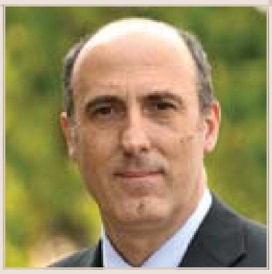


***Ramon Malla Castells**, Chairman of the UITP Observatory of Automated Metros and Director of Automated Metro, TMB, Spain*

Automated metro operation: greater capacity and safer, more efficient transport

Automated operation helps increase transportation capacity, something which the Observatory of Automated Metros is already aware of from the in-depth discussions and experiences of its members.

Key factors in transport capacity

Automated operation increase transport capacity in two main ways:

- The possibility to run trains at shorter intervals
- Operational flexibility.

Although the impact of shorter intervals is an obvious benefit, operational flexibility also has great potential in terms of increasing transport capacity. It should be emphasised that capacity improvement is achieved in the safety environment of metro automation and with measures ensuring a high level of economic efficiency.

Headway

Signalling systems for driverless lines offer greater precision in locating trains. Combined with centrally-controlled management and information regarding trains (in terms of location, speed, safety distances, etc), this makes shorter headways possible. Technology plays a decisive role and constant progress in this area is enabling further improvement. Technology is the largest contributor to increasing transport capacity and one of the main drivers behind the conversion of conventional lines into automated lines.

Flexibility

Unattended trains overcome the normal organisational constraints that govern human-driven trains and also means that trains can more easily be included in or removed from circulation. This real-time adaptation of supply to demand lets the operator add trains where they are most needed at specific times. This provides the user with a better transport service.

We tend to associate transport capacity with peak hours. However, there are other scenarios in which the flexibility of driverless trains offers the kind of additional capacity that is difficult to achieve with conventional lines:

- **Sporting and other major events**

  An automated line enables the necessary trains to be injected into the required part of the line with short headways in response to atypical peaks in demand.

- **Viable service during off-peak hours and at night (24/7)**

  A major challenge is striking a balance between an appealing service that is also efficient during off-peak hours and at night. An automated line contributes to the provision of a viable transport service with lower operational costs and greater operational flexibility.

UITP Observatory of Automated Metros

The Observatory of Automated Metros is a UITP body composed of leading operators in this sector worldwide. Its mission is to disseminate and share knowledge with a cross-cutting approach to all the business perspectives of the automated lines operation. It also analyzes the global evolution identifying future trends, presenting them in periodical reports and events.

- **Incidents and maintenance breaks**

  Flexibility ensures transport service quality can be maintained even in the event of incidents or special breaks for maintenance.

More capacity and greater efficiency and safety

Automated operation gets us closer towards achieving this goal, so elusive in other businesses. Flexibility contributes to eliminating areas of inefficiency in the demand-supply curve, ensuring better use of resources.

Driverless lines also offer great potential for energy savings.

Safety is a key feature of driverless lines. All measures that increase transportation capacity at the same time provide the added bonus of safety through measures that are undoubtedly superior to those of conventional operations.

Capacity: a key reason for conversion

Many conventional lines that have reached the limits of their capacity see conversion to driverless operation as the way to overcome this problem. This will surely be, in the coming years, one of the main reasons for the automation of metro lines, which the OAM will monitor and study with a view to identifying key future trends.

Contact: *rmalla@tmb.cat*
copying editor@uitp.org

Translated from the Spanish original version

Vancouver SkyTrain: building capacity through automation

Left: With automated operation, the number of trains that can be injected is independent of staffing levels.
Right: Automation boosts service quality by enabling short, frequent trains to be delivered for the same cost.

Marking a quarter century of operation, Vancouver's SkyTrain has exploited the benefits of automated driverless operation to build ridership through service frequency, and adaptable capacity.

When the initial 21 km and 15 stations of the Expo Line opened in January 1986, the regional population was 1.4 million, and the transit system carried an annual ridership of 60 rides per capita. Capacity was not the problem – initial ridership into downtown averaged 5,000 passengers during the peak hour. The challenge was to deliver the service quality (frequency) associated with high volume metros, on a new and developing line, *without* the cost burden of excess capacity or a high ratio of operating staff. The operation of short trains (two or four 12.7 metre cars) allowed for economical frequent service from the first year of operation – 5 minutes or better throughout the service day, from 05:00 to 01:00, with an average of 3.5 minutes during the commuter peaks. The high initial frequency was particularly important in attracting off-peak ridership, as passenger waiting time for infrequent service is a major deterrent in many systems. It also reduced the friction of transfer connections from bus, and allowed the bus network to be strengthened in its cross-regional function, building new travel markets.

With a staffing level largely independent of the number of trains, the lower marginal cost structure of driverless operation influenced strategic decisions – adding service was financially easier to justify, as well as being technically easier to implement. Conversely, the cost savings of service reductions were less, alleviating some of the pressures for counter-productive cutbacks during tough economic times. While there are still appreciable power and maintenance costs for vehicle operation, there are advantages to the use of shorter trains – the cost of delivering a 2-car train every 5 minutes is identical to a 6-car train every 15 minutes, but with a substantial difference in service quality. This is particularly important for new systems in mid-sized urban regions.

The Vancouver region added a million people in a quarter century, and could reach three million by 2025. This, along with demonstrated ridership growth, provided the justification for extensions to the system, including the integrated Millennium Line in 2002, which generated more passengers, and a need for more capacity along the original segment. Short trains gave way to longer trains (4 to 6 cars of our first generation vehicle; typically 4 cars of the newer 17-metre “Mark II” vehicles). In addition, service frequency has been further improved, with only a limited increase in line staff. Sustained headways of 108 seconds are now operated on the inner 22km during weekday AM and PM commuter peaks, allowing the system to deliver an average of 14,000 pphpd, nearly triple the early years. Peak hour ridership into the city centre has tripled from under 5,000 at the beginning, to around 13,000 currently, while total system boardings have quadrupled from 20 million per year to nearly 80 million in 2010.

Driverless operation has also facilitated enhanced service for special events at the 60,000 seat football stadium, 18,000 seat hockey arena, and recently expanded downtown convention centre, all well served by the line. While additional field staff are required for crowd management, security, and supplementary fare collection, the extension of trains beyond afternoon rush hour, or the insertion of extras at the end of the event, is not dependent on additional train drivers, enabling the system to be more pro-active in service. This flexibility to increase capacity and adapt to demand was demonstrated during the Expo ’86 world’s fair in the first year of operation, and again in February 2010 during the Winter Olympics, when the system ran at peak levels from early morning till late night for 17 days straight.

Future potential for increased train capacity, with headways at or below 95 seconds, will allow the system to achieve its design potential of 25,000 pphpd within the next one or two decades.

Optimization and consistency of speed and travel time, as well as automated operation through the majority of the storage yard and primary service facility have also enhanced fleet productivity, and thereby capacity.

Driverless operation has also been the mode of success for the 2-year old Canada Line, with daily boardings averaging 120,000, roughly 20% above projection.

While technically possible to operate high levels of service in a more conventional system, driverless operation provided the opportunities which were successfully exploited in Greater Vancouver to build service and capacity over the past 25 years.

Ian R. Graham

Senior Operations Planner, B.C. Rapid Transit Co. Ltd., Burnaby, BC Canada

Contact: *Ian_Graham@BCRTC.BC.CA copying editor@uitp.org*

São Paulo: boosting critical Line 4 capacity

Photo: Digna Imagem/Clóvis Ferreira

Photo: Digna Imagem/Clóvis Ferreira

Left: Only full automation will allow 60,000 pphpd to be carried. Here, Paulista station on Yellow Line 4.
Right: Line 4 connects with Line 3, one of the world's busiest.

São Paulo metro's Yellow Line 4 operated by concessionaire ViaQuatro will be 13 kilometres long with 11 stations once fully implemented, and capable of carrying up to 1 million passengers per day. Currently at 9 kilometres long and with six stations, it already transports 470,000 passengers per day.

In a city where 9 million people use public transport on a daily basis, of which 4 million in the metro system alone, Line 4's main characteristic is that it integrates with other metro lines and commuter trains. Line 4 connects with Lines 1 and 3, two of the world's busiest lines, which requires Line 4 to adjust its services to cope with the high passenger connection demand (more than 90% of the passengers transfer to other lines). This close integration with other lines is capable of causing – as a repercussion of any disruption on the network – severe demand variations at the integrated stations. In addition, Line 4 passes through important locations with high passenger flows, such as two football stadiums and large avenues frequently staging public events.

Only full automation would enable 60,000 pphpd to be carried with a decreased headway and a comfort level of six standing passengers per sqm during peak hours. In other words, reaching an equivalent level of line capacity would be impossible in a conventional system.

Line 4, which began operating on May 2010, was designed with state-of-the-art signalling equipement at the heart of the UTO (Unattended Train Operation) system. The driverless system option was well received by users only familiar with conventional signalling systems. In addition, and in the interests of service improvements, service staff will circulate in trains and at stations. Line 4's layout allows a minimum headway of 75 seconds between trains, although the current operational headway is 90 seconds, ensuring a maximum frequency and thereby enabling the gap between 75 and 90 seconds to be used for service adjustments. Eliminating human factor interference brings the operational headway closer to the theoretical one, i.e., in a non-automated system, the turnaround time is slowed down by drivers changing cabins. A driverless system allows higher flexibility and operational optimisation in turnaround zones.

Additionally, when injecting more trains in the line, driverless systems allow for new functions not possible in conventional systems, such as anti-bunching, which prevents trains from getting stuck between stations when a malfunction can cause the next train to stop for a long time in the tunnel. Under automated operation, anti-bunching ensures a better carrousel optimisation without impacting line capacity and assuring maximum passenger comfort.

Full automation enables services to be adjusted during peak and off-peak hours to make them more attractive to passengers, and allows supply to be increased by injecting trains without the need for operators.

Factors such as expected higher demand, the need to adjust supply to demand variation throughout the day, and others like safety, service quality and savings, were crucial when choosing full automation as a solution for the Line 4 project.

Cláudio Andrade

Director, ViaQuatro, Companhia de Concessões Rodoviárias S/A, São Paolo, Brazil

Contact: *claudio.andrade@grupoccr.com.br copying editor@uitp.org*

Better adapting supply to demand: Paris metro Line 1 automation

Left: Half-height platform screen doors prevent intrusions – a major source of disruption.
Right: Drivers of lines that have been automated can be promoted to the Control Centre.

The automation of Line 1 forms part of the programme to modernise the command and control systems of the Paris metro. The acknowledged benefits of Line 14 in terms of service quality and reactivity of supply to demand underpinned the decision of RATP to launch its ambitious project to automate Paris metro's busiest line in 2003.

Line 1 was chosen due to the difficulty of adapting supply to demand. Its route layout and passenger flows make Line 1 traffic unpredictable. Moreover, Line 1 was the only one that was at the right stage for revamping – economically-speaking – due to the age of its installations.

Full automation will enable the operator to anticipate variations in line loading and adapt supply to demand almost instantly. Moreover, the absence of driver-management constraints, as well as the expected performance of the new system, will:

- increase the operating speed of the line by cutting terminus turnaround times and optimally complying with speed profiles
- reduce the number of trains in reserve by optimising their line position

The system chosen by RATP is based on CBTC radio communication and a virtual block signalling system. This allows train headways to be cut to as little as 85 seconds compared to the present 105 seconds. Wayside signalling is retained for operations in downgraded mode.

As part of the automation work, RATP has fitted half-height platform screen doors to all Line 1 platforms. The screen doors are vital for guaranteeing that there are no passengers or staff on the tracks. However, they also prevent intrusions – a major source of disruption in the Paris metro network – and secure platforms.

The Line 1 automation project is economically viable. Savings made from cutting a proportion of driver posts (these staff can be redeployed as drivers on other lines or promoted to the control centre) mean that the return on investment from the additional cost of the Line 1 modernisation programme (fully automating all train movements and installing platform screen doors) will be achieved in under 10 years.

The project for automating Line 1 also comes within the scope of RATP's sustainable development policy, as the higher operating speeds cut passengers' travel time. Alongside this, serious passenger accidents will be averted and energy consumption optimised.

Ultimately, the Line 1 automation project – thanks to system performance – will provide a transport capacity reserve of over 20%, the deployment of which will depend simply on rolling stock availability.

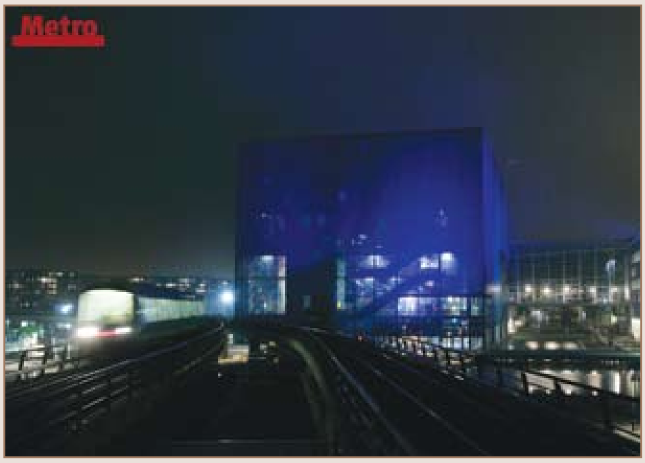
Translated from the French original version

Gérald Churchill

Automation Project Director, RATP, Paris, France

Contact: *gerald.churchill@ratp.fr copying editor@uitp.org*

Copenhagen: automation enabling 24/7 operation



Left: Operational flexibility ensures there is enough spare capacity to cater for exceptional events.
Right: 24/7 operation is simpler to provide, as train operation no longer depends on staff availability.

After the initial settling in period, the Copenhagen metro has taken up its place as a backbone of urban transit in the city. Early public debate on the benefits of going fully automated quickly transformed to an overwhelming agreement that driverless systems offer considerable benefits to the user.

For the operator, The Metro Company, the experience in Copenhagen has also been essentially a positive one. The experience of creating a green-field project subject to fewer historical constraints enabled the company to assess whether UTO (Unattended Train Operation) actually delivers greater flexibility in operation and if this flexibility is effectively exploited.

Operational flexibility

The Copenhagen metro currently runs a fleet of 27 trains in the peak service over 21km of route and with 22 stations. Peak service headway is currently 2 minutes with each 39-metre train having a capacity of 300 people. UTO allows frequent small trains to provide the required capacity. Because of the small size of the trains, operational flexibility is important to ensure that there is sufficient spare capacity to cater for exceptional events. The absence of rosters for drivers means that the control room operator can respond immediately to sudden changes in demand by inserting extra trains or by altering the service to redirect trains to areas in need. Removing the constraint of driver shift changeovers and the like allows the service to be continually tuned to ensure even headways and optimal recovery after delays. 24/7 operation is also much less constrained because the operation of the train is separated from the needs of the supervising staff.

Capacity management

Planned and unplanned service enhancements can be and are introduced. However, unused capacity can also be easily pared back, though generally this is planned in advance. Matching capacity to demand allows new timetables to be compiled easily and introduced as frequently as necessary with only minor impacts on the operating staff, as staff numbers and shift patterns are generally unaffected.

Cost effectiveness

Because there are no labour costs associated with incremental changes in the supply of capacity, costs are limited to the effort needed to compile and introduce the new service plan and the consequent changes to energy and equipment wear and tear levels. All of these items are easily identifiable, allowing the service level to be optimised as frequently as desired.

Lessons learnt

The success experienced by the Copenhagen metro confirms the validity of the original concept. Opting for a driverless solution is no longer considered a controversial aspect of the metro design but seen as a progressive element of the overall concept. The recently agreed Copenhagen Cityring project – a circle line set to open in 2018 – is almost identical in concept and underscores the decision to use a driverless solution. Development of the Cityring design has focused more on the enabling technologies and using these to support a robust operation.

Christopher J. Cox

Manager of Operations, The Metro Company, Copenhagen, Denmark

Contact: *CJC@m.dk*
copying editor@uitp.org