Automated metro lines are a proven solution for metro systems around the world. As of July 2016, there are 55 fully automated metro lines in 37 cities around the world, operating in total 803 km, a 14.2% increase in km over 2014 figures. The projection is that by 2025 there will be over 2,300 km of automated metro lines in operation. This report offers a general overview of the state of the art in metro automation, covering line characteristics, technological trends, supplier market share and estimated future evolution.
The avant-garde of metros, fully automated metro lines are a window into the future of all metro systems. This report covers the complete field of fully automated metro lines in public transport operation in the world. The analysis of these flagship lines, some of them in operation for several decades, offers a unique opportunity to operators, authorities and industry suppliers to better understand the future evolution of metro systems.

There are currently 55 fully automated metro lines, operating public transport services over 803 km. Together they serve 848 metro stations in 37 cities across the world: 23% of the cities with a metro network have at least one fully automated metro line in operation (see box).

**METRO AUTOMATION IN 2016**

There are currently 55 fully automated metro lines, operating public transport services over 803 km. Together they serve 848 metro stations in 37 cities across the world: 23% of the cities with a metro network have at least one fully automated metro line in operation (see box).

**OVERVIEW: CONVENTIONAL VS AUTOMATED METROS**

Nearly a quarter of the world’s 157 metro cities have at least one line operating in full automated mode - in km, this represents 6% of the world’s metro infrastructure. This development took place in the last 30 years, a relatively short time span when considering the 153 years of metro history.

The analysis at a regional level shows that the share of fully automated metro lines is significantly higher in Middle East and Europe, where fully automated lines represent respectively 15% and 10% of their metro infrastructure.

In Asia, the leading world region for automation, automated lines represent 5% of the km of metro in the region – a consequence of Asia’s large metro market, and of the late adoption of automation in China.

**AUTOMATION IS A GLOBAL SOLUTION**

Asia and Europe together are home to close to 75% of the km of fully automated metro lines (see figure 1), followed by North America (13%), which was in fact one of the pioneering regions in metro automation. In the last decade, both Latin America and the Middle East have developed fully automated lines, with the Middle East showcasing one of the higher rates of growth.

Half of the world’s fully automated metro infrastructure is concentrated in 4 countries: France, South Korea, Singapore and the United Arab Emirates. France continues to lead the ranking with 16% of the world’s km of fully automated metro lines, followed closely by South Korea (15%). (See figure 2)
The three cities with the most km of metro operated in automated mode are outside Europe – Singapore (93 km), Dubai (80 km) and Vancouver (68 km) - as depicted in figure 3.

The diversity of urban scenarios that represent the above figures highlights the flexibility of full driverless metro operation: automated lines have been deployed now in 37 cities around the world, depicting very different mobility needs and demographic contexts. This demonstrates that fully automated metro solutions are not limited to one type of city, mobility pattern or culture.

One of the recurrent questions raised by decision makers concerning automation is public opinion – in particular citizen’s reaction to a train without a driver on front. The variety of cultural contexts in which full metro automation has been successfully deployed demonstrates this is not a real barrier. Another clear indicator on the acceptance of automation is that when a city builds an automated metro line, it never opts for building subsequent lines in conventional, manual operation.

CHARACTERISTICS & TRENDS

Capacity

Although fully automated metro solutions were initially deployed in low capacity lines, growth in the last decade corresponded mostly to medium and high capacity systems (see figure 4). Currently, close to 80% of the world’s automated metro infrastructure correspond to medium and high capacity lines, when considering the capacity of the trains. Most high capacity lines are deployed in Asia and Europe (see figure 5), with the significant exception of São Paulo’s Line 4 in Latin America: with over 32,000 passengers per hour per direction, it is one of the most heavily loaded lines in the world.

Figure 3: Top 10 cities with fully automated automated metro lines (km in operation per city)

Figure 4: Km of automated lines per train capacity & % of growth in the last decade

Figure 5: % of km of automated metro lines per world region - train capacity
Signalling technology

CBTC has consolidated as the preferred signalling solution for fully automated metro lines. Currently, 68% of the world’s km of automated metro lines are operated using CBTC systems and even more significantly, close to three quarters of the new fully automated metro infrastructure built in the last decade was equipped with CBTC (see figure 6).

Thales, with close to 250 km of automated metro lines equipped, is the market leader for fully automated metro lines, closely followed by Siemens (see figure 7).

Platform track protection systems

The safety of the platform/track interface is crucial for fully automated metro lines. The installation of Platform Screen doors remains the dominant solution over track intrusion detection systems (see figure 8) since they prevent persons and objects from falling on the track, improving the performance of the line. Currently, 76% of stations in automated metro lines in operation are equipped with platform screen doors, a trend that is confirmed by the evolution in the last decade: only 15% of the stations inaugurated since 2006 are protected with intrusion detection systems.

Rolling stock market

As of 2016, 10 rolling stock suppliers serve the market for fully automated metro lines. Bombardier, Alstom and Siemens are the leading suppliers; serving with their trains close to 60% of the km of fully automated metro in operation (see figure 9). Asia is the most diversified market, with lines equipped by 9 different suppliers and no dominant market leader, whereas for Europe, North America and the Middle East, the market is concentrated in 3 or 2 suppliers.
Construction model

There is no predominant alignment solution for automated metro lines; underground and elevated stations are fairly equally split, as depicted in figure 10. Over 60% of the stations inaugurated in the last decade, however, correspond to underground alignment. When considering the wheel/rail interface system, a majority of lines opt for steel wheels, as opposed to rubber-tyred trains: in the last decade, close to 70% of the km of new automated metro used steel wheel systems.

Figure 10: Constructive model - underground vs. elevated (number of stations & percentage of growth in the last decade)

FUTURE GROWTH

In the 30 years since the implementation of the first automated metro lines, the growth rate for automated metro has doubled with each passing decade – an exponential growth that is set to quadruple in the coming decade. Current forecasts, based on confirmed projects, indicate that by 2025 there will be over 2,300 km of fully automated metro lines in operation (figure 11).

Figure 11: Total growth in automated metros (km of lines operated in full automated mode)

THE CASE FOR CONVERSION

Conversion of metro lines from conventional to fully automated operation is a complex project that requires careful timing to ensure the technical and financial viability of the project.

The signalling upgrade must be complemented with a significant modification or the renewal of the rolling stock fleet and the retrofitting of platform-track protection systems at stations. When timed appropriately with the end of the life cycle of the existing assets, the investment can be recovered in a relatively short time (within a decade). Conversion projects must also consider and address from the beginning the organisational implications of full automated operation for the company, and involve staff at all company levels since the early stages of the project. Following the successful conversions of U2 in Nuremberg in 2009 and L1 in Paris in 2012, six European cities have confirmed conversion projects in the coming decade: Glasgow - G. Subway, London - Docklands, Lyon - LA & LB, Marseille - L1 & L2, Paris - L4, Vienna - U5.

This growth will mainly concentrate in the Middle East, Europe and Asia (see chart 19) – together they will account for 88% of new km of automated lines, with Latin America accounting for another 11% of the total projected growth. Significantly, 26% of the new km in Europe will correspond to conversion projects (see box).

In 2025, Asia and Europe are expected to account for 33% and 30% of the world’s km of automated metro lines respectively, followed by the Middle East: thanks to its elevated growth rates, it will represent 25% of the world’s km of automated metro. China announced the opening of two new fully automated lines for the end of 2017 - one of them built using exclusively Chinese technology. This significant development may translate in even higher growth rates if China embraces full automation for its many expanding systems.

Figure 12: Current length of automated metro lines and projected growth for the next decade, per world region

Km in operation
Projected growth
Current length of infrastructure for automated metros
Projected growth (2025) in infrastructure

FUTURE GROWTH

Underground
Elevated
CONCLUSION

The three decades of automated metro operation around the world summarised in this brief demonstrate that full automation is a consolidated solution – one that brings many advantages to operators, authorities, and users.

Fully automated metro lines offer increased safety, unrivalled reliability and the capacity to respond flexibly to surges in demand. For operators, automation has the potential to be a lever of change to develop new organisational models, enriching job profiles and more efficient maintenance and operation. Building on these strengths, metro operating companies are able to offer better service to their customers and respond efficiently to their increasingly changing mobility needs, raising the attractiveness of public transport and ultimately contributing to improving the quality of life in our cities.

Full automation brings therefore the opportunity to generate a step change for metro systems and a more sustainable urban mobility. The exponential growth trend observed in this report, set to quadruple in the coming decade, confirms that increasingly authorities and operators around the world are ready to take the leap towards this new referent in metro service and operation.

This report covers exclusively fully automated metro lines, defined as those metro lines in which trains can be operated without staff onboard - a defining characteristic is the absence of a driver’s cabin on the train. This type of operation is also known as Unattended Train Operation (UTO), or Grade of Automation 4 in standard IEC 62267 (see table below). Moreover, only lines in public transport service have been considered.

<table>
<thead>
<tr>
<th>Grade of Automation</th>
<th>Type of train operation</th>
<th>Setting train in motion</th>
<th>Stepping train</th>
<th>Door closure</th>
<th>Operation in event of disruption</th>
</tr>
</thead>
<tbody>
<tr>
<td>GoA1</td>
<td>ATP* with driver</td>
<td>Driver</td>
<td>Driver</td>
<td>Driver</td>
<td>Driver</td>
</tr>
<tr>
<td>GoA2</td>
<td>ATP and ATO* with driver</td>
<td>Automatic</td>
<td>Automatic</td>
<td>Driver</td>
<td>Driver</td>
</tr>
<tr>
<td>GoA3</td>
<td>Driverless</td>
<td>Automatic</td>
<td>Automatic</td>
<td>Train attendant</td>
<td>Train attendant</td>
</tr>
<tr>
<td>GoA4</td>
<td>UTO</td>
<td>Automatic</td>
<td>Automatic</td>
<td>Automatic</td>
<td>Automatic</td>
</tr>
</tbody>
</table>

*ATP - Automatic Train Protection; ATO - Automatic Train Operation

The data in this Statistics Brief is sourced from the global database of automated metro lines of the UITP Observatory of Automated Metros. This Observatory gathers the world’s leading operators with experience in full automated metro operation. It exchanges best practices in key issues affecting automated metro operation and monitors the global evolution and trends on this field. For more information on the Observatory work, and further content on metro automation, consult the Observatory website: www.metroautomation.org.

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