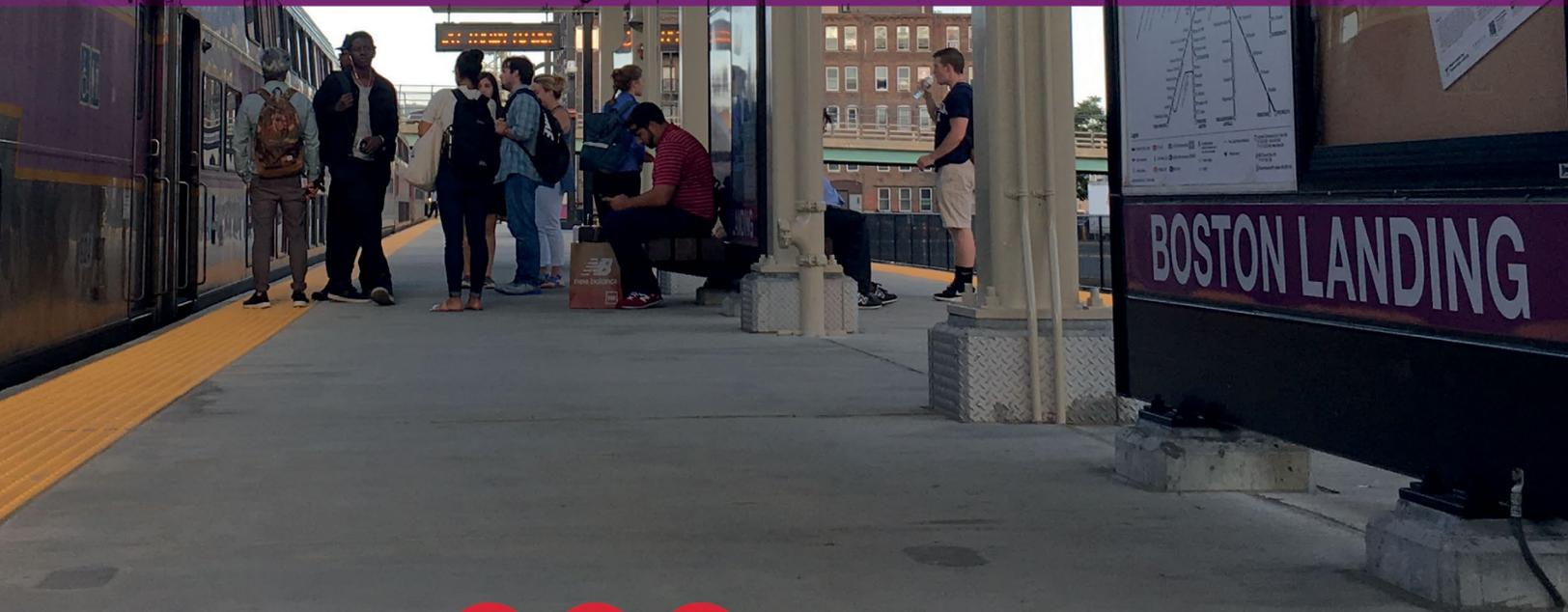


Regional Rail Proof of Concept

*How Modern Operating Practice
Adds Capacity to the Current
Commuter Rail Network*

*How to Provide Frequent, All-day
Service on the Worcester Line*



TRANSITMATTERS

Fall 2019



Acknowledgements

This Proof of Concept paper is the product of a collaborative effort by TransitMatters members led by **Alon Levy** and **Ethan Finlan**. We wish to acknowledge the contributions of the following TransitMatters members (in no particular order):

- » **Josh Fairchild** » **Peter Brassard**
- » **Ted Pyne** » **Charles Li**
- » **Jim Aloisi** » **Cindy Heredia**
- » **Tim Lawrence** » **Zak Koehler**
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How Modern Operating Practice Adds Capacity to the Current Commuter Rail Network

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Fall 2019

Introduction

This Proof of Concept paper is the first in a series of supplements to the TransitMatters 2018 report entitled *Regional Rail for Metropolitan Boston*. Throughout this paper, our reference to the term “Regional Rail” refers to the vision we set forth in that 2018 Regional Rail report: a vision of fast, frequent, all day electrified train service for the Boston metropolitan region. Additionally in that report, we explicitly called for the cancellation of the proposed South Station expansion (“SSX”), a \$2-3 billion project of practically no transportation value that will cement, perhaps irretrievably, outdated approaches to providing intercity rail service in the Commonwealth of Massachusetts. This Proof of Concept supplement is meant to elaborate on cheaper, more modern alternatives and provide the framework of an approach that we recommend the Massachusetts Bay Transportation Authority (“MBTA”) adopt to achieve our Regional Rail vision.

Modernized operating practices can maximize train throughput, thus adding capacity to the MBTA’s current commuter rail system.

Specifically, this Proof of Concept highlights how modernized operating practices can maximize train throughput, thus adding capacity to the MBTA’s current commuter rail system. These methods and that additional capacity will permit a large expansion of commuter rail service at a significantly lower cost than many both inside and outside the MBTA and MassDOT presently assume. This capacity question is an urgent one for the Metro Boston region, as passenger volumes on commuter rail are up 20% over the last 6 years. Unfortunately, the MBTA’s only proposed capacity solutions to date are an ill-advised multibillion-dollar expansion of South Station, and an equally ill-advised new order of bilevel coaches to be powered by diesel locomotives that are approaching an average age of 40 years of service.¹

The adoption of global best practice operating protocols, combined with relatively minor track upgrades, would render the South Station Expansion (SSX) project completely unnecessary, even for the transformative service levels proposed in our Regional Rail Report. Moreover, single-level

electric multiple unit trainsets (EMUs)² combined with better frequency from faster turnaround times, would enhance capacity without the inherent drawbacks of bilevel trains (sometimes called double-decker coaches), which should be consigned to the dustbin of antiquated mid-20th century “9 to 5” commuter rail systems.

Maximizing Train Throughput: A Low-Cost Approach to Increasing Capacity at South Station

Our guiding principle, as always, is *organization before electronics before concrete*.³ This means that before investing in anything else, the MBTA should immediately take steps to improve rail operations by maximizing train throughput. Some modifications are required to make sure trains can run more frequently, but these modifications involve better scheduling, more reliable electrical equipment, resignaling the terminal zone, and minor trackwork, all of which are significantly less expensive and more cost-effective than relocating property in Downtown Boston to expand the station footprint. With better operations, SSX is unnecessary and its budget can be reinvested in better projects, such as high-level platforms and electrification across the entire MBTA regional rail system. The resources exist; they simply need to be spent wisely.

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The essential lesson is that the capacity of a terminal zone is dependent on how fast trains can enter and exit the station and its throat.⁴ At both South and North Stations, there are 10 mph speed limits for about half a mile out, which can be lifted to about 30 mph. There are also generous margins of error required by frequent failure rates endemic to the MBTA’s current diesel locomotive fleet, margins that can be specifically decreased with modern equipment.

Rather than run any meaningful level of reverse-peak service and midday service, the MBTA instead sends morning peak

trains to sit idle in large, inefficient layover yards within Boston (the second most expensive real estate market on the east coast of North America.) This wasteful practice requires conflicting movements of trainsets across the main line, imposing further strain on downtown terminal capacity. The precious terminal capacity tied up by these practices could instead go toward providing transformative levels of regional rail service to the Greater Boston area.

TransitMatters proposes to eliminate these capacity-killing problems through a cost-effective combination of operational reforms and targeted investments. No station footprint expansion is needed. The trackwork required is at very small scale and entirely within the right-of-way. In the mid-to-long term, following implementation of these reforms and targeted investments, construction of the North-South Rail Link (NSRL) would provide a more direct trip to downtown Boston from the North Side, thus warranting higher frequency of service for all North Side lines and full realization of a transformative Regional Rail vision.⁵

Frequency

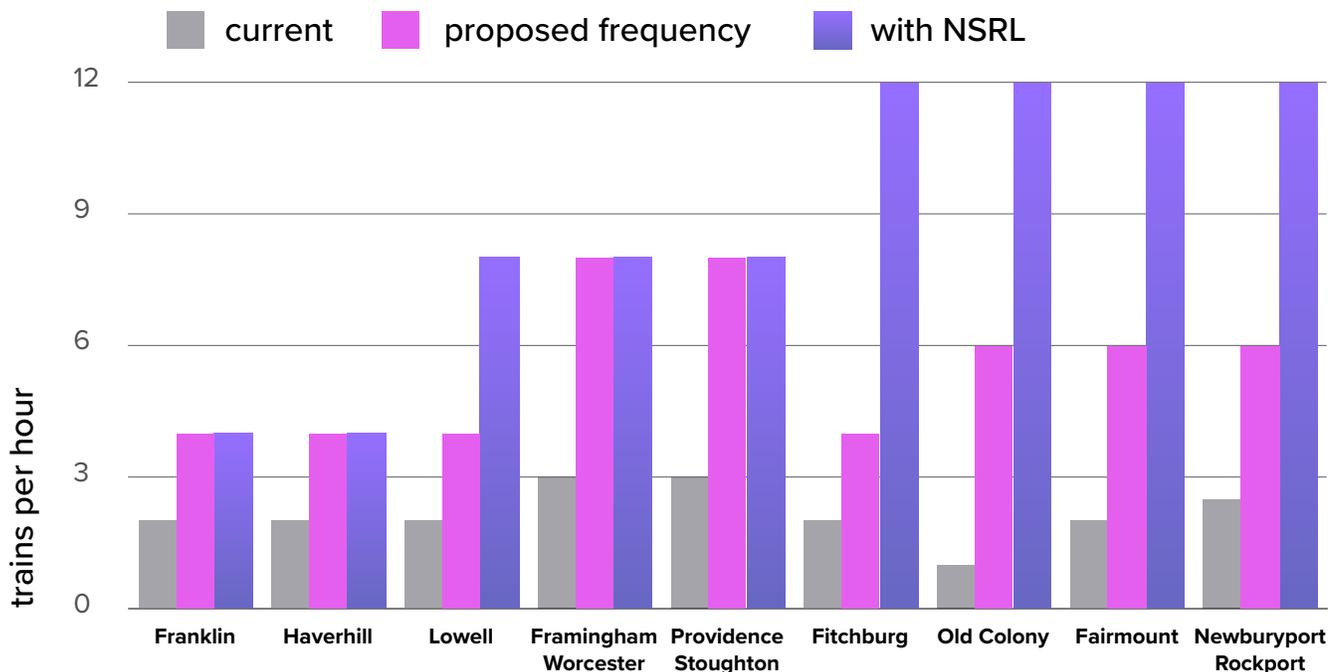
South Station has 13 platform-terminating tracks, which are utilized to serve 20 trains per hour (tph) per direction (inbound/outbound) at peak commute times. Based on current operations elsewhere in the world (as we will explain below), we believe that South Station could be optimized to serve 26 to 30 regional rail tph (that is, 26 to 30 tph in each direction) and North Station could serve 18 regional rail tph

(in each direction, again). These capacity figures are only about half as high as these stations' ultimate capacities. We propose the following as a realistic (but not maximum) capacity schedule in each direction at peak times of the day:

- » **Franklin Line:** 4 tph, either all running via the Southwest Corridor or all interlining²⁴ with Fairmount
- » **Haverhill Line:** 4 tph
- » **Lowell Line:** 4 tph
- » **Worcester Line:** 8 tph
- » **Providence/Stoughton Line:** 4 tph to Providence, 4 to Stoughton
- » **Fitchburg Line:** 4 tph
- » **Old Colony Lines:** 6 tph, 2 per branch
- » **Fairmount Line:** 6-8 tph
- » **Newburyport/Rockport (Eastern) Line:** 6 tph between the branches

These frequencies of trains per hour do not include Amtrak or other non-MBTA trains but leave sufficient room for them to operate. With our proposed speedup of the Providence Line, the infrastructure has room for 4 hourly slots for Amtrak's Northeast Corridor services, for a total of 30-34 peak tph at South Station.

South Station's 13 terminal tracks are sufficient to permit separating the four trunks heading into the station, thereby keeping the Worcester Line on two tracks, the Old Colony on two, Fairmount on two, and the Northeast Corridor (including Needham, Franklin, Providence/Stoughton and Amtrak) on the remaining tracks. (See **Figure 1**)



At North Station, the current infrastructure is a barrier to completely separating the lines. However, a project to add approach tracks, which would permit separating the Lowell and Fitchburg Lines, is already funded. Unlike SSX, this North Station project is worthwhile, because it removes an infrastructure-based constraint to improve operations. Regardless, traffic at North Station is low enough that the current infrastructure provides more than enough capacity to meet the needs of Regional Rail.

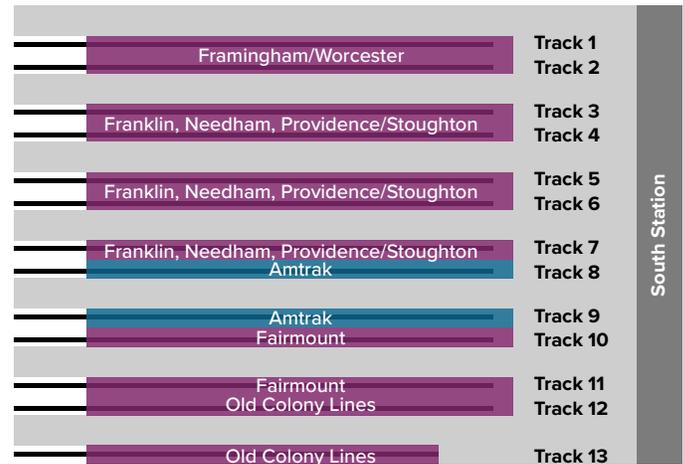
The Terminal Interlockings and Speed

Our projected schedules have trains traveling between South Station and Back Bay in 2.5 minutes, and between South Station and Ruggles in 4.5 minutes. Today, trains are timetabled to take 5 and 8 minutes respectively. This difference is due in part to the assumption of electrification,⁶ and partly to speeding up the slowest part of the route - namely, the South Station approaches and terminal capacity limits. While city center terminals such as North and South Station will always face inflexible constraints absent costly expansion, the switches can support much higher speeds than the current 10 mph limit.

There are two primary reasons for today's conservative 10 mph speed limit. First, as is typical in the United States, many passenger train speed limits are simply too low, a legacy of the steam era, and have never been revised. For example, the extent of legally allowable centrifugal force on a train moving through a curve, which in turn governs its maximum speed, is based on a passenger comfort experiment conducted in the 1950s with New Haven Railroad trains; this outdated requirement reduces allowable speed on curves by 15-30% relative to best practice. Thankfully, the regulations were recently superseded by the Federal Railroad Administration ("FRA"), but the MBTA has not taken advantage of the change.⁷

Second, the design of American switches (or "turnouts") is handed down from a bygone era and does not properly control for the change in acceleration experienced by a diverging train. Based again on steam-era standards, current American industry standards for switches require the diverging rail to be straight where it crosses the straight rail, a point called the "frog." In contrast, for example, German switches are curved through the frog and are designed for smoother transition between the straight segments and the curved ones, enabling greater speed through the curves. The point being, our switch turnouts are significantly slower than other world-class train systems.⁸ These are resolvable barriers to better train speed and throughput.

Figure 1: Proposed track assignments at South Station



It is hard to overstate the importance of removing the slowest speed restrictions, which are in place at both North and South Stations. A half mile at 10 mph takes 3 minutes to traverse. In contrast, at 30 mph, with dedicated tracks to improve reliability, that time is cut by two-thirds; trains in that same half-mile approach would spend a minute going into a station terminal and a minute going out. This is not done today as a result of suboptimal switch design and antiquated signaling circuits, some of which hail from the steam era. These slow zones are unnecessary and relatively easy to fix, alongside fixes to terminal capacity. To add perspective to the relative cost and impact of our proposal, the modest investments in reliability and switch design that we propose can save more time in the last half mile into North or South Station than would Amtrak's \$450 million project to increase top speed in New Jersey from 135 to 160 mph.

The pinch point in the South Station throat is an interlocking called Tower 1.⁹ It features a complex of switches called a *ladder track*: trains from tracks at one end can take the diverging path on a series of switches, thus gaining access to all of the different South Station terminal track options. North Station has an interlocking called Tower A with similar characteristics that allow trains from any track to access any other track at the North Station terminal. While on the surface this seems practical, it is one more vestige of prior century railroading and it slows the trains down, thereby limiting the capacity of each terminal. With all day service by reliable trains and separated track assignments for each line, there is no need for trains to have infinite track options.¹⁰

Fortunately, the process of reconfiguring the switches to allow smoother, faster travel, called "*kinematic gauge optimization*", does not require infrastructure modifications beyond the rails themselves. The switches do not need to be made longer. Modifying the switches to smooth the transition to the curve

requires track geometry changes so subtle they can be done within the right of way, without hitting various utility and catenary poles. The project requires laying rails but does not require any of the usual difficult sitework complicating capital construction. Thus, this improvement is relatively inexpensive and has also been recently undertaken and completed by one of our neighbor railroads: Metro-North Railroad recently upgraded 40 mph turnouts to 65 mph at a cost of only a few hundred thousand dollars each.

With the switches so modified, trains could enter and exit the terminals at speeds up to 30-35 mph, allowing trains to clear the station throats rapidly. This alone would serve to increase terminal station capacity, since moving trains in and out faster increases the maximum throughput.

Dedicated Terminal Tracks

The best industry practice at a terminal station serving multiple lines is to separate different lines to different, consistent platforms and minimize interaction between the lines. The reason for this is to isolate delays: if trains on one line are delayed, then they will delay other trains on the same line no matter what, but with perfect separation, delays will not cascade on any other lines.

Unfortunately, MBTA practice is light years away from full line separation. The T prefers being able to connect every line to every terminal track, in order to allow trains on one line to substitute for trains for other lines. The MBTA's aging diesel locomotives today break down every 7,600 miles¹¹, so often that the T assumes breakdowns will happen in the terminal zone as a routine matter.¹² Modern EMUs are far more reliable - the LIRR's M-7 trains break down every 500,000 miles.¹³ With high equipment reliability, it is easy to separate trains between tracks; the T would not need a train on one line to substitute for a train on another. In short, the T is letting the unreliability of its aging diesel locomotive fleet have a negative impact on its ability to adopt best practice line separation at South Station.

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Even with today's rolling stock, it's unclear that the MBTA's current practice is necessary or optimal. However, what is certain is that given train reliability levels achieved in London, Paris, Zurich, and other cities with 21st-century practices, rail line separation is the best policy. London is spending

considerable money and effort on disentangling different services in South London for this very reason.¹⁴ Switzerland has many small-scale track separation projects at junctions preventing delays on one train from cascading to other lines; the Netherlands is copying this policy at Utrecht, the country's busiest train station, citing Japanese precedent.

Boston already has the infrastructure for separation, especially at South Station, as the four mainlines entering the station do not cross; unlike London, the MBTA need not spend much money to disentangle its operations. At South Station, it is very easy to separate the Providence and Worcester Lines from the Fairmount and Old Colony Lines; separating each of those lines further is possible, but requires more extensive modifications to Tower 1, which currently has a six-track pinch-point. At North Station, separation is more difficult, but there is less traffic, so that this is less critical.

With the high reliability of EMUs and mostly separated tracks between lines, it is possible to run trains with high schedule discipline. High schedule discipline in turn permits running trains more regularly and more often.

The bottom line: with the high reliability of electric trains (or EMUs as we propose), and mostly separated tracks between lines, it is possible to run trains with high schedule discipline. High schedule discipline in turn permits running trains more regularly and more often, at least at the frequency levels we have outlined earlier in the Frequency section of this paper.

The Importance of Clockface Scheduling and Rapid Turn Times

A disciplined schedule must repeat on a clockface pattern. This means that if a train runs every 15 minutes and serves a station inbound at 9:05, it will serve it in that direction at :05, :20, :35, and :50 every hour all day. Passengers can memorize these schedules more easily than the complex schedules favored by American planners. Moreover, infrastructure planning is simplified when trains run at consistent intervals, since overtakes and meets on single track are at predictable locations. One Swiss planner humorously put it this way: "We Swiss are lazy, so we plan one hour and repeat it for the rest of the day."

If trains enter and exit a station throat on a frequent, repeating timetable, and they only occupy the interlocking for a minute in each direction, the maximum capacity of the throat is much higher than current practices allow. Functions such as refueling, which currently require trains to reverse to the yard

and not back onto the mainline at downtown terminals, can be handled at suburban terminals and layover yards (and with electrification, refueling ceases to be relevant.)

Turning trains more quickly¹⁵ increases terminal throughput and capacity. American commuter trains turn in 10 minutes at New Haven, and occasionally in Worcester when recovering from delays. Amtrak Keystone trains regularly turn in 10 minutes at Philadelphia's 30th Street Station. By contrast, in Germany, trains routinely turn in less than 5 minutes. The MBTA can achieve these turn-around metrics as well if it adopts the global best practices we set forth in this supplement.

High frequency all day in both directions, proof-of-payment fare collection, and automatic door opening all combine to increase labor efficiency to the point that train crews can quickly disembark from the train they used to reach Boston, and operate another train ready for departure. This way crews can be perfectly positioned on standby (these are called *dropback crews*) for departure, reducing turnback times below 5 minutes.

Even accepting 10 minutes as a turnaround time, trains can be scheduled to occupy each track for 15 minutes: 10 minutes of turn time and 5 minutes of approach time and schedule contingency. While far from world class, even improving the MBTA's turn times to this extent would allow a peak frequency of 4 tph per terminal track. With 4 tph, South Station's 13 tracks could accommodate 52 trains per hour. Today, peak traffic into South Station is 20 trains per hour per direction, less than half of what is realistically possible, while still being at the lower end of best-in-class railroads.

Why Single-Level Trains

The busiest urban rail lines in the world run single-level trains, and so should the T.

In order to achieve the quickest possible station departure and turn times, the MBTA should use single-level trains, not bilevels. The busiest urban rail lines in the world run single-level trains, and so should the T. Bilevel trains have higher seated capacity than single-level trains which is why they are favored by the old-fashioned peak-focused commuter rail model in service in Metro Boston and throughout North America. Unfortunately, bilevels require climbing or descending stairs to reach the egress doors, which requires trains to have longer dwell times at stations.¹⁶

Single level trains can have several sets of evenly-spaced doors located along the length of the car. It will help the reader to think of the door placement on subway cars as opposed to the end-only door placement on typical commuter coaches (the older MBTA single level commuter coaches are exactly the wrong model to have in mind). Even the best-made bilevels (*i.e.* more and wider doors) have longer egress times, which lead to longer dwell times in city center at rush hour. Long dwell times result in reduced capacity per hour. Therefore, lower capacity single level trains actually translate to higher capacity per hour if the single level trains are paired with frequent service (all-day frequent service being the main thrust and assumption of Regional Rail).

In Tokyo, the crowding level is such that practically all equipment is single-level with many doors, usually four pairs per car. Bilevel trains would simply take too long to unload. Berlin and Munich use single-deckers as well on their S-Bahn networks, with three door pairs per car. The Munich S-Bahn does so in a context in which one line has 840,000 riders per weekday¹⁷, almost as many as all MBTA rail lines combined.¹⁸

At frequencies sufficient to achieve all-day frequent service (a minimum headway of 15 minutes at peak inside Route 128), the excessive dwell times and accessibility challenges imposed by bilevels cancel out their theoretical capacity gains.

Ultimately, theoretical capacity based on seats per train set is an insufficient metric against which to weigh the merits of single-level versus bilevel cars. At frequencies sufficient to achieve all-day frequent service (a minimum headway of 15 minutes at peak inside Route 128), the excessive dwell times and accessibility challenges imposed by bilevels cancel out their theoretical capacity gains. If passengers fill single-level trains to capacity, the solution is to buy more cars and run longer, more frequent trains. This serves to not only move more passengers, but increase flexibility of the service through more frequent trips. When trains are sufficiently frequent, passengers become relatively indifferent to which train they are on so long as they can get on the next one. This reduces the extent of peak crowding now seen on specific trains.

Though the MBTA is accustomed to ordering and maintaining bespoke equipment, modern trains are more like commodities. Vendors offer modular products, fabricating them at their existing plants with customization for local needs. Such trains have wide doors, weigh about 44 short tons¹⁹ per US-length car, and cost about \$2.5 million. The contrast with today's

MBTA equipment is stark. The MBTA's coaches do not all have automatic doors - conductors manually operate the doors. The aisles are narrow (and easily obstructed) and the doors are at the ends of the car rather than at the quarter points (four evenly spaced doors per car-side), slowing down the boarding and alighting process. Some trains take 5 minutes to fully unload at South Station at rush hour. It can feel like waiting to deplane from the rear of an aircraft. These dwell times completely undermine the speed and frequency required for regional rail to be a functional, competitive, and favorable transportation mode.

Massachusetts must immediately commit to procuring single-level EMUs, starting with the Providence Line and continuing rollout to other lines while in the course of rapid and successive electrification of the entirety of the current and planned commuter rail system.

We are now well past the point of delaying the decision that must be correctly made in the public interest: Massachusetts must immediately commit to procuring single-level EMUs, starting with the Providence Line and continuing rollout to other lines while in the course of rapid and successive electrification of the entirety of the current and planned commuter rail system. Any further investment in bilevel coaches or diesel locomotives would be, in our view, not merely questionable – it would be irresponsible as it continues a system that is highly inefficient and that, because of its inherent inefficiency, serves as a constant drag on better frequencies and requires unnecessary costly initiatives like SSX. Our proposed Regional Rail operating model would move more people by optimizing frequency gains from single-level EMUs. The existing equipment, both locomotives and coaches, is not compatible with modern operations, and the write-down on its remaining useful life is less than the damage it causes through slow operations and limited capacity.

Any further investment in bilevel coaches or diesel locomotives would be irresponsible.

Nonetheless, assuming a staged adoption of electrification, current coaches with remaining useful life should be reallocated to the non-electrified lines to increase service frequency and capacity to the extent possible prior to electrification and completion of high-level platform construction. They may also be useful for new intercity service to western Massachusetts, or even as far as Albany, at least until such service is electrified.

Regional Rail would move more people by optimizing frequency gains from single-level EMUs.

The Role of NSRL

In our Regional Rail report, we said that while the North-South Rail Link was not critical to implementing a robust Regional Rail system, it would be a “highly useful enhancement providing the flexibility and connectivity to which many riders and potential riders would be drawn.” If NSRL is constructed, frequencies are likely to rise because of an increase in passenger traffic demand (especially on the North Side, as North Station is not in the CBD and South Station is) and the more useful service would induce much greater demand. Thankfully, through-stations do not have problems with terminal interlockings and turn access capacity to which much of this paper is devoted. The following frequencies will become viable upon completion of the NSRL²⁰:

- » **Worcester Line:**²¹ 8 tph on the inner segment to Newton, 4 continuing farther out
- » **Providence Line:** 4 tph
- » **Stoughton Line:** 4 tph
- » **Franklin Line:** 4 tph
- » **Fairmount Line:** 12 tph if Franklin trains operate via Fairmount, or 8 if Franklin trains remain on the Southwest Corridor
- » **Old Colony Lines (Kingston/Plymouth, Greenbush, and Middleborough/Lakeville):** 12 tph, 4 per branch
- » **Eastern Lines (Newburyport/Rockport):** 12 tph on the inner segment to Salem, 4 per branch
- » **Haverhill Line:** 4 tph
- » **Lowell Line:** 4 tph if Haverhill Line trains continue to operate as today, 8 if they go via the Wildcat Branch
- » **Fitchburg Line:** 12 tph on the inner segment to Brandeis/Roberts, 4 continuing farther

NSRL would also allow a further increase in speed, since the tracks would continue through downtown rather than terminating at stub end terminals where trains must slow to approach. The reason to enter South and North Stations at 30 mph (as advised in this report) is that the consequences of overrunning the bumpers are catastrophic. At through-stations, entering at 50-60 mph even in city centers is feasible.

With NSRL in place, only a small subset of trains would still need to navigate the surface terminal interlockings at North and South Stations. Within the tunnel, tracks should be dedicated similar to the track separation we propose for terminal stations, in the sense that one portal only pairs with

the Providence and Worcester Lines and another only with Fairmount and Old Colony. This would permit about 24 tph in each direction per tunnel pair, or 48 for the four-track system. The remaining additional trains not traversing the tunnels would use surface terminal platforms.²²

Schedules would continue to run clockface, except at higher frequency. The S-Bahns in Berlin and Munich have high frequency and almost total through-running and maintain their clockface patterns, as does the Paris RER off-peak.

Single-level trains become even more crucial with NSRL. The minimum headway in the NSRL tunnel is determined by the sum of station dwell time and the time it takes the train to stop decelerating from full speed. Bi-level train dwell times will never support the necessary headways for running a regional rail system through NSRL tunnels.

NSRL engineering must be based upon optimized Regional Rail operations, specifically the use of single-level EMUs. Moving forward with NSRL without first putting Regional Rail into operation would result in a NSRL tunnel that could never live up to its true potential.

Ultimately, NSRL is a major booster for Regional Rail. It is not necessary for the basic Regional Rail system, nor for more efficient use of current South Station platforms, which require good operations and electrification. But as a non-trivial investment in concrete infrastructure, NSRL is the logical extension building upon the modernization of organization and electronics as prescribed above because it greatly improves access to Boston and the entire metro area. As such, NSRL engineering must be based upon optimized Regional Rail operations, specifically the use of single-level EMUs.²³ Unfortunately, as we've pointed out, the 2018 NSRL feasibility reassessment commissioned by MassDOT grossly understated the benefits of the NSRL by building in assumptions of antiquated operations and equipment in the tunnels, which had the added effect of artificially driving up the projected cost. Moving forward with NSRL without first committing to achieving Regional Rail operations as a predicate would result in a NSRL tunnel that could never live up to its true potential.

Conclusion

Regional Rail is not an unattainable vision; it is an achievable standard for intercity rail in Massachusetts. This new business model for the provision of intercity rail service is an essential component of a regional approach to linking Gateway Cities to Greater Boston, reducing traffic congestion, and providing access to jobs, healthcare, school and affordable housing to Metro Boston residents. In short, Regional Rail is essential to our quality of life.

We state clearly: the proposed \$2-3 billion South Station expansion is neither necessary nor advisable.

This supplement to our initial Report has focused on one essential aspect of our approach to Regional Rail: improving capacity at North and South Stations. We have demonstrated how a short list of relatively simple and low-cost actions can significantly improve capacity at the downtown terminals and systemwide, thereby increasing throughput without the need to implement a costly expansion of platforms and tracks. We state clearly: the proposed \$2-3 billion South Station expansion is neither necessary nor advisable. The financial resources for transit and rail needs are too scarce to waste on expansion of South Station, and are better spent on measures which will have substantially more impact improving the mobility of Massachusetts and Rhode Island residents. Throughput and capacity can be increased at relatively low cost simply by following the advice we have offered in this supplemental report.

At TransitMatters, we are duty-bound to offer specific ideas and best practice recommendations that will get the job done at the lowest cost possible. Our Regional Rail report, and this supplement do exactly that. We hope that the MBTA will seriously consider delaying South Station expansion and exploring the efficacy of our recommendations in a serious and measurable way. We look forward to working with them and other stakeholders as we advance the effort to bring 21st century Regional Rail to the people of Metro Boston.

Case Study: Framingham/Worcester Line

How to Provide Frequent, All-day Service on the Framingham/Worcester Line

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Current situation

The Framingham/Worcester Line is a major transportation link traversing the corridor between Boston and Worcester, serving the MetroWest region of Massachusetts. With 18,637 average weekday riders as of 2018,²⁵ the line is the MBTA's second-busiest. It connects the Commonwealth's two largest cities to each other and numerous intermediate suburbs. It also provides access to people along the corridor to job centers, primarily in Downtown Boston and Back Bay but also in smaller job clusters in Worcester and suburbs in between.

The need for frequent and reliable transit and rail mobility along this corridor is urgent.

The Commonwealth faces a decade of significant vehicular mobility disruption on Interstate 90 (the Massachusetts Turnpike) due to anticipated reconstruction and relocation of the elevated highway approaching downtown Boston and private sector air rights developments in the same area. The need for frequent and reliable transit and rail mobility along this corridor is urgent. The MBTA should immediately increase off-peak frequency, and invest money in electrification and new rolling stock to commence high-quality Regional Rail operations as soon as possible.

The plan we propose supports both short-and long-term mobility along the corridor. The ultimate goal is a transition to Regional Rail (according to the vision for fast, frequent, all day, electrified service set forth in our Regional Rail report), and all future infrastructure investments must be undertaken with this goal in mind.

Turnpike Reconstruction & Relocation Mitigation: A First Step Towards Regional Rail

The near-term goal is to implement an achievable and meaningful mitigation program in response to the planned reconstruction and relocation of the Massachusetts Turnpike in Allston, mitigation that will boost the frequency of all-day service to the maximum enabled by existing infrastructure. Accordingly, it is essential for the relevant state agencies

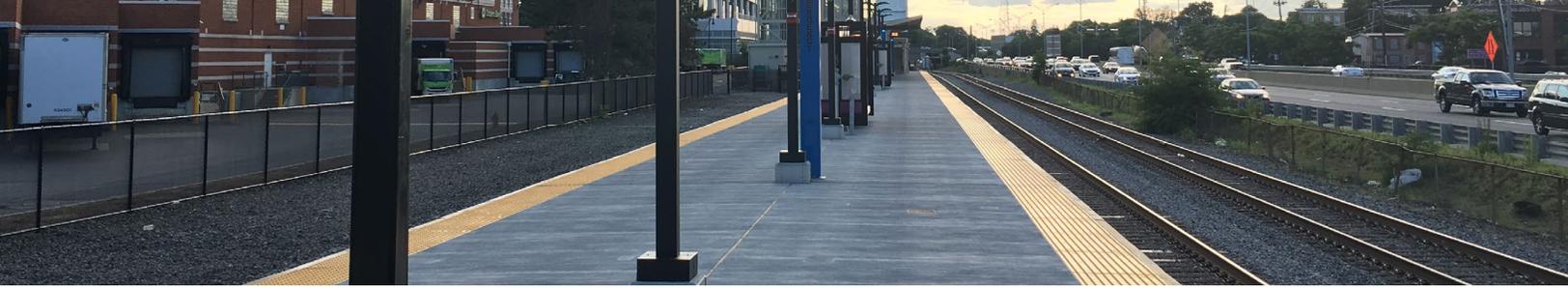
to commit to keeping both tracks on the Worcester Line in operation during all service hours for the duration of the I-90 realignment project.

It is essential for the relevant state agencies to commit to keeping both tracks on the Worcester Line in operation during all service hours for the duration of the I-90 realignment project.

This mitigation program would consist of higher frequency bidirectional service throughout the entire service day from early morning to late-night. Outside of rush hour, trains would run at least hourly at a consistent interval.²⁶ Half-hourly service would be optimal; however, current signaling constraints may dictate that in the short-term hourly off-peak frequency is the limit. Implementing this short-term goal would require maintaining two tracks during operating hours throughout turnpike reconstruction, moving any layover area from Allston to somewhere near the intersection of Interstate 90 and Route 128, and resolution of equipment and staffing constraints, to potentially include reassigning split shifts in the off-peak midday period. Negotiations with Keolis and rail unions ought to commence promptly, with the objective of resolving all barriers to implementing this program within the next 12 months. If half-hourly off-peak trains were implemented during the mitigation period, they may need to skip the Newton stations in the reverse peak direction until the Newton stations have platforms on both tracks, as discussed further below.

Our mid-term goals for the line incorporate efforts already underway along with additional efforts that should be achievable in a reasonable period of time. These include the following:

- » Completion of the construction project at Natick Center (currently in design), which will convert this station to a fully accessible station with full-length high-level platforms;
- » Conversion of the three Newton stations to full-length high-level platforms (already planned on one side of each station). We advocate that high-level platforms be



added to the opposite sides of these Newton stations as soon as possible and on an accelerated timeline;

- » Completion of the upgrades to the signaling system (ATC / cab signals) on the Framingham to Boston segment (currently in design); and
- » Completion of the new island platform at Worcester Union Station, along with the associated interlocking improvements near Worcester Station (both currently in design).

We advocate that high-level platforms be added to the opposite sides of these Newton stations as soon as possible and on an accelerated timeline.

These treatments will greatly improve service relative to the status quo, and lay the groundwork for the broader transformation of the line's operation along a Regional Rail operating model. We describe the necessary conditions towards achieving this standard for the remainder of this document.

Line Characteristics

- » The Worcester Line is 44.2 miles from the Boston terminal district to Worcester Union Station. Physically, the line continues west from Worcester to Western Massachusetts into upstate New York and beyond. A single daily Amtrak roundtrip uses the line to run from Boston to Chicago, serving Springfield, Pittsfield, and Albany along the way.
 - » In recent years, there has been substantial advocacy for multiple passenger trains per day between Boston and Springfield, and possibly beyond to Pittsfield, Albany, and/or Hartford and New York City. We believe such service would be beneficial, and should be approached in a manner that complements Regional Rail.
- » Many other former and current branch connections including lines to Milford, Leominster, Upton, Providence, RI, and New London, CT exist, but only one sees regular passenger service - the Framingham Secondary between Walpole and Foxborough. Bi-

directional freight service runs daily between Walpole and Framingham.

Needed Improvements

The Worcester Line had some of the worst performance in the system from the late 1990s through early 2000s, suffering from freight interference, low passenger train priority, and aging infrastructure. The purchase of the rail right-of-way from CSX in 2009 and progressive upgrades to track infrastructure have led to significant improvements. The entire line is double tracked up to Worcester, and has only five at-grade street crossings. Further incremental improvements are required to enable Regional Rail-type service.

High Level Platforms

As discussed in our Regional Rail report, high level platforms enable step-free accessibility to the train and decrease train boarding/deboarding dwell times dramatically, which will significantly decrease the train trip times over the line. Unfortunately, of the 18 stations on the route, only South Station, Lansdowne, and Boston Landing have full-length high-level platforms. Worcester has a partial high-level platform, while Back Bay²⁷, West Natick, Framingham, Ashland, Southborough, Westborough, and Grafton have mini high-level platforms built in the early 2000s. The half-measure of "mini-high platforms" meets a bare minimum accessibility standard, but requires passengers needing high platforms to register intent with conductors, wait in the correct portion of the train, or force the train to stop twice at a given station stop. In addition, rush hour crowds require passengers to spread out throughout the low-level platform, making it prohibitive to restrict boarding to mini-highs. All stations from Newtonville to Natick Center lack even mini-highs and are thus totally inaccessible and highly inefficient.

As a result, dwell times are far too lengthy and accessibility is insufficient, a condition completely unacceptable for modern rail service. High-level platforms must be added at all stations in order to enable the fastest possible service. The most urgent priorities are at Back Bay and the three stations in Newton.

Back Bay is the third highest-ridership commuter rail station in downtown Boston, serving what is effectively the city's second downtown; some 62,000 jobs are located in a half-mile radius. The lack of high-level platforms on the Worcester side of the station imposes a substantial delay on peak-hour trains in particular. The addition of a full high-level platform here is an immediate need.

The stations in Newton currently have only a single platform on one track, which prevents higher frequency at those stations. While switches in Brighton and Weston allow for some flexibility of operation, the status quo severely inhibits potential service levels. Service is configured such that the Newton stations receive primarily rush hour station stops (inbound AM, outbound PM). Currently only one inbound train makes stops in Newton during the evening, and only one outbound train stops in the morning well after the morning peak is over (10:35 -10:45 AM).

As a result of the advocacy of TransitMatters, the MBTA changed course on a short-sighted plan to construct a high-level platform for one track at Auburndale. In practice, the plan would have permanently single-tracked the station on the opposite track from the existing platforms at the other two Newton stations, severely altering the schedule pattern at all the Newton stations. The MBTA completed a study to reexamine the Newton stations holistically, and the resulting plan advanced now includes full-length high-level platforms on a single track - but the same track - at all three stations. The designs for each station also allow for the future addition of high-level platforms on the opposite track. The execution of that future option should be accelerated in order to permit bidirectional service to the three Newton stations all day. Combined with electrification allowing for EMU-operated service, this would improve trip times for the local neighborhoods, and relieve overcrowding on some of the express and local buses operating along this corridor.

Speed and Signaling

The maximum speed on most of the line is currently 60 MPH. However, the MBTA has recently upgraded the limit to 79 MPH in places where track has been upgraded.

Most of the line can support 90 MPH and some segments are straight enough for 100. Between Allston and Framingham, the tightest curve (at Riverside) permits 87 MPH provided trains can take it at modern speeds. Railroad tracks can be banked (known as "superelevation") to facilitate taking curves at speed. The Worcester Line's curves currently have weak levels of banking which stand to be increased significantly. Moreover, federal regulations for train speed on

curves were modified at the beginning of this decade allowing trains to run faster, subject to testing; unfortunately, the MBTA is still not making use of the new rules.

It is possible that signals will need to be updated to allow for the requisite frequency improvements. The MBTA should explore best-practice signaling technology and procedures, drawing on international expertise. Keolis Commuter Services, the present commuter rail concessionaire, has experience operating high-frequency services, chiefly the RER network in Paris (one of the systems which informs our operating model). MassDOT and the MBTA should draw on this knowledge base, and future contracting decisions should take experience with modern signaling into account.

The Issue of Express Service

At 44.2 miles, the Framingham/Worcester Line is the second-longest line in the commuter rail network, behind the Fitchburg Line. The line has numerous stations, with an average stop spacing of 2.6 miles, while also connecting Massachusetts' two largest cities. The MBTA operates both local and express service on the line to keep travel times reasonable at peak hours. In recent years, two super-express one-way trains have been introduced, one running from Worcester to Boston in the morning and another running back in the evening, nonstop between Lansdowne and Worcester. Under a Regional Rail operating model, with frequent all-day service and possible infill stations on the urban end, intra-urban service would be provided as well.²⁸

To improve express service, the MBTA is currently in the process of planning for an express-only third track between Framingham and Route 128. This express track would extend from just east of Framingham Station (specifically Control Point (CP) 21, between Concord Street and Bishop Street) to a point between Wellesley Farms and Auburndale (CP 11, just west of Route 128). Triple-tracking is a significant project that would require realignment of all the tracks and reconstruction of all the stations, but the existing ROW is sufficiently wide to avoid land takings or displacement of buildings, and no major bridge reconstruction will be required. The tracks would be arranged such that the center track is an express track with no platforms at the five affected stations, which would have full-length high-level side platforms on the outer "local" tracks. The almost complete design for Natick Center accommodates the potential center third express track.

We do not, however, believe that a third track spanning the entire length of this distance is necessary. Building an overtake "siding" track at a strategic location between CP 21

and CP 11 (at Wellesley) instead would save money on tracks that could be redirected to spending on measures that further reduce trip time, specifically electrification. In particular, the time savings from electrification and clockface scheduling optimization would provide trip times better than those provided by the nonstop Worcester-Lansdowne service.

When the schedule repeats itself on a clockface pattern throughout the day, express trains always overtake local trains at the same location. Thus, only that location needs additional tracks. Typically, this requires quadruple rather than triple tracking, or else the express trains are forced into what is for them a single-track bottleneck; however, it is feasible, though difficult, to schedule the trains around the bottleneck.

All medium- and long-term investment in the Worcester Line must take into account increases in service quality based on Regional Rail upgrades. The gains described above from full-length high-level platforms lead to significant reductions in dwell time. Moreover, achieving the ultimate goal of an all-EMU fleet is critical for providing the best speed and service possible, as they have low operating costs, high reliability, and a very high acceleration rate.²⁹ These treatments have other benefits, but they particularly reduce the speed difference between local and express trains.

With minor track improvements allowing trains to take curves at higher speed than today (by increasing the banking through curves), EMU-operated local trains could go between Boston and Worcester in less than an hour, faster than today's nonstop trains.

With minor track improvements allowing trains to take curves at higher speed than today (by increasing the banking through curves), EMU-operated local trains could go between Boston and Worcester in less than an hour, faster than today's nonstop trains. Trains running express to Framingham could do the trip in 45 minutes, making local stops from Framingham west; there is no need for nonstop Boston-Worcester trains, which take service from intermediate stations. Even before the line is fully electrified, the improvements in trip time from increased banking would be beneficial in the short term. Each station that is converted to full-length high-level platforms also adds incremental reductions in trip duration.

If Worcester Line service runs every 15 minutes, the speed difference between local and express trains requires a single

overtake location. That necessary overtake location is in Wellesley, where the station platforms need to be completely rebuilt anyway. With a Wellesley overtake, there is enough capacity for an express as well as a local every 15 minutes. Off-peak, local trains should still run every 15 minutes to guarantee frequent service to Newton, but express trains can run at a lower frequency, every half hour. A half-hourly frequency is not so onerous to passengers between Worcester and Boston, a 45-minute trip, as to passengers between West Newton and Boston, a 17-minute trip.

There are consequences of the express train option on potential future service growth. Due to scheduling complexity, the presence of express trains will impose a limit of 4 trains per hour (“tph”) for local service between Boston and Auburndale. To operate more frequent local service while preserving express trains, additional tracks would be required.

Fare Structure

Though the Worcester Line boasts numerous stops within the rapid transit and bus service area, these stations are little used outside of peak commuting hours. We believe this is due to high fares as well as poor off-peak frequency. It is a gross under-utilization of extremely valuable right of way and railroad assets.

For instance, Auburndale Station is little more than a half mile from Riverside, the terminus of the Green Line's D branch. Yet the fare for a trip to South Station or Back Bay is \$7.00 from Auburndale on Commuter Rail, versus only \$2.40 to Park Street or Copley station on the Green Line. Leveling fares within Route 128 would incentivize passengers to ride Regional Rail, which has lower marginal operating costs than the express buses and Green Line. This is especially notable given that current trip time to South Station from Auburndale is only 26 minutes on the Worcester Line compared with about 40 minutes from Riverside to Park Street on the Green Line. We urge this change not to take passengers away from the Green Line, but rather so mainline rail assets can expand the availability of service. This could potentially also free-up for other operations the many buses that currently supplement Newton's poor commuter rail schedules.

To the fullest extent possible, fare pricing for the mitigation program discussed above ought to take this issue into consideration. Lower fares will encourage drivers to shift to commuter rail, and continuing this practice of lower fares and high frequency will encourage long-term, sustainable mode shift.

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The trip time on commuter rail would only improve with fast-accelerating EMUs and reduction of dwell times after the implementation of full-high level platforms, as discussed below. Improved service from West Newton and Newtonville is even more vital since there are few direct connections to downtown other than express busses running from Newton Corner.

Infill Stations

Between Lansdowne and Newtonville, the line passes through the dense neighborhoods of Allston, Brighton, and northern Newton. The addition of Boston Landing station has proven successful, serving many weekday passengers. With fast EMU acceleration and full high-level platforms reducing the time it takes to make stops, trains could make multiple additional stops without increasing overall trip times vs. current levels. The most immediately promising location is “West Station” in Allston, at the former Beacon Park freight yards. West Station is discussed in greater detail below.

Newton Corner is another strong candidate, and we include it on our schedules. A station was located here until 1959. The site still has somewhat denser development than Newtonville, West Newton, and Auburndale. While the station would potentially require complex engineering work - the footprint is surrounded by a hotel built over the Turnpike and tracks - strong value is added from allowing a transfer from local buses. Several bus routes pass by Newton Corner between downtown Boston and Newton, Watertown, Waltham, and Needham. With a transfer to fast and frequent rail service, it may become possible to terminate at least some of these routes in Newton, and use the buses and operators that don't need to go all the way to Boston to increase bus service, frequency, and potentially geographical reach in the surrounding area. Improvements to rail service in Newton and other communities along the Worcester line corridor should be accompanied by a re-evaluation of connecting local bus service, which will be more useful and necessary as ridership demand increases in response to Regional Rail.

A more speculative infill location is in Brighton at Brooks Street. Like Newton Corner, it historically had a station,

called Faneuil, and abuts dense housing. Moreover, the area is far from the Green Line, and a station here could provide a transfer to the 57 and 64 buses, the former being among the MBTA's busiest. We do not include it on our schedule, but we do plan the overtakes in a way that makes future addition of Faneuil Station easy with minor timetable modifications.

The proximity of the Worcester Line to major highways presents at least one opportunity to capture auto traffic outside the urban core. It may be feasible to open a park-and-ride station near the interchange between I/90 (the turnpike) and Route 128 (I/95). Commuters from locations far from the line bound for jobs in the Back Bay and Allston-Brighton, or reverse commuting to Framingham and Worcester, could easily take advantage of frequent regional rail. Such a location would also be ideal for connections to shuttle bus service to job centers in the 128 corridor west from Waltham to Needham.

West Station

The proposed West Station provides a once-in-a-generation opportunity to transform a location to provide local residents or regional commuters with efficient, sustainable mobility as a vibrant and modern Mobility Hub – a gateway to Greater Boston and, from Greater Boston to the communities of MetroWest and Worcester. The mobility network connected to West Station must be approached as a unified system whose components work synergistically to provide people with sustainable choices to access jobs and other key destinations. This station will provide access to Boston University and Harvard's expanding campus, relieve Turnpike congestion, and encourage transit-oriented development in Allston. With the activation of the Grand Junction Railroad via the BU Bridge (serving Kendall Square and numerous transit hubs such as Lechmere) for frequent rapid transit service, and the addition of connecting bus service to points throughout Cambridge, Allston-Brighton, and Brookline, West Station would become a major intermodal hub. The design for the station, particularly for connecting bus infrastructure, should reflect comprehensive service planning and ridership-maximizing bus network routing.

The MBTA should build West Station as a priority on the front-end of the Allston I-90 realignment project.

West Station is already in planning, and was slated to begin construction this year, but has been delayed. The MBTA should resolve this situation and build the station as a priority on the front-end of the Allston I-90 realignment

project. We do not believe that the previously announced cost-to-build of \$90 million, resulting from a needlessly overbuilt design, is either credible or necessary to design and build a fully functional station. Decisions regarding pedestrian and cycling movements, bus routes radiating into and from West Station, the use of the Grand Junction line to access jobs-and-education-rich Cambridge, and the frequency of intercity rail travel along the Worcester Line must be considered as intersecting parts of the whole, designed and built in a manner and on a schedule enabling the system to function at a high level of modal efficiency. To ensure access to planned and existing developments, MassDOT and the MBTA must make West Station a top priority.

MassDOT and the MBTA must make West Station a top priority.

Train Scheduling

- » Trains should operate between 5 am and 1 am, 7 days a week.
- » Scheduling should adhere to recurring clockface intervals (e.g. on a 30-minute headway, a train departing at 1:35 should be followed by one departing at 2:05) with timed overtakes for any express service.
- » The top speed should be 90 mph, except where constrained by track geometry and approach restrictions near South Station.³⁰

Frequency

The Regional Rail Proof-of-Concept white paper details cost-effective improvements to South Station and the entire “terminal district” that would allow for an increase in frequency on all lines, including dedicated platform assignments and reconfiguration of the Tower 1 interlocking. Assuming these and the aforementioned improvements are made, a frequency of 4 local trains per hour - or a train every 15 minutes - in both directions on the Framingham/Worcester Line is achievable.³¹ Increasing frequency to 8 trains per hour, 4 local and 4 express, is still possible within the footprint of two dedicated terminal station tracks, but imposes constraints on the schedule as discussed above.

The following frequency proposal assumes that there are overtake facilities in Wellesley:

Station Segment	Peak	Current	Off-Peak	Current
South Station - Framingham (local)	15 min	35 min	15 min	90 min
South Station - Worcester (express)	15 min	35 min	30 min	n/a
Stations receiving both local and express	7.5 min	20 min	15 min	n/a

Note: Current frequencies shown on this chart are general averages of present frequencies.

Travel Times

FRAMINGHAM/WORCESTER			
Station	Local	Express	Current
South Station	0:00	0:00	0:00
Back Bay	0:03	0:03	0:06
Lansdowne	0:05	0:05	0:11
West Station	0:08	0:07	--
Boston Landing	0:10	(0:08)	0:16
Newton Corner	0:13	(0:10)	--
Newtonville	0:15	(0:11)	0:21
West Newton	0:17	(0:12)	0:25
Auburndale	0:19	(0:12)	0:28
Wellesley Farms	0:22	(0:14)	0:32
Wellesley Hills	0:24	(0:15)	0:35
Wellesley Square	0:26	(0:16)	0:39
Natick Center	0:30	(0:18)	0:44
West Natick	0:32	(0:19)	0:49
Framingham	0:35	0:21	0:55
Ashland	(0:38)	0:25	1:02
Southborough	(0:42)	0:29	1:07
Westborough	(0:46)	0:33	1:16
Grafton	(0:51)	0:38	1:21
Worcester	(0:57)	0:45	1:34

To be clear: we do not endorse express service over all trains running local service; that decision requires the fully informed input of all stakeholders. Rather the purpose of the schedule above and our discussion of express service in this report is to demonstrate what best practices would be possible if express service is implemented, while setting forth some of the trade-offs to be considered. We also explicitly note here that the choice of express stations above is for demonstration purposes only. There are multiple possible options, each reflecting a choice among competing alternatives, all of which must be considered by stakeholders. A key issue for riders from points west may be that they do not have the choice of all stops, meaning that someone working near Boston Landing (in our example schedule) and coming from Worcester would only have half as many trains to choose from.

Times in parentheses on the express trains indicate the time at which the train will pass a station without stopping; on the local trains they indicate the time the train would serve the station if it kept running local to Worcester.

With the above schedule, 6 trainsets are required to run local service and 8 are required to run peak express service, of which 4 are also required for off-peak express service. In total, 14 trainsets are needed for typical weekday service, not including spares.

Endnotes: Proof of Concept

- 1 As of the printing of this supplement, MassDOT is currently engaged in a RailVision study to identify and study various future scenarios for the future of what we currently call commuter rail service in Massachusetts and Rhode Island. Most scenarios assume that South Station must be expanded to accommodate any significant increase in current service levels. We reject the assumption that SSX is either necessary or advisable.
- 2 In our Regional Rail Report, we go into detail about the distinction between EMUs and electric locomotives and why EMUs are in every way preferable. Please see that report for further explanation of this topic.
- 3 See our Regional Rail Report at p. 16.
- 4 The “throat” is the narrow point of convergence where trains separate from the running track and divide into platform tracks.
- 5 The role of NSRL is further discussed below. We endorse the immediate planning of NSRL in tandem with initial regional rail improvements, but we emphasize that NSRL is not a prerequisite for large increases in service, nor should disagreement over NSRL be a reason to hold off on advancing Regional Rail by adopting the operational practices, strategic investments, high level platforms and electrification.
- 6 By adopting our proposal to separate lines to specific platforms, Regional Rail service improvements can be adopted line by line, meaning that having only partial electrification will not preclude partial Regional Rail levels of service.
- 7 Regardless of the new regulations, there are numerous main line curves throughout the system, not only those in terminal zones, that could see a significant increase in maximum speed.
- 8 A diagram offered by CSX for the tightest switch used on any American rail mainline, a No. 10 switch, shows a curve radius of 774 feet, which a modern passenger train could take at 34 mph, higher than the current speed limit at the station throats, which is 10 mph. (See: <https://www.csx.com/index.cfm/library/files/customers/industrial-development/site-design-guidelines-and-specifications/> p. 26)
- 9 An interlocking is a way to describe an arrangement of rail signals that prevents conflicting movements, in this instance as trains are entering the terminal environment.
- 10 Another benefit of separated track (and platforms) is that riders will always know what track their train will be on, even if they take a different train than usual.
- 11 FMCB Commuter Rail Update, November 2017.” <https://cdn.mbtacom/sites/default/files/fmcb-meeting-docs/2017/november/2017-11-20-fmcb-keolis-commuter-rail-update.pdf>, p. 17
- 12 This measurement of breakdowns per miles is called Mean Distance Between Failures, or “MDBF” for short. We discussed it further in the Regional Rail Report.
- 13 “MTA Long Island Rail Road Sets New Goals to Boost On-time Performance & Improve Fleet Reliability.” MTA, January 20, 2015. <http://www.mta.info/press-release/lirr/mta-long-island-rail-road-sets-new-goals-boost-time-performance-improve-fleet>
- 14 “The Kent Route Study (Part 1): London Bridge Metro Services.” London Reconnections, March 21, 2017. <https://www.londonreconnections.com/2017/kent-route-study-part-1-london-bridge-metro-services/>
- 15 In railroad terminology, “turning” or “turnaround time” refer to a train reversing direction at its terminal, rather than physically turning around.
- 16 The meaning and import of dwell times are addressed at length in our Regional Rail report.
- 17 “S-Bahn Munich: Numbers, Dates, and Facts.” Deutsche Bahn. https://www.s-bahn-muenchen.de/s_muenchen/view/wir/daten-fakten.shtml
- 18 MBTA 2014 Blue Book, p. 2
- 19 The British ton is the long ton (2240 pounds), while the U.S. ton is the short ton (2000 pounds).
- 20 See note 5.
- 21 See the more detailed analysis of the Framingham/Worcester Line included in this Supplement.
- 22 There is a slight discrepancy in North Side versus South Side frequencies serving the entirety of the lines – 36 for the former, 40 for the latter. This is because there are higher commuter volumes from the South than the North, and demand to the south will likely remain somewhat higher even with NSRL. The remaining 4 tph can be sent to short turn within the urban area; we propose Brandeis/Roberts (or perhaps a new consolidated station near Route 20) on the Fitchburg Line.
- 23 A 2018 feasibility reassessment of the NSRL commissioned by MassDOT assumed minimal upgrades to the system due to its limited scope. For instance, its tunnel distance may be longer than necessary, because it assumed operation of push-pull locomotives, which accommodate lesser grades than EMUs. See also: <https://commonwealthmagazine.org/opinion/states-rail-link-study-full-of-flaws/>
- 24 Interlining is the practice whereby trains (or buses - the term is not reserved only for trains) serving different origins or destinations share the same route for a portion of their respective routes (sometimes this portion of the route is contextually referred to as a “trunk route”). Interlining can also be used to mean that after a trainset reaches a terminal where multiple routes converge, it then heads back out serving a different route and thus the train is interlined. The latter meaning is specifically not applicable to any use of “interlining” in this paper.

Endnotes: Framingham/Worcester Line

- 25 “State of the System Report: Commuter Rail.” Focus40: The 2040 Investment Plan for the MBTA, December 2015. https://static1.squarespace.com/static/57757a3cff7c50f318d8aae0/t/5c005d6fb8a04555cf1976be/1543527793352/Focus40_SoS_Ccommuter+Rail_103015+-+Final_Accessible3.pdf
- 26 For instance, if a train arrives at a given station at 9:40, and service operates on an hourly frequency, all prior and subsequent trains in that direction should arrive at that station at :40 minutes past the hour. If frequency during the peak period doubles, trains would arrive at the station at :10 and :40 past the hour during that time. This scheduling strategy, known as clockface scheduling, is discussed further below and in depth in the Regional Rail Proof of Concept Report (2019).
- 27 Back Bay is effectively two stations, with one serving the Worcester Line and the other serving the Providence/Stoughton, Franklin, Needham, and Amtrak Northeast Corridor Lines. The latter side hosts full high-level platforms for all tracks for those lines.
- 28 The Providence/Stoughton and Lowell lines are also examples of such urban/suburban rail systems. However, these lines have very little actual service to the communities within Route 128; the Orange Line parallels the Providence Line through Roxbury and Jamaica Plain, while the under-construction Green Line Extension will serve neighborhoods along the Lowell Line in Somerville. In contrast, the urban segment of the Worcester Line has especially tight station spacing and lacks a parallel rapid transit line.
- 29 The TransitMatters Regional Rail Report (2018) and 2019 Proof of Concept Report include a more complete discussion of the benefits and virtues of EMUs and single-level trains.
- 30 See the Regional Rail Proof-of-Concept white paper for discussion of approach speeds and capacity constraints at South Station.
- 31 There is a view that half-hourly off-peak service is justified west of Auburndale, where demand skews more heavily towards peak-hour commutes. We would prefer greater frequencies in order to encourage meaningful modal shift. However, scheduling constraints from balancing local and express service as discussed above prevent the use of Auburndale as a turnback point. As such, Framingham may have to accommodate 15-minute all day headways as a matter of sound scheduling.



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