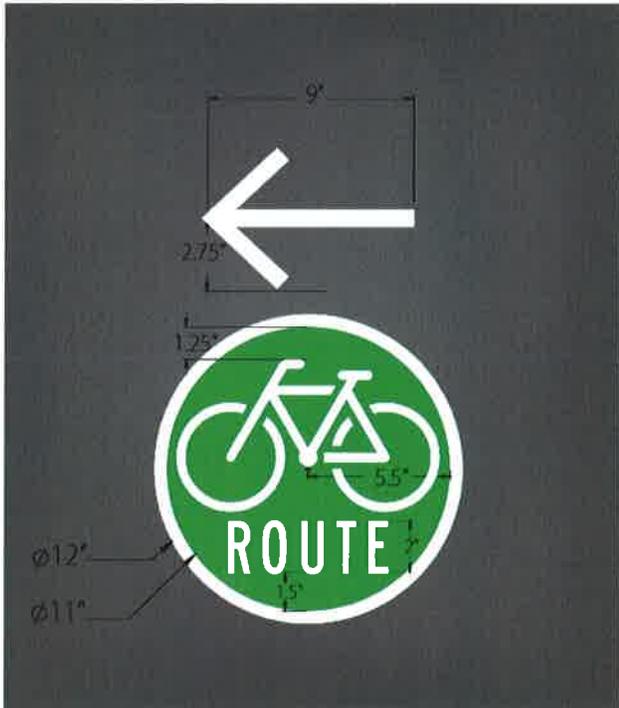


Figure 5. Proposed half-size Type 2 pavement marking symbols for off-street facilities

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The City of Columbia proposes to test the marking under controlled conditions in the University of Missouri - Columbia vehicle simulator. The UMC simulator has a flexible framework that uses a large screen and two side screens, as well as uses virtual reality (VR) glasses. Currently the simulator is used to test effectiveness of signing and markings for motor vehicle users. Prior experiments have been successfully completed for Missouri Department of Transportation. University staff will modify the simulator for bicyclist testing. The key detail of the transition of the simulator for a motor vehicle to a bicycle will be to simulate the position of the bicyclist in the simulator by using a handlebar and /or a bike and trainer stand.

The goal of the simulation will be to evaluate the effectiveness of the candidate pavement marking on bicyclist decision making in attempting to follow a marked bikeway route.

This experiment seeks to evaluate the effectiveness of wayfinding pavement markings with cyclists who have a demonstrated understanding of the rules of the road. The test group is defined as a sample of no more than 50 participants, who will be recruited through PEDNET, a local advocacy organization, and incentivized with a small promotional item to take part in the simulation.

Volunteers will be fitted to the simulator bicycle. The volunteer will ride through a series of bikeway types five times. The initial ride in the simulator will be using only wayfinding signage. The second and third rides will include only wayfinding markings. The final two rides will include wayfinding signing and both types of markings. Evaluation measures such as elapsed time to complete the course, use of hand signals at decision points, and qualitative assessments of the wayfinding elements will be utilized to evaluate pavement marking for decision making as an element of the bicycling route system, and as an aid in decision making for navigation. The experiment will also be able to measure the most effective way of relating information along a route, by sign, pavement marking or both. In the tests proposed testing will include wayfinding treatments intermixed with other typical road signs and signals.

## **SCOPE AND WORK PLAN**

### **Phase 1 - Selection and evaluation**

The City of Columbia proposes to collect data from the test group of volunteers selected from a list of individuals with on-road cycling training using a traffic simulator on the University of Missouri Engineering Department campus. Data collection will focus on behavior exhibited by the participants with respect to pavement markings selected for the experiment. The markings will be general enough for use in any part of the United States.

Once a preferred On-Street symbol is selected, it will be tested in the vehicle simulator to ensure it is not confusing to motor vehicle operators.

In addition, the most favored option of wayfinding marking will be tested for the same (Figure 2 and 3), and reduced size (Figure 4 and 5), on paved shared use paths to test the recommended size and configuration for the Type 1 and Type 2 off-street wayfinding symbols.

### **Proposed Selection Criteria for Participants in the Study**

As noted above, this experiment will utilize a test group of cyclists familiar with being on the road, as opposed to novice riders. PEDNET, a local advocacy organization, will help to identify participants. An equal number of males and females will be selected. The size of the test group

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will range from no fewer than 20, and no more than 50 participants total. In an effort to streamline the experiment, we plan only one test group.

## **Proposed Data Collection Methodology**

### Phase 1 - Simulator Testing of Proposed Wayfinding Markings in a controlled Environment

The City of Columbia has contracted with Alta Planning + Design (Alta) and the University of Missouri to coordinate experiment and data collection activities. Alta in coordination with the City and University of Missouri staff will develop a questionnaire designed to gather user information for the three parts of the simulation; with signing only, with pavement markings only, and finally with both signing and pavement markings. The data will be collected by University of Missouri staff and graduate students using the UMC Simulator on campus. The simulation will focus on observed measurable behavior through the questionnaire, as well as video tape of the participants in the simulator.

The participants will perform three timed rides through a series of streets with a set of bikeways that include shared lane markings, bike lanes and shared use paths. While the bikeways may resemble Columbia streets, it intended to simulate bikeway types used in any city.

The riders will traverse the same route 5 times in each of the three conditions:

- 1) Condition 1: markings on the pavement that include only those that are normally applied to the pavement with addition of MUTCD compliant wayfinding signage;
- 2) Condition 2 (Two Rides): markings on the pavement that include only those that are normally applied to the pavement with the addition of the two types of pavement markings that are the subject of this experiment.
- 3) Condition 3 (Two Rides): Condition 2 with addition of the three types of pavement markings that are the subject of this experiment

The following performance metrics will be recorded for each condition:

- Elapsed time to complete course
- Time stamped comparison of use of hand signals at decision points
- Bicyclist positioning relative to signing and striping
- Transitions between bikeway types,
- Response to subjective survey questions assessing level of confidence in decision making, recognition of pavement markings and signs, and other questions to assess the perceived differences between the three routes.

### Phase 2 Implementation and Public Opinion On-Line survey (by City staff)

After the simulator testing, evaluation and analysis, and interim reporting, the City will field test the marking on two major cross city marked bicycle routes that transverse the City (see attached map):

1. The ten-mile north-south Providence Bikeway
2. The nine-mile east-west Worley-Hominy Bikeway.

These routes are composed of a variety of bicycle facilities including shared use paths, side paths, bike boulevards, bike lanes, bike routes (marked with SLM's) and in one short section a wide 8' sidewalk/sidepath.

Once implemented the City will create and publicize an on-line survey to solicit community comments, suggestions and effectiveness. The results of the survey would be included in the final report

## SCHEDULE

Table 1 presents the proposed wayfinding pavement markings experiment schedule. Since there are not weather related issues or implementation of markings involved, we can begin the experiment once the RTE is approved and the simulator is adapted to the bicycle simulation discussed above. The schedule assumes FHWA approval by September 2014.

**Table 1 – Proposed Wayfinding Pavement Markings Experiment Schedule**

| Task                             | Summer 2014 | Fall 2014 | Winter 2015 | Spring 2015 | Summer 2015 | Fall 2015 | Winter 2016 |
|----------------------------------|-------------|-----------|-------------|-------------|-------------|-----------|-------------|
| Submit RTE to FHWA               | X           |           |             |             |             |           |             |
| Prepare Simulator for Experiment |             |           | X           |             |             |           |             |
| Select Participants              |             |           |             | X           |             |           |             |
| Collect Data                     |             |           |             | X           |             |           |             |
| Synthesize and Analyze Data      |             |           |             | X           |             |           |             |
| Marking Implementation           |             |           |             |             | X           |           |             |
| On-Line Public Opinion Survey    |             |           |             |             |             | X         |             |
| Final Report                     |             |           |             |             |             |           | X           |

## EVALUATION PROCEDURES/MEASURES OF EFFECTIVENESS

After data collection is complete, City of Columbia staff will work with Alta to determine if there were measurably significant changes in the following behavioral areas listed below. If positive changes are noted, the City of Columbia will suggest that the wayfinding pavement marking treatments be considered as an option and included in a future MUTCD revision. These behavioral changes include:

- Ability to follow a designated route with minimum wrong or missed turns
- Improved bicyclist behavior as measured through use of hand signals, lane placement, and route selection along network
- Awareness of proper lane placement for bicyclists.
- Understanding of facility types and network by bicyclists.
- Proper use of bikeway types and transitions between bikeway types

## REPORTING

Reporting will be submitted as specified by FHWA and submitted to the Columbia City Council, Missouri Department of Transportation, and FHWA National Headquarters Office. This will include semi-annual progress reports for the duration of the experimentation and a copy of the final results to the FHWA's Office of Transportation Operations within three months of the conclusion of the experiment.

## ADMINISTRATION

The City of Columbia will be the sponsoring agency with support as needed from consultants including Alta and University of Missouri. The proposed bicycle wayfinding pavement markings are not protected by patent or copyright.

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## REMOVAL OF EXPERIMENT

The City of Columbia agrees to remove the on-street markings within three months of completion of the study if necessary, based on the ultimate decision by FHWA. In the event FHWA reaches a decision that changes to the MUTCD are warranted to consider the wayfinding pavement markings, the experiment will be permanent. In the event the experiment creates substantial safety hazards that warrant removal prior to the planned end of the experiment, the City of Columbia will discontinue the experiment, and remove the markings.

## REFERENCES

1. City of Columbia, *Street Standards*, Accessed [https://www.gocolumbiamo.com/Council/Code\\_of\\_Ordinances\\_PDF/Street\\_Standards/](https://www.gocolumbiamo.com/Council/Code_of_Ordinances_PDF/Street_Standards/) on June 7, 2004.
2. National Association of City Transportation Officials (NACTO). *Urban Bikeway Design Guide*. Accessed <http://nacto.org/cities-for-cycling/design-guide/bicycle-boulevards/> on Jun 25, 2013.
3. FHWA, *BIKESAFE Bicycle Countermeasure Selection System*, Accessed <http://www.bicyclinginfo.org/bikesafe/> on June 25, 2013.
4. Ewing, Reid and Brown, Steven. (2009). *U.S. Traffic Calming Manual*.