# Lane gain

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## SPTrans' Sílvio Rogério Tôrres discusses the practical application of microsimulation techniques to the reversible lane in the M'Boi Mirim bus corridor in São Paulo, Brazil

Brazilian cities are celebrated for their excellent bus services and São Paulo is no exception. The city has a complex surface transit network and, over the years, the various reserved bus lanes that have been installed have greatly improved bus speeds and reliability. However, solutions need to evolve to cope with increasing demand: the M'Boi Mirim bus corridor was built in 2003 and, ten years later, it remains the only way to get from the southwest districts of São Paulo to the central business district by public transport. Unsurprisingly, travel times and queues have increased dramatically and, by March 2010, during the morning peak hours, the average bus speed had dropped as low as 8km/h on weekdays (Figure 1).

A new metro line connecting the neighbourhoods of M'Boi Mirim and Jardim Ângela with the central business district is currently under construction to alleviate the problem but, in the meantime, São Paulo Transporte (SPTrans), the municipal transit authority responsible for the management of public bus transport in the city, needed a fast, short-term, stop-gap solution.

The M'Boi Mirim corridor itself is made up of three lanes: two lanes for mixed traffic and local bus lines and one lane reserved for trunk lines that use standard, articulated and bi-articulated buses; however, there is no additional bus lane for overtaking manoeuvres.

SPTrans used the Aimsun traffic modelling software to simulate two scenarios: before and after implementation of reverse flow on an outbound reserved bus lane. This allowed traffic and transit specialists to evaluate the effectiveness of the proposed measures, which were designed to eliminate bus bunching on the CBD-bound bus lane, as caused by increasing passenger numbers from the surrounding areas and the corresponding increase in bus frequency and transit lines.

Figure 1 shows the effectiveness of the adopted measures confirmed by the increase

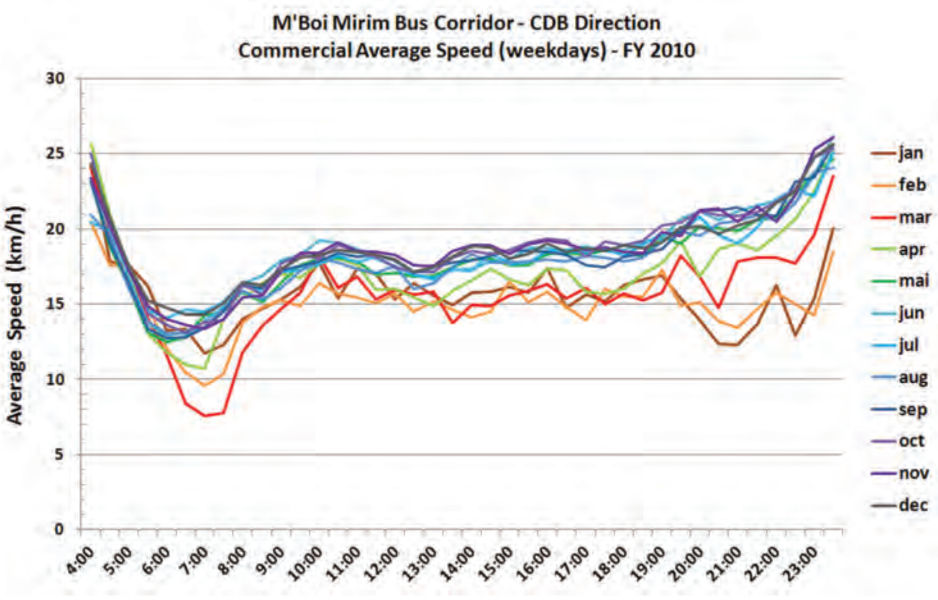



**Figure 1 – Commercial average speeds for buses in the M'Boi Mirim Corridor collected by on-board GPS devices** *Source: São Paulo Transporte, 2010*

**Figure 2 – CBD-bound buses queuing** *Source: São Paulo Transporte, 2009*

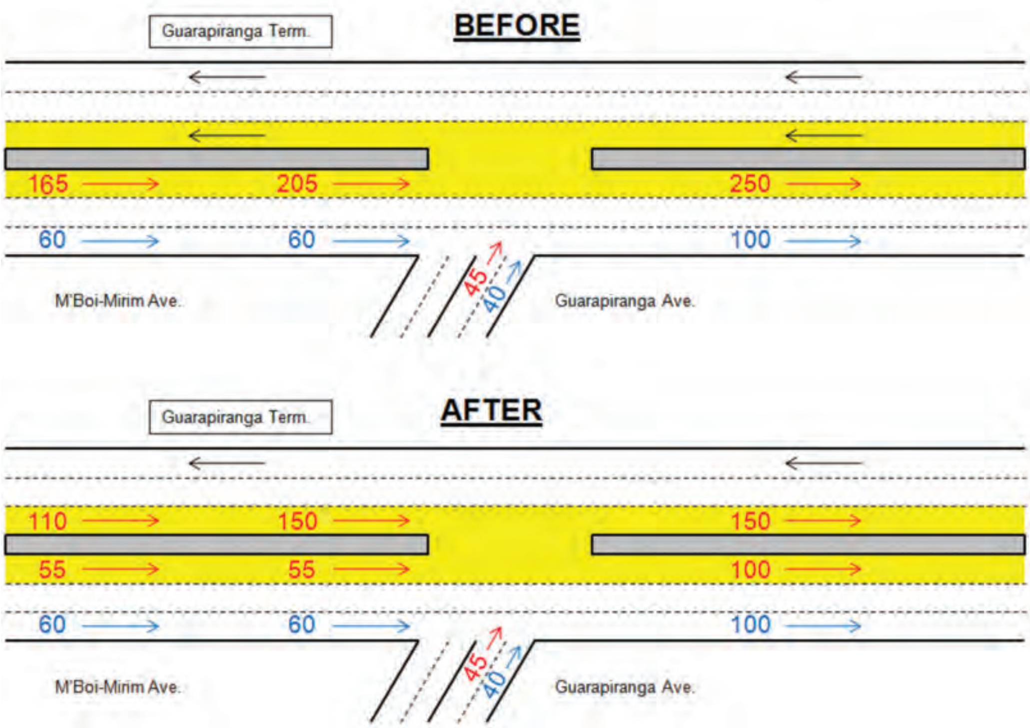
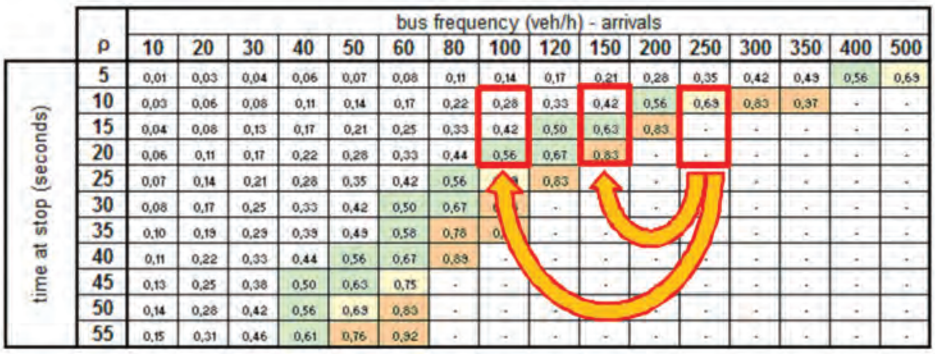



**Figure 3 – Bus volumes at critical section before and after the implementation of the reversible lane** *Source: São Paulo Transporte 2010*

**Figure 4 – Saturation index (queueing theory) – bus volumes, dwelling times (boarding/alighting times)** *Source: Adapted from: www.silvio-torres.com/files/Filas%20-%20S3.pdf*



| time at stop (seconds) | bus frequency (veh/h) - arrivals | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ρ | 10 | 20 | 30 | 40 | 50 | 60 | 80 | 100 | 120 | 150 | 200 | 250 | 300 | 350 | 400 | 500 |
| 5 | 0,01 | 0,03 | 0,04 | 0,06 | 0,07 | 0,08 | 0,11 | 0,14 | 0,17 | 0,21 | 0,28 | 0,35 | 0,42 | 0,49 | 0,56 | 0,69 |
| 10 | 0,03 | 0,06 | 0,08 | 0,11 | 0,14 | 0,17 | 0,22 | 0,28 | 0,33 | 0,42 | 0,56 | 0,69 | 0,83 | 0,97 | - | - |
| 15 | 0,04 | 0,08 | 0,13 | 0,17 | 0,21 | 0,25 | 0,33 | 0,42 | 0,50 | 0,63 | 0,83 | - | - | - | - | - |
| 20 | 0,06 | 0,11 | 0,17 | 0,22 | 0,28 | 0,33 | 0,44 | 0,56 | 0,67 | 0,83 | - | - | - | - | - | - |
| 25 | 0,07 | 0,14 | 0,21 | 0,28 | 0,35 | 0,42 | 0,56 | [illegible] | 0,83 | [illegible] | - | [illegible] | - | - | - | - |
| 30 | 0,08 | 0,17 | 0,25 | 0,33 | 0,42 | 0,50 | 0,67 | [illegible] | - | [illegible] | - | [illegible] | - | - | - | - |
| 35 | 0,10 | 0,19 | 0,29 | 0,39 | 0,49 | 0,58 | 0,78 | [illegible] | - | - | [illegible] | [illegible] | - | - | - | - |
| 40 | 0,11 | 0,22 | 0,33 | 0,44 | 0,56 | 0,67 | 0,89 | - | - | - | - | - | - | - | - | - |
| 45 | 0,13 | 0,25 | 0,38 | 0,50 | 0,63 | 0,75 | - | - | [illegible] | - | - | - | - | - | - | - |
| 50 | 0,14 | 0,28 | 0,42 | 0,56 | 0,69 | 0,83 | - | - | - | [illegible] | - | - | - | - | - | - |
| 55 | 0,15 | 0,31 | 0,46 | 0,61 | 0,76 | 0,92 | - | - | - | - | - | - | - | - | - | - |

**Queue Length**

- 0<L<1
- 1<L<2
- 2<L<3
- 3<L<99

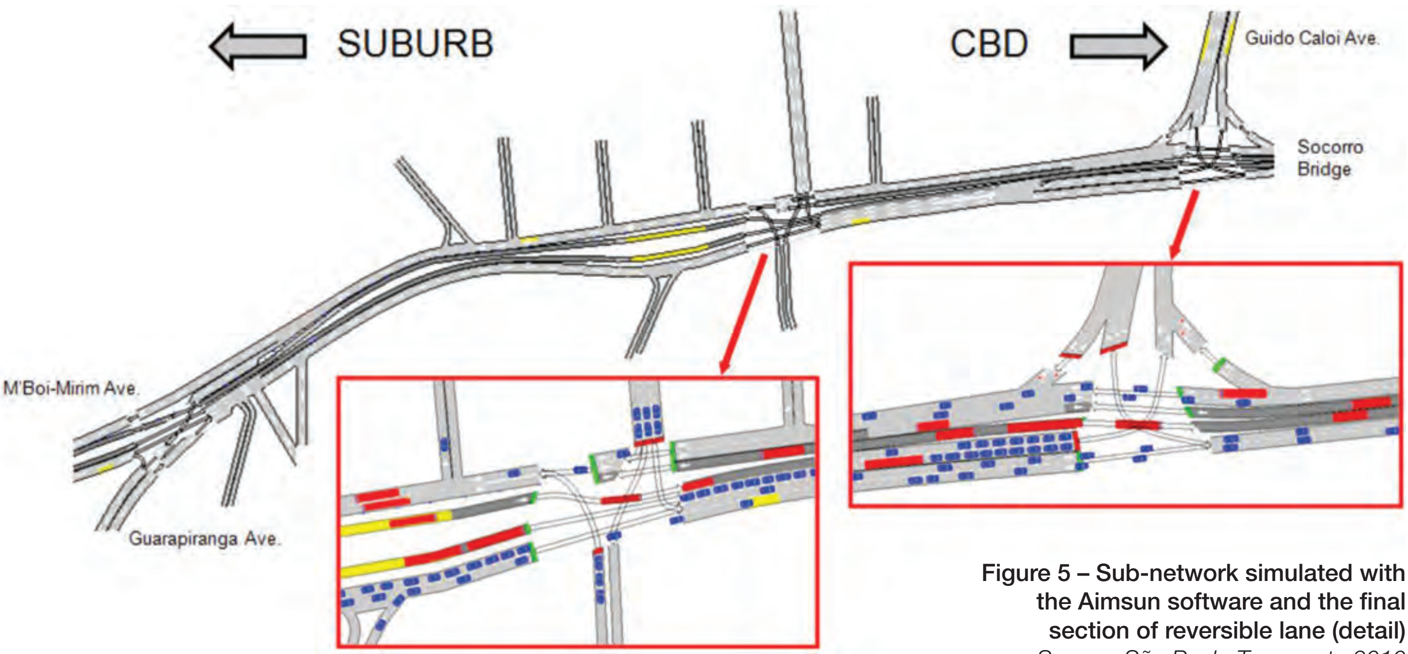



**Figure 5 – Sub-network simulated with the Aimsun software and the final section of reversible lane (detail)**
*Source: São Paulo Transporte 2010*

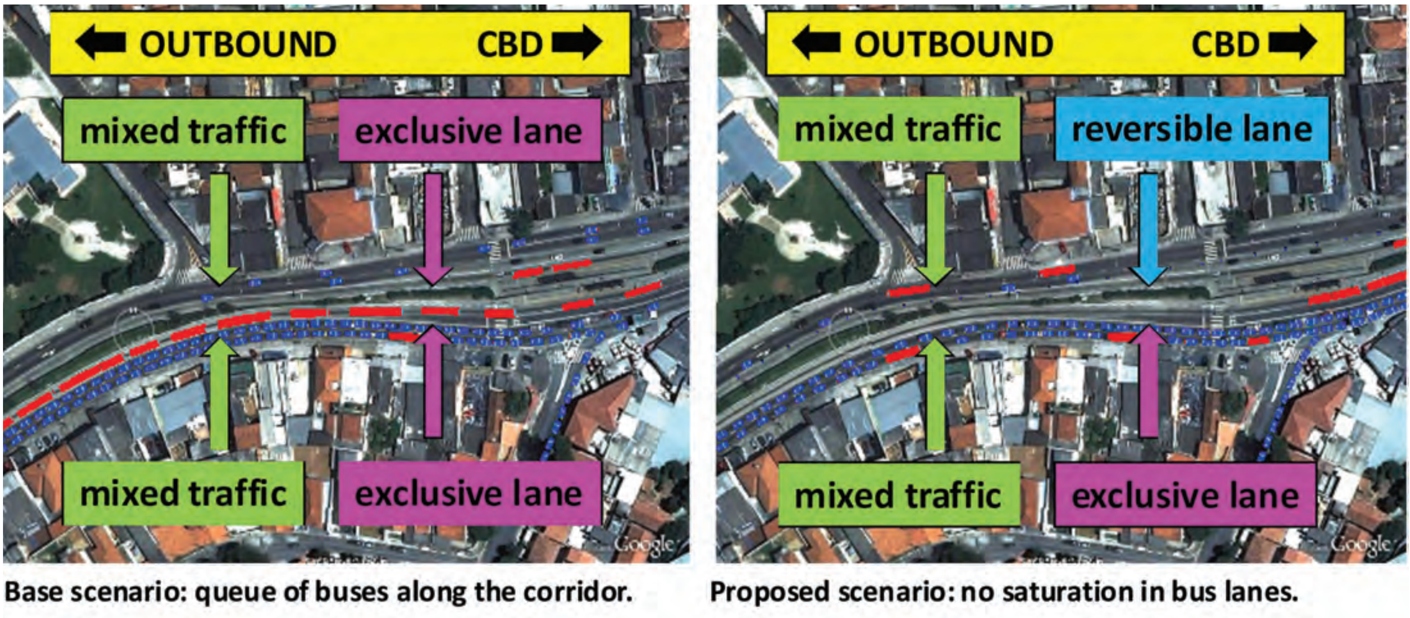



**Figure 6 – Snapshots for both base scenario (without reversible lane) and proposed scenario (with reversible lane)** *Source: São Paulo Transporte 2010*

in commercial average speeds in the months after the implementation of the 5-km reversible lane for buses in the corridor on April 2010.

## A closer look

The corridor load is about 26,000 passengers per hour heading towards the CBD on weekdays. Its most critical section has over 50 bus lines running on the reserved lane and on general purpose lanes; this concentration of buses and users means that stops along the corridor cause bottlenecks.

There were long queues of buses during the morning rush hour and any incident during the day was sufficient to cause problems in the corridor.

Taking all routes and transit lines into account, there are around 350 CBD-bound buses per hour: 250 in the reserved lane and 100 outside the corridor.

The idea was to redistribute the excessive bus volume of the reserved lane by diverting part of it to the reversible exclusive lane (see Figure 3, 'After'). This decreased the saturation index '**ρ**' to an acceptable level according to queueing theory, as shown in Figure 4.

All the necessary input data (transit routes, traffic counts, turns, signals, free-flow speeds, buses frequencies, times at stops, etc.) were collected in order to simulate the sub-network (see Figure 5).

Microsimulation runs indicated that the proposed scenario with the reversible lane would eliminate queues of buses in the reserved lanes and that average speeds would return to acceptable levels (15-20km/h). The reduced travel times and queues were confirmed by both field counts and by data collected from GPS and AVL (Automatic Vehicle Location) devices installed in the 15,000-strong operating bus fleet.

Microsimulation was key in assuring decision makers that the reversible lane was a feasible solution for the chronic congestion. Figure 6 is a snapshot of the base and proposed scenario at the same time of day during the simulation. Note the queues of buses in the base scenario without the reversible lane and the proposed scenario with buses running in a non-congested situation in both exclusive lanes (original and reversible).

The opposite direction (outbound) was not affected by the additional returning bus volumes because in the morning there are very few people travelling out to the suburbs. The prevalence of work trips and the need for commuters to arrive at work punctually make this flow direction more complicated but, as the attraction zones for afternoon return trips from the CBD are more dispersed, it was not necessary to implement the reversible lane for the afternoon peak hours.

Figure 7 shows the operation of the reversible bus lane a few days after its implementation. The dedicated signals, separators and other structural adjustments were installed for the safety of pedestrians and drivers; on-site member of staff were also prepared to orient road users and keep operations running smoothly.

At the time of writing, the benefits of the reversible lane still remain and the solution proved that although it is not a definitive and structural response to the problem, in cases such as this, operational measures can greatly minimise congestion.

**Figure 7 – The reversible bus lane in operation.** *Source: São Paulo Transporte 2010*