Finance and Capital Committee

Information Item IV-C

November 20, 2025

Rail Modernization Program

Board Document

OVERVIEW			
PRESENTATION NAME	Rail Modernization Program	**DOCUMENT NO.**	**XXXXXX**
ACTION OR INFORMATION	[X] Information [ ] Action		
STRATEGIC TRANSFORMATION PLAN GOAL	[X] Service Excellence [ ] Talented Teams [X] Regional Opportunity and Partnership [ ] Financial Stewardship and Resource Management		
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DOCUMENT INITIATOR	Mark Irvine		
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COMMITTEE	[ ]Exec/OIG [ ]Board [ ]Exec/Non-OIG [X]Finance & Capital [ ]Safety & Ops [ ]Board (consent)	**COMMITTEE DATE**	November 20, 2025
PURPOSE/KEY HIGHLIGHTS	Provide a summary of Metro's Rail Modernization Program, including Metro's vision for modernizing and automating the Metrorail system, a summary of the elements of the program and how they build upon each other, as well as the business case for modernization, showing how the potential benefits to Metro and the region exceed the costs of the program.		
DISCUSSION	Metro continues to provide vital, high-capacity transit service across the region, but faces growing challenges that could limit its ability to deliver the safest, most reliable, and most efficient experience possible. Its legacy signal system—first built in the 1970s—is increasingly prone to failures, driving up costs and		

	causing millions of minutes in passenger delays each year. Core segments operate near capacity, especially on the Blue/Orange/Silver corridor (between Rosslyn and Stadium-Armory stations), while terminal constraints and limited fleet flexibility restrict service. These pressures come amid rising regional demand, making strategic investment in core systems essential. Meeting this moment requires more than replacing aging infrastructure—it calls for upgrading to modern signaling technology, deploying new and retrofitted railcars, and a new approach to service delivery. Metro envisions a rail system that sets a new standard in North America for speed, reliability, and customer experience. With the right investments, Metro can deliver faster, more frequent, and more dependable service, positioning the region alongside global leaders in transit. Cities with world-class metro systems—including Barcelona, Copenhagen, Madrid, Montreal, Paris, Singapore, Stockholm, and Toronto—have already adopted or are advancing toward this model, showing that these technologies are not merely aspirational—they are now the global standard. Communications-based train control (CBTC) unlocks higher throughput and faster recovery from delays. Platform screen doors (PSDs) virtually eliminate train strikes, enable orderly boarding, and reduce dwell times. Full automation improves reliability, allows service to scale with demand, and reduces operational costs. Together, these elements form a flexible framework for upgrading Metro's rail system—adaptable and responsive to funding opportunities and regional priorities. Replacing Metro's aging signal technology is a system-wide need, and also an opportunity to consider new potential service capabilities with modernization. A new CBTC signal system would be the foundation for additional investment in PSDs and automated operations. The Rail Modernization Program Plan lays out a strategic framework for upgrading infrastructure, rolling stock, and operations to meet long-term transit needs. It defines the vision, scope, costs, benefits, and implementation approach for replacing the signal system and enabling future improvements—including new railcars, platform screen doors, and fully automated service.

	While a new signaling system is required, other elements of the program (including Platform Screen Doors and automating Metro's operations) can be pursued based on available resources and regional priorities. Each upgrade delivers immediate value while building toward a safer, more efficient, more reliable system with greater capacity. The Program Plan is organized around **four core benefits: safety, reliability, capacity, and efficiency.** These themes reflect the most urgent challenges facing the system and the most impactful improvements for riders. CBTC, PSDs, and full automation directly support these goals—reducing delays, increasing throughput, and improving safety for passengers and workers. **Safety:** Decades of global experience show automation reduces human error and enhances worker protection through precise train location data. Platform screen doors (PSDs) further improve safety by virtually eliminating track intrusions, suicides, trespassing incidents, and fatalities from persons struck by trains. Automation also leads to smoother acceleration and braking, reducing the risk of passenger falls onboard. **Reliability**: Automation improves on-time performance, achieving 95–99% reliability. It enables more consistent and optimized dwell times, supports higher speeds, and allows for faster recovery from delays. Service is no longer constrained by operator availability and can adjust quickly to disruptions or demand surges. The new system will require fewer repairs and experience fewer critical incidents, reducing the likelihood of extended service delays. Together, these improvements reduce waiting times for customers and increase overall system resilience. **Capacity:** Automation increases train throughput using existing infrastructure, helping avoid or delay costly expansion projects. By optimizing operations with the same fleet and rail lines, Metro can increase capacity substantially. Throughput improvements will raise practical capacity limits from 24 to 30 trains per hour or more—equivalent to trains approximately every 2 minutes. Faster turnbacks enabled by automation further increase capacity. These enhancements make the system more attractive to riders, supporting projected ridership growth and increase fare revenue potential over time. **Efficiency**: End-to-end travel times are expected to decrease by 15–20% with automation, driven by optimized acceleration and

	deceleration. Automated train coupling and uncoupling also enables more effective train sizing based on demand, reducing unnecessary energy use and improving fleet utilization. Beyond operational improvements, these upgrades deliver broader regional benefits by improving access to jobs, education, and services, supporting economic growth, and strengthening the region's competitiveness. Service enhancements—such as faster trips, more frequent trains, and smoother boarding—are expected to improve customer satisfaction and overall quality of life. Together, these improvements create a system that is not only faster and more dependable but also more appealing to customers. Customers will experience smoother boarding, faster trips, and a more comfortable journey, while Metro staff will benefit from more dynamic, higher-paid roles aligned with evolving labor market expectations. These changes support customer satisfaction, workforce stability, and the long-term sustainability of the transit network. Metro's Capital Improvement Program supports key modernization efforts, including planning for a new advanced signaling system, procurement of 8000-series railcars, and upgrades to the rail power network. Metro is exploring several pathways to pursue federal funds for Rail Modernization, including Capital Investment Grant (CIG) funding. Metro has flexibility in structuring each potential corridor-based project. Each carries trade-offs in timing, complexity, and risk. Capital Investment Grants require a multi-year, multi-step process before signing a grant agreement. Funds are not available until a construction grant agreement is signed, and costs are only reimbursable after Project Development begins. Legal requirements limit pre-construction activities, impose a two-year Project Development timeline, and require a five-year service commitment after implementation. Risks include legislative changes, regional funding uncertainty, and project-level challenges such as NEPA analysis, third-party agreements, and procurement. Metro is also considering other federal programs, including TIFIA and BUILD, to support specific components of the modernization effort. CIG funding is competitive and is not guaranteed for applicants. Metro is working to align the various planning activities to support a competitive application, including analyzing alternative

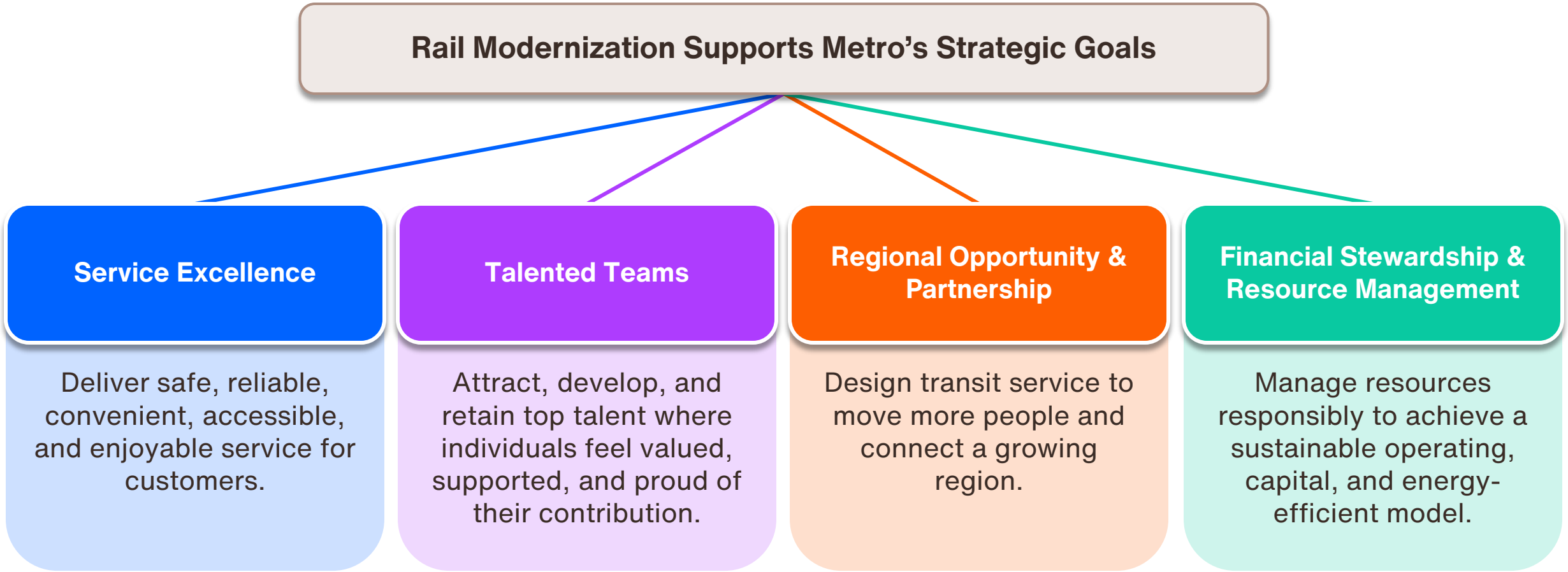
	investments, developing estimates of project costs and benefits, and identifying funding sources that can be used as a local match. We anticipate additional project development work to continue in the coming year to support a future federal funding grant application.
INTERESTED PARTIES	For conflict-of-interest purposes, staff has identified the following contractors and interested parties involved in the Rail Modernization Program and other related efforts: Alstom, Deutsche Bahn E.C.O. NA, Hitachi, HNTB, Kawasaki, Knorr-Bremse, Parsons Transportation.
RECOMMENDATION/NEXT STEPS	In December, the General Manager and Chief Executive Officer will propose the FY2027-2032 Capital Improvement Program, which is anticipated to include initial funding for the Rail Modernization Program.
FUNDING IMPACT	While there is no funding impact from providing this information, a decision to move forward with the Rail Modernization Program will start a once-in-a-generation upgrade of the Metro Rail System.

Rail Modernization Program Plan

Finance and Capital Committee
Washington Metropolitan Area Transit Authority
November 20, 2025

Supporting Your Metro, the Way Forward

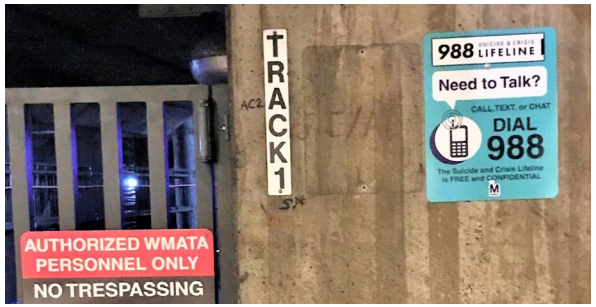
Your Metro, the Way Forward provides a long-term strategy and guides day-to-day decision making



1. Vision for Rail Modernization and Automation

Metrorail is facing multiple challenges, with a system that is aging and increasingly outdated

Safety



Ongoing trespassing incidents

- Trespassers, trash, slips/trips/falls
- Human error in operation
- Challenging to mitigate with current system design

Reliability

Aging and unreliable infrastructure

- Inconsistent acceleration and braking by operators and signal system failures causing delays
- Growing maintenance costs; replacement parts are increasingly difficult to source

Capacity

Insufficient room for long-term growth

- Bottlenecks at key locations limit service
- Expensive alternatives to adding capacity

Efficiency

Outdated concept of operations

- Rising operating expenses and inflexible service model

Investing in modernization elements directly addresses Metro's key challenges

Program Elements

Signals

Fleet

Stations/Platforms

Operations

Safety

- **Safer operations**: keep trespassers off tracks, reduce track fires.

Reliability

- **Increase service reliability** up to 99%.
- **Less physical infrastructure to maintain.**

Capacity

- **Increased capacity with more trains per hour.**

Efficiency

- More productive service with **lower operating costs**.
- **Grow ridership & revenue**.

Grades of Automation

Grades of Automation (GoA) are the international standard describing roles and responsibilities for train control systems and on-board staff

Increasing Automation

Grade of Automation	Type of Train Operation	Setting Train in Motion	Stopping Train	Door Closure	Operation in Event of Disruption
GoA 1 	**Manual Operation** with Automatic Train Protection (ATP)	**Operator**	**Operator**	**Operator**	**Operator**
GoA 2 	**Semi-automatic Operation** with ATP & Automatic Train Operation (ATO)	**Automatic**	**Automatic**	**Operator**	**Operator**
GoA 3 	Driverless Train Operation (DTO)	**Automatic**	**Automatic**	**Train Attendant**	**Train Attendant**
GoA 4	**Full Automation**, capable of Unattended Train Operation (UTO)	**Automatic**	**Automatic**	**Automatic**	**Automatic**

International Standard IEC-62290-1

Metro operated in manual mode as a **GoA 1** system from 2009 to 2025

Metro's Automatic Train Operation (ATO) is a **GoA 2** system

Metro has always embraced automation

The rail modernization program will continue leveraging cutting-edge technology to provide the best service for the region

Past: Designed for ATO

Metro was designed and built in the 1970s for **automatic train operation (ATO)**, which provides semi-automated operations.

Present: Return to ATO

Metro **returned to using ATO** in December 2024 and plans to use **automatic track inspection vehicles** to monitor the quality of tracks with speed and accuracy.

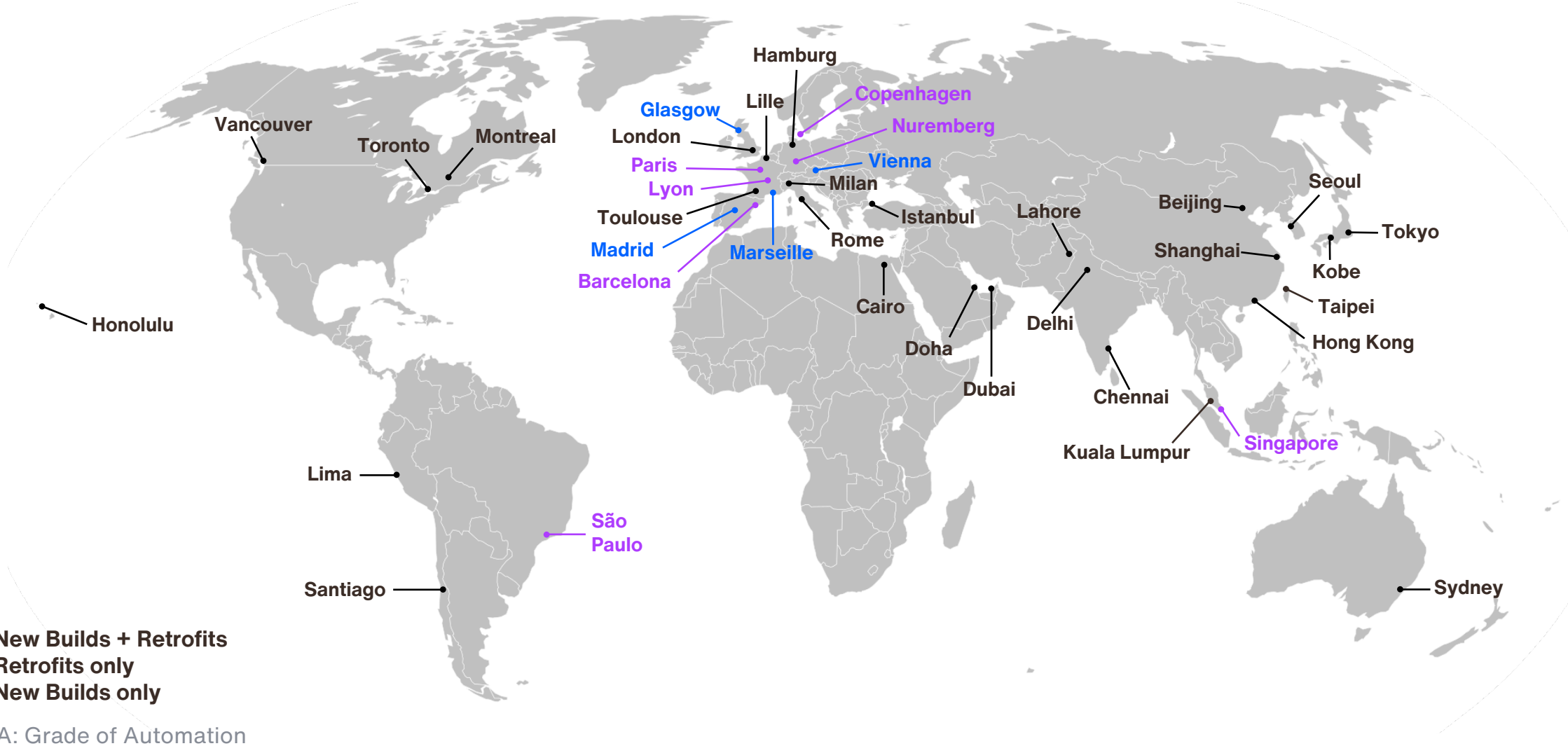
Future: Rail Modernization

Metro has developed a **rail modernization program plan** to keep pace with advancements in signaling technology and train operation.

1970s → **2020s** → **2025+**

Metros are automating across the world

Selection of Grade of Automation 3/4 (GoA 3/4) lines, current and in development



GoA: Grade of Automation

Replacing Metro's signal system is a systemwide need

Planning to start with incremental investment in the Red Line; it has the oldest and most self-contained infrastructure footprint

R Red Line

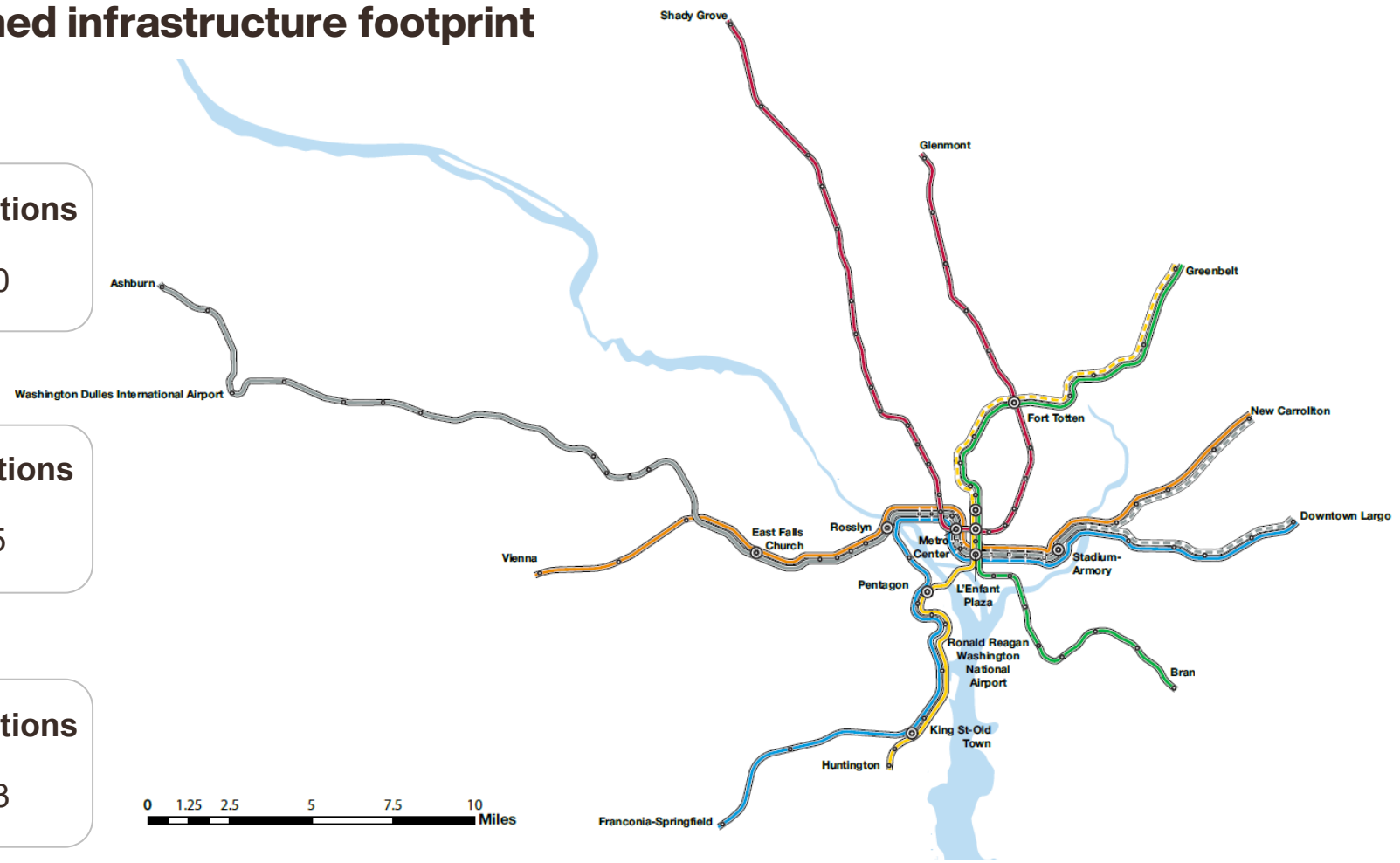
Route Miles	Stations	Avg. Age	Yards	Junctions
32	27	43	3	0

B O S Blue, Orange, and Silver Lines

Route Miles	Stations	Avg. Age	Yards	Junctions
58	43	35	3.5	5

G Y Green and Yellow Lines

Route Miles	Stations	Avg. Age	Yards	Junctions
38	32	34	2.5	3



2. Rail Modernization Program Elements

Components of fully automated rail transit

Fully automated rail systems rely on communications-based train control, platform screen doors, and an updated service model

Signals

Metro Integrated Command & Communications Center (MICC)

Modern communications-based train control (CBTC) with capability to control all aspects of train operations, including detection of obstacles on the track

Fleet

Paris Metro: MP05 rolling stock

Railcars must be equipped with CBTC technology – systems use more onboard equipment with less wayside infrastructure

Stations/Platforms

Honolulu Skyline: Hālawa station

Protect customers on the platform with physical barriers, such as platform screen doors

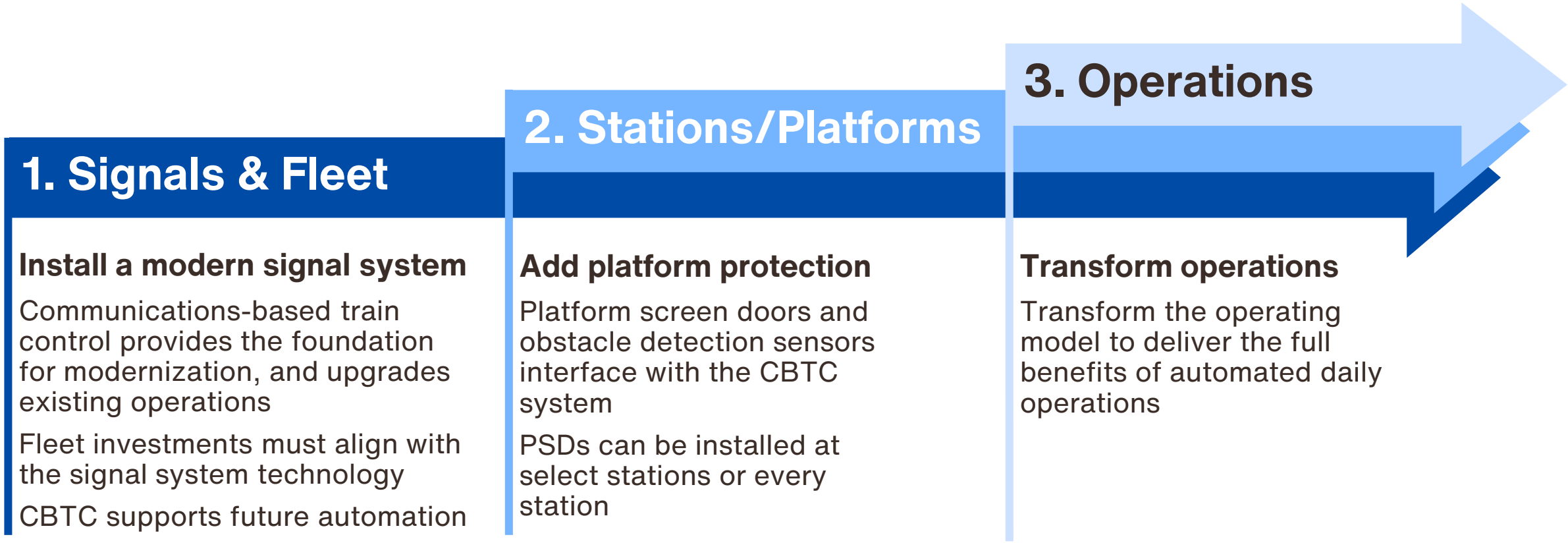
Operations

Greenbelt interlocking

Service shifts to centralized control, with train frequency adjusted dynamically based on demand rather than fixed schedules

Building blocks of modernization and automation

A new, modern signal system is the foundation for additional investments in platform screen doors and automating operations



Each investment builds upon the foundation of CBTC, with independent value at each step in the sequence

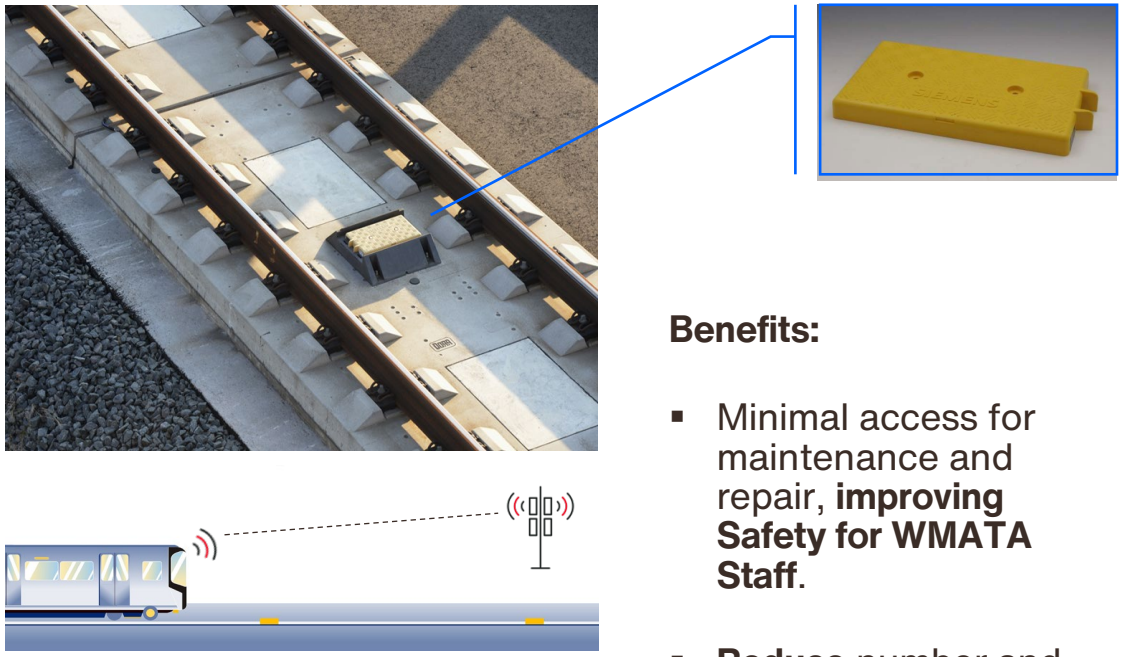
Current track side vs. CBTC

New technology streamlines infrastructure and safety performance

WMATA Legacy 70's & 80's Train Detection

- **3500+** Track circuits with **14,000+** Bonds.
- **700+** Miles of copper cables on the track.
- **100+** Signals on the track.

CBTC use advance communications technology



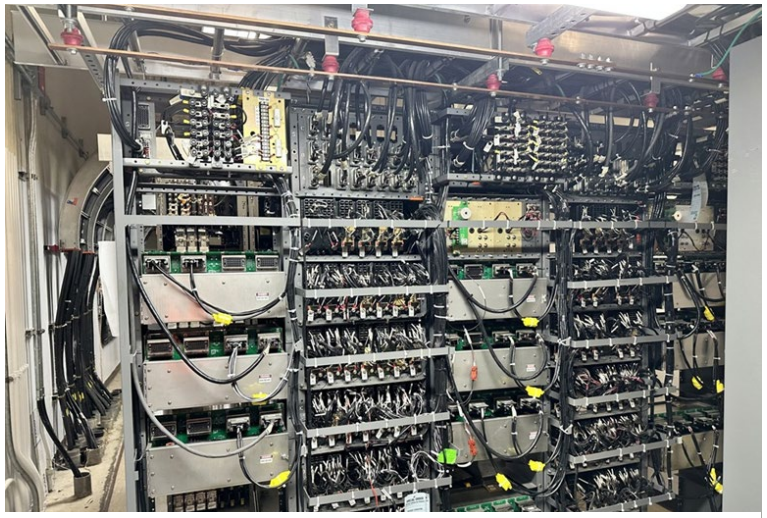
Benefits:

- Minimal access for maintenance and repair, **improving Safety for WMATA Staff**.
- **Reduce** number and duration of revenue **service disruptions**.

Current control rooms vs. CBTC

New technology streamlines operations and maintenance

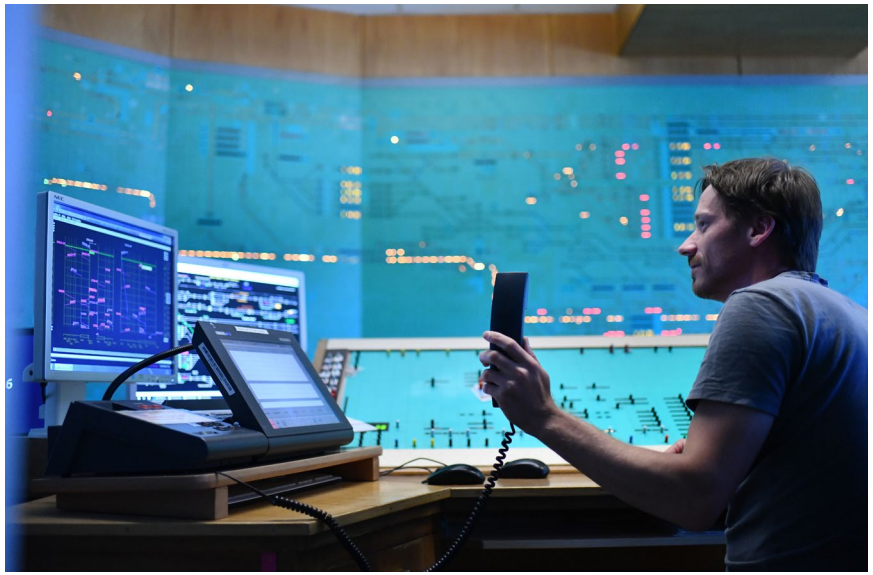
WMATA Legacy 70's & 80's Electromechanical Rooms



WMATA Red Line Train Control Room

- **165** Train Control Rooms.
- **28,000**+ relays with over **300,000** connections.

CBTC uses powerful computers at the MICC running advanced software



Benefits

- **Fewer** control rooms and failure points.
- Built-in redundancy **improves reliability**.
- **Automated diagnostics** speed up maintenance.

3. Business Case

Rail Modernization Strategy

Metro can improve safety, reliability, capacity, and efficiency with incremental investments

Service Improvements → **Rail Modernization and Automation** → **Expansion**

Maximize Use of Existing Assets		Modernize the System		Expand the System
Use Metro's design capabilities and maximize use of existing assets		Add new capabilities and capacity to Metro's existing 128-mile system		Expand Metro's network
▪ Automatic Train Operation ▪ Return to design speeds up to 75 mph	▪ Service increases ▪ More eight-car trains	▪ Modern signaling (CBTC) ▪ 8000-series railcars	▪ Platform screen doors ▪ Full automation	▪ Serve new markets in a growing region

Why Modernization?

Only Modernization addresses each of Metro's needs

Metro considered three major investment options to address Metro's multiple challenges, including aging infrastructure and capacity constraints.

- ● Meets Metro's needs
- ◑ Partially meets Metro's needs
- ○ Does not meet Metro's needs

Alternatives	Safety	Reliability	Capacity	Efficiency
1. **Maintain the Existing Signal System:** Attempt to sustain operation of existing system.	○	●	○	○
2. **Expand the Metrorail System:** Build a new Metro line to add capacity and coverage.	○	◑	●	○
3. **Modernize the System:** Upgrade to Communications-Based Train Control (CBTC), integrate with new railcars, and install platform screen doors.	●	●	●	●

How Modernization improves safety

Preventing access to the track and reducing human error in operation improves safety across the system

- **Platform screen doors:** Provide a physical barrier between customers and moving trains, preventing intrusions, falls, and suicides
- **Modern signal systems:** Reduce human error in operation, increasing worker safety, reduced need to access to the right-of-way
- **Consistent speed and acceleration:** smoother rides result in fewer on-board injuries

Post-event platform crowding at Gallery Place

Platform screen doors provide stand-alone benefits and enable automated operations

PSDs enhance safety, reliability, and quality of experience and are a new global standard for rail transit platform amenities

Safety
- A physical barrier between customers and moving trains reduces risk of injury or death

System Reliability
- This barrier prevents intrusions onto the track and limits trash and debris, preventing delays
- Trains can enter stations at full speed, even with crowded platforms

Quality of Experience
- Customers feel safer on crowded platforms
- Peer agencies show PSD-enabled lines rate highest for customer satisfaction
- Additional improvements to platform air quality, energy efficiency for climate control, etc.

Paris Metro: Line 4 Platform Screen Door Testing

Platform screen door implementation can be phased

Copenhagen's fully automated Metro opened in 2002 with a partial installation of platform screen doors, and later installed doors at all stations to improve reliability

Orestad Station, without platform screen doors – 2013

Each of the below-ground stations were built with platform screen doors; above-ground stations used a sensor system to detect obstacles instead of doors

Kastrup Station, with platform screen doors – 2015

Retrofits in 2014-15 replaced sensor systems with more reliable PSDs at above-ground stations while maintaining fully automated operations

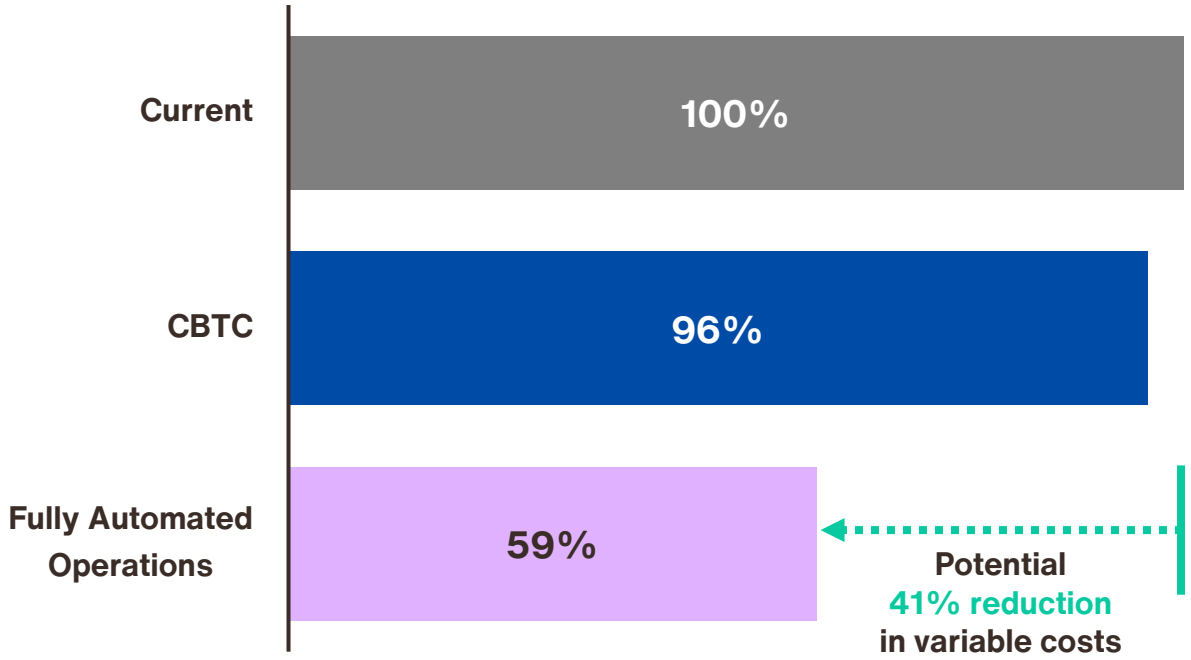
How Modernization can address Metrorail system capacity

	Constraint	Solution
	Fleet size	Better utilization of existing railcars
	Yard storage and maintenance capacity	More efficient fleet and yard utilization
	Traction power	Reduced traction power demand
	Core throughput	Shorter headways and automated turnbacks
	Terminal capacity & turnbacks	Turnback flexibility, expanding terminal capacity
	Platform length and dwell time at stations	Optimizes dwell times and passenger flow

Modernization allows Metro to deliver more service at lower cost

Full automation would reduce marginal operating costs by up to 41%, enabling efficient operation of high-frequency service all day to maximize ridership and revenue.

Incremental Cost to Add Rail Service



Increased system efficiency with CBTC could result in up to a **15% reduction in traction power expenses**. These costs make up about 20% of Metrorail's variable costs.

Fully automated operations allow **staffing model flexibility** that allow much more rail service to be added without additional staff costs.

How Red Line Modernization delivers value

Direct cost savings, new revenue, and time and lives saved will offset the upfront costs of investing in new infrastructure.

R	CBTC	Fully Automated Operations
Metro	• Reduced costs for traction power and signal maintenance from system efficiency. • Ridership and revenue growth due to faster speeds and better reliability. **Up to $6M/year of cost reductions** **Up to $10M/year in new revenue**	• Significantly reduced costs per car mile from more flexible staffing model. • Ridership and revenue growth due to faster speeds and better reliability. **Up to $13M/year of cost reductions** **Up to $14M/year in new revenue**
Region	• Passenger travel time savings due to faster speeds and better reliability. **Up to $58M/year in regional benefits***	• Passenger travel time savings due to faster speeds and better reliability. • Value of travel time and lives saved due to automation. **Up to $93M/year in regional benefits***

* Using values of travel time savings, wait time savings, and fatalities avoided from USDOT Benefit-Cost Analysis Guidance.

Benefits of Modernization address Metro's needs

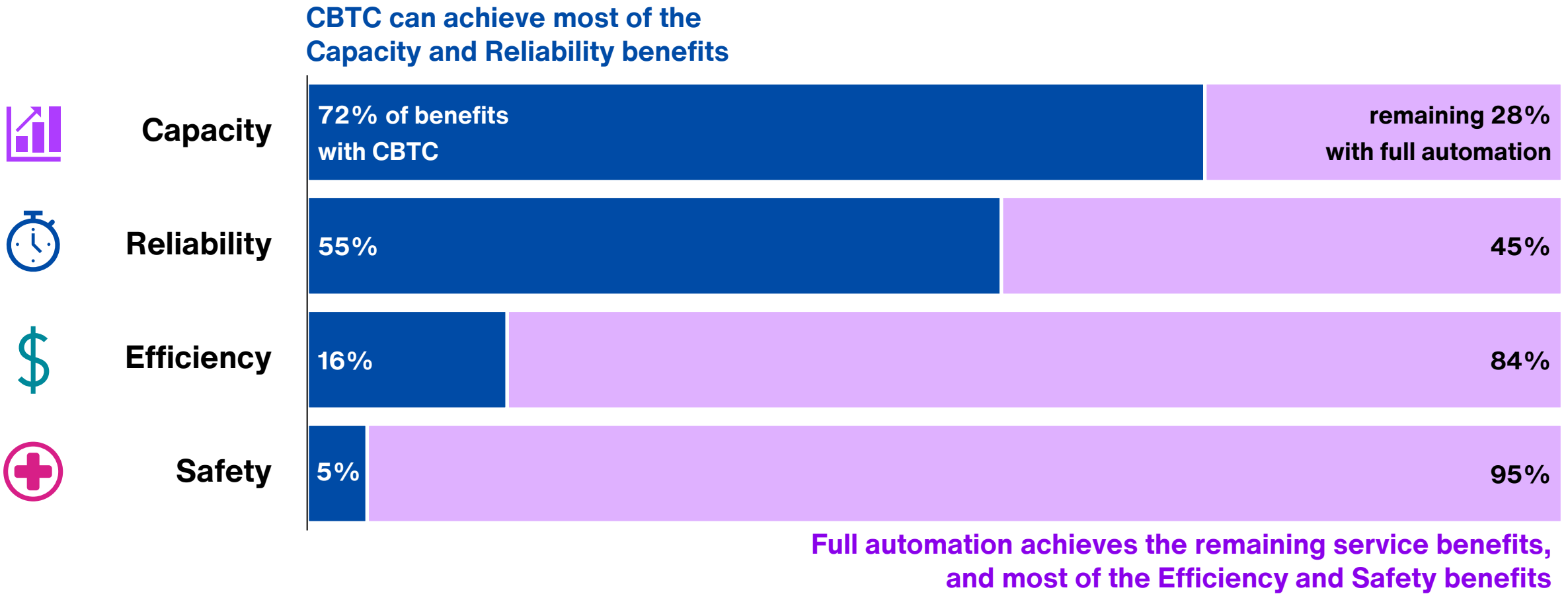
Signal system upgrades, platform screen doors, and automation provide benefits across four key areas of Metrorail service

	Benefits
Capacity	▪ Increase train throughput from 24 trains per hour to 30+ trains per hour
Reliability	▪ Increased on-time performance up to 98% with automated operations ▪ Reduced signal incidents, delays
Efficiency	▪ Faster cycle times ▪ Lower marginal costs / revenue hour
Safety	▪ Reduce fatalities and trespass incidents by 80% to 100% with platform screen doors

Benefit estimates based on international benchmarking of capabilities of similar systems, rail operations simulations of Metro's system, and analysis of Metro internal data

The region can realize more benefits with automation

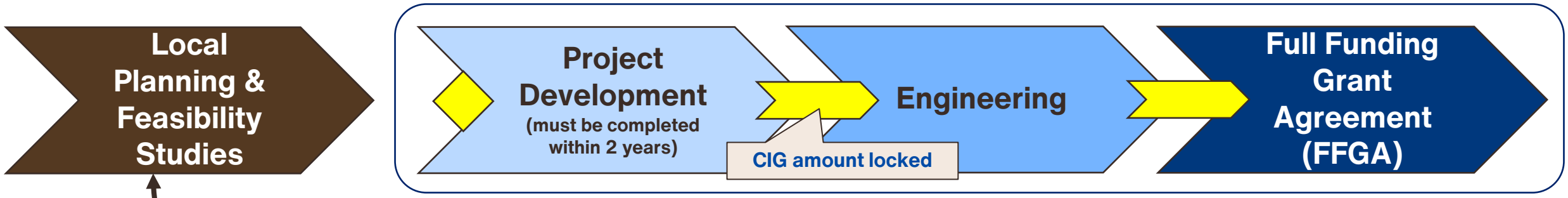
Modernizing Metro's signal system can incrementally improve Metro's capacity and reliability; automation enables transformation for safety and efficiency



Federal Capital Investment Grants can help fund Modernization

The CIG Core Capacity grant program is a good match for modernization; peer experience indicates federal grants could cover 40% of capital costs

The Capital Investment Grant (CIG) Core Capacity program requires a multi-year, multi-step process



We are here:

- Advancing locally preferred alternative
- Including Red Line Signal System in FY2027-2032 CIP

Legend

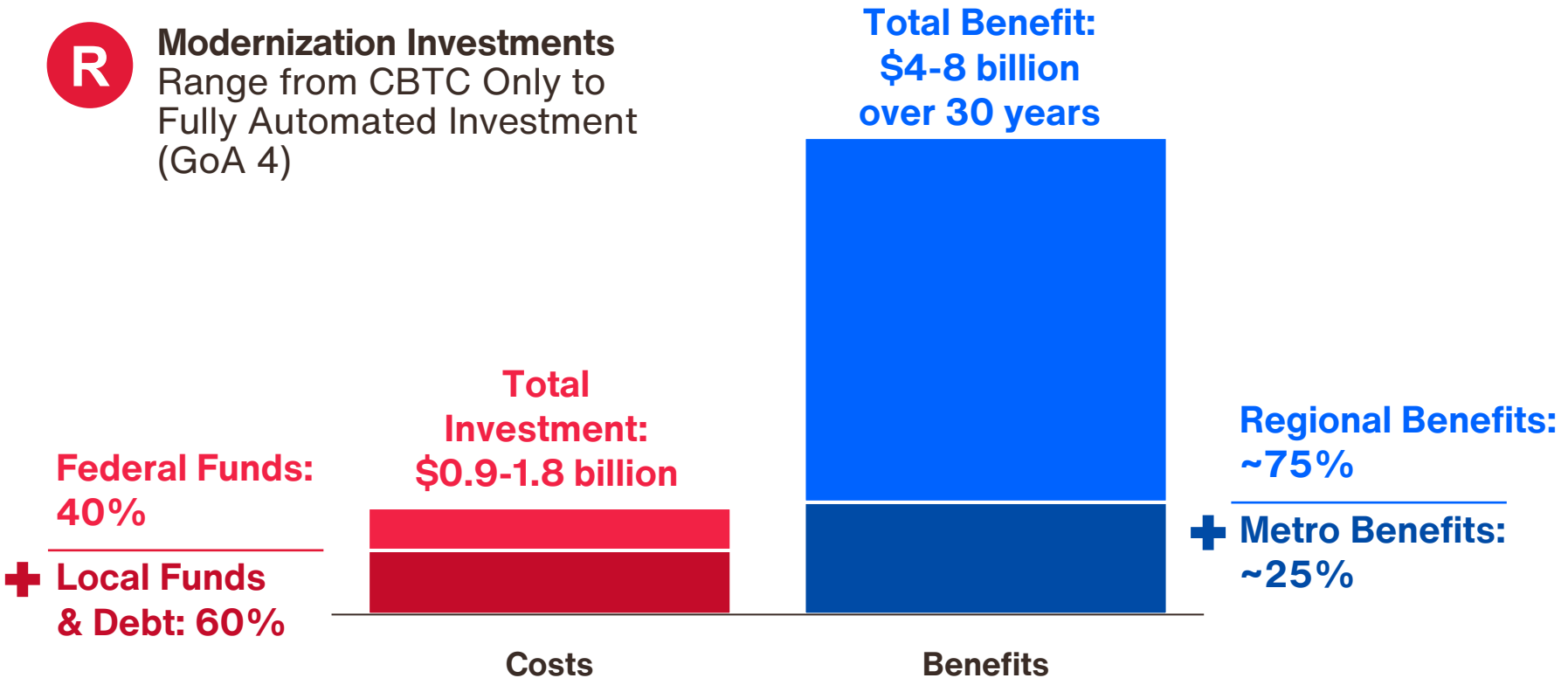
- Federal Transit Administration (FTA) acknowledgement
- FTA evaluation, rating, and approval

*This step can be funded by other federal programs, just not CIG

Red Line Modernization investment will deliver significant benefits

Leveraging local funds to secure competitive federal grants (60% / 40% local/federal split) improves the return on investment considering local funds only

Modernization Investments
Range from CBTC Only to Fully Automated Investment (GoA 4)



- Harnessing federal funds reduces the local expenditures required to deliver the program, **increasing the cost/benefit ratio** of the local funding.
- This also allows the program to achieve a positive net benefit to the region earlier after completion.

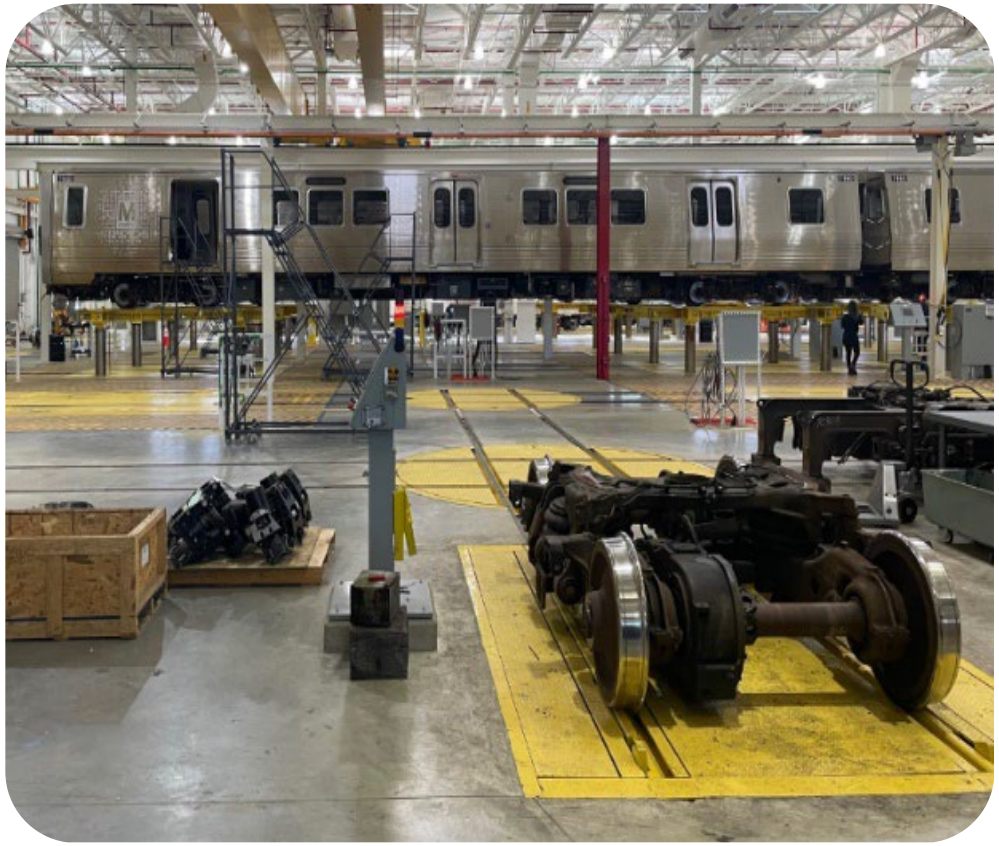
Expenditures and benefit figures shown here in year-of-expenditure and year-of-benefit dollars. Costs reflect rough order of magnitude (ROM) estimates for considered program scope and timeline and are likely to change as project development advances.

Rail Modernization enables capital cost savings

Efficiently using existing assets can both add capacity and reduce the amount of investment needed in the future

Compared to Metro's current signal system, Modernization can achieve higher capacity without the need to incur as many large capital expenses:

- **Railcar purchases:** can achieve better service and higher capacity with fewer railcars than would otherwise be required
- **Lifecycle maintenance costs:** a smaller, more efficient fleet reduces the lifecycle expenses for maintenance
- **Rail yard and shop expansion:** can avoid need for some railcar storage expansion projects by operating more efficiently within the existing footprint of Metro's yards



Dulles Yard Service & Inspection Building

Efficiencies reduce capital needs for yards and facilities

Modernization can deliver increased Red Line service more efficiently than the current signal system, reducing the need for fleet and facilities expansion

Red Line scenarios	Cycle time (minutes)	4-minute service requirements (15 trains per hour)		3-minute service requirements (20 trains per hour)		Current storage capacity	Storage deficit
		Trains	Railcars	Trains	Railcars	Railcars	Railcars
ATC (Current)	136	36	346	48	**462**	**388**	**-74**
CBTC	126	34	328	44	**424**	**388**	**-36**
Automation	118	32	308	42	**404**	**388**	**-16**

Reduced vehicle requirements with modernization would require a smaller scope of yard improvement projects to maximize efficiency.

58 fewer railcars would realize approximately $320 million in lifetime capital purchase and renewal savings

Train requirements include revenue service trains and gap trains.
Railcar requirements assume 100% eight-car trains on the Red Line during peak service and a 20% spare ratio.

Lifecycle capital cost savings from efficient fleet utilization

Each new railcar is also a long-term commitment to maintain that asset over the railcar's lifespan

Over a 40-year lifespan, each railcar would undergo six separate Scheduled Maintenance Program (SMP) cycles.

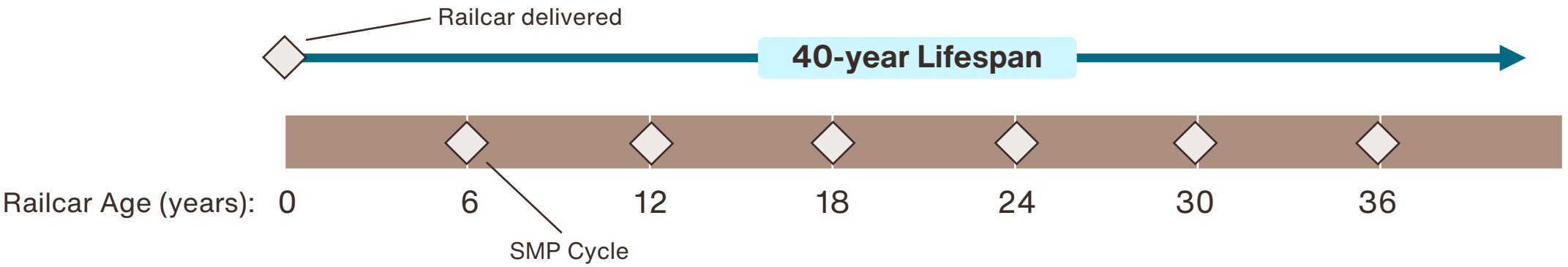
Metro's Scheduled Maintenance Program overhauls railcars in stages on a recurring six-year cycle in order to improve vehicle performance and stabilize maintenance.

SMP is part of Metro's Capital Program. These costs are separate from regular operating maintenance costs.

Over the lifetime of a railcar:

~$3 million purchase cost

~$2.5 million total rehabilitation cost



Modernization can deliver more service from existing infrastructure

Efficient fleet utilization reduces demand for railcar storage expansion

Modernization and Automation can:

- Add Red Line service without the need to increase rail yard storage and maintenance capacity
- Automate yard operations with automatic coupling and uncoupling of trains to more effectively use existing storage tracks
- Automated dispatching can enable train length optimization during the day

Example: Shady Grove Yard

- 166 total railcar storage spaces; 72% of railcars can be stored as 8-car trains

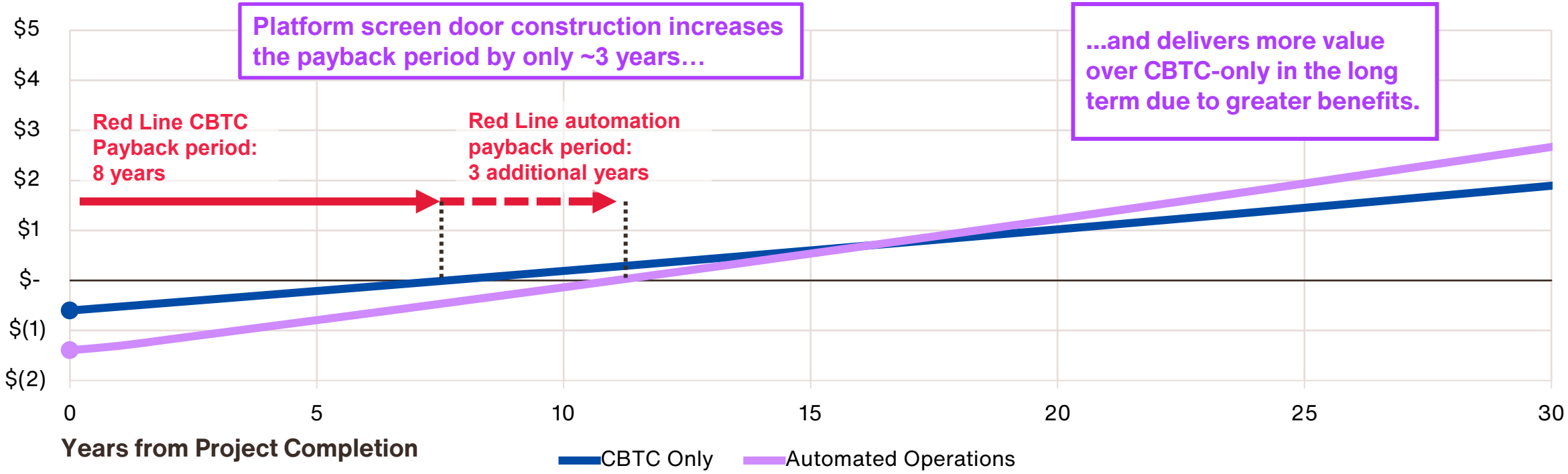
Estimated rail yard capital needs:

- **$1.3 billion** estimated total system cost
- **$300-400 million** for Red Line rail yard projects

Red Line Modernization delivers billions in net benefits to region

Cost savings, new revenues, and regional benefits fully offset upfront costs of infrastructure investments

Regional Net Benefit from Rail Modernization ($ billions, 2025 $'s)



4. Migration Strategy

Incremental approach minimizes risk and maximizes learning across lines

System Migration Strategy

Phase 1

Red Line

- Most self-contained line in the system
- Lessons learned will improve implementation processes for the subsequent lines
- Opportunity to leverage 8000-series procurement

Phase 2

Blue Line segments, Orange Line, and Silver Line

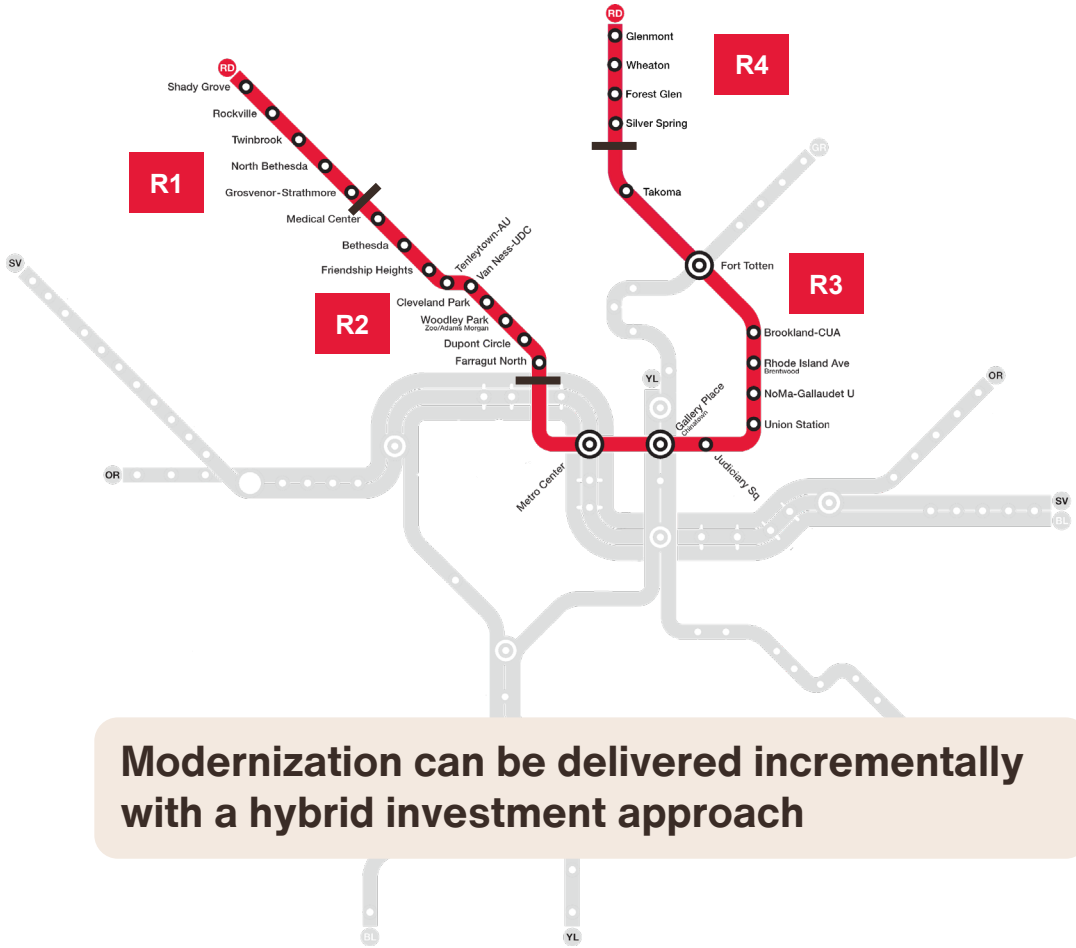
- Increases capacity in the most congested sections
- Complex and high requirement for railcars to be equipped with CBTC

Phase 3

Yellow Line, Green Line, and remaining Blue Line sections

- Final rollout phase to complete systemwide CBTC deployment allowing full operational flexibility

Red Line installation segmentation



Modernization can be delivered incrementally with a hybrid investment approach

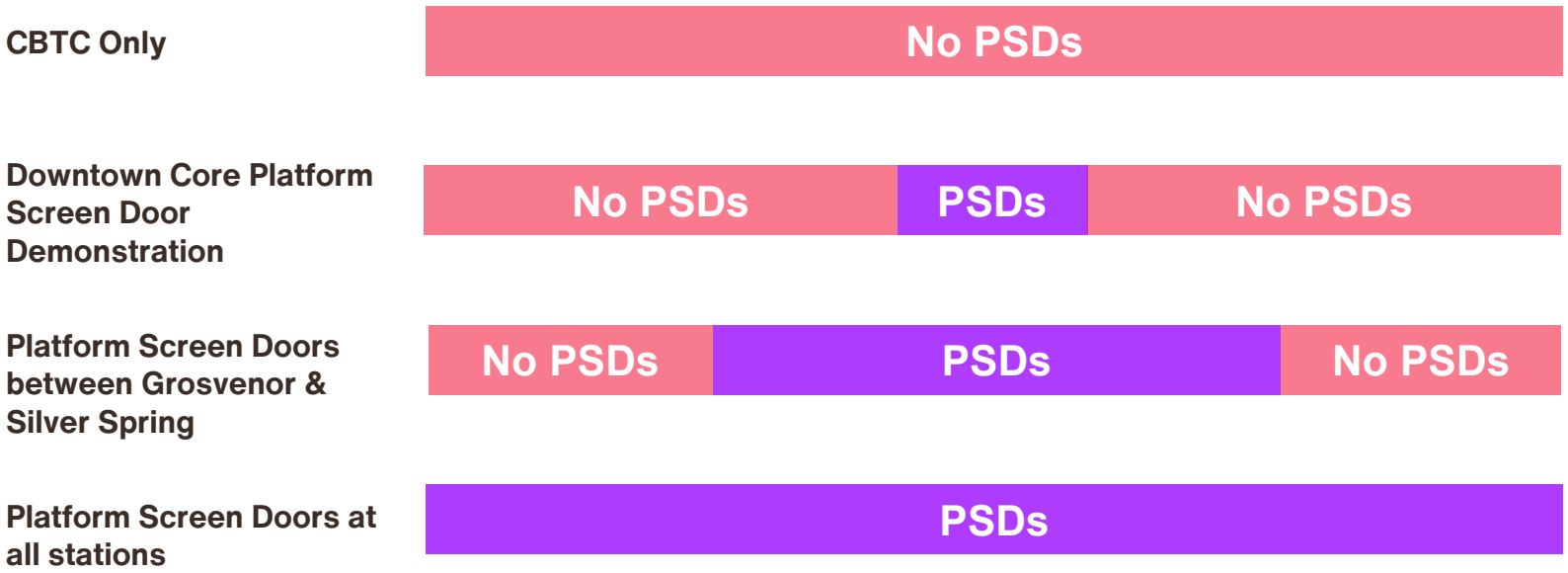
Current segmentation concept: begin CBTC work with the R1 segment to ensure access to largest Red Line rail yard at Shady Grove

Criteria for segmentation

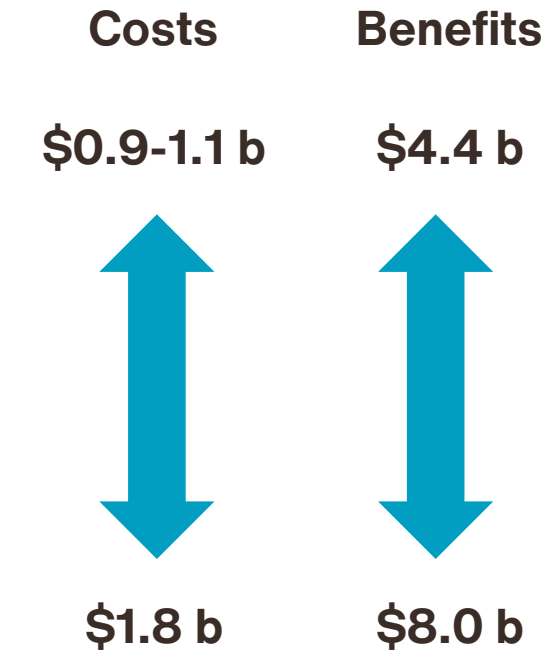
- **Four segments for installation and testing:** Dividing installation and testing in a staggered approach to minimize disruptions in the entire line. Commissioning and start of CBTC operations expected to include two or more segments.
- **Operational flexibility:** Segments are sized for installation and testing, balancing complexity against the cost of many smaller segments. Each segment includes a yard connection, pocket track, or crossover to allow turn-backs during tests
- **Safe transitions:** Segment borders will be placed at stations, so operators can safely switch operating during the dwell time.

Red Line Modernization incremental investment options

Investments can be phased to add new capabilities over time

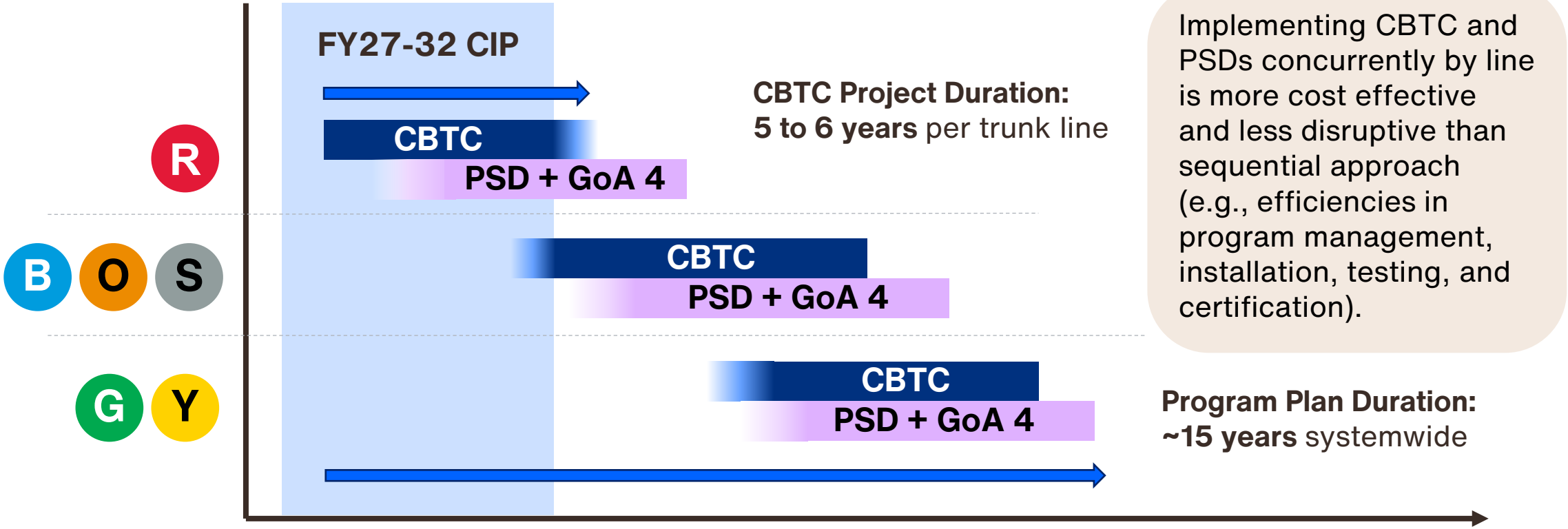


Range of Potential Costs and Benefits
Specific costs and benefits vary based on the scope of Platform Screen Door installation and the ultimate Grade of Automation



Roadmap to modernize Metro

Incremental investment begins with CBTC on the Red Line; Timing and scope for additional projects to modernize each trunk line is dependent on funding availability



CBTC: Communications-Based Train Control PSD: Platform Screen Doors GoA4: Grade of Automation Level 4 – Full Automation

5. Next Steps

Rail Modernization Next Steps

Program Summary

- Advance the Rail Modernization and Automation Program with a long-term goal of automating operations across the entire rail system
- Develop modernization projects incrementally on a corridor-by-corridor basis:
  - Red Line
  - Blue/Orange/Silver Lines
  - Green/Yellow Lines
- Build internal capacity to deliver these projects efficiently

Next Steps

- Approval of FY2027-2032 Capital Improvement Program, including Red Line advanced signaling
- Advance technical and functional requirements for Rail Modernization & engage stakeholders on Platform Screen Door design
- Prepare grant applications for federal funding

Interior front view of a driverless train, Copenhagen Metro

Appendix 1: Rail Modernization Background

Rail modernization is the path to world-class transit

Investment in modern, automated systems can transform the way Metro operates

Metro has a unique opportunity to align needed investments in our major systems (railcars and signals) by upgrading our capabilities with next-generation technology.

Automation's benefits can transform Metro's operations

1. **Safer:** reduce staff on roadway, keep trespassers off tracks, reduce track fires
2. **More reliable:** increase service reliability up to 99% with precision operation and dynamic adjustments, less physical infrastructure to maintain
3. **Greater capacity:** faster trips and more trains running per hour
4. **More efficient:** more productive service with the same assets and lower operating costs; growing ridership and revenue

Metro is mobilizing to pursue federal funding opportunities, including core capacity grants and low interest financing.

Program Elements

Signals

Fleet

Stations/Platforms

Operations

Full automation is the global standard

Automation is the norm for new rail projects and a growing trend for existing lines

New Lines & Systems

Copenhagen Metro

Designing for driverless operation is the global standard for newly built rail transit lines

Airports

Washington Dulles AeroTrain

More than 25 fully automated systems operate in US Airports; the oldest operating since the 1970s. These are often “must-ride” systems with no alternative, demanding high reliability 24/7

Retrofits

Paris Metro: Line 4 Platform Screen Door Testing

Cities are retrofitting conventional lines (including 100+ year old Lines 1 & 4 in Paris) for full automation to add capacity, improve service, and decrease cost

Components of fully automated rail transit

Fully automated rail systems rely on communications-based train control, platform screen doors, and an updated service model

Signals

Metro Integrated Command & Communications Center (MICC)

Modern communications-based train control (CBTC) with capability to control all aspects of train operations, including detection of obstacles on the track

Fleet

Paris Metro: MP05 rolling stock

Railcars must be equipped with CBTC technology – systems use more onboard equipment with less wayside infrastructure

Stations/Platforms

Honolulu Skyline: Hālawa station

Protect customers on the platform with physical barriers, such as platform screen doors

Operations

Greenbelt interlocking

Service shifts to centralized control, with train frequency adjusted dynamically based on demand rather than fixed schedules.

Metro will have fewer centralized assets to maintain resulting in increased availability and reliability

Today's System:
Relay-based track circuits
Grade of Automation 2

- 165 localized Train Control Rooms
- 700+ miles of copper cable
  28,000+ vital relays
- 3,500+ track circuits

Fewer parts,
Smaller & simpler footprint,
Better performance

Modern, Automated Systems:
Communications-Based Train Control
Grade of Automation 4 Capable

- Centralized control;
  Significant reduction in train control rooms
- Fiber optic infrastructure
  Modern zone control
- Less wayside equipment;
  Railcar-based equipment

How Rail Modernization increases capacity

Modern signal systems can safely increase throughput for existing tracks

Potential Service Delivery vs. Tunnel Capacity (trains per hour)

Current Service

Service operating below maximum scheduled throughput of 24 trains per hour

Add Capacity via Expansion (Blue Line Loop concept)

Building a new tunnel adds capacity but inefficiently uses it. Tunnels limited to same maximum throughput

Add Capacity via Modernization

New technology increases throughput and capacity; efficiently uses Metro's existing tunnel infrastructure

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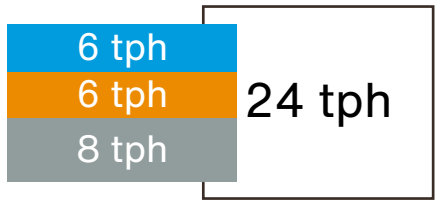
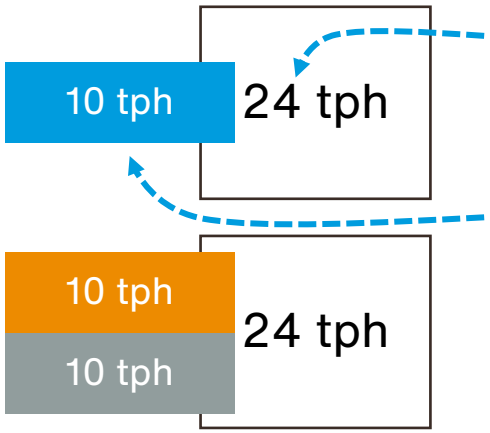


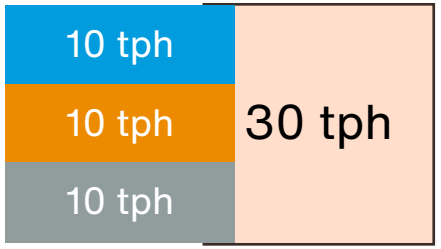
20 trains per hour
Capacity utilization: 83%



New tunnel has the same throughput as the current tunnel

Blue Line service limited by shared tracks with the Yellow Line

30 trains per hour
Capacity utilization: 63%



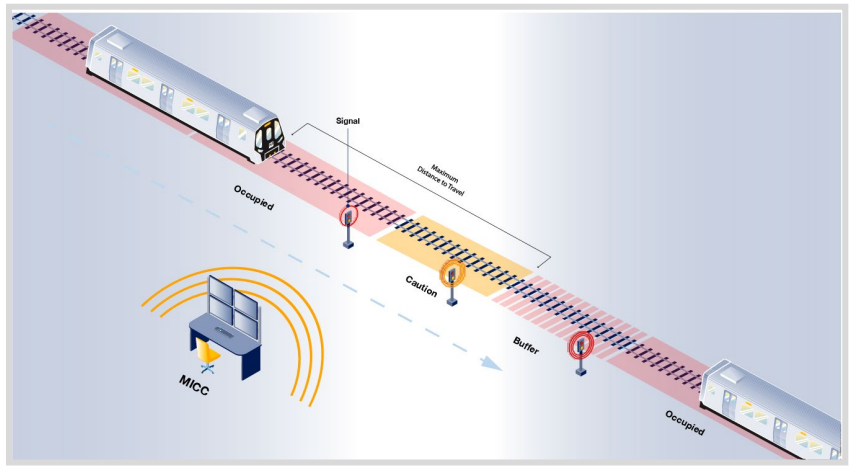
30 trains per hour
Capacity utilization: 100%

Same capacity increase
Same total service delivered
(30 trains per hour)

Rail Modernization enables higher capacity

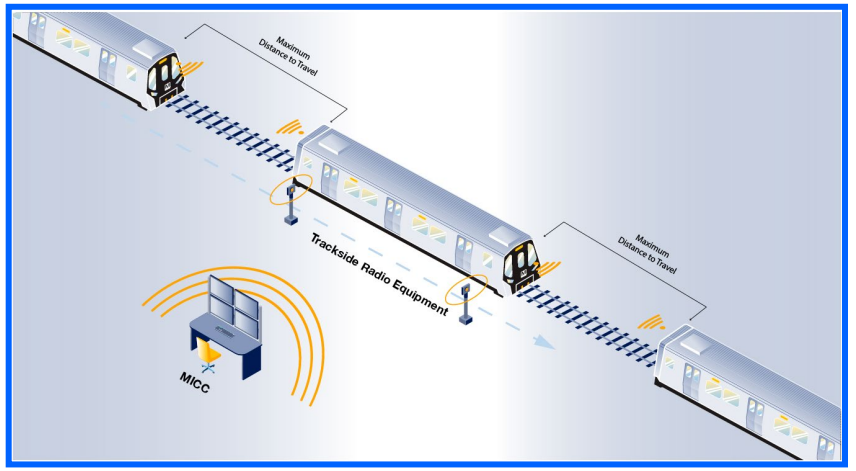
Existing System (As Is)
Train Control System – Fixed Block

- Aging technology
- Increasing maintenance costs
- Decreasing reliability
- Increasing part obsolesce



Future Solution (To Be)
CBTC Moving Block

- Alignment with Global Market
- Reduced Operations & Maintenance Costs
- Increased Reliability
- Address Parts Obsolescence
- Improved Roadway Worker Safety



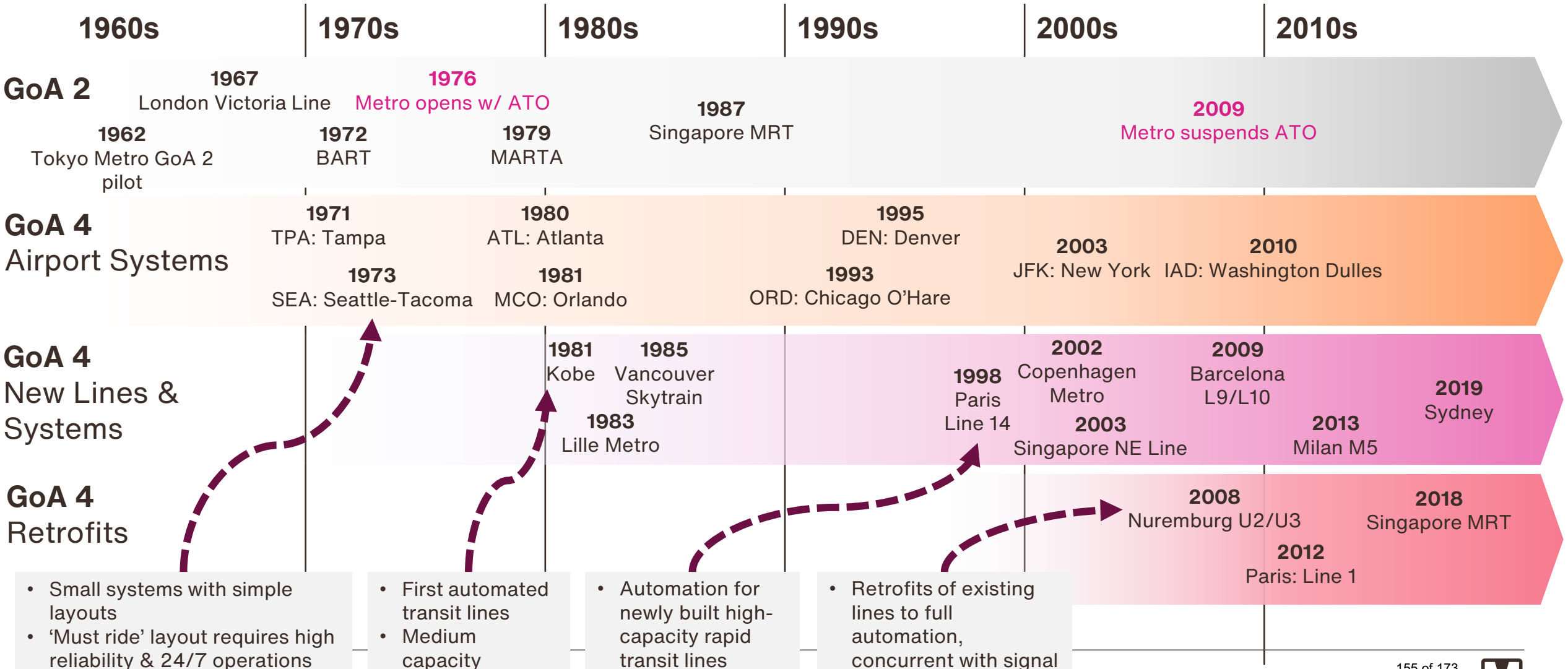
Platform screen doors are a global standard for rail transit systems

Many European systems and most Asian systems have implemented PSDs in some or all stations

Source: The Transport Politic

Automation history

Timeline of selected transit automation milestones



Red Line provides the ideal place to test and validate CBTC before broader deployment

32 route miles

27 stations

3 yards

360 Railcars

Select stations with Platform Screen Doors

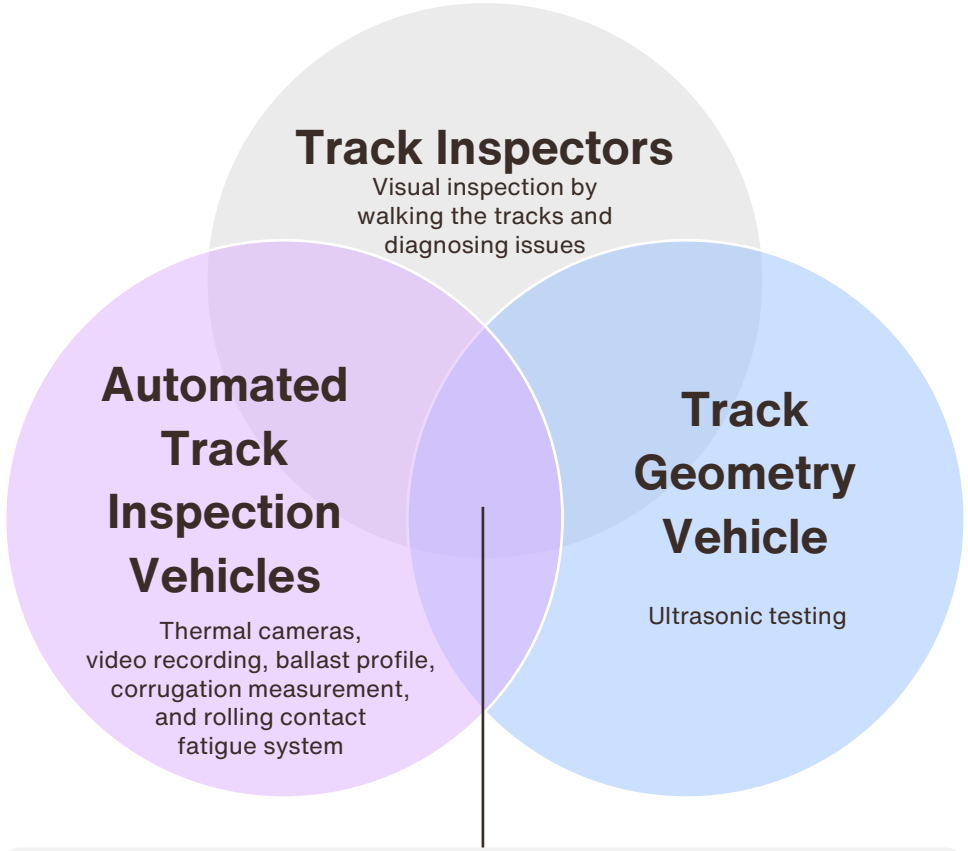
Driving Factors

- **Oldest line** and **least interlining with other Metro lines**.
- Leverages CBTC **provisioning on 8000-Series design**.
- **Delivers full benefits earlier** as compared to other lines.
- Allows **lessons learned to be translated to complex interlined parts of the system**.

Automation will transform current track inspection operations

Automated Track Inspection Vehicles (ATIVs) add new capabilities and sensors Metro does not currently have, and automate Metro's existing visual inspections:

- Automate and improve defect identification and prediction, targeting specific areas for in-person diagnosis and repair
- Use sensors to identify more defects virtually impossible to do with visual inspection alone
- Operate at track speed: reduce needed track time to inspect track and increase in revenue time availability



Both vehicles assess track geometry, rail profile, contact rail geometry, and ATC system monitoring, but **ATIVs can run at full revenue speed and cover the system more frequently**

Appendix 2: Rail Modernization Systemwide Business Case

Retrofitting for automation is less expensive and benefits the whole system faster than building new lines

	Automation Retrofit	New Build Rail Line
Cost per mile	$40 to 50m	$800 to 1,000m
		20x
Rationale	Increase capacity and quality of existing system incrementally	Expand in one area, providing new connections, relieving existing bottlenecks

Federal grants can help fund Modernization

Based on experience from peer agencies, Metro is assuming federal grants can cover 40% of the capital costs for Modernization

Grants for Existing Systems:

Core Capacity: A substantial corridor-based capital investment in an existing fixed guideway system that increases capacity of that corridor

Examples: **BART Transbay Corridor Project**;
MBTA Green Line Transformation; CTA Red & Purple Line Modernization Ph. 1

Grants for New and Expanding Systems:

New Starts: A new fixed guideway system or an extension of an existing system (rail or BRT) with a total project cost ≥$400M and requesting ≥$150M in CIG funding. If BRT project, must be at least 51% in dedicated lanes.

Examples: Maryland Purple Line; Silver Line Phase 1

Small Starts: A new fixed guideway system or an extension of an existing system with a total project cost <$400M and requesting <$150M in CIG funding

Example: Viers Mill Road Flash BRT

Rail Modernization is a good match for the Capital Investment Grant Program (CIG)

Core Capacity grants focus on projects that add capacity to existing corridors; New Starts and Small Starts focus on expanding systems.

In 2020, **BART was awarded a $1.17 billion Core Capacity grant** for their modernization program, including CBTC. The grant covers **43% of the program cost.**

How Modernization delivers value systemwide

Direct cost savings, new revenue, and time and lives saved will offset the upfront costs of investing in new infrastructure.

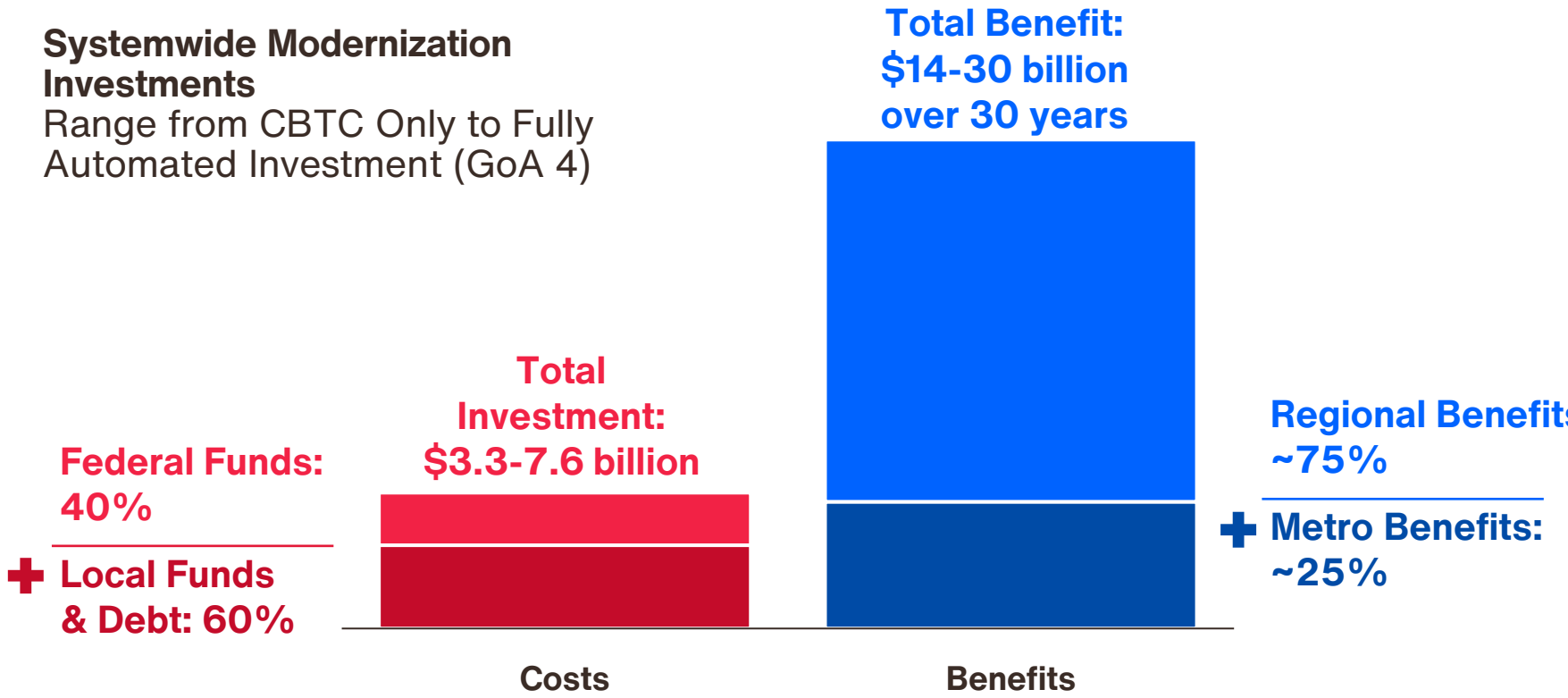
	CBTC	Fully Automated Operations
Metro	▪ Reduced costs for traction power and signal maintenance from system efficiency. ▪ Ridership and revenue growth due to faster speeds and better reliability. **Up to $26M/year of cost reductions** **Up to $32M/year in new revenue**	▪ Significantly reduced costs per car mile from more flexible staffing model. ▪ Ridership and revenue growth due to faster speeds and better reliability. **Up to $57M/year of cost reductions** **Up to $55M/year in new revenue**
Region	▪ Passenger travel time savings due to faster speeds and better reliability. **Up to $160M/year in regional benefits***	▪ Passenger travel time savings due to faster speeds and better reliability. ▪ Value of travel time and lives saved due to automation. **Up to $283M/year in regional benefits***

* Using values of travel time savings, wait time savings, and fatalities avoided from USDOT Benefit-Cost Analysis Guidance.

Systemwide modernization delivers significant benefits to the region

Leveraging local funds to secure competitive federal grants (60% / 40% local/federal split) improves the return on investment considering local funds only

Systemwide Modernization Investments
Range from CBTC Only to Fully Automated Investment (GoA 4)



- Harnessing federal funds reduces the local expenditures required to deliver the program, **increasing the cost/benefit ratio** of the local funding.
- This also allows the program to achieve a positive net benefit to the region earlier after completion.

Expenditures and benefit figures shown here in year-of-expenditure and year-of-benefit dollars. Costs reflect rough order of magnitude (ROM) estimates for considered program scope and timeline and are likely to change as project development advances.

Total Estimated Program Cost

	FY2025 $s	Year of Expenditure $s	Projected Local YOE $ *60%/40% Local/Federal Split*
Communications-Based Train Control (CBTC) and GoA 4 systems	$3.3 billion	$4.7 billion	$2.8 billion
Platform Screen Doors	$2.1 billion	$2.9 billion	$1.8 billion
Total	**$5.4 billion**	**$7.6 billion**	**$4.6 billion**

Costs reflect rough order of magnitude (ROM) estimates for considered program scope and timeline and are likely to change as project development advances.

Appendix 3: Case Studies

Barcelona L9 and L10

Transports Metropolitans **de Barcelona**

Barcelona's Line 9 and Line 10 are fully automated lines using the same trunk line through the center of Barcelona. L9 opened in 2009, followed by L10 in 2010. These two lines were the first fully automated Metro line in Spain. All stations are equipped with platform screen doors.

Trains are controlled from the Metro Control Center at La Sagrera. **L9 also inter-operates with other Metro lines.**

The S9000 rolling stock is capable to run with or without drivers and are also utilized on Barcelona's other lines.

L9 (orange) and L10 (blue) in Barcelona's transit network

Copenhagen Metro

Copenhagen's driverless, light metro system embodies efficient and reliable transit service that also connects to other public transportation

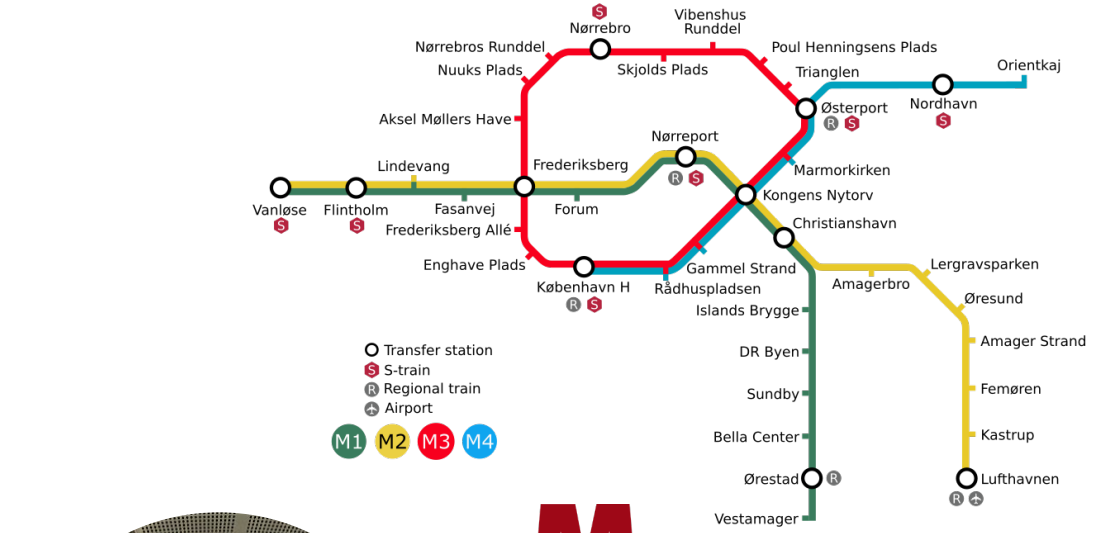
Copenhagen Metro opened in 2002 as a fully automated driverless (GoA 4) system, with a **partial installation of platform screen doors**

Hybrid operations

- Each of the below-ground stations were built with full-height platform screen doors
- above-ground stations did not include doors

Copenhagen Metro originally opted for an **obstacle detection system (ODS)** over platform screen doors at outdoor stations.

However, they **have since converted from ODS to platform gates at outdoor stations** because of performance and reliability issues; too many false positives of track intrusions had trains stopping more frequently.



London Elizabeth Line

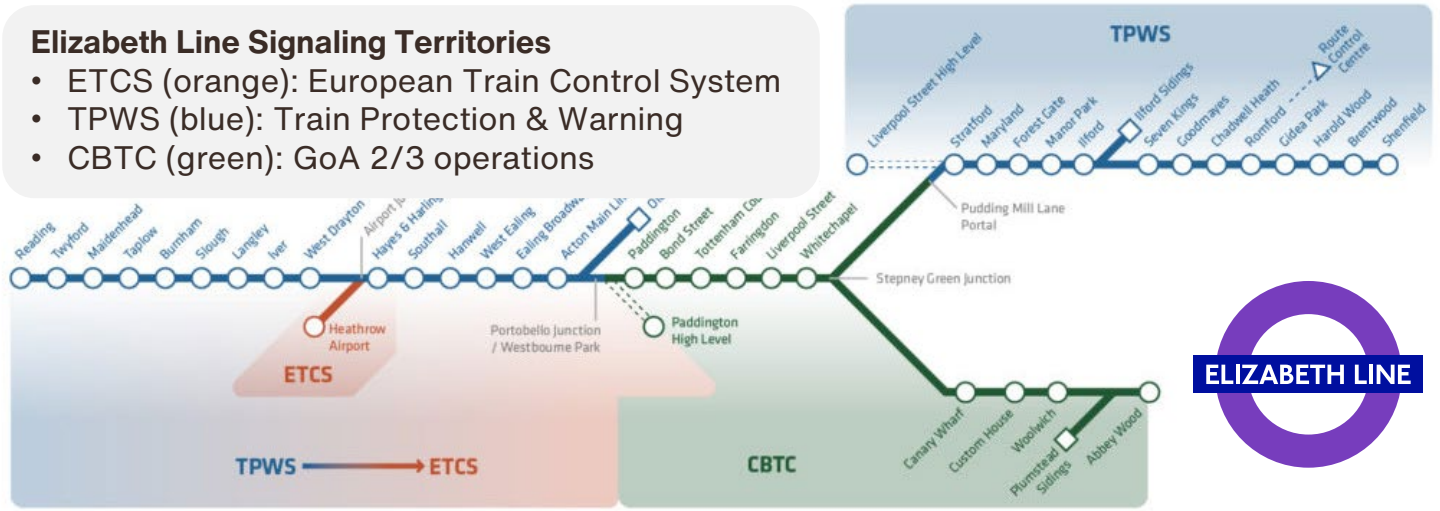
London's Elizabeth Line is one of Europe's largest infrastructure projects related to rail rapid transit, which opened in 2022.

It incorporated a CBTC signaling system for the central section of the line (operating like a Metro) while also being compatible with mainline rail signaling systems for the east and west surface sections (operating on shared tracks with commuter and intercity trains).

The Elizabeth Line's CBTC system is integrated with platform screen doors for additional safety and efficiency. It currently operates at GoA 2 in the core section but **uses GoA 3 automation for reversing moves at terminals**.

Elizabeth Line Signaling Territories

- ETCS (orange): European Train Control System
- TPWS (blue): Train Protection & Warning
- CBTC (green): GoA 2/3 operations



Madrid Metro Lines 6 and 8

Metro de Madrid is retrofitting two lines for fully automatic operation by 2030 to reduce passenger journey times and improve capacity and reliability.

- **Line 6 –** circular line, system's busiest – completed by 2027
- **Line 8 –** connects to airport – completed by 2030

The program was announced in February 2024 and work began March 2025 on Line 6.

The program includes overnight work and segment shutdowns to complete rapidly in just two years.

The program includes major contracts with CBTC and platform doors suppliers. The **timing aligns with new fleet procurement and planned track and power infrastructure renewal** on these lines.

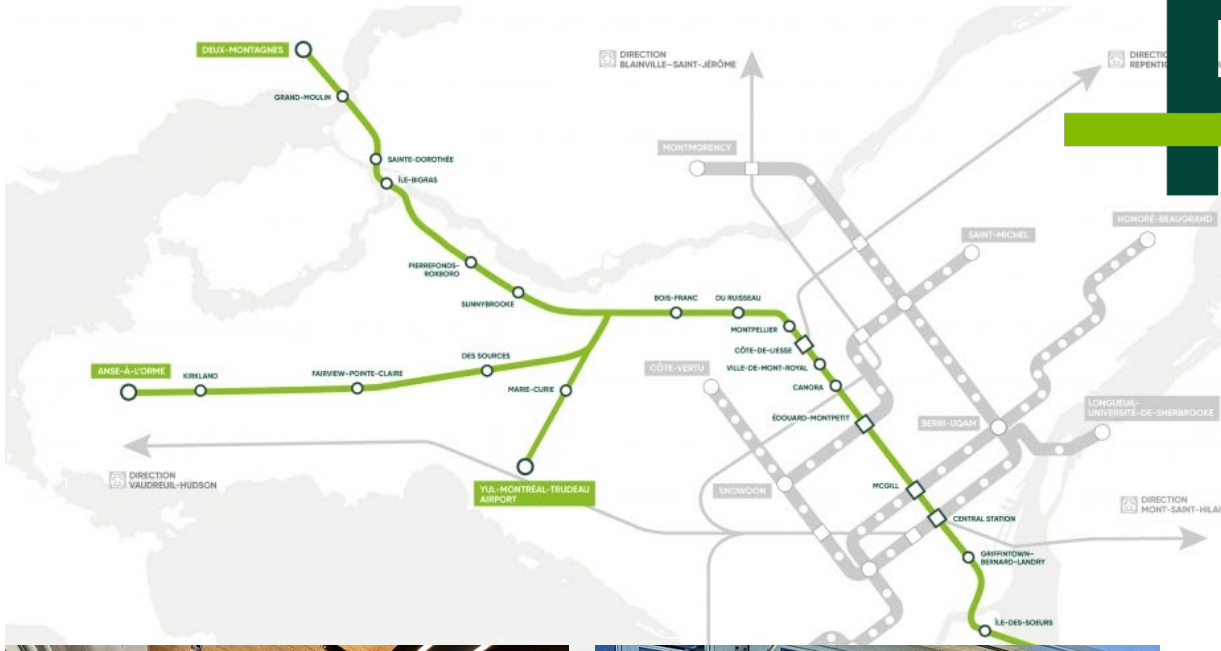
Montreal REM

The **Réseau Express Métropolitain** (Metropolitan Express Network) is a fully automated medium capacity Metro system, built as a complementary network to Montreal's existing Metro system.

The system was announced in 2016; Phase 1 opened in July 2023. The ultimate system will be 42 miles long with 26 stations. Portions of the system are a **conversion of a commuter rail line to automated rapid transit.**

Automation and high frequency service provide the needed capacity, allowing for smaller station footprints (250' long, vs. 500' on the Montreal Metro) to reduce construction cost. All stations have platform screen doors.

Map of REM system, overlaid on Montreal Metro and Commuter Rail



Paris Metro

Notable Figures:
- OTP improved from 79% to 98%
- Capable of 85 second headways

1

Paris Métro is a pioneer for automated transit. In 1998, Paris opened **Line 14**, the first high-capacity automated line in the world.

Following the success of Line 14, officials decided in 2004 to retrofit the 100+ year old **Line 1** (Métro's busiest line) to fully automated operations. Métro completed the retrofit in 2012.

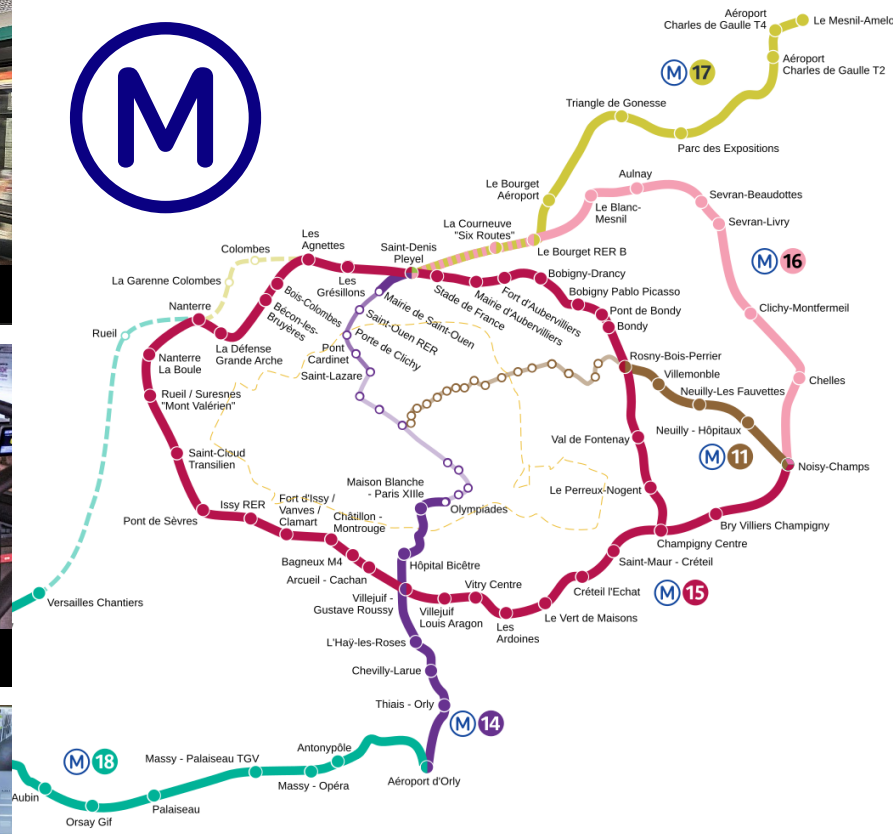
Since then, Métro has continued to build new fully automated lines and retrofit existing ones.

The Grand Paris Express will add 120 miles of automated lines with four new lines & two extensions. Meanwhile, Métro converted **Line 4** to automated operation in 2022 and will convert **Line 13** by 2035.


Line 1 Retrofit


Line 14 New Build


Line 4 Retrofit



Grand Paris Express:
- 120 miles of new Metro routes (opening 2024 to 2030)
- Four new lines (15, 16, 17 & 18)
- Two line extensions (11 & 14)
- 68 new stations

Singapore MRT

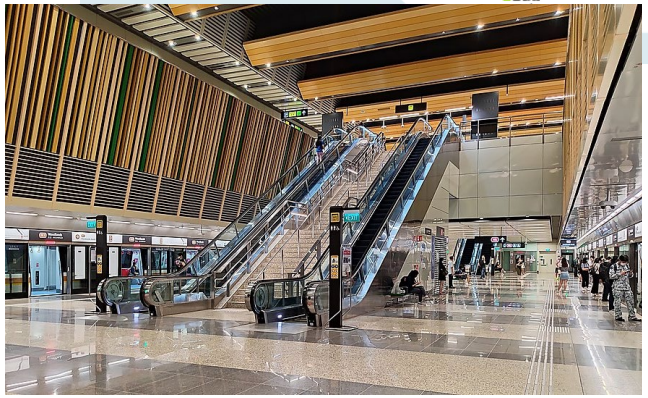
Singapore's Mass Rapid Transit (MRT) system operates six lines serving 143 stations over 150 route miles of track. The entire system is capable of automated operation.

The system opened in 1987 with two lines, the North-South Line and East-West Line. Both of the original lines were **upgraded to CBTC and driverless operation by 2019.**

Four additional lines opened between 2003 and 2020, each fully automated and driverless.

Singapore **pioneered the use of Platform Screen Doors.** The initial lines included platform screen doors at all underground stations, while every above-ground station was retrofit to include doors by 2012.

Automation Retrofits
- North-South Line (red): opened 1987, automated in 2019
- East-West Line (green): opened 1987, automated in 2019



Stockholm Metro

Stockholm Metro (or Tunnelbana) system operates three lines with branching service patterns over 66 route miles of track. Stockholm is currently expanding the system with three line extensions and one new Automated Metro line (the Yellow line).

Yellow Line automation will enable several efficiencies in construction: Trains and station platforms will be ~250’ long (vs. ~500’ on older lines) and will feature platform screen doors. The line will be isolated from the rest of Stockholm’s interlined network.

Long-term plans include converting other lines to GoA 4 automation. The Metro canceled a CBTC contract for the Red Line in 2017 due to delays. However, **new C30 trains delivered in 2019 are designed for future driverless operation.**

Toronto Ontario Line

Toronto's Ontario Line is the city's newest transit project. With a projected service date of 2031, the line will include a **new fleet of driverless subway trains** fitted with CBTC that supports GoA 4 with **90 second headways**. Capacity is expected to be ~30,000 passengers per hour.

The Ontario Line will not be compatible with Toronto's other subway lines, using a different track gauge, train control system, and shorter trains. The line will achieve high capacity with increased frequency from automation. Automation also enables smaller station footprints, reducing construction cost.

Part of the project includes the construction of a **new digital control center, platform screen doors, and a maintenance and storage facility**. Hitachi rail will maintain and operate trains and the line for 30 years.

Ontario Line (blue) and connections to Toronto's transit network