C Systemwide Alternatives Results

Based on the line level analysis, six unique systemwide alternatives carried forward key service concepts. The analysis of the six systemwide alternatives used a number of tools, as described in more detail in Chapter 5.

This appendix includes a section for each of the six Systemwide Alternatives. Each section includes tables of results for each alternative for the evaluation metrics defined in Chapter 5. As described in Chapter 5, these metrics reflect each of the six overarching project objectives used throughout the project. Each section also contains a detailed description of the ridership results, and a summary of the capital needs projected based on the service plan.

In addition to the summary of results included in this appendix, Appendix D provides more detail on the ridership results across alternatives. Appendix E also provides more detail on the results of the EJ analysis.

Alternative 1: Higher Frequency Commuter Rail

Results by Objective and Metric

Table C-1   Alternative 1, Objective 1: Match Service with the Growing and Changing Needs

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Maximize Commuter Rail Ridership	1.1	Change in daily commuter rail boardings	+19,000
Maximize Commuter Rail Ridership	1.2	Change in off-peak commuter rail boardings	+4,100
Maximize Commuter Rail Ridership	1.3	Change in reverse peak commuter rail boardings	+9,000
Maximize Commuter Rail Ridership	1.4	Change in daily commuter rail passenger miles	+37,700
Maximize Transit Ridership	1.5	Change in daily MBTA systemwide boardings	+25,800

Table C-2   Alternative 1, Objective 2: Match Service with the Growing and Changing Needs

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Improve access to jobs and opportunities	2.1	Change in number of jobs accessible within 1 hour of using commuter rail	2,085
Improve access to jobs and opportunities	2.2	Change in population accessible within 1 hour of North Station/South Station/Back Bay	733,491

Table C-3   Alternative 1, Objective 3: Improve the Passenger Experience

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Continue making commuter rail competitive to driving	3.1	Average change in trip time (in minutes)	-0.1
Support ability to travel	3.2	Change in the number of daily commuter rail train trips	+234
Support ability to travel	3.3	Change in the number of daily commuter rail train miles	+7,300
Relieve capacity constraints on the MBTA bus and rapid transit network	3.4	Change in the number of daily passenger trips on the MBTA bus and rapid transit network	+6,800

Table C-4   Alternative 1, Objective 4: Provide an Equitable and Balanced Suite of Investments

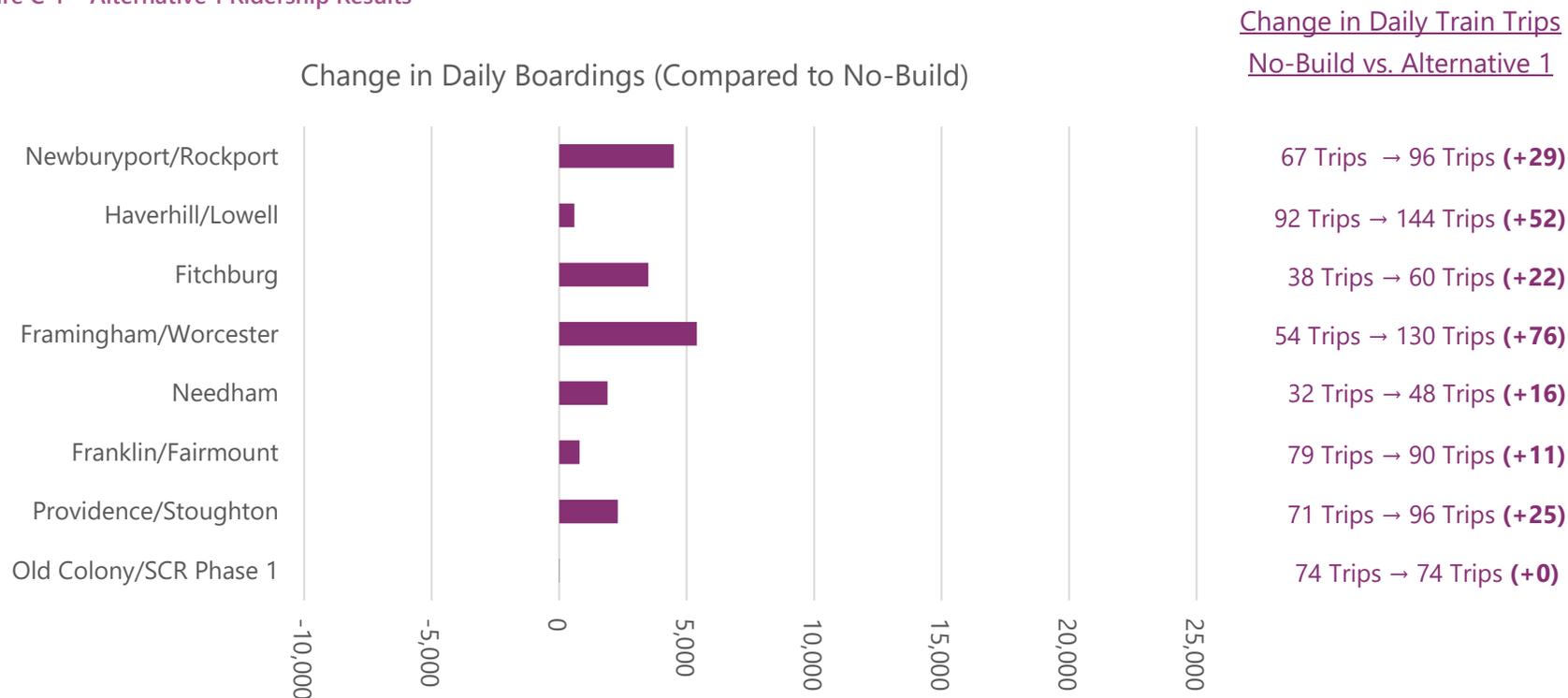| Project Objective	Metric Number	Evaluation Metric	System-Level Result
Improve access to jobs for disadvantaged communities	4.1	Change in accessibility to employment for EJ compared to non-EJ communities	Change Less than the Margin of Error
Improve the quality and level of commuter rail service to disadvantaged communities	4.2	Change in average travel time – transit serving EJ communities	Change Less than the Margin of Error
Does not adversely affect disadvantaged communities	4.3	Does not adversely burden the EJ population	No burden

Table C-5   Alternative 1, Objective 5: Help the Commonwealth Achieve its Climate Change Resiliency Targets

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Reduce greenhouse gas emissions	5.1	Change in daily kg of greenhouse gas emissions	NOx: +10 kg CO: -220 kg CO_2: +44,400 kg
Reduce dependence on personal vehicles	5.2	Change in commuter rail transit mode share	+ <0.1%
Reduce dependence on personal vehicles	5.3	Number of daily auto diversions	8,100
Reduce dependence on personal vehicles	5.4	Change in average daily VMT for personal vehicles	-188,000
Reduce dependence on personal vehicles	5.5	Change in average daily VHT for personal vehicles	-25,000

Table C-6   Alternative 1, Objective 6: Maximize Return on Investment (Financial Stewardship)

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Minimize capital cost, compared to benefit	6.1	Estimated capital costs (in 2020$)	$1.7 billion
Minimize the annual O&M cost	6.2	Order-of-magnitude change in annual O&M cost (in 2020$)	+$130 million
Maximize state agency revenues	6.3	Order-of-magnitude change in annual revenue (MBTA systemwide fares) (in 2020$)	+$29 million
Maximize efficiency of the commuter rail system	6.4	Change in operating subsidy per passenger	+$0.56

Figure C-1   Alternative 1 Ridership Results

Change in Daily Boardings (Compared to No-Build)

Line	Change in Daily Train Trips
Newburyport/Rockport	67 Trips → 96 Trips **(+29)**
Haverhill/Lowell	92 Trips → 144 Trips **(+52)**
Fitchburg	38 Trips → 60 Trips **(+22)**
Framingham/Worcester	54 Trips → 130 Trips **(+76)**
Needham	32 Trips → 48 Trips **(+16)**
Franklin/Fairmount	79 Trips → 90 Trips **(+11)**
Providence/Stoughton	71 Trips → 96 Trips **(+25)**
Old Colony/SCR Phase 1	74 Trips → 74 Trips **(+0)**

Ridership Summary

The ridership modeling for Alternative 1 assumed that all stations would maintain their existing parking capacities, and that today's fare structure would remain. All other alternatives provided unlimited parking at some or all stations. **Figure C-1** provides a line-level breakdown, while **Table C-1** summarizes the results.

Alternative 1 generates the highest ridership growth rate on the north side of the system at 19% over the No-Build, with the greatest growth occurring on the Newburyport/Rockport Line and the Fitchburg Line.

However, the south side of the system, while at a lower growth rate, generates the highest increase in passenger boardings, adding 10,400 passengers per day, a 10% increase.

The highest increases are on the south side are on the Framingham/Worcester Line, which gains the greatest increase in the number of weekday train trips provided within this alternative, and includes multiple express (Heart-to-Hub) trips to/from Worcester throughout the day.

The ridership growth in Alternative 1 is distributed between the peak period in the peak direction (31%), the peak period in the reverse peak direction (47%), and off-peak periods (21%). Alternative 1 has the highest proportion of reverse peak growth of all alternatives, as it focuses on providing bi-directional service with moderate infrastructure investments (other alternatives provide higher levels of infrastructure to offer higher peak frequencies).

Capital Needs Summary

The map in **Figure C-2** illustrates the $1.7 billion (2020 dollars) / $2.3 billion (2030 dollars) in capital needs that would support the Alternative 1 service plan.

These needs include approximately 4 miles of new track, primarily consisting of new passing sidings on the Franklin Line and double tracking on the Fitchburg Line around Waltham. The improvements would include approximately six grade crossings, six bridges and structures, and nine station improvements.

Alternative 1 includes expanding the existing fleet of diesel locomotives and bi-level cab cars and coaches.

This alternative includes the additional services of SCR Phase 1 (which is excluded from the capital cost estimates).

Figure C-2   Alternative 1 Capital Needs

Table C-7   Alternative 1 Order of Magnitude Capital Costs

Cost Category	2020$	2030$
Track, signal, structures, stations & facilities	$1.1 billion	$1.5 billion
Fleet	0.6 billion	0.8 billion
System expansions	0.0 billion	0.0 billion
Total Capital Costs	**$1.7 billion**	**$2.3 billion**

Table C-8   Alternative 1 Fleet Needs

Fleet Needs	New	Total
Diesel locomotives	27	120
Bi-level cab cars	33	120
Bi-level coaches	62	411

Alternative 2: Regional Rail to Key Stations (Diesel)

Results by Objective and Metric

Table C-9   Alternative 2, Objective 1: Match Service with the Growing and Changing Needs

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Maximize Commuter Rail Ridership	1.1	Change in daily commuter rail boardings	+36,200
Maximize Commuter Rail Ridership	1.2	Change in off-peak commuter rail boardings	+13,900
Maximize Commuter Rail Ridership	1.3	Change in reverse peak commuter rail boardings	+10,100
Maximize Commuter Rail Ridership	1.4	Change in daily commuter rail passenger miles	-357,200
Maximize Transit Ridership	1.5	Change in daily MBTA systemwide boardings	+74,800

Table C-10   Alternative 2, Objective 2: Match Service with the Growing and Changing Needs

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Improve access to jobs and opportunities	2.1	Change in number of jobs accessible within 1 hour of using commuter rail	2,103
Improve access to jobs and opportunities	2.2	Change in population accessible within 1 hour of North Station/South Station/Back Bay	878,104

Table C-11   Alternative 2, Objective 3: Improve the Passenger Experience

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Continue making commuter rail competitive to driving	3.1	Average change in trip time (in minutes)	-5.8
Support ability to travel	3.2	Change in the number of daily commuter rail train trips	+577
Support ability to travel	3.3	Change in the number of daily commuter rail train miles	+22,000
Relieve capacity constraints on the MBTA bus and rapid transit network	3.4	Change in the number of daily passenger trips on the MBTA bus and rapid transit network	+38,300

Table C-12   Alternative 2, Objective 4: Provide an Equitable and Balanced Suite of Investments

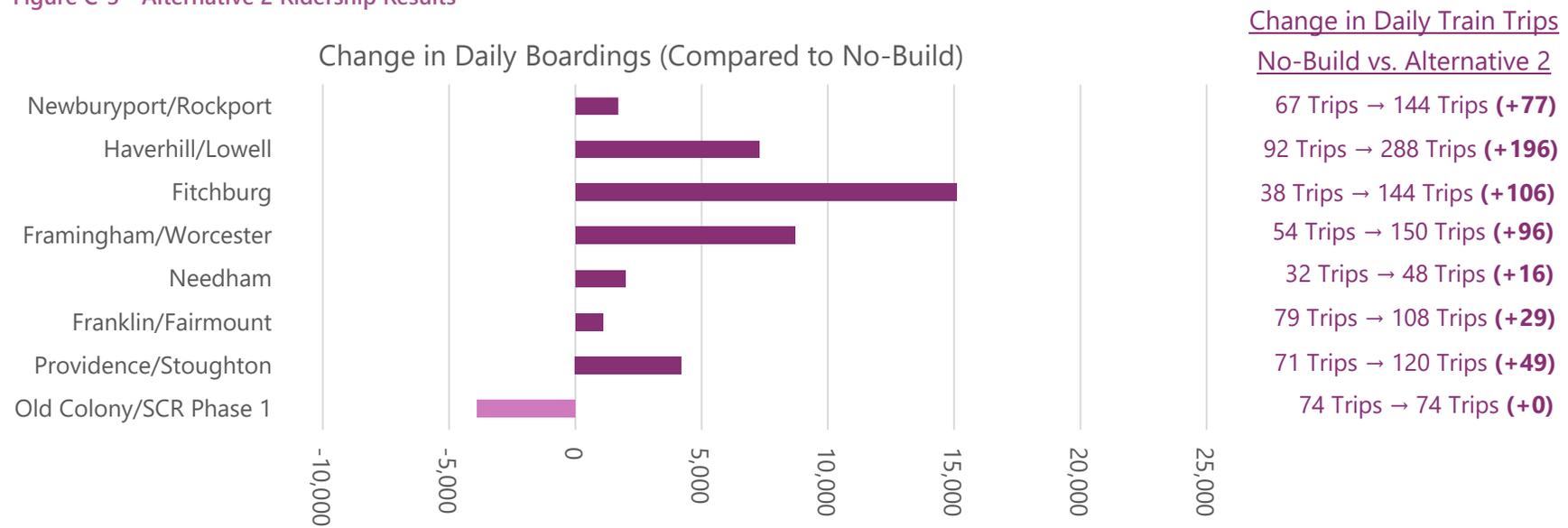| Project Objective	Metric Number	Evaluation Metric	System-Level Result
Improve access to jobs for disadvantaged communities	4.1	Change in accessibility to employment for EJ compared to non-EJ communities	Change Inside the Margin of Error
Improve the quality and level of commuter rail service to disadvantaged communities	4.2	Change in average travel time – transit serving EJ communities	Change Inside the Margin of Error
Does not adversely affect disadvantaged communities	4.3	Does not adversely burden the EJ population	No disproportionate benefit or burden

Table C-13   Alternative 2, Objective 5: Help the Commonwealth Achieve its Climate Change Resiliency Targets

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Reduce greenhouse gas emissions	5.1	Change in daily kg of greenhouse gas emissions	NOx: +320 kg CO: -880 kg CO_2: +90,700 kg
Reduce dependence on personal vehicles	5.2	Change in commuter rail transit mode share	+0.1%
Reduce dependence on personal vehicles	5.3	Number of daily auto diversions	35,500
Reduce dependence on personal vehicles	5.4	Change in average daily VMT for personal vehicles	-592,000
Reduce dependence on personal vehicles	5.5	Change in average daily VHT for personal vehicles	-140,000

Table C-14   Alternative 2, Objective 6: Maximize Return on Investment (Financial Stewardship)

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Minimize capital cost, compared to benefit	6.1	Estimated capital costs (in 2020$)	$4.5 billion
Minimize the annual O&M cost	6.2	Order-of-magnitude change in annual O&M cost (in 2020$)	+$379 million
Maximize state agency revenues	6.3	Order-of-magnitude change in annual revenue (MBTA systemwide fares) (in 2020$)	+$52 million
Maximize efficiency of the commuter rail system	6.4	Change in operating subsidy per passenger	+$4.97

Figure C-3   Alternative 2 Ridership Results

Change in Daily Boardings (Compared to No-Build)

Change in Daily Train Trips
No-Build vs. Alternative 2

Line	Change
Newburyport/Rockport	67 Trips → 144 Trips **(+77)**
Haverhill/Lowell	92 Trips → 288 Trips **(+196)**
Fitchburg	38 Trips → 144 Trips **(+106)**
Framingham/Worcester	54 Trips → 150 Trips **(+96)**
Needham	32 Trips → 48 Trips **(+16)**
Franklin/Fairmount	79 Trips → 108 Trips **(+29)**
Providence/Stoughton	71 Trips → 120 Trips **(+49)**
Old Colony/SCR Phase 1	74 Trips → 74 Trips **(+0)**

Ridership Summary

The ridership modeling for Alternative 2 assumed unlimited parking at key stations, and that today's fare structure would remain. **Figure C-3** provides a line-level breakdown, while **Table C-9** summarizes the results.

Growth on the north side of the system is nearly double that of the south side, with an increase of 24,100 forecast average weekday passengers on the north side compared to 12,100 on the south side. This is likely due to the increased frequencies on the north side of the system compared to the south side, which has limited capacity at South Station.

The Fitchburg and Haverhill/Lowell Lines are forecast to drive the 52% increase in ridership on the North Side.

The growth on the South Side does represent a 12% increase in average weekday passengers. It is driven by increases on the Framingham/Worcester and Providence/Stoughton Lines. In Alternative 2, ridership is forecast to decrease on the Old Colony/SCR Phase 1 lines even though there is no change in the number of train trips.

This decrease is due to Alternative 2's assumption of unlimited parking at key stations. Because of this assumption, riders who may have otherwise chosen to travel on the Old Colony/SCR lines instead are forecast to drive to Braintree, where they can also use the Red Line.

Providing unlimited parking at key stations also impacts the ridership projections. Approximately 10,000 additional trips would access the Commuter Rail by car, so capturing all of this ridership would require additional parking and other improved first/last mile connections. Providing unlimited parking also results in passengers driving to stations closer to their destinations to park, demonstrated by the reduction in daily commuter rail passenger miles.

The ridership growth in Alternative 2 is distributed fairly evenly between the peak period in the peak direction (34%), the peak period in the reverse peak direction (28%), and off-peak periods (38%).

Capital Needs Summary

The map in **Figure C-4** illustrates the $6.3 billion (2030 dollars) in capital needs to support the Alternative 2 service plan.

These needs include approximately 34 miles of new track, primarily consisting of double track on the Franklin Line between Norwood Central and Norfolk, the Newburyport line between Rowley and North Beverly, the Haverhill Line between Reading and Wilmington Junction, and the Fitchburg Line between Lincoln and Waltham. Additional track is often required to accommodate express services, which pass by local trains. The improvements would include approximately 35 grade crossings, 36 bridges and structures, and 32 station improvements.

Alternative 2 includes expanding the existing fleet of diesel locomotives and bi-level cab cars and coaches, as well as adding six electric locomotives for use on the Providence line. This alternative includes the additional services of SCR Phase 1 and service to Foxboro (which are excluded from the capital cost estimates).
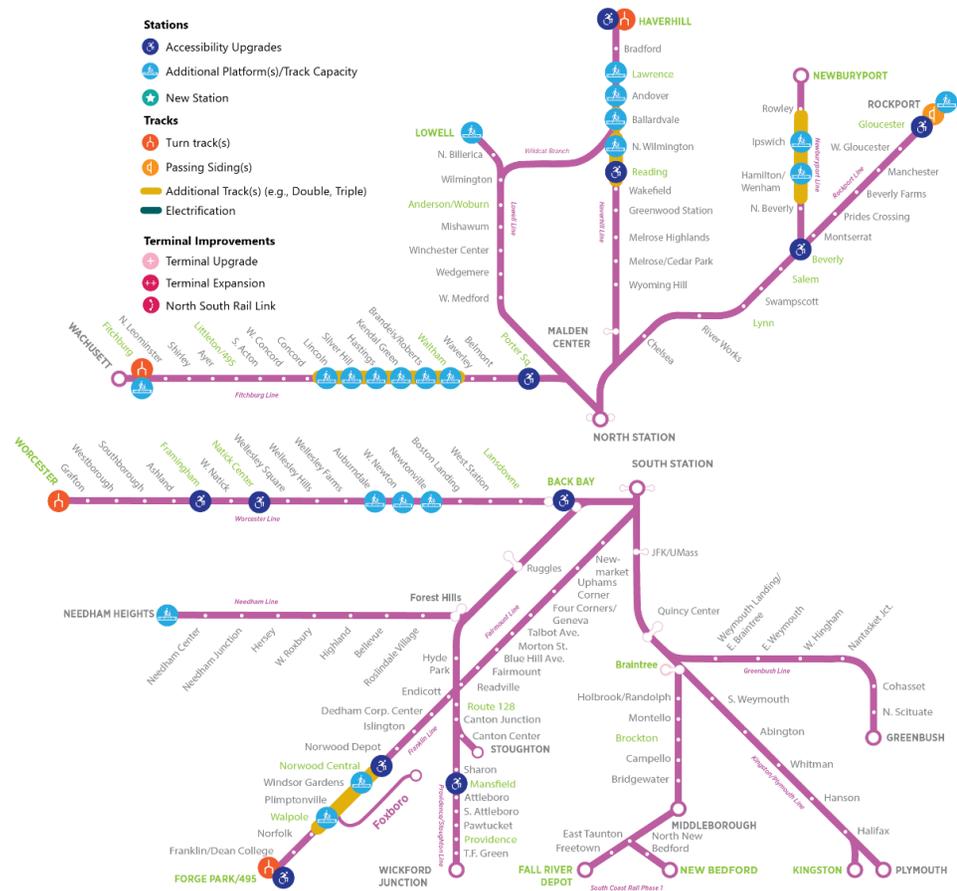
Figure C-4   Alternative 2 Capital Needs

Table C-15   Alternative 2 Order of Magnitude Capital Costs

Cost Category	2020$	2030$
Track, signal, structures, stations & facilities	$2.8 billion	$3.9 billion
Fleet	1.7 billion	2.4 billion
System expansions	0.0 billion	0.0 billion
Total Capital Costs	**$4.5 billion**	**$6.3 billion**

Table C-16   Alternative 2 Fleet Needs

Fleet Needs	New	Total
Diesel locomotives	64	157
Electric locomotives	6	6
Bi-level cab cars	76	163
Bi-level coaches	180	529

Alternative 3: Regional Rail to Key Stations (Electric)

Results by Objective and Metric

Table C-17   Alternative 3, Objective 1: Match Service with the Growing and Changing Needs

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Maximize Commuter Rail Ridership	1.1	Change in daily commuter rail boardings	+52,900
Maximize Commuter Rail Ridership	1.2	Change in off-peak commuter rail boardings	+17,200
Maximize Commuter Rail Ridership	1.3	Change in reverse peak commuter rail boardings	+15,400
Maximize Commuter Rail Ridership	1.4	Change in daily commuter rail passenger miles	+381,300
Maximize Transit Ridership	1.5	Change in daily MBTA systemwide boardings	+98,500

Table C-18   Alternative 3, Objective 2: Match Service with the Growing and Changing Needs

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Improve access to jobs and opportunities	2.1	Change in number of jobs accessible within 1 hour of using commuter rail	13,918
Improve access to jobs and opportunities	2.2	Change in population accessible within 1 hour of North Station/South Station/Back Bay	980,823

Table C-19   Alternative 3, Objective 3: Improve the Passenger Experience

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Continue making commuter rail competitive to driving	3.1	Average change in trip time (in minutes)	-10.0
Support ability to travel	3.2	Change in the number of daily commuter rail train trips	+1,003
Support ability to travel	3.3	Change in the number of daily commuter rail train miles	+33,500
Relieve capacity constraints on the MBTA bus and rapid transit network	3.4	Change in the number of daily passenger trips on the MBTA bus and rapid transit network	+45,100

Table C-20   Alternative 3, Objective 4: Provide an Equitable and Balanced Suite of Investments

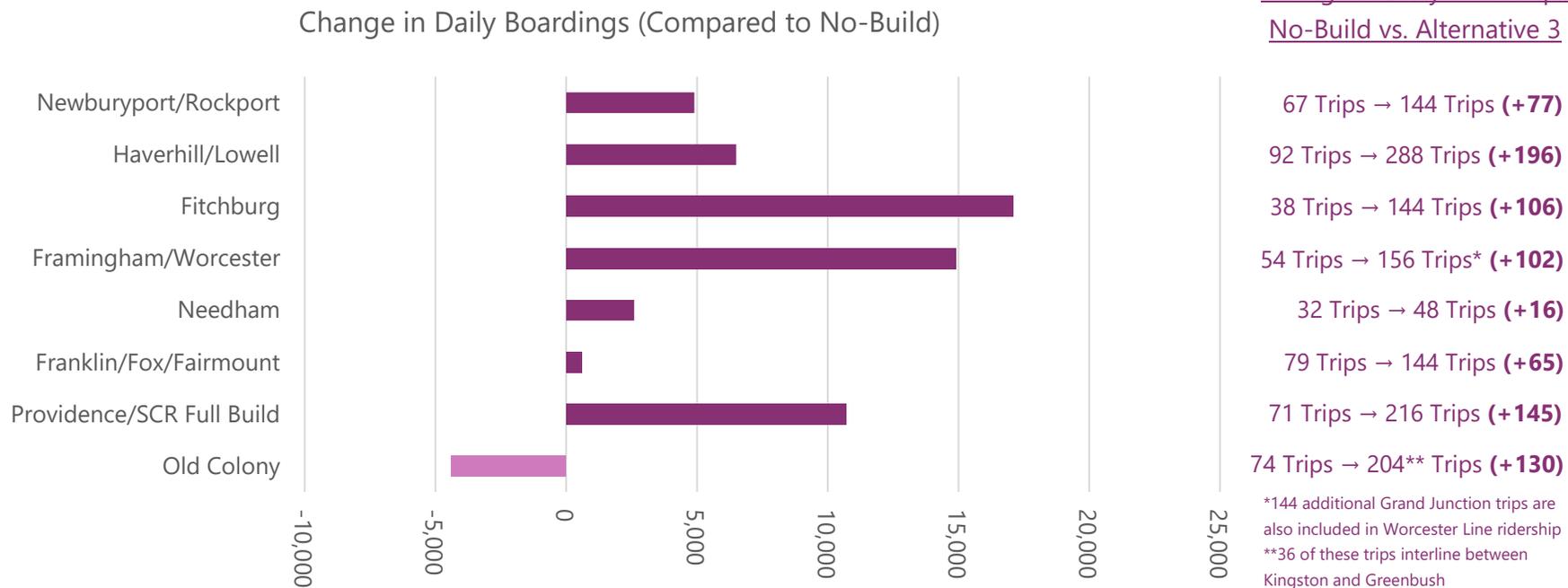| Project Objective	Metric Number	Evaluation Metric	System-Level Result
Improve access to jobs for disadvantaged communities	4.1	Change in accessibility to employment for EJ compared to non-EJ communities	Change Inside the Margin of Error
Improve the quality and level of commuter rail service to disadvantaged communities	4.2	Change in average travel time – transit serving EJ communities	Change Inside the Margin of Error
Does not adversely affect disadvantaged communities	4.3	Does not adversely burden the EJ population	No disproportionate benefit or burden

Table C-21   Alternative 3, Objective 5: Help the Commonwealth Achieve its Climate Change Resiliency Targets

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Reduce greenhouse gas emissions	5.1	Change in daily kg of greenhouse gas emissions	NOx: -1,840 kg CO: -1,210 kg CO_2: -728,100 kg
Reduce dependence on personal vehicles	5.2	Change in commuter rail transit mode share	+0.1%
Reduce dependence on personal vehicles	5.3	Number of daily auto diversions	48,700
Reduce dependence on personal vehicles	5.4	Change in average daily VMT for personal vehicles	-818,000
Reduce dependence on personal vehicles	5.5	Change in average daily VHT for personal vehicles	-165,000

Table C-22   Alternative 3, Objective 6: Maximize Return on Investment (Financial Stewardship)

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Minimize capital cost, compared to benefit	6.1	Estimated capital costs (in 2020$)	$17.9 billion
Minimize the annual O&M cost	6.2	Order-of-magnitude change in annual O&M cost (in 2020$)	+$439 million
Maximize state agency revenues	6.3	Order-of-magnitude change in annual revenue (MBTA systemwide fares) (in 2020$)	+$52 million
Maximize efficiency of the commuter rail system	6.4	Change in operating subsidy per passenger	+$5.13

Figure C-5   Alternative 3 Ridership Results

Change in Daily Boardings (Compared to No-Build)

Change in Daily Train Trips
No-Build vs. Alternative 3

Line	
Newburyport/Rockport	67 Trips → 144 Trips **(+77)**
Haverhill/Lowell	92 Trips → 288 Trips **(+196)**
Fitchburg	38 Trips → 144 Trips **(+106)**
Framingham/Worcester	54 Trips → 156 Trips* **(+102)**
Needham	32 Trips → 48 Trips **(+16)**
Franklin/Fox/Fairmount	79 Trips → 144 Trips **(+65)**
Providence/SCR Full Build	71 Trips → 216 Trips **(+145)**
Old Colony	74 Trips → 204** Trips **(+130)**

*144 additional Grand Junction trips are also included in Worcester Line ridership
**36 of these trips interline between Kingston and Greenbush

Ridership Summary

The ridership modeling for Alternative 3 assumed unlimited parking at key stations, and that today's fare structure would remain. **Figure C-5** provides a line-level breakdown, while **Table C-17** summarizes the results.

Growth on the north side of the system outpaces that on the south side, with an increase of 28,500 projected average weekday passengers on the north side compared to 24,400 on the south side. The Fitchburg and Haverhill/Lowell Lines drive the 62% increase in ridership on the North Side.

The South Side growth represents a 23% increase in average weekday passengers, driven by increases on the Framingham/Worcester and Providence/Stoughton/South Coast Rail Lines. This increase is greater than Alternative 2, since South Station Expansion allows for higher frequencies and express trips on the south side lines. Since this alternative assumes South Coast Rail Full Build, South Coast Rail ridership is included with the Providence/Stoughton Line rather than the Old Colony Lines.

Like Alternative 2, the decrease in ridership on the Old Colony lines is partially due to the assumption

of unlimited parking at key stations. Because of this assumption, riders who may have otherwise chosen to travel on the Old Colony lines instead are forecast to drive to Braintree where they can also use the Red Line.

Approximately 19,400 additional trips would access the Commuter Rail by car, so capturing all of this ridership could require additional parking and other improved first/last mile connections.

The ridership growth in Alternative 3 is distributed fairly evenly between the peak period in the peak direction (38%), the peak period in the reverse peak direction (29%), and off-peak periods (32%).

Capital Needs Summary

The map in **Figure C-6** illustrates the $25.2 billion (2030 dollars) in capital needs to support the Alternative 3 service plan.

These needs include electrification of the entire commuter rail system and approximately 50 miles of new trackwork, primarily consisting of similar segments as Alternative 2, along with several segments on the Old Colony lines (including the Middleborough Main Line), and upgrading Grand Junction for revenue service. Like Alternative 2, many of these track improvements allow for express trains to key stations pass trains making all stops. The improvements would include approximately 51 grade crossings, 50 bridges and structures, and 38 station improvements.

Since Alternative 3 assumes all-electric service, the entire fleet is replaced with EMUs.

This alternative includes the additional services of SCR Full Build and service to Foxboro (which are excluded from the capital cost estimates), South Station Expansion, Grand Junction, and the double track of the Middleborough Main Line.

Figure C-6   Alternative 3 Capital Needs

Table C-23   Alternative 3 Order of Magnitude Capital Costs

Cost Category	2020$	2030$
Track, signal, structures, stations & facilities	$9.1 billion	$12.8 billion
Fleet	4.8 billion	6.8 billion
System expansions	4.0 billion	5.6 billion
Total Capital Costs	**$17.9 billion**	**$25.2 billion**

Table C-24   Alternative 3 Fleet Needs

Fleet Needs	New	Total
Diesel locomotives	0	0
Bi-level cab cars	0	0
Bi-level cab coaches	0	0
Electric Multiple Units (EMUs)	733	733

Alternative 4: Urban Rail (Diesel)

Results by Objective and Metric

Table C-25   Alternative 4, Objective 1: Match Service with the Growing and Changing Needs

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Maximize Commuter Rail Ridership	1.1	Change in daily commuter rail boardings	+80,400
Maximize Commuter Rail Ridership	1.2	Change in off-peak commuter rail boardings	+37,800
Maximize Commuter Rail Ridership	1.3	Change in reverse peak commuter rail boardings	+17,700
Maximize Commuter Rail Ridership	1.4	Change in daily commuter rail passenger miles	+582,300
Maximize Transit Ridership	1.5	Change in daily MBTA systemwide boardings	+50,700

Table C-26   Alternative 4, Objective 2: Match Service with the Growing and Changing Needs

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Improve access to jobs and opportunities	2.1	Change in number of jobs accessible within 1 hour of using commuter rail	32,174
Improve access to jobs and opportunities	2.2	Change in population accessible within 1 hour of North Station/South Station/Back Bay	1,091,377

Table C-27   Alternative 4, Objective 3: Improve the Passenger Experience

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Continue making commuter rail competitive to driving	3.1	Average change in trip time (in minutes)	-0.1
Support ability to travel	3.2	Change in the number of daily commuter rail train trips	+859
Support ability to travel	3.3	Change in the number of daily commuter rail train miles	+16,200
Relieve capacity constraints on the MBTA bus and rapid transit network	3.4	Change in the number of daily passenger trips on the MBTA bus and rapid transit network	-29,800

Table C-28   Alternative 4, Objective 4: Provide an Equitable and Balanced Suite of Investments

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Improve access to jobs for disadvantaged communities	4.1	Change in accessibility to employment for EJ compared to non-EJ communities	Benefit for minority and low-income populations
Improve the quality and level of commuter rail service to disadvantaged communities	4.2	Change in average travel time – transit serving EJ communities	Change less than the forecasting error for minority and low-income populations
Does not adversely affect disadvantaged communities	4.3	Does not adversely burden the EJ population	Benefit for minority populations is greater than for non-minority population. Benefit for low-income population is less than for non-low-income population*

* Note: Appendix E contains a more detailed discussion of these results, including discussion of mitigation.
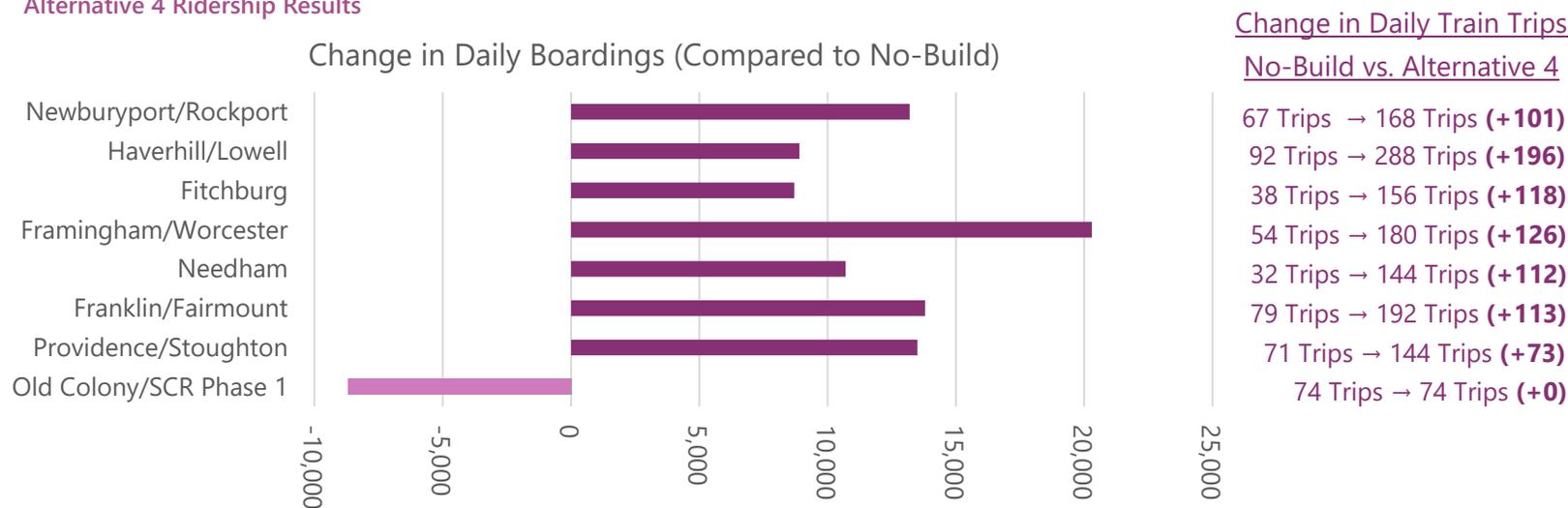
Table C-29   Alternative 4, Objective 5: Help the Commonwealth Achieve its Climate Change Resiliency Targets

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Reduce greenhouse gas emissions	5.1	Change in daily kg of greenhouse gas emissions	NOx: +1,210 kg CO: -800 kg CO_2: +161,000 kg
Reduce dependence on personal vehicles	5.2	Change in commuter rail transit mode share	+0.1%
Reduce dependence on personal vehicles	5.3	Number of daily auto diversions	62,700
Reduce dependence on personal vehicles	5.4	Change in average daily VMT for personal vehicles	-545,000
Reduce dependence on personal vehicles	5.5	Change in average daily VHT for personal vehicles	-124,000

Table C-30   Alternative 4, Objective 6: Maximize Return on Investment (Financial Stewardship)

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Minimize capital cost, compared to benefit	6.1	Estimated capital costs (in 2020$)	$8.9 billion
Minimize the annual O&M cost	6.2	Order-of-magnitude change in annual O&M cost (in 2020$)	+$333 million
Maximize state agency revenues	6.3	Order-of-magnitude change in annual revenue (MBTA systemwide fares) (in 2020$)	+$58 million
Maximize efficiency of the commuter rail system	6.4	Change in operating subsidy per passenger	+$1.24

Figure C-7   Alternative 4 Ridership Results

Change in Daily Boardings (Compared to No-Build)

Change in Daily Train Trips
No-Build vs. Alternative 4

Line	Trips
Newburyport/Rockport	67 Trips → 168 Trips **(+101)**
Haverhill/Lowell	92 Trips → 288 Trips **(+196)**
Fitchburg	38 Trips → 156 Trips **(+118)**
Framingham/Worcester	54 Trips → 180 Trips **(+126)**
Needham	32 Trips → 144 Trips **(+112)**
Franklin/Fairmount	79 Trips → 192 Trips **(+113)**
Providence/Stoughton	71 Trips → 144 Trips **(+73)**
Old Colony/SCR Phase 1	74 Trips → 74 Trips **(+0)**

Ridership Summary

The ridership modeling for Alternative 4 assumed unlimited parking at urban rail termini, and that today's fare structure would remain. **Figure C-7** provides a line-level breakdown, while **Table C-25** summarizes the results.

In Alternative 4, growth on the south side of the system outpaces that on the north side (in magnitude, but not percentages), with an increase of 49,600 forecast average weekday passengers on the south side compared to 30,800 on the north side.

The Newburyport/Rockport line is forecast to have the highest ridership increase on the north side of the system, with the Haverhill/Lowell and

Fitchburg Lines also driving the 67% increase in ridership on the north side.

The south side of the system is projected to increase weekday ridership by 47%. The greatest increase, by over 20,000 passengers per average weekday, is on the Framingham/Worcester Line, followed by increases on the Fairmount and Providence/Stoughton Lines.

In Alternative 4, ridership is forecast to decrease on the Old Colony/South Coast Rail Phase 1 lines due to Alternative 4's assumption of unlimited parking at urban rail termini.

Riders who may have otherwise chosen to travel on the Old Colony/South Coast Rail lines instead are forecast to drive to Route 128 and other stations with higher frequency service.

Providing unlimited parking at urban rail termini also impacts the ridership projections. Approximately 12,600 additional trips would access the Commuter Rail by car, so capturing all of this ridership would require additional parking and other improved first/last mile connections.

The ridership growth in Alternative 4 is distributed between the peak period in the peak direction (31%), the peak period in the reverse peak direction (22%), and off-peak periods (47%). Alternative 4 has the highest proportion of off-peak growth of all alternatives, as it focuses on high frequency, all-day service to the inner core, providing service more like rapid transit.

The urban rail service also results in a projected reduction of 29,800 passenger trips per day on the MBTA bus and rapid transit network. This would help ease crowding on the core network.

Capital Needs Summary

The map in **Figure C-8** illustrates the $12.6 billion (2030 dollars) in capital needs to support the Alternative 4 service plan.

These needs include approximately 24 miles of new track, primarily consisting of double track on the Haverhill Line between Reading and Wilmington Junction, and Wyoming Hill and North Station, the Needham Line between Forest Hills and Needham Heights, and the Franklin line between Norwood Central and Windsor Gardens. The improvements would include approximately 21 grade crossings, 49 bridges and structures, and 47 station improvements. New stations are included at Wonderland, I-93 (Haverhill Line), I-95 (Fitchburg Line), and Riverside (Worcester Line).

Alternative 4 includes expanding the existing fleet of diesel locomotives and bi-level cab cars and coaches, as well as adding DMUs for urban rail.

This alternative includes the additional services of SCR Phase 1 (which is excluded from the capital cost estimates) and South Station Expansion.

Figure C-8   Alternative 4 Capital Needs

Table C-31   Alternative 4 Order of Magnitude Capital Costs

Cost Category	2020$	2030$
Track, signal, structures, stations & facilities	$3.5 billion	$5.0 billion
Fleet	3.0 billion	4.2 billion
System expansions	2.4 billion	3.4 billion
Total Capital Costs	**$8.9 billion**	**$12.6 billion**

Table C-32   Alternative 4 Fleet Needs

Fleet Needs	New	Total
Diesel locomotives	21	114
Bi-level cab cars	27	114
Bi-level cab coaches	94	443
Diesel Multiple Units (DMUs)	336	336

Alternative 5: Urban Rail (Electric)

Results by Objective and Metric

Table C-33   Alternative 5, Objective 1: Match Service with the Growing and Changing Needs

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Maximize Commuter Rail Ridership	1.1	Change in daily commuter rail boardings	+81,600
Maximize Commuter Rail Ridership	1.2	Change in off-peak commuter rail boardings	+36,900
Maximize Commuter Rail Ridership	1.3	Change in reverse peak commuter rail boardings	+22,100
Maximize Commuter Rail Ridership	1.4	Change in daily commuter rail passenger miles	+502,000
Maximize Transit Ridership	1.5	Change in daily MBTA systemwide boardings	+58,800

Table C-34   Alternative 5, Objective 2: Match Service with the Growing and Changing Needs

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Improve access to jobs and opportunities	2.1	Change in number of jobs accessible within 1 hour of using commuter rail	36,215
Improve access to jobs and opportunities	2.2	Change in population accessible within 1 hour of North Station/South Station/Back Bay	1,118,922

Table C-35   Alternative 5, Objective 3: Improve the Passenger Experience

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Continue making commuter rail competitive to driving	3.1	Average change in trip time (in minutes)	-0.9
Support ability to travel	3.2	Change in the number of daily commuter rail train trips	+1,027
Support ability to travel	3.3	Change in the number of daily commuter rail train miles	+20,000
Relieve capacity constraints on the MBTA bus and rapid transit network	3.4	Change in the number of daily passenger trips on the MBTA bus and rapid transit network	-22,900

Table C-36   Alternative 5, Objective 4: Provide an Equitable and Balanced Suite of Investments

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Improve access to jobs for disadvantaged communities	4.1	Change in accessibility to employment for EJ compared to non-EJ communities	Benefit for minority and low-income populations
Improve the quality and level of commuter rail service to disadvantaged communities	4.2	Change in average travel time – transit serving EJ communities	Change less than the forecasting error for minority and low-income populations
Does not adversely affect disadvantaged communities	4.3	Does not adversely burden the EJ population	Benefit for minority populations is greater than for non-minority population. Benefit for low-income population is less than for non-low-income population*

* Note: Appendix E contains a more detailed discussion of these results, including discussion of mitigation.
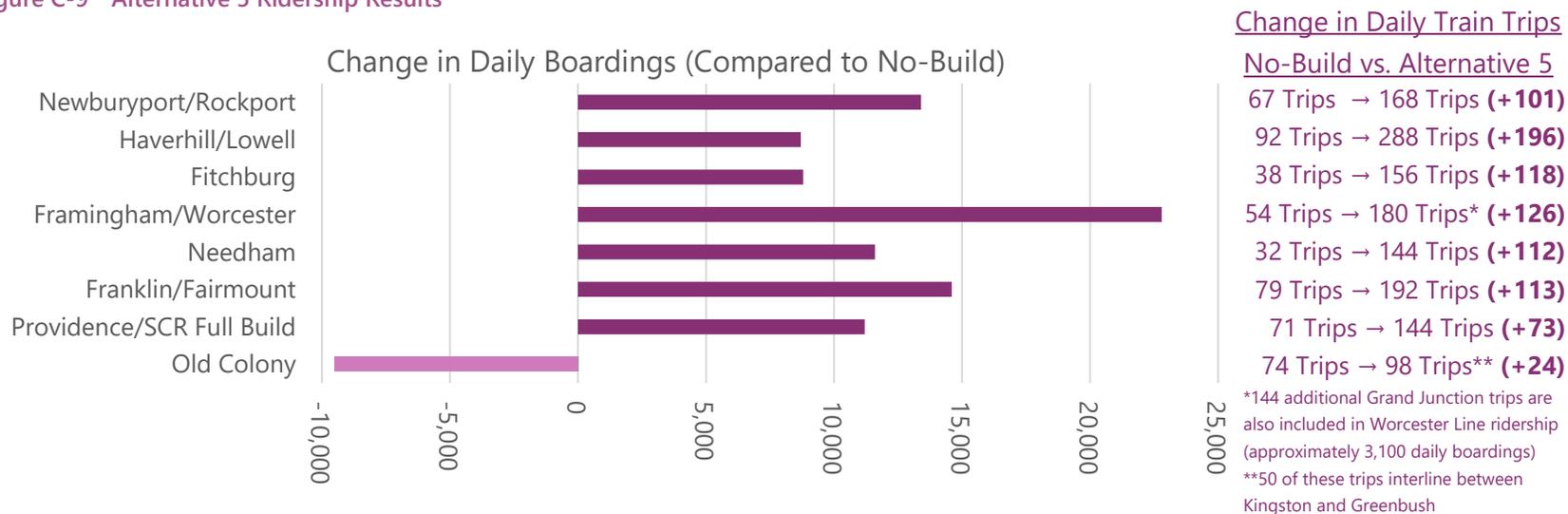
Table C-37   Alternative 5, Objective 5: Help the Commonwealth Achieve its Climate Change Resiliency Targets

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Reduce greenhouse gas emissions	5.1	Change in daily kg of greenhouse gas emissions	NOx: -190 kg CO: -820 kg CO_2: -169,500 kg
Reduce dependence on personal vehicles	5.2	Change in commuter rail transit mode share	+0.1%
Reduce dependence on personal vehicles	5.3	Number of daily auto diversions	59,700
Reduce dependence on personal vehicles	5.4	Change in average daily VMT for personal vehicles	-521,000
Reduce dependence on personal vehicles	5.5	Change in average daily VHT for personal vehicles	-117,000

Table C-38   Alternative 5, Objective 6: Maximize Return on Investment (Financial Stewardship)

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Minimize capital cost, compared to benefit	6.1	Estimated capital costs (in 2020$)	$10.6 billion
Minimize the annual O&M cost	6.2	Order-of-magnitude change in annual O&M cost (in 2020$)	+$304 million
Maximize state agency revenues	6.3	Order-of-magnitude change in annual revenue (MBTA systemwide fares) (in 2020$)	+$48 million
Maximize efficiency of the commuter rail system	6.4	Change in operating subsidy per passenger	+$1.36

Figure C-9   Alternative 5 Ridership Results

Change in Daily Boardings (Compared to No-Build)

Change in Daily Train Trips
No-Build vs. Alternative 5

Line	Trips
Newburyport/Rockport	67 Trips → 168 Trips **(+101)**
Haverhill/Lowell	92 Trips → 288 Trips **(+196)**
Fitchburg	38 Trips → 156 Trips **(+118)**
Framingham/Worcester	54 Trips → 180 Trips* **(+126)**
Needham	32 Trips → 144 Trips **(+112)**
Franklin/Fairmount	79 Trips → 192 Trips **(+113)**
Providence/SCR Full Build	71 Trips → 144 Trips **(+73)**
Old Colony	74 Trips → 98 Trips** **(+24)**

*144 additional Grand Junction trips are also included in Worcester Line ridership (approximately 3,100 daily boardings)
**50 of these trips interline between Kingston and Greenbush

Ridership Summary

The ridership modeling for Alternative 5 assumed unlimited parking at urban rail termini, and that today's fare structure would remain. A variation of Alternative 5 reduced fares in the urban rail, resulting in an increase in ridership. The results shown here represent the existing fare structure. Figure C-9 provides a line-level breakdown, while Table C-33 summarizes the results.

In Alternative 5, growth on the south side of the system outpaces that on the north side (in magnitude, but not percentages), with an increase of 50,700 forecast average weekday passengers on the south side compared to 30,900 on the north side. Results are comparable to Alternative 4, as the reduction in travel times due to electrification minimally impacts ridership.

The Newburyport/Rockport Line is forecast to have the highest ridership increase on the north side, with the Haverhill/Lowell and Fitchburg Lines also driving the 67% increase in ridership on the north side.

The south side of the system is projected to have a 48% increase in weekday ridership. The greatest increase, by over 20,000 passengers per average weekday, is on the Framingham/Worcester Line, followed by increases on the Fairmount, Needham, and Providence/Stoughton Lines. The Framingham/Worcester Line, which adds 126 train trips per weekday, and includes approximately 3,100 passengers on the Grand Junction shuttle.

South Coast Rail Full Build ridership is included with the Providence/Stoughton Line. Like Alternative 4, the decrease in ridership on the Old Colony lines is partially due to diversions to other

stations. The interlining of the Greenbush and Kingston/Plymouth Lines also necessitates a transfer for travel into Boston, which further hinders ridership.

Approximately 10,300 additional trips would access the Commuter Rail by car, so capturing all of this ridership would require additional parking and other improved first/last mile connections.

Like Alternative 4, the ridership growth in Alternative 5 is distributed between ridership in the peak period in the peak direction (28%), the peak period in the reverse peak direction (27%), and especially during off-peak periods (45%).

The urban rail service also results in a projected reduction of 22,900 passenger trips per day on the MBTA bus and rapid transit network. This would help ease crowding on the core network.

Capital Needs Summary

The map in **Figure C-10** illustrates the $14.9 billion (2030 dollars) in capital needs to support the Alternative 5 service plan.

These needs include partial system electrification, and approximately 39 miles of new trackwork, primarily consisting of similar segments as Alternative 4, along with several segments on the Old Colony lines, and upgrading Grand Junction for revenue service. The improvements would include approximately 40 grade crossings, 58 bridges and structures, and 53 station improvements. New stations are included at Wonderland, I-93 (Haverhill Line), I-95 (Fitchburg Line), Riverside (Worcester Line), and Kendall.

Alternative 5 includes expanding the existing fleet of diesel locomotives and bi-level cab cars and coaches, as well as adding EMUs for urban rail.

This alternative includes the additional services of SCR Full Build (which is excluded from the capital cost estimates), South Station Expansion, and Grand Junction.

Figure C-10 Alternative 5 Capital Needs

Table C-39 Alternative 5 Order of Magnitude Capital Costs

Cost Category	2020$	2030$
Track, signal, structures, stations & facilities	$5.8 billion	$8.0 billion
Fleet	2.2 billion	3.1 billion
System expansions	2.6 billion	3.8 billion
Total Capital Costs	**$10.6 billion**	**$14.9 billion**

Table C-40 Alternative 5 Fleet Needs

Fleet Needs	New	Total
Diesel + Electric locomotives	22	112
Bi-level cab cars	25	112
Bi-level cab coaches	101	450
Electric Multiple Units (EMUs)	185	185

Alternative 6: Full Transformation

Results by Objective and Metric

Table C-41   Alternative 6, Objective 1: Match Service with the Growing and Changing Needs

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Maximize Commuter Rail Ridership	1.1	Change in daily commuter rail boardings	+225,900
Maximize Commuter Rail Ridership	1.2	Change in off-peak commuter rail boardings	+73,200
Maximize Commuter Rail Ridership	1.3	Change in reverse peak commuter rail boardings	+37,900
Maximize Commuter Rail Ridership	1.4	Change in daily commuter rail passenger miles	+2,672,800
Maximize Transit Ridership	1.5	Change in daily MBTA systemwide boardings	+184,200

Table C-42   Alternative 6, Objective 2: Match Service with the Growing and Changing Needs

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Improve access to jobs and opportunities	2.1	Change in number of jobs accessible within 1 hour of using commuter rail	53,611
Improve access to jobs and opportunities	2.2	Change in population accessible within 1 hour of North Station/South Station/Back Bay	1,307,760

Table C-43   Alternative 6, Objective 3: Improve the Passenger Experience

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Continue making commuter rail competitive to driving	3.1	Average change in trip time (in minutes)	-5.1
Support ability to travel	3.2	Change in the number of daily commuter rail train trips	+1,215
Support ability to travel	3.3	Change in the number of daily commuter rail train miles	+39,300
Relieve capacity constraints on the MBTA bus and rapid transit network	3.4	Change in the number of daily passenger trips on the MBTA bus and rapid transit network	-50,900

Table C-44   Alternative 6, Objective 4: Provide an Equitable and Balanced Suite of Investments

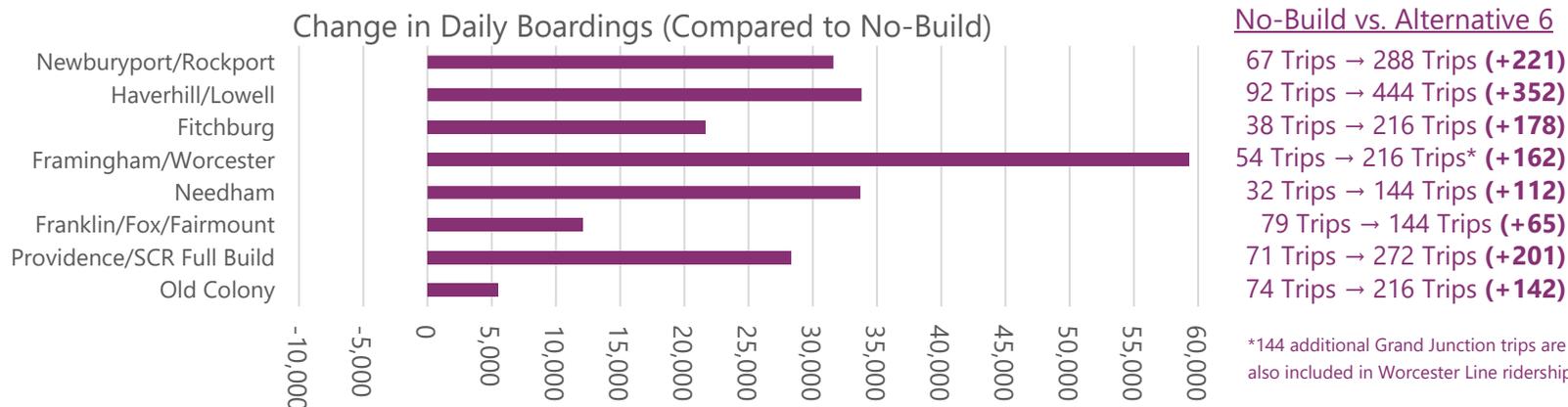| Project Objective	Metric Number	Evaluation Metric	System-Level Result
Improve access to jobs for disadvantaged communities	4.1	Change in accessibility to employment for EJ compared to non-EJ communities	Benefit for minority and low-income populations
Improve the quality and level of commuter rail service to disadvantaged communities	4.2	Change in average travel time – transit serving EJ communities	Change less than the forecasting error for minority and low-income populations
Does not adversely affect disadvantaged communities	4.3	Does not adversely burden the EJ population	Benefit for both EJ populations is greater than for non-EJ populations

Table C-45   Alternative 6, Objective 5: Help the Commonwealth Achieve its Climate Change Resiliency Targets

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Reduce greenhouse gas emissions	5.1	Change in daily kg of greenhouse gas emissions	NOx: -1,820 kg CO: -1,780 kg CO_2: -756,800 kg
Reduce dependence on personal vehicles	5.2	Change in commuter rail transit mode share	+0.3%
Reduce dependence on personal vehicles	5.3	Number of daily auto diversions	116,900
Reduce dependence on personal vehicles	5.4	Change in average daily VMT for personal vehicles	-1,339,000
Reduce dependence on personal vehicles	5.5	Change in average daily VHT for personal vehicles	-206,000

Table C-46   Alternative 6, Objective 6: Maximize Return on Investment (Financial Stewardship)

Project Objective	Metric Number	Evaluation Metric	System-Level Result
Minimize capital cost, compared to benefit	6.1	Estimated capital costs (in 2020$)	$28.9 billion
Minimize the annual O&M cost	6.2	Order-of-magnitude change in annual O&M cost (in 2020$)	+$643 million
Maximize state agency revenues	6.3	Order-of-magnitude change in annual revenue (MBTA systemwide fares) (in 2020$)	+$80 million
Maximize efficiency of the commuter rail system	6.4	Change in operating subsidy per passenger	+$0.61

Figure C-11 Alternative 6 Ridership Results

Change in Daily Boardings (Compared to No-Build)

Change in Daily Train Trips
No-Build vs. Alternative 6

67 Trips → 288 Trips **(+221)**	Newburyport/Rockport
92 Trips → 444 Trips **(+352)**	Haverhill/Lowell
38 Trips → 216 Trips **(+178)**	Fitchburg
54 Trips → 216 Trips* **(+162)**	Framingham/Worcester
32 Trips → 144 Trips **(+112)**	Needham
79 Trips → 144 Trips **(+65)**	Franklin/Fox/Fairmount
71 Trips → 272 Trips **(+201)**	Providence/SCR Full Build
74 Trips → 216 Trips **(+142)**	Old Colony

*144 additional Grand Junction trips are also included in Worcester Line ridership

Note: Growth in line level boardings includes NSRL ridership and uses an approximate distribution of boardings for through-running trips.

Ridership Summary

The ridership modeling for Alternative 6 assumed unlimited parking at all stations not shared with rapid transit that have at least 50 parking spaces today. The modeling also assumed a distance-based fare structure based on the structure proposed for the North South Rail Link (to provide an appropriate fare for through-trips without a surcharge for going through downtown Boston), as well as reduced urban rail fares of $3.40 for all trips between urban rail stations (or the existing fare, whichever is lower). **Figure C-11** provides a line-level breakdown, while **Table C-41** summarizes the results.

In Alternative 5, growth on the south side of the system outpaces that on the north side (in magnitude, but not percentages), with an increase

of 138,900 passengers on the south side compared to 87,900 on the north side.

While the combined Haverhill/Lowell Line forecast ridership increase is the highest of the north side lines, the growth on the Newburyport/Rockport line is similar, with a smaller number of additional train trips. Fitchburg Line ridership growth also outpaces many of the south side lines.

The Framingham/Worcester Line has the greatest projected growth, which includes approximately 4,500 passengers on the Grand Junction shuttle. The Needham Line is projected to have the second highest increase in passenger boardings on the south side of the system, with approximately the same increase as on the Haverhill/Lowell Line. South Coast Rail Full Build ridership is included with the Providence/Stoughton Line.

Providing unlimited parking at most stations greatly impacts the ridership projections.

Approximately 94,400 additional trips would access the Commuter Rail by car, so capturing all of this ridership would require additional parking and other improved first/last mile connections.

The ridership growth in Alternative 6 is distributed between the peak period in the peak direction (50%), the peak period in the reverse peak direction (18%), and off-peak periods (32%). Alternative 6 has the highest proportion of peak period growth of all alternatives, as it focuses on providing new connections while also providing unlimited parking at most stations. Alternative 6 provides an estimated 94,000 new "drive access" boardings, and approximately 35,000 boardings using the new through-service via NSRL.

The urban rail service also results in a projected reduction of 50,900 passenger trips per day on the MBTA bus and rapid transit network. This would help ease crowding on the core network.

Capital Needs Summary

The map in **Figure C-12** illustrates the $40.7 billion (2030 dollars) in capital needs to support the Alternative 6 service plan.

These needs include electrification of the entire commuter rail system and approximately 59 miles of new trackwork, with a number of extended double track segments (including the Middleborough Main Line). The improvements would include approximately 35 grade crossings, 82 bridges and structures, and 87 station improvements (including accessibility upgrades so that all stations would have high-level platforms). New stations are included at Wonderland, I-93 (Haverhill Line), I-95 (Fitchburg Line), Riverside (Worcester Line), and Kendall.

Since Alternative 6 assumes all-electric service, the entire fleet is replaced with EMUs.

This alternative includes the additional services of SCR Full Build and service to Foxboro (which are excluded from the capital cost estimates), North-South Rail Link, Grand Junction, and the double track of the Middleborough Main Line.

Figure C-12 Alternative 6 Capital Needs

Table C-47 Alternative 6 Order of Magnitude Capital Costs

Cost Category	2020$	2030$
Track, signal, structures, stations & facilities	$12.1 billion	$17.0 billion
Fleet	6.5 billion	9.2 billion
System expansions	10.3 billion	14.5 billion
Total Capital Costs	**$28.9 billion**	**$40.7 billion**

Table C-48 Alternative 6 Fleet Needs

Fleet Needs	New	Total
Diesel locomotives	0	0
Bi-level cab cars	0	0
Bi-level cab coaches	0	0
Electric Multiple Units (EMUs)	964	964