Effectiveness of Two-stage Turn Queue Boxes in Massachusetts: A Comparison with Bike Boxes

MassDOT Innovation Webinar Series

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Research Team

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What is a Two-Stage Turn Queue Box (TSTQB)?
TWO-STAGE TURN QUEUE BOX ADVANTAGES

- Reduce conflicts between motor vehicles and bicycles
- Improve bicyclist visibility
- Provide a space for formal queueing of bicyclists
- Reduce conflicts between bicyclists and pedestrians
TWO-STAGE TURN QUEUE BOX ADVANTAGES

- Separate through moving and turning bicyclists
- Improve bicyclist comfort
- Facilitate safer crossings of streetcar tracks
TWO-STAGE TURN QUEUE BOX
DISADVANTAGES

- Increased delay for bicyclists
- Bicyclist discomfort from waiting within the intersection
- Higher maintenance costs
PROJECT OBJECTIVES

1. Create an inventory of two-stage turn queue boxes in Massachusetts

2. Characterize left-turning bicyclist behavior at intersections with two-stage turn queue bike boxes and compare TSTQB utilization when bike boxes are also present vs when not

3. Recommend guidelines on the design and implementation of two-stage turn queue boxes
PRESENTATION OUTLINE

- Literature Review Findings & Existing Guidelines
- Inventory of two-stage turn queue boxes across Massachusetts
- Field data collection & analysis: left-turning bicyclist behavior at two-stage turn queue boxes
- Conclusions
LITERATURE REVIEW
### DESIGN GUIDELINES

<table>
<thead>
<tr>
<th>Guidebook</th>
<th>TSTQB Depth [ft]</th>
<th>TSTQB Width [ft]</th>
<th>Bicycle Stencil and Turn Arrow</th>
<th>Green Colored Pavement</th>
<th>White Line Boundary</th>
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</table>

*: when impractical to complete the turn in a different way
TSTQB CONFIGURATIONS

Cycle Track Buffer

Parking Lane

Crosswalk Setback

Bike Box

T-intersection Parking Lane

T-intersection Jughandle Sidewalk
BICYCLIST BEHAVIOR

- 70% of left-turning cyclists legally completed two-phase turns, while approximately 55% of bicyclists utilize TSTQBs (Casello et al., 2017)
- Other studies indicate inconclusive results with regards to the proper use of TSTQBs and bike boxes (Ohlms and Kweon, 2018)
- Consistent use of TSTQBs by left-turning bicyclist, with use being affected by the presence of other bicyclists on the TSTQB (FHWA, 2017)
- 86.5% of the left turning bicyclists in Copenhagen used the TSTQB (Colville-Andersen, 2024)
SAFETY

• Increased perceived safety (Götschi et al., 2018)

• Inconclusive results with regards to safety improvements (Ohlms and Kweon, 2018)

• TSTQB’s safety benefits are promising, but further research is needed for conclusive evidence (DiGioia et al., 2017)
INVENTORY
Massachusetts Two-Stage Left-Turn Queue Box Installations - District 1

The UMass Transportation Center has partnered with MassDOT to conduct a research study evaluating the implementation of Two-Stage Left-Turn (or TSLT) Queue Boxes at intersections across the Commonwealth of Massachusetts.

The research team would greatly appreciate your time and efforts in completing this survey. Please take no more than 5 minutes of your time. Please attach and comments you have in the appropriate section.

Note: This survey is for town/city/areas in MassDOT Districts listed below.

If you have any additional questions or would prefer not to complete this online, please contact:

Francis Tainter
Research Assistant Professor
UMass Amherst

ftainter@umass.edu

<table>
<thead>
<tr>
<th>MassDOT District</th>
<th>Number of Responses</th>
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TSTQB LOCATIONS
LIDAR DATA COLLECTION
LIDAR DATA COLLECTION
## LIDAR DATA COLLECTION

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<th>Intersection</th>
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*The depths and widths of the TSTQB were estimated based on the bounding boxes due to the irregular shape.

*Only one edge of the TSTQB has painted lines.
LIDAR DATA COLLECTION

http://massdot.ecs.umass.edu/TSTQB/
TSTQB CONFIGURATIONS
BICYCLE INFRASTRUCTURE TREATMENTS
OTHER TSTQB APPROACH CHARACTERISTICS

![Bar Chart]

- TSTQB Sign
- Bike Signal
- "No Turn on Red" Sign
- Protected Left-turn Phasing
- Dedicated Left Turn Lane
- Intersection Crossing Markings

Percent of TSTQB (%)
BICYCLIST BEHAVIOR
FIELD DATA COLLECTION
BICYCLIST BEHAVIOR OBSERVATIONS

Two-Stage Maneuver

Bicycle at Beacon St. at Park Dr., Boston, MA

Massachusetts Ave. at Columbus Ave., Boston, MA

Beacon St. at Park Dr., Boston, MA

Beacon St. at Harvard St., Brookline, MA

TSTQB
BICYCLIST BEHAVIOR OBSERVATIONS

Using Crosswalk

Beacon St. at Park Dr., Boston, MA

Massachusetts Ave. at Columbus Ave., Boston, MA

Using Bike Box

Beacon St. at Park Dr., Boston, MA

Beacon St. at Park St., Somerville, MA
BICYCLIST BEHAVIOR OBSERVATIONS

Left Turn

Beacon St. at Park Dr., Boston, MA

Beacon St. at Park St., Somerville, MA
BICYCLIST LEFT-TURNING BEHAVIOR

Percentage of Left Turning Bicyclists (%)

Movement Type

Conventional Left Turn
Two-Stage Maneuver
TSTQB
Crosswalk
Bike Box

Control Approach
TSTQB Approach

29
BICYCLIST LEFT-TURNING BEHAVIOR

<table>
<thead>
<tr>
<th>TSTQB Approach</th>
<th>Conventional Left Turn</th>
<th>Two-Stage Maneuver</th>
<th>TSTQB</th>
<th>Crosswalk</th>
<th>Bike Box</th>
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<td>Park Dr. at Beacon St. (NB-WB)</td>
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<td>Beacon St. at Park St. (NB-WB)</td>
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<td>Beacon St. at Park St. (SEB-NEB)</td>
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<td>Washington St. at Massachusetts Ave. (SB-EB)</td>
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<td>Washington St. at Prospect St. (NB-WB)</td>
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<td>Somerville Ave. at Prospect St. (SB-EB)</td>
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<tr>
<td>Somerville Ave. at Prospect St. (EB-NB)</td>
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</table>
HYPOTHESES

1. The presence of a bike box at an approach reduces TSTQB utilization
2. The presence of a bike lane at an approach increases TSTQB utilization
3. The presence of a protected bike lane at an approach increases TSTQB utilization compared to when conventional bike lanes are in place
4. The existence of protected left-turn phasing decreases TSTQB utilization
5. The presence of dedicated left turn lanes decreases TSTQB utilization
6. The presence of TSTQBs at intersections increases the occurrence of two-stage maneuvers
HYPOTHESES

7. TSTQB utilization is greater at larger compared to smaller intersections
8. Crosswalk utilization for left-turning bicyclist maneuvers is greater when there is no TSTQB
9. The presence of a TSTQB sign increases TSTQB utilization
10. The TSTQB parking lane configuration increases its utilization compared to the crosswalk TSTQB configuration
## BIKE BOX PRESENCE

<table>
<thead>
<tr>
<th>Condition</th>
<th>Number of Left-Turning Bicyclists</th>
<th>Number of Left-Turning Bicyclists Using the TSTQB</th>
<th>Percent of Left-Turning Bicyclists Using the TSTQB (%)</th>
<th>z-test statistic</th>
<th>p-value</th>
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<tbody>
<tr>
<td>Bike Box</td>
<td>129</td>
<td>20</td>
<td>15.50</td>
<td>0.856822</td>
<td>0.391543</td>
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<td>95</td>
<td>11</td>
<td>11.58</td>
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BIKE LANE PRESENCE

Beacon St. at Park St., Somerville, MA
Somerville Ave. at Prospect St., Somerville, MA
Park Dr. at Beacon St., Boston, MA
Beacon St. at Harvard St., Brookline, MA
## BIKE LANE PRESENCE

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<tr>
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<th>Number of Left-Turning Bicyclists Using the TSTQB</th>
<th>Percent of Left-Turning Bicyclists Using the TSTQB (%)</th>
<th>z-test statistic</th>
<th>p-value</th>
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<tbody>
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<td>Sharrow</td>
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Somerville Ave. at Prospect St., Somerville, MA

Beacon St. at Harvard St., Brookline, MA
## PROTECTED LEFT-TURN PHASING

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<th>Number of Left-Turning Bicyclists Using the TSTQB</th>
<th>Percent of Left-Turning Bicyclists Using the TSTQB (%)</th>
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## INTERSECTION SIZE

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<th>Number of Left-Turning Bicyclists Using the TSTQB</th>
<th>Percent of Left-Turning Bicyclists Using the TSTQB (%)</th>
<th>z-test statistic</th>
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Massachusetts Ave. at Columbus Ave., Boston, MA

Massachusetts Ave. at Washington St., Boston, MA
# CROSSWALK UTILIZATION

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<th>Condition</th>
<th>Number of Left-Turning Bicyclists</th>
<th>Number of Left-Turning Bicyclists Using the Crosswalk</th>
<th>Percent of Left-Turning Bicyclists Using the Crosswalk (%)</th>
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Massachusetts Ave. at Columbus Ave., Boston, MA

Massachusetts Ave. at Washington St., Boston, MA
CONCLUSIONS
CONCLUSIONS: INVENTORY

- 88 TSTQBs were identified and inventoried.
- Boston has the most TSTQBs in Massachusetts.
- The Crosswalk Setback Configuration is the most common.
- Most approaches feature "No Turn on Red" signage, complying with guidelines.
- Except for the Park Dr. at Beacon St. (SB) approach, all other approaches include bicycle stencils and turn arrows.

Beacon St. at Park Dr., Boston, MA
CONCLUSIONS: BICYCLIST BEHAVIOR

- Presence of other bicycle infrastructure does not affect TSTQB utilization (i.e., bike boxes, bike lanes, etc.)
- Intersection size does not have a statistically significant impact
- No difference in TSTQB utilization based on TSTQB configuration (parking vs crosswalk setback)
- Lack of protected left-turn phasing or dedicated lanes induce higher TSTQB utilization
- Higher crosswalk use by left-turning bicyclists in the absence of TSTQBs
RECOMMENDATIONS: DESIGN

- Compliance with the newly published MUTCD
- Implement regulatory or guidance TSTQB signs to increase bicyclist awareness
- Position TSTQB near corner curbs of intersections to enhance bicyclist comfort
- Consider implementation of two-stage turn queue boxes in the absence of dedicated left-turn lanes
- Position TSTQB near the through moving path of bicyclists to improve utilization.
- Implement TSTQB at locations with high crosswalk use for bicyclists’ left-turning maneuvers.
RECOMMENDATIONS: EDUCATION

- Educate bicyclists on the proper use of TSTQBs, emphasizing advantages of using TSTQBs and correct positioning within the box.
- Implement educational campaigns to enhance driver awareness of bicyclists and the function of TSTQBs.
RECOMMENDATIONS: DATA COLLECTION

- Develop and administer surveys to supplement existing data
- Expand data collection to cover a more diverse range of intersection designs and layouts, as well as demands, and seasons.
- Collect and analyze bicyclist and motorist trajectories at intersections with TSTQBs
- Investigate alternative bike infrastructure usage at intersections where TSTQBs are not utilized.
FUTURE WORK

- Continuously updating the TSTQB inventory
- Repeat the analysis with data from more TSTQBs
- Correlate behavior with specific dimensions and bicycle demand
- Survey bicyclists to allow for correlations of their behavior with levels of comprehension and familiarity.
- Crash/conflict analysis

Beacon St. at Park Dr., Boston, MA
Acknowledgments

- Mike Wang
- Zaw Htet Lin
- Hsu Shwe Yee Naing
- Brigham Stevenson
QUESTIONS?
What is a Two-Stage Turn Queue Box (TSTQB)?