



Together
we move



Case study Spain

CITYFLO 650 - Metro de Madrid

Solving the capacity challenge and reducing the whole life cycle cost with proven communication-based train control (CBTC) without interruption to services

As more and more passengers switch to rail to make their journeys into city centres, the world's metro systems have to cope with increased demand for rapid, efficient services.

Many existing metro operations are rapidly reaching their maximum capacity, yet upgrades have to be carried out with minimal disruption to service.

Metro de Madrid is no exception. The metro system in Spain's capital city is the second longest in Europe, serving greater Madrid's population of approximately 6 million people. It is also one of the busiest, recording

over 600 million passengers per year, with as many as 2.5 million passengers in a single day. With passenger numbers increasing by 5.2% per year and peaks as high as 9%, capacity has been reaching its maximum level.

To cope with this increased demand, in 2004, Metro de Madrid commissioned the re-signalling of line 1 (23 km) and line 6 (24 km), choosing the *BOMBARDIER* CITYFLO* 650* moving block communication-based train control (CBTC) system to increase capacity through reduced headways.

600

million passengers per year.

This makes Metro de Madrid one of the busiest networks in Europe.

50%

increased passenger capacity.

The CBTC implementation doubled passenger capacity on Line 6 and increased speed with 5% to 42 km/h.



Shorter headways with CITYFLO 650

The challenge to Bombardier was not only to increase capacity but also to reduce whole life cost. Equally important was to ensure installation of the system could take place without interruption to services, and no loss of revenue or inconvenience to passengers.

CITYFLO 650 is a CBTC, moving block automatic train control (ATC) system. It fully exploits the capacity of the system and reduces energy and wear on the track and vehicles. The system does not require track circuits and can be used as an overlay radio-based train control system to upgrade existing fixed block systems.

It also eliminates wayside equipment due to its simple, reliable radio-based train-to-wayside communications systems, thereby permitting shorter, more consistent headways.

The upgrade of 68 trains from line 1 and 25 trains from Line 6 was part of the project and these vehicles have been in CBTC commercial operation since July 2008. 30 new trains for Line 6 have been retro fitted with *CITYFLO 650* CBTC system and entered service in 2011.

The *CITYFLO 650* solution is well proven to offer moving block CBTC semi-automatic train operation (STO) upgradeable to unattended train operation (UTO), the first of its kind for the Madrid Metro. To ensure continued operation of the previous track circuit-based automatic train protection (ATP) system in parallel, an overlay approach was chosen by the customer.

The ability to provide mixed mode operation promised no interruption to service for passengers, and provided low risk migration to CBTC with the opportunity to test the new system in 'shadow mode'.

This safe environment proved the functionality and safety of the new system, whilst the previous ATP still had full control of operation.

Introducing a new system always poses unique challenges. The added requirement to interface with different vehicle types and implementing the system on two lines simultaneously added to the complexity of the task.

During 2008, two important milestones were achieved for the Metro de Madrid signalling upgrade project:

- In March 2008, the first on-track demonstration on Line 6 verified the close headway spacing between two trains offered by *CITYFLO 650*. On this line a 40-second dynamic headway has been achieved.
- In July of the same year, the first CBTC equipped train entered passenger operation on Line 6 under control of *CITYFLO 650*, this was then extended to revenue operation involving multiple trains.

Bombardier is accustomed to working in close partnership with its customers and this project proved to be an excellent demonstration of this approach, ensuring that the overlay took place seamlessly.



These first vehicles running in commercial operation immediately achieved shorter headways and increased availability, meaning that more trains could run on the same track and infrastructure, without compromising safety.

In January 2009, Line 6 was already operating with all 25 of the 5000 series trains in CBTC and mixed trains operating under the legacy ATP system.

Even though increased capacity was not an objective during this mixed mode configuration, upon commissioning the CITYFLO 650 CBTC system into operation, a capacity increase of 11% was immediately demonstrated.

With the introduction in 2011 of the 30 new CBTC-equipped trains that are being procured by Metro de Madrid, the entire Line 6 fleet will then be under CBTC control thereby enabling a 30% increase in passenger carrying capacity.

The same success has been achieved on Line 1 where operation under control of the CITYFLO 650 CBTC system was initiated in May 2009. As with Line 6, the CBTC system is configured to support mixed mode operation and all 68 of the 2000 series trains are providing service in CBTC mode.

Improving operations

A further advantage of the CITYFLO 650 system is its ability to collect real-time operating data, enabling Metro de Madrid to focus on ways to further improve operations.

In addition to reducing dwell time by analysing operational behaviour, the system has enabled the operator to take appropriate and targeted maintenance actions on the most critical trains, thereby fine-tuning train performance and improving reliability and availability.

Metro de Madrid CITYFLO 650 components

EBI Screen control room	1
EBI Lock computer-based interlocking	16
EBI Com radio block centre	6
EBI Cab ATC onboard equipment	186
EBI Switch point machines	130
EBI Track train detection	433
EBI Light signals	420
EBI Tool design and maintenance	1



EBI Cab ATC onboard equipment

Key achievements

- The CBTC solution implemented as an overlay allows mixed mode operation and seamless transition, resulting in no track possessions, and no interruption to service.
- Enabling reduced headways and increased availability.
- A key future focus for Metro de Madrid's programme to increase capacity and improve quality of service.
- The CBTC implementation delivered a 50% increase in passenger capacity on line 6, a capacity improvement ahead of expectations, and an average speed increase of 5% to 42 km/h.
- Since July 2012, line 1 has only been operating entirely in CBTC mode.
- Bombardier's capability to customise the system for Metro de Madrid's environment simplified for end users the transition to a completely new signalling concept.
- The strong partnership between the Metro de Madrid and Bombardier was fundamental to overcoming all obstacles during its implementation on a busy existing line, on which the commuting population of Madrid depends.



Progress through partnership

The techniques, methodologies adopted and strong partnership between Bombardier and Metro de Madrid ensured the resignalling project was delivered without a single day's loss of revenue service or a single passenger being inconvenienced to the extent that passengers were not aware that a major change was taking place on the lines they were riding every day.

Outlook for the Spanish capital

These advancements are just the start for Metro de Madrid. In the future, the operator plans to continue its work to increase capacity, adding more trains to the lines to meet passenger demand. The partnership with Bombardier will lead to long term benefits of safe, efficient signalling for maximising capacity at low life cycle cost.

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