



BUS AND RAPID TRANSIT CAPACITY GAP ANALYSIS (DRAFT)



September 2016

CAPACITY GAP ANALYSIS OVERVIEW

RESEARCH QUESTION:

Where are Rapid Transit and bus routes in the MBTA system over capacity today during the morning peak, and where is the system likely to be over capacity in 2040?

- Where is the system over capacity given scheduled vs. actually operated service?
- Where would the system be over capacity given:
 - State of Good Repair investments affecting capacity
 - AFC 2.0
 - Municipal cooperation affecting capacity such as bus lanes and transit signal priority

WHAT DO WE MEAN BY “CAPACITY”?

Theoretical capacity. Under perfect conditions, a transit line could carry:

$$\text{CAPACITY} = \text{TRAINS PER TIME PERIOD} * \text{PEOPLE PER CAR} * \text{CARS PER TRAIN}$$

- **Trains/buses per time period:** Also known as “frequency”, this is the number of trips scheduled or actually operated during a specific time period
- **People per car:** The policy capacity as defined by the MBTA Service Delivery Policy strives to represent a maximum of comfortable conditions for traveling.

WHAT DO WE MEAN BY “CAPACITY”?

But, perfect conditions are rare, especially during the peak hour: To account for the variations in demand and operations during the peak hour, such as weather or fluctuations in arriving passengers, transit systems – like other systems – shouldn’t be planned to use their full theoretical capacity. Highways are often considered “at capacity” at 85% of their theoretical capacity. Therefore for this analysis we use:

$$\text{CAPACITY} = \text{TRAINS PER TIME PERIOD} * \text{PEOPLE PER CAR} * \text{CARS PER TRAIN} * \text{“peak hour factor”}$$

- **Peak hour factor:** Recommended for use in calculating transit capacity by the Transit Capacity and Quality of Service Manual, the peak-hour factor “reflects the diversity of demand over the course of a peak hour and produces a person capacity that reflects the number of people that can consistently be served day after day at the desired number of people per train/bus.”
- **Recommended peak hour factor for heavy rail:** 0.8
- **Recommended peak hour factor for walk-up (frequent) bus service:** 0.85

ASSUMPTIONS



Even considering the system “at capacity” at 80-85% of its true theoretical capacity, this analysis can’t account for all the variability of operations and passenger behavior between trips, and may not reflect every passenger’s day to day experience. For example, this analysis:

- Assumes even headways (time between trains or buses)
- Assumes even distribution of passengers between and within train cars/buses
- Assumes each passenger utilizes the same amount of space
- Assumes an average day of passenger demand
- Assumes no one is left behind on a given trip (due to lack of data when this occurs)

RAPID TRANSIT CAPACITY GAP ANALYSIS

- **Rapid Transit capacity issues today during 7:30-8:00AM, 8:00-8:30AM peak**
 - Under scheduled service
 - Under actual operations
 - With programmed State of Good Repair (SGR) investments
- **Rapid Transit issues in 2040 during 7:30-8:00AM, 8:00-8:30AM peak**
 - Under today's scheduled service
 - Under today's operated service
 - With programmed SGR investments

RAPID TRANSIT ANALYSIS

DATA SOURCES

— Loads

- Rail load profiles constructed from April 2016 ODX data, accessed through MIT/MBTA research server, for 7:30-8:00am, 8:00-8:30am weekday periods
- Used April 2016 data to be able to capture system with Government Center re-opened

— Scheduled frequency

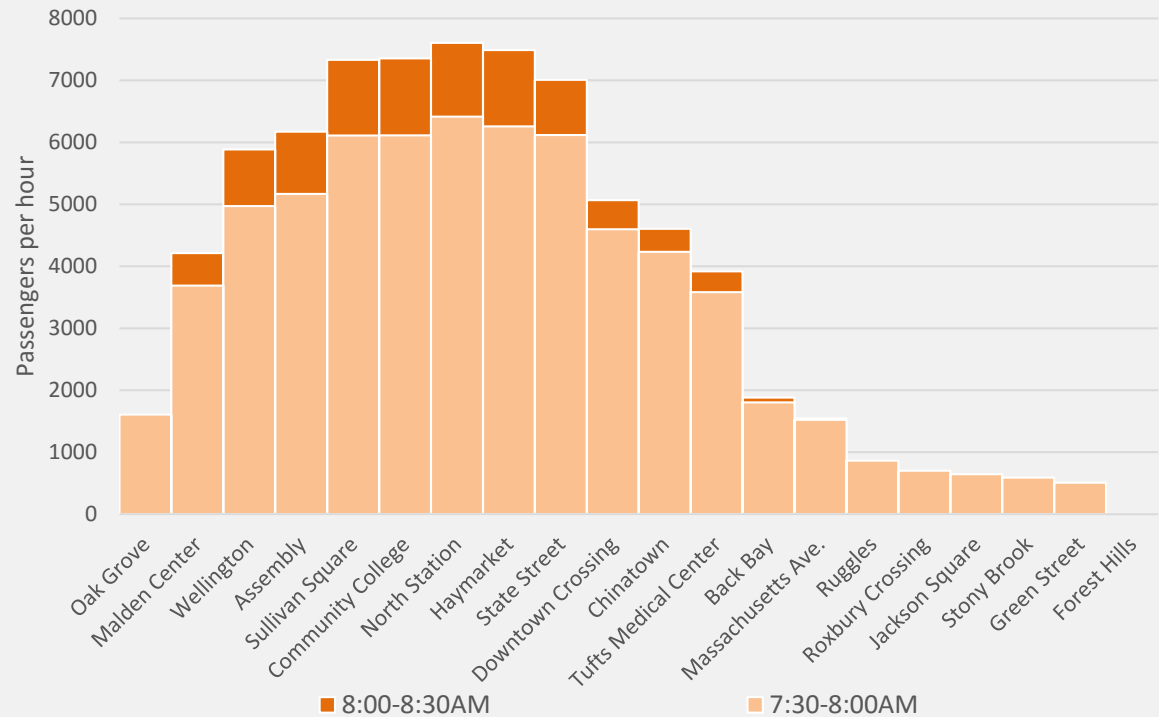
- GTFS, counting unique trips scheduled to begin each route (or branch) within designated time periods

— Operated frequency

- TTR (train location) data accessed through MIT/MBTA research server for one year leading up to and including month for load data (5/1/15-5/1/16)
- Counted unique trips that began each route within designated time periods, looked at average, median, 10th, 25th, 75th, 90th percentile days.

How does rail capacity vary?

- Today, due to internal and external factors, there typically aren't as many trips run during the peak hour as scheduled
- Getting to scheduled capacity is an important step, but to get more capacity, other capital investments may be necessary.

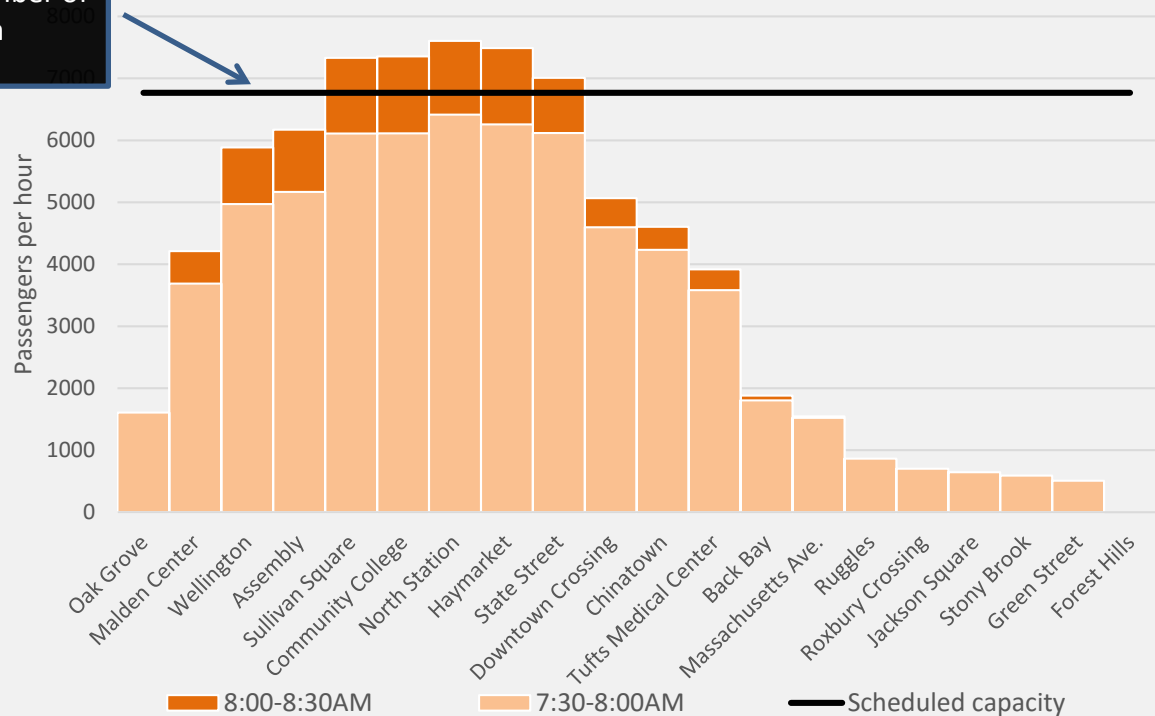


How does rail capacity vary?

- Today, due to internal and external factors, there typically aren't as many trips run during the peak hour as scheduled
- Getting to scheduled capacity is an important step, but to get more capacity, other capital investments may be necessary.

Scheduled capacity

Capacity given the scheduled number of trips between 7:30-8:30am

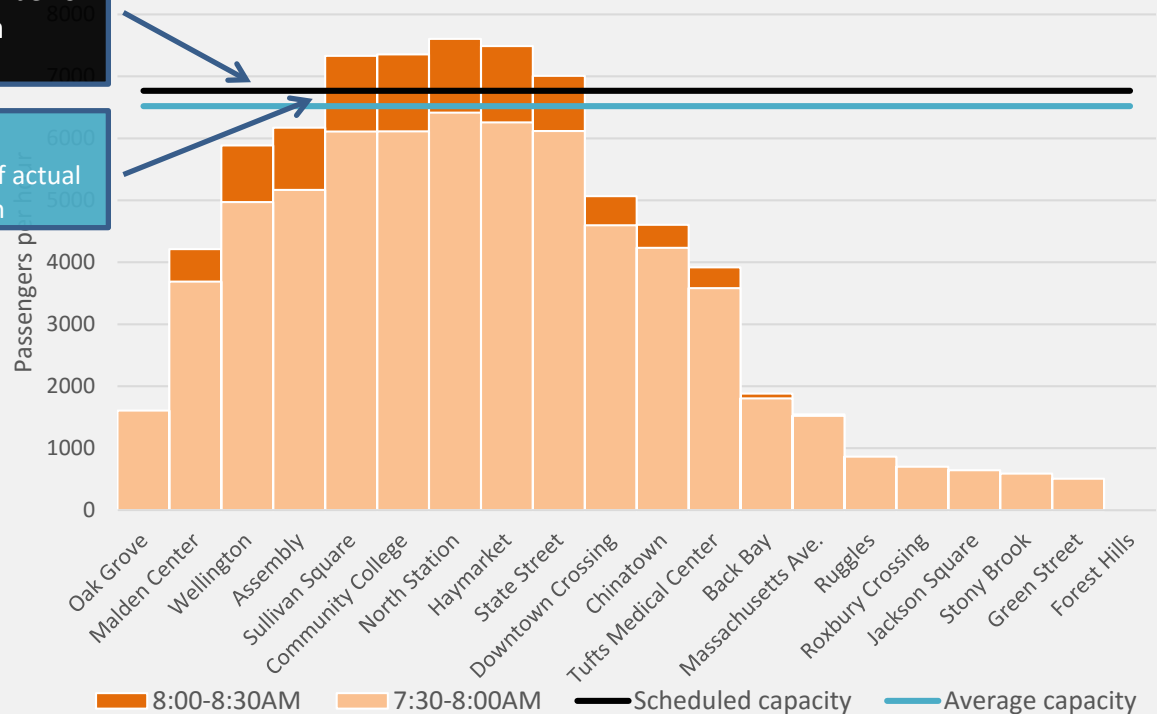


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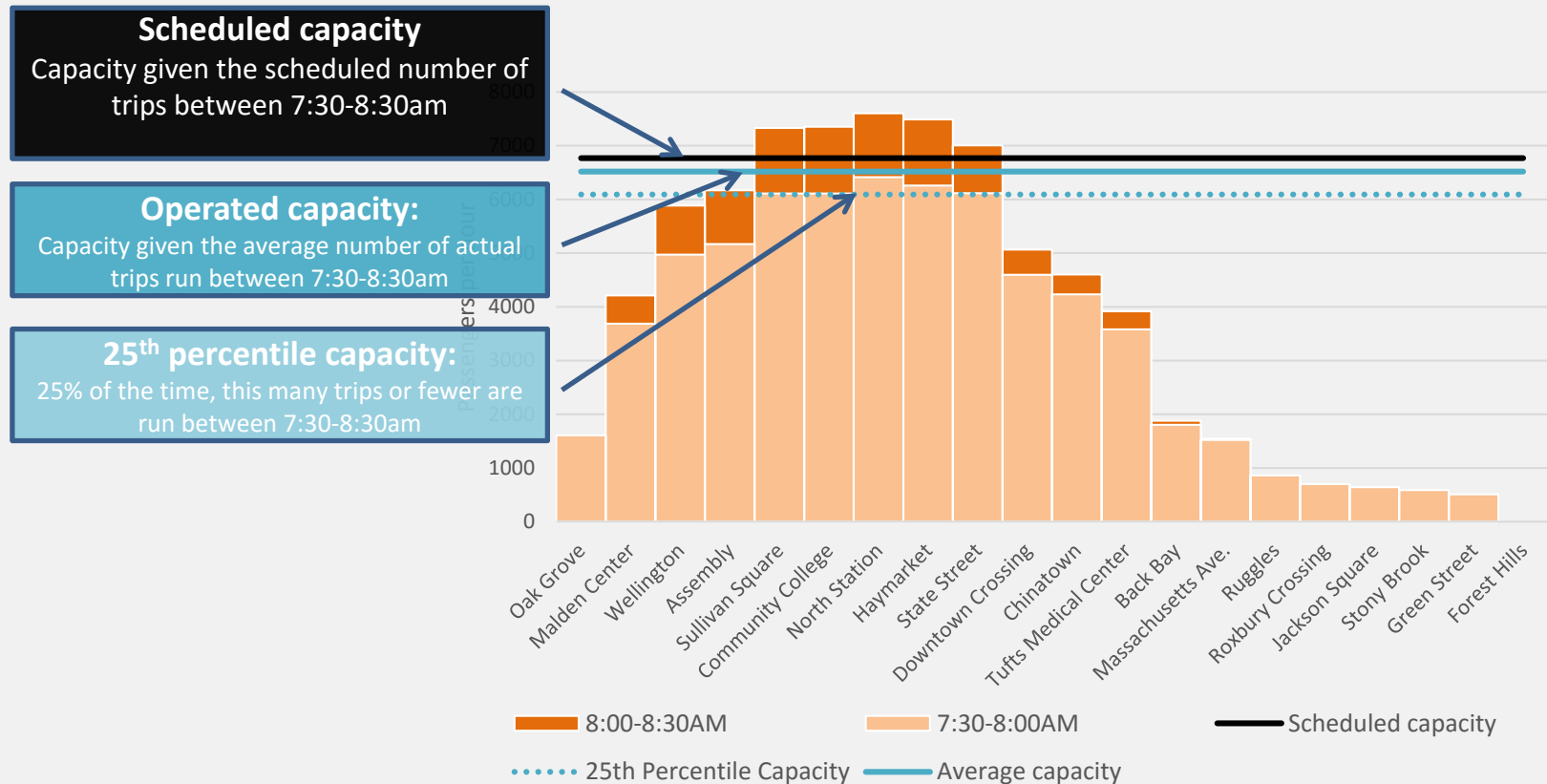
Scheduled capacity
Capacity given the scheduled number of trips between 7:30-8:30am

Operated capacity:
Capacity given the average number of actual trips run between 7:30-8:30am



How does rail capacity vary?

- Today, due to internal and external factors, there typically aren't as many trips run during the peak hour as scheduled
- Getting to scheduled capacity is an important step, but to get more capacity, other capital investments may be necessary.



Which lines will see the most new jobs and households?

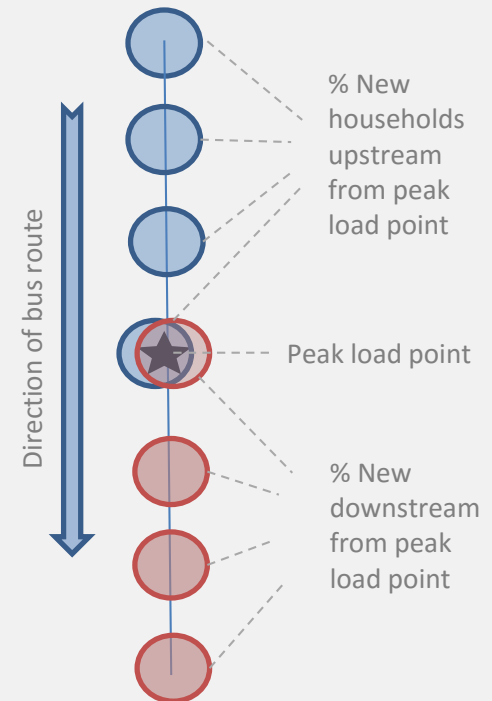
Methodology

Rapid Transit lines were assessed based on how close to capacity they are today, and how much development is forecast near them by 2040:

1. **% Average operated capacity utilized** – Ratio of passengers to average operated capacity at the peak load point* for 7:15-8:15AM.
2. **Percent new households upstream** - the percent** of new households forecast to be in walking distance (1/2 mile) of stops at or before the peak load point along the route.
3. **Percent new jobs downstream** - the percent of new jobs forecast to be in walking distance (1/2 mile) of stops at or after the peak load point along the route.

*Peak load point is the station with the highest number of riders passing through

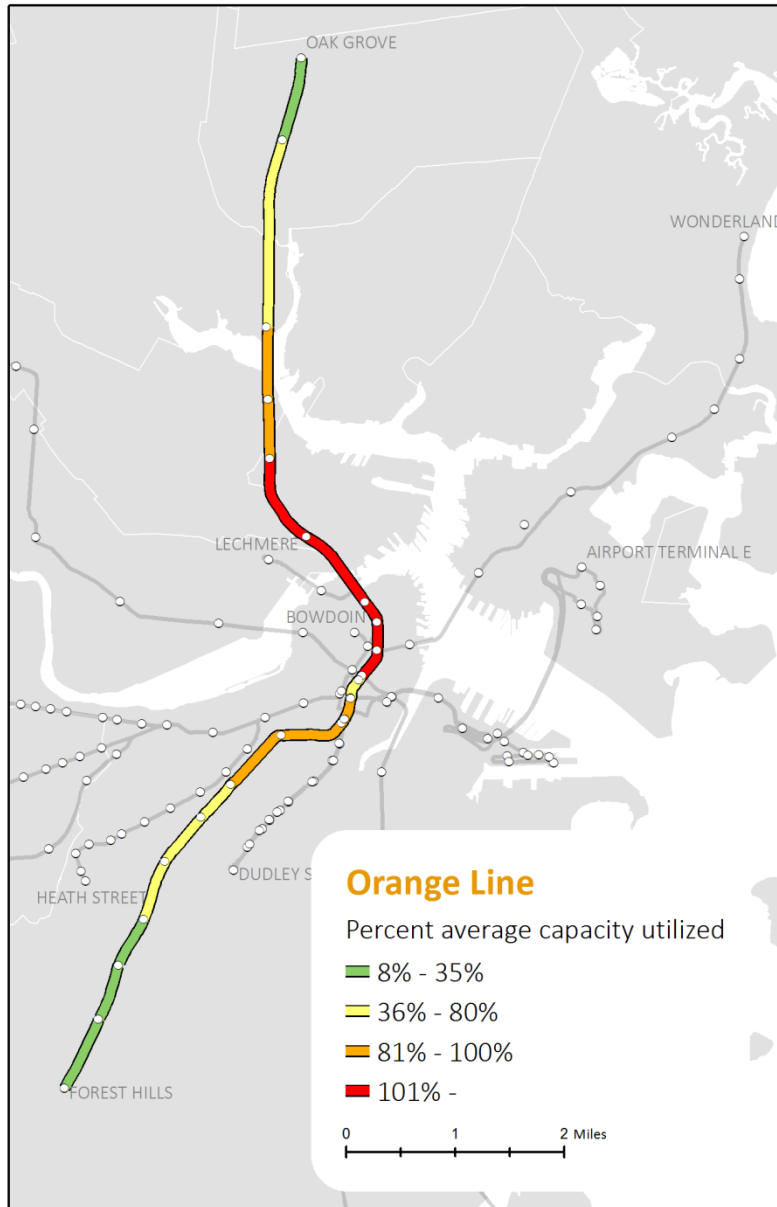
**For 2040 jobs or households with ranges, the lower bound is the number of jobs or households forecast by MAPC, while the upper bound is the number of households or jobs planned or proposed in the development pipeline for 2040, where data is available.



Example – Orange Line Northbound

Direction	Peak Load Point	Percent capacity utilized today	2010 - Households upstream	2040 - Additional households upstream	2040 - Percent additional households upstream	2010 - Jobs downstream	2040 - Additional jobs downstream	2040 - Percent additional jobs downstream
Northbound	Back Bay	86.3%	31,100	8,000	26%	401,000	27,600–54,900	7% - 14%

ORANGE LINE CAPACITY TODAY

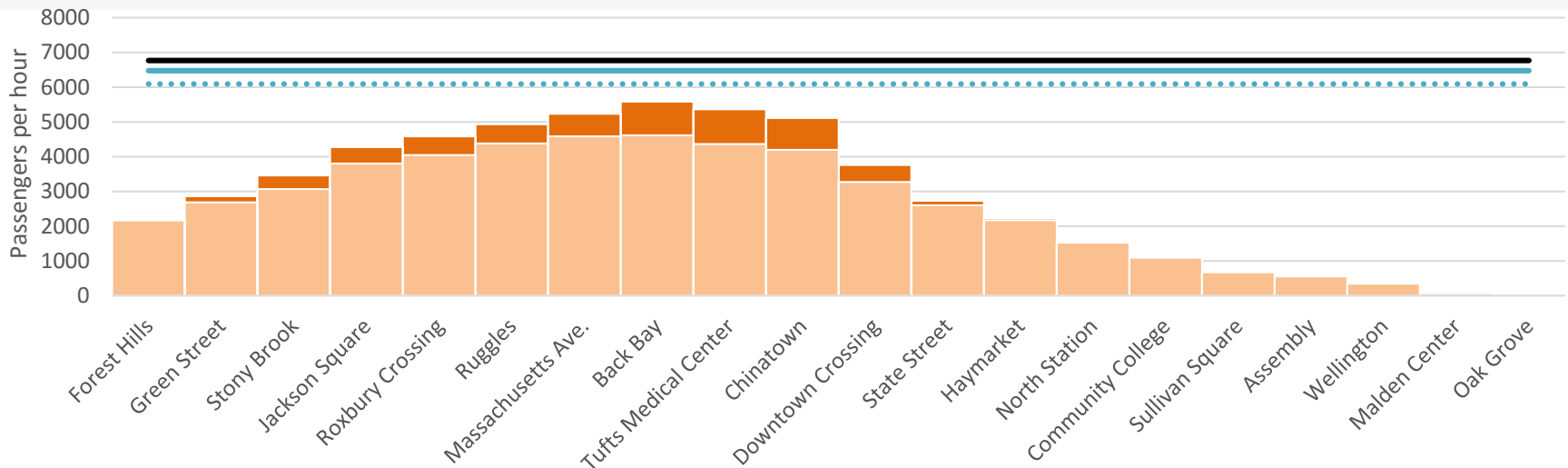


- Percent capacity utilized is the ratio of passengers to the average operated capacity along that segment today
- Map represents passengers flowing inbound towards Downtown Crossing in both directions

ORANGE LINE CAPACITY TODAY

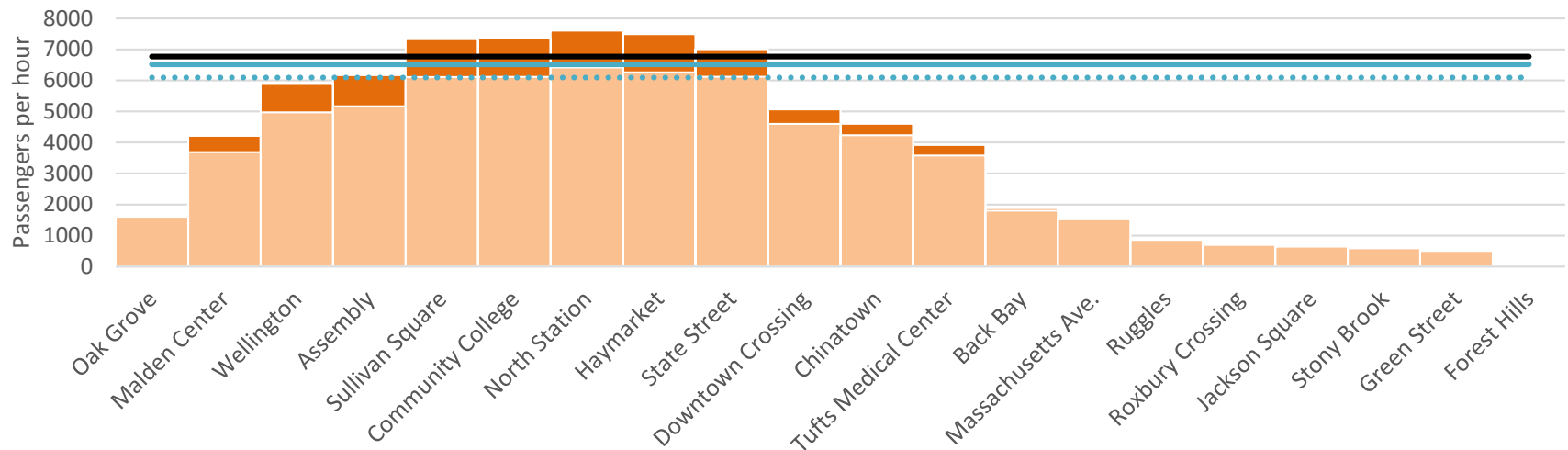
NORTHBOUND: FOREST HILLS TO OAK GROVE

4/2015-4/2016 Trains per AM Peak Hour: Schedule: 10 | Average weekday: 9.6 | 25th percentile weekdays: 9



SOUTHBOUND: OAK GROVE TO FOREST HILLS

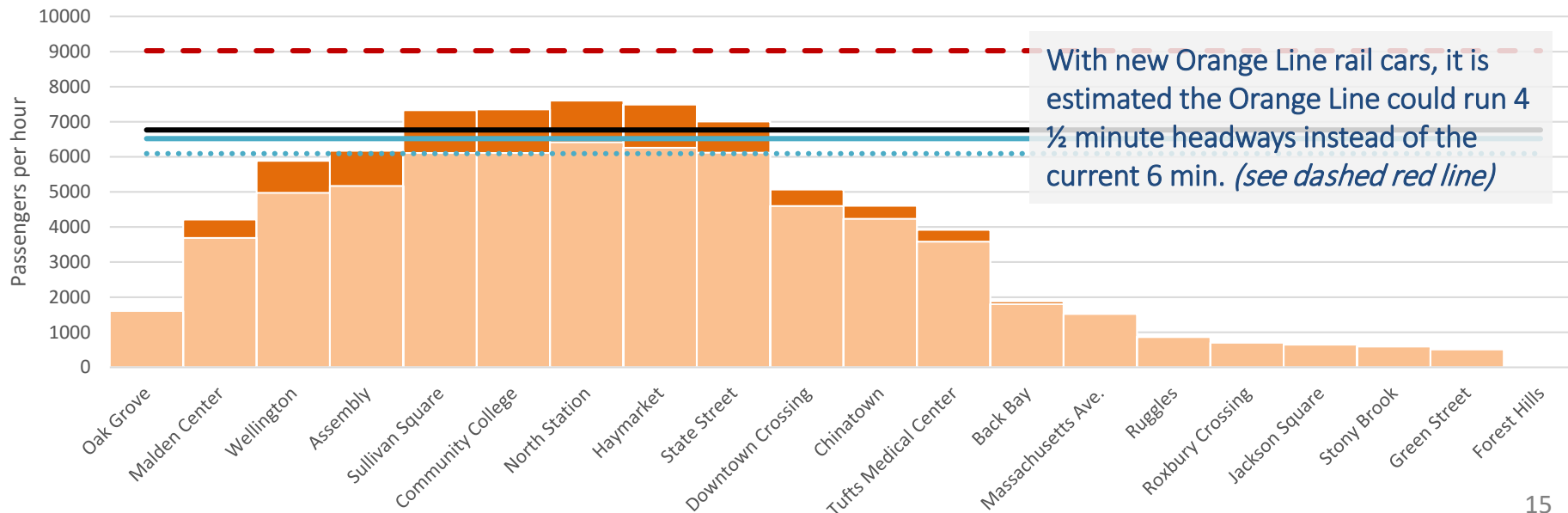
4/2015-4/2016 Trains per AM Peak Hour: Schedule: 10 | Average weekday: 9.6 | 25th percentile weekdays: 9



ORANGE LINE – FUTURE LAND USE

Direction	Peak Load Point	Percent capacity utilized today	2010 - Households upstream	2040 - Additional households upstream	2040 - Percent additional households upstream	2010 - Jobs downstream	2040 - Additional jobs downstream	2040 - Percent additional jobs downstream
Northbound	Back Bay	86.3%	31,100	8,000	26%	401,000	27,600–54,900	7% - 14%
Southbound	North Station	116.6%	13,300	6,000 – 8,700	45% - 65%	426,200	30,000 – 49,000	7% - 11%

ORANGE LINE – PLANNED FUTURE CAPACITY



BUS CAPACITY GAP ANALYSIS

- **Bus capacity issues today**
 - Under scheduled service
 - Under operated service
 - With improvements planned by the MBTA (AFC 2.0)
 - With potential improvements led by municipalities
- **Bus capacity issues in 2040**
 - Under today's scheduled service
 - Under today's operated service
 - With improvements planned by the MBTA (AFC 2.0)
 - With potential improvements led by municipalities

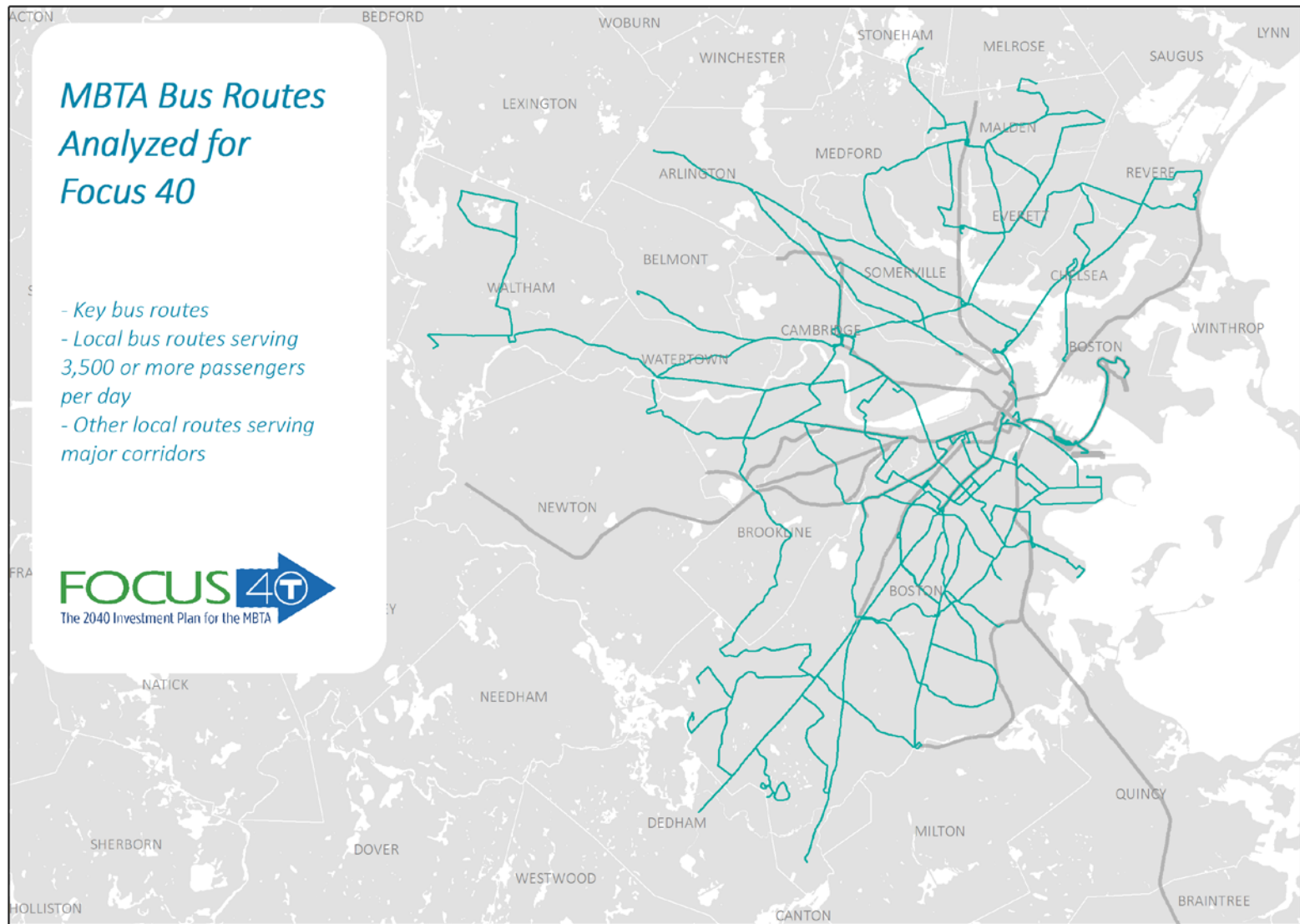
BUS ANALYSIS

DATA SOURCES & NOTES

- Loads
 - Bus load profiles constructed from 8/24/2015-12/15/2015 ODX data, accessed through MIT/MBTA research server
 - Compared to 2015 APC data from CTPS (primarily uses APC)
- Scheduled frequency
 - GTFS, counting unique trips scheduled to begin each route within designated time period (7:15-8:15AM weekdays)
- Operated frequency
 - AVL data accessed through MIT/MBTA research server for all of 2015
 - Counted unique trips that began each route within designated time period, looked at average, median, 10th, 25th, 75th, 90th percentile days.
- Looks only at main variant for each route (most frequent)
- All data is presented in the inbound direction, unless otherwise noted

MBTA Bus Routes Analyzed for Focus 40

- Key bus routes
- Local bus routes serving 3,500 or more passengers per day
- Other local routes serving major corridors



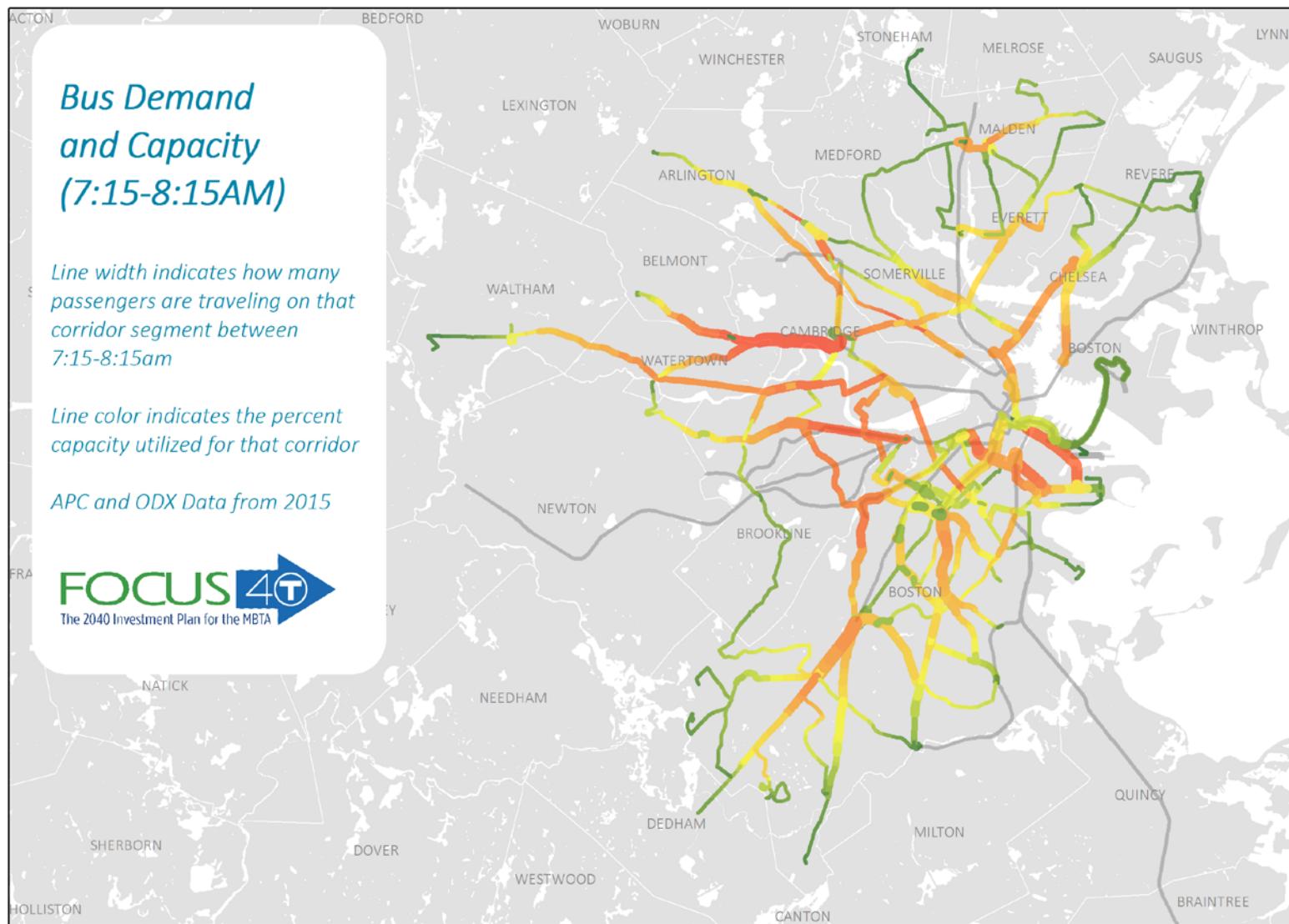
**Routes serving the Lynnway and 1A were analyzed, but not represented here due to low ridership and few capacity issues found.*

Bus Demand and Capacity (7:15-8:15AM)

*Line width indicates how many
passengers are traveling on that
corridor segment between
7:15-8:15am*

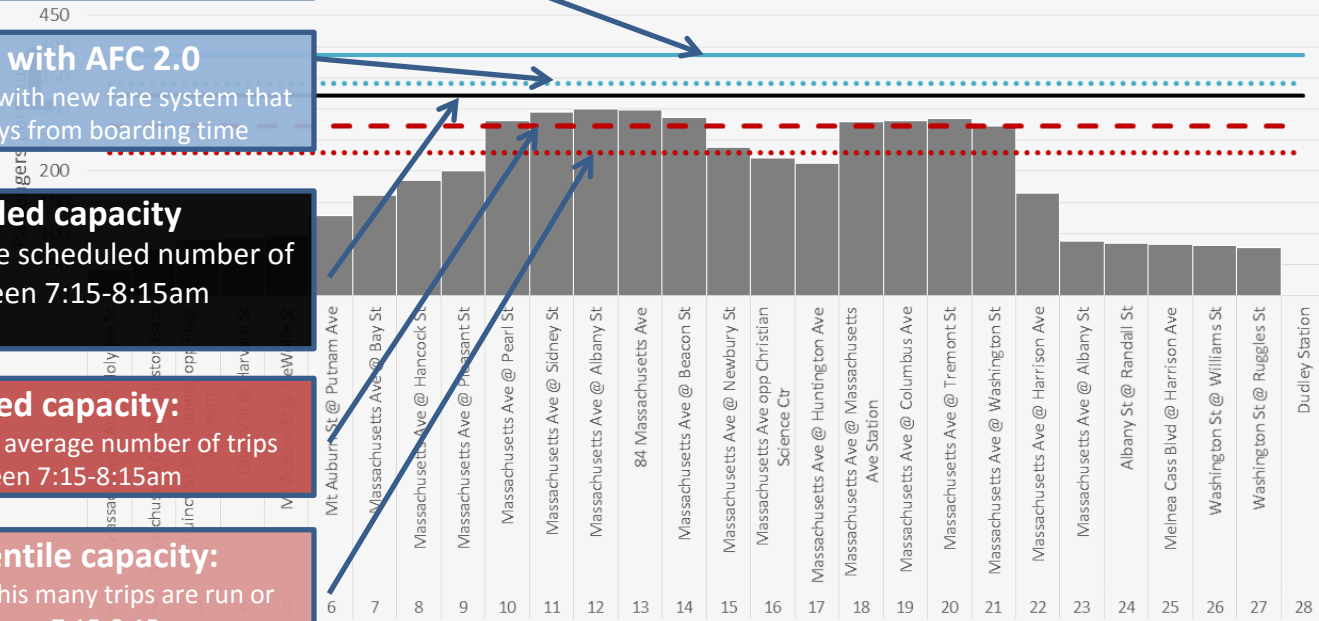
*Line color indicates the percent
capacity utilized for that corridor*

APC and ODX Data from 2015



How does bus capacity vary?

- Today, due to internal and external factors, there typically aren't as many trips run during the peak hour as scheduled
- Getting to scheduled capacity is an important step, but to get more capacity, transit priority measures can help without large investments.



How do AFC 2.0 and other bus priority measures impact capacity?

- Buses will spend less time at stops with AFC 2.0, and less time in traffic if they had bus lanes and traffic signal priority – over a whole route, these saved minutes add up, enabling the same number of buses to offer incrementally more trips.
- In some cases, such as the 1, 7, 9, 32, and 77 buses, it's estimated that AFC 2.0 and bus lanes/traffic signal priority could enable running more than one additional trip per hour without needing any more buses.
- Estimates derived from the MassDOT Dedicated Bus Lanes Study and MBTA Fare Validation Study

Route	Scheduled trips 7:15-8:15AM	Trips enabled with AFC 2.0	Trips enabled with Dedicated Bus Lanes/TSP
1	7	7.4	8.4
7	16	16.4	17.1
9	14	14.3	15.1
32	20	20.7	22
77	9	9.2	10.3

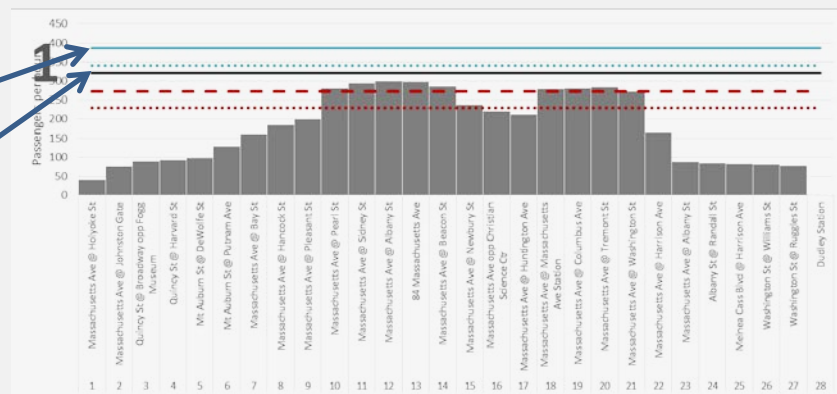
What do the blue lines mean?

Capacity w AFC 2.0 + Bus Priority

Capacity with new fare systems, bus lanes, and transit signal priority that will reduce delay from boarding, traffic

Capacity with AFC 2.0

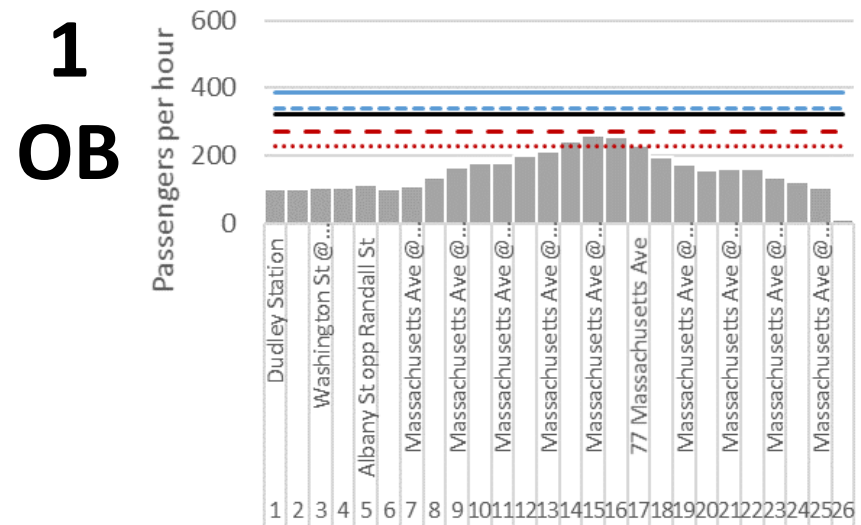
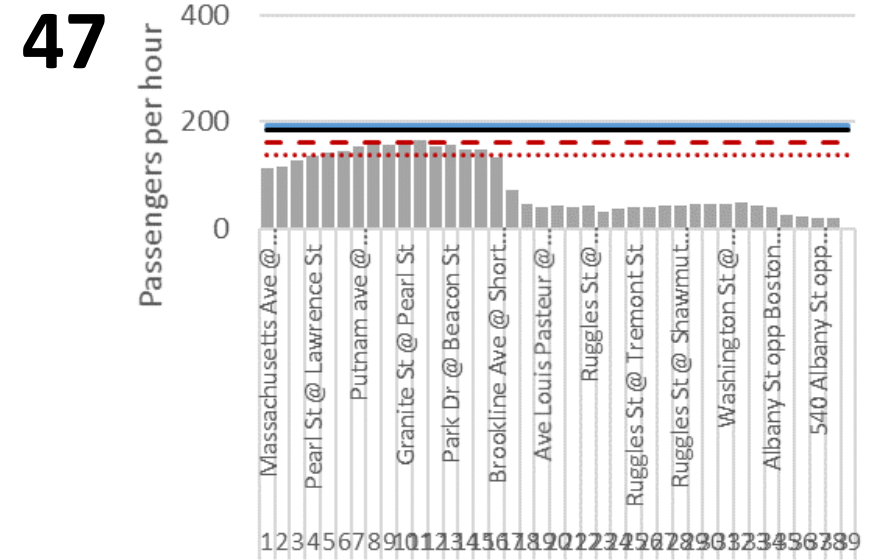
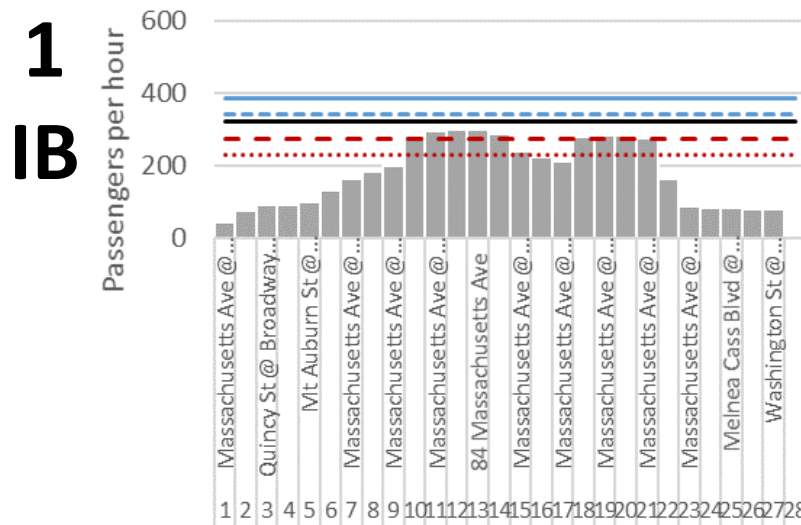
Estimated capacity with new fare system that will reduce delays from boarding time



Key

- Passenger load (2015 APC)
- Capacity with AFC2 + bus lanes
- - - Capacity with AFC2
- Capacity w scheduled frequency
- - - Capacity w operated frequency
- Capacity w 25th pctile frequency

- *Graphs depict inbound travel unless otherwise noted*

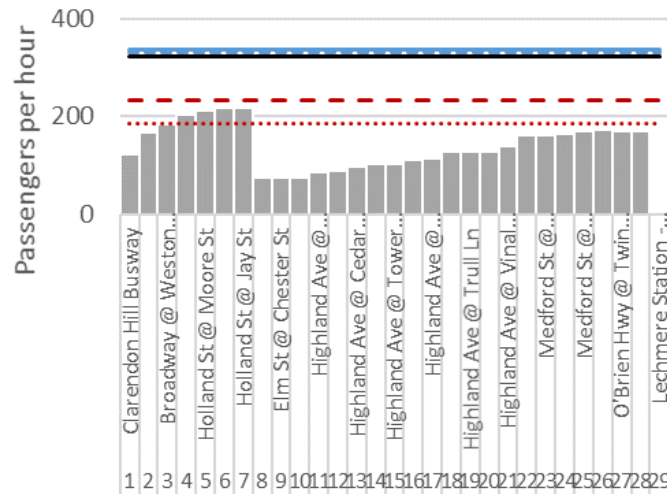


Key

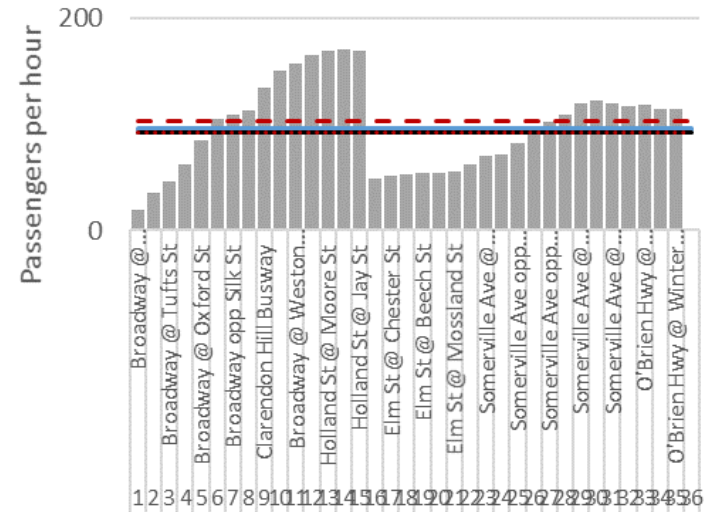
- Passenger load (2015 APC)
- Capacity with AFC2 + bus lanes
- Capacity with AFC2
- Capacity w scheduled frequency
- Capacity w operated frequency
- Capacity w 25th pctile frequency

- Graphs depict inbound travel unless otherwise noted
- Route 101 inbound does not reach capacity constraints during the AM peak and is not pictured
- 87 capacity constraints likely to be relieved due to GLX

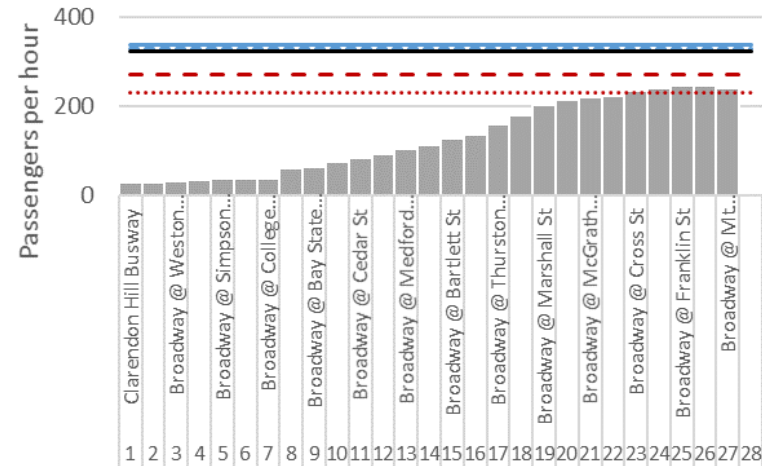
88



87



89



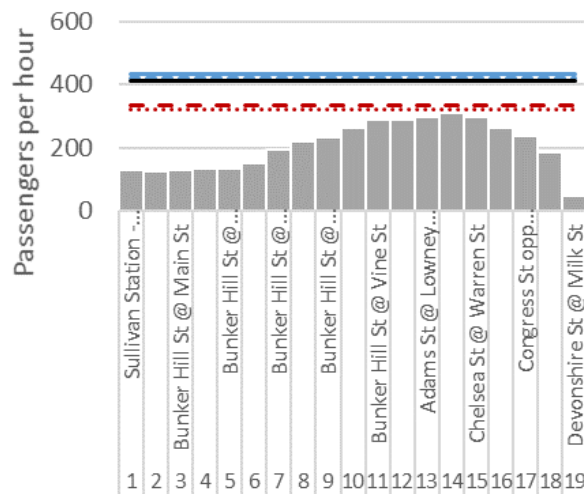
CHELSEA & CHARLESTOWN BUS CAPACITY

Key

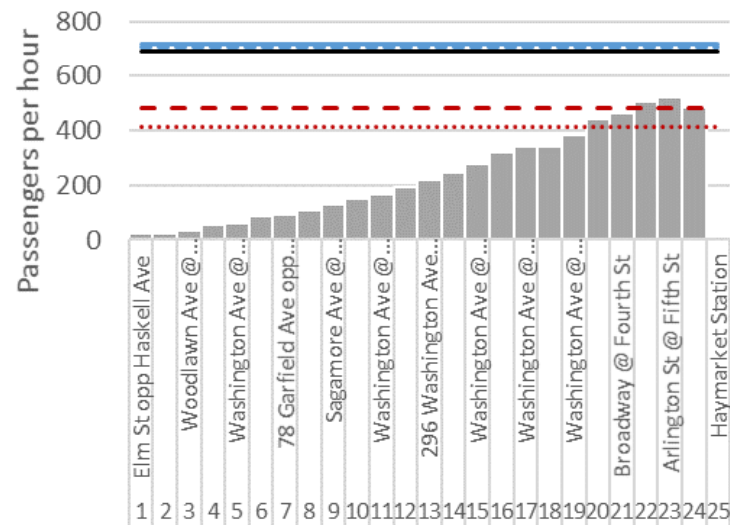
- Passenger load (2015 APC)
- Capacity with AFC2 + bus lanes
- Capacity with AFC2
- Capacity w scheduled frequency
- Capacity w operated frequency
- Capacity w 25th pctile frequency

- Graphs depict inbound travel unless otherwise noted
- Routes 99, 104, 106, 108, and 109 do not reach capacity constraints during the AM peak and are not pictured

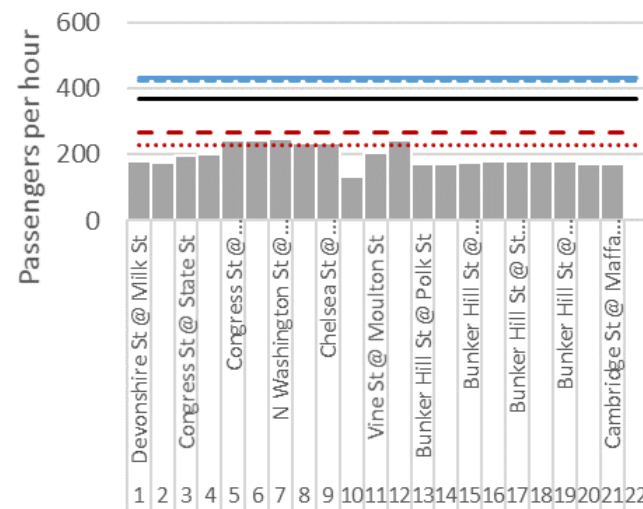
93
IB



111



93
OB

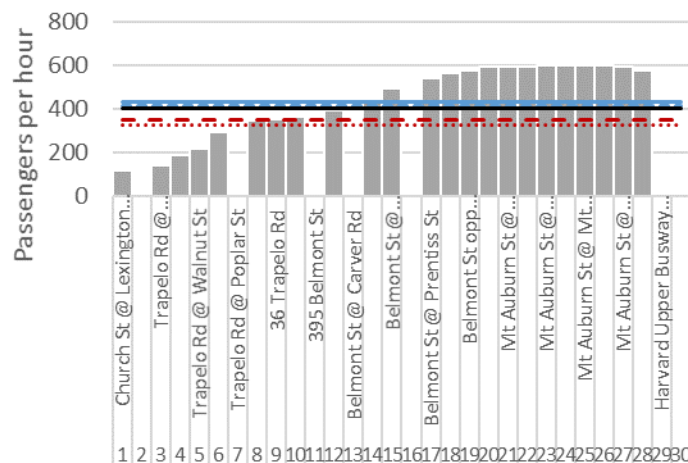


Key

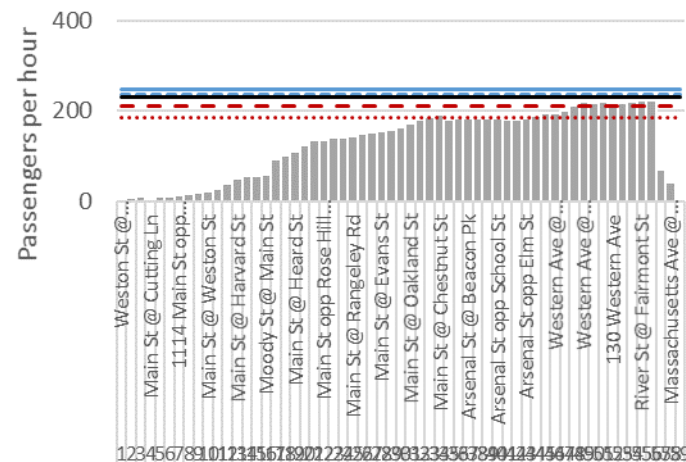
- Passenger load (2015 APC)
- Capacity with AFC2 + bus lanes
- Capacity with AFC2
- Capacity w scheduled frequency
- Capacity w operated frequency
- Capacity w 25th pctile frequency

- Graphs depict inbound travel unless otherwise noted

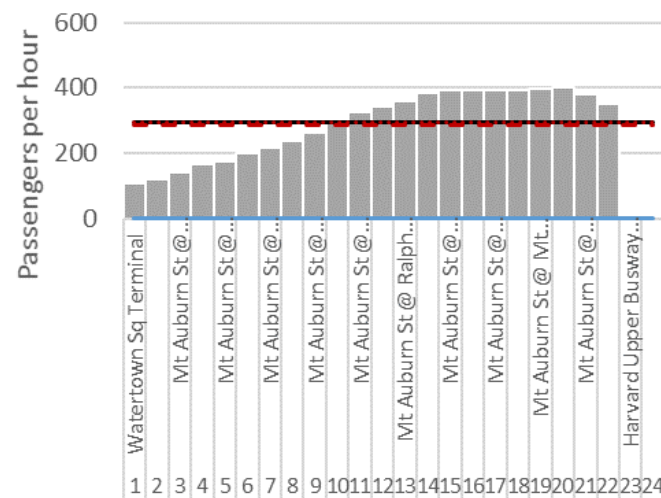
73



70




71



Summary: Bus routes with capacity constraints today, 7:15-8:15AM

Route	Corridor	Passengers over average operated capacity	Passengers over scheduled capacity	Passengers over capacity with AFC 2.0 + Dedicated Bus Lanes
1	Charles River	Y		
7	South Boston	Y	Y	Y
9	South Boston	Y	Y	Y
34	Roslindale-Forest Hills	Y	Y	
37	Roslindale-Forest Hills	Y		
40	Roslindale-Forest Hills	Y		
50	Roslindale-Forest Hills	Y		
57	Watertown-Waltham	Y	Y	
70	Watertown-Waltham	Y		
71	Watertown-Waltham	Y	Y	
73	Watertown-Waltham	Y	Y	Y
77	Arlington	Y		
87	Somerville	Y	Y	Y
111	Chelsea	Y		
117	Chelsea	Y		
57A	Watertown-Waltham	Y	Y	

	Under average operations	Under scheduled operations	With bus priority (AFC 2.0, bus lanes)
 ~ ESTIMATED ADDITIONAL BUSES NEEDED FOR AM PEAK	21	11	5

Summary: Likely bus routes with capacity constraints in 2040

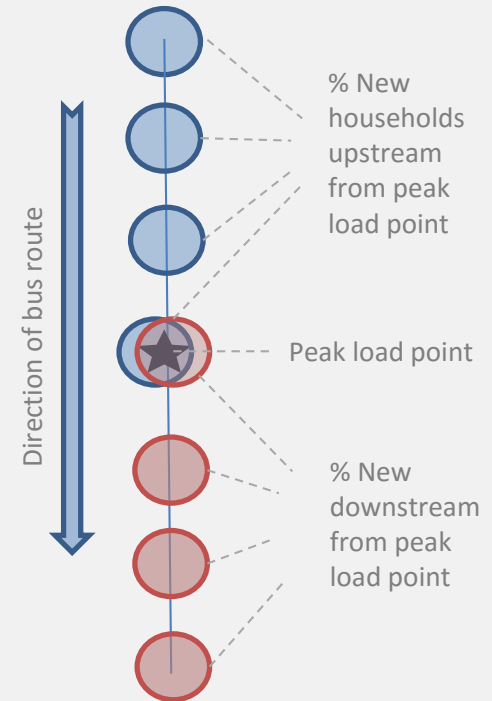
Methodology

Routes were assessed based on how close to capacity they are today, and how much development is forecast near them by 2040:

1. **% Average operated capacity utilized** –Ratio of passengers to average operated capacity at the peak load point* for 7:15-8:15AM.
2. **% Scheduled capacity utilized** –Ratio of passengers to scheduled capacity at the peak load point for 7:15-8:15AM.
3. **Percent new households within ½ mile upstream** - the percent** of new households forecast to be in walking distance (1/2 mile) of stops at or before the peak load point along the route.
4. **Percent new jobs within ½ mile downstream** - the percent of new jobs forecast to be in walking distance (1/2 mile) of stops at or after the peak load point along the route.

*Peak load point is the station with the highest number of riders passing through for that route

**For 2040 jobs or households with ranges, the lower bound is the number of jobs or households forecast by MAPC, while the upper bound is the number of households or jobs planned or proposed in the development pipeline for 2040, where data is available.



Example

Route	Corridor	% Average Operated Capacity Utilized	% Scheduled Capacity Utilized	Percent new households within ½ mile "upstream"	Percent new jobs within ½ mile "downstream"
77	Arlington	103.5%	81.3%	14%	6-100%

Percent capacity utilized

Over 100% 85% - 100% Below 85%

Percent new households/jobs

Over 25% 15% - 25% Below 15%

Summary: Likely bus routes with capacity constraints in 2040

Route	Corridor	% Average Operated Capacity Utilized	% Scheduled Capacity Utilized	Percent new households within ½ mile "upstream"	Percent new jobs within ½ mile "downstream"
77	Arlington	103.5%	81.3%	14%	6-100%
1	Charles River	110.0%	93.2%	18%	24%
47	Charles River	94.2%	83.0%	18%	23% - 76%
66	Charles River	90.8%	86.2%	21%	16%
86	Charles River	98.5%	86.7%	38% - 65%	15% - 40%
93	Charlestown	93.3%	75.0%	20%	6%
111	Chelsea	105.2%	73.9%	35%	17%
116	Chelsea	91.7%	73.9%	34%	12%
117	Chelsea	107.0%	82.8%	34%	12%
22	Crosstown South	89.8%	73.0%	19%	13% - 73%
19	Dudley	100.7%	82.8%	18%	16% - 45%
23	Dudley	96.5%	74.3%	17%	26% - 102%
28	Dudley	91.5%	85.1%	18%	26% - 102%
108	Everett	86.2%	90.7%	35%	1%
110	Everett	95.8%	84.3%	48%	3%
34	Roslindale-Forest Hills	129.3%	103.5%	20%	16% - 46%
36	Roslindale-Forest Hills	93.4%	74.4%	18%	16% - 46%
37	Roslindale-Forest Hills	129.5%	92.7%	18%	16% - 46%
39	Roslindale-Forest Hills	93.9%	93.9%	22%	12%
40	Roslindale-Forest Hills	105.1%	84.6%	18%	16% - 46%
50	Roslindale-Forest Hills	111.0%	90.2%	18%	12%
51	Roslindale-Forest Hills	90.1%	74.5%	18%	16% - 46%
741	SL Waterfront	91.0%	90.3%	63%	25% - 49%
87	Somerville	167.7%	186.6%	22%	24%
89	Somerville	91.2%	76.4%	31%	132%
7	South Boston	124.9%	107.1%	51%	20% - 38%
9	South Boston	142.8%	110.0%	36%	10% - 26%
11	South Boston	98.5%	89.1%	22%	12%
57	Watertown-Waltham	140.4%	120.1%	21%	15%
70	Watertown-Waltham	105.5%	96.6%	20%	24%
71	Watertown-Waltham	141.2%	137.5%	18%	1%
73	Watertown-Waltham	173.0%	149.3%	18%	1%
57A	Watertown-Waltham	113.4%	111.3%	23%	15%

SPATIAL GAP ANALYSIS

- **Major employment destinations**
 - Focus on areas outside of the downtown core (Longwood, Logan, Seaport, Kendall, etc)
 - Determine relative transit access to workforce
- **Underserved residential neighborhoods**
 - Focus on areas close to Boston's core with relatively long travel times (Roxbury, Dorchester, Mattapan, Chelsea, Everett, etc.)
 - Determine relative access to employment
- Evaluate investment strategies for effectiveness in closing gaps
- Visualize gaps using the CoAXs "collaborative accessibility" tool

SPATIAL GAP ANALYSIS – LMA EXAMPLE

CoAXs | Job Access in the Boston Area | Beta Version

Innovation happens where the right people can work together.
Innovative companies need access to a wide workforce.

Click a station to see how transit provides the *reach* and *capacity* required to connect workers and jobs.

DOWNTOWN

KENDALL

LMA

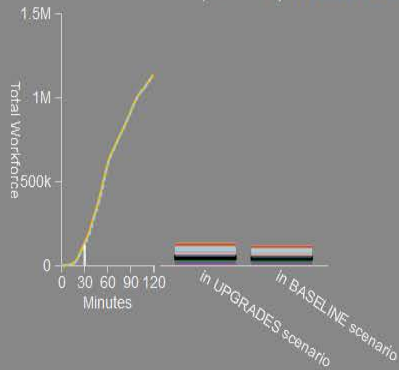
WTC

Point-to-point mode ☐

Workforce reachable from Longwood Medical Area
within 30 min. by public transit.

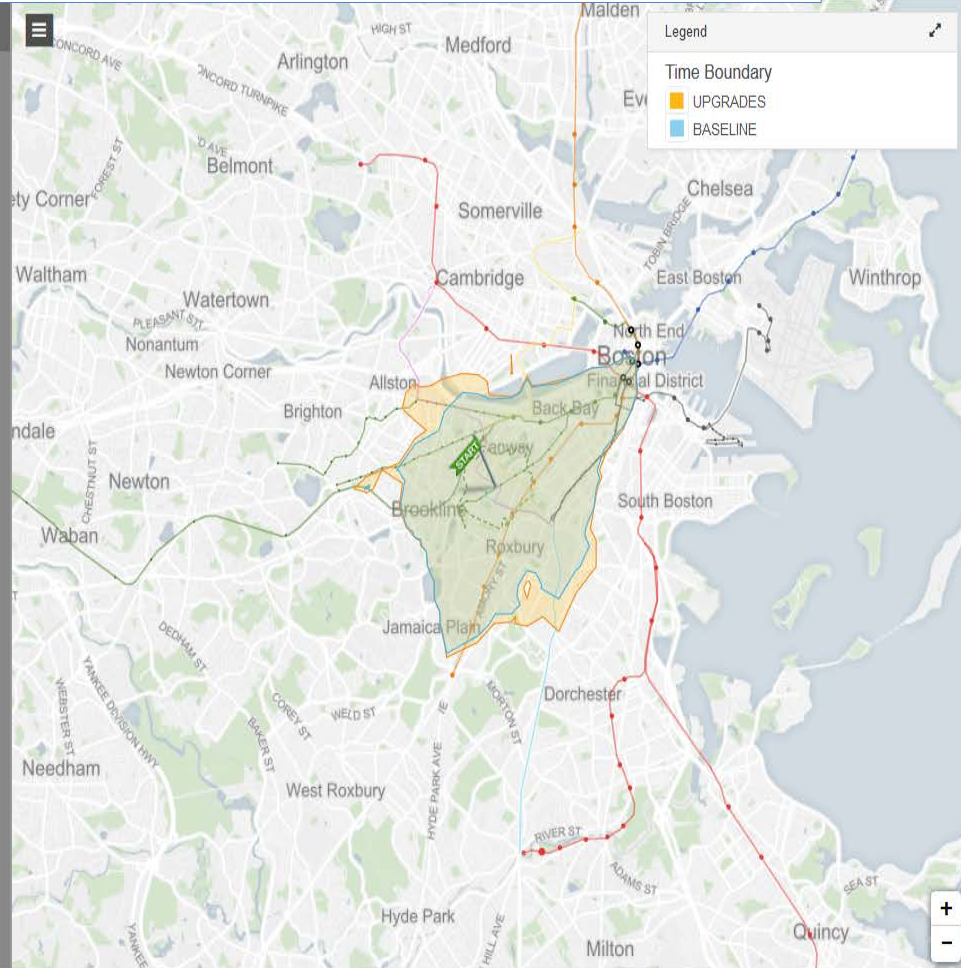
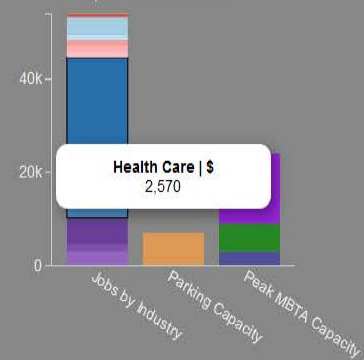
124,000 Total
27,000 Health Care

110,000 Total
24,100 Health Care



Jobs and Transport Capacity at
Longwood Medical Area:

54,000 Total
34,400 Health Care



Time Map

Scenario Comparison: UPGRADES vs. BASELINE

Corridor Editor

Service Editor



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DOWNTOWN

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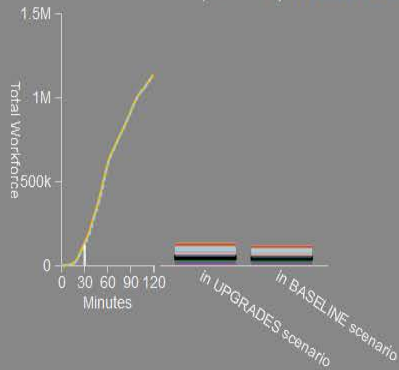
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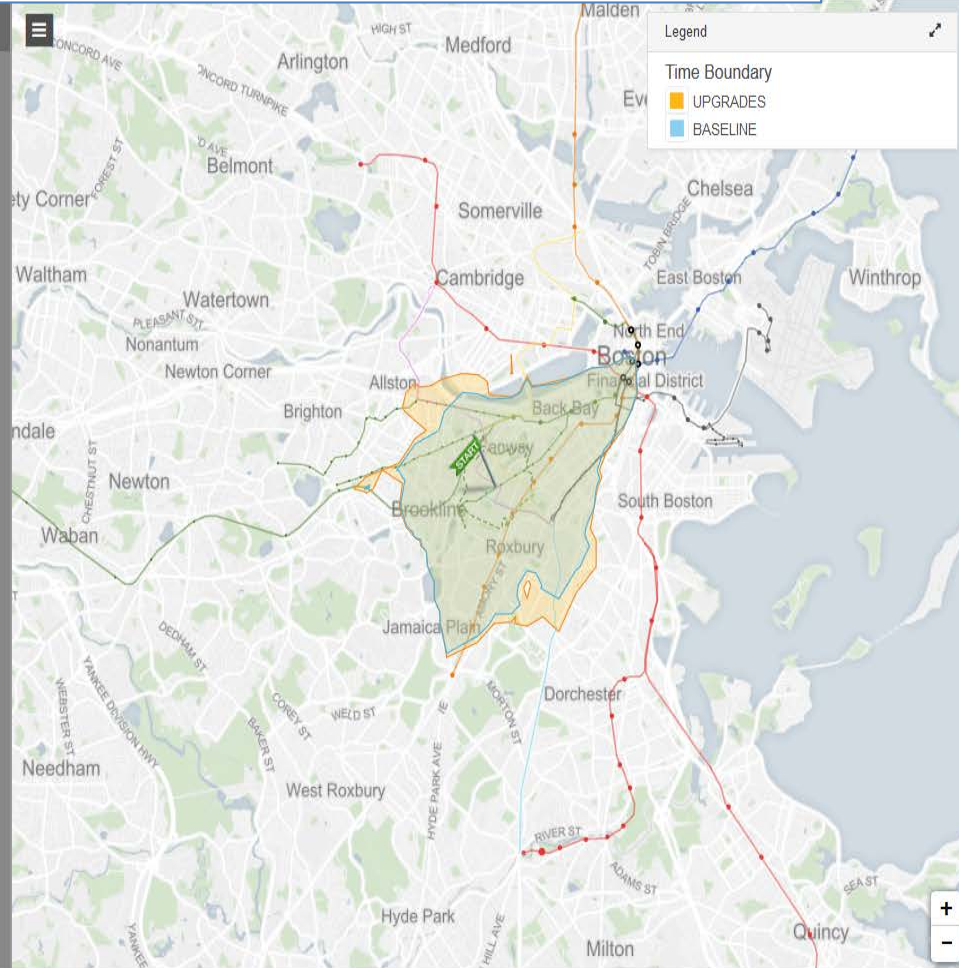
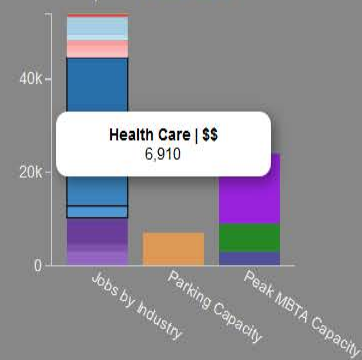
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SPATIAL GAP ANALYSIS – LMA EXAMPLE

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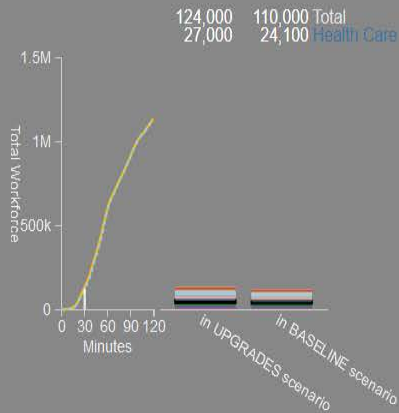
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Innovative companies need access to a wide workforce.

Click a station to see how transit provides the *reach* and *capacity* required to connect workers and jobs.

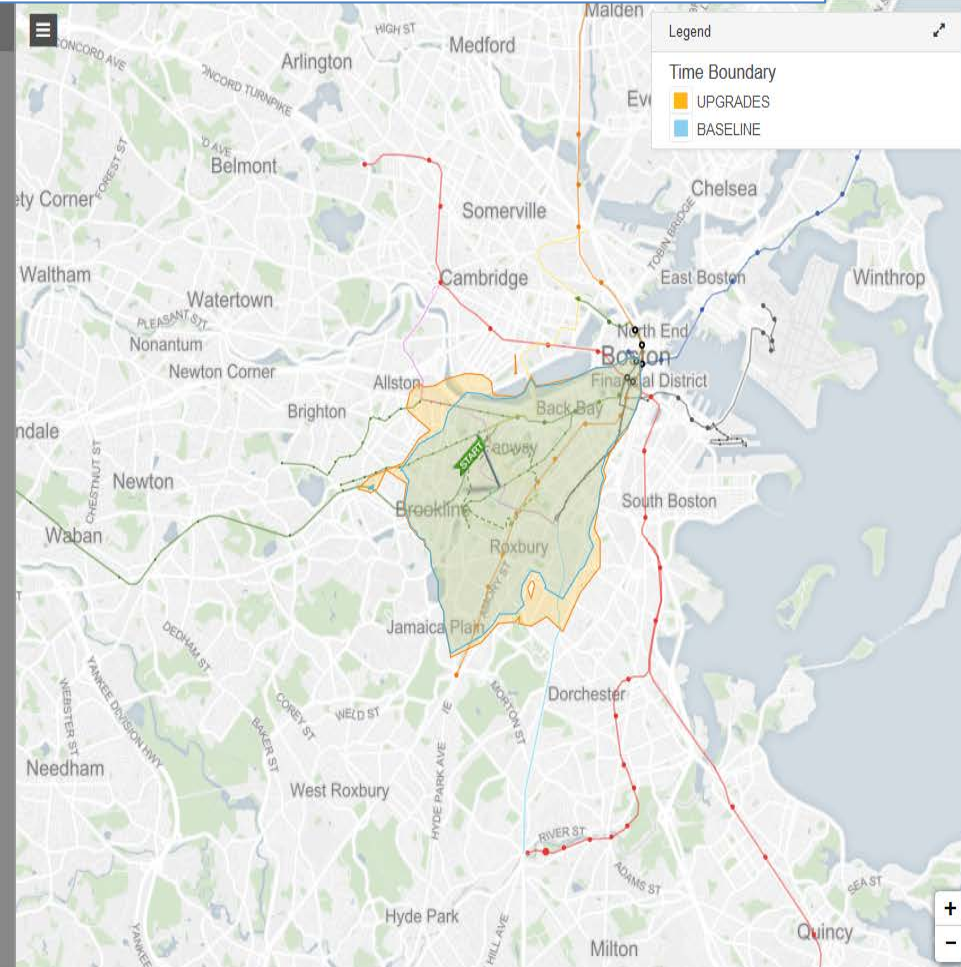
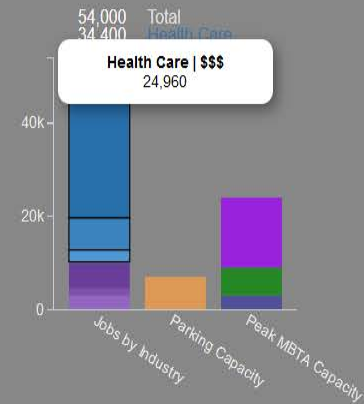


Point-to-point mode ☐

Workforce reachable from Longwood Medical Area
within 30 min. by public transit.



Jobs and Transport Capacity at
Longwood Medical Area:



Time Map

Scenario Comparison: UPGRADES vs. BASELINE

Corridor Editor

Service Editor



SPATIAL GAP ANALYSIS – LMA EXAMPLE

CoAXs | Job Access in the Boston Area | Beta Version

Innovation happens where the right people can work together.
Innovative companies need access to a wide workforce.

Click a station to see how transit provides the *reach* and *capacity* required to connect workers and jobs.

DOWNTOWN

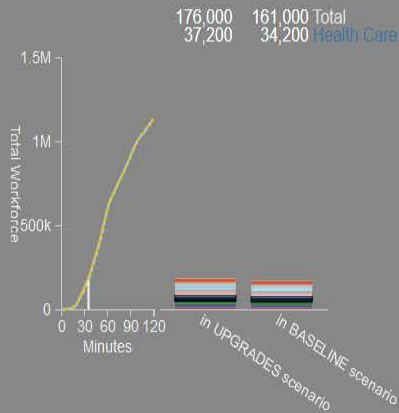
KENDALL

LMA

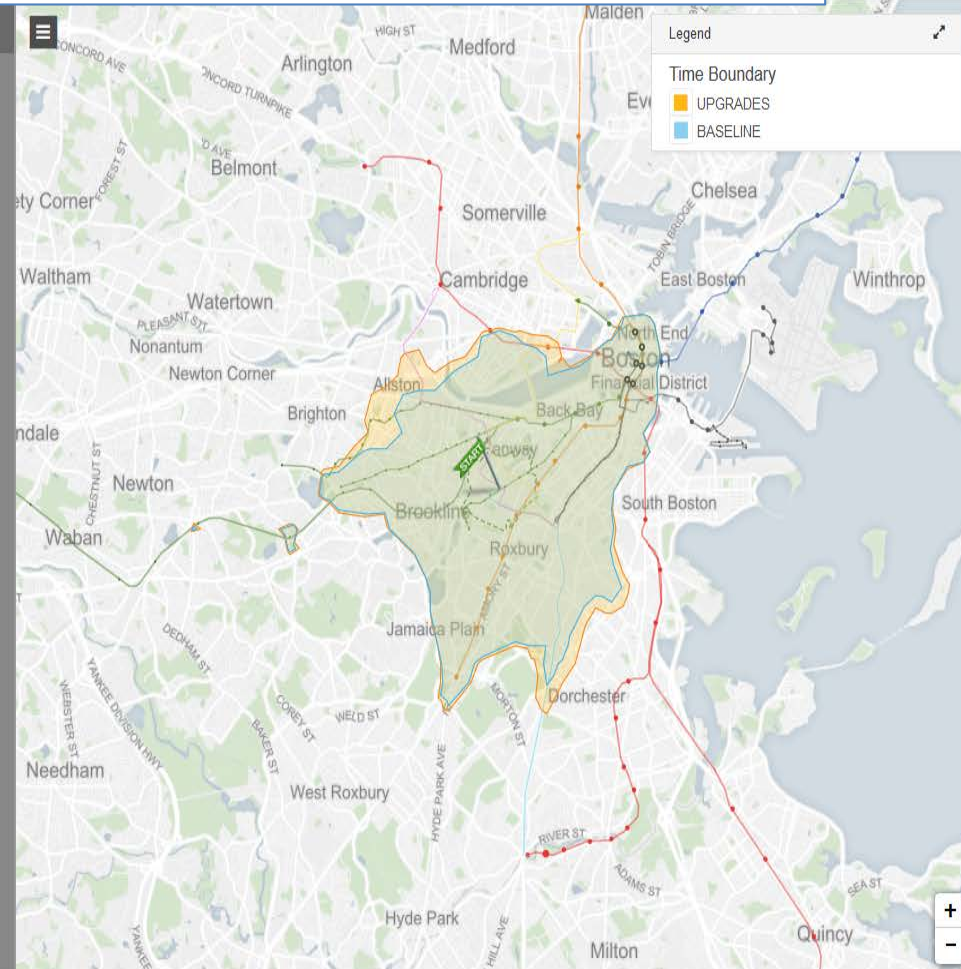
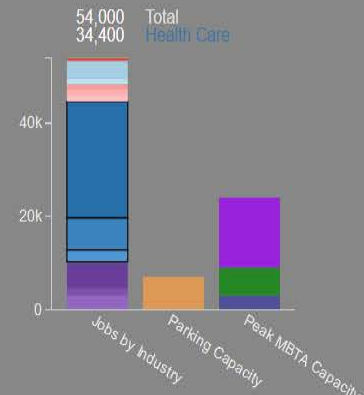
WTC

Point-to-point mode ☐

Workforce reachable from Longwood Medical Area
within 35 min. by public transit.



Jobs and Transport Capacity at
Longwood Medical Area:



Time Map

Scenario Comparison: UPGRADES vs. BASELINE

Corridor Editor

Service Editor



SPATIAL GAP ANALYSIS – LMA EXAMPLE

CoAXs | Job Access in the Boston Area | Beta Version

Innovation happens where the right people can work together.
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DOWNTOWN

KENDALL

LMA

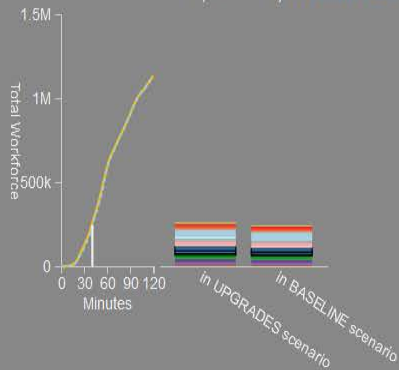
WTC

Point-to-point mode ☐

Workforce reachable from Longwood Medical Area
within 40 min. by public transit.

246,000
51,600

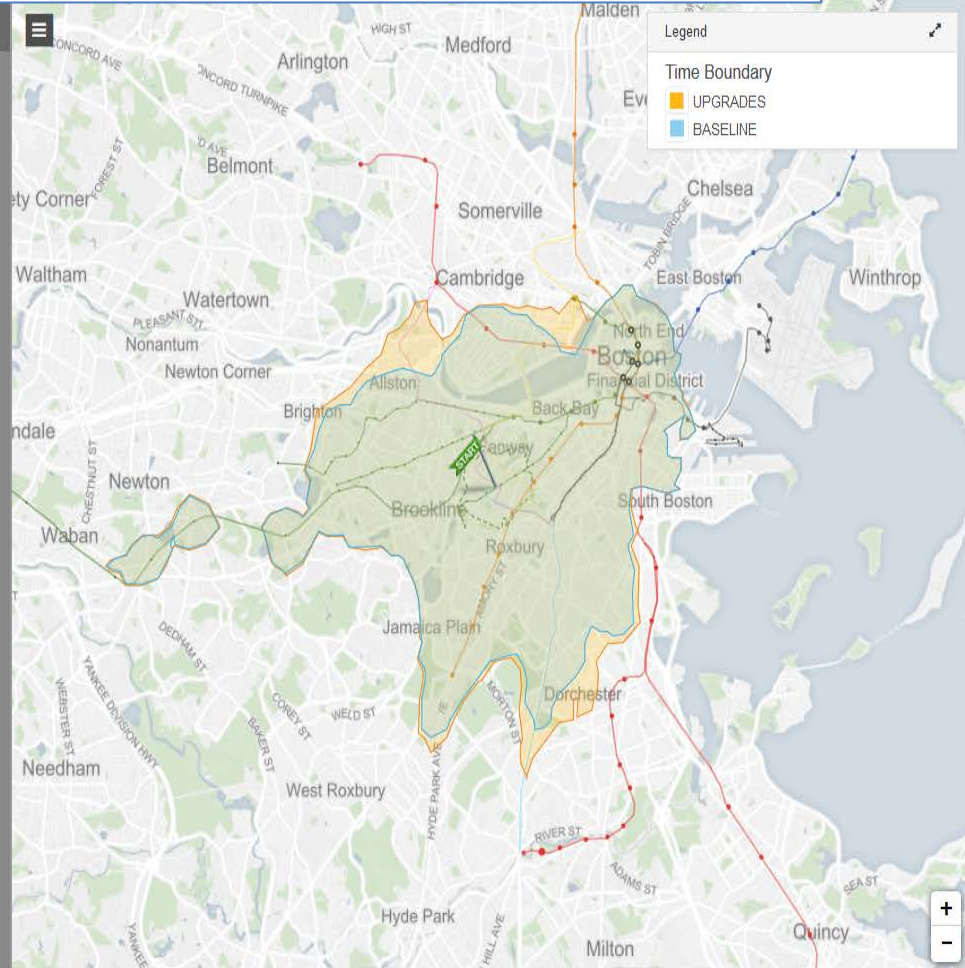
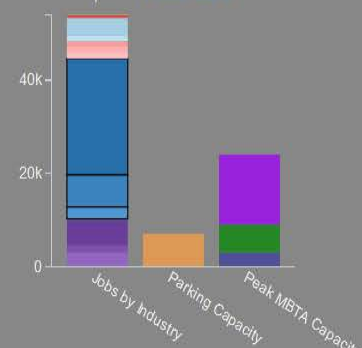
227,000 Total
47,800 Health Care



Jobs and Transport Capacity at
Longwood Medical Area:

54,000
34,400

Total
Health Care



Time Map

Scenario Comparison: UPGRADES vs. BASELINE

Corridor Editor

Service Editor



SPATIAL GAP ANALYSIS – LMA EXAMPLE

CoAXs | Job Access in the Boston Area | Beta Version

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DOWNTOWN

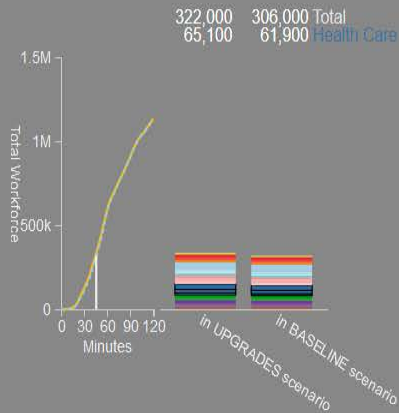
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LMA

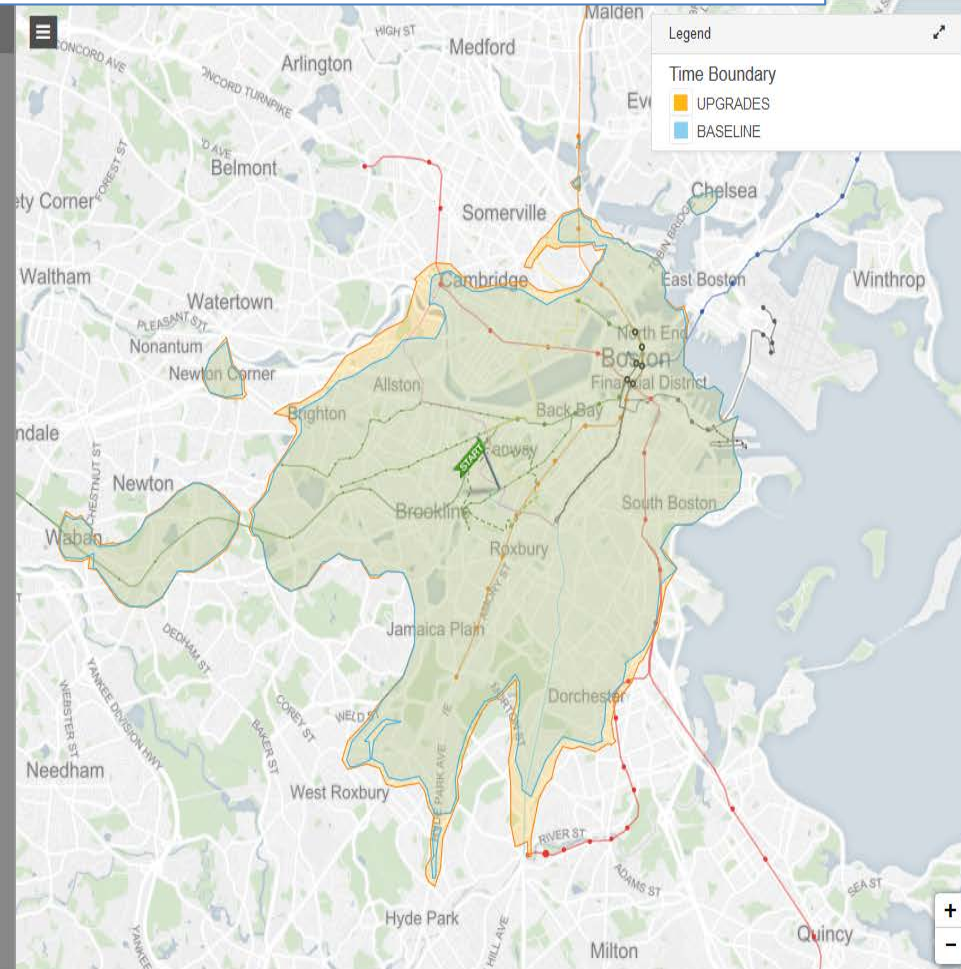
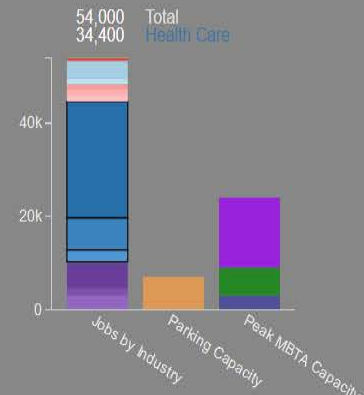
WTC

Point-to-point mode ☐

Workforce reachable from Longwood Medical Area
within 45 min. by public transit.



Jobs and Transport Capacity at
Longwood Medical Area:



Time Map

Scenario Comparison: UPGRADES vs. BASELINE

Corridor Editor

Service Editor

