

CAPACITY & RELIABILITY STUDY



SUMMARY OF PREVIOUS WORK



Overview

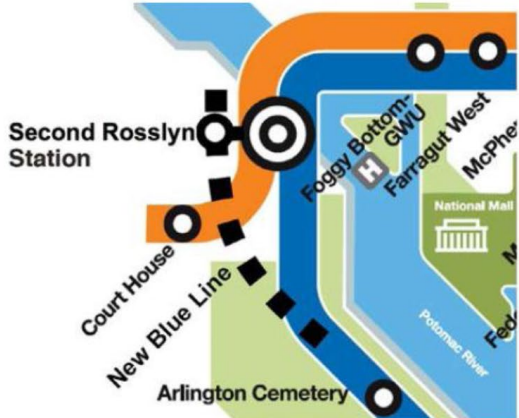
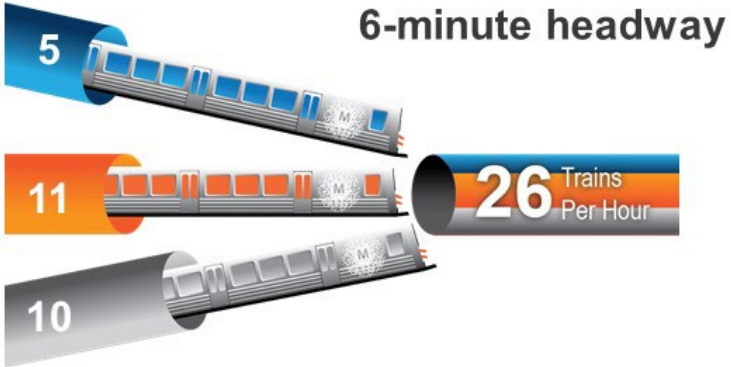


The Blue/Orange/Silver Capacity and Reliability Study evolves a history of Metro grappling with ridership demand, service needs, and inadequate infrastructure in the rail corridor shared by these three lines. As early as 2002, Metro saw warning signs that by 2020 peak-hour, peak-direction ridership that would overwhelm trains, platforms, and escalators in the system's core. Metro responded by recommending the expansion of core station capacity and deployment of 8-car trains during peak periods. Those strategies, which require a lot of advance planning and capital resources, are still part of Metro's long-range vision today.

Those needs started receiving renewed attention when the Silver Line opened in 2014. The first new Metrorail line in a decade expanded Metro service into a new market, but its interlining with the Orange and Blue lines also resulted in serious operational challenges and poor on-time performance. Metro began investigating options to enhance operational flexibility and resilience in the BOS corridor, in addition to addressing capacity needs. The ability to deploy variable service patterns is made even more critical by the ongoing construction work for Metro's State of Good Repair program.

So why another study? Most of those past efforts focused on systemwide capacity needs, or investigated a particular problem or type of solution. To date, Metro hasn't compared different types of potential solutions against each other, evaluated how well they'd address all the needs in the corridor, or decided on a plan of action. The BOS Capacity and Reliability Study will deliver that type of comprehensive analysis and recommend a preferred solution.

But in trying to figure out where to go, it's helpful to look at where we've been. This document provides a summary of that past work. On the following pages, click the study's title to download a copy of the full document.



Core Capacity Study - 2002

Issues and Findings

The Core Capacity Study explored infrastructure and operational strategies to accommodate forecasted growth in population and jobs, and to mitigate likely impacts on rail service in the core.

- Intended to maintain transit's mode share in existing markets; create new markets through station area development; and expand access to stations.
- The study predicted that successful realization of those goals, combined with forecasted population growth, would double Metro ridership by 2025.
- The study also established several of the operational and capacity constraints that still guide Metrorail planning today:
 - Minimum headways of 140 seconds/2.3 minutes, equaling 26 trains per hour (TPH);
 - Maximum consist length of 8 railcars per train;
 - An ideal target of 100 passengers per car (PPC) as indicative of sustainable ridership levels; and
 - 120 PPC as the threshold for severe crowding. 120 PPC translates to maximum passenger throughput of 18,700 per hour in 6-car trains, 25,000 in 8-car trains.
- Identified Rosslyn and L'Enfant Plaza as the Metrorail system's primary bottlenecks.

Recommendations

Invest in expanding capacity to accommodate a doubling of ridership in the next 30-40 years. Estimated investment totaled \$4.5 billion in 2000. Many of the recommended strategies were similar to initiatives later included in *Momentum* and still discussed at Metro today, like:

- Deploying all 8-car trains during peak periods. Estimated to be required by passenger loads on OR Line by 2020, on other lines by 2025.
- Using high-ridership bus lines as priority transit, rather than truncating to serve as rail feeders.
- Expanding bike, ped, and bus access to stations.
- Expanding and improving core stations, including platform and mezzanine expansions and pedestrian tunnels.
- Building new interline connections between 1) Court House and Arlington Cemetery, and 2) Pentagon and L'Enfant Plaza.
- Building flexibility for short turns and relief trains. The study called for more pocket tracks, particularly one on OR Line between Eastern Market and Potomac Avenue stations.



Figure 5. Metrorail Core

Station Access & Capacity Study - 2008

Issues and Findings

The Station Access & Capacity Study was one effort to advance the recommendations from the 2002 Core Capacity Study. It specifically focused on that study's recommendation to expand and improve core stations, and provided an assessment of capacity and existing service levels at all stations (then 86) to answer:

How will ridership grow over the next 25 years?

Is there sufficient capacity to handle that growth?

How will customers access the system?

- Regional planners were forecasting population and job growth of 50% each by 2030. That growth was expected to increase Metrorail ridership to 970,000 per weekday.
- 50% of the ridership would begin or end in core stations, but higher rates of growth were projected for non-core stations.
- 10 of the 20 stations forecast for highest ridership by 2030 were in the BOS corridor.
- Projected that the Arlington sections of the OR and BL/YL lines would generate the highest share of AM peak trips, and that the combined OR/SV line would carry the largest peak-hour passenger loads.
- Verified 8-car trains would be needed on most lines by 2020.

Recommendations

- Prioritized capacity expansions at major transfer stations, especially Metro Center, L'Enfant Plaza, Farragut North, and Gallery Place.
- Called for new pedestrian tunnels linking the Farragut stations, and between Gallery Place and Metro Center. Also new vertical circulation elements at several stations.

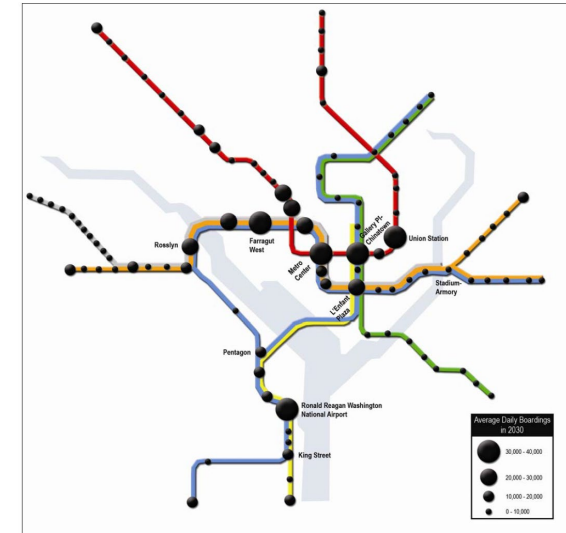


Figure 14. Average Daily Boardings in 2030

Table 1. Existing and Future Station Capacity Issues

| Station | Mezz | Vertical | | Faregate | |
|-------------------------------------|------|----------|------|----------|------|
| | | 2005 | 2030 | 2005 | 2030 |
| Archives-Navy Memorial-Penn Quarter | | ○ | ○ | | |
| Bethesda | | ○ | ○ | | |
| Branch Ave | | ○ | ○ | | |
| Cleveland Park | | | | | ○ |
| Court House | | | ○ | | ○ |
| Farragut North | SE | ⊗ | ⊗ | | |
| Farragut West | W | ○ | ○ | | |
| Foggy Bottom-GWU | | ○ | ○ | | |
| Franconia-Springfield | | | ○ | | |
| Gallery Pl-Chinatown | N | ○ | ⊗ | ○ | ⊗ |
| | W | | | | ○ |
| Judiciary Square | E | | ○ | | |
| L'Enfant Plaza | E | ○ | ⊗ | | |
| | W | | ⊗ | | |
| | N | ○ | ⊗ | | ○ |
| | S | ⊗ | ⊗ | | |
| | W | | ○ | | |
| Navy Yard* | E | | | | ○ |
| Shady Grove | | ○ | ⊗ | | |
| Takoma | | | | ○ | ○ |
| Twinbrook | | | | | ○ |
| White Flint | | | | | ○ |
| Union Station | S | ○ | ○ | | |
| | W | ○ | ○ | | |

Legend
 ○ Needs study ($0.5 \leq v/c < 0.75$)
 ⊗ Needs improvement ($v/c \geq 0.75$)

Momentum 2025 Strategic Plan - 2013

Issues and Findings

Momentum updated the needs analysis and project recommendations from the Core Capacity and Station Access & Capacity studies. It also recognized over a decade of lack of investment in maintaining the system, resulting in service disruptions and degraded customer experience. Momentum called for a 10-year strategic investment plan to advance four goals:

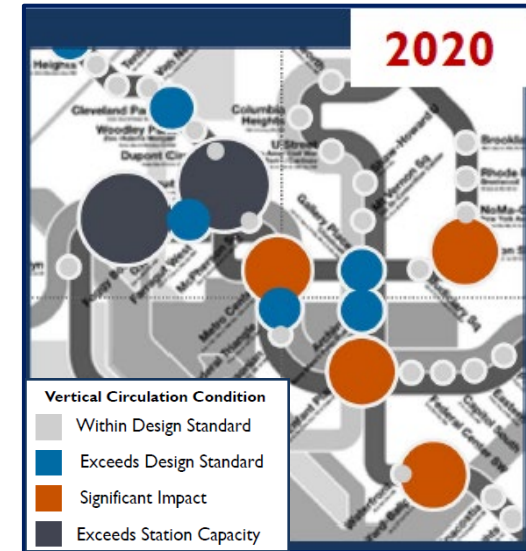
- Build and maintain a premier safety culture and system
- Meet or exceed expectations by consistently delivering quality service
- Improve regional mobility and connect communities
- Ensure financial stability and invest in our people and assets



Table 3: Metrorail System Peak Period Capacity by Line without Fleet Expansion

| | 2012 | 2020 | 2025 | 2040 |
|---------------|------|------|------|------|
| Red | ✓ | — | — | ✗ |
| Yellow | ✓ | ✓ | ✓ | — |
| Green | ✓ | — | — | ✗ |
| Blue | ✓ | — | — | ✗ |
| Orange/Silver | — | ✗ | ✗ | ✗ |

✓ Acceptable (average passengers per car (PPC) <100)
 — Crowded (PPC between 100 and 120)
 ✗ Extremely crowded (PPC >120)

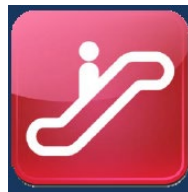


Recommendations

Momentum laid out a 10-year, \$6 billion system investment plan that included:



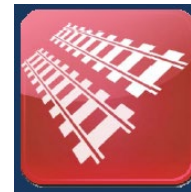
100% 8-Car Trains
During Peak



Core Station
Improvements



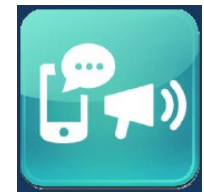
Priority Corridor
Network, Fleet Expansion



Pocket Tracks and
Operational Flexibility



Fix Rosslyn Portal –
New BL Line



Next Gen
Communications

New Blue Line Connections Study - 2014

Issues and Findings

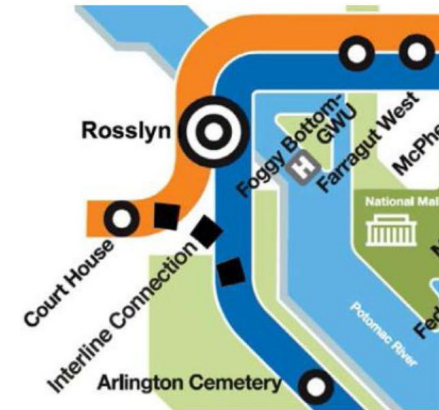
Momentum's 10-year strategic investment plan included preliminary work on studying the most effective way to fix the "Rosslyn Bottleneck" by reconfiguring Blue Line service. Introduction of Silver Line service in 2014 meant three lines were sharing one tunnel and set of tracks between Rosslyn and the Anacostia River. Interlining meant the operational constraint of 26 slots/trains per hour (TPH) had to be divided between the three lines. Metro based its new operating plan on then-current ridership patterns and projected demand; it greatly reduced Blue service levels and reassigned those slots to Silver trains. BL Line customers immediately began experiencing long waits and crowded trains. This study investigated options to restore service levels by reconfiguring BL Line service through Rosslyn.

- With the advent of Silver Line service, three lines would be sharing the Rosslyn Tunnel.
- Introduction of Silver Line service reduced the Blue Line to 5 TPH (11 OR, 10 SV) during peak periods.
- BL customers who couldn't easily switch to YL trains immediately experienced longer waits and severely crowded trains.

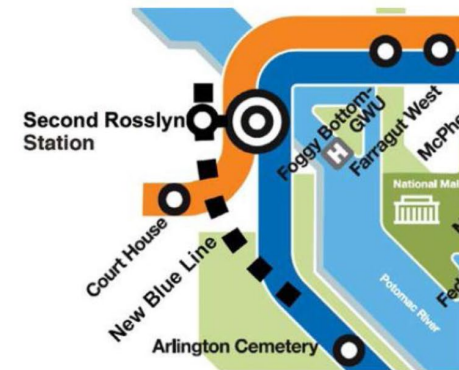
Recommendations

The study assessed two options: 1) an interline connection between the OR/SV lines at Court House and the BL at Arlington Cemetery, or 2) a second Rosslyn Station that would serve as the terminus for BL trains. The second option could also serve as a starter segment for a New Blue Line across the Potomac.

- The Interline Connection was found infeasible due to excavation issues, constructability concerns, and potential property impacts. It also would do little to increase capacity for future demand.
- Metro found the Second Rosslyn Station feasible from an engineering perspective. However, it would only increase capacity from 5 to 6 TPH, and would force transfers for customers traveling past Rosslyn.
- The study recommended the Second Rosslyn Station as the preferred alternative, but cautioned it may only make financial sense as a starter segment for an eventual BL Line extension.



Interline Connection



Second Rosslyn Station

ConnectGreaterWashington Regional Transit System Plan - 2014

Issues and Findings

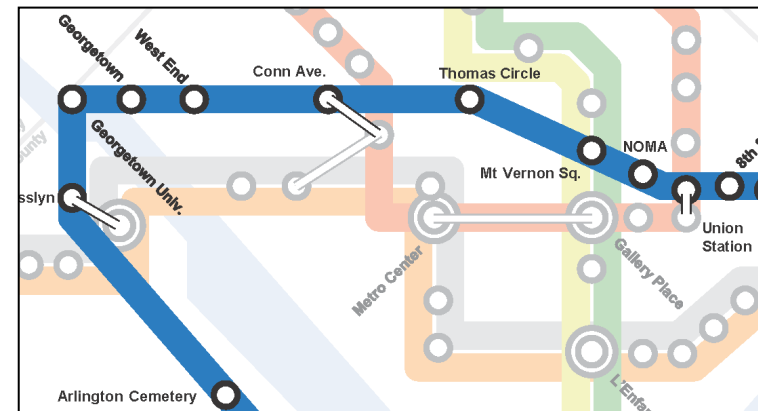
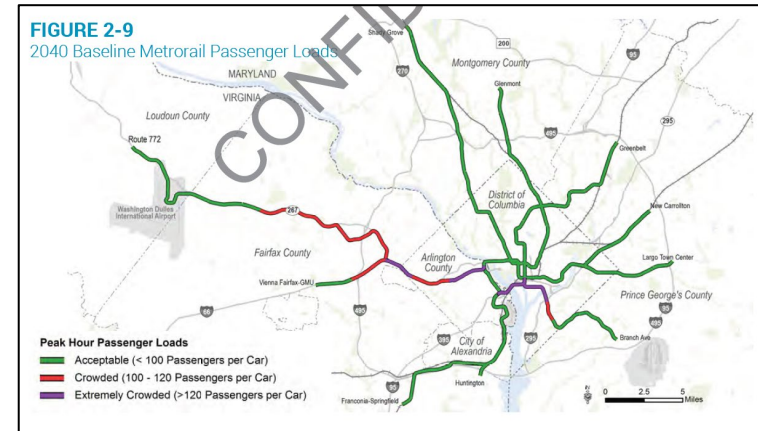
In 2014 Metro exercised its role as the primary regional transit planner and developed the *ConnectGreaterWashington Regional Transit System Plan*. The RTSP researched land use and transportation plans developed by partner jurisdictions and agencies; worked with COG staff and data models to forecast expected growth in population, employment, and economic activity across the region; and recommended a regional network of high-capacity transit services to meet those needs. Taken as a whole, the proposed network would:

- Reduce congestion in the core of the regional transit system;
- Improve connections among suburban activity centers;
- Create cross-jurisdictional links;
- Enhance circulation within the inner jurisdictions; and
- Improve access to the regional transit system

Recommendations

CGW is a 30-year system plan built off of *Momentum* and the goals listed above. It includes several reconfigurations or expansions of the BL/OR/SV lines:

- Second Rosslyn Station, as a New Blue Line starter hub
- New Blue Line, from Rosslyn to Georgetown to Union Station via M Street
- New OR/SV Express Line, a separate relief line between East Falls Church and Rosslyn
- Core station improvements



Metrorail Capacity White Paper - 2015

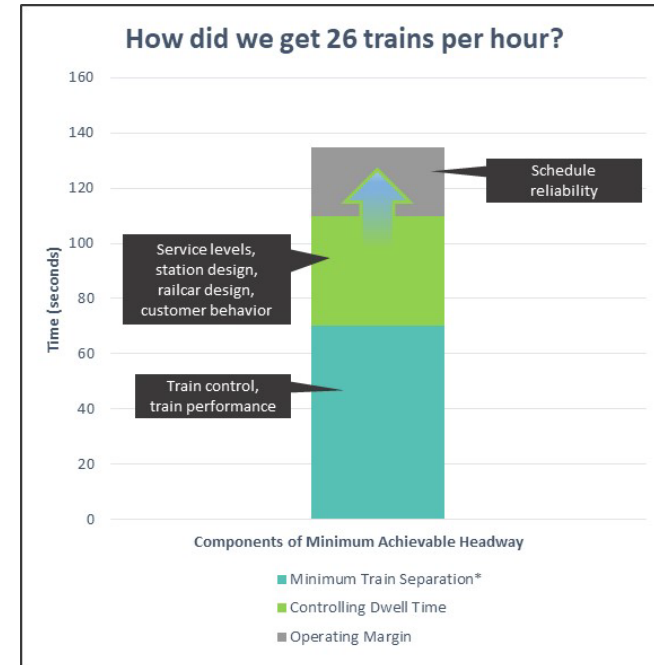
Issues and Findings

The Metrorail system's core needs more capacity, but are there ways of expanding capacity without building expensive new lines? This paper compared Metro to several peer agencies on capacity measures and rail signal operations, and explored whether advanced train control technology could increase throughput. Major findings included:

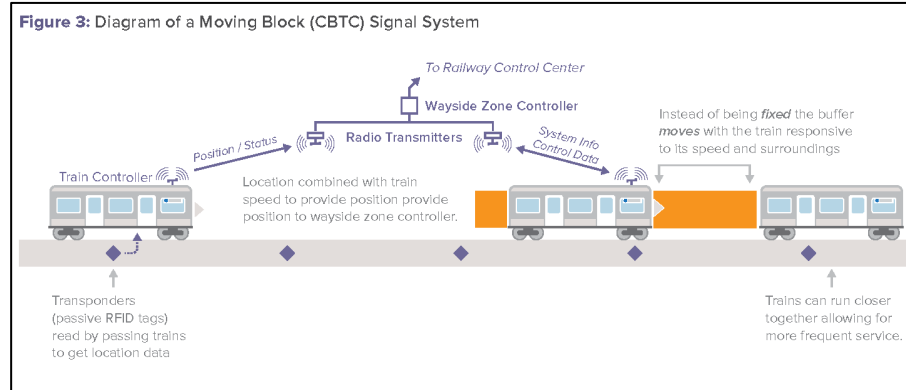
- Merging trains create conflict points and potential delays
- Delays on trains switching between two lines can cause trains to miss a scheduled slot
- Closely spaced stations constrain Automatic Train Control (ATC) speeds and delay following trains
- A small number of busy transfer stations increases dwell times and majorly impacts throughput
- Terminal turnback time can exceed headways, delaying following trains
- Metrorail exceeds most peers in train throughput, track geometry, and train control systems
- It compares less favorably in terms of dwell time due to railcar design, the small number of busy transfer stations, variable-length trains, and lack of full-time Automatic Train Operations (ATO)

Conclusions

The study team simulated a Communications-Based Train Control (CBTC) system to estimate capacity impacts. It found that CBTC would significantly improve reliability and could increase capacity / train throughput, but not enough to meet longer-term projected ridership needs.



* includes reaction, safe braking, acceleration, and clearance times

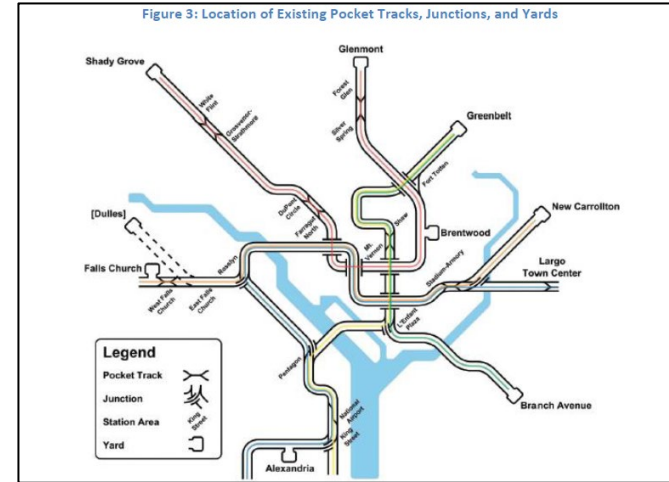


Silver Line Junction Feasibility Study - 2016

Issues and Findings

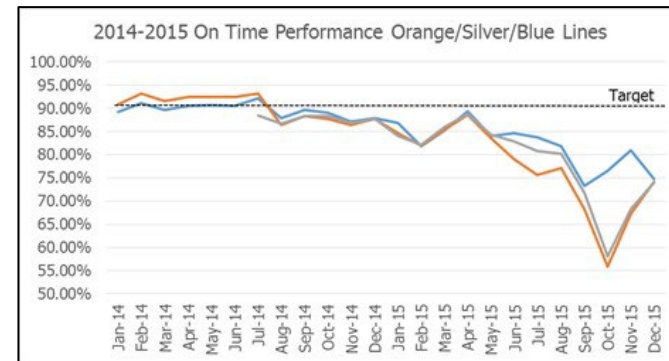
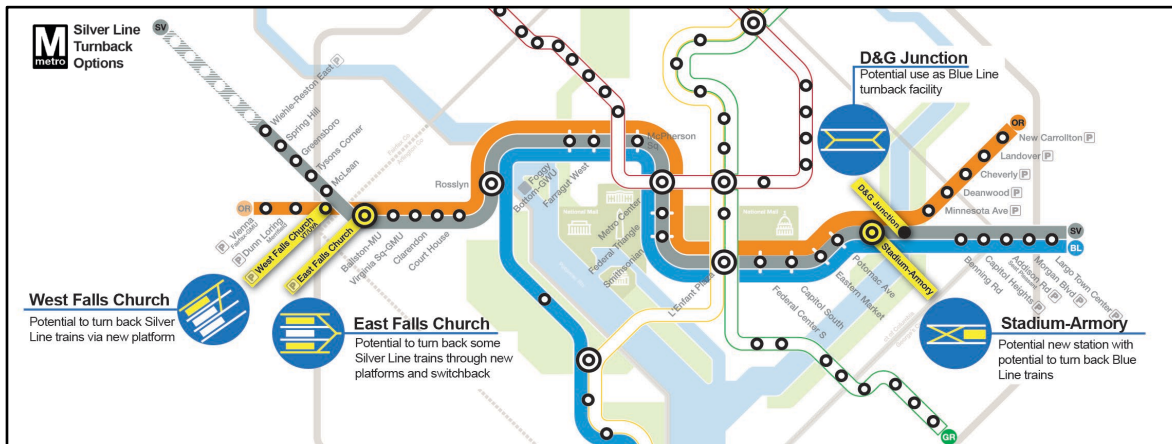
The Junction Study advanced the initiatives listed in *Momentum* by developing conceptual options for new junctions and pocket tracks in the BOS corridor. The primary goals were to provide operational flexibility, improve reliability, and lower operating costs, but also to explore whether any options could increase service capacity through the Rosslyn tunnel.

- The Metrorail System has limited ability to short-turn trains or deploy relief trains
- On-time performance in the BOS corridor dramatically decreased after the SV Line opened
- SV Line originally intended to terminate at the D&G Junction, but the structure was found unsuitable
- Due to 26 TPH max, BL trains were limited to 5 TPH under the 6-minute peak schedule; OR/SV ran 10-11 TPH



Recommendations

The study delivered four options for short-turning trains, deploying variable service patterns, and swapping slots through Rosslyn. None would increase capacity through Rosslyn.



Silver Line Junction Study: Proposed Options and Potential Outcomes

| Option | Schematic | Description | Increases Capacity thru Rosslyn? | Swap Slots thru Rosslyn? | Increases Reliability? | Operational Flexibility? | Lower Operating Costs? | Capital Cost (2015) | Other Impacts and Considerations |
|---------------------------------|---|--|----------------------------------|--------------------------|------------------------|--------------------------|------------------------|--|---|
| WFC Junction |  | <p>Reroutes the inbound SV Line through the WFC yard. Builds a new crossover and pocket track east of WFC station.</p> <p>Most SV trains turn back at WFC. 2 TPH continue to Largo.</p> | ✗ | ✓ | ✓ | ✓ | ✓ | \$300 M | <p>Requires relocating railyard to Dulles</p> <p>Allows more TPH on SV in VA</p> |
| EFC Junction |  <p style="font-size: small; margin-top: 5px;">*Includes aerial, underground options</p> | <p>Provides separate tracks for SV and OR east of WFC. Builds new platforms, crossover, and pocket track east of EFC.</p> <p>Most SV trains turn back at WFC. 2 TPH continue to Largo.</p> | ✗ | ✓ | ✓ | ✓ | ✓ | \$350 M | <p>Encroaches on I-66</p> <p>Allows more TPH on SV in Dulles-Tysons</p> |
| RFK Stadium |  | <p>Infill station northeast of RFK, two new tracks leading to a #15 crossover and tail tracks.</p> <p>Turn back BL trains.</p> | ✗ | ✗ | ✓ | ✓ | ✓ | \$375 M | <p>Maintains equal service to Largo</p> <p>4% slope</p> <p>New development, but federal land</p> |
| D&G Junction Upgrade |  | <p>Expand existing pocket track 170' westward (to 820') and upgrade #6 switches to #10.</p> <p>Turn back BL trains.</p> | ✗ | ✗ | ✓ | ✓ | ✓ | \$13 M (extension; entire structure ~\$60 M) | <p>RAIL and study team held #10 switches needed for 6-min peaks</p> |

Blue/Orange/Silver Corridor Capacity & Reliability Study – 2019, ongoing

Purpose

The BOS Study is an ongoing effort to leverage the extensive body of knowledge described in the previous slides, culminating in a consensus corridor strategy and project or projects Metro can advance into project development and competition for federal funding. It is study is intended to build on the previous work with fresh data, new analysis, and substantial stakeholder and public engagement. That engagement, particularly with jurisdictional agency staff, established four goals for the BOS Corridor that shaped the current six alternatives (shown to right).



Goal 1:
Provides Sufficient Capacity to Serve Ridership Demand



Goal 2:
Improves Reliability & On-Time Performance



Goal 3:
Improves Operational Flexibility & Cost-Efficiency



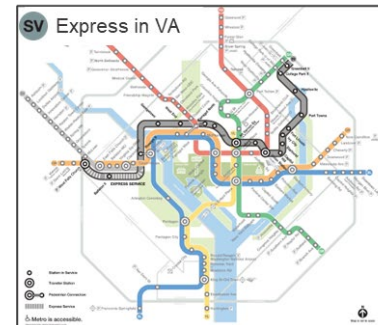
Goal 4:
Supports Sustainable Development & Expands Access to Opportunity

No-Build Alternative

- Existing Services
- State of Good Repair
- Silver Line Phase 2
- Potomac Yard
- Funded Partner Projects (e.g. Purple Line)

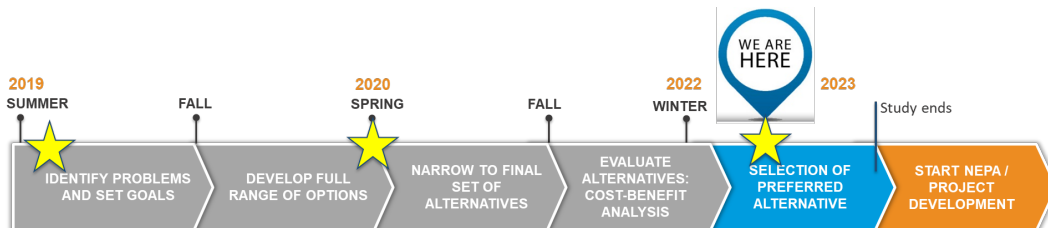
Lower Capital Cost Alternative

- Enhanced bus service
- Dynamic rail scheduling
- Railcar capacity
- Rail turnbacks
- Core station expansions



Next Steps in Finishing the Study

The study has completed two rounds of public engagement, identified six alternatives, and analyzed costs and benefits. The next step is a final round of public engagement before asking the Board to select a preferred option.



★ = PUBLIC ENGAGEMENT ACTIVITIES

