

Report on the Efficacy of Red Bus Lanes as A Traffic Control Device

Prepared For:

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Table of Contents

Executive Summary.....	p. 4
I. Introduction.....	p. 5
II. Effect of Red Treatment on Illegal Bus Lane Occupancy and Bus Travel Time Experiments: Methodology and Results.....	p. 6
III. Effect of Red Lane Treatment on Parking Behavior: Methodology and Results...	p. 11
IV. Effect of Red Lane Treatment on Right Turn Behavior: Methodology and Results.....	p. 13
V. Bus Lane Product and Processes Evaluation: Summary of Methodology and Results.....	p. 17
VI. Recommendations.....	p. 17

Executive Summary

Starting in 2006, the New York City Department of Transportation (NYCDOT) received permission from the Federal Highway Administration (FHWA) to conduct an experiment with red colored pavement for exclusive bus lanes (experimentation number 3-198 Ex). The purpose of the experiment was to determine if red colored bus lanes could increase the speed and reliability of bus service by further discouraging the use of such lanes by non-authorized vehicles. The experiment is part of NYCDOT and MTA New York City Transit's (NYCT) Bus Rapid Transit (BRT) program, which includes five pilot BRT routes across the city. Two of these routes are in operation and have been outfitted with red bus lanes.

NYCDOT and its partner NYCT have undertaken a series of experiments to evaluate the effect and safety of the red bus lane treatment. These experiments included:

- 2007 test of the effect of red treatment on bus travel times and illegal bus lane occupancy by non-bus vehicles (57th Street in Manhattan and Fordham Road in the Bronx).
- 2010 test of the effect of red treatment on bus travel times and illegal bus lane occupancy by non-bus vehicles (First Avenue in Manhattan).
- 2011 test of the effect of red treatment on legal parking behavior in red bus lanes during non-bus lane hours (Second Avenue in Manhattan).
- 2011 test of the effect of red treatment on non-bus vehicle right turning behavior and intersection safety (multiple locations in Manhattan).

Overall, the 2007 and 2010 tests show that the red treatment is effective at reducing unauthorized bus lane usage, including illegal parking and illegal driving in the bus lane. The experiment on First Avenue in 2010 showed that the addition of the red treatment to a curb bus lane reduced illegal standing and parking in the lane by over one third. This finding is also supported by more limited data collection on Fordham Road in the Bronx and on 57th Street in Manhattan. Due to the low rate of use of the bus lane by buses on First Avenue, the 2011 experiment was unable to determine the impact of the red treatment on bus speeds. On a well used bus lane, however, DOT expects that a lower frequency of bus lane blockages will lead to improved bus travel times.

The 2011 tests also show that the red treatment achieves these benefits without negative impacts on non-bus driver behavior. The 2011 test on parking behavior found that the red treatment did not dissuade non-bus vehicles from using curbside bus lanes for legal parking during times when the bus lane is not in effect. There was no significant change in the parking occupancy at the test location after the installation of the red treatment. Additionally, the red treatment does not induce non-bus drivers to make right turns from the incorrect lane. The 2011 test on right turn behavior found that there was no significant difference in the percentage of drivers turning from the desired curb lane between a red curbside bus lane and a standard (non-red) bus lane.

In conclusion, the data indicate that the red treatment is an effective and safe traffic control device suitable for inclusion in the *Manual on Uniform Traffic Control Devices* (MUTCD).

I. Introduction

On October 31 2006, the New York City Department of Transportation (NYCDOT) received permission from the Federal Highway Administration (FHWA) to conduct an experiment with red colored pavement for exclusive bus lanes (experimentation number 3-198 Ex). The purpose of the experiment was to determine if red colored bus lanes could increase the speed and reliability of bus service by further discouraging the use of such lanes by non-authorized vehicles. On May 13, 2010 the NYCDOT received permission from FHWA to continue its experiment with red colored pavement for exclusive bus lanes through July 2012.

The experiment is part of NYCDOT and MTA New York City Transit's (NYCT) Bus Rapid Transit (BRT) program, which includes five pilot BRT routes across the city.¹ Two of these routes, the Bx12 Select Bus Service (SBS) on 207th Street in Manhattan and Fordham Road and Pelham Parkway in the Bronx, and the M15 SBS on First Avenue and Second Avenue in Manhattan, are currently in operation. These two SBS routes, as well as two other major bus corridors—34th Street in Manhattan and Livingston Street in Brooklyn—have been outfitted with red bus lanes, as have other selected bus-only lanes elsewhere in the city.

NYCDOT and its partner NYCT have undertaken a series of experiments to evaluate the effect and safety of the red bus lane treatment (henceforth referred to as the “red treatment”). This report summarizes the results of these experiments and lays out recommendations for best practices in the implementation of red bus lanes. The experiments included:

- 2007 test of the effect of red treatment on bus travel times and illegal bus lane occupancy by non-bus vehicles (57th Street in Manhattan and Fordham Road in the Bronx).
- 2010 test of the effect of red treatment on bus travel times and illegal bus lane occupancy by non-bus vehicles (First Avenue in Manhattan).
- 2011 test of the effect of red treatment on legal parking behavior in red bus lanes during non-bus lane hours (Second Avenue in Manhattan).
- 2011 test of the effect of red treatment on non-bus vehicle right turning behavior and intersection safety (multiple locations in Manhattan).

This report also includes a brief summary of an additional study by NYCDOT and the Pennsylvania State University on the durability of different red bus lane products and application processes.

Overall, the data show that the red treatment is effective at reducing unauthorized bus lane usage, including illegal parking and illegal driving in the bus lane. The data also show that the red treatment achieves these benefits without negative impacts on non-bus driver behavior. The red treatment does not dissuade non-bus vehicles from using curbside bus lanes for legal parking during times when the bus lane is not in effect. Additionally, the red treatment does not induce non-bus drivers to make right turns from the incorrect lane. Overall, the data indicate that the red treatment is an effective and safe traffic control device suitable for inclusion in the *Manual on Uniform Traffic Control Devices* (MUTCD).

¹ More information on the current status of the program can be found on the program website: <http://www.nyc.gov/brt>

II. Effect of The Red Treatment on Illegal Bus Lane Occupancy and Bus Travel Time: Methodology and Results

2007 Red Lane Experiment: Illegal Occupancy and Bus Travel Times

Methodology

In 2006, NYCDOT worked in partnership with NYCT to develop a methodology to test the effectiveness of colored bus lanes. NYCDOT and NYCT selected the following bus lane segments for analysis:

- 57th Street between Second Avenue and Fifth Avenue in Manhattan (.52 mi): this corridor was seen as a good candidate because it carries a high volume of buses and is characteristic of a number of curb bus lanes found in the Manhattan central business district.
- Fordham Road between University Avenue and Valentine Avenue in the Bronx (.48 mi): this corridor was seen as a good candidate because it carries a high volume of buses and was slated to be part of the first pilot BRT route in the NYCDOT-NYCT joint BRT program.



Fordham Road Red Bus Lane (Bronx)



57th Street Red Bus Lane (Manhattan)

NYCDOT and NYCT then collected baseline data for the two corridors prior to installing the red treatment. Agency staff recorded bus travel times across the segments for the AM and PM peak periods during one weekday. The AM peak was defined as 7 AM to 10 AM and the PM peak as 4 PM to 7 PM. The travel times were recorded using teams of checkers stationed at either end of each segment. In addition to the travel time data, agency staff also recorded violations of the bus lane by unauthorized vehicles. Agency staff were stationed at each block along the segment to record violations during the AM and PM peak periods on one weekday. Every ten minutes the agency checker would inspect the block for unauthorized vehicles; if no vehicle was present the lane was marked “clear”, if a vehicle was present, the lane was marked “blocked”.

After the baseline data was collected and tabulated, NYCDOT installed terracotta red lanes on both of the experiment segments (as per the color recommendation of FHWA). On both segments, the agency piloted two colored lane designs as shown in schematic below: alternative #1, a full width colored lane, and alternative #2, a 5- to 6-foot wide strip in the middle of the lane.

Alternative #1: BUS ONLY written words and RED solid-color bus lane



Alternative #2: BUS ONLY written words and RED stripe in middle of bus lane



The color was applied using IPC Ride-A-Way, a high durability paint designed for street markings. Following the installation, agency staff repeated the same data collection program as was used for the baseline condition.

Results

Due to the limited amount of data—a one weekday snapshot for both the baselines and built condition—the results of this test were preliminary. In addition, there were problems with the data collection process rendering some data unusable, so only partial results are available for both segments. The test on curb occupancy by unauthorized vehicles showed that the red lanes had a positive impact on driver behavior. In three out of the four segments for which data is available, illegal parking and driving in the bus lane decreased. The test also indicated that the red coloring improved bus running times. Overall, the testing found no difference in the effect of the two red treatment designs. As a result, NYCDOT decided to install all future red lanes using the Alternative #1 full width design, which is simpler to install.

Due to the limited data collected and problems with the data collection plan, further testing was necessary to verify the impact of the red lane treatment on bus run times and reliability. Therefore, NYCDOT and NYCT decided to undertake additional data collection. This new plan, outlined to FHWA in 2010, called for a more robust testing methodology and stricter data collection quality controls. The results of the 2010 data collection are discussed in the next section.

2010 Red Lane Experiment: Illegal Occupancy and Bus Travel Times

Methodology

NYCDOT and MTA New York City Transit (NYCT) launched a second pilot BRT route on First Avenue and Second Avenue—the M15 SBS—on October 10, 2010. Portions of this project replaced existing standard curbside bus lanes with red colored bus lanes. As part of the phased implementation of this project, the installation of red bus lane markings was not initially accompanied by new signs or changed bus lane hours, providing a natural opportunity for a test to isolate the effectiveness of the red treatment alone. NYCDOT and NYCT selected the segment of First Avenue in Manhattan from 61st Street to 79th Street, a .9 mile segment, as the project study area.

It is important to note that while the New York City Police Department (NYPD) has responsibility for enforcing bus lanes, in practice the level of enforcement during this test was quite low. Since NYPD enforcement of the bus lanes during the experiment was very light, the observations primarily showed the effectiveness of the red treatment.

NYCDOT and NYCT were interested in the effects of the red treatment on three measures of effectiveness:

- Number of unauthorized vehicles stopping in the bus lane
- Number of unauthorized vehicles driving in the bus lane
- Average bus speeds

Unauthorized Vehicle Occupancy Analysis (Stopping or Driving in bus lanes)

NYCDOT and NYCT measured unauthorized vehicle occupancy on three block faces within the study area before and after the installation of the red treatment. The pre-red lane installation data collection took place over four data collection periods in May 2010. The post-red lane data collection took place over two data collection periods in late September and early October 2010. Each data collection period comprised three hours of observation from 4 p.m. to 7 p.m. on a weekday. One surveyor was assigned to each block face and catalogued each incident of illegal bus lane use during the data collection period, including vehicles driving in the bus lane, vehicles standing in the bus lane (defined as less than 30 minutes), and vehicles parking in the bus lane (defined as more than 30 minutes). Right turns were not allowed on each of the three block faces selected, so no vehicles were making a right turn at the next intersection (a legal reason to drive in the bus lane). This methodology provided a richer body of data than the 2007 data collection.

Bus Travel Time Runs (Bus Speeds)

NYCDOT and NYCT also measured bus travel times northbound on First Avenue (which is a one-way street) from 61st Street to 79th Street before and after the installation of the red treatment on the segment's curbside bus lane. The pre-red lane installation data collection took place over four data collection periods in May 2010. The post-red lane data collection took place over two collection periods in late September and early October 2010. Each data collection period comprised three hours of observation from 4 p.m. to 7 p.m. on a weekday. One checker was placed at either end of the segment and tracked the ID number of each NYCT bus passing their observation location and the exact time that each of those buses passed the location, as well as whether that bus was making all stops (Local) or major stops only (Limited). From this data,

NYCDOT matched the bus ID number and times from each observer and calculated the travel time for each bus run observed. On average, about 45 bus runs were observed during each data collection period, comprised of M15 local buses and M15 Limited buses. The data collection for the post period was done after the installation of the red lanes, but before the introduction of the other BRT elements as part of the M15 SBS project.

Results

The results of the unauthorized vehicle occupancy analysis are summarized in Chart 1, on the next page. On average, the number of vehicles driving illegally in the bus lane declined, from an average of 16.8 during the three hour period to 7.5, a decrease of 55%. The number of vehicles standing—the principal cause of bus lane blockage—also declined, from an average of 15.7 incidents to 10.2 incidents, a decrease of 35%. The number of vehicles parking illegally rose slightly from 1.4 incidents to 1.8 incidents, an increase of 29%. This increase reflects an increase at one of the three locations--65th Street to 66th Street—and may be attributable the small sample size of parking incidents in both the pre and post red treatment installation periods. Overall, the analysis indicates that the red treatment is effective in deterring illegal driving and standing in a bus lane.

Chart 1: Results of Unauthorized Vehicle Occupancy Analysis

	Measure	# of vehicles driving in bus lane	# of vehicles standing <30 min in bus lane	# of vehicles parking >30 min in bus lane
Average per block face	<i>Pre Red Treatment</i>	16.8	15.7	1.4
	<i>Post Red Treatment</i>	7.5	10.2	1.8
	<i>Difference</i>	-9.3	-5.5	+0.4
	% Change	-55.4%	-35.1%	+29.4%

The results of the bus travel time run analysis are summarized in Chart 2, below. As part of the unauthorized vehicle occupancy data collection, NYCDOT and NYCT also noted the number of buses driving in the bus lane. The data indicated that fewer than 10% of buses were actually driving in the bus lane during both the pre and post red treatment installation periods. There are several factors that may contribute to this: traffic generally flows well on First Avenue and bus drivers may be choosing to drive farther from the curb; and although the red lanes reduced unauthorized bus lane use, it did not eliminate that use, as even a single stopped vehicle renders a section of curb bus lane unusable. As a result of the small number of buses driving in the bus lane, the application of the red treatment to the bus lane predictably had little effect on bus travel times.

Chart 2: Results of Bus Travel Time Runs

Measure	M15 Limited Travel Time	M15 Local Travel Time
Average Travel Time Pre Red Lane Installation (Minutes)	0:06:07	0:10:42
Average Travel Time Post Red Lane Installation (Minutes)	0:06:10	0:10:52

These results show that the red bus lanes do have a real effect on reducing unauthorized use of bus lanes, but are not by themselves sufficient to keep the bus lanes completely clear. Effective

enforcement is a key element to helping make for an effective bus lane. DOT experience has been that when well enforced, bus lanes can significantly improve bus travel times. For example, the M15 SBS project, which included new red bus lanes on First and Second Avenues, reduced bus in-motion time by 8%. Similarly, the red bus lane project on 34th Street in Manhattan, which was installed along with other geometric changes to the street, reduced bus travel times by 17%. In discussions about enforcement, NYPD has indicated that the red treatment makes enforcement of bus lanes easier for their officers, since the coloration eliminates any excuse from drivers that they did not observe the existence of the bus lane. As a result, enforcement along First Avenue has improved significantly following the collection of the data presented in this report.

NYCDOT is also observing the use of red paint in “offset” bus lanes, a design being piloted on parts of the M15 SBS route. Unlike a curbside bus lane, an offset bus lane is located adjacent to the parking lane. A similar before and after comparison was not possible since these lanes were newly implemented, but DOT is monitoring the impact of the offset lanes as part of the evaluation of M15 SBS project. Feedback from NYPD, NYCT bus operators, and other observers suggest that the red paint is similarly helpful in helping keep these offset bus lanes clear.

III. Effect of The Red Lane Treatment on Legal Parking Behavior: Methodology and Results

Methodology

A potential issue with red bus lanes would be if the treatment discourages legal driving and parking behavior that should be occurring in the bus lane. To understand these issues, NYCDOT collected data on the impact of the red treatment on the legal use of bus lanes. In most locations, non-bus vehicles are allowed to use a bus lane to make a right turn at all times, and to park or stand during hours when the bus lane is not in effect. This section discusses the effect of the red treatment on legal parking, while next section addresses effects on right turn behavior.

The purpose of the experiment was to determine if the red treatment deterred vehicle drivers from parking in a bus lane even when it is legal to do so. Many bus lanes are in effect limited hours, with parking allowed during mid-days, overnight, and/or on weekends. To better understand how the red treatment impacts legal use of a curbside bus lane for parking, NYCDOT evaluated the impact of the red treatment on parking occupancy on a two block section of curbside bus lane on Second Avenue between 15th Street and 17th Street (Manhattan). This two block section is part of the M15 SBS route, allowing for a comparison of parking occupancy before and after the installation of the red treatment. The midday parking regulations on the segment remained the same before and after the addition of the red treatment: parking was permitted during times that the bus lane was not in effect. The two data collection periods were as follows:

- *Pre-red treatment installation:* in February and March of 2010 NYCDOT conducted a parking occupancy survey of all of Second and First Avenue as part of the planning for the M15 SBS route. For this analysis, NYCDOT examined the curb occupancy for the western curb of Second Avenue between 15th Street and 17th Street between 11 AM and 1 PM. Prior to October 2010, the bus lane was in effect 7-10 AM and 4-7 PM only.
- *Post-red treatment installation:* in June and July of 2011 NYCDOT conducted a parking occupancy survey western curb of Second Avenue between 15th Street and 17th Street between 11 AM and 1 PM. After October 2010, the bus lane has been in effect from 7-10 AM and 2-7 PM.



Vehicles legally parked in the red bus lane between 16th and 17th Streets during midday hours

For each curb occupancy survey, an observer recorded the number of legally and illegally parked cars on each block face, broken down by vehicle classification (car, van, truck, bus and ambulance). For the pre-red treatment data, counts were done once an hour, i.e. between 11 AM-12 PM and 12 PM-1 PM. For the post data, counts were done every 15 minutes between 11 AM and 1 PM to provide a more robust data set. Each block face was surveyed on four weekdays.

Results

Chart 3, presented below, summarizes the results of the pre and post red treatment parking surveys. Parking occupancy equals the total number of parked vehicles observed divided by the total number of parking spaces, presented as a percentage. In each case the total number of parking spaces remained the same: 10 spaces for the western block face between 15th and 16th Streets and four spaces for the western block face between 16th and 17th Streets.

Chart 3: Effect of The Red Treatment on Average Midday Parking Occupancy

Data Collection Period	15th-16th Streets (10 spaces)	16th-17th Streets (4 spaces)
Pre-Red Treatment Average weekday parking occupancy between 11AM and 1 PM	58%	60%
Post-Red Treatment Average weekday parking occupancy between 11AM and 1 PM	65%	70%

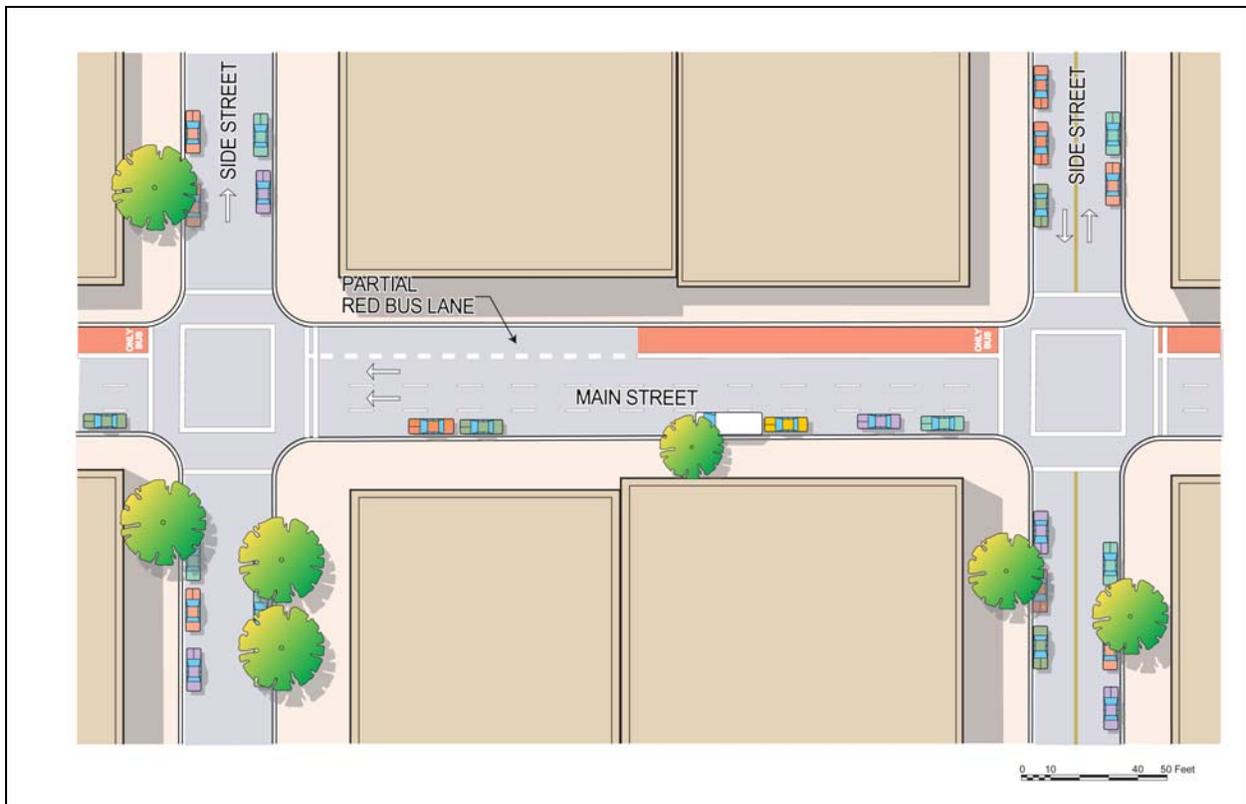
As the chart above indicates, there was no significant change in the parking occupancy after the installation of the red treatment. In fact, the data show that parking occupancy actually increased from an average of 58% to 65% on the 15th-16th Street block face and from 60% to 70% on the 16th to 17th Street block face. This small increase is likely due to natural fluctuations, and occupancy for the two observation periods should be considered equivalent. Therefore the data shows that the red treatment does not have a negative impact on legal parking behavior when the bus lane is not in effect.

IV. Effect of The Red Lane Treatment on Right Turn Behavior: Methodology and Results

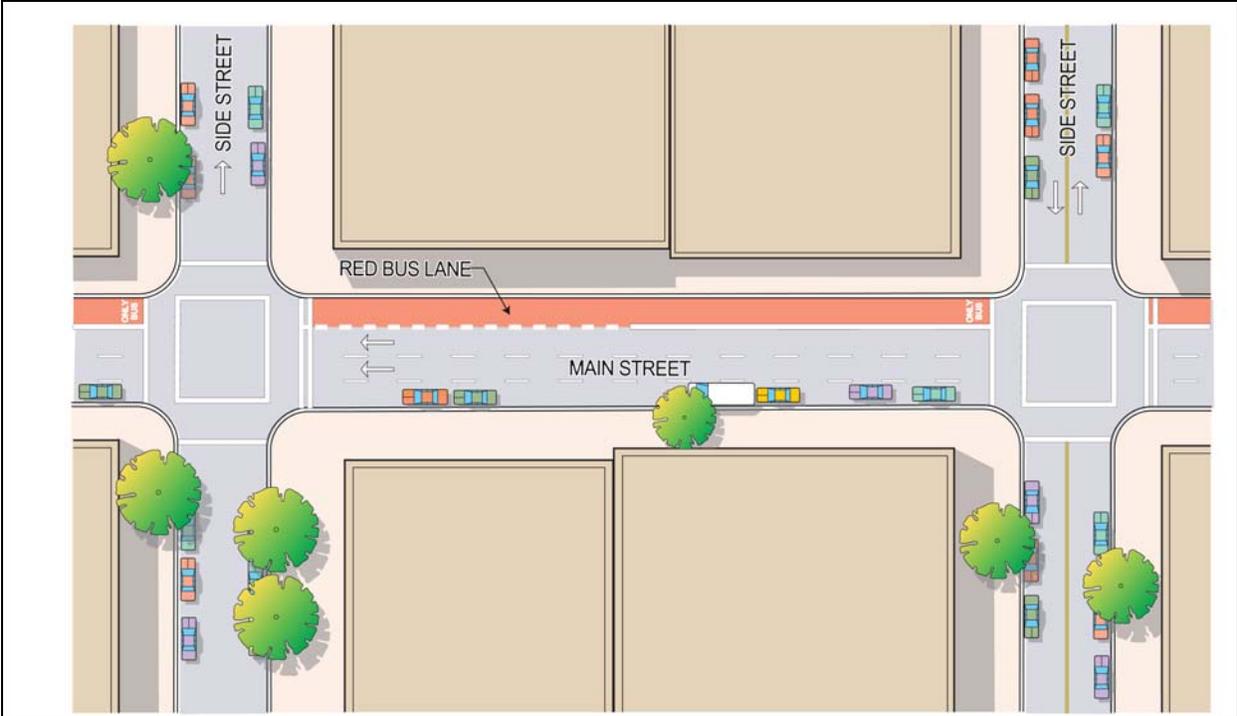
Methodology

A concern with red bus lanes is the potential impact of the red treatment on the legal right turn behavior of non-bus vehicles. Under New York City’s traffic rules, vehicles are typically required to make right turns from the bus lane at all times, unless the turn is prohibited by signage or other provisions are created.

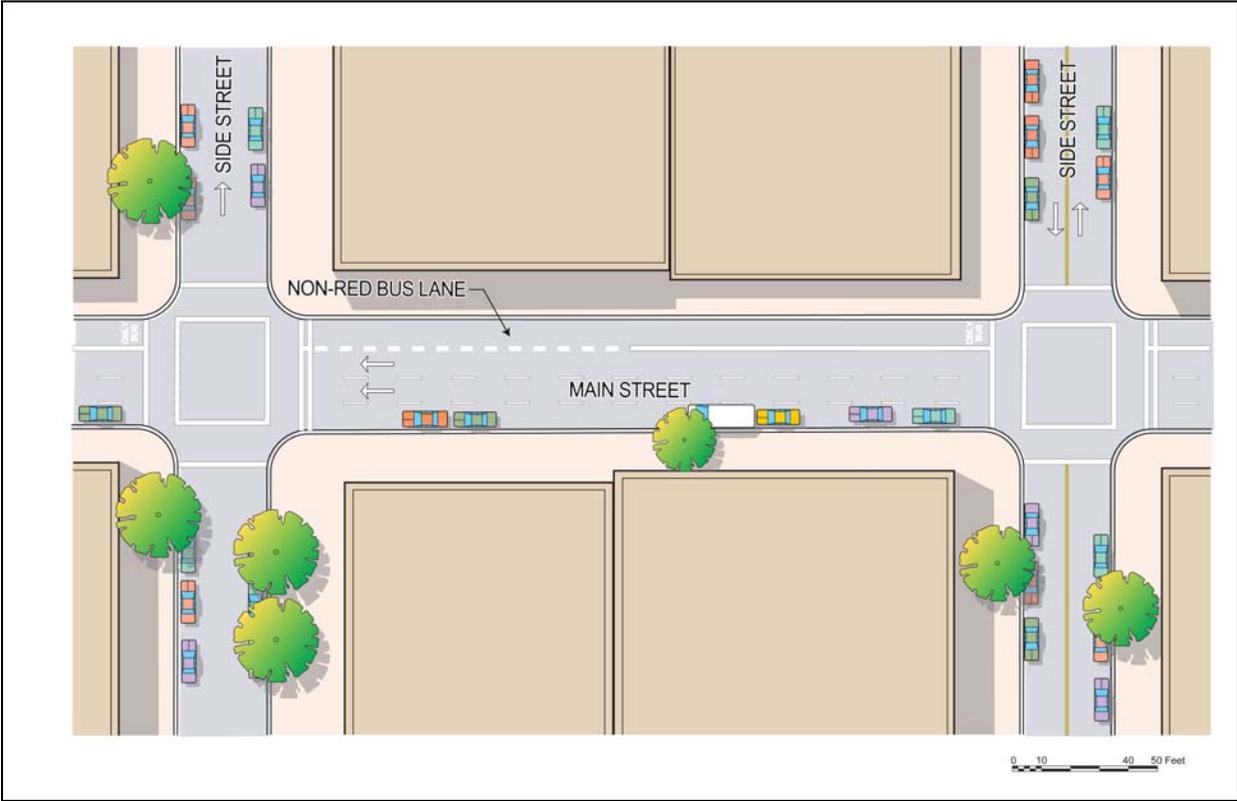
As part of the M15 SBS project, DOT implemented a new red bus lane marking pattern to communicate to drivers when a legal right turn is allowable from the bus lane (see Plan 1, below). This design stopped the red treatment midblock and included a dashed line between general traffic and the bus lane. Unfortunately, since implementation DOT and NYCT have observed that the non-red sections of the First Avenue and Second Avenue bus lanes were prone to more frequent parking violations than the red sections. Therefore, DOT has adopted a modified design (see Plan 2, next page), which extends the red treatment to the intersection, while retaining the dashed line indicating to general traffic that it is legal to use the bus lane for a right turn.



Plan 1: Red Bus Lane Design Used on First and Second Avenues



Plan 2: Recommended Red Bus Lane Design



Plan 3: Standard Non-Red Bus Lane Design

To ensure that the recommended design is safe, NYCDOT wanted to determine if the use of the red treatment to the intersection causes some drivers to make a right turn from the lane next to bus lane instead of the bus lane itself. Failure to turn from the appropriate lane may cause traffic back-ups in through traffic lanes and may also cause potential safety issues, i.e. a turning vehicle cutting in front of a bus to make a right turn. To better understand this issue, NYCDOT observed the right turn behavior of non-bus vehicles at a curbside bus lane without the red treatment (see Plan 3 on the previous page) and at a curbside bus lane with the red treatment (Plan 2). The observation locations were:

- *A major street with a standard (non-red) curb bus lane:* Third Avenue at 42nd Street. This bus lane features a solid white line in most sections, with a dashed white edge line on the approaches to right turns. The dashed line indicates to drivers that it is permitted to cross into the bus lane to make a right turn. These lane marking comply with current MUTCD standards for preferential lanes.²
- *A major street with a red curb bus lane:* 34th Street at Lexington Avenue. This bus lane features a solid white line, with red coloration continued to the intersection. Signage indicates to drivers that it is permitted cross into the lane to make a right turn.³



34th Street and Lexington Ave: right turn from a red bus lane



Third Ave and 42nd Street: right turn from a standard (non-red) bus lane

Right turn behavior was observed at each location for three one hour periods: an AM peak hour (8-9 AM or 9-10 AM), a midday hour (12-1 PM or 1-2PM), and a PM peak hour (4-5 PM or 5-6 PM). Data was collected on Thursday June 2, 2011. Observers focused on a single movement and recorded the number of right turns made from each lane, e.g. the curb lane, first travel lane, second travel lane, etc. Observers recorded the data in 15 minute increments and noted any blockages of the bus lane, e.g. a delivery truck standing in the bus lane, a vehicle illegally parking in the bus lane, etc. The data from those time periods in which a blockage occurred were then excluded from the analysis of right turning behavior, as right turning vehicles could not use the bus lane during these periods.

² 2009 MUTCD, section 3D.02, p. 419.

³ Note that this design was installed in 2008 and does not include a dashed edge line, as NYCDOT is now recommending. This does not affect the validity of the test, as the 34th Street design provides fewer visual cues to drivers than the recommended design (Plan 2), and therefore the test remains conservative.

Results

Chart 4 below presents the results of the observations.

Chart 4: Effect of Red Lane Treatment on Right Turn Behavior

	Standard Curbside Bus Lane: NB right turn from Third Ave onto 42nd St		Red Curbside Bus Lane: EB right turn from 34th St onto Lexington Ave	
	% RTs from bus lane	% RTs not from bus lane	% RTs from bus lane	% RTs not from bus lane
AM	72%	28%	62%	38%
Midday	72%	28%	68%	32%
PM	65%	35%	70%	30%
TOTAL	69%	31%	66%	34%

As the data shows, roughly two-thirds of the right turning vehicles in both types of bus lanes (standard and red treated) made the right turn from the bus lane, as intended. Roughly one third made the turn from the lane adjacent to the bus lane or from the center of the roadway. There is no significant difference in the right turn behavior of vehicles between the standard bus lane and red bus lane. The data indicate that the red treatment does not have a negative impact on right turn behavior.

V. Red Treatment Product and Processes Evaluation: Summary of Methodology and Results

In the fall of 2010, NYCDOT launched a study to identify more durable red lane treatment options. NYCDOT has encountered problems with the durability of our current product on older asphalt and concrete surfaces (the product has performed satisfactorily on new asphalt surfaces). NYCDOT is partnering with the Thomas D. Larson Pennsylvania Transportation Institute (PTI) at the Pennsylvania State University for this effort. Through a request for information and market research, NYCDOT identified eight products to test. NYCDOT and PTI are now conducting both field and laboratory tests of the eight products. The full results of this testing will be completed by fall of 2011, and NYCDOT can share the results with FHWA if desired.

VI. Recommendations

Based on the results of the analysis on Fordham Road and First Avenue, NYCDOT feels that the red treatments has proven effective in reducing unauthorized vehicle occupancy of bus lanes. This treatment is most effective when combined with active enforcement of the bus lane rules and well designed bus lanes. The benefits of the red treatment also come without negative impacts on non-bus vehicle behavior. The red treatment does not dissuade drivers from legally parking in a bus lane when the bus lane regulation is not in effect, and the red treatment does not result in an increase in unsafe right turn behavior. Given this data, as well as our positive operational experience with the lanes and their safety, NYCDOT recommends adding red coloration for bus lanes to the MUTCD.