RATP DEV

Unlocking the Full Potential of Automated Metro

Insights from the Global Ecosystem

RATP GROUP

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UNLOCKING THE FULL POTENTIAL OF AUTOMATED METRO

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Dear reader,

We are pleased to share with you this study, “Unlocking the Full Potential of Automated Metro – Insights from the Global Ecosystem.”

Automated metro has now reached a high level of maturity and is widely recognised as a proven solution. Its performance is the result of the long-standing involvement of public transport authorities, operators, manufacturers (OEMs), engineering firms, contractors, financiers and partners who study, design, deliver, finance, operate, and upgrade these systems across greenfield and brownfield projects, in very diverse urban contexts.

Today, the question is no longer whether automated metros perform. It is how to consistently unlock their full potential and ensure long-term success over time.

This study builds on this accumulated experience. It draws on more than 30 interviews with key actors from across the automated metro ecosystem, complemented by contributions from RATP Group specialists. Together, they help identify the key success factors that make the difference in delivering robust, high-performing, and sustainable automated metro systems.

We hope this collective work will contribute to the continued success and evolution of automated metros worldwide and help Public Transport Authorities address current and future challenges.

We wish you an insightful read,

Edgar Sée
RATP Dev
Deputy Director, International Business Unit

Fabien Gervois
RATP Dev
Automated Metro Director

Executive Summary

Automated metro systems are now widely recognised as proven solutions for high-capacity needs. They have demonstrated a distinctive combination of benefits at scale: higher performance, stronger reliability and improved energy efficiency.

Drawing on insights from over 30 interviews across the automated metro ecosystem, complemented by RATP Group expertise, this report identifies the key success factors to consistently unlock performance across greenfield and brownfield projects.

01

Build strong governance and adopt collaborative contracting models

Challenge: Automated metro projects involve many actors. Multiparty projects can suffer from fragmented governance and differing priorities, which slow decision making.

Key success factor: High-performance automated metros require aligned objectives across authority, operator, engineering and industry partners. Alliance type or collaborative contracts drive shared risk, faster issue resolution, and "Best for Project" behavior. Their exact form depends on local rules, but transparency and shared goals consistently improve outcomes.

02

Involve the operator early to secure the operational concept, operability and long-term performance

Challenge: In greenfield projects, systems sometimes underperform because initial specifications do not fully reflect real operating needs and conditions at the time of commissioning nor anticipate how these needs evolve over the system's lifecycle.

Key success factor: Performance is secured when experienced operators shape functional requirements early, steer system design, define operations-maintenance interfaces, while embedding a forward-looking operational vision that anticipates future needs (such as traffic growth, upgrades, extensions). Early operator involvement appears as a universal success condition across authorities, manufacturers (OEMs) and engineers.

03

Make automation a human-centric transformation while managing technical complexity

Challenge: In automation and modernisation projects on existing lines, technology maturity does not eliminate complexity. Deploying new automated systems without disrupting operations remains a major technical, human and operational challenge. Automation reshapes roles, and without clear staff engagement, performance gains remain fragile.

Key success factor: Successful projects involve teams early, explain each step of the transition and give visibility on future roles. Combining early team engagement with strong project management and specialized expertise is essential to automate existing lines without compromising everyday operations.

04

Anticipate obsolescence and prioritise adaptable systems

Challenge: Obsolescence is one of the industry's main risks. Technology cycles continue to accelerate, moving faster than metro lifecycles and creating growing obsolescence risks that affect cost, reliability and maintainability. This acceleration also puts pressure on skills, as systems must be maintained and upgraded over long periods despite occasional technological shifts.

Key success factor: Using open standards, modular designs and long-term support agreements help manage these risks. Early discussions with suppliers also help secure future upgrades. Designing for long-term evolution, not only for initial commissioning, is now essential.

05

Deliver a continuously improving passenger experience

Challenge: Automation alone does not guarantee passenger satisfaction. Expectations continue to evolve, and passengers assess the overall experience including feeling of safety, accessibility, comfort, wayfinding and service regularity.

Key success factor: Providing reliable operations, clear, consistent and real-time information, a visible and reassuring human presence, and well-designed stations and passenger facilities build passengers trust in the metro system. Continuously improving the passenger experience therefore requires ongoing innovation and the ability to adapt solutions to local needs.

06

Leverage data, AI and innovation to boost performance, reliability and reduce lifecycle costs

Challenge: Automation creates potential, but only if data is reliable and usable. Without reliable data flows and predictive tools, automated metro systems cannot reach their full potential. At the same time, increased connectivity expands exposure to cyber threats.

Key success factor: Condition-based maintenance, AI-supported supervision, robotics and targeted operational innovation, embedded in robust cybersecurity frameworks, can maximize performance and reduce lifecycle costs. Each network moves at its own pace, but a culture of continuous, data-driven improvement makes a clear difference over time.

07

Position the automated metro as a sustainable and resilient backbone of urban transformation

Challenge: Automated metro systems must support broader urban objectives. They should be seen not only as transport lines, but as key backbones for urban development and major contributors to cities' sustainability and resilience goals.

Key success factor: Success lies in fully leveraging the environmental and resilience value of automation, notably through energy-efficient driving and rapid service adaptation. Aligning automated metro projects with urban strategies, such as transit-oriented development, and leveraging infrastructure for complementary services, including fibre optics or heat recovery, maximizes long-term urban performance.

Introduction

This study sets out a clear conviction: automated metro systems will be a cornerstone of urban mobility in the years ahead, but delivering their promise requires more than technology.

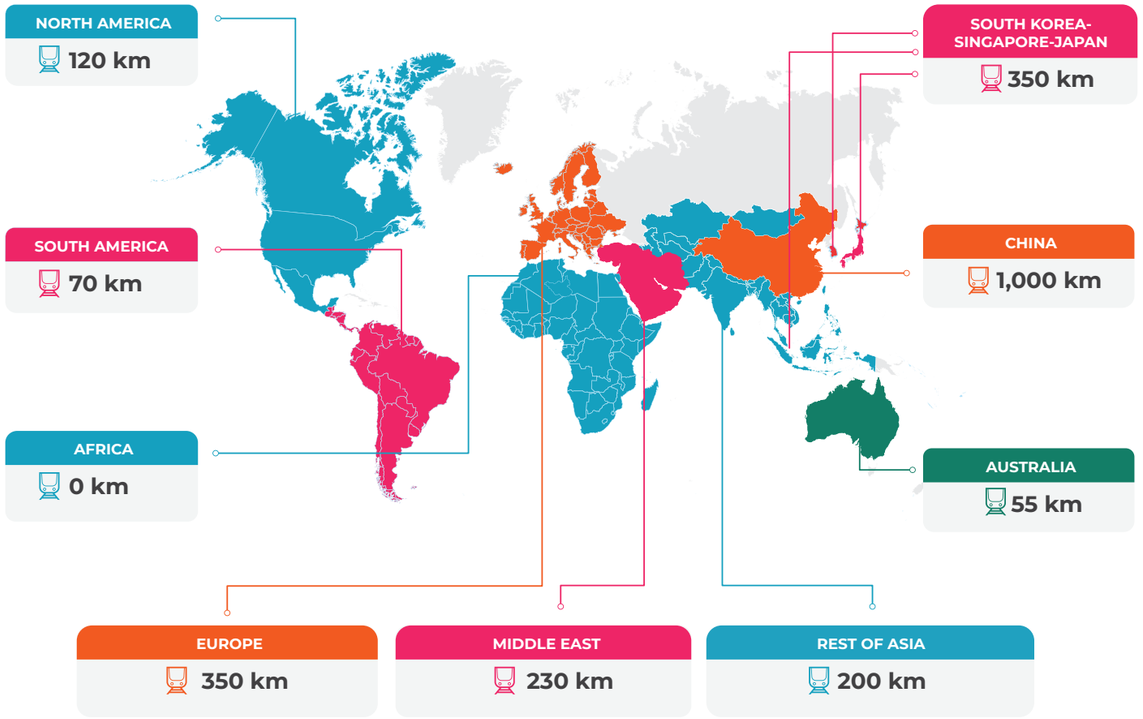
Automated metro systems have a long and well established operational track record. From greenfield projects in fast-growing cities to brownfield transformations in mature networks, they have consistently proven their ability to deliver a high level of safety, while also raising performance and reliability at scale.

The future of automated metro will be shaped by worldwide networks expansion, through brownfield conversions within existing systems and greenfield lines in growing cities. The next step is to unlock the full potential of automation, by mastering complexity, enhancing resilience and strengthening collaboration across the value chain.

The next frontier lies in adapting to increasingly diverse contexts and rising expectations.

The global GoA4 network is currently exceeding 2,300 km and is projected to double by 2030[1]. Yet future growth will depend on the ability to manage technical complexity, evolving financing models and stronger cross-stakeholder partnerships.

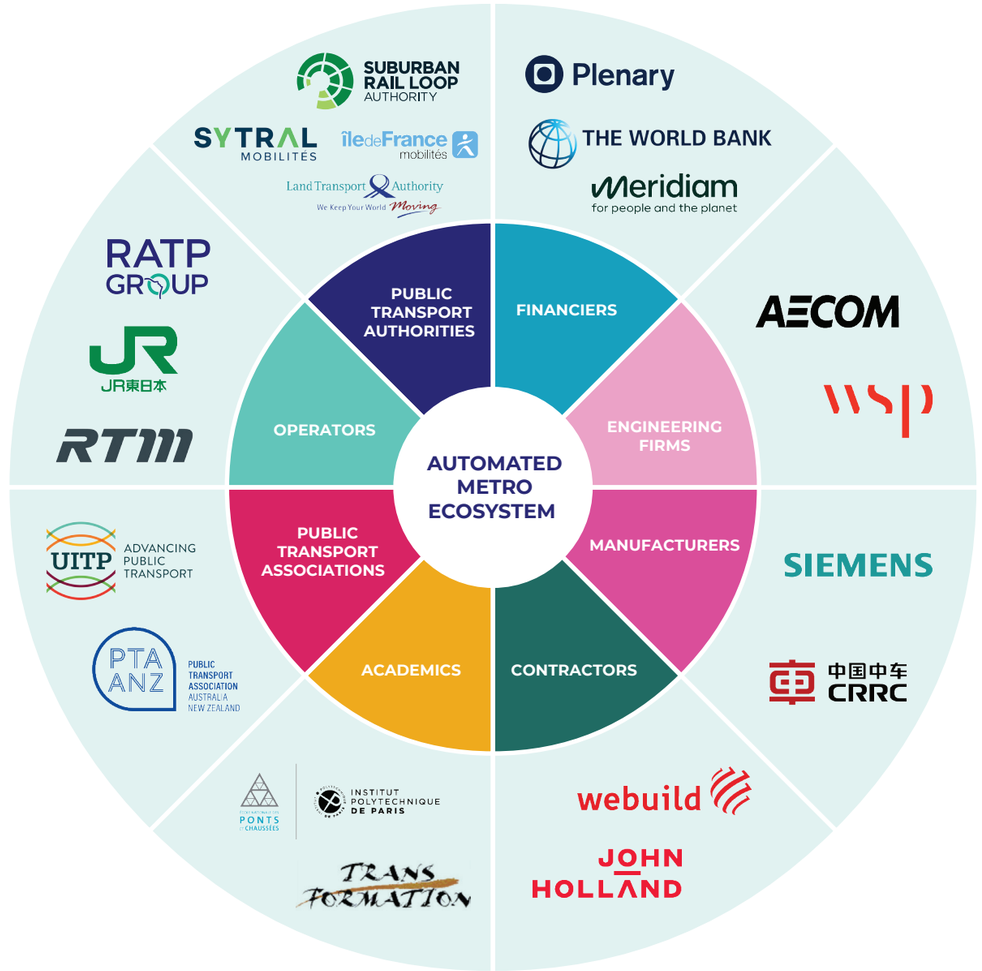
Global Automated Metro Footprint 2025



[1]Railway Gazette International, Automated Metro Market Analysis, February 2024

Methodology

This study, conducted by RATP Dev in 2026, is based on more than thirty interviews with stakeholders across the automated metro ecosystem, representing a wide range of geographies and industry perspectives. It also draws on the broader expertise of the RATP Group, with a particular contribution from the Automated Metro Experts Club. Together, these insights provide a comprehensive, cross-regional understanding of the key trends shaping automated metro systems.



Part I

Automated Metro Systems as the New Standard

From Breakthrough to Baseline: Automated Metro as the Benchmark for High-Capacity Mobility

Automated metro as the natural solution for high-capacity needs

Across the ecosystem, a clear consensus has emerged: Public Transport Authorities, operators, engineering firms, civil works contractors and Original Equipment Manufacturers (OEMs) increasingly share the same conclusion: automated metro systems have become the reference standard for high-capacity urban rail. This reflects both technology maturity and a growing body of operational experience, which together have shifted automated metro from a differentiating innovation to an established delivery model.

Beyond this finding, the ecosystem is also converging on how automated metros should be delivered: performance hinges on disciplined collaboration to manage interfaces across all actors and keep the system coherent end to end. While automated metros are no longer experimental, capturing their full value remains demanding. Success depends on embedding technology into the right governance and operational readiness, through operating model design and workforce preparation, to long-term stewardship of performance, and, over time, upgrades and innovation.

Ultimately, automated metro should be pursued only where it addresses a genuine operational or capacity need.

A proven and scalable system, backed by decades of operations

Automated metro systems have evolved from breakthrough innovation to a global standard, supported by a mature ecosystem, and decades of operational know-how. For greenfield projects, driverless operation is increasingly the baseline choice.

This shift has been enabled by the maturity of core technologies, especially CBTC (Communication-Based Train Control), which have progressed through multiple generations and are now deployed worldwide in a wide range of network configurations. The technology stack is broadly proven, with a growing ability to upgrade and migrate systems progressively, although these transitions remain complex and require deep experience to execute safely.

Maturity has also aligned perspectives across the ecosystem. Suppliers, engineering partners and civil works contractors have scaled globally, test and validation capabilities have strengthened, and operators have accumulated experience in driverless operations. This effectiveness comes from a distinctive combination of benefits: capacity uplift through reduced headways and stable operations, stronger reliability through independence from driver availability, greater adaptability through more flexible service patterns, enhanced safety through continuous speed control and platform protection, and increased energy savings through system-level optimization.

> *All metro lines will eventually become fully automated; it's only a matter of time.*

Eric Peissel
WSP
Global Director Transport & Infrastructure

> *The return on investment of automation is well established: operational and financial gains are significant, including energy savings around 15-20%.*

Sophie Espié
Siemens Mobility France
Strategy, Sales and Bids Director

Urban pressures make automation the perfect match

Cities are facing a converging set of pressures: rapid urbanization and demographic concentration, worsening road congestion, and tightening climate constraints. These pressures raise expectations for mass transit systems that can absorb growth while remaining reliable, attractive, and sustainable over the long term.

In rapidly developing cities, automated metro is a practical and powerful response to congestion and a lever to shift demand away from private cars. This modal shift requires a level of service, high frequency, regularity and operational consistency that can compete with the perceived convenience of driving. These dynamics often correspond to greenfield contexts, where new networks are built to structure urban growth.

In mature networks, the challenge is to raise capacity on constrained assets, since expansion is often slow, disruptive, and politically difficult in dense environments. In this brownfield setting, higher grades of automation unlock additional robustness on existing lines. They support more stable high-frequency operations and offer greater degraded-mode flexibility, with more recovery levers to contain disruption, without relying solely on costly infrastructure expansion.
Climate pressures reinforce this trajectory. Cities must accelerate the shift towards low-carbon mobility, making high-capacity metro a cornerstone of decarbonization strategies. At the same time, they must adapt to more frequent extreme conditions, such as heatwaves, storms, and flooding, by improving travel conditions for users and ensuring the reliability of infrastructure.

Public buy-in: automation is increasingly understood, accepted and expected

Automated metro systems are increasingly perceived as a legitimate and desirable urban standard by cities and communities. In the Paris region, Professor Jean-François Révah (Trans/Formation) highlights the remarkable level of public acceptability achieved by automated metros, an outcome that is not a given in major public service transformations. This acceptability has been fostered by the high level of trust in automated metro systems, proven to be highly safe and reliable.

Acceptance has become expectation. In many parts of the world, the driverless dimension is no longer a central question; what is expected is a tangible, high-quality experience. Beyond core performance, short, reliable intervals and stable regularity, networks are increasingly judged by the quality of the everyday journey they deliver. Automated metros meet these expectations. They support service continuity and operational agility, such as extended service hours and capacity adjustments, reinforcing the value of a metro that “keeps running” in daily life.

Sustaining acceptability over time requires maintaining trust after commissioning. Trust depends on disciplined degraded-mode management, combining technical recovery with credible passenger information and visible reassurance when incidents occur. This calls for an operator with proven capability to embed these practices into day-to-day operations and governance.

The decision to implement an automated metro system is primarily driven by the line’s operational complexity and capacity requirements.

Stéphane Maillet

Île-de-France Mobilités
Head of Transportation System Engineering Department, Rail Division

Automated metro has become the obvious choice. It offers major advantages: very high capacity (high Passengers Per Hour Per Direction), flexibility to adapt service levels, and the ability to encourage modal shift.

Federico Antoniazzi

Ecole des Ponts
Director of Advanced Master in Railway and Urban Transport System Engineering

Our mission is to move more people more efficiently. And to do that, automated metro system are the answer now. An automated metro should act as the city’s backbone, guiding communities to connect and thrive within the evolving urban landscape.

Marco Assorati

WeBuild
Senior Executive Vice President Operations

In the USA, people can feel a bit insecure to take automated driverless metro systems due to the lack of physical presence. We need more demonstration projects to showcase the benefits of automation and to reassure the public about passenger safety.

Veronica Vanterpool

AECOM
Senior Vice President Americas Transit Lead

Reshaping Cities

Automated metro as a catalyst for urban vitality and attractiveness

Automated metro systems reshape cities by acting as a high-capacity backbone that expands access and makes urban mobility more efficient. By providing dense, predictable service, they help relieve congestion and reduce the economic cost of time lost in traffic, strengthening day-to-day productivity for commuters. Automated metros also reinforce urban connectivity by linking key destinations such as airports, major employment areas, hospitals, education facilities and event venues to city centers and metropolitan hubs. This improved access supports more inclusive urban growth, particularly where mobility constraints would otherwise reinforce spatial and social inequalities.

Automated metros can also strengthen a city's attractiveness by projecting modernity and high service ambition, and by reinforcing its position among global peers. This value becomes especially visible during major events, when automation enables extended service hours and rapid capacity adjustments when demand peaks, capabilities that are harder to mobilize in conventional operations due to staffing and operating model constraints.

Beyond mobility, automated metros contribute to the transformation of station precincts and to broader real-estate dynamics. New or renovated metro stations can transform neighborhoods by improving accessibility and supporting wider urban regeneration, attract investment, and accelerate transit-oriented development. In the Paris region, the Grand Paris Express is designed to transform neighbourhoods around 68 new stations, supporting large-scale redevelopment. A similar logic underpins Sydney Metro - Western Sydney Airport line, linking residential areas, the new airport and job hubs within the Aerotropolis Bradfield city center.

Economic impact also comes through jobs and skills. Automation redefines rather than removes human roles: it shifts value toward continuous, higher-skilled activities (maintenance engineering, system integration and qualification, cybersecurity, and supervision from control centers), while keeping strong field roles for passenger support and station operations. This creates sustained employment needs and pathways for local recruitment and upskilling.

Smooth and safe passenger journeys

For passengers, the value of automated metro is measured in the quality of the everyday journey. Automation enables frequent, regular and predictable service, shaping a smooth travel experience that passengers quickly come to rely on. In many projects, automation programs create the opportunity to deploy latest-generation rolling stock, station equipment, and passenger information systems. This can improve comfort, reduce noise, and provide clean, well-maintained facilities along with state-of-the-art passenger information.

Safety is another core impact. Automated operation strengthens safety through continuous supervision and control. Platform screen doors, in particular, help keep platform areas safe while supporting smooth passenger flows and service regularity on busy lines. More broadly, automation contributes to safer operations on high-traffic lines as part of an overall uplift in performance and quality of service.

Beyond functional safety, perceived safety and comfort reinforce the everyday confidence passengers place in the system. Automated metro networks are increasingly expected to deliver a welcoming environment with state-of-the-art passenger information that remains actionable during disruptions, and in some contexts, reassurance by visible staff presence, especially in the earlier stage of line opening.

Together, reliable access, safety and comfort build trust in the service, encourage sustained mode adoption, and support confidence in the wider transport network.

Paris Line 14 - Expanding mobility, diversifying users

Paris Metro Line 14 illustrates how an automated backbone can reshape mobility patterns and broaden the diversity of users. After an unprecedented extension program launched in 2015, the line now connects Saint-Denis-Pleyel in the north to Orly Airport in the south, changing its scale and role within the network. By linking central Paris to a major airport in around 20 minutes, Line 14 attracts new passenger profiles beyond daily commuters—tourists, business travelers, and occasional users—while maintaining a high-quality experience for frequent riders.

This shift supports wider social objectives: improved accessibility with stations equipped for reduced-mobility users, more equal access to the city's resources (e.g. hospitals and education facilities), and contribution to the energy transition through reliable, high-frequency mass transit. The project also embeds local inclusion mechanisms: for the southern extension alone, 460,000 integration hours were planned to support recruitment of residents facing barriers to employment.

In short: Line 14 shows how automation and extension can simultaneously raise performance, diversify ridership, and strengthen social impact.

As Melbourne grows, fast, regular and reliable trains will unlock fantastic opportunities to bring more homes, jobs and services within walking distance of the new stations.

Jamie Burn
Suburban Rail Loop Authority
Package Director, Linewide & Operations

Automated metro and rail are a major opportunity for us. With an ageing population, our goal is to focus staff more on customer service and less on pure operations, enabling more human-centered services.

Kenji Murasaki
JR East
Division Senior Manager

Automation as an accelerator of energy efficiency and decarbonization

Automated metro systems support cities' decarbonization strategies. Automation reduces energy use within the rail system. It enables regenerative braking, which can recover around 30% of braking energy compared to mechanical braking. Consumption can be optimized through line profiles and coasting, and energy-saving speeds in off-peak periods. Frequency can also be adapted to passenger volumes, improving efficiency while maintaining service quality. Tangible results are already reported on a long-term basis. In Paris, Metro Line 4 has shown a 15% reduction in energy consumption since automation. On Line 14, the latest-generation MP14 trains deliver electricity savings through regenerative braking and improved design, thereby achieving a stable overall electricity consumption even as the line length has doubled.

Environmental impact is not limited to traction energy. As with any new transport network, automated metro programs increasingly address air quality in metro spaces by reducing particulate emissions, for instance through optimized electric braking, and by strengthening ventilation and maintenance practices. They also target station energy use through solutions such as geothermal systems and more efficient heating and cooling.

More broadly, automated metro projects are also an opportunity to embed environmental requirements from design and construction, since civil works and materials can represent a significant share of lifecycle carbon. This reflects the growing environmental commitments of public transport authorities, which increasingly seek to manage carbon impacts across the full project lifecycle. It reinforces the value of whole-of-life approaches, aligning low-carbon design choices, construction methods, and long-term operating performance.

Riyadh Metro - Driving transformation nationwide

Riyadh Metro illustrates how a greenfield automated network can reshape mobility habits at the scale of a capital city. Delivered in a single phase, it comprises six automatic lines, totalling 176 km and 85 stations, and transported over 200 million passengers between December 2024 and March 2026, reflecting rapid uptake in a city long dominated by private cars. Beyond ridership, its core value is time. By offering fast, frequent and predictable journeys, it can outperform peak hour car travel and turn time saved into economic value and quality of life.

The project is also driving a visible social inclusion shift. The metro enables greater autonomy for many women and young people, by offering access to jobs, education, services and major hubs such as the King Abdullah Financial District without the need for family drivers, taxis or informal arrangements. Inside stations and trains, the system also creates new shared public spaces where different groups coexist, making public mobility part of daily urban life in a society where it was previously limited. Complemented by an 89-line bus network spanning a vast, heat-constrained city, the metro is progressively reshaping everyday life in Riyadh.

Finally, Riyadh Metro is contributing to the emergence of a public transport sector in the country, creating new operational roles and supporting skills development through training and local upskilling pathways.

In short: By transforming everyday mobility habits and accelerating inclusion, Riyadh's automated metro is creating a step-change in a country where mobility was long dominated by the private car.

Automated metro projects are attractive assets. They are reshaping cities, delivering sustainable high-quality services.

Patrick Lauren

Plenary
Chief Investment Officer

Key Takeaways

01

Automated metro is accepted and increasingly expected

Across cities and communities, automated metros are now perceived as a legitimate urban standard. For passengers, acceptance has matured into expectation: the driverless dimension is no longer the key question; what matters is the "everyday experience" — short, reliable intervals, stable regularity, comfort, and clear, actionable information. Sustaining this trust over time depends on disciplined operations and credible reassurance in degraded modes.

02

Four decades of operations have proven the case at scale

With more than 40 years of operational track record, automated metros have demonstrated a distinctive combination of benefits at scale: higher capacity and performance, stronger reliability, and improved energy efficiency. Automation also supports cities' decarbonization strategies by enabling a modal shift away from private cars, reducing emissions and local pollution. Beyond climate impact, automated metro creates broader economic and social value by reducing congestion costs and supporting more inclusive urban growth.

03

The ecosystem is aligned, and the next frontier is to unlock full potential through experienced operations

Across the value chain, stakeholders increasingly converge on automated metro as the new standard. This convergence reflects a mature ecosystem, built on decades of delivery and operating experience, and a clearer view of what drives success. A key lesson is that performance comes from collaboration and interface discipline across all actors, from design through operations. The next frontier is to unlock the full potential of automation.

Part II

Building the foundation for success

Secure project delivery and operational readiness

Forge a strategic pathway from vision to delivery

Automated metro starts with a long-term pathway that connects investment planning, rolling stock strategy, system technology, and infrastructure readiness into one realistic roadmap. For Public Transport Authorities, the first step is to define the end-state objectives. This should address both future demand and technology change, so the system can scale with ridership and evolving requirements. The next step is to translate objectives into staged decision points and prerequisites. The pathway should match the authority's capabilities and translate into a delivery model with clear governance and interfaces.

For greenfield projects, line planning is embedded in broader urban development strategies. The pathway must integrate land use and station location, permitting and environmental constraints, and corridor preparation, including interfaces with utilities and, where relevant, land acquisition. Early advisory needs therefore combine mobility planning, urban integration and delivery strategy to select the most suitable contractual setup.

For brownfield programs, rolling stock renewal or the obsolescence of the signalling system is often the trigger for Public Transport Authorities to launch the automation pathway. The trigger could be also the need for higher performance in operations that cannot be achieved by the legacy system. This automation pathway should start with an infrastructure and constructability assessment, to confirm that existing civil works and station layouts can accommodate the automated metro and its interfaces (for instance, the installation of platform screen doors). In many cases, a direct switch to full automation is feasible and recommended as it avoids building intermediate solutions that later require significant redesign to reach higher automation grades. If a Public Transport Authority opts for a gradual approach, automation can start with enabling upgrades such as platform screen doors and progress from GOA2 to higher grades.

Anticipating and managing risks

Automation does not remove risk, it changes where it sits and how it must be managed. For Public Transport Authorities, the objective is therefore not to "avoid risk", but to keep control through disciplined governance, clear ownership across the value chain, and an operating model able to respond reliably in day-to-day service. Interviewed stakeholders highlight four risk families that require upfront attention in automated environments: cybersecurity, safety in degraded modes, obsolescence, and operational fit with maintenance and passenger needs.

Cybersecurity is a prerequisite to sustaining reliable performance. Automated metros use open and connected systems, remote access and, in some cases, cloud-hosted components, which increase exposure and make protection an integral part of system design and operations. A core difficulty is to reconcile two logics: in IT, protection improves when patches are applied quickly, while in safety-critical environments, stable and safety-approved configurations limit change. Managing this tension requires clear interface responsibilities, controlled access and configuration practices, and rigorous change control and testing.

Automation strengthens the safety model through consistent system control and, where implemented, platform-edge protection. Yet driverless operations change the posture in degraded situations. With no staff onboard, incidents can escalate faster if passengers feel unattended. Maintaining confidence depends on fast detection and response, rapid mobilization of field and station teams, and communications that remain available in degraded situations.

> *The most important success factor for any major project is a shared vision. Authorities, operators, and industry must be aligned on the ultimate goal: creating efficient, livable outcomes for the community.*

Lauren Streifer
Public Transport Association Australia and New Zealand
Chief Executive

Obsolescence is becoming more central as metro systems become more software- or IT-intensive. Digital components, such as telecoms and passenger-facing systems, tend to reach obsolescence faster than traditional rail assets, driven by innovation and rising expectations. In addition, over time, some components may no longer be produced, making metros difficult to maintain in operational condition if sufficient spare parts have not been stocked or secured. Long-term performance depends on planning for upgrades, patching and renewals as part of normal lifecycle management. This requires clear responsibilities across suppliers, an explicit upgrade strategy, and contract mechanisms that make incremental evolution predictable rather than exceptional. Some Public Transport Authorities go further by contracting product support and maintenance horizons over decades for key components, to secure continuity and control costs over time.

Finally, interviewees cautioned against deploying a system that is technically compliant but misaligned with operational requirements and passenger expectations. An inadequately designed system can lead to significant operational cost overruns and recurring service issues.

The performance of automated metros is both their strength and their challenge. By conditioning passengers to expect exceptional reliability, even rare incidents become much less acceptable. The real issue is therefore no longer just reliability, but maintaining trust when the unexpected occurs.

Jean-François Révah
TRANS/FORMATION
Psychosociologist and President

While private investment remains largely untapped, securing funding continues to be the greatest challenge.

Veronica Vanterpool
AECOM
Senior Vice President Americas Transit Lead

Cybersecurity: a mastered condition for reliable automated operations

Cybersecurity is now part of business as usual for automated metros. As modern networks rely on digital components across signalling, supervision, station systems and passenger services, protection cannot be treated as a standalone IT topic. It supports the same objective as the rest of the program: sustaining safe, reliable performance and passenger trust over the long term.

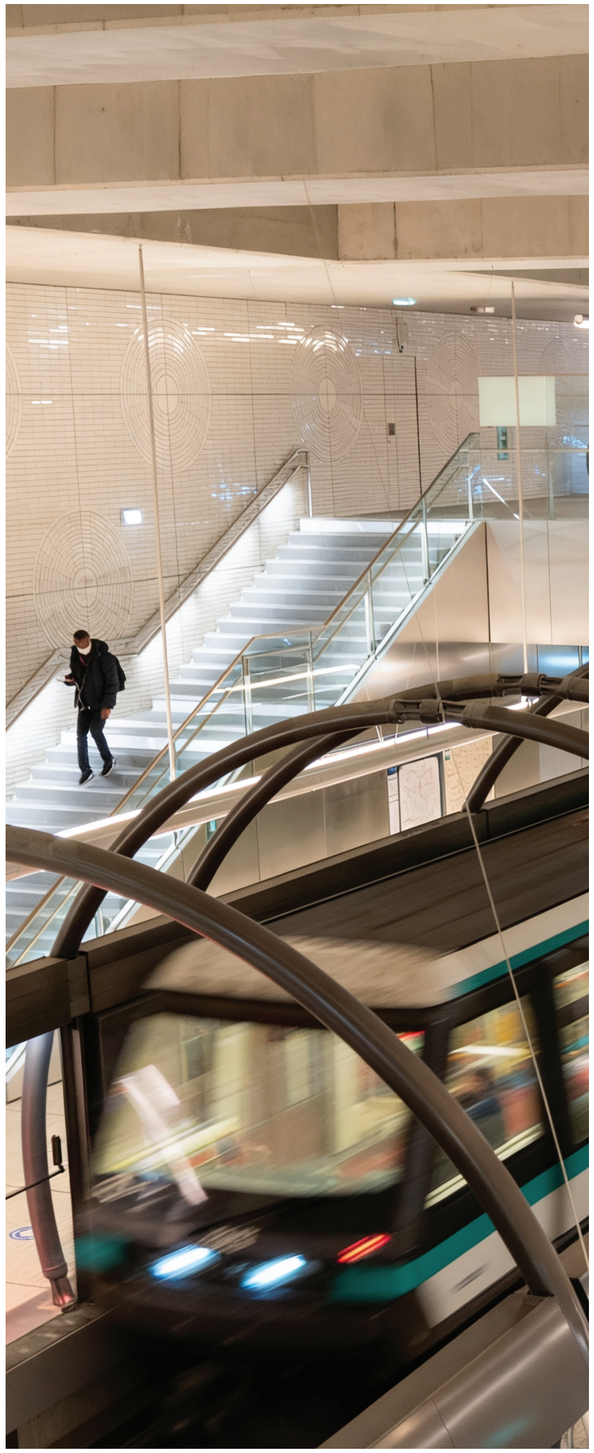
Effective approaches start early, with clear cybersecurity requirements embedded in specifications and acceptance criteria, then carried through disciplined governance across the value chain. Cyber requirements are increasingly framed by recognized industry standards, making compliance easier to specify and measure. The Public Transport Authority, operators and suppliers must each own their responsibilities and interfaces. In practice, this translates into identifying critical assets and implement proven measures to ensure business continuity, such as secure architecture and segmentation, controlled remote access for maintenance, strong authentication and access rights, robust operating and maintenance procedures, and continuous monitoring adapted to rail constraints.

Cybersecurity is sustained through operational routines, and through organisation and design choices that make the system resilient in crises. Regular testing, updated training, and structured incident readiness keep the system resilient in day-to-day operations as technologies evolve. It also requires clear maintenance responsibilities and legal and regulatory compliance to keep decision-making reliable when events occur.

In short: Cybersecurity is a manageable part of automated metro delivery, provided it is treated as an end-to-end discipline embedded in design, governance, operations and maintenance.

In such projects, time to market is long. What we specify at the start is often no longer valid by the time the metro becomes operational.

Russell Jackson
AECOM
Global Transportation Chief Executive



Belgrade metro: bringing the operator lens upstream to secure delivery

Belgrade is structuring its first fully automated metro as a multi-line program, with three planned lines and a delivery timeline stretching over several years. This project stands as the largest and most significant infrastructure initiative in the Republic of Serbia today. In such a context, value is unlocked when collaboration is engineered early, before design and construction choices become difficult to reverse.

The City of Belgrade awarded and then renewed an "Early Operator Assistance" contract, asking RATP Dev to review and advise on functional design and specifications, with a focus on passenger experience, safety, operations and maintenance concepts, and life cycle cost optimization.

In short: Early operator involvement helps translate design choices into operable and maintainable realities, reduce interface risk across packages, and secure smoother readiness and handover.

System obsolescence is a strategic risk that must be proactively managed and fully embedded into long-term O&M and life-cycle contracts.

Jean-Christophe Lebreton
Siemens Mobility France
Technical Director

Obsolescence risks must be anticipated as early as possible, notably through contractual arrangements with suppliers.

Stéphane Maillet
Île-de-France Mobilités
Head of Transportation System Engineering Department, Rail Division

Structuring funding and contract models for long-term performance

Getting the CAPEX and OPEX balance right secures lifecycle ROI

Automation can improve the economics of a metro network when it is designed and operated for efficiency from the outset.

Compared with conventional lines, UITP[2] reports that fully automated metros can achieve energy savings of up to 15% and overall OPEX reductions of 15% to 30%, driven by energy efficiency, workforce optimisation and higher system availability. These improvements result in lower operating costs per train-kilometre by 25% to 35%, reflecting overall productivity gains rather than additional or cumulative savings. On the CAPEX side, the cost gap between automated and conventional systems is narrowing. While signalling for full automation remains a key cost driver, rolling stock is no longer systematically more expensive. Platform and track protection systems remain a significant investment, but are increasingly deployed beyond automation and benefit from economies of scale. Higher productivity also allows equivalent capacity to be delivered with fewer vehicles, with reported fleet savings of 5% to 10%, reducing long-term capital exposure.

Lifecycle ROI is therefore secured when CAPEX choices are made to remove long-term friction in operations, maintenance and renewals. For Public Transport Authorities, this means business cases must go beyond initial delivery costs and integrate long term performance.

Structuring delivery contracts that align governance and risk through design and build

There is no single contractual or financing model that guarantees success for automated metro programs. Public service contracts, concessions, public financing approaches, public-private partnerships (PPP), and more collaborative arrangements, such as alliances, can all be relevant. The right choice depends on context, including greenfield or brownfield conditions, the authority's financial and technical capacity, how clearly responsibilities and interfaces can be defined upstream, and the level of innovation being pursued.

Under public financing, the authority typically retains strong control over scope, sequencing and delivery decisions. This preserves public ownership and governance, but requires disciplined interface coordination and timely decision-making across multiple contracts involving system suppliers, civil works contractors and operators. Concessions and PPPs can be effective when long-term objectives are stable and responsibilities are clear. By aligning design, construction, operations and maintenance over longer horizons, they support life-cycle performance and maintainability, not only short-term delivery. They also require careful calibration of risk allocation and incentives to keep commitments credible over time.

Across all models, outcomes hinge on governance and risk mechanics embedded in the contract. Civil works, systems, rolling stock, signalling, supervision systems, stations and operations must converge into one coherent solution. This convergence is easier to manage when the delivery set up ensures that an operator-led perspective is present early in the contractual process, translating operational needs into design choices before changes become costly. The contract therefore acts as a delivery framework, shaping decision rights, interface routines, escalation paths, as well as the day-to-day discipline of contract management.

Finally, risk allocation should be designed to create alignment. If risk is pushed too far onto one party, contingencies and claims harden, driving costs and slowing resolution. Conversely, when risks remain ambiguous or unowned, interface topics can drift and surface late, when fixing them becomes most disruptive.

> *Strong governance between the transport authority, the operator, and the engineering authority (project manager) is essential to ensure effective project execution.*

Pierre Geneste
SYTRAL Mobilités
COO Metro and Metro Head of Department, Technical Expertise & Asset Management Division

> *In projects with significant interfaces or uncertain complexities, collaborative delivery is a powerful tool. It aligns all parties to focus on resolving issues as they arise, rather than seeking to assign blame. The goal is to shift from a culture of blame to a culture of resolution.*

Ian Pitcher
AECOM
Director Global Alternative Delivery

> *Success only happens if everyone is aligned – system suppliers, operators, maintainers, policymakers – ensuring technical coordination and effective planning.*

Michel Obadia
Siemens Mobility APAC
CEO

> *The alliance model creates a true shared outcome – win together or lose together – which drives the right behaviours across all stakeholders.*

Jamie Burn
Suburban Rail Loop Authority
Package Director, Linewide & Operations

> *It is essential, from the design phase onward, to involve either the future O&M operator or a "shadow operator" to ensure maintainability.*

Thomas Paineau
Meridiam
Senior Investment Director

Alliance contracting: a "one team" model for complex delivery

Alliance contracting remains relatively innovative in public transport, yet this is increasingly considered when large-scale projects face high uncertainty, evolving constraints, or a scope that is not yet fully stabilized by the Authority. In automated metro, technology integration risk (rather than component-level technology risk) is part of what makes the alliance model attractive, with rapid joint decisions to manage complex interfaces. In this context, an alliance brings civil works, systems, rolling stock, stations and operations into one integrated delivery team.

This model is designed around transparency and shared incentives. It typically relies on open-book cost baseline, an agreed target cost, and gainshare / painshare mechanisms, so performance and overruns are managed collectively rather than pushed on to one party. For instance, the target cost is typically set collaboratively during a development phase, not imposed upfront.

In practice, alliances have been proven across major transport infrastructures, like airports, and complex industries, such as defense, and are now used in automated metro programs, for instance in Australia. They make perfect sense when the public sponsor is willing to carry cost risk on its own balance sheet, partners accept open-book discipline, and collaborative behaviours are enforced through governance, capabilities and leadership. Hybrid set-ups are also possible, with alliance packages alongside other forms of contract, provided interfaces are clearly governed.

In short: An alliance is less about "transferring" risk and more about selecting partners who commit to a "Best for Project" mindset, so the team can make joint decisions quickly and keep delivery coherent under uncertainty.

[2] UITP, The benefits of full metro automation (2019)

Design operating contracts that unlock operational flexibility

Operating contracts should be designed for whole life performance, protecting long-term availability, maintainability, and renewal capacity through the right operational and renewal choices. This is particularly true in long-term O&M contracts, where incremental upgrades and obsolescence management become part of day-to-day delivery and should be explicitly governed. In many long-term delivery arrangements, performance regimes adjust payments when availability or service quality falls short, so outcomes are shaped by both operating costs and exposure to performance-related reductions over time.

Automation also creates value through operational flexibility, allowing service to be adjusted to real-time demand whether planned, such as major events, or unplanned, such as disruptions. This flexibility can reduce energy and maintenance costs by avoiding unnecessary train-kilometres. However, many operating contracts still rely on fixed output indicators, such as planned frequency or in-service kilometres. While these metrics support accountability, they can lock the system into rigid service plans, turning capacity adjustments into contractual negotiations rather than operational levers.

The compensation model also shapes how flexibility is valued and where revenue risk sits. Under gross cost contracts, fare revenues typically remain with the Public Transport Authority, and the operator is paid a fixed fee, with optional incentives. Under net cost contracts, the operator commits to revenue performance, and the Authority provides a balancing subsidy. Under cost-plus contracts, the operator is reimbursed for costs plus a margin, which can support ramp-up or major transformation but requires tight governance to protect efficiency.

To fully benefit from automation, contractual models should combine clear performance expectations with practical change mechanisms. Service commitments can be defined as ranges and response rules, rather than as a single fixed timetable, complemented by incentives rewarding demand-responsive performance, such as crowding management, headway regularity, and recovery disruption. It also requires a robust service change regime, with agreed unit rates and governance, so capacity can be adjusted quickly while preserving transparency on cost and risk.

I strongly believe that in any alliance, the operator and maintainer should be involved from the very start. They need to understand the system to ensure efficient and cost-effective operations. Involving the operator early reflects a long-term vision.

Steve Butcher
John Holland
Managing Director & Executive General Manager, Rail & Transport Division

Projects of this type are particularly well suited to Public-Private Partnerships (PPPs), which represent the most advanced form of these delivery models. They are highly complex, combining civil works, driverless systems and rolling stock manufacturing, with an operator acting on behalf of the client, to ensure maintenance and driving the project's long-term vision.

Patrick Lauren
Plenary
Chief Investment Officer

Key Takeaways

01

Build a long-term roadmap that delivers today and preserves tomorrow's upgrade path

Automation value is secured upstream. For Public Transport Authorities the starting point is to define end-state objectives and translate them into a realistic roadmap that connects investment planning, rolling stock strategy, system technology and infrastructure readiness. A well-designed pathway supports long-term affordability by aligning the right level of investment over time with the efficiency and performance expected in operations, while preserving tomorrow's upgrade path.

02

Align contracts, payments and governance to deliver as one team

Automated metros concentrate interfaces across civil works, systems, rolling stock, stations, supervision and operations. Performance depends on structured coordination mechanisms that align decisions, manage interfaces as one agenda, and resolve constraints before they reach live service. This discipline is best enabled by choosing contractual models that fit the project's risk profile, the maturity of the scope, and the capabilities of the parties involved.

03

Bring an experienced O&M perspective from day one

Bringing an experienced O&M perspective early as an upstream advisor, whether through the future operator or a credible shadow operator role, strengthens strategy, design arbitration, procurement choices and governance setup. It ensures that operational constraints, readiness conditions and lifecycle performance are built in rather than corrected later.

Part III

Transforming existing metro systems

Managing evolution while keeping operations running successfully

Understanding the starting point: diagnosing brownfield complexity

Brownfield projects cover a wide range of situations, from converting conventional metro lines to full automation, to upgrading partially automated systems, and modernising existing GOA4 networks. This is increasingly common as first-generation automated metros reach the end of their lifecycle. These starting points are fundamentally different in terms of constraints, risks, and operational dependencies, yet they share the same requirements: maintain service continuity as much as possible, limit impacts on passengers and mitigate risks for the operator's teams.

Managing brownfield complexity therefore requires a genuinely case-by-case approach. It begins with a diagnosis of the baseline: system architecture and interfaces, asset condition and obsolescence, operating rules, and service constraints. This diagnosis enables the definition of realistic milestones, sequencing, and governance.

Key decisions include the choice of signalling and interlocking approach, the rolling stock strategy, and the coordination of other critical adjacent systems that may not be migrated at the same pace but can strongly constrain the overall pathway. The diagnosis should prioritise the human dimension, including workforce impacts, with the aim of generating broad stakeholder buy-in from all involved in the transition.

Planning the migration: a sequenced pathway to modernise while maintaining service

Once the baseline has been diagnosed, the next challenge is to define how the system will be migrated, while maintaining service during transformation.

Commissioning projects hinge on a central tension: due to limited off-site testing capabilities, a significant share of validation must be carried out on the live network, meaning each test must strike the right balance between robust testing and minimizing service impact. As a result, the most appropriate strategy is progressive integration, enabling gradual commissioning within existing operations while limiting disruption.

This approach requires a finely paced migration plan. It typically combines a phased rollout of subsystems with a clear rolling stock strategy, and an integration pathway that allows the new system to be introduced and then progressively expanded. In practice, this often means a train-by-train migration. The new system is deployed, then trains are progressively equipped and introduced over time, so performance can be consolidated gradually, and operational routines can mature without disrupting day-to-day service. However, a "big-bang" strategy is also possible, with all trains switching into the new system at the same time (cf. Focus Box on Paris Line 14).

> *In a brownfield project, upgrading to a GOA3 system can be an interesting step, offering a smart return on investment without bearing the high cost of platform screen doors.*

Eric Peissel
WSP
Global Director Transport & Infrastructure

> *Brownfield projects are the most complex, with more interfaces and more stakeholders to manage.*

Marco Assorati
WeBuild
Senior Executive Vice President Operations

Several decisions become structuring at this stage. Signalling and interlocking choices set integration complexity and drive safety considerations. The rolling stock strategy determines how legacy and modernised generations can coexist, and how ramp-up can be managed without losing operational stability. Adjacent subsystems can become critical constraints when they are not migrated at the same pace, including power supply, control and supervision, station equipment, telecommunications, and many others. These dependencies need to be made explicit early and managed through a single interface agenda, so integration risk is resolved before it reaches live service.

Finally, the migration plan must be built as a joint operating and project calendar. It needs disciplined governance, clear readiness gates, and close coordination between the operator, the transport authority, and industrial partners. This joint calendar should also intergrate the workforce impact, so staffing, training, and evolving roles remain aligned with each migration step.

Proving reliability under live service constraints

In brownfield automation, credibility is won on day one. After managing both work and service continuity, the modernised line is expected to deliver visible value immediately. Reliability cannot be treated as an objective to reach only after a stabilization phase. Meeting this level of expectation requires treating testing as a first-class workstream, since both reliability and operational maturity at commissioning depend largely on what has been proven before passengers are exposed to the new operating model.

Testing must be both intensive and iterative, leveraging industrial capabilities to deploy the most representative test platforms. Large volumes of trials, sometimes totalling thousands of hours, are needed to converge through successive corrections, rather than learning during live commercial operation. Beyond technical validation, readiness also relies on rapid-response discipline. Escalation routines must be rehearsed, crisis scenarios simulated, and drills repeated so that Operations Control Center (OCC) teams and frontline supervisors build durable operational sharpness in driverless environments, where incidents can escalate quickly.

These ambitions must fit the reality of live service. Many metros operate close to 20 hours per day, leaving only a narrow night window for maintenance. Test programs must protect that window, otherwise they gradually erode the very maintenance capacity that underpins system robustness. Maximizing factory and dedicated-site testing helps limit the impact on operations.

Given that the existing metro system is reaching the end of its lifecycle, is increasingly difficult to maintain, and is affecting service quality, the decision was made to transition to a more flexible and modern automated metro solution.

Patrick Fedele

Régie des Transports Métropolitains (Marseille)
Metro Director

As World Bank, we finance different types of projects: greenfield projects, extensions of existing lines or modernisation programs. When it comes to signalling and systems, extensions and upgrades are the most difficult ones.

Edpo Covalciuk Silva

The World Bank
Senior Transport Specialist

Paris Line 14 – A global first GoA4-to-GoA4 modernisation delivered alongside a major extension

Paris Metro Line 14 is a landmark case of GOA4-to-GOA4 modernisation, combining a full renewal of the automated system with a major line extension. Delivered by RATP Group for its Public Transport Authority Île-de-France Mobilités, the project was brought forward by two years compared to the initial schedule to be fully operational for the 2024 Paris Olympic & Paralympic Games.

Delivery relied on a staged migration strategy designed to maintain control, safety, and service. Trains were progressively renewed while both fleets operated on the legacy system. Once the renewal was complete, the new trains supported both legacy and new systems for testing. All trains then switched in a coordinated cutover, followed by commissioning of the extension.

Successful project delivery was ensured through rigorous planning, disciplined execution, a 2,500-hour comprehensive testing program, close coordination across stakeholders, and daily collaboration between operations, maintenance, and the project team. Comprehensive training and a change management program ensured smooth adoption of the new system by the teams.

Disruptions for passengers remained limited: punctuality and regularity KPIs were maintained at 100% and line closures were kept to a minimum, supported by a dedicated communications plan and proactive passenger information.

Since the end of the modernisation project, the 99.5% peak hour target set out in the contract has been exceeded every month. Daily ridership has increased from 750,000 in 2023 to 820,000 in early 2026. Moreover, despite nearly doubling the line length, traction energy consumption remained almost unchanged.

Orchestrating interfaces to keep the city moving during tests

Brownfield upgrades multiply interfaces: legacy and new assets, multiple contractors and a live network that cannot stop. The challenge is amplified by the growing integration of metro systems. Modern networks are no longer a set of isolated subsystems: station equipment, platform screen doors, vertical circulation, passenger-information assets and control technologies are increasingly interconnected. In this context, coordination becomes a decisive capability to maintain service continuity while modernizing. This requires an operator able to align the full delivery chain end-to-end, clarify responsibilities and manage interfaces.

Brownfield projects also require tight collaboration with the transport authority to steer the works calendar, agree on acceptable disruption windows, secure substitute mobility options, and ensure consistent passenger information.

This orchestration ability must be matched by a strong internal organization. Brownfield delivery cannot be run as "a project next to operations". It demands coordination between operations, maintenance, safety, passenger experience, and the project team. This coordination becomes most sensitive during the coexistence phase, when legacy and new systems run in parallel. Control rooms must manage mixed traffic and evolving procedures, while depots require continuously updated safety rules as automated shuttles progressively occupy space. Staff circulation zones evolve as the fleet grows, which means organization, training, signage, and supervision routines must be adapted on an ongoing basis.

When coordination is approached as disciplined orchestration, integration risk is reduced, and confidence is maintained across staff, passengers and stakeholders throughout the transition.

Paris Line 4 automation - Modernising legacy infrastructure and upgrading capacity

Paris Metro Line 4 illustrates how a century-old metro line can be modernised and upgraded in capacity while remaining in operation.

Following the automation of Line 1, works to automate Line 4 began in 2016. The project, managed by RATP Group and fully financed by Île-de-France Mobilités, upgraded one of the busiest metro lines in Paris and was completed without major disruption.

The program upgraded the line from GOA2 to GOA4 and delivered a line extension with two new stations in 2022. From September 2022 to December 2023, the line ran mixed driverless and driver-operated services before switching to full automation. This transitional phase allowed testing and operating routines to mature in live conditions while service expanded.

Performance followed, with peak hour service delivery improving from 91% to 102%, demonstrating the system's ability to not only absorb peak hour adjustments without eroding regularity, but also to exceed expectations. Regarding security, trespass incidents fell to zero in 2024 following the installation of platform screen doors.

The extension to the city of Bagneux strengthened access to jobs and education and supported visible neighbourhood transformation around the station area, including a new public square that will host a future interchange with Metro Line 15.

Ensuring a 360° acceptability

Ensuring public acceptability of project impacts

Brownfield automation projects require sustained effort to secure public acceptability, because works, testing phases and temporary service constraints disrupt an already-used network and can quickly irritate passengers. Acceptability also involves local stakeholders, such as elected officials and community groups. Limiting them requires strong coordination with local authorities, supported by a clear and consistent narrative on scope, impacts, and timeline.

Acceptability is therefore built on two complementary pillars. The first is supporting passengers throughout the disruption. Communication should explain the rationale and benefits in passenger language, including reliability, capacity, comfort, and service continuity, and address the "no driver" topic through operational reassurance. Automated metro should not feel dehumanized. Human presence where needed, clear safety cues, and confidence-building messages help maintain trust.

In parallel, disruption must be managed end-to-end: a 360° communications plan, credible replacement services, multimodal alternatives when possible, and visible on-the-ground assistance at key stations and transfer points.

The second pillar is maintaining control of the agenda and public perception over time. Trust is built on fair and accurate information: communicating impacts early with a clear description of scope and duration for each milestone. It also depends on credible mitigation, with adequately resourced replacement services, coherent multimodal alternatives and clear guidance to help passengers plan their journeys. Information must be repeated and relayed across channels, several times and well ahead of key dates so passengers are genuinely aware and can plan accordingly. Also, credibility depends on delivery so published milestones must be met.

Ensuring social acceptability is a must

Brownfield automation is as much a human transition as a technical one. Social acceptability is therefore a delivery condition: it must be managed as a structured change program aligned with milestones, as daily roles, responsibilities, and working environments evolve under tight operational constraints.

It starts with early workforce engagement, moving from "affected staff" to project ownership. It is essential to clarify the rationale, provide a predictable roadmap, and offer visible redeployment pathways before the start of the project. This includes providing credible perspectives for affected roles, such as progression to supervisory or management roles for part of the workforce, transfers to other lines in large networks, moves toward customer-facing or maintenance roles, or structured late-career pathways aligned with retirement horizons.

The successful transition to an automated metro also depends on anticipating social dialogue and supporting the evolution of skills and roles within teams.

Patrick Fedele
Régie des Transports Métropolitains (Marseille)
Metro Director

Change management for teams is critical to the success of an automation project.

Pierre Geneste
SYTRAL Mobilités
COO Metro and Metro Head of Department, Technical Expertise & Asset Management Division

During mixed-operation phases, operational rules and responsibilities evolve continuously and must be applied consistently to preserve control and safety. This ultimately depends on staff acceptability. Sustained support is therefore essential, so rules are applied consistently, and confidence is maintained throughout ramp-up.

Besides, automation transitions raise a workforce strategy question combining skills, age profiles, and knowledge transfer. Operational mastery takes time to build and relies on experience-based know-how and operational memory, making transmission a success factor during the most demanding phases. Different staffing strategies can then be adopted, each with distinct trade-offs in capability, organization, and acceptability: leaning on younger, more flexible hires to ease transition management, or relying more on experienced profiles to secure continuity and accelerate knowledge transfer.

All these questions are shaped by the social dialogue context. In some environments, delivery relies on structured engagement with unions and negotiated agreements as roles and workloads evolve; in others, constraints may be lighter. In all cases, building trust and sharing vision and benefits with staff remains essential to sustain the transformation over time.

End-to-end expertise unlocks long-term performance

RATP Group relies on an integrated model that combines Operations and Maintenance expertise with engineering capabilities. This end-to-end approach is especially valuable for automated metro programs, where performance is shaped as much by delivery choices as by day-to-day operations. In brownfield transitions, it helps anticipate risks early, structure realistic migration pathways, and manage interfaces across civil works, systems, rolling stock and stations. It also strengthens commissioning discipline by aligning testing, readiness gates and degraded mode procedures with real operating constraints. Once in service, integrated expertise supports asset stewardship, making upgrades, patching and renewals part of normal lifecycle management rather than disruptive events.

For Public Transport Authorities, this creates a clearer line of responsibility and a more stable basis for long-term performance.

In short: Unlocking the full potential of automated metro requires integrated expertise that connects design decisions, asset management and operational performance within one coherent responsibility chain.

When introducing automation, it's critical to address the human element with sensitivity. We must bring the workforce along on the journey, transforming existing roles into the higher-skilled jobs of the future. Close communication and a clear pathway for reskilling are essential.

Lauren Streifer
Public Transport Association Australia and New Zealand
Chief Executive

I firmly believe that automation is first and foremost a project of social transformation. Its success depends not only on technology, but on the ability to turn this change into a real opportunity for growth and development for the men and women delivering the service.

Jean-François Révah
TRANS/FORMATION
Psychosociologist and President

Key Takeaways

01

Build a continuous upgrade capability for brownfield context

Brownfield automation requires continuous control: baseline diagnosis, interface governance and readiness gates shared across safety, operations, maintenance, IT/cyber and passenger information. Public Transport Authorities should mandate a case-by-case sequencing strategy, protect maintenance windows, and use ramp-up milestones (tests, trial running, progressive frequency).

02

Build 360° acceptability around the project as a delivery workstream, not a communication add-on

Brownfield automation is delivered on a live city and a live network: it affects passengers through disruption, staff through changing roles and mixed operations, and local stakeholders through visible surface constraints (permits, traffic, access). Securing acceptability across these groups is therefore a prerequisite for maintaining service continuity and trust. Public Transport Authorities should jointly orchestrate with the operator a full end-to-end acceptability plan: clear passenger information, credible replacement systems, multimodal alternatives and on-the-ground support.

03

Rely on an experienced systems integrator with a strong track record in orchestrating complex, end-to-end integrations

Brownfield automation requires tight orchestration across engineering, operations, workforce transformation, safety and passenger experience, particularly during mixed-operation phases. In this context, Public Transport Authorities should prioritize operators with proven experience in automated networks and complex project delivery, capable of aligning technical choices with live-service constraints, managing interfaces across stakeholders, and securing day-one performance while sustaining trust over time.

Part IV

Achieving excellence in operations

Unlocking high-performing systems

Operational excellence: turning automation into a performance system

Automation raises expectations. Excellence is measured in regularity, the ability to restore service quickly after disruption, and stable day-to-day delivery. The scale shift comes when performance management becomes a data-driven system, continuously recalibrated as the network evolves, using KPIs and real time signals that detect drifts early.

Operations Control Centers (OCCs) become the performance engine, supported by ergonomic interfaces and AI solutions. These tools integrate real-time monitoring of passenger flows and station environments, enabling earlier detection of abnormal situations and faster mobilization of the right response. On the ground, teams evolve with more versatile roles combining passenger support, station oversight, light maintenance and rapid response.

For Public Transport Authorities, the unlock lies in practical levers: governance, roles and metrics must remain fit for purpose as the system matures, supported by adapted contractual models.

AI and shared data as performance multipliers

Automation unlocks a new operating layer based on AI and shared data. Real-time analytics can detect weak signals, predict incidents, and support faster decisions in the Operations Control Center and on the ground. With centralized multimodal data, AI can strengthen travel information, monitor crowding, simulate demand and support capacity planning and scheduling across modes. It also enables automated response management during incidents, helping coordinate operators when disruption cascades across the network.

The scale shift comes when data flows across the value chain. Operators, suppliers, and maintainers share common dashboards on asset health, service quality and cyber posture, with clear ownership and access rules. This enables quicker diagnosis, smoother upgrades and continuous performance improvement without destabilizing service.

> *The future of automated metro may lie less in what passengers see – though service and comfort improvements remain important – and more 'behind the scenes': in control centres, back-office operations like fare collection, or maintenance management systems.*

Antoine Lerat
CRRC Hong Kong
Deputy General Manager

> *Tomorrow, but already today, AI is "inside" – dealing with the system, sharing data about the system and helping in the self-assessment of the different parts of the automated metro.*

Michel Obadia
Siemens Mobility APAC
CEO

Asset management: from maintenance to performance stewardship

Automated metros are asset-intensive and software-rich. The unlock is to move from preventive and curative maintenance to predictive. Condition-based monitoring, digital twins and predictive maintenance reduce failures, protect availability and cut disruption costs.

RATP Group reports a 25% reduction in maintenance costs through predictive maintenance group-wide, and reports 800 incidents processed and avoided on Paris Metro Lines 1 and 14 through its predictive maintenance program.

Obsolescence is now central. Digital components, especially communication systems, evolve faster than traditional rail assets, so upgrades, patching and renewals must become business as usual. For Public Transport Authorities, the key is governance and contractual clarity: clear responsibilities across suppliers, including long-term maintenance and spare parts commitments, predictable upgrade pathways and evolvable systems that improve without destabilizing service.

Automated metro as real-life innovation laboratory

Unlocking the full potential of automated metro also means treating it as a real-life innovation laboratory, where new ideas can be tested safely in operations before being scaled. As systems become more software-intensive, value increasingly comes from continuous improvement, not only from one-time delivery. This calls for structured sandbox environments, with clear governance, safety and cybersecurity guardrails, and agreed test and validation protocols. When designed well, these living labs accelerate learning, reduce deployment risk and help Public Transport Authorities turn innovation into measurable performance gains.

Rethinking 24/7: the reality behind automated operations

Automation often evokes the promise of a metro that never stops. In practice, 24/7 operations are possible, but they are not a default outcome of GOA4. They require systems designed from the outset for continuous service, operating models built around demanding maintenance strategies, and strong human capabilities to manage the moments when automation reaches its limits.

Continuous availability comes with a structural constraint: maintenance. Automated metros rely on frequent inspections, calibrations, component replacements, and regular software updates. When infrastructure and operating models are deliberately designed from the start to allow operations and maintenance to coexist, continuous service can be achieved. Otherwise, providing occasional 24/7 operations requires strong control over the entire system and its interfaces, both in transport operations and in passenger services. This entails extensive organisational adjustments and anticipation of the impacts on overall system performance, including after the event.

Beyond technical feasibility, 24/7 service is ultimately an economic decision. In some cities, sustained night demand and urban policy objectives make all-night service a strong value proposition. In others, targeted late-night extensions, weekend patterns or event-specific operations can capture most benefits at lower cost.

In short: Automation can enable 24/7 operations, but sustaining them requires upfront design choices and strong human capabilities. "Is it worth it in our context?" is the key question the Public Transport Authority must answer.

Adaptability, open standards and open data define the new era. It's no longer just an infrastructure, system and rolling stock challenge, it's a software and platform challenge.

Russell Jackson
AECOM
Global Transportation Chief Executive

Automation makes it possible to enhance existing networks by introducing high-capacity signalling systems within the current infrastructure.

Ian Pitcher
AECOM
Director Global Alternative Delivery

The future of automated metro is condition-based monitoring and automated maintenance: deploying data-driven solutions, bringing more robotics into depots and creating the equivalent of OCCs for maintenance.

Boon Cheow Yee
Land Transport Authority (LTA) Singapore
Deputy Chief Executive, Infrastructure & Development

As capital and operational costs rise, the future of automated metro will likely bring a clash between traditional mindsets and innovation. As an industry, we need to cross-fertilize with other sectors and dare to experiment.

Russell Jackson
AECOM
Global Transportation Chief Executive

Unlocking full value for passengers and the city

Passenger experience at scale: a human-centered journey

Service excellence in a driverless metro is built around the human journey. Real-time passenger information becomes the backbone, consistent, proactive, multi-channel, multimodal and inclusive. Crowding information helps passengers position themselves on the platform and improves comfort and perceived safety. Indoor guidance can also direct passengers to the best exit and to step-free paths with faster lift access.

Beyond train rides, stations shape the full journey experience. Automation programs often create the opportunity to turn stations into welcoming anchors with services and retail. Architecture, lighting and wayfinding improve legibility and perceived safety, supporting a calmer, more confident journey end-to-end. Cultural elements such as arts, heritage and local narratives can also strengthen orientation and identity, helping passengers feel connected to the place.

Transit-oriented development and urban utilities: the next value layer

Automated metro creates value beyond mobility when it is integrated into the city fabric. Transit-oriented development links stations with housing, jobs and services, and can accelerate regeneration around new or upgraded hubs. Urban integration also means using metro assets as urban utilities. Heat recovery can support district heating, tunnels can host fibre optic networks, and station sites can enable social housing or mixed-use developments above and around stations. These cross-sector opportunities connect transport performance with wider city services and long-term urban outcomes.

Culture is a powerful accelerator of urban anchoring and public appropriation

By embedding arts, heritage and local narratives into design, stations become recognisable landmarks that strengthen identity and comfort. In Paris, Louvre-Rivoli is a well-known example, with replica artwork displayed on platforms to echo the nearby museum. In Cairo, RATP Dev also states its intent to promote Egypt's cultural and artistic heritage across Metro Line 3 stations.

Automated lines often rank highest in customer satisfaction, but this is due to a broader package - modern stations, platform screen doors, and strong reliability - not automation alone.

Fatima Arroyo-Arroyo
The World Bank
Senior Transport Specialist
Global Co-Lead Urban Mobility

Future developments will come from better integration of transport systems within the urban environment, particularly through transit-oriented development and the expansion of adjacent infrastructure.

Thomas Paineau
Meridiam
Senior Investment Director

Many programs combine transport and real estate development, which is essential when governments aim to maximize network attractiveness and improve connections between places of work and residence.

Patrick Lauren
Plenary
Chief Investment Officer

The future of automated metro lies in fully leveraging the flexibility automation provides – particularly the ability to adapt service frequency to demand.

Kenji Murasaki
JR East
Division Senior Manager

Automated metro agility unlocks city scale responsiveness

Automation's real unlock is operational agility. With the right procedures and control center tools, automation expands the operating playbook, enabling agile train management such as turning trains back, isolating incidents and keeping the rest of the line moving.

Where fleet strategy allows it, capacity can also be matched through rolling stock choices, using higher-capacity trains during peak periods and lower-capacity ones during off-peak hours to reduce unnecessary energy consumption. In the future, systems could dynamically adjust service to real-time demand, planned or unplanned, without turning every change into a contractual renegotiation. This requires forecasting, real-time crowd insights and an operating model able to trigger the right response.

Agility also creates a new value proposition for cities. Automated metros can run high-intensity corridors linking major venues and critical districts (mass transit), and flexible service when demand surges, like Doha Metro did during the 2022 FIFA World Cup.

In Paris, Covid-related service adjustments reduced capacity by up to 50% during off-peak periods, while automated Lines 1 and 14 maintained normal service levels, highlighting the resilience of driverless operations under staffing constraints.

Four years later, for the 2024 Paris Olympic & Paralympic Games opening ceremony, automated Lines 1, 4 and 14 ran all-night operations in selected stations, demonstrating how automation can support large-scale event mobility.

Stations as urban anchors: beyond "walk-through" spaces

Automated metro stations are increasingly designed as urban anchors, not just transit points. The shift is to turn walk-through infrastructure into active places, combining retail and services with public amenities and a station realm that feels safe, legible and welcoming throughout the day.

In Sydney, integrated station developments link new metro stations with commercial space, community facilities and improved pedestrian connections. Access to and visibility of the station is obviously critical: there is a need for well-indicated and well-lit buildings.

In the future, we could go even further by leveraging data to better determine the demand and adapt the transport offer.

Boon Cheow Yee
Land Transport Authority (LTA) Singapore
Deputy Chief Executive, Infrastructure & Development.

Automated metro systems offer more flexibility to respond to demand, using dynamic headways.

Antoine Lerat
CRRC Hong Kong
Deputy General Manager

Key Takeaways

01

Harness the capabilities of automated metro systems

Maximizing operations and maintenance performance requires a robust core system, boosted by advanced technologies like data analytics, AI and robotics, and powered by deep operational expertise. Together, these elements drive efficiency, reliability, and agility, enabling dynamic adaptation of service to demand, optimizing costs, and reducing environmental impact.

02

Leverage advanced technologies and human care to elevate the passenger experience

Excellence is measured by the quality of the passenger journey. Advanced technologies open new possibilities, from AI-driven personalised information to autonomous service robots. Yet, the human touch remains irreplaceable. Automation frees staff to focus on customer care. This perfect blend of technology and human presence provides a superior passenger experience.

03

Integrate the metro into the urban environment to create wider value for communities

The metro's value extends beyond mobility. By integrating stations into neighborhood life with local services, and by leveraging infrastructure for urban utilities like fibre optics or waste heat recovery, the automated metro becomes a catalyst for urban regeneration and a direct contributor to the quality of city life.

Conclusion

Unlocking the full potential of automated metro will depend on the ability to manage technical complexity, evolving financing models, and stronger cross-stakeholder partnerships. The future of automated metro will depend less on technological innovation than on collaboration and orchestration between the different stakeholders. Cooperation will not be a buzzword but rather an expectation from decision-makers to deliver a successful greenfield or brownfield project.

UNLOCKING THE FULL POTENTIAL OF AUTOMATED METRO

Thanks

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UNLOCKING THE FULL POTENTIAL OF AUTOMATED METRO

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- Christophe Serge Glava, Technical Director, CRRC Hong Kong

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- RATP Group experts

Academics
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- Jean-François Révah, Psychosociologist and President, TRANS/FORMATION

Public Transport Associations
- Lauren Streifer, Chief Executive, Public Transport Association Australia and New Zealand (PTAANZ)
- Union Internationale des Transports Publics (UITP)

RATP Dev:

Delivering localized world-class expertise in automated metro

RATP Dev is a subsidiary of RATP Group, global leader in automated metro systems and the world's third largest urban transportation operator. The Group has a century-long heritage as the operator of the ultra-dense, constantly-modernised Paris network.

RATP Dev delivers localized, world-class expertise to the management of urban transportation systems worldwide, serving more than 120 operations in 16 countries.

We listen to our clients to understand the local context and leverage our expertise to provide financially-effective, tailored solutions.

We build, deliver and commit for the best of public transport – every day, everywhere, for everybody – to make it the natural choice for cities and passengers.

Automated Metro Experts Club

The RATP Group created the Automated Metro Experts Club to share and capitalise on this expertise, which has been acquired over decades of experience leading numerous projects in France and across the world.

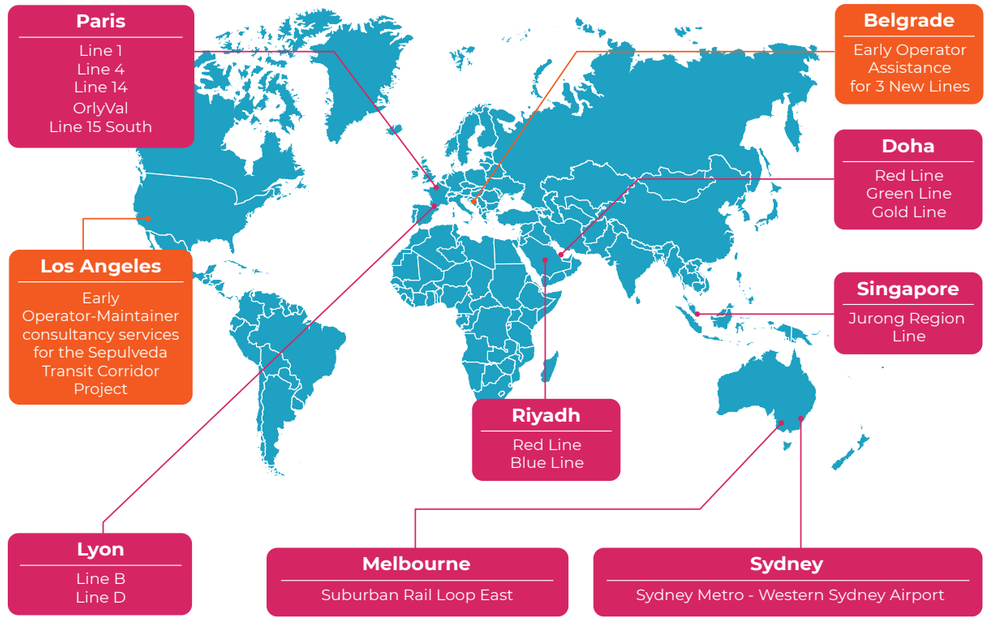
The Club comprises 20 members who are world renowned experts in this transport mode. Through the diversity of its members and the variety of projects that the Group has worked on, the Club possesses a comprehensive understanding of designing, operating and modernising automated metro systems.

30
metro lines
including **15 automated metro lines** currently or soon operated

1.9
billion
annual passenger journeys on our metro lines including **720 million** on our automated metro lines

590
km
of metro lines including **330+** of automated metro lines

RATP Group
Automated metro footprint



RATP Group
Advancing automated metro systems since 1952

75 Years of Innovations

1952 — First automated operations tested on metro lines.

1979 — 90% of the Paris metro network operated using an automated driving system with staff on board.

1991 — Commissioning of Orlyval, the first fully automated light rail line in Paris.

1998 — Metro Line 14 enters service: a world first — a high-capacity, fully automated metro line with no staff on board.

2012 — Full automation of Metro Line 1, the oldest and busiest line in the Paris network, completed without major traffic disruption.

2017 — RER Line A becomes the first high-capacity suburban railway line equipped with Automatic Train Operation on its central Paris section.

2023 — Full automation of Metro Line 4, the second busiest line in Paris, without major traffic disruption.

2024 — Global first: complete renewal of the automated system of Metro Line 14 (GoA4 to GoA4), alongside a line extension, all without major traffic disruption.

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UNLOCKING THE FULL POTENTIAL OF AUTOMATED METRO

RATP DEV

Unlocking the Full Potential of Automated Metro

Insights from the Global Ecosystem

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