UITP ADVANCING PUBLIC TRANSPORT

KNOWLEDGE BRIEF

THE BENEFITS OF FULL METRO AUTOMATION

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INTRODUCTION

Full metro automation has been a reality for over 35 years; every day, over 1000 km of metro are operated automatically around the world, carrying millions of passengers safely and reliably to their destination.

A quarter of the world's metros already have at least one fully automated line, representing 7% of the metro infrastructure in operation today. In the coming 5 years, full automation is expected to become the mainstream design for new metro lines.

Yet authorities, decision-makers and operators still face many questions on the advantages of automation over conventional operation. This Knowledge Brief presents the analysis of the experienced networks of the UITP Observatory of Automated Metros on the benefits that full automated operation (FAO) can bring to a metro network.

THE FIVE KEY DIMENSIONS IN PUBLIC TRANSPORT SYSTEM DESIGN

When implementing a public transport system, there are five key dimensions that any authority must consider in its design:

MOBILITY: the transport system must efficiently address current and future mobility needs

SAFETY: ensuring that mobility is safe for customers and staff

AFFORDABILITY: ensuring the most efficient total cost of ownership for the transport system

ECOLOGY: minimising the ecological imprint of the mobility solution

HUMANITY: ensuring that the transport system is designed to human scale i.e. placing the customer at the centre and providing a motivating work environment

According to the professional views of the members of the UITP Observatory of Automated Metros, FAO supports metro companies in achieving these goals:

- Improving the mobility offer
- Enhancing safety
- Contributing to the economic balance of the system
- Reducing its ecological imprint
- Providing customers with an improved travel experience while enhancing staff satisfaction

Benefits of these five strategic dimensions are delivered in 10 key areas, which are relevant to any metro network.

MOBILITY: FULL AUTOMATION FOR AN EVEN MORE ATTRACTIVE METRO

CAPACITY

Automation maximises capacity by enabling minimum headways and higher commercial speed, thanks to consistently optimised speed curves and dwell times, and continuous reporting of accurate train location across the service. **FAO systems can achieve up to 30% capacity increase compared with a conventional line.**

Moreover, automation's flexibility facilitates delivering capacity 'when' (peak hour, but also better levels of service off-peak) and 'where' (inner loops) it is most needed. This, in turn, has a positive impact on customer satisfaction, as passengers benefit from reduced waiting time due to shorter intervals, and faster overall journey thanks to increased commercial speed.

- **Minimum headway**: line capacity is increased by enabling minimum headways at peak hours. The service can achieve headways as low as 60-90s (with the minimum theoretical limit just constrained by train length).
- **Optimised and consistent dwell time** across the whole service results in an increase of overall system capacity.
- **Higher commercial speed**: as a result of improving the dwell time as well as optimising interstation speed curves and turn-backs (up to 10% increase).
- **Reduced waiting time**: Thanks to the increased commercial speed and more flexible delivery of with higher flexibility customers benefit of shorter waiting times

AVAILABILITY

Automation minimises operational disruption, thanks to the increased reliability, regularity and built in redundancy in the system, and the reduction of customer-related disruptions through the secure platform/track interface. It eases responsiveness in case of incidents providing overall higher service availability. **FAO systems usually achieve between 99.1 - 99.9% availability.**

- **Robustness**: (technical) operational disruptions are minimised due to technology redundancy, along with the reliability and regularity of the automated system. FAO systems also force an improved maintenance organisation, as it is not possible to keep trains in operation with minor failures, as opposed to conventional systems, where these can be mitigated to a certain extent by the presence of a driver; therefore the level of availability is higher.
- **Anti-intrusion systems**: track intrusion prevention systems, and Platform Screen Doors (PSD) in particular, result in a reduction of customer related disruptions and improve overall service availability (see section on passenger protection).
- **Operational responsiveness**: automation provides operators with a wider array of options in case of disruption, such as automated train rescue, and allows operators to shorten the setup times of alternative services. The only exception is in case of big failures, when systems are down. In these very rare instances, the automated system requires staff to be able to deal with complex issues. Thus, appropriate staff profiles and adequate training are necessary.
- **Automated coupling/uncoupling**: This feature allows operators to implement remote rescue operations for disrupted trains between stations, shortening rescue time.

FLEXIBILITY

Automation makes for adaptable operation, offering the capacity to react to demand surges by injecting trains in almost real time, or adjust itineraries for express and mixed services. **It renders off-peak services more affordable and facilitates 24/7 operation.**

- **Demand surges**: automation facilitates matching supply to demand, particularly in the case of demand surges, whether they are planned (maintenance works, large events) or unexpected (line or network issues – for example, absorbing passengers from other lines

with problems or capacity shortages), resulting in a more flexible operation.

- **Off-peak hours affordability**: automation facilitates improved service levels during off peak hours, even allowing 24/7 service, with minimal marginal costs and easing safe track possession
- **Itineraries adaptability**: FAO systems unlock new service opportunities for itineraries, breaking with the traditional end-to-end running or stopping at every station. This renders express and mixed services possible, and allows for night single track operation during maintenance work. By implementing loops, shuttle services, skip stations and alike, capacity can be conveniently allocated to meet customers' needs while optimising fleet.
- **Train size adaptability**: By breaking the constraint of 'one train-one employee', it is no longer necessary to operate large trains to render a driver's activity more productive. This allows operators to use shorter trains (reducing headway) while keeping the same hourly capacity.

HUMANITY: BETTER JOBS MEANS BETTER CUSTOMER SERVICE

CUSTOMER ORIENTATION

Automation facilitates improved customer service at equal staffing levels. Systems that have both worlds show that **customers are more satisfied with fully automated lines**, an outcome that cannot be solely attributed to the novelty factor, as satisfaction rates remain consistently high after years of operation. Aside from the perception of a more technological and reliable system, the increased presence of visible and interactive staff contributes to customer satisfaction.

- **Closer to the customer**: 'unlocked' from their cabins, multi-skilled and versatile roving staff are visible and closer to passengers, thereby contributing to a better travel experience.
- **Affordable & attractive customer care**: there is a potential to improve customer service at equal staffing levels through face-to-face customer assistance, and faster interventions on 'small asset failures' (resetting escalator or PSD, cleanliness).
- **Security**: with equal staffing, the more visible presence of staff on a FAO line is a major element for an increased feeling of security.

FULFILLING JOB POSITIONS

Automation fosters an organisational model with job positions that require a wider set of skills and bring added value to the service, increasing employee satisfaction. These new job profiles align with a labour market with higher education and professional expectations, and bring greater potential for career evolution.

- **Happier employees**: in the experience of operators that manage both automated and conventional lines, FAO employees are more fulfilled and committed to the service, presenting lower absenteeism rates. This can be attributed to a higher diversity in FAO line tasks. The traditional borders between line and maintenance jobs are diluted in a more process-oriented model (compared to a traditional specialised model), working in closer cooperation with the OCC (rotation of field staff to the OCC).
- **Better employability**: these positions require multi-skilled staff with better qualifications (or internal training) and a customer-oriented mindset, more aligned with the labour market and the expectations of new generations (Centennials). FAO job profiles are therefore more attractive and have a greater potential to evolve with the organisation. This can have a potential impact on talent retention, with multi-skilled and polyvalent employees leaving for internal promotion or external opportunities.

BENEFITS OF FULLY AUTOMATED METRO OPERATION

SAFETY: IMPRESSIVE SAFETY RECORDS

PREVENTING HUMAN ERROR

Repetitive yet safety-critical tasks are automated and freed from human fallibility. **Fully Automated Metro operation holds an impressive safety record, with no fatalities in over 35 years.**

- **Human error**: by definition, FAO lines are safer than conventional lines, as there are risks linked to human error that are simply not present in a FAO line: signals passed at danger and over speeding - although this also applies to conventional lines with Automatic Tram Operation (ATO). These risks can be quantified in the safety case through the methodological approach of risk allocation.

PASSENGER PROTECTION

In fully automated metro lines, **advanced track protection systems ensure that passengers enjoy enhanced protection from approaching trains.** The smoother ride patterns or automated lines reduce the risk of passenger injuries from falls inside the trains.

- **Track intrusion protection**: track protection systems safeguard passengers from injury either preventing access to the tracks (with platform screen doors, PSD) or through the integration of intrusion detection systems with signalling (using obstacle detection systems), so that approaching trains are stopped immediately in case of intrusion. As a consequence, there is a lower rate of platform/track incidents and suicides are minimised.

PSDs are the predominant solution. It is the technology of choice for 87% of automated line stations built in the last decade[1]:

- PSDs offer better protection results and improved performance on the line, as they prevent intrusions instead of just detecting them. They do not suffer from false detection positives, reducing the associated operational impact.
- PSDs reduce door trapping incidents, both accidental and intentional. In this last case, PSDs influence positively passengers' behaviour: Passengers less frequently attempt to hold both train doors and PSD. Aside from the operational impact, the reduction of door holding incidents also equates to lower rates of train door failures.

- **Smoother rides**: automation helps to implement smoother train rides, reducing passenger injuries inside trains.
- **Safety and security perception** are higher with fully automated lines. A more intensive use of technology (CCTV on trains and intercoms) allows for improved monitoring and establishes direct communication channels between passengers and the Operations Control Centre. FAO organisational models free staff resources to be closer to the customer, either as security guards or as roaming service agents who are visible and accessible to the travelling public.

1 - World Report on Metro Automation 2018, Observatory of Automated Metros, UITP, June 2019

AFFORDABILITY: MAXIMISING RETURN ON INVESTMENT & INCREASING OPERATIONAL EFFICIENCY

CAPEX

Automation enables fleet and infrastructure optimisation: Fleet investment is minimised by leveraging FAO's capacity to deliver higher commercial speed, combined with an appropriate line design. Alternatively, the increased train frequency can offer capacity with shorter trains, allowing for shorter platforms and smaller stations, lowering civil work costs without losing on overall system capacity.

- **System costs**: differences in cost between fully automated and conventional systems are declining. While a fully automated signalling system continues to be more expensive than a conventional one, fully automated trains are no longer necessarily more expensive. Platform/track protection systems remain the main added cost element. However PSDs are increasingly being implemented in conventional lines too, resulting in economies of scale that lower their CAPEX.
- By properly managing the higher capacity that FAO can offer, CAPEX can be reduced, through **infrastructure and fleet optimisation**, resulting in less investment and fewer maintenance costs (see section on OPEX).

FLEETS	INFRASTRUCTURE
Keeping the same capacity offer than a conventional line, FAO achieves fleet savings ranging from 5%-10%, thanks to the increase in commercial speed gained through optimised speed profiles & dwell times, and automated turn back. This increased fleet productivity can be used to reduce the number of trains or, alternatively, the number of cars per train, leading in this case to infrastructure savings.	FAO offers similar or even higher capacity with shorter trains, which result in shorter platforms, smaller stations & workshops.
Improved maintenance regimes under FAO minimise the need for a reserve fleet for maintenance, as opposed to the conventional planning of up to 15% fleet reserve.	Automated coupling and uncoupling also allows for the design of smaller workshops.
	FAO allows to park trains in tunnels or stations, reducing the size of stabling yards.

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OPEX

Operators benefit from a combination of increased revenue, optimisation of labour resources and energy savings. **Current practices show that opex savings can reach up to 15% - 30% in comparison to a conventional line.**

More revenue: due to the increased availability of automated lines there are fewer disruptions, which contributes to more ticket validations. This increased availability, combined with a better level of service, improves customer trust and fidelity.

More efficient operation: FAOs are more efficient, reducing the overall car km costs by 25%-35% by combining power saving, fleet optimisation (frequency increase, train coupling), and the reduction of non-value added train movements (lean approach - for example, to empty stabling yard for maintenance).

Energy savings: automation helps reduce power consumption. Energy savings can reach up to 15% in comparison with conventional lines, with minimum impact in service levels.

Automatic coupling/uncoupling: this function allows to adjust train sizes more efficiently, facilitating operation with shorter trains during off peak hours, reducing costs (energy, wear of equipment).

More efficient organisation: The above figures can be further improved by developing a more efficient operation, as the organisational concept implemented in FAO is conductive to a more efficient use of staff resources.

Train services are no longer constrained by the availability of drivers, allowing for a more flexible operation. Moreover, traditional staff rostering criteria can be evolved to response time instead of asset coverage.

Driver costs: The job position of drivers disappears but, depending on the company's customer service approach, associated savings can be directed to other customer care positions.

Maintenance: The OPEX, linked to the maintenance of a fully automated line, has reductions in some equipment balanced out by increased costs in others. Overall, the maintenance costs of an automated line are not necessarily higher than those of conventional lines:

INCREASE IN COST	REDUCTION IN COST
Higher technical profiles required to maintain FAO systems	FAO lines are equipped with better diagnostic means, facilitating maintenance optimisation
Extra maintenance costs for track protection system devices	Fewer equipment parts on the tracks
	Reduced costs in materials and labour time, as a result of more predictable and focused asset wear due to the accuracy and regularity of FAO

ECOLOGY: AN EVEN MORE ECO-FRIENDLY METRO

Automation reduces the overall power consumption of the system thanks to the optimisation of fleet sizing and operations, environmentally-friendly driving patterns and maximising the impact of regenerative braking. A combination of these measures can yield an estimated **15% in energy savings, and up to 30% when operating with train coupling.**

- **Fleet size & flexibility**: rendering an optimum level of service with a reduced fleet results in an overall reduction in power consumption. Moreover, the capacity in FAO can be allocated optimally (where and when it is needed), generating further power savings as the system minimises moving unused capacity; an advantage that can be maximised by adapting train length through automated coupling and uncoupling.
- **Eco-friendly mode**: the regular and repetitive behaviour of the system maximises the outcome of coasting in optimised running diagrams at off-peak hours, which account for up to 80% of overall service time.
- **Regenerative breaking**: Automation enables train synchronisation (thrusting & braking trains) for effective regenerative braking.

THE SKY IS THE LIMIT... OR IS IT?

The capacity to leverage the full potential of FAO can be limited by a 'traditional' approach in design...

- Flexibility: Civil works can become the constraint that limits the flexibility and performance of the system. To make the most of FAO it is important to align the design of the civil works to match the level of flexibility that is sought in operation.
- Affordability: CAPEX savings can be conditioned by a 'traditional' design approach, or in the case of conversion, by the constraints of the legacy design features of the line infrastructure.

...or in organisation, with flexibility, efficiency gains and OPEX affected by the difficulties to change mindsets and implement organisational change.

CONCLUSION

Full automation has often been approached as a technological solution to fulfil a specific need – often linked to its capacity to deliver improved capacity performance. This brief demonstrates that full automated operation provides a much wider array of benefits, supporting authorities and operators across the five strategic dimensions of the transport system. FAO benefits are interlinked and retro feed into a continuous virtuous circle of improved performance, safety, sustainability, affordability, and attractiveness to customers and staff.
The Observatory of Automated metros encourages authorities and operators to broaden their assessment of automation projects to truly assess the full beneficial impact that automation can deliver to their metro network.

In order to reap this potential, however, authorities and operators must also broaden their focus in FAO projects beyond the implementation of a technological innovation and:

- *Develop an adapted line concept design from the early stages of the project.*
- *Implement a cooperative project management approach, allowing all stakeholders to share the goal and concepts, and buy into the project.*
- *Prepare for organisational change, addressing management, procedures and mindsets – a particularly important dimension for systems already operating conventional lines.*

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This is an official Knowledge Brief of UITP, the International Association of Public Transport. UITP has over 1,700 member companies in 100 countries throughout the world and represents the interests of key players in this sector. Its membership includes transport authorities, operators, both private and public, in all modes of collective passenger transport, and the industry. UITP addresses the economic, technical, organisation and management aspects of passenger transport, as well as the development of policy for mobility and public transport worldwide.

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