The L Train Shutdown:
A preliminary assessment of proposed NYC DOT and MTA mitigation measures

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Forward
Transportation Alternatives contracted BRT Planning International (BRTPlan) to evaluate the ramifications of the pending L Train shutdown and assess the adequacy of the proposed New York City Department of Transportation (NYCDOT) and Metropolitan Transportation Authority (MTA) response.

This report contains that evaluation as of January 2018. It is based on the information that has been released by NYCDOT and MTA to the public, supplemented by BRTPlan's own data collection. As NYC DOT and MTA release additional data and plans, the conclusions will be updated, and some changes may be made.
Executive Summary
The L Train, between Eighth Avenue in Manhattan and Bedford Avenue in Brooklyn, will be closed for approximately 15 months, beginning in April of 2019. This shutdown is necessary to finalize repairs to damages caused by flooding from Superstorm Sandy. The potential cataclysm that this represents cannot be overstated. The L Train, which moves an estimated 400,000 passengers a day, is one of highest demand subway lines in New York City and the US.

In December 2017, NYCDOT and MTA jointly released an L Train shutdown mitigation plan. The street design measures included in this plan are bold and necessary. The replacement bus routes serve the most adversely affected commuters and are direct and short. With minor changes, this plan could significantly mitigate the problem.

However, the scale of the shutdown is so considerable that even these bold measures do not go far enough. If more is not done to increase transit speeds, many L Train passengers will switch to cars and taxis, significantly worsening today’s already severe congestion. The current response to the problem relies heavily on Select Bus Services (SBS). Most SBS routes operate at between 6 and 7 mph. New York City can do better.

Bus Rapid Transit (BRT) systems across the US average speeds between 11 mph and 17 mph. If the L Train replacement services take the form of SBS, this will be a significant improvement over standard shuttle buses, but not sufficient to avoid severe bus congestion on 14th Street. Bus speeds will drop below normal SBS speeds to under 3 mph; there will be severe traffic impacts across the city; and significant time loss for up to a hundred thousand daily commuters.

We therefore make the following key recommendations:

**Recommendation 1: 24/7 operation of exclusive bus facilities.**
High ridership on the L Train is not clearly limited to peak hours. L Trains are often packed throughout the day, and on nights and weekends, and congestion on 14th Street is constant throughout the day. Many of the sidewalk improvements included in NYCDOT/MTA's plan are only viable if the exclusive busway operates 24 hours. If the peak period can handle the loss of a mixed traffic street, so too can the off-peak, when traffic is lighter. Local deliveries and parking garage access will still be possible via the busway.

**Recommendation 2: Extend the 14th Street busway and add more bus lanes in Brooklyn.**
The proposed routes extend well beyond the dedicated bus lanes. The 14th Street busway should extend from the Ferry Terminal to 9th Avenue and if extending it that far is too challenging, then to at least Avenue A. The highest bus ridership on 14th Street will be between the Ferry Terminal on the far east side, and Union Square in the AM peak. Berry and Roebling Streets in Williamsburg should also have dedicated bus lanes or bus speeds in Williamsburg will be extremely slow: Today, the Bedford L Station is one of the highest volume subway stations in New York City. The Grand Street shuttles should have a stop at or nearby Borinquen Place to better serve the large segment of population currently boarding at Lorimer Station, as well as many passengers displaced by overcrowding at the Marcy Avenue J/M/Z.
Recommendation 3: Design bus stops to handle much higher passenger volumes.

All bus stops on the 14th Street SBS and the Brooklyn shuttles will have very heavy passenger volumes. There will need to be two places where each bus can allow passengers to board and alight, with enough space in between for bus passing.

NYCDOT/MTA’s plan shows bus stops right up against the intersection, which can quickly jam up the busway. Bus stops should be set back at least 65’ and ideally 130’ from the nearest intersection to allow buses to clear the station for the next bus.

Bus stops should be level with the bus floor. At-level boarding can cut the boarding time for each passenger by about half a second and can save more than a minute and a half for each wheelchair user. It also makes for a more pleasant boarding experience.

Recommendation 4: Restrict vehicular turns across bus lanes.

Bus lanes in New York City allow mixed traffic to enter them to turn right. Wherever right turns are allowed across bus lanes (i.e., all planned bus lanes outside of the 14th Street busway), they will cause significant delay to buses. Hence, all turning movements that can be practically forbidden across the proposed bus lanes should be removed.

Recommendation 5a: Make all 14th Street and Brooklyn shuttles free.

NYCDOT/MTA’s plan on the 14th Street Select Bus (SBS) Route is for passengers to pay off-board, with periodic inspections once onboard. As with the other SBS routes, inspectors must stop the whole bus to perform the inspection. Any delay on 14th Street will lead to gridlock in the busway at those volumes. Further, it is not clear from the plans whether or not the M14A and M14D will also benefit from off-board fare collection. If not, they will continue to operate as pay on board, front-door only, meaning that the 14A and 14D will block the 14th Street busway, even if the other 14th Street recommendations are taken. No fare payment plan has been released for the Brooklyn shuttle bus routes.

Normally when a subway line is shut for repairs, it is replaced by a free shuttle bus. This helps offset the inconvenience of losing a subway line, but also greatly hastens the boarding process.

Recommendation 5b: Alternatively, implement pre-paid zones at all bus stops: If the MTA determines that it cannot afford to make all the services free, the other way to address the boarding delay is to create pre-paid zones. Like in a subway station, bus passengers would enter a bus stop or station by paying their fares, and then passing through a barrier (a turnstile, or even a painted line). This would allow all buses, including the 14A and D, to benefit from pre-paid all-door boarding and would avoid the problem of periodic inspection delays.

If these measures are implemented, travel time for passengers adversely affected by the L Train could be minimized to the maximum extent technically feasible given the time and budget. Moreover, as these measures would have the greatest chance of retaining transit passengers inside the transit system, they have the greatest chance of minimizing traffic congestion. Finally, they would also allow NYCDOT and MTA to simultaneously pilot several key innovations. Implementing these measures will be the difference between a mild inconvenience and a stuck-on-the-bus nightmare.
Introduction

The Manhattan section of the L Train, and the Canarsie Tunnel of the L train between 1st Avenue in Manhattan and Bedford Avenue in Brooklyn, will be closed for approximately 15 months, starting in April 2019.

The potential cataclysm that this represents cannot be overstated. The L train which moves an estimated daily 400,000 passengers, is one of the highest volume single subway lines in the United States.

Approximately 225,000 daily passengers, or about 22,500 peak hour passengers, that currently enter Manhattan from Brooklyn through the L Train’s Canarsie Tunnel, will now have to reach their destinations in some other way. Even with the L Train in operation, it is frequently heavily overcrowded, the nearby bridges and tunnels across East River are badly congested, and most of the subway services that cross the East River are nearing capacity. What’s more, the extensive up-zoning of the Brooklyn waterfront has led to an unprecedented scale of new development and new transit trips dependent on the L Train, many of them Manhattan-bound.

In addition, the 50,000 daily passengers that currently use the L Train within Manhattan only, will have to make their trip in another way; most likely by walking, cycling or surface bus.

What if NYC DOT and MTA “Do Nothing”?

While many cities such as London, Washington DC, and even New York have faced major subway line repairs in the past, these problems have almost always been dealt with by evening and weekend closures. The authors of this report could discover no precedent for such a major subway line to be closed entirely for such an extended period of time. No one, including at the MTA or NYC DOT, is really sure what is going to happen.

Gridlock for Cars and Trucks

Given that the Williamsburg Bridge is already heavily congested, not only in the morning but pretty much all day (Figure 1), even a very small increase in car traffic on the bridge can have dire consequences. If all the displaced L Train passengers tried to take an Uber or Lyft into Manhattan, there would need to be between 12 and 19 additional bridge and tunnel lanes, and since there is zero additional bridge and road capacity, the result would be miles of gridlock lasting much of the day.

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1 MTA and NYC DOT “Fixing the L Line’s Canarsie Tunnel.” June 8, 2017.
2 Ibid.
3 Absent better data, it is typical to estimate peak hour, peak direction ridership at 1/10 daily ridership
4 The capacity of a mixed traffic lane is a function of the expected speed or ‘level of service’ (LOS) for a given number of passenger car units (PCUs), which will carry a variable number of passengers. If one assumes 1,000 PCUs per hour per lane and 1.2 passengers per vehicle, which is fairly typical, this would be a reasonably good LOS (B, more or less), as according to the Highway Capacity Manual. This yields 1,200 passengers per lane per hour. Either a lower LOS (D) or a greater number of
On the Manhattan side, there are currently about 3,000 peak hour peak direction bus passengers traveling along 14th Street on the M14A and M14D, and another 5,000 peak hour peak direction L Train passengers with origins and destinations within Manhattan. If the 5,000 L Train passengers switched to private cars, taxis, or Ubers, it would require between three and four extra lanes in the peak flow direction to keep the road from gridlock. Clearly, it is impossible to widen 14th Street; neither of these scenarios are realistic, but very significant gridlock is a real possibility even if only a few passengers switch to cars.

Traffic congestion on 14th Street, like most Manhattan crosstown streets, is ubiquitous throughout the day, with no clear peak during rush hour and no clear decrease except in the early morning and late evening.

In other words, it takes only a few people becoming frustrated with the L Train replacement services to make a bad traffic situation a nightmare.

**A Very Long Commute for L Train Riders**

If NYC DOT and the MTA “Do Nothing”, L Train riders that choose to remain on transit will be greatly impacted. Trips between Williamsburg, Greenpoint, and inner Bushwick and the 14th Street corridor in Manhattan will be worst affected. Figure 2 shows the likely shortest path transit trips in the "Do Nothing" scenario.

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5 passengers per vehicle would yield a higher number of passengers per lane per hour, yielding a reasonable maximum of about 2,000. So 22,500/2000 = 12 and 22,500/1200 = 19. The number is for illustration purposes only.

6 MTA and NYC DOT “Fixing the L Line’s Canarsie Tunnel.” June 8, 2017.

7 The authors used Google Maps "Typical Traffic" to view traffic speeds on 14th Street at various times throughout the day.
Figure 2: New trips / shortest path for existing trips between L Train stations

Figure 3 shows the estimated increases in travel times that L Train riders, traveling between L Train stations and other common destinations, are likely to face once the L Train shuts down. This table was created based on a shortest path analysis, using the existing MTA system, as well as existing ferries.

L Train riders (around 55,000 daily) from East Williamsburg and the Williamsburg waterfront to the East Village face up to 35 minutes of additional travel time. This is because there are few ways to get to First Avenue and 14th Street besides the L Train. Many other trips are also adversely affected.

Over the course of 15 months, this results in a loss of roughly 25 million person-hours\(^9\). Using a reasonable value of travel time\(^{10}\), this is going to cost the residents of North Brooklyn and the 14th Street Corridor about $125 million. Impacts to businesses are much higher.

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\(^{8}\) This analysis assumes new 6 minute headways on remaining L Train but does not account for slower bus and subway speeds due to higher frequencies and ridership.

\(^{9}\) 55,000 L passengers affected * 35 minutes of average additional travel time * two (i.e., 2 times a day) * 300 days a year * over the course of 15 months (or 1.25 years) / 60 (i.e., minutes into hours) = 25 million person-hours

\(^{10}\) Transport economists typically use 1/3 of hourly per capita income to estimate a value of travel time. This works out to $5.00 an hour for New York City.
In December 2017, MTA and NYC DOT jointly released an L Train shutdown mitigation plan. The plan can be broken down into four main areas, with the responsibility for each area resting on either MTA or NYC DOT:

- Transit routing (MTA)
- Subway Stations (MTA)
- Street design (NYC DOT)
- Fare collection (MTA/NYC DOT)

**Transit Routing**

As MTA is responsible for operating transit services, the agency developed a service plan, then analyzed which services - rail and bus - would become the most prominent alternatives for L Train riders.

![MTA's Service Plan Map](image)

*Figure 4: MTA’s map of planned transit services (bus, subway, ferry) to operate during the L Train shutdown*

MTA’s service plan map depicts the following service plan affecting existing L Train riders:
1. **L Train:** The L Train will still be operational between Bedford Avenue Station and points east, but out of service from Bedford, under the East River, and across 14th Street in Manhattan.

2. **G Train:** The G Train is shown as a major subway-based alternative, with improvements at several stations which allow displaced L Train riders to transfer from the G Train onto a Manhattan-bound subway alternative.

3. **J/M/Z Trains:** The J/M/Z Trains are also shown prominently in the MTA’s service plan as major Manhattan-bound subway alternatives offering a direct ride into Manhattan.

4. **Shuttle Buses:** The most notable addition to the MTA service plan map is a set of new shuttle bus replacement services. These include:
   a. A shuttle bus route from the Grand Street L Station in Brooklyn, across Grand Street and the Williamsburg Bridge, and up 1st Avenue (down 2nd) to terminate at 14th Street
   b. A shuttle bus route operating as a one-way pair on Bedford Avenue and Roebling Street, across the Williamsburg Bridge, and terminating at the Spring Street 6 Train Station.
   c. A new Select Bus Service (SBS) route picking up passengers from a new East River Ferry terminal at East 20th Street in Manhattan, traveling south to 14th Street, and across 14th Street to the West Side Highway.

5. **Ferry services:** A new ferry route will operate from North Williamsburg to East 20th Street in Manhattan.

*The MTA’s service plan, taken on its own, is reasonable for replacing the lost trips.* The routes serve the most severely impacted areas well, with direct trips providing extensive connections to subway lines. The main concern we have with the services is that the Grand Street shuttle bus route makes no stops in Brooklyn other than at the Grand Street L Station. The Grand Street shuttle bus route is designed as if most of its passengers are coming from the still-operating eastern portion of the L Train, and transferring in order to get into Manhattan. This will indeed account for some of the Grand Street shuttle bus passengers; however, L Train passengers coming from points east have the alternative of using the Canarsie-bound L Train to transfer to the M or A Trains. At least as affected, will be those passengers currently boarding the L Train at Lorimer Station as well as passengers attempting to board the J/M/Z at Marcy station but unable to access the platform due to crowding conditions (see section "Subway Stations"). An additional stop on the Grand Street shuttle bus routes near Borinquen Place or elsewhere on Grand Street is recommended.

After developing these services, the MTA ran its transit model to estimate passenger volumes on each of the major bus and subway alternatives. The MTA assumed that its subway lines have enough capacity to absorb about 85% of the demand from former L Train passengers\(^\text{11}\), and that the remaining 15% percent would need to be accommodated with shuttle buses.

\(^{11}\) MTA and NYC DOT “Fixing the L Line’s Canarsie Tunnel.” June 8, 2017.
Figure 5 shows the results of MTA’s model run (the thicker the line, the more expected passengers). The speeds assumed by this modeling exercise are unknown.

These model results indicate that the most popular alternative for displaced L Train riders will be to shift to the M and J Trains, beginning their trips at the Lorimer, Hewes, and Marcy J/M/Z Stations. The next most popular alternative for displaced L Train riders will be to shift to the G Train and transfer at Court Square for the M, E, and 7 Trains.

Our visual estimate of the new travel paths for the 22,500 AM peak hour Manhattan-bound L Train passengers, based on MTA’s map in Figure 5, is as follows:

- J/M/Z: 10,000
- G to Court Square: 5,000
- Shuttle buses: 3,800
- Ferry: 1,500
- Other: 2,300

This analysis seems largely correct; however, while the trains may have the capacity to absorb 85% of the former demand, several critical station platforms do not, and will constitute bottlenecks. The next section describes in detail the capacity constraints of Marcy and Court Square Stations, concluding that only 75% of current L Train Riders, can actually be accommodated by the subway system.
While 75% of L Train passengers can be accommodated on the subway system (with some increased frequencies and additional cars on the G Train) they will be significantly inconvenienced. Passengers traveling between North Brooklyn (Williamsburg, Greenpoint, and Bushwick) and the 14th Street Corridor between Union Square and points east, are the most inconvenienced, with additional travel times of between 30 and 40 minutes.

If the speeds on the shuttle bus replacement services are increased as a result of including various design elements, then they would draw even more passengers from cars and the subway alternatives. Since MTA released only the map shown in Figure 5 and not an explanation of what speeds it assumed the shuttle buses would travel (nor the design elements it assumed would be included in order to achieve those speeds), the number of passengers it assumes will take the buses could vary significantly.

As the shuttle bus routes are highly direct, they would also mitigate a lot of the time loss caused by the L Train shutdown, and after the L Train service is restored, they may prove worth retaining as a way of alleviating ever worsening overcrowding on the L Train.

**Subway Stations**

The Marcy J/M/Z Station is by far the closest alternative to the Bedford L station for a vast number of L Train riders in Central Williamsburg and the Williamsburg waterfront. After measuring the platforms and calculating the platform capacity, we estimated that the platform is currently at about 56% capacity.

![Figure 6: Current platform crowding, Marcy Station, 10am](image)

The basis of this calculation is shown in Figure 7. The results are sensitive to how one defines the space required per waiting passenger. In the US, capacity is commonly defined as 10 square feet per waiting passenger, while internationally even 3 square feet per person is sometimes considered capacity. The calculations below already consider a very tight 5 feet per waiting passenger.
The current level of platform saturation is calculated based on a waiting capacity which requires two feet of width for a safety zone (the yellow stripe) and three feet of width for circulation up to 2,000 passengers per hour. Given Marcy’s 8-foot wide platforms, this leaves only 3 feet for waiting passengers times the usable platform length (392-feet) or 1176 square feet of usable space. Divided by five feet per passenger yields 235 passengers that can wait per train. Irregularity diminishes the platform capacity, and we used a standard irregularity index of 0.3 which means that the average deviation from the scheduled headway is around 30%. Passenger capacity per train is adjusted downward by this 30%, or 165 passengers per train. We estimate that the maximum frequency that the J/M/Z can handle is about 15 trains per hour, so 165 * 15 = 2,470 passengers per hour. Given an estimated 1,380 passengers per hour, this yields a current level of station saturation at 56%.

With the L Train shutdown, we estimate that another 1,872 passengers would attempt to use Marcy Station (half of the Bedford peak hour boardings and one third of the Lorimer peak hour boardings). We estimate that about 800 passengers will be unable to access the station due to overcrowding during the peak hour. Though the MTA plans some improvements to Marcy Station, we do not see how the platforms can be significantly expanded.

Another significant bottleneck exists on the E/M platform at Court Square Station (Figure 8). Using a similar methodology as above, we estimate that about 1,200 passengers will be unable to use the Court Square E/M platform.
In total, only about 75% of the current Manhattan-bound L passengers can be accommodated by the existing subway services, due to platform bottlenecks. This is in line with the MTA’s recently revised estimate of 70% - 80% can be accommodated by other subway lines. In other words, another 2,000 peak hour passengers will be unable to access their nearest alternative subway station due to overcrowding. Whether they are drawn to take shuttle buses or end up in cars causing a massive additional traffic jam will largely depend on the speed and convenience of the shuttle services.

Street Design

While bus and subway operation is the realm of MTA New York City Transit, street design is managed by New York City Department of Transportation (NYC DOT). As such, street treatments to prioritize the shuttle bus replacement services are the responsibility of NYC DOT.

While NYC DOT has not released conceptual designs for the roads on which these services will operate, some sketch-level designs have been released for 14th Street and for Grand Street in Brooklyn.

One commonality across all of the designs and plans is the uncertainty regarding the hours of operation for exclusive bus facilities, including bus lanes.

Recommendation 1: All bus exclusive bus lanes should operate 24 hours a day, 7 days a week. High ridership on the L Train is not limited to peak hours. L Trains are often packed throughout the day, including on nights and weekends. Many of the sidewalk improvements included in NYCDOT/MTA’s plan are only viable if the 14th Street busway operates 24 hours. If the peak period can handle the loss of a mixed traffic street, so too can the off-peak, when traffic is lighter. Local deliveries and parking garage access will still be possible on most, if not all, of the planned bus lanes.
Design for 14th Street

Preliminary information released by NYC DOT shows that 14th Street between 8th and 3rd Avenues is planned to be bus- and local deliveries-only. The hours of these restrictions is yet to be determined.

Figure 9: General strategy for 14th St. busway, NYC DOT and MTA

Discussions with NYC DOT indicate that this 14th Street busway will include one lane for buses in each direction except at stops where there will be two lanes in the direction served by the bus stop. Due to significantly heightened pedestrian volumes, NYC DOT is proposing widened sidewalks and pull-over areas for delivery vehicles. The stops are depicted as being immediately before or after the intersection. No bike lanes are included; two directional parking-protected bike lanes have been included on 13th Street. University Place and Union Square West would no longer function as through streets and would become new public spaces. Finally, there are no plans to make the bus stop platforms level with the bus floor.

MTA predicts that there will be about 70,000 daily passengers using 14th Street buses under the current plan. These come from the following three sources:

- Ferry passengers
- Current M14A and M14D passengers, which will continue
- Former L Train passengers

The following are our recommendations for modifying the 14th Street designs in order to ensure that the buses move at speeds approaching those of the L Train:

Recommendation 2: Extend the 14th Street busway from the Ferry Terminal to 9th Avenue, or otherwise, at least to Avenue A. The highest bus volumes on 14th Street buses will be between the Ferry Terminal and Union Square in the morning peak (see "Combined Maximum Load" in Table 1). If 14th Street is open to mixed traffic between 3rd and 1st Avenues, as is currently planned, buses will get stuck in traffic. Moreover, high volumes of vehicles will need to turn off of 14th Street before the start of the busway, creating a significant risk that turning vehicles will block the buses, and causing significant delays.

After Union Square, the highest volume boarding station on the 14th Street busway in the morning peak will be at First Avenue (see "Combined Boardings" in Table 1). This station should ideally be situated...
between First Avenue and Avenue A in the westbound direction to avoid forcing transferring passengers to cross the street. 14th Street also widens significantly east of 1st Avenue. The station should be between 1st and 2nd Avenue in the eastbound direction for the same reason (i.e., the Brooklyn shuttle buses will use 2nd Avenue in the southbound direction). As additional road width is needed to provide passing lanes at this station, the busway is going to already consume a minimum of four lanes. 14th Street remains two traffic lanes and a parking lane per direction from 1st Avenue to the East River, but there is a wide service lane that could theoretically be reconfigured.

**Recommendation 3a: Platforms level with the bus floor.** At-level boarding is key to significantly reducing the time it takes for riders to get on and off New York City subway cars. Buses with "all-door boarding" take an average of two seconds per passenger to board and one second to alight.\(^\text{12}\) \(^\text{13}\)

While this does not seem high, it adds up to a lot of time when you multiply this by thousands of peak hour passengers at the highest demand stops. The step up into the bus does not exist on New York City subway cars, which is one element in their very high capacity. With at-level boarding, boarding time can be reduced to one second or less and alighting time to 0.6 seconds or less.\(^\text{14}\)

![Figure 10: Person exiting an SBS bus, taking a step down to the street](image)

This is largely because it takes a lot less time for elderly passengers, passengers in wheelchairs, passengers with shopping carts, or luggage to enter the bus at-level.

\(^\text{12}\) SFMTA, 2014. "All Door Boarding, Final Report"  
\(^\text{13}\) Seattle DOT, 2016. "Third Avenue Dwell Time Study, Final Report"  
\(^\text{14}\) Based on extensive international and domestic examples, at-level, all-door boarding can reduce the dwell time per boarding passenger to 1 second or less, and to 0.6 seconds per alighting passenger. This is conservatively estimated, as TransMilenio in Bogota achieves 0.4 seconds per boarding passenger and 0.2 seconds per alighting passenger, but it does so with a variety of small additional measures (4 doors, wider doors, specific internal bus design issues).
This does not even factor in the impact of wheelchair access. Wheelchair boardings were measured and counted in Seattle. We observed the amount of time caused by each wheelchair ramp deployment on 14th St, and every boarding or alighting wheelchair-bound passenger added approximately two minutes of extra time.

Figure 11: Seattle measured delay per wheelchair boarding and total wheelchair boardings

NYC DOT should count the number of wheelchair deployments on 14th Street during the peak hour and time them so that a better estimate can be made of the time wheelchair-bound passengers add to boarding and alighting time without at-level boarding.

At-level boarding is increasingly widespread in BRT systems in the US. Cleveland, Eugene, San Bernardino, Hartford/New Britain, Grand Rapids, and Albuquerque have all successfully designed station platforms at-level with the bus floor.

Figure 12. There are six US BRT systems with at-level boarding

At-level boarding, with such a short timeframe, will require the fabrication of temporary rubber or steel platforms that can be built remotely and bolted to the roadway rapidly in the same manner as the Citi
Bike docking stations and the bus bulbs on the Bedford/Nostrand SBS Corridor (which, incidentally, were not raised to the level of the bus floor). Portions of the at-level boarding platforms in Grand Rapids, Michigan were prefabricated.

*Figure 13. Example of a bus bulb in Brooklyn that can easily be installed and removed. It could easily be made level with the bus floor.*

In the early phases of SBS planning, there were concerns about drainage with platform level boarding. NYC DOT has since resolved the drainage issue by the design used on 34th Street SBS.

*Figure 14. Bus bulb on 34th Street SBS set away from the curb to allow drainage. This platform could have been raised to the level of the bus floor to help wheelchair users.*

**Recommendation 3b: Set the stations back from the intersections.** Placing bus stops close to intersections seems like a good idea because of the convenience to the cross street where there may be
other bus routes or subway stations. However, once bus headways drop, the risk of conflict between the bus stop and the intersection increases significantly. This is why the BRT Standard recommends setting stations back from intersections by at least 85 feet.  

In Kunming, China (Figure 15, left), the bus stop is placed just after the intersection. When the traffic light changes, only three of the six buses waiting will be able to move through the intersection as the station still contains buses. The remaining three will need to wait at the traffic signal despite the green light. While they are waiting, the next series of buses will arrive, generating a bus queue.

In Taipei (Figure 15, right), the station is before the intersection. The buses in front have already finished boarding passengers but they are waiting for the signal to change. The buses behind are not able to access the station because they cannot reach the bus stop.

Either configuration reduces the capacity of the busway to three buses per signal phase. The problem is easily solved by setting the station back from the intersection by two bus lengths. Unless NYC DOT sets its 14th Street stations back from the intersections, major backups, like those in Kunming and Taipei, will occur.

**Estimated Impact of 14th Street Recommendations**

In order to estimate the impacts of the above recommendations, we first estimate how many of the roughly 7,000 peak hour, peak direction passengers will board and alight at each proposed bus stop (Table 1).

These figures are estimated from boarding and alighting counts on the 14A and 14D and estimated boarding and alighting percentages on the L Train. We assume that the faster SBS 14th Street Shuttle would draw away passengers from the 14A and 14D local services, so that only about 2,000 are left, and

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The remaining 5,000 peak hour passengers will be on the SBS 14th Street Shuttle. The MTA should be able to generate more accurate numbers which would improve the quality of the estimate.

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</table>

Table 1: Estimated Boarding, Alighting, and Loads, 14th St AM peak

In Table 2, the variable dwell time at each station under the MTA/NYC DOT plan is shown. First, the boardings for the 14A and 14D from Table 1 are multiplied by 4.6 seconds per boarding passenger based on empirical counts of the time it took each person to board, in the absence of the need to deploy a wheelchair lift. The alightings are then multiplied by one second per passenger based on empirical observation. For the 14th Street SBS service, we do not have locally collected information about how much time boarding takes per passenger. However, two studies of similar systems in the United States,\(^{16}\)\(^{17}\) conclude that dwell time per passenger for all-door boarding in a three door bus in a dense urban area is roughly two seconds per boarding passenger and about one second per alighting passenger.

The necessary frequency is derived by dividing the maximum "Load" from the combined services (Table 1) by the bus capacity (assumption is that the buses will be articulated buses with a capacity of 128 passengers). This results in a required frequency of eight per hour for the 14A and 14D and 17 per hour for the new shuttle bus service, or 25 buses per hour in total on 14th Street.

Each time a bus pulls up to a bus stop it must slow down, and open and close its doors, which takes about 16 seconds per bus. This is known as fixed dwell time and calculating total fixed dwell time per station over the course of an hour is a matter of multiplying the total frequency times the fixed dwell time. The total dwell time is then derived by adding the variable dwell times for the 14A and 14D and the 14th Street SBS service to the total fixed dwell time.

Next, as it may be the case that all critical stations have more than one sub-stop where a bus can board and discharge passengers, the total dwell time is divided in two assuming the buses will be divided equally between the two sub-stops.

Presented next is the total dwell time if all-door-boarding is also introduced onto the 14A and 14D ("All SBS" in Table 2). To do this, the boarding time per 14A and 14D passenger is reduced from 4.6 to 2.

Finally, the dwell time is calculated in the case that the bus stops are also level with the bus floor ("Level Boarding" in Table 2). Based on extensive international and domestic examples,\(^{18}\) at-level, all-door-boarding can reduce the dwell time per boarding passenger to one second or less, and to 0.6 seconds.

\(^{16}\) SFMTA, 2014. "All Door Boarding, Final Report"

\(^{17}\) Seattle DOT, 2016. "Third Avenue Dwell Time Study, Final Report"

per alighting passenger. This is conservatively estimated, as TransMilenio in Bogota achieves 0.4 seconds per boarding passenger and 0.2 seconds per alighting passenger, but it does so with a variety of small additional measures (four doors on buses, wider doors, specific internal bus design issues).

<table>
<thead>
<tr>
<th>Bus Stop</th>
<th>Variable Dwell Time</th>
<th>Total Dwell Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M14AD</td>
<td>14 SBS</td>
</tr>
<tr>
<td>Ave C, Ferry</td>
<td>1,353</td>
<td>3,000</td>
</tr>
<tr>
<td>Ave B, A</td>
<td>2,638</td>
<td>-</td>
</tr>
<tr>
<td>1st Ave</td>
<td>2,279</td>
<td>3,125</td>
</tr>
<tr>
<td>3rd Ave</td>
<td>778</td>
<td>1,123</td>
</tr>
<tr>
<td>Union Square</td>
<td>2,447</td>
<td>5,403</td>
</tr>
<tr>
<td>6th Ave</td>
<td>1,021</td>
<td>1,824</td>
</tr>
<tr>
<td>8th Ave</td>
<td>635</td>
<td>403</td>
</tr>
<tr>
<td>10th Ave</td>
<td>48</td>
<td>121</td>
</tr>
</tbody>
</table>

Table 2: Calculation of dwell time, Current Proposal

The result is that with each additional measure accepted into MTA/NYC DOT’s plan, the total dwell time drops at each station. The lower the dwell time, the faster the buses will move and the less likely the 14th Street busway is to saturate.

Next, the degree of station saturation for each planned stop along the 14th Street busway is presented. To do this, we take the total dwell time per bus stop per hour and divide it by the number of seconds available per hour (3,600). Due to the irregularity of the arrival of buses, a bus stop is considered to be at risk at a saturation rate of anything over 0.4.19

<table>
<thead>
<tr>
<th>Bus Stop</th>
<th>MTA/NYCDOT Plan</th>
<th>MTA/NYCDOT Plan 2 substops</th>
<th>All SBS 2 substops</th>
<th>All SBS Level boarding 2 substops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave C, Ferry</td>
<td>132%</td>
<td>66%</td>
<td>55%</td>
<td>30%</td>
</tr>
<tr>
<td>Ave B, A</td>
<td>84%</td>
<td>42%</td>
<td>21%</td>
<td>14%</td>
</tr>
<tr>
<td>1st Ave</td>
<td>161%</td>
<td>81%</td>
<td>65%</td>
<td>36%</td>
</tr>
<tr>
<td>3rd Ave</td>
<td>64%</td>
<td>32%</td>
<td>27%</td>
<td>17%</td>
</tr>
<tr>
<td>Union Square</td>
<td>229%</td>
<td>115%</td>
<td>104%</td>
<td>61%</td>
</tr>
<tr>
<td>6th Ave</td>
<td>90%</td>
<td>45%</td>
<td>39%</td>
<td>23%</td>
</tr>
<tr>
<td>8th Ave</td>
<td>40%</td>
<td>20%</td>
<td>16%</td>
<td>12%</td>
</tr>
<tr>
<td>10th Ave</td>
<td>16%</td>
<td>8%</td>
<td>8%</td>
<td>7%</td>
</tr>
</tbody>
</table>

Table 3: Estimated bus stop saturation and speeds under different scenarios

The results show that with two sub-stops at each platform and both 14th Street SBS services and 14A and 14D local services operating as planned, the 1st Avenue station is at grave risk of saturation and the Union Square station is almost certainly going to saturate, meaning that buses will be severely backed.

19 BRT Planning Guide, 4th Edition, Chapter 7, Figure 7.5: https://brtguide.itdp.org/branch/master/guide/system-speed-and-capacity/understanding-station-saturation
up there during the peak hour, slowing bus speeds to a crawl. We estimate bus speeds at 3 mph but they could be lower.\textsuperscript{20}

If the all-door boarding of the SBS service is also introduced onto the 14A and 14D, then 1\textsuperscript{st} Avenue would still saturate but less so, and Union Square would still badly saturate, but less so. It is possible that in this case, the SBS speeds achieved elsewhere in New York City (6 mph) could be achieved.

With at level boarding, however, there is very limited risk of station saturation, and a reasonably good chance that bus speeds could be increased to 12 mph.

<table>
<thead>
<tr>
<th>Corridor</th>
<th>Speed (mph)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pittsburgh West Busway Pennsylvania,</td>
<td>34</td>
<td>[ii]</td>
</tr>
<tr>
<td>Pittsburgh Martin Luther King, Jr. East Busway</td>
<td>34</td>
<td>[vi]</td>
</tr>
<tr>
<td>Pittsburgh South Busway, Pennsylvania,</td>
<td>34</td>
<td>[iii]</td>
</tr>
<tr>
<td>Ottawa Transitway, Canada</td>
<td>32</td>
<td>[i]</td>
</tr>
<tr>
<td>Orange Line, Los Angeles</td>
<td>20</td>
<td>[v]</td>
</tr>
<tr>
<td>Bogotá, Colombia, TransMilenio</td>
<td>17</td>
<td>[vi]</td>
</tr>
<tr>
<td>Curitiba, Brazil, Linha Verde</td>
<td>16</td>
<td>[vi]</td>
</tr>
<tr>
<td>Beijing (Lines 1, 2, 3, 4)</td>
<td>15</td>
<td>[vi]</td>
</tr>
<tr>
<td>Ahmedabad, India, Janmarg</td>
<td>15</td>
<td>[vi]</td>
</tr>
<tr>
<td>Guangzhou, China, GBRT</td>
<td>14</td>
<td>[vi]</td>
</tr>
<tr>
<td>Las Vegas Metropolitan Area Express (MAX)</td>
<td>14</td>
<td>[vi]</td>
</tr>
<tr>
<td>Curitiba, Brazil, RIT corridors</td>
<td>11</td>
<td>[vi]</td>
</tr>
<tr>
<td>Cleveland HealthLine</td>
<td>11</td>
<td>[vi]</td>
</tr>
<tr>
<td>Mexico City, Mexico, Insurgentes</td>
<td>11</td>
<td>[vi]</td>
</tr>
<tr>
<td>Eugene Emerald Express Green Line (EmX)</td>
<td>11</td>
<td>[vi]</td>
</tr>
</tbody>
</table>

Sources:

Table 4: Comparative observed speeds on other Bus Rapid Transit corridors

Table 5 shows the impact of these same measures on station saturation in the eastbound PM peak. It is roughly similar to the westbound AM peak except the 8\textsuperscript{th} Avenue stop is at greater risk of saturation.

\[\textsuperscript{20}\] It is difficult to project speeds in a hyper-congested situation as an equilibrium will be reached where people simply give up on using transit. Speeds are estimated in the following way: For 'Do nothing', since the corridor would be hyper-saturated, speeds are assumed to reach equilibrium at walking speed. Speeds for the current plan are assumed to be 3 mph, slightly below the current 4.1 mph due to the heavy saturation of the corridor. Speeds with all SBS treatments are estimated based on SBS speeds in other corridors in New York. Speeds in full BRT conditions are estimated from similar BRT systems listed in Table 4.
Table 5: Estimated bus stop saturation on 14th St, eastbound PM Peak

With these estimated impacts on speed, the impact on travel times is estimated as shown in Table 6.

Table 6: Projected travel times (minutes) from the 1st Avenue L Station under different scenarios

Table 6 indicates that a full BRT option on 14th Street, which requires only modest revisions to NYC DOT’s current plans, could help to maintain existing L Train travel times on 14th Street. Current 14A and 14D passengers would even experience an improvement in travel time due to the 14A and 14D buses benefiting from the new treatments.

For trips between Williamsburg and east side of the 14th Street corridor, the new services could not match the current L Train but it could roughly cut the travel times resulting from NYC DOT / MTA’s plan in half, minimizing the number of passengers who switch to cars with generally positive effects on overall traffic congestion. For this to be achieved, the Brooklyn-side street designs must also be implemented and expanded.

**Brooklyn Shuttle Bus Street Designs**

NYC DOT has proposed the following street designs to improve the speed and reliability of the proposed Brooklyn shuttles:

- Grand Street in Brooklyn will be dedicated to buses, bikes, and local deliveries (hours of operation TBD)
- Additional streets will have dedicated bus lanes to accommodate the Brooklyn shuttles:
  - Delancey Street (Manhattan)
  - Kenmare (Manhattan)
• The Williamsburg Bridge will be HOV-3 and truck-only, perhaps with HOV-3 on the inner lanes and bus-and truck-only on the outer two lanes.

**Figure 16: Street design measures for Brooklyn shuttle bus routes**

**Grand Street**
Grand Street is a narrow commercial street that currently has one parking lane, one bike lane, and one through travel lane in each direction. It currently carries extensive truck traffic, both through trips and local delivery.21

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21 Author’s field observations
Today, the main cause of delay is the saturation of the road and turning movements. The bottleneck tends to dissipate under the Williamsburg Bridge access road. The NYC DOT plan is shown in Figure 18.

NYC DOT proposes that Grand Street from the Grand Street L Station at Bushwick Avenue to Rodney Street be open only to buses and trucks. Whether this Grand Street busway will be limited to trucks making local deliveries or trucks more generally has yet to be defined. We support this bold approach,
with the caveat that all of the measures proposed for the 14\textsuperscript{th} Street busway should also be applied to Grand Street, namely the platform-level boarding at stations.

Grand Street widens at Borinquen Place, creating the possibility of adding an additional bus stop for the Grand Street Shuttles that would better serve displaced L Train passengers from Lorimer Station and those unable to board at the overcrowded Marcy J/M/Z Station.

Figure 19 shows a cross section we developed to demonstrate how a Borinquen Place station might be sited.

Designing the bike lane behind the bus stop would significantly reduce conflicts between cyclists and passengers boarding the bus.
Other Brooklyn Streets

The shuttle bus routes that will serve the Bedford L Station are currently scheduled to operate in mixed traffic on Berry and Roebling. Ideally, bus lanes would also be put on these streets. Roebling is one of the few wide streets in the area and could handle a bus lane.

Delancey, Kenmare, and Allen Streets

Bus lanes have also been promised on Delancey, Kenmare and Allen Streets. We support this proposal. For these streets with parallel mixed traffic, an additional measure becomes critical:

**Recommendation 4: Restrict turning movements.**

The Manhattan side exit of the Williamsburg Bridge backs up for much of the day, not primarily because of the capacity of the bridge, but because of the capacity of Delancey and Kenmare Streets. At every intersection, a lane is lost for every turning movement allowed. Vehicles turning right are generally stuck behind crossing pedestrians, and right turns are allowed with a busway in the right lane, the busway will be blocked by the turning movements in the same manner the current M15 SBS is blocked at many intersections. One way to minimize the risk that the Williamsburg Bridge will congest is to disallow right turning movements along Delancey Street, at least as far as Allen Street. Similarly, turning movements should be disallowed on Allen and Kenmare Streets.

Williamsburg Bridge HOV

The MTA/NYC DOT plan is to convert the Williamsburg Bridge into HOV-3 and truck-only. The details have not been released. The Williamsburg Bridge badly congests, in part due to capacity constraints on Delancey Street as discussed above. We support this plan, though recognize that the Williamsburg Bridge may saturate anyway due to the heavy volume of light commercial vehicles. The definition of truck may need to be restricted to trucks of a certain minimum size.
**Fare Collection**

One of the most important causes of delay on buses is the time it takes for passengers to pay their fares. SBS has partially solved this problem with the introduction of off-board fare validation and proof-of-payment inspection. This innovation has significantly reduced per passenger dwell times on SBS services. Precisely how much this method reduces boarding delay should be further studied by NYC DOT and MTA, but studies from other systems indicate it reduces delay to about two seconds per boarding passenger; about a 50% improvement over standard payment methods.\(^{22}\)

However, the current proof-of-payment inspection regime has some disadvantages:

1. **Inspection Delay:** Each time there is an inspection of the M15 SBS route, the bus is stopped while the inspectors walk through the bus checking ticket vouchers. This causes significant delay and is particularly problematic on heavy congested routes where inspectors have a hard time working their way through a crowded bus. It also creates passenger anxiety as there is always the risk of losing the voucher.

2. **Inability to integrate other routes:** Because proof-of-payment does not have an option to pay off-board at some stations and on-board at others, it requires fare kiosks to be installed at all stops along a route. In the case of the 14th Street busway, this means that were NYCDOT to allow all bus routes to benefit from off-board fare collection, every stop along the M14A and M14D would need kiosks, which means many stops that go well beyond the reaches of 14th Street. As a result, it is less costly and administratively complicated to separate the M14A and M14D from the M14 SBS route. This comes at a very large loss of time cost, however, as slow boarding on the M14A and D will result in all buses congesting along 14th Street.

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For these reasons, two alternatives should be considered:

**Recommendation 5a: Make all 14th Street bus routes and Brooklyn shuttle routes free**

Normally when a subway line is closed for repairs, the route is replaced by a free shuttle bus. The simplest way to remove passenger boarding delay is to make the service free. This would address the problem of delay related to ticket inspection, and the administrative burden of installing ticket vending machines on 14th Street. Normal fare payment could also continue to be required for stations off of 14th Street on the M14A and D. The same is true for potential heavy delays at the stops on the Brooklyn shuttle shuttles. Free services will also go part of the way towards compensating displaced passengers for the inconvenience.

**Recommendation 5b: Install pre-paid zones at all stops along 14th Street & the Brooklyn shuttle routes**

If the MTA determines that it cannot afford to make all the services free, the other way to address boarding delay and include the M14A and D is to create pre-paid zones along 14th Street. Like in a subway station, bus passengers would pay their fares before entering a bus stop via a barrier (anything from a turnstile to a painted line). This would benefit all bus routes on 14th Street, as the M14A and D would not require fare kiosks off of 14th Street (passengers could pay on-board off of 14th Street).

![Figure 22: Pre-paid zone, Orange Line BRT, Los Angeles](image_url)

Pre-paid fare zones are much easier for inspectors who can check tickets inside the fare zone, which is generally less crowded than inside a bus, so it allows the inspection process to occur without stopping the bus. Given that the proposed L train shuttles will have very few stops, it is not particularly complicated to deploy inspectors randomly at each stop.

Pre-paid zones can be made of temporary materials, as has been done in Santiago de Chile (Figure 23). These pre-paid zones are only demarcated with airport tape, and fare validators are placed at a few stops.
entrances. These facilities need to be manned, which can be expensive for permanent use, but can only be deployed during the peak hour and removed when not in use.

Figure 23: Temporary pre-paid zones as used in Transantiago, Santiago, Chile, might be a good option

Either option would solve the problems inherent to proof-of-payment fare collection, as found in SBS. Either option would go a long way in reducing the risk of the 14th Street busway saturating. It is critical, then, that MTA and NYC DOT work together to determine which of these options is more feasible. Because Recommendation 5a would be within the purview of MTA and Recommendation 5b the purview of NYC DOT, both agencies must take responsibility for this critical issue.
Conclusion

Increasing the speeds on L Train replacement services is the key to weathering the L Train shutdown. With higher speeds, more people will use the bus services, keeping them out of private cars and off the congested alternative subway platforms. Higher speeds will also reduce the MTA’s operating costs and the amount of buses they will need in order to provide these alternative services.

Table 7: Variance in speed, trip time, and fleet by scenario

<table>
<thead>
<tr>
<th>Proposed Service</th>
<th>No Street Improvements</th>
<th>Current Proposal</th>
<th>All SBS</th>
<th>Full BRT Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimated Speed</td>
<td>Estimated Trip Time</td>
<td>Estimated Fleet</td>
<td>Estimated Speed</td>
</tr>
<tr>
<td>14A &amp; 14D</td>
<td>2</td>
<td>108</td>
<td>31</td>
<td>4</td>
</tr>
<tr>
<td>14th St. SBS</td>
<td>2</td>
<td>57</td>
<td>56</td>
<td>4</td>
</tr>
<tr>
<td>Grand to First Ave &amp; 14th</td>
<td>4</td>
<td>56</td>
<td>44</td>
<td>9</td>
</tr>
<tr>
<td>Bedford to Broadway Lafayette</td>
<td>4</td>
<td>65</td>
<td>41</td>
<td>9</td>
</tr>
<tr>
<td>Grand to Broadway Lafayette</td>
<td>4</td>
<td>52</td>
<td>41</td>
<td>9</td>
</tr>
<tr>
<td>Total Fleet</td>
<td>126</td>
<td>171</td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

The MTA/NYC DOT plan already nearly cuts in half the estimated trip time and required fleet over a standard replacement bus shuttle. If MTA and NYC DOT provide SBS-style improvements for the 14A and 14D services, the trip times and bus fleet required for the 14th Street routes would drop by another 33%, a significant improvement. If at-level boarding and the other street design measures recommended are implemented, the fleet required would drop by another 43% and travel time by another nearly 50%. How many passengers these higher speeds would draw out of private cars and out of the congested subway system is impossible to tell without modeling, but the benefits would be significant.

Most of the differences between the current MTA/NYC DOT plan and the recommendations included in this report are not the issues that are the most likely to cause political controversy. The issues that will be the heaviest political lift are mostly already included in the plan and the two agencies should be commended and supported for their political courage.

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23 Fleet requirements are calculated in the following manner: The maximum loads per service are taken from Table 2. Routes were measured for length, and the full trip cycle time is calculated based on the speed (per scenario), derived as explained above, the distance, and a five minute assumed layover at the terminus. The fleet calculation is the (Maximum Load * Cycle Time) / bus capacity, following the recommended methodology in The BRT Planning Guide, 4th Edition, Chapter 6.4, op. cit.