East-West Passenger Rail Study

Ridership Methodology Report

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1. Introduction

This report presents the methodology used to forecast ridership for the East-West Passenger Rail Study. The East-West Rail corridor connects the Massachusetts cities of Boston and Pittsfield, via Springfield. Included in this analysis are connections to the MBTA Worcester Line, CTDOT and Amtrak service on the Hartford Line from Springfield, MA to New Haven, CT, as well as the Amtrak Vermonter and Lake Shore Limited services. This work builds on the previous study that was undertaken in the region, which examined a similar study area, the Northern New England Intercity Rail Initiative (NNEIRI) Study. This work used the same model from the NNEIRI project as the basis for this analysis, with updated input data and additional geographic coverage to include points west of Springfield.

The model utilized for this study is based on travel market data throughout Massachusetts and Connecticut (and the Northeast Corridor), historical rail ridership data and trends, and demographic data. Other models providing a foundation for this study's model includes those developed for Amtrak's Northeast Corridor, Southeast Corridor, California Corridor, Florida and the Midwest States.

2. Study Area Geography

This study area covers the proposed East-West Rail Corridor, connecting Boston to Springfield and Pittsfield, MA, as well as incorporates connecting rail services. This study area includes the states of Massachusetts and Connecticut, as well as the New York metro area (Manhattan, Long Island, and Jersey City, NJ). These services include the following:

- Northeast Regional trains originating in Boston providing service to Springfield, Hartford, and New York, continuing to Washington, D.C.
- Lake Shore Limited trains originating in Boston providing service to Springfield, continuing to Chicago, IL
- Vermonter trains originating in St. Albans, VT providing service to Vermont stations, Springfield, Hartford, and New York
- CTrail Hartford Line trains operating between Springfield and New Haven

The entire project study area can be seen in Figure 1, but the demand is generated based on twenty-mile straight-line buffers around each station, weighted for areas closer to the stations.

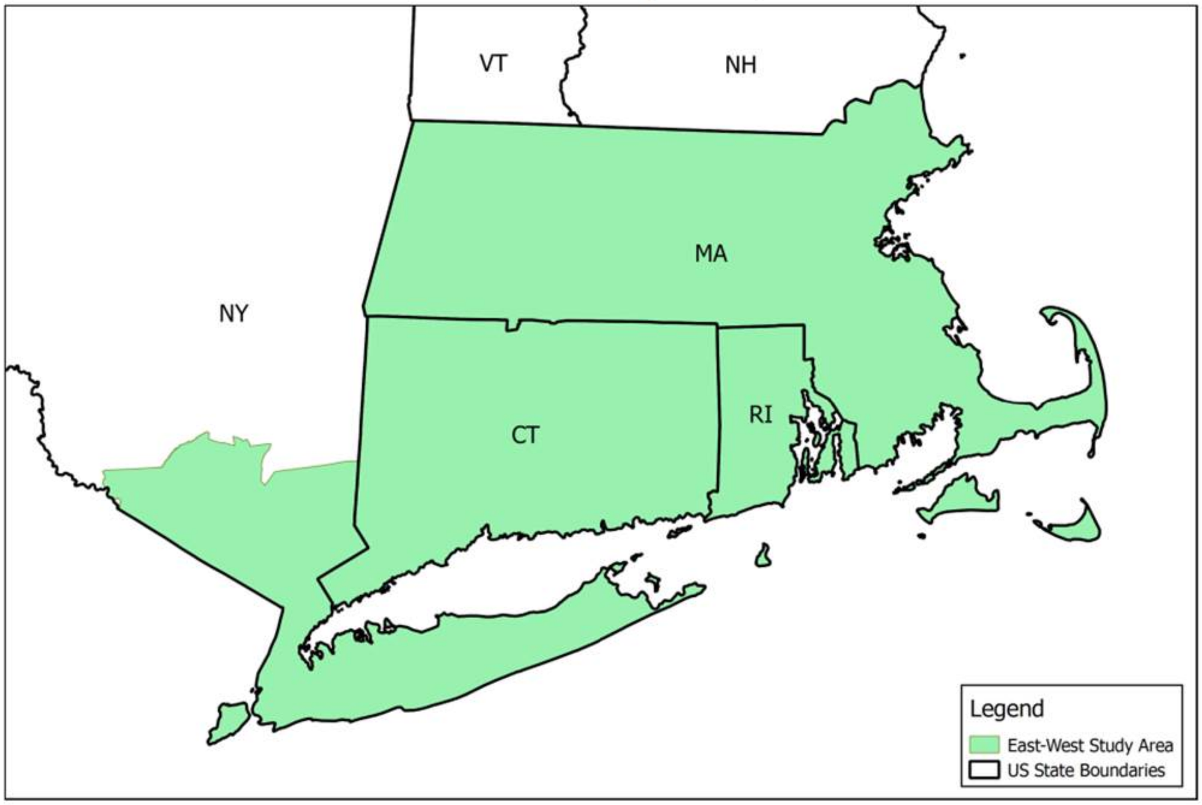

Figure 1. Study Area

3. Travel Demand Model Description

The travel demand modeling approach used in this study was based on a passenger rail incremental model system and used in many previous applications to evaluate proposed intercity and high-speed rail services for several states and Amtrak throughout the country. The travel demand model was originally developed from extensive market research and observed travel volumes and service characteristics by mode, which were conducted/assembled in various study corridor markets including the Northeast, Southeast, and other regions.

The model is an incremental model that only forecasts rail ridership, as opposed to total travel by all modes. The model pivots off existing ridership and service by station pair, and the forecasts are based on demographic growth and service characteristics such as departure/arrival times of day, travel time between station pairs and train headways. In cases where there is no existing service, a proxy station pair is assigned that has similar characteristics to the new station pair (such as distance between stations and market size), and the base ridership is adjusted to account for differences in market size and service. Each train is modeled separately, which allows for time-of-day factoring for both departure and arrival times. Connections are explicitly modeled and factored lower to reflect the lower appeal of a required transfer.

The model incorporates the Amtrak service and other rail service in the region, such as connecting MBTA trains and bus service, as well as potential connections in the Amtrak network. The model has been thoroughly calibrated and updated to effectively evaluate extensions to the current system and connections with both Amtrak and the MBTA Worcester Line. The model calibration is described in more details in Section 5. It’s also important to note that the model produces ridership forecasts that are unconstrained with regard to train seating capacity and parking capacity.

As the model is incremental, it starts with a base number of riders per station pair that is then adjusted for two dimensions. The first dimension forecasts the growth based on the market size, and the second dimension forecasts the growth based on service characteristics. The key markets addressed in the forecasting model system are defined by geographical location (i.e., origin-destination station pair).

The first dimension addresses the growth in intercity person travel volumes due to socio-economic growth factors, including population, employment, and income. This is done both to account for base year to future year growth and to adjust for differences between the actual station pair and the proxy station pair (if necessary). The second dimension adjusts the rail ridership in each market, based on the following service characteristics:

- Line haul travel time
- Frequency of service
- Time of day of service

Total market-to-market frequencies are scaled based on arrival and departure times of each train serving the market. These scaling factors are based on the observed performance of trains in different departure/arrival time slots within rail corridors throughout the US. A train's utility and market share are determined by the combination of arrival and departure factors along with the time to the previous and subsequent trains, travel time, cost, and on-time performance. The model outputs include ridership, revenue, and vehicle miles traveled (VMT) diverted for each alternative.

4. Model Inputs

The intercity passenger travel market data for this study was assembled from a number of different sources. These sources included socio-economic data and travel-related service characteristics for the study markets. In the current study, socio-economic data was obtained from the Regional Planning Associations in the study area, including:

- Berkshire Regional Planning Commission (BRPC)
- Cape Cod Commission (CCC)
- Central Massachusetts Regional Planning Commission (CMRPC)
- Franklin Regional Council of Governments (FRCOG)
- Metropolitan Area Planning Council (MAP)
- Montachusett Regional Planning Commission (MRPC)
- Martha’s Vineyard Commission (MVC)
- Merrimack Valley Planning Commission (MVPC)
- Northern Middlesex Council of Governments (NMCOG)
- Nantucket Planning and Economic Development Commission (NPEDC)
- Old Colony Planning Council (OCPC)
- Pioneer Valley Planning Commission (PVPC)
- Southeastern Regional Planning and Economic Development District (SRPEDD)

Travel-related service data was collected from publicly available sources, including ridership information and rail schedules from Amtrak.

The base model year is 2018 in order to account for the new CTrail Hartford Line service between Springfield and New Haven, which opened in June of 2018. Data obtained for different years was adjusted as discussed in the following sections.

4.1 Base Year Data

As described above, this methodology used an incremental model that pivots off existing base year data including ridership, revenue, and passenger-miles. All three of these types of data are at the annual station-to-station bi-directional level by route, including connections between routes. The routes used for this analysis are as follows:

- Amtrak:
  - NE Regional trains on the segment Boston to New York via New Haven
  - NE Regional and Amtrak shuttles operating on the Hartford Line from Springfield to New Haven
  - Lake Shore Limited
  - Vermonter
  - Downeaster (added for the Final Alternatives analysis)
- CTrail Hartford Line from Springfield to New Haven
- MBTA Worcester Line

The baseline data were developed separately for each service operator, and the sources are listed in Table 1. As the ridership was available at the boardings and alightings level, not flows, an iterative proportional fitting (IPF) process was used to develop a flow table from the count data. In this way it is an estimated flow table but based on actual counts. While not a model input, base year revenue was used to calculate the forecasted revenue by multiplying station to station fares by ridership. The revenue used either the average fare (for connecting services) or a formula based on station to station average passenger yields (for Amtrak services). The passenger miles were calculated using station rail mileposts for all three service providers.

Table 1. Base Year Data Sources

Service Operator	Ridership Data Source	Revenue Data Source	Passenger Miles Data Source
Amtrak	Amtrak Station boardings and alightings FY18	Estimated revenue per passenger formula based on NNEIRI analysis	Estimated based on station mileposts
CTrail	CTrail station average daily boardings and alightings, 2018	Assumed average fare of $6.01 based on examination of station to station fares	Estimated based on station mileposts
MBTA	MBTA weekday boardings and alightings by train, Spring/Fall 2018	Assumed average fare of $7 based on examination of station to station fares	Estimated based on station mileposts

4.2 Proxy Station Pair Assignment

While not a traditional model input, the proxy station assignment is an important variable in determining the final ridership forecast in the incremental model. As described above, this model is an incremental model operating at the station pair level, meaning it pivots off the base ridership data described in Section 4.1. In cases where there is no existing service, or when major changes in available rail service are anticipated (e.g., going from one round trip daily to 20 round trips daily), it is necessary to assign a proxy station pair. This gives a baseline ridership number that the model can then adjust based on market factors (both future growth and adjusting for differences in the proxy stations) and service factors (how the proposed service differs from the proxy station service).

Particularly for this analysis, the East-West Corridor would see substantial increases in frequency over the existing one Lake Shore Limited train per day. To account for these differences, station pair proxies that were similar in terms of market characteristics and existing service offered, were assigned as needed. These were based on the following criteria:

- Station pair distance. In travel demand modeling, trip production is frequently based on distance, using a gravity model formulation. In this case, we want to ensure the station pairs we are substituting are a similar distance apart to the new station pair, so they have a similar attraction. This factor is not explicitly accounted for in our proxy station factor adjustments, but it helps control for variances.
- Market size. The base ridership is directly factored based on the population and employment on both ends of the trip for the proxy pair versus the new pair. By choosing a pair with similar market sizes, we can minimize this adjustment. In most cases, the proxy market size does not have to be identical to the market being modeled, as the model is able to adjust the demographics up or down to account for size differences. In cases such as Boston, which is a very large market compared to others in the region with a strong employment base, special care must be taken to ensure the baseline ridership is adjusted appropriately.
- Service offered (travel time, frequency, time of day, etc). The base ridership is directly factored based on the service characteristics of the proxy pair versus the new pair. By choosing a pair with similar service types, we can minimize the impact of this adjustment.

The proxy market pair selection process for this analysis is described in more details for the Preliminary and Final Alternatives in Section 6.2 and Section 6.3.

4.3 Socio-Economic Data

The socio-demographic data in the model was updated with data obtained from local MPOs to ensure the most current forecast data for population, employment, and income was included in this study. Data sources included the following:

- Massachusetts town and RPA-level population and employment for years 2010, 2020, 2030, and 2040
- Connecticut and New York metro area population, employment, and income from NYMTC for years 2010, 2020, 2030, and 2040

Demographic forecasts are one of the key inputs to the model, in addition to the rail service operating plan. The model process requires that the demographic data be at the station level, which is at a smaller scale than the town level. To translate town-level demographic data to station-level data, the town-level forecasts were first split to the Census Division level, which is a much smaller geographic area. Using 2010 Census data, the ratios of Census Division population to town population were estimated. These ratios were used to split population and income. Similarly, employment was split using the ratios of employment at the Census Division level versus town level from 2010 Census Data. Once the demographic forecasts were split, a custom GIS application was employed to calculate the population and employment contained within buffers around the stations. Concentric buffers ranging from five to twenty miles around stations were used, and a weighted average population and employment of the buffers is the actual input into the ridership model. The weights are applied to all four buffers (five, ten, fifteen, and twenty miles), with the closer buffers being weighted higher to account for a higher likelihood that those residents/employees are more likely to use the station versus the further out buffers. This weighted average accounts for the fact that people closer to a station are more likely to use transit, as opposed to other modes, and the weighted average also accounts for access time to the station.

4.4 Service Data

There are currently several different types of rail service in the study area:

- Northeast Regional trains originating in Boston providing service to Springfield, Hartford and New York, continuing to Washington, D.C. with intermediate stops.

- Northeast Regional trains originating in Springfield providing service to Hartford, local Connecticut stops, and interlining with the main Northeast Regional route at New Haven.
- CTrail Hartford Line trains operating between Springfield and New Haven
- Lake Shore Ltd trains originating in Boston providing service to Springfield continuing to Chicago, IL
- Vermonter trains originating in St. Albans, VT providing service to Vermont stations, Springfield, Hartford and New York

Market data for rail travel was developed from the station boardings and alightings for Amtrak FY18[1] and CTDOT Hartford Line counts for September 2018[2]. This provided the baseline ridership numbers for the calibration run of the model.

The service inputs for the model included a daily timetable for all trains in the corridor and was developed using published timetables from Amtrak and CTDOT. For future alternatives, these timetables were developed based on previous work in the corridor, and that process is described in more detail in Section 6.2. Table 2 below summarizes existing Amtrak service in the corridor, providing the number of daily round trips serving a selection of major stations. The daily round trips in the table provide a summary of the different types of services in the study area.

Table 2. Number of Existing Weekday Trains by Service (Round Trip)

Service	NE Regional	Lake Shore Ltd	Vermonter	CTrail	Total
Boston-Springfield-Pittsfield	0	1	0	0	**1**
Springfield-Hartford-New Haven	8	0	1	8	**17**
St. Albans-Springfield	0	0	1	0	**1**

Source: Amtrak Lake Shore Timetable (effective 9/4/18), Amtrak Vermonter Timetable (effective 3/4/19), and CTrail Timetable for both NE Regional trains and CTrail (effective 11/12/18)

The final service characteristic that is needed to evaluate the rail alternatives is the average rail fares, which were computed by dividing the actual Amtrak revenue by ridership and applying it at the station-to-station level. This is not a direct input to the modeling, but fares are instead applied to the forecasted ridership to produce an estimate of the total revenue generated per alternative.

5. Model Calibration

In order to calibrate the intercity model, the base year input data were first reconciled into a common base year, and then the model was calibrated to match the existing count data. This section describes the process used to do these steps.

5.1 Base Year Reconciliation

In order to produce a base year calibration run, all of the data sources were reconciled into a common year, including both socio-economic data and ridership data. The latest available Amtrak ridership data was for 2018, which was the baseline year for data. The socio-economic data was available for 2010 and 2020, so it was interpolated to produce a consistent 2018 set of population, employment, and income. As

[1] https://www.amtrak.com/state-fact-sheets
[2] Provided by CTDOT

the CTDOT Hartford Line service started operation in 2018, the September 2018 counts were factored using the same factors from the socio-economic data to ensure they were consistent with the Amtrak ridership data.

For the service side, the 2018 service plans for CTrail Hartford Line service and the 2018 timetables for Amtrak were used.

5.2 Model Calibration

Once all the model input data was reconciled to the base year of 2018, the model was calibrated to match the base year boardings and alightings at the station-level and the route-level ridership totals. The calibration process involved running the model using the time, cost, and frequency characteristics of the existing Amtrak and CTDOT service, with current population, employment, and income data. The model calibration parameters were then adjusted until the forecasted output corresponded with the actual ridership data. Table 3 below shows the actual versus modeled route-level totals for the calibration run.

Table 3. Calibration Run Route-Level Annual Ridership

Route	Base Year Ridership	Forecast Ridership	Absolute Difference	Percent Difference
Lake Shore Limited	4,200	3,900	-300	-7.1%
Hartford Line (CTrail/Amtrak)	197,900	197,700	-200	-0.1%
NE Regional	626,200	607,000	-19,200	-3.1%
Vermonter	2,300	2,600	300	13.0%
MBTA Worcester Line	2,799,500	2,819,600	20,100	0.7%

Source: AECOM

6. Alternatives Analysis

For analysis purposes, all alternatives tested had a forecast year of 2040. This section describes the process used to develop the No-Build alternative, the Preliminary Alternatives, and the refinements for the Final Alternatives.

6.1 No Build Alternative

The No-Build Alternative forecast was developed using the base year service as described in Section 4.4, using the 2040 socio-economic data as described in Section 4.3. This forecast provided a baseline for evaluating the Preliminary and Final Alternatives against the natural socio-economic growth in the corridor.

6.2 Preliminary Alternatives

This analysis examined six preliminary alternatives for rail service in the corridor, ranging from extending current MBTA Worcester trains with bus transfers to Pittsfield up to high-speed service in the entire Boston to Pittsfield corridor, with the following general characteristics:

- Alternative 1: Extend current MBTA service from Worcester to Springfield along with some additional rail connections between Worcester and Springfield, bus service from Springfield to Pittsfield.
- Alternatives 2: New East-West service between Boston and Springfield, bus service from Springfield to Pittsfield.

- Alternative 3: New East-West service between Boston and Pittsfield, speed increases versus Alternative 2.
- Alternative 4: New East-West service between Boston and Pittsfield, small speed and frequency increases versus Alternative 3.
- Alternative 5: New East-West service between Boston and Springfield, bus service from Springfield to Pittsfield. Speed increases in BOS-SPG segment, frequency increases versus Alternative 4.
- Alternative 6: New high-speed East-West service between Boston and Pittsfield, large speed and frequency increases over all other alternatives.

In addition to the East-West service, the alternatives allow for transfers at Springfield onto the Hartford Line. These six Preliminary Alternatives were specified as a daily timetable, including station stops and detailed schedules in both directions, for input into the model. Example frequency and travel time characteristics of each Preliminary Alternative are shown in Table 4 and Table 5 below.

Table 4. Preliminary Alternatives Service Plan Summary – Frequency (Round Trips)

Segment	No Build	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
BOS-SPG	1 direct	1 direct	7 direct	8 direct	10 direct	10 direct	18 direct
Lansdowne/Boston Landing - SPG (MBTA transfers)	0	4 conn.	6 conn.	7 conn.	9 conn.	9 conn.	17 conn.
SPG-PIT	1 direct	1 direct, 4 bus conn.	1 direct, 6 bus conn.	5 direct	5 direct	1 rail, 9 buses	17 direct
BOS-NHV (connections to HL are not coordinated)	1 conn.	5 conn.	6 conn.	6 conn.	6 conn.	8 conn.	10 conn.

Table 5. Preliminary Alternatives Service Plan Summary – Average Travel Time (Minutes)

Segment	No Build	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
BOS-SPG	148	162	134	118	115	100	81
BOS-PIT	232	240	219	196	191	185	141

For the Preliminary Alternatives analysis, the East-West service was assumed to be similar to the Hartford Line service, and example proxy station pairs chosen include Springfield-Hartford for East-West station pairs with larger populations and Springfield-Wallingford for station pairs with smaller populations. The 2018 base annual ridership for Springfield-Hartford was approximately 75,000 and the 2018 base ridership for Springfield-Wallingford was approximately 5,500.

6.3 Final Alternatives

After the Preliminary Alternatives were evaluated, the consultant team made revisions to the modeling assumptions based on feedback from the Study Advisory Committee and the public prior to estimating ridership for the three final action alternatives. Major comments received included the following:

- 20-mile radius around stations for potential riders is too small.
- Initial ridership forecasts are too low given comparable corridors in the region such as the Downeaster.
- Ridership forecasts should include induced demand.

The project team examined the impact of adjusting the station buffers used to develop the demographic inputs to the model. The straight-line 20-mile buffers enabled a reasonable coverage of the state in most cases, as seen in Figure 2 on the next page. Expanding the buffers beyond that to allow for longer rural station access would create problematic station assignment patterns at the edge of the buffers and overlap with other more logical transit options. The one case that it was reasonable to adjust the buffers was the Springfield station. The demographic buffers are typically split between stations to ensure that the demographics were not being double counted, leading to an overestimation of ridership. In the case of Springfield, this was forcing potential East-West riders north and south of Springfield to first get on either the Vermonter or Hartford Line and transfer onto the East-West line, with a less attractive transfer time and penalty associated with this movement. A more realistic action would instead have the rider drive slightly longer to the Springfield station and access the East-West line directly. By releasing this constraint at Springfield, the model was better able to capture the areas surrounding Springfield, particularly the 5 Colleges area.

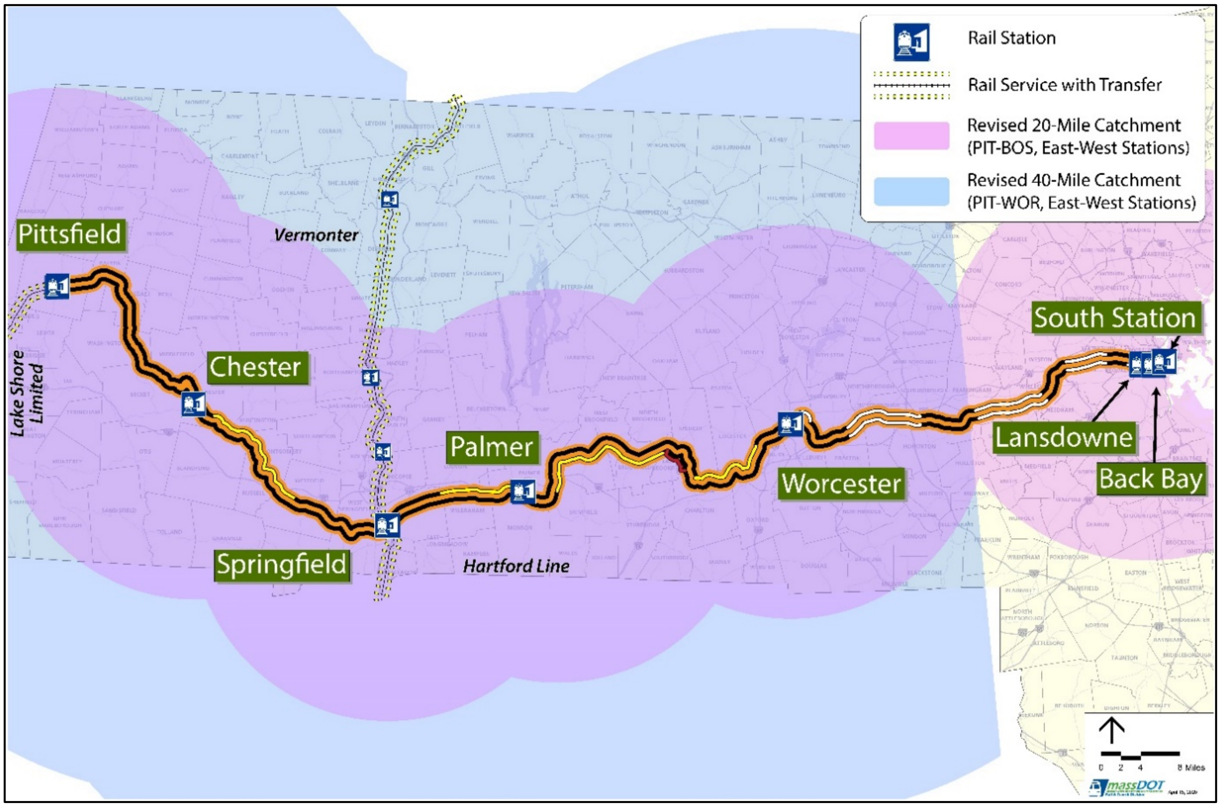

Figure 2. Demographic Buffers

The major adjustment to the modeling methodology was to closely examine the proxy station assignment process to better represent some of the unmodeled attributes of the rail line, and to account for the large pull of the Boston market, which is of a different scale than on the Hartford Line. During this process, the project team developed two modeling assumptions which were used to create a new ridership range for the final three alternatives. The first proxy case utilized the Hartford Line baseline ridership but refined the station pairs chosen and adjusted these to account for the larger pull of Boston. The second proxy case switched to using the Downeaster service as the baseline, which is outside of the East-West study area but represented a mature rail service in the region, which was grounded with Boston as a terminus, similar to the East-West line.

Other suggested proxy services and reasons why they were not used in the final analysis included the following:

- Boston to Providence: This is a shorter corridor, which inherently changes trip patterns (attractions are highly tied to trip distance), and is a commuter line, with very different service characteristics, fares, and trip purpose than anticipated on the East-West line. The Amtrak service in the corridor could be considered comparable but would be similar to the Downeaster service that was used as one of the proxies.

- Chicago's South Bend: It is assumed the mid-west has very different attitudes towards rail versus the Northeast. Like the previous corridor, this corridor is shorter than the East-West. Chicago's metro population is approximately double that of Boston, which could distort the ridership.
- Stockton, San Francisco: This is a commuter line, and typically has very different underlying travel patterns. The Bay area typically has much longer commute trip lengths than anywhere in the country, with the possible exception of NYC. There are too many differences in the unmodeled factors to be a reasonable base.
- Beacon, New York to New York City: New York City is not a comparable market to anywhere else in the United States. The demographic differences between Boston and New York are just too great for any model to adjust in a reasonable manner.

Table 6 summarizes the modeled and unmodeled attributes of the Hartford Line and Downeaster services and how they compare to the East-West service. For the modeled characteristics, an approximate fit is reasonable to utilize because the model adjusts for these components. Unmodeled attributes should be aligned to match as closely as possible.

Table 6. Proxy Service Comparisons

Attribute Type	Attribute Name	Hartford Line Proxy	Downeaster Proxy
Modeled	Trip Length	• Shorter trips	• Good match
Modeled	Population and Employment	• Matches medium-sized pairs • Missing small and large pairs	• Good match
Modeled	Rail Service	• Frequency matches higher alternatives • Speeds match medium alternatives	• Good match to alternatives 3/4 • Scales well to alternatives 1/2/5/6
Unmodeled	Total Market Size and Competition	• Doesn't include a clear representation of Boston (large employment draw) • Good match – includes multiple medium/large metro areas for competition (NYC, HFD, NHV)	• Directly includes Boston (large employment draw) • Larger total market – includes only a single large metro area (no competition)
Unmodeled	Traveler Type and Purpose Split (mostly unknown for East-West)	• Less than half commuters	• Commuter-focused • Includes student populations
Unmodeled	Fares	• Approximately $0.21/mile CTrail, $0.42/mile Amtrak	• Approximately $0.20/mile

The final refinement to the ridership methodology included examining induced demand in the forecast. The model does not directly include induced demand, which is a measure of new total travel on top of baseline demand. This does not include new trips due to demographic shifts, but rather travelers who previously would not have made a trip but could do so because of the introduction of a new mode or a greatly improved mode that improves the transportation network as a whole and not just rail. For example, rail travelers see faster travel times and more frequencies in the higher alternatives, while auto travelers who shift to high-speed rail because the rail is faster reduce the number of automobiles on the freeways, and therefore also reduces congestion for auto travel. For the case of the Downeaster proxy, the baseline ridership already includes what could be considered induced demand, as it is a mature service and has captured those new trips already. The Hartford Line is a relatively new service and has seen tremendous growth over the first year of its service, exceeding forecasts and continuing to grow. Therefore, it would be reasonable to assume some level of induced demand above the ridership estimated off of the baseline proxy ridership. The project team examined other rail ridership forecasts in the US and globally and concluded an increase of five percent to fifteen percent in ridership due to induced demand would be reasonable and considered the high end of the US rail forecasting practice. This percentage increase was applied at the station pair level based on area type of both stations:

- Rural-Rural – 5% increase
- Rural-Urban – 10% increase
- Urban-Urban – 15% increase

The urban stations include Boston, Worcester, and Springfield, and the rural stations include Pittsfield, Lee, Chester, Blandford, and Palmer.

Table 7 contains a summary of the model refinements made for the Final Alternative forecasts.

Table 7. Ridership Modeling Refinements Summary

Modeling Factor	Hartford Line Proxy	Downeaster Proxy
Boston Representation	Factored to better reflect the large pull of Boston employment	Included directly in Downeaster baseline
Market Competition	Adjusted for Hartford Line having more medium or large competitive markets (i.e., New York, Hartford, New Haven)	Adjusted for Downeaster not having any other medium or large competitive markets (only Boston)
Trip Distance	Switched to longer-distance station pairs to reflect a better mix of intercity and commuter travel	Trip distances match well with Downeaster station pairs
Market Types/Proxy Pairs	Refined station pairs to better match on market types (rural, urban, demographics, etc.)	Refined station pairs to better match on market types (rural, urban, demographics, etc.)
Demographic Buffers	Released constraint on Springfield buffer to reduce required rail transfers	Released constraint on Springfield buffer to reduce required rail transfers
Induced Demand	Added into final forecast	Assumed included in Downeaster baseline proxy ridership

After presenting the results of the model refinements for Preliminary Alternative 3 to the Advisory Committee, the three Final Alternatives were selected:

- Alternative 3: New East-West service between Boston and Pittsfield, with same travel time and frequency characteristics as the initial Alternative 3.
- Alternative 4: New East-West service between Boston and Pittsfield, with same travel time and frequency characteristics as the initial Alternative 4.
- Hybrid Alternative 4/5: New East-West service between Boston and Pittsfield, combining the speed increases of the initial Alternative 5 between Boston and Springfield with the rail service between Springfield and Pittsfield from the initial Alternative 4.

In addition to the East-West service, the alternatives allow for transfers at Springfield onto the Hartford Line. These three Final Alternatives were specified as a daily timetable, including station stops and detailed schedules in both directions, for input into the model. Example frequency and travel time characteristics of each Final Alternative are shown in Table 8**Error! Reference source not found.** and Table 9 on the next page.

Table 8. Final Alternatives Service Plan Summary – Frequency (Round Trips)

Segment	No-Build	Alt 3	Alt 4	Alt 4/5
BOS-SPG	1 direct	8 direct	10 direct	10 direct
Lansdowne/Boston Landing - SPG (MBTA transfers)	0	7 conn.	9 conn.	9 conn.
SPG-PIT	1 direct	5 direct	5 direct	5 direct
BOS-NHV (connections to HL are not coordinated)	1 conn.	6 conn.	6 conn.	6 conn.

Table 9. Final Alternatives Service Plan Summary – Average Travel Time (Minutes)

Segment	No-Build	Alt 3	Alt 4	Alt 4/5
BOS-SPG	148	118	115	97
BOS-PIT	232	196	191	170

6.4 Ridership Results

The 2040 annual ridership forecast results for the Preliminary Alternatives at the segment- and individual station-level are shown in Table 10 and Table 11, respectively, beginning on the following page. For the Preliminary Alternatives, ridership in Alternative 1 is moderately higher compared to 2040 No Build, and ridership in Alternatives 2 – 6 is substantially higher than the No-Build due to increased service and lower average travel times (between Boston to Springfield and Boston to Pittsfield) in each of these alternatives. Alternative 6 is forecasted to have the most annual ridership, nearly double the ridership of Alternative 4, which has the second-most forecasted ridership.

For Alternatives 2 – 6, roughly two-thirds of overall ridership occurs within the Boston-Springfield market and only about 2 percent of overall ridership occurs within the Springfield to Pittsfield market. Ridership between the Boston-to-Palmer and Chester-to-Pittsfield markets is relatively low to moderate in Alternatives 1 – 5 and substantially higher in Alternative 6, which includes the most direct connections between Boston and Springfield and Springfield to Pittsfield.

The number of transfers from East-West service to the Hartford Line is small in Alternative 1 and larger for Alternatives 2 – 6. Alternative 6 has the most forecasted East-West to Hartford Line transfers, with about 50 percent more transfers than Alternative 5, which has the second-most forecasted transfers. The number of transfers between MBTA service and East-West service at Worcester is low for Alternatives 1 and 2, moderate for Alternatives 3 – 5, and highest for Alternative 6. For Alternatives 2 – 6, roughly 80 percent of boardings at Worcester and at Springfield are made by passengers who directly access these stations (via drive or walk access); the other roughly 20 percent of boardings are made by passengers who transfer from MBTA or Hartford Line services.

Alternatives 3 and 4 offer similar service, except Alternative 4 has two more direct connections between Boston and Springfield. Total annual ridership in Alternative 4 is about 62 percent higher than in Alternative 3, with about 80 percent of the increase in ridership occurring within the Boston-Springfield market. Alternatives 5 and 6 provide service to the same set of stations, but Alternative 6 provides far more and faster service relative to Alternative 5. As a result, total annual ridership in Alternative 6 is approximately double the ridership in Alternative 5, with much of the increase in ridership occurring in the Boston-Springfield market (59 percent) and between the Boston-Palmer and Chester-Pittsfield segments (33 percent).

Table 10. 2040 Annual Ridership Forecast Results by Segment – Preliminary Alternatives (One-Way Bi-Directional Trips)

Alternative	**No-B**	**No-B**	**1**	**1**	**2**	**2**	**3**	**3**	**4**	**4**	**5**	**5**	**6**	**6**
Ridership Segment (*) / Boarding Measure	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily
Within Boston-Springfield Segment	2,900	10	5,200	17	34,100	113	47,400	157	83,500	276	80,200	266	164,600	545
Within Springfield-Pittsfield Segment	400	1	600	2	900	3	1,800	6	2,800	9	2,300	8	5,300	18
Between BOS-PLM and CHS-PIT Segments	1,300	4	4,000	13	5,000	17	12,900	43	20,200	67	19,500	65	57,800	191
Between BOS-PLM and WNL-NHV Segments* (transfer trips from East-West to Hartford Line)	400	1	1,300	4	7,900	26	10,200	34	10,600	35	13,000	43	19,900	66
Total Ridership	**4,950**	**16**	**11,150**	**37**	**48,000**	**159**	**72,250**	**239**	**117,100**	**388**	**115,050**	**381**	**247,700**	**820**

*Segment-level ridership may not exactly match the total annual ridership due to rounding.

Table 11. 2040 Annual Ridership Forecast Results by Station – Preliminary Alternatives (One-Way Bi-Directional Trips)

Alternative	No-B	No-B	1	1	2	2	3	3	4	4	5	5	6	6
Station / Boarding Measure	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily
Boston (South Station), MA (E-W service)	1,550	5	850	3	8,400	28	11,800	39	20,400	68	21,600	72	46,050	152
Boston (Back Bay), MA (E-W service)	450	1	350	1	4,100	14	5,700	19	9,850	33	10,500	35	22,150	73
Lansdowne, MA (E-W service)	0	0	0	0	700	2	2,800	9	5,400	18	4,900	16	9,650	32
Framingham, MA (LSL service)	150	0	100	0	750	2	700	2	700	2	650	2	950	3
Worcester, MA (direct access, E-W service)	300	1	1,900	6	9,700	32	13,000	43	22,650	75	23,950	79	49,850	165
Worcester, MA (MBTA transfers)	0	0	1,950	10	2,850	9	5,150	17	5,800	19	6,700	22	12,650	42
Palmer, MA (E-W service)	0	0	450	1	2,950	10	3,900	13	6,700	22	0	0	11,150	37
Springfield, MA (direct access, E-W service)	1,450	5	2,300	8	11,650	39	16,750	55	28,750	95	29,300	97	53,650	178
Springfield, MA (HL transfers)	200	1	650	2	3,950	13	5,100	17	5,300	18	6,500	22	9,950	33
Lee, MA (E-W service)	0	0	200	1	400	1	0	0	0	0	1,950	6	5,200	17
Blandford, MA (E-W service)	0	0	400	1	400	1	0	0	0	0	1,850	6	4,950	16
Chester, MA (E-W service)	0	0	0	0	0	0	950	3	1,600	5	0	0	0	0
Pittsfield, MA (E-W service)	850	3	2,000	7	2,150	7	6,400	21	9,950	33	7,150	24	21,500	71
Total Ridership	**4,950**	**16**	**11,150**	**37**	**48,000**	**159**	**72,250**	**239**	**117,100**	**388**	**115,050**	**381**	**247,700**	**820**

Forecasted ridership results for the Final Alternatives at the segment- and individual station-level are shown in Table 12 and Table 13 beginning on the following page. The Final Alternatives include Preliminary Alternatives 3 and 4 and a hybrid alternative that blends Preliminary Alternatives 4 and 5. The forecasts in Table 12 and Table 13 include model results for two versions of each Final Alternative: "Hartford Line Base Enhanced" (abbreviated as "HL" in the tables) and "Downeaster Base" (i.e., "DE" in the tables), which are described in Section 6.3.

Total annual forecasted ridership for the Final Alternatives is high relative to ridership in 2040 No-Build. Generally, the Alternative 4/5 Hybrid has higher forecasted overall ridership, segment-level ridership, and station-level boardings compared to Alternative 4, which generally has higher ridership and boardings compared to Alternative 3 (when comparing the same version across alternatives – either Hartford Line Base Enhanced or Downeaster Base). For each alternative, the Downeaster Base version has higher forecasted ridership and boardings compared to the Hartford Line Base Enhanced version, with the exception of boardings at Framingham.

For the Hartford Line Base Enhanced version in each Final Alternative, approximately 85 percent of ridership is forecasted to occur within the Boston-Springfield market, followed by approximately 7 percent of ridership between Boston-Palmer and Chester-Pittsfield segments and 6 percent between Boston-Palmer and the Hartford Line. In the Downeaster Base version of the Final Alternatives, between 70 – 74 percent of ridership occurs in the Boston-Springfield market, followed by 15 percent of ridership between the Boston-Palmer and Chester-Pittsfield segments and about 10 percent between Boston-Palmer and the Hartford Line.

The number of transfers between the Hartford Line and East-West service stays approximately the same across alternatives for a given Base version (i.e., Downeaster Base or Hartford Line Enhanced Base), and the Downeaster Base version has about twice as many Hartford Line to East-West transfers compared to the Hartford Line Base Enhanced version in each alternative. The number of transfers at Worcester between MBTA service and East-West service does not vary much across alternatives for a given Base version, and the Downeaster Base version has about 30 – 50 percent more of these transfers compared to the Hartford Line Base Enhanced version, depending on the alternative.

For each Final Alternative, about 80 percent of passengers that board at Worcester directly access the station (via drive or walk access); the remaining 20 percent or so of boardings are made by passengers who transfer from MBTA service. Similarly, about 90 percent of passengers that board at Springfield directly access the station (via drive or walk access), and the remaining 10 percent or so of passengers transfer from Hartford Line service.

Table 12. 2040 Annual Ridership Forecast Results by Segment – Final Alternatives (One-Way Bi-Directional Trips)

Alternative	No-B	No-B	3	3	3	3	4	4	4	4	4/5	4/5	4/5	4/5
Proxy Service Scenario (+)	**N/A**	**N/A**	**HL**	**HL**	**DE**	**DE**	**HL**	**HL**	**DE**	**DE**	**HL**	**HL**	**DE**	**DE**
Ridership Segment (*) / Boarding Measure	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily
Within Boston-Springfield Segment	2,900	10	231,900	768	251,500	833	297,300	984	302,900	1,003	335,300	1,110	346,200	1,146
Within Springfield-Pittsfield Segment	400	1	3,900	13	7,300	24	4,500	15	7,700	25	4,500	15	7,700	25
Between BOS-PLM and CHS-PIT Segments	1,300	4	21,500	71	55,300	183	26,100	86	63,600	211	28,400	94	68,100	225
Between BOS-PLM and WNL-NHV Segments* (transfer trips from East-West to Hartford Line)	400	1	20,500	68	44,400	147	21,000	70	42,300	140	22,500	75	47,200	156
Total Ridership	**4,950**	**16**	**278,300**	**922**	**358,250**	**1,186**	**349,350**	**1,157**	**416,050**	**1,378**	**391,200**	**1,295**	**469,000**	**1,553**

+ - "HL" refers to the Enhanced" Hartford Line proxy service forecast scenario while "DE" refer to the Downeaster scenario.

*Segment-level ridership may not exactly match the total annual ridership due to rounding.

Table 13. 2040 Annual Ridership Forecast Results by Station – Final Alternatives (One-Way Bi-Directional Trips)

Alternative	**No-B**	**No-B**	**3**	**3**	**3**	**3**	**4**	**4**	**4**	**4**	**4/5**	**4/5**	**4/5**	**4/5**
Proxy Service Scenario (+)	**N/A**	**N/A**	**HL**	**HL**	**DE**	**DE**	**HL**	**HL**	**DE**	**DE**	**HL**	**HL**	**DE**	**DE**
Station / Boarding Measure	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily
Boston (South Station), MA (E-W service)	1,550	5	56,750	188	62,650	208	72,250	239	74,650	247	81,650	271	85,250	282
Boston (Back Bay), MA (E-W service)	450	1	45,450	151	54,700	181	58,100	192	65,150	216	65,650	218	74,150	245
Lansdowne, MA (E-W service)	0	0	15,150	50	18,200	60	19,350	64	21,700	72	21,900	73	24,700	82
Framingham, MA (LSL service)	150	0	1,550	5	650	2	1,550	5	450	1	1,750	6	800	3
Worcester, MA (direct access, E-W service)	300	1	19,300	64	35,250	117	23,250	77	39,500	131	25,500	84	43,250	143
Worcester, MA (MBTA transfers)	0	0	6,400	21	9,450	31	7,250	24	9,550	32	8,100	27	11,350	38
Palmer, MA (E-W service)	0	0	4,950	16	6,550	22	6,050	20	7,100	24	6,500	22	8,000	26
Springfield, MA (direct access, E-W service)	1,450	5	105,700	350	116,750	387	135,700	449	140,600	466	152,400	505	159,500	528
Springfield, MA (HL transfers)	200	1	10,250	34	22,200	74	10,500	35	21,150	70	11,250	37	23,600	78
Lee, MA (E-W service)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blandford, MA (E-W service)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chester, MA (E-W service)	0	0	1,400	5	4,200	14	1,700	6	4,700	16	1,850	6	5,000	17
Pittsfield, MA (E-W service)	850	3	11,400	38	27,650	92	13,650	45	31,500	104	14,650	49	33,400	111
Total Ridership	**4,950**	**16**	**278,300**	**922**	**358,250**	**1,186**	**349,350**	**1,157**	**416,050**	**1,378**	**391,200**	**1,295**	**469,000**	**1,553**

+ - "HL" refers to the Enhanced" Hartford Line proxy service forecast scenario while "DE" refer to the Downeaster scenario.
*Segment-level ridership may not exactly match the total annual ridership due to rounding.