Green lights for Paris tram

Alexandre Torday and Gabriel Funés, TSS - Transport Simulation Systems, describe how microsimulation modelling helped stakeholders in Paris choose the best design for the Tramway des Maréchaux.

Trams have experienced something of a resurgence across Europe during the last several years as manifested by new or expanded tram networks in Spain, Portugal, the Netherlands and the UK. Trams present an environmentally friendly and attractive way for city councils to increase modal share for public transport.

Our case study from the city of Paris sheds light on some of the urban planning and traffic engineering challenges associated with the introduction of a new tramline. It also, we hope, illustrates the usefulness and advantages of micro simulation in addressing these challenges.

The tramline in question, introduced as part of on-going improvements to the French capital's transport infrastructure, follows the 'Boulevards des Maréchaux' urban ring road. The study, which we carried out using Aimsun, focused on the area between Porte de Vincennes and Porte de Bagnolet; this includes some fifteen signalised intersections and two large signalised roundabouts.

Segregation

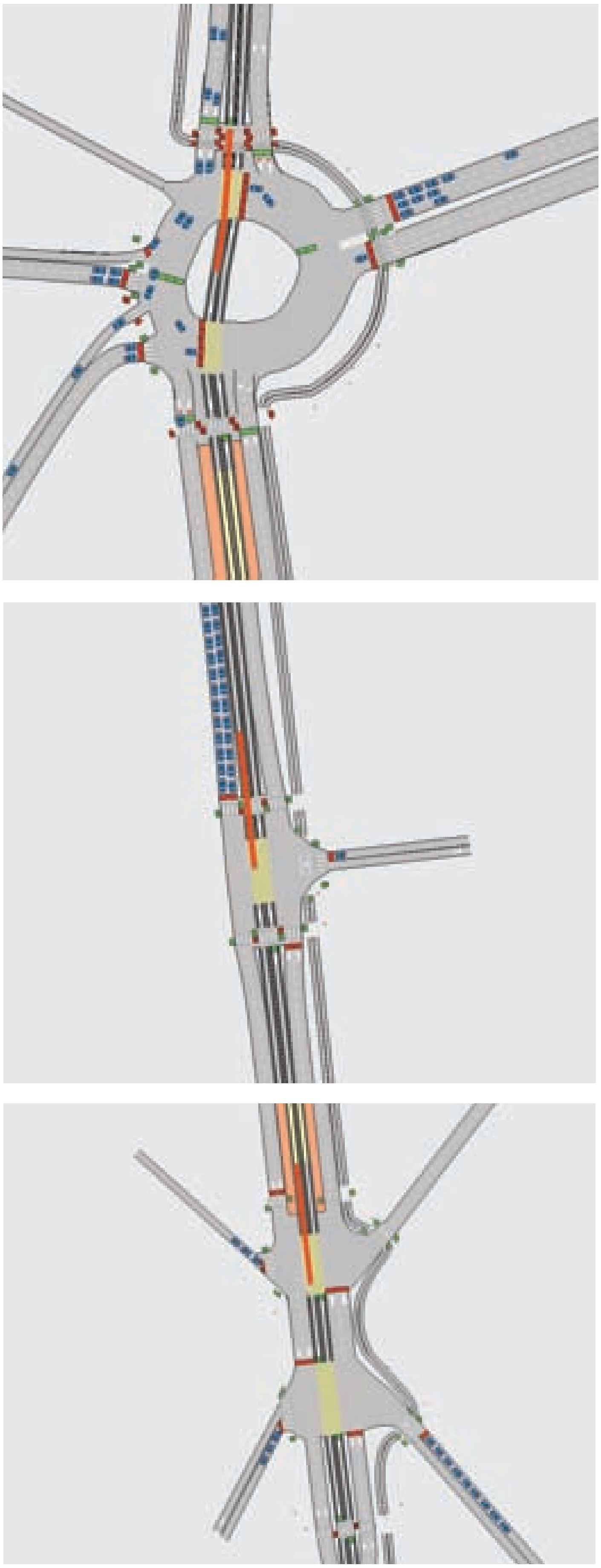
The French capital's authorities opted for segregated tramways. This approach limits the interactions between trams and other transport modes to intersections only. Segregation mitigates delays and accidents that could arise if space were shared. In addition, by taking away some of the existing road capacity, a dedicated tramway provides a further incentive (counter-incentive, even) to Parisian commuters: since travel time by passenger cars on that same route is likely to increase as a result of the new tramline, more people will be tempted to shift from cars to trams.

This is a question of striking a delicate balance, though: taking away too much road capacity can increase unwanted congestion, accidents, delays and emissions. Conversely, a tramline with too little effective capacity is unlikely to sustain sufficient demand. Long or unreliable journey times are never helpful in that regard. Therefore, the selection of an appropriate design and its subsequent implementation become equally important.

Axial versus lateral

During the bidding phase, four different scenarios were put forward by urban planners for implementing the desired segregation. One of those scenarios involved an axial tramway whereas the remaining three involved lateral tramways in different configurations. The differences between those schemes in terms of the capacity impact that they implied were far from trivial. Firstly, the nature, magnitude and frequency of pedestrian-car-tram interactions are very different for an axial tramline compared to, for example, bi-lateral tramways, a fact that was confirmed rather dramatically by our study. Secondly, some proposals submitted to the city authorities involved doing away with more lanes than others resulting in a more drastic road capacity reduction.

This is one of those cases where assessing the impact of a design scheme and optimising the implementation aspects cannot and should not be separated. The ability to consider how a proposed layout would work under optimised management is essential in understanding its true



potential and, ultimately, the only way to make an informed choice.

Fortunately, the Parisian authorities recognised this and defined the brief as that of understanding the complete impact of the tramline, meaning the selection of the best physical design together with the best possible revised traffic control plan.

Intelligent trade-offs

To enable the tram to have an interrupted journey without having to slow down for signal changes, the existing fixed cycle control plans needed to be complemented by adaptive control (tram pre-emption).

Notwithstanding the prerogative of keeping the tram moving, there were other important criteria to be kept in mind. In this particular case, pedestrian safety occupied the top spot. Further down the list, the city was intent on controlling (minimising) the impact of the tramline on cross streets whereas the capacity of the boulevards themselves received a lower priority ranking. The trade-off between these conflicting priorities was one of the two issues complicating the design of tram pre-emption. The other was the need to combine pre-emption with the existing fixed cycle plans. Ideally this would be done such that the trams would have a green signal some one hundred metres before arriving at the intersection. Fortunately, this hybrid scheme can be easily modelled in Aimsun and this allowed us to fine-tune the triggering of the necessary inter-phases to minimise disruptions.

To evaluate the performance of the four designs, we deployed a staged approach. In the first stage, we compared the performance of all designs and various associated control plans on the most representative intersection. This enabled us to fine-tune a traffic control concept for each scenario. The next stage was a global evaluation.

And the winner is . . .

Simulations of the entire area studied showed that the axial scenario outperformed the other schemes with respect to the multiple criteria defined by the Paris scheme.

The safety-related aspects were assessed on a qualitative basis: experts examined the visual outputs of the simulation and studied the interactions between trams and other modes (apart from buses and private vehicles, the model included proxies for bicycles and pedestrians at intersections). As far as the capacity-related criteria, after collecting the numerical outputs (queue lengths at intersections as a function of time), we collated them into a table that summarised the risk of blockage for each scenario. The axial layout ranked best whereas the bi-lateral layout had the worst performance by some margin.

On the strength of this study, the axial design was selected for the Tramway des Maréchaux (East side). In addition, the control plans (including tram pre-emption) designed as part of this simulation study will be implemented after some refinement related to practical limitations.

This is a typical situation in which modelling and in particular microscopic simulation is at its best. There were numerous scenarios to be considered; each scenario being made up of a physical design and an associated traffic control strategy. There were multiple, partly or directly conflicting objectives.

Quantification of detailed dynamics was essential: vehicles blocking part of an intersection, pedestrians crossing late, trams passing over a detector were all minute details which may make a difference. On top of that, we were able to include stochastic elements and to examine a range of possible situations as is expected to be the case in reality.

Finally, not only are the analytical outputs indispensable but a visual quality audit gave stakeholders confidence to endorse a solution at reduced risk and with the maximum possible objectivity. There is something tangible about being able to be a virtual passenger in the tram and travel through the entire model with virtually no slow-downs at intersections.

These snapshots show how simulation helped stakeholders confirm that the tram did not stop at intersections – in real life this was done with a video.