Bus Rapid Transit For New York City
Appendixes

Prepared for

Transportation Alternatives

NYPIRG Straphangers Campaign

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Schaller Consulting
94 Windsor Place, Brooklyn, NY
(718) 768-3487
schaller@schallerconsult.com
www.schallerconsult.com

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Appendix I. BRT Features

BRT Features

BRT implementations integrate the specific features that are feasible and effective for a given situation. Each implementation can draw from features in the following areas:

- ***Fast and reliable service***. Methods include HOV lanes, bus lanes, traffic signal priority, headway-based scheduling and bus lane enforcement.
- ***Attractive stations***. Includes distinctive station design, raised platforms and bus bulbs.
- ***Easy to board, comfortable vehicles***. Includes low-floor, articulated and distinctively marked buses.
- ***Rapid fare collection***. Includes pre-boarding fare collection and smart cards.
- ***Frequent service on well-marked routes***.

All of these features work to increase bus speeds and improve bus reliability. All of these features can also establish a distinctive image and identity for the BRT service.

This Appendix provides additional detail and examples of each feature. Relatively greater focus is given to features that would improve bus speeds and reliability, the primary problems with bus service in New York City. Conversely, relatively less attention is given to branding and identity, since there is less need to attract non-riders to use public transportation in New York than in the typical U.S. city.

Fast and Reliable Service

Goal: faster travel times and better reliability of travel time.

Features (detailed on the following pages) include:

- Highway HOV lanes and busways
- Bus lanes on arterial streets
- Bus guideways
- Bus traffic signal priority
- Headway-based schedules
- Bus lane enforcement
- Raised lane dividers to discourage other vehicles from using bus lanes

These features can be implemented singly or in combination. For example, bus traffic signal priority can be implemented with bus lanes on arterial streets; raised lane dividers can be implemented with bus lanes that are shared with trucks and cars accessing a curb lane for goods deliveries and right turns.

HOV lanes and busways

This category includes two types of bus lanes on highways:

- High-occupancy vehicle (HOV) lanes are dedicated highway lanes open to buses and private passenger vehicles with at least two (or three) occupants. They are generally separated either physically or with pavement markings from general purpose lanes.
- Busways are lanes exclusively for buses. Busways may be on highways but can also use a separate right of way.

Because buses can bypass traffic congestion in the general use lanes, HOV lanes and busways greatly enhance bus speeds and reliability. HOV lanes have encountered political opposition and in some cases have been dismantled (as in New Jersey) particularly when the public perceives them to be underutilized. HOV lanes have had greater success when built as additions to existing highways rather than when removing a lane used by general traffic.

Bus lanes and busways primarily serve relatively long trips, typically between suburbs or outlying areas of the city and the downtown core. They are most effective where volumes of buses and high-occupancy passenger cars is relatively heavy.

Long Island Expressway HOV lane

HOV lanes and busways

- Example pictured: Miami busway - 8.2 mile busway built for and used exclusively by buses.
- In the New York area, HOV lanes:
  - I-495 into the Lincoln Tunnel - contraflow lane with capacity of 730 buses/hour
  - Long Island Expressway - contraflow lane in the AM peak
  - Gowanus Expressway - contraflow lane from 92 St. in Brooklyn (end of Verrazano Bridge) to the Battery Tunnel, with concurrent section from 72 Street to Shore Parkway in AM peak
  - Prospect Expressway - contraflow lane northbound in AM peak
- Other examples
  - Pittsburgh - busways built largely on railroad rights of way
  - Houston and Los Angeles - extensive network of HOV lanes on freeways, many with separate lanes for entrances, exits and interchanges.
  - San Diego - HOV lane open to buses and cars willing to pay a toll, which varies depending on congestion levels.

Exclusive bus lanes in the median of arterial streets

Cities in South America and Europe have built exclusive bus lanes down the center of major arterials. Buses can bypass traffic on congested streets, and are not slowed by the need to pull into and out of bus stops. The median alignment avoids conflicts with right turns from general purpose traffic. Left turns must either be banned or be given a separate traffic signal phase.

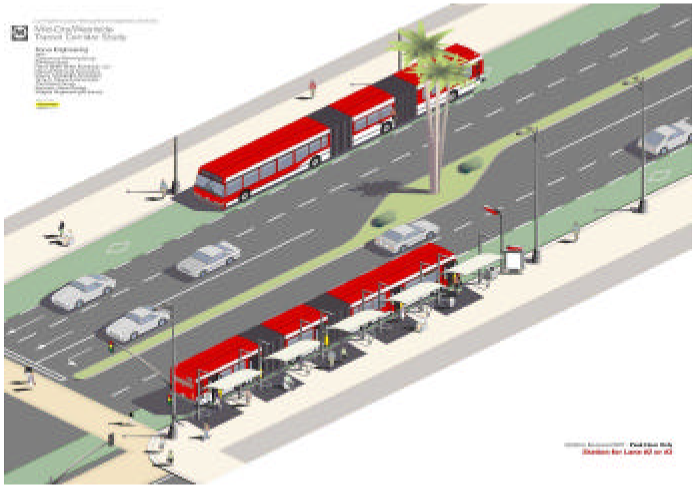
Exclusive bus lanes in the median are relatively space intensive, particularly at bus stops. An additional lane may also be needed so that buses can pass each other.

- Examples pictured: Quito, Equador (top); concept in San Francisco (bottom)
- Other examples: Sao Paulo, Brazil; Rouen, France; Leeds, England; Bogota, Colombia.

Bus lane on arterial streets using the curb lane(s)

Curbside bus lanes are less space intensive than median exclusive lanes since bus stops can remain on the curb rather than taking over a lane of traffic. It is difficult to reserve curbside bus lanes exclusively for buses, however, because of the need for other vehicles to make right turns and the need for goods deliveries, pickups and drop-offs. Curbside bus lanes in New York City typically allow trucks to make deliveries during midday hours and allow cars to use the lanes for right turns. The lanes are often blocked during the rush hour for deliveries, pickup/drop-offs and right turns, however, reducing their effectiveness for buses.

- Example pictured: Los Angeles (in planning)
- In New York City: bus lanes on 18 streets, including most of the avenues in Midtown Manhattan from First to Eighth Avenue and major cross-streets from 34 to 57 Street. Also, 49 and 50 Streets in Midtown are limited to buses, taxis with passengers and other vehicles making stops on the block. Unfortunately, motorist compliance with bus lane restrictions is spotty.



Bus guideways

Bus guideway technology enables buses to stop very close to the curb to facilitate level boarding, which is especially important for wheelchairs. Guideways also enable buses to operate in a narrower right of way. When using guideways, steering is controlled automatically while the driver controls the acceleration and braking.

Several guideway technologies are available:

- Physical guideways - using guide-wheels attached to the bus or an arm attached to a slot in the pavement
- Optical guideways - buses follow painted stripes along the bus route

Guideways are sometimes used only at bus stops. When the bus approaches the guideway, the driver steers the bus into a funnel section and this adjusts the path of the bus smoothly into the guideway proper. (Pictured: Leeds, England)

Bus traffic signal priority

Bus priority involves adjustments to traffic signals to reduce or eliminate the time that buses spend at red lights. There are two broad types of priority:

- **Passive priority** - the area-wide traffic signal timing scheme is set at the average bus speed instead of the average vehicle speed. Suitable where traffic volumes are low.
- **Active priority** - adjusts signals using an algorithm that can take into account various factors such as the bus location, whether the bus is running "late," cross-street traffic volumes and other factors. Types of active priority include:
  - Green extension - extends the green time when a bus is approaching the intersection. One of the most effective forms of bus priority, but does not appear suitable for a one-way street with signal progression, since every succeeding signal would need to give priority until the bus reaches its next stop.
  - Early green - shortens the red time of preceding phases to expedite return to the green.
  - Queue jump phases - gives bus an early green, allowing buses to enter the downstream link ahead of other vehicles.
  - Actuated transit phase - signal phase displayed only when a bus is detected at the intersection, for example, an exclusive left turn lane for buses only. Similar to the "T" signal used where light rail lines operate in mixed traffic. Queue jumps are also an example of actuated phases.
- Use of bus priority is constrained by competing needs which include cross-street traffic volumes and allowing time for pedestrians to finish crossing the street.

How does bus priority work?

A basic application is accomplished at the intersection level. The bus is detected as it approaches the intersection, a request for priority is made, and the traffic signal controller utilizes an algorithm to determine whether to grant priority.

In more sophisticated approaches, determination is made whether the bus is behind schedule and thus whether it should request priority. In Los Angeles, for example, priority is requested only when it will help create more consistent headways between buses.

Applications require vehicle detection and communications between buses, traffic signal controllers and, in some cases, a central traffic management center.

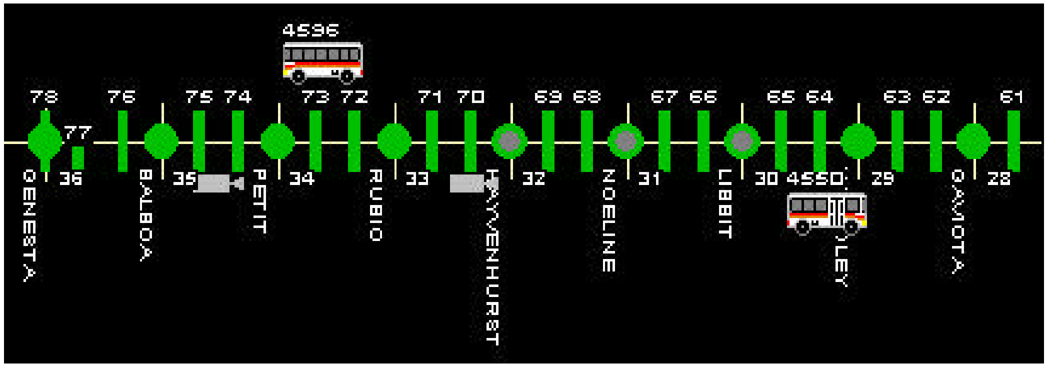
Technology may include:

- Vehicle detection technology - such as loop detectors (devices buried in the pavement that detect passing vehicles), roadside detectors mounted on poles, and Global Positioning Systems (GPS), which are now accurate to within 30 feet.
- Traffic signal controllers capable of adjusting signal timings when buses are detected.
- Communication links between the bus, traffic signal controllers and the traffic management center.

Examples of bus priority

Installations in England and France have shown a 6-42% reduction in transit travel time, with only 0.3-2.5% increases in auto travel time.[(6)*]

Pictured at right: Los Angeles bus priority tracking screen.



Other examples:[(6)]

- Toronto
- Charlotte
- Portland
- Cermack Road in Chicago
- Zurich and Amsterdam have a majority of intersections enabled for transit signal priority.

*See Sources at end of main report.

Headway-based schedules

Bus schedules are based on the amount of time that buses need, on average, to traverse the route. Bus drivers are required to adhere to the schedule at designated timepoints. Ideally, buses arrive at the scheduled time and at regular intervals. Since traffic, passenger loads and the number of wheelchair boardings can vary considerably from the average, however, buses often fall behind schedule despite the best efforts of drivers. Conversely, buses often travel more slowly than necessary in order to avoid jumping ahead of schedule.

Headway-based scheduling seeks to achieve even spacing between buses while letting buses travel as fast as prevailing conditions allow. In Los Angeles, for example, drivers are instructed to drive as fast as they can safely travel. Headways are adjusted by giving selected buses traffic signal priority when they are falling too far behind the bus ahead of them.

Enforcement of bus lanes

New York City and London have attempted to keep bus lanes clear through enforcement.

- In New York, a six-week sustained enforcement effort in 1992 at selected locations reduced bus running times, but only as long as enforcement was sustained.(12)
- In another approach, London has installed video cameras roadside and mounted on buses to enforce against bus lane violations.
  - Cameras record twin images -- traffic conditions in the bus lane and adjacent lane (so that bus lane offenses can be seen in their wide context) and a close up of the vehicle plate. See example at right.
  - The bus recording system reads its location from roadside beacons and records the location and time of day. The system is activated only when the bus is in an operational bus lane.
  - Tapes are reviewed in a secure facility and summonses with fines of £80 ($120) are issued to violators.(19)

Better bus lane enforcement is critical to Alternatives A and B.

Raised Lane Dividers

Mixed-use bus lanes are a compromise between the needs of buses for an exclusive lane and the need to use the curb lane for right turns, pickup/drop-offs and goods deliveries. Ideally, mixed-use bus lanes are self-enforcing as motorists observe and obey the bus lane restrictions. The ideal, of course, is often not achieved. Raised lane dividers seek to discourage cars from entering bus lanes when they are not supposed to be there.

- Raised lane dividers are raised markers about 8” in diameter, narrow cones or 6” high linear timber barriers. They form a barrier which can be mounted slowly by vehicles seeking access across the bus lane but are intended to be uncomfortable and damaging to cross repeatedly.
- Raised lane dividers can be placed along the stripe that divides the bus lane from general traffic.
- Raised lane dividers can also be placed at each intersection across the bus lane at the point where the bus would enter. There is space between the markers where bus tires would pass for the bus to enter but discourage cars from entering.

Raised lane dividers are an key part of dual bus lanes in Alternatives A and B.

Attractive Stations

Goals:

- Easy on and off to reduce dwell times at bus stops.
- Distinctive and easily identifiable to create a clear identity for the BRT service.

Features include:

- Distinctive designs for bus stops/stations -- provides shelter from the elements and a distinctive identity for the BRT service, and can contribute to the character of the community.
  - Example: LA Metro Rapid

Customer Information

- Extensive customer information helps inform and attract riders. Stops can include maps, schedules and real-time vehicle arrival information, as pictured here from Los Angeles.
- NYC Transit is planning to install real-time information screens at bus stops throughout the city, although the system will not be in place until later in the decade.

All 3 alternatives include improved customer information.

Level Boarding

- Raised platforms - provide level boarding into vehicles and reduce dwell time, especially for wheelchair users. Raised platforms require either a connecting ramp between the bus stop and the bus, or require buses to pull very close to the stop. Guideway technology can help accomplish the latter.
  - Example pictured: Quito, Equador

Alternative C includes BRT stations with level boarding.

Bus Bulbs

- Bus bulbs, which bring the bus stop out to the second lane of traffic. Buses use the same lane as both their travel lane and stopping lane. Bulbs are generally used where parking or goods deliveries are allowed on the rest of the block. Bulbs eliminate the delay produced when buses pull into bus stops and then merge back into traffic after passengers board and exit.
  - Example: University Way in Seattle - parking lane prior to bulb.

Bus bulbs are used in Alternative B.

Easy to Board, Comfortable Vehicles

Goals:

- Adequate passenger capacity, especially to avoid packed buses that greatly increase boarding and alighting times.
- Fast on and off
- Distinctive design for system identity

Vehicle features:

- Low-floor buses, which can help speed boarding and alighting, particularly for wheelchair users.
  - Example pictured: Los Angeles

Vehicle features

- Articulated buses, to increase passenger capacity
  - Example pictured: Edmonton, Canada
- Distinctive markings, coloring and designs, to create a distinct image and identity.

Alternative C includes use of articulated buses to increase capacity. All three alternatives include more distinctive markings for the BRT service than is currently used on M15 limited buses, which are difficult to distinguish from local buses.

Rapid Fare Collection

The time required for on-board fare payment can slow buses considerably. In New York, customers using MetroCard take a significant amount of time to orient the MetroCard properly, insert it and wait for the transport mechanism to return the card.

BRT fare collection features include pre-boarding fare payment methods such as passenger loading platforms, proof-of-payment systems and smart cards:

- **Smart Cards -** Smart cards are fare cards with a microchip that allow transit agencies to offer a more sophisticated fare policy. *Contactless smart cards* (also called proximity cards) need only be waved at a marked spot and thus reduce payment time.
  - Chicago and Washington DC are in the process of implementing smart cards.
  - Los Angeles is planning to combine smart cards with proof of payment on their BRT routes. Customers will pay at football-size validators at the bus shelter and can then board at any door. LACMTA is working out how customers will prove fare payment once on the bus.

Rapid Fare Collection

- **Fare control areas**. Used at bus and rail transfer stations and bus-only transfer points, allowing customers to transfer without paying their fare a second time. Non-transferring passengers pay the fare before entering the paid zone. This approach requires space, barriers and/or staffing to minimize fare evasion.
- **Passenger loading platforms** - The bus tubes in Curitiba, Brazil are the most famous example of this approach, which are a form of fare control area. Passengers enter a loading area by paying a fare in a turnstile. The tubes are staffed to minimize fare evasion. The tubes also provide level boarding and alighting since there are no steps between the platform and the bus.

Alternatives A and B use temporary, staffed fare control areas for boarding at high volume times/stops. Alternative C includes a fare control area for boarding the rear door using barriers and high-entry turnstiles.

Rapid Fare Collection

- **Proof-of-payment (POP) fare collection** - Passengers must board with either a pass or validated ticket and thus there are no barriers at stations (San Jose light rail station is pictured at right). Inspectors randomly board buses and give fines to passengers who cannot show the required pass or ticket. This system is exclusively used in new light rail systems in the U.S., including the Hudson-Bergen line in New Jersey and the Newark city subway but appears incompatible with the MetroCard system.

Frequent Service on Well-Marked Routes

Goals:

- Speed
- Easy to use

Features

- 2-5 minute scheduled headways
- Overlapping express and local
- Feeder network
- Simple route structure

Alternatives A, B and C all recommend increased service levels.

Appendix II. How Alternatives A, B and C Will Work

How Alternative A will work

Dual bus lanes on First and Second Avenue:

- The objective of establishing bus dual lanes on First and Second Avenue is to ensure that at least one if not both lanes are clear for buses.
  - Eliminates time wasted merging into traffic while exiting bus stops.
  - When the light is red, buses will be able to reach the intersection after picking up passengers. This eliminates time wasted in the cue at red lights.
  - From the lead position in the platoon of traffic, buses will be able to travel without stopping to the next bus stop most if not all of the time, eliminating delay caused by stopping at red lights between bus stops.
- Raised lane dividers will discourage cars from using the bus lane as a through traffic lane, while still providing access to the curb lane for goods deliveries, taxi pickup/drop-off and right turns. (See page 14.)

How Alternative A will work

Other features of Alternative A:

- Several locations experience heavy boarding activity and long dwell times at peak hours. These include First Avenue just above Houston and 14 Street in the AM rush hour and 42 Street on both First and Second Avenues in the PM peak. Pre-boarding fare payment will significantly reduce dwell times.
  - Pre-boarding fare payment can be accomplished by erecting a railing parallel to the avenue and several feet from the curb. A portable MetroCard farebox will be needed where customers enter the line. The line will need to be staffed while operational.
  - Customers will pay their fare and enter the line. They can then enter either the front or back doors of the next bus and will not need to stop to pay the fare. Dwell times will be reduced very substantially.
  - When pre-boarding fare payment is not operational, customers will line up and board in the usual manner and pay fares on the bus.
- Use of low-floor buses will also reduce boarding times, particularly for wheelchair users.
- Eliminating stops that are not at major cross-streets will reduce delays from bus stops, and also concentrate customers at locations with pre-boarding fare payment.
- We observed some passenger confusion between limited and local services. Local buses should be clearly marked as a local bus to reduce uncertainty.

How Alternative B will work

- Through the use of bus bulbs at the stops, buses will not need to pull into and out of each bus stop, thus speeding their movement.
- Camera enforcement patterned after London's program will also help enforce the bus lanes.
- The combination of GPS, headway-based operations and bus priority for late buses will help maintain even spacing between buses. Priority will be requested only when bus spacing becomes irregular and holding a green light or using the queue jump would help the "late" bus reduce the distance between it and the lead bus. Operators at the bus control center can also coordinate by voice with bus operators to maintain even spacing between buses, such as by directing an uncrowded bus to pass very crowded buses.
- See Alternative A for discussion of features that are in both Alternatives.

How Alternative C will work

- By providing a dedicated lane for BRT service, Alternative C guarantees that buses move quickly between stations.
- Pre-boarding fare payment at every BRT station minimizes dwell time.
  - Station at each BRT stop enclosed by barriers and high-entry turnstiles. Customers pre-paying their fare can board through the rear door, which opens when the bus stops. Passengers in wheelchairs can simultaneously board in the front door.
- Guideways enable buses to stop very close to the platform; wheelchair users can simply roll onto the bus from a slightly raised platform.
- With headways of between 45 seconds and 1.5 minutes for the BRT service at peak hours, capacity will be greatly expanded and customers will be guaranteed a very minimal wait for the next bus.
- General traffic essentially loses one lane of moving traffic.
  - Currently, general traffic moves on 4-5 lanes. Of the seven total lanes, the two curb lanes are blocked by one or more vehicles per block, and buses most frequently use the second lane from the curb, which prompts most motorists to move out of the lane.
  - Under Alternative C, general traffic moves on 3-4 lanes. This also assumes that both curb lanes are blocked by one or more vehicles and that an additional lane is taken at points by the BRT stop or local bus movements.

Appendix III. Modeling Travel Time Savings

Description of Model

To predict the effects of the proposed BRT implementations on bus speed and reliability, a simple model was created to measure how a bus spends its time in the morning rush hour (see accompanying spreadsheet).

Basis of the Model

The model is based on data collected on five actual trips on the M15 Limited, between 125 St. and Houston St., taken on mornings between March 26 and April 1. Three trips were taken heading downtown along 2nd Av., departing 125 St. between 8:20 am and 9:05 am. Two trips were taken heading uptown along 1st Av., departing Houston St. between 8:20 am and 9:35 am. Running time ranged from 41 to 58 minutes on these trips.

The model is designed to simulate the morning rush hour only.

Components of the Model

Each of the items below are discrete events that occur during a bus trip. Entered into the model are the number of occurrences of each type of event, and the average number of seconds elapsed per each type of event.

Red Lights

1. Red At Stop – red light immediately after a bus stop
2. Other Red – red light elsewhere in the route

Bus Stops

1. Peak Boarding stop – before Midtown; many passengers board
2. Peak Exiting stop – in Midtown; many passengers exit
3. Off-Peak Stop – after Midtown; light boarding and exiting
4. Total Wheelchairs – wheelchairs add time regardless of where they board or exit

In Motion

1. Blocks Traversed – 125 blocks, the length of the route

Scenarios Modeled

Four scenarios are modeled – the present operation of the bus ("Now") and the three BRT implementations (Alternatives A,B,C). For each of these scenarios, there are a total of four models – uptown and downtown trips are both modeled for best-case and worst-case conditions. Additionally, the five actually observed trips are modeled, so that the results of the model may be compared to actual observation.

Some values are held constant across all scenarios:

Seconds per red at stop:	25 seconds
Seconds per other red:	35 seconds
Number of blocks traversed:	125

Data from the five observed trips suggests that these values do not vary widely, regardless of passenger loads or traffic congestion.

Now (Current Conditions)

This is the present operation of the bus. The best-case scenario assumes typical passenger loads (no inconsistent bus headways, which would lead to unusually light or heavy loads on a bus); no wheelchairs; and free-flow traffic. All values are based on the data from the five observed trips, but no observed trip, in its entirety, was as good as the best case or as bad as the worst case.

Items that vary from the best case to the worst case are shown in red in the spreadsheet.

The model predicts trip times of 39 to 64 minutes, which is consistent with the actual running times of 41 to 58 minutes on the five observed trips.

Red lights:
The best case assumes that the bus hits a red light immediately after every stop (a total of 17 “Red At Stops”) and does not hit any other red lights. Essentially this means that congestion does not impede the motion of the bus, so the bus is able to travel in synch with the traffic lights. The worst case assumes the worst number of red lights observed on the five observed trips – 5 red at stops, and 15 other reds. In this case, the bus is traveling totally out of synch with the traffic lights, and is stopping at more lights overall.

Peak boarding stops:
In the downtown direction, these are 116, 106, 96, 86, 79, 72, 68, and 61 Streets
In the uptown direction, these are St. Marks, 14, and 23 Streets
60 seconds per peak boarding stop in the best case (data suggests this is typical)
75 seconds per peak boarding stop in the worst case (consistent with the worst observed)

Peak exiting stops:
In the downtown direction, these are 57, 50, 42, and 34 Streets
In the uptown direction, these are 29, 34, and 42 Streets
30 seconds per peak exiting stop

Off-peak stops:
In the downtown direction, these are 28, 23, 14, and 9 Streets
In the uptown direction, these are 49, 57, 67, 72, 79, 86, 97, 105, 116, and 120 Streets
15 seconds per off-peak stop

1 St./Houston St and 125 St./126 St. were not counted as stops at all, because they are the terminals of the route.

Total wheelchairs:
The best case assumes no wheelchairs
The worst case assumes two wheelchairs (the most observed on any single trip)

Total time that a wheelchair adds to a trip, including boarding and exiting, is 210 seconds

In motion:
Seconds per block traversed is a measure of the bus's speed when in motion
180 / seconds per block = miles per hour
The best case assumes 12 seconds per block (15 mph)
The worst case assumes 16 seconds per block (11.25 mph)

The Five Observed Trips

These trips were modeled by starting with the "Now" best case, and plugging in the actual number of red lights; number of wheelchairs; and average seconds per block. Additionally, seconds per peak boarding stop was adjusted to account for bus bunching (very lightly loaded bus) on one trip and bus delays (very heavily loaded bus) on other trips. With these alterations, the model successfully represented each trip to within one minute of the actually observed time.

Items that vary from the best case to the actual case are shown in red in the spreadsheet.

Alternative A

Items that vary from the Now best case to the Alternative A best case are shown in blue in the spreadsheet. Items that vary from the Alternative A best case to the Alternative A worst case are shown in red in the spreadsheet.

- Dual bus lanes reduce congestion

In the worst case, bus comes closer to traveling in synch with the traffic lights
Seconds per block reduced in the worst case only (the best case already represented free flow conditions)

- Fewer stops

Peak boarding stops are 116, 106, 96, 86, and 72 Streets in the downtown direction
Peak boarding stops are 14 and 23 Streets in the uptown direction
Peak exiting stops are 57, 42, and 34 Streets in the downtown direction
Peak exiting stops are 34 and 42 Streets in the uptown direction

Fewer stops also means fewer red lights, in the best case, because the bus only stops at a red light after a bus stop

- Greater service frequency reduces passenger crowding
- Pre-boarding fare payment at selected locations
- Low floor buses speed boarding and exiting

Number of seconds at peak boarding stops is reduced in both cases
Number of seconds at peak exiting stops is slightly reduced in both cases
Number of seconds at off-peak stops is slightly reduced in the best case
Number of seconds per wheelchair is cut in half in both cases

Number of seconds per stop (peak boarding and off-peak) is nevertheless higher in the worst case than in the best case because a delayed bus may become very crowded and thus take longer to load.

Alternative B

Items that vary from the Alternative A best case to the Alternative B best case are shown in blue in the spreadsheet. Items that vary from the Alternative B best case to the Alternative B worst case are shown in red in the spreadsheet.

- New York Bus Lane concept reduces congestion
- Camera enforcement of bus lanes reduces congestion

Seconds per block reduced in both cases (even in the best case, movements such as pulling in and out of bus stops should be faster)

Number of red lights reduced in the worst case only (the best case already represents travel in synch with traffic lights)

- Automatic vehicle location maintains spacing between buses
- Headway based operations maintain spacing between buses

Dwell times in the best and worst cases are now the same at off-peak stops, and the differential between the best and worst cases is reduced at peak boarding stops

Alternative C

Items that vary from the Alternative B best case to the Alternative C best case are shown in blue in the spreadsheet. Items that vary from the Alternative C best case to the Alternative C worst case are shown in red in the spreadsheet.

- Dedicated bus lane eliminates the effects of traffic congestion

Bus stops only at red lights immediately after bus stops in the worst case, as well as in the best case

Seconds per block reduced in both cases to 9 sec. (20 mph)

- Low-floor articulated buses increase capacity and reduce onboard crowding
- Guideway technology is used so that buses "dock" at curb
- BRT station design facilitates more efficient passenger loading/unloading

Number of seconds at peak boarding stations is reduced in both cases, and the differential between the best and worst cases is reduced

Number of seconds at peak exiting stations is slightly reduced in both cases

The number of seconds at off-peak stations is not reduced because it is already very low

- A ramp located at the front door facilitates wheelchair boarding/exiting

Number of seconds per wheelchair reduced to 90 sec.

Now (Current Conditions)

*** Heading Downtown, Morning Rush, Best Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	17	25	7
Other Red	0	35	0
BUS STOPS			
Peak Boarding Stop	8	60	8
Peak Exiting Stop	4	30	2
Off-Peak Stop	4	15	1
Total Wheelchairs	0	210	0
IN MOTION			
Blocks Traversed	125	12	25
TOTAL TRIP TIME IN MINUTES			43

*** Heading Downtown, Morning Rush, Worst Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	5	25	2
Other Red	15	35	9
BUS STOPS			
Peak Boarding Stop	8	75	10
Peak Exiting Stop	4	30	2
Off-Peak Stop	4	15	1
Total Wheelchairs	2	210	7
IN MOTION			
Blocks Traversed	125	16	33
TOTAL TRIP TIME IN MINUTES			64

*** Heading Uptown, Morning Rush, Best Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	17	25	7
Other Red	0	35	0
BUS STOPS			
Peak Boarding Stop	3	60	3
Peak Exiting Stop	3	30	2
Off-Peak Stop	10	15	3
Total Wheelchairs	0	210	0
IN MOTION			
Blocks Traversed	125	12	25
TOTAL TRIP TIME IN MINUTES			39

*** Heading Uptown, Morning Rush, Worst Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	5	25	2
Other Red	15	35	9
BUS STOPS			
Peak Boarding Stop	3	75	4
Peak Exiting Stop	3	30	2
Off-Peak Stop	10	15	3
Total Wheelchairs	2	210	7
IN MOTION			
Blocks Traversed	125	16	33
TOTAL TRIP TIME IN MINUTES			59

Alternative A

*** Heading Downtown, Morning Rush, Best Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	11	25	5
Other Red	0	35	0
BUS STOPS			
Peak Boarding Stop	5	35	3
Peak Exiting Stop	3	25	1
Off-Peak Stop	2	10	0
Total Wheelchairs	0	105	0
IN MOTION			
Blocks Traversed	125	12	25
TOTAL TRIP TIME IN MINUTES			34

*** Heading Downtown, Morning Rush, Worst Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	7	25	3
Other Red	10	35	6
BUS STOPS			
Peak Boarding Stop	5	50	4
Peak Exiting Stop	3	25	1
Off-Peak Stop	2	15	1
Total Wheelchairs	2	105	4
IN MOTION			
Blocks Traversed	125	14	29
TOTAL TRIP TIME IN MINUTES			47

*** Heading Uptown, Morning Rush, Best Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	11	25	5
Other Red	0	35	0
BUS STOPS			
Peak Boarding Stop	2	35	1
Peak Exiting Stop	2	25	1
Off-Peak Stop	6	10	1
Total Wheelchairs	0	105	0
IN MOTION			
Blocks Traversed	125	12	25
TOTAL TRIP TIME IN MINUTES			33

*** Heading Uptown, Morning Rush, Worst Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	7	25	3
Other Red	10	35	6
BUS STOPS			
Peak Boarding Stop	2	50	2
Peak Exiting Stop	2	25	1
Off-Peak Stop	6	15	2
Total Wheelchairs	2	105	4
IN MOTION			
Blocks Traversed	125	14	29
TOTAL TRIP TIME IN MINUTES			45

Alternative B

*** Heading Downtown, Morning Rush, Best Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	11	25	5
Other Red	0	35	0
BUS STOPS			
Peak Boarding Stop	5	35	3
Peak Exiting Stop	3	25	1
Off-Peak Stop	2	10	0
Total Wheelchairs	0	105	0
IN MOTION			
Blocks Traversed	125	11	23
TOTAL TRIP TIME IN MINUTES			32

*** Heading Downtown, Morning Rush, Worst Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	7	25	3
Other Red	6	35	4
BUS STOPS			
Peak Boarding Stop	5	45	4
Peak Exiting Stop	3	25	1
Off-Peak Stop	2	10	0
Total Wheelchairs	2	105	4
IN MOTION			
Blocks Traversed	125	12	25
TOTAL TRIP TIME IN MINUTES			40

*** Heading Uptown, Morning Rush, Best Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	11	25	5
Other Red	0	35	0
BUS STOPS			
Peak Boarding Stop	2	35	1
Peak Exiting Stop	2	25	1
Off-Peak Stop	6	10	1
Total Wheelchairs	0	105	0
IN MOTION			
Blocks Traversed	125	11	23
TOTAL TRIP TIME IN MINUTES			31

*** Heading Uptown, Morning Rush, Worst Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	7	25	3
Other Red	6	35	4
BUS STOPS			
Peak Boarding Stop	2	45	2
Peak Exiting Stop	2	25	1
Off-Peak Stop	6	10	1
Total Wheelchairs	2	105	4
IN MOTION			
Blocks Traversed	125	12	25
TOTAL TRIP TIME IN MINUTES			38

Alternative C

*** Heading Downtown, Morning Rush, Best Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	11	25	5
Other Red	0	35	0
BUS STOPS			
Peak Boarding Stop	5	25	2
Peak Exiting Stop	3	20	1
Off-Peak Stop	2	10	0
Total Wheelchairs	0	90	0
IN MOTION			
Blocks Traversed	125	9	19
TOTAL TRIP TIME IN MINUTES			27

*** Heading Downtown, Morning Rush, Worst Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	11	25	5
Other Red	0	35	0
BUS STOPS			
Peak Boarding Stop	5	30	3
Peak Exiting Stop	3	20	1
Off-Peak Stop	2	10	0
Total Wheelchairs	2	90	3
IN MOTION			
Blocks Traversed	125	9	19
TOTAL TRIP TIME IN MINUTES			30

*** Heading Uptown, Morning Rush, Best Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	11	25	5
Other Red	0	35	0
BUS STOPS			
Peak Boarding Stop	2	25	1
Peak Exiting Stop	2	20	1
Off-Peak Stop	6	10	1
Total Wheelchairs	0	90	0
IN MOTION			
Blocks Traversed	125	9	19
TOTAL TRIP TIME IN MINUTES			26

*** Heading Uptown, Morning Rush, Worst Case ***

	Number	Sec. Per	Total Min.
RED LIGHTS			
Red At Stop	11	25	5
Other Red	0	35	0
BUS STOPS			
Peak Boarding Stop	2	30	1
Peak Exiting Stop	2	20	1
Off-Peak Stop	6	10	1
Total Wheelchairs	2	90	3
IN MOTION			
Blocks Traversed	125	9	19
TOTAL TRIP TIME IN MINUTES			29