MULTI-MODAL SIMULATION-BASED PLANNING FOR PEDESTRIANS

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ABSTRACT

In this contribution Strasbourg's plan piéton will briefly be summarized and as a part of it the traffic situation around the central bridge Pont Kuss will be introduced. At Pont Kuss a number of safety and convenience issues in pedestrian traffic are reported. This is the motivation for a multi-modal microscopic simulation project which assesses measures to improve the situation for pedestrians. The assessment includes both: benefits for pedestrian and potential drawbacks for vehicular traffic. It will be shown in detail that clear benefits for pedestrians and for public transport are opposed by only small – if at all – drawbacks for vehicular traffic. It is concluded that multi-modal micro-simulation is a powerful tool to handle all traffic modes with equal care and equal rights in the planning process and that it is at the same time a powerful tool to produce material for communication with the public.

INTRODUCTION

Many Old Towns – predominantly in, but not limited to Europe – have two properties in common: their narrow street network and attractiveness for local population and tourists alike. In the Old Towns traffic and mobility infrastructure and popular living spaces are most closely intermingled and therefore also in conflict.

Pedestrians should feel comfortable in these areas. To formulate it as a political position: the desires, needs and rights of citizens in traffic must not depend on their travel mode choice. However, there is also a more tangible reason: city centers and particularly Old Towns have a considerable economic (touristic) potential which can only be fully realized, if vehicular traffic is not pre-dominant.

On the contrary – and particularly in the face of an aging population – motorized traffic has to be granted a minimum access. Delivery services might come to mind first, but it is also important to consider people with reduced mobility and especially with difficulties to walk and keep their balance. For them being taken somewhere with a car can be the by far easiest way or even the only chance to go somewhere. However, once motorized access to some location is granted, typically there are many good reasons to extend the accessibility with motorized traffic further and further. As a consequence planners have to

perform a balancing act between both contrary objectives to maintain the city's character livable and as a living space.

In this work it is argued that this can only – or at least most easily – be achieved when all modes of traffic – pedestrians, cyclists, motorized individual traffic, and public transport – are planned at the same level of detail, with the same visibility and in this way are granted the same level of awareness. Doing – on the contrary – a micro-simulation with second-wise signal plan optimization for vehicular traffic and plan for pedestrians with a simple spread sheet will often disadvantage pedestrians in aspects which may seem minor at first. It may then, however, happen that pedestrian lights regulating a crossing to a tram platform always show red when a tram stops. As a result pedestrians face the alternative to miss the bus or cross at red. More examples of traffic organization which may result from the approach is described below. Equal awareness for all modes of mobility is automatically guaranteed, when all modes are integrated in the same planning tool. Such a planning approach is demonstrated here along a concrete planning example.

Planning for pedestrians and cyclists in some aspects is simpler than planning for vehicular traffic. For example usually all pedestrians and cyclists waiting at a traffic light can pass a junction within one green signal phase, no matter how short the phase is. For vehicles this is not the case. Sometimes drivers have to wait three, four or even more cycles before they can pass. For such reasons elaborate methods for the planning of vehicular traffic in cities have been developed and are in perpetual use. With these tools often the vast majority of awareness and working hours are invested in vehicular traffic with the implicit assumption that cyclists and especially pedestrians always "somehow" will make their way.

As a consequence pedestrians do not receive proper attention during the planning process and thus potential problems are more likely missed and pedestrians therefore are disadvantaged.

The Old Towns may most clearly show the necessity for integrated and balanced planning, but considering the rapid urbanization process which is currently going on (United Nations 2012) it becomes clear that integrated planning is desirable for larger if not the whole urban area for the sake of giving equal rights to pedestrians and by that motivate and promote walking, the most space-efficient way of movement. In this way the Old Towns become trendsetters and point to the future of city and traffic planning to create safe and livable city streets.

STRASBOURG'S PLAN PIÉTON

Early in 2012 the city of Strasbourg has announced a ten years (2011 – 2020) plan which intends to improve the situation of pedestrians (Communauté Urbaine de Strasbourg 2012) (Conseil Municipal de Strasbourg 2012) (Chabrol und Rouiller 2012). As motivation for this *Plan Piéton* ecological reasons are mentioned, economic interests (see above), freedom and autonomy, and public health (countering the ever more prevailing obesity), but also – and particularly emphasized – a civic interest: counteracting "mutual strangeness".

The plan piéton on a strategic level encompasses all city quarters (see FIGURE 1) and breaks this down stepwise to smaller areas (see FIGURE 2) for a detailed analysis.
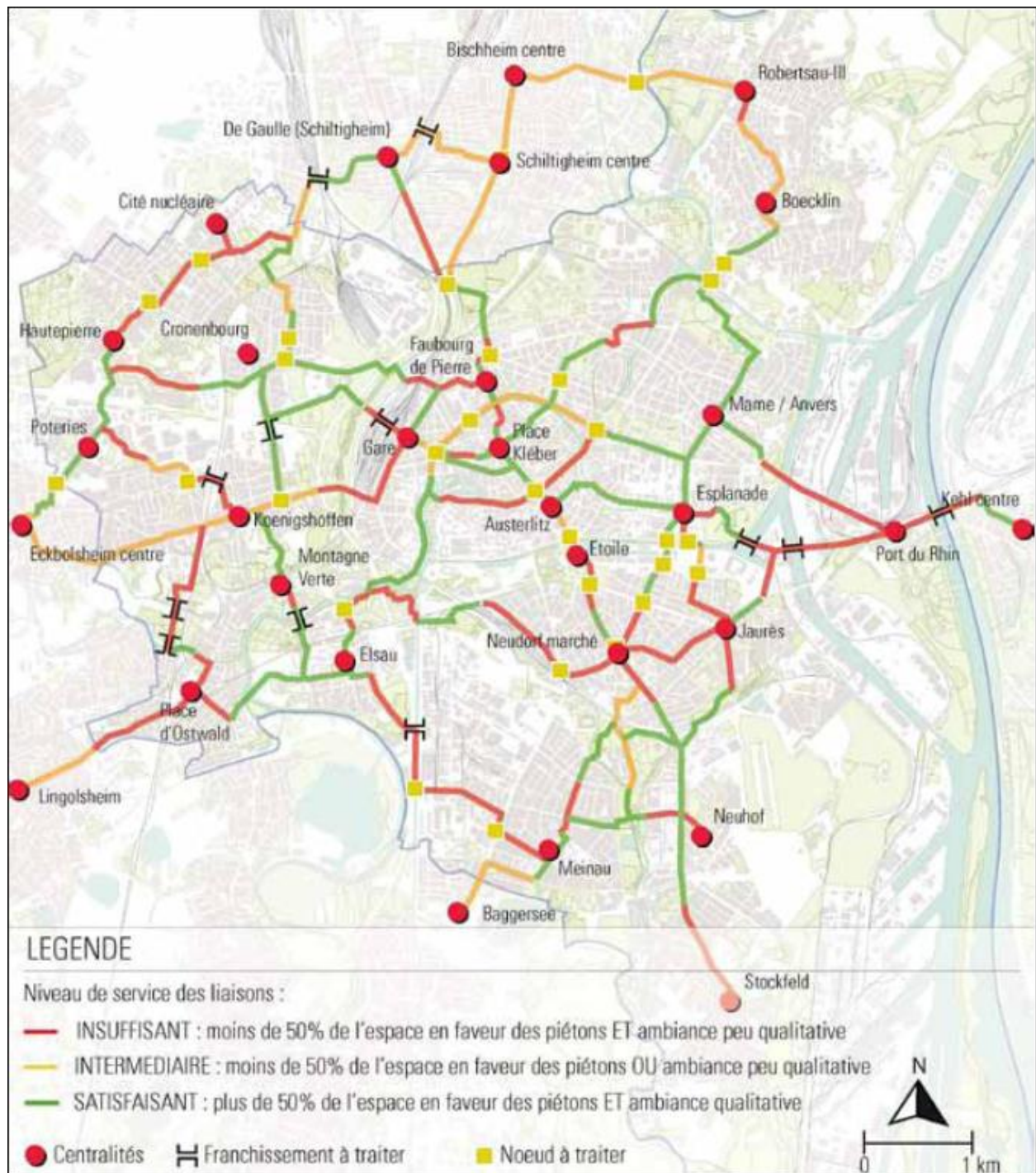
FIGURE 1: Major Pedestrian Network (Réseau Piéton Magistral) in Strasbourg with a three-level assessment of the current suitability for pedestrian needs for each link. Source: (Communauté Urbaine de Strasbourg 2012, p. 47).
Translation of legend: Level of service along the links:
[red] INSUFFICIANT: less than 50% of space for pedestrians AND low quality atmosphere
[yellow] INTERMEDIATE: less than 50% of space for pedestrians OR low quality atmosphere
[green] SATISFYING: more than 50% of space for pedestrians AND high quality atmosphere.
Centers   Passage to cross   Traffic node to cross

From the analysis ten fields of action are deduced:

1) Promote (the relevance) of walking.
2) Redistribute the street space in favor of pedestrians.
3) Reduce conflicts between pedestrian and bike traffic.
4) Apply instruments of city and regional planning to pedestrian traffic to enhance the pedestrian network.
5) Assign at least 1% of the budget of any major project to pedestrian issues.
6) Improve ways to schools and promote walking to school (Pedibus).
7) Reduce separating impact of arterials.
8) Arrange road nodes pedestrian-friendly.
9) Create new pedestrian links along and across waters to close gaps in the pedestrian network.
10) Create a Major Pedestrian Network (Réseau Piéton Magistral, FIGURE 1)
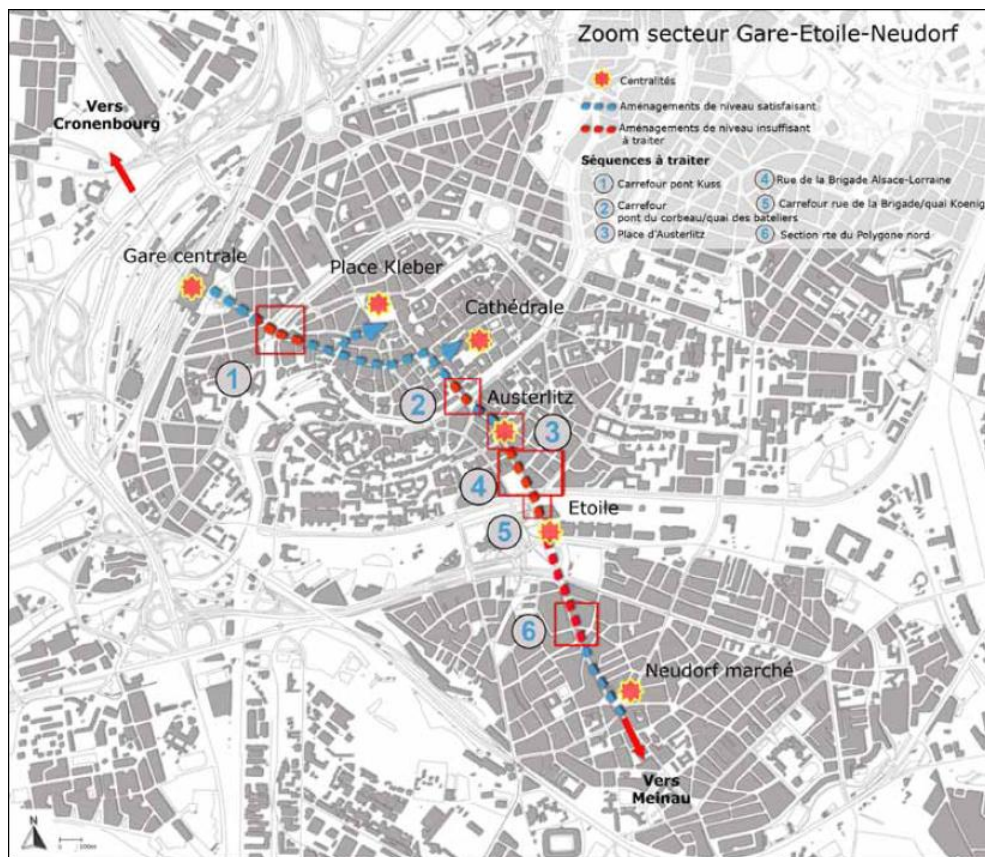

FIGURE 2: Zoom to city center. Red dots mark areas of insufficient level of quality for pedestrian needs. The red square marked with (1) is Pont Kuss. Source: (Communauté Urbaine de Strasbourg 2012, p. 48).
Translation of legend: Zoom of sector Station-Etoile-Neudorf
Center
[blue dots] Arrangements of satisfactory quality
[red dots] Arrangements of insufficient quality have to be passed

TRAFFIC AT PONT KUSS

It was decided to simulate the traffic (pedestrians, cyclists, motorized individual traffic, and public transport) around Pont Kuss – one of the hotspots – microscopically applying PTV Vissim and Viswalk (Fellendorf und Vortisch 2001) (Kretz, Hengst und Vortisch, Pedestrian Flow at Bottlenecks-Validation and Calibration of Vissim's Social Force Model of Pedestrian Traffic and its Empirical Foundations 2008) (Bönisch und Kretz 2009) (Fellendorf und Vortisch 2010) (PTV Group 2011). Micro-simulation was used to be able to take into account uncertainties from adaptive or acyclic behavior, to measure travel and waiting times on complete routes and at crossings, to reproduce the current situation, and to use the 3D output as powerful element in the communication with the public (Laugel und Reutenauer 2011).

Pont Kuss is a bridge over the Ill connecting Strasbourg's main station and its Old Town, which is entirely surrounded by the river Ill, see FIGURE 3. As such Pont Kuss is heavily frequented during rush hour by pedestrians. A count which stood at the beginning of the project gave a number of 1,850 pedestrians per hour (see FIGURE 4) who share two sidewalks with each having a width of short to 2 meter while on the contrary for counted 250 vehicles per hour there is two lanes with a width of 3.5 m each, which implies that even if all cars were fully occupied a citizen using a car would be granted more public space than a walking citizen. This makes the location appear to be a potential case for number 2 of the previously mentioned ten fields of action. However, does this unbalanced distribution of public space really cause problems for pedestrians? And if so, can these be resolved by redistributing space and with other measures? And if so how severe are the drawbacks for motorized individual traffic and what is the impact for public transport?

The second and third question later will be answered using micro-simulation. The first question, however, is a case for a field study which was done together with the aforementioned counts.

FIGURE 3: The location of the project with traffic modes (red: public transport, yellow: motorized individual, green: pedestrians and cyclists). The main station is to the West (left), the Old Town to the East (right). See also http://goo.gl/maps/GpBI .
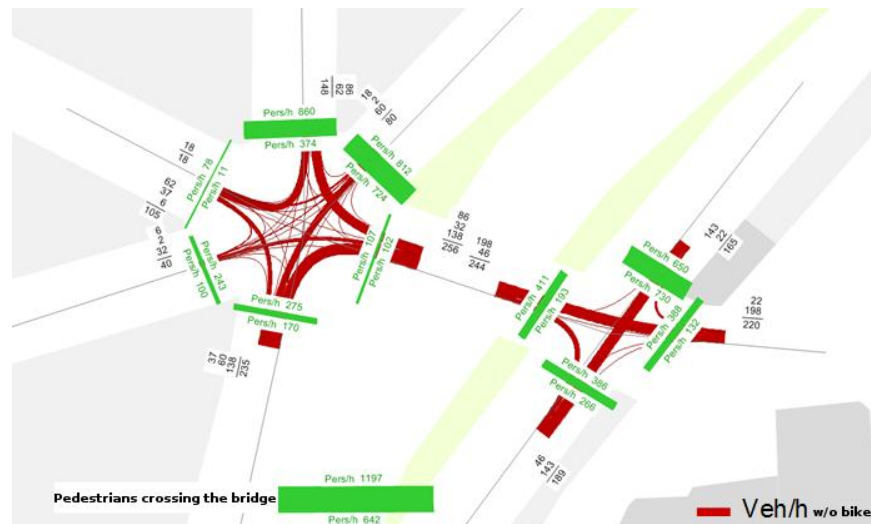
FIGURE 4: Volume counts of pedestrians (green) and motorized vehicles (red) during peak hour. The sum of 1849 pedestrians per hour who cross the bridge is not equally distributed but more use the northern side.

Two major issues were identified. The first is that pedestrians on the northern side of the bridge often step on the adjacent road lane when evading opposing or overtaking slower pedestrians as the width of the sidewalk on the northern side of the bridge is not sufficient for the demand, see FIGURE 5. The asymmetric utilization of the bridge is a consequence of a tram stop ("Alt Winmärik") which poses a major origin and destination for pedestrians on the north-eastern side. Second the space on the sidewalk on the southern side at the road to the main station in the west is occupied by cafes. This makes pedestrians change to the northern side. See FIGURE 6.

The causes for the asymmetric usage cannot be eliminated, but it would be possible to increase the width of the sidewalk on the northern side by assigning one of the road lanes to the pedestrians. The benefit of that measure for pedestrians is obvious and the impact for vehicular traffic was investigated with simulations (see below).

FIGURE 5: Pedestrians inundating the road, compare (Yuan, Giese und Lew 2009). This can even be observed off-peak, see http://goo.gl/maps/NrfLh .
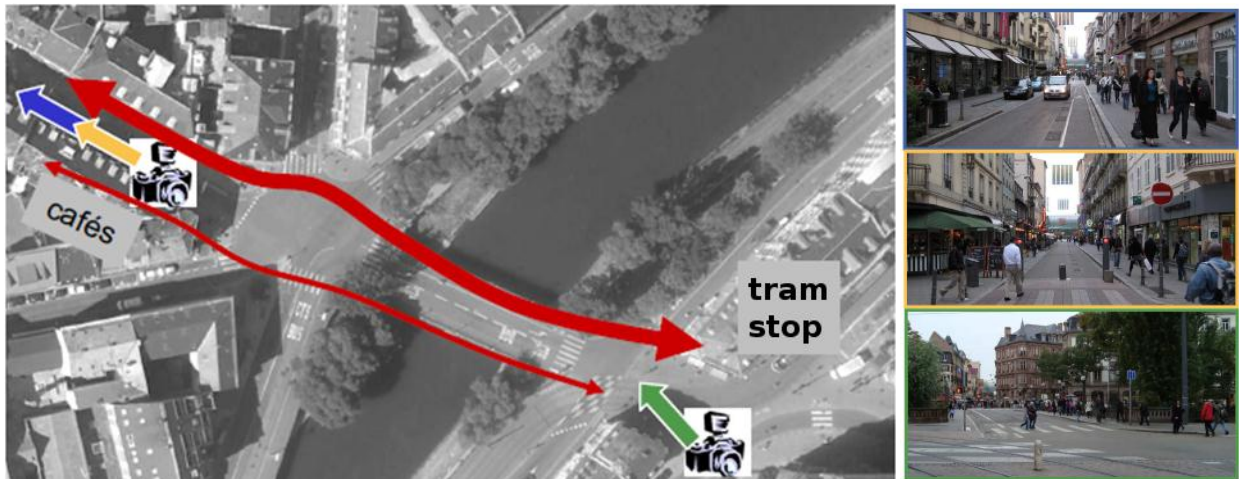
FIGURE 6: Asymmetric pedestrian usage of the bridge and its causes. The arrows in the left image indicate the position of the photographer for the photos on the right side. With the color of arrows and image frames the photos can be assigned to positions.

The second issue which was identified is that pedestrians on the large crossing on the western side do not follow the intended path, see FIGURE 7. A major, albeit not necessarily the only, motivation for this behavior was found in the simulations of the current state: the current traffic signalization is such that if a pedestrian obeys the intended path and red light signals he or she will have to wait twice rather long at both of the signals. The implicit assumption is that if a signalization was put in place that is more in favor of pedestrians the level of obedience to the intended path would increase.

As a consequence of the identified issues three measures were considered and investigated and assessed with micro-simulation: 1) reassigning the northern vehicle lane on the bridge to the northern sidewalk, 2) extending pedestrian spaces on the western crossing into what so far is space for vehicles, and 3) modifying the signal programs in favor of pedestrians.
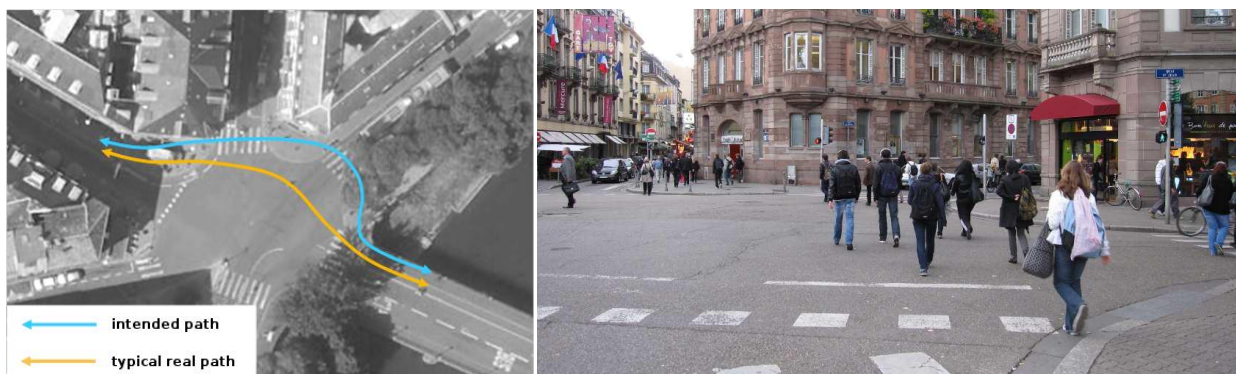

FIGURE 7: Pedestrians short-cutting. This phenomenon also occurs off-peak: http://goo.gl/maps/VeaZ .

SIMULATION OF MULTI-MODAL TRAFFIC AT PONT KUSS

Simulation models of the current situation and two alternative scenarios have been created, see FIGURE 8. The simulation results showed that dwell times of pedestrians at all crossings would significantly drop in both alternative scenarios, see FIGURE 9. At the same time no significant drawbacks for vehicular traffic could be found as can be seen in FIGURE 10 or that drawbacks are balanced with gains, see FIGURE 11. Finally it was found that the travel time of some PT lines reduces significantly in the alternative scenarios, see FIGURE 12.

FIGURE 8: Current situation (left, "Voirie de'l etat actuel") and two alternative scenarios (center and right). The two alternatives differ in their signal programs ("”feu") and in that in the second alternative scenario there is a right turning lane for the vehicles leaving the bridge ("2 voies"). An animation of a simulation run of the current state can be seen here: http://youtu.be/YzPYwfHe0VU . The 3D visualization of the buildings of the environment is one single 3D model which has been loaded as background into the simulation software. This is not a requirement for the simulation.

As a side notice: initially it was also discussed if traffic could work out without traffic lights in a kind of shared space configuration (see FIGURE 13), but this proposition did not make it to the point of being modeled in the simulation software – which would have been a challenge up to date.
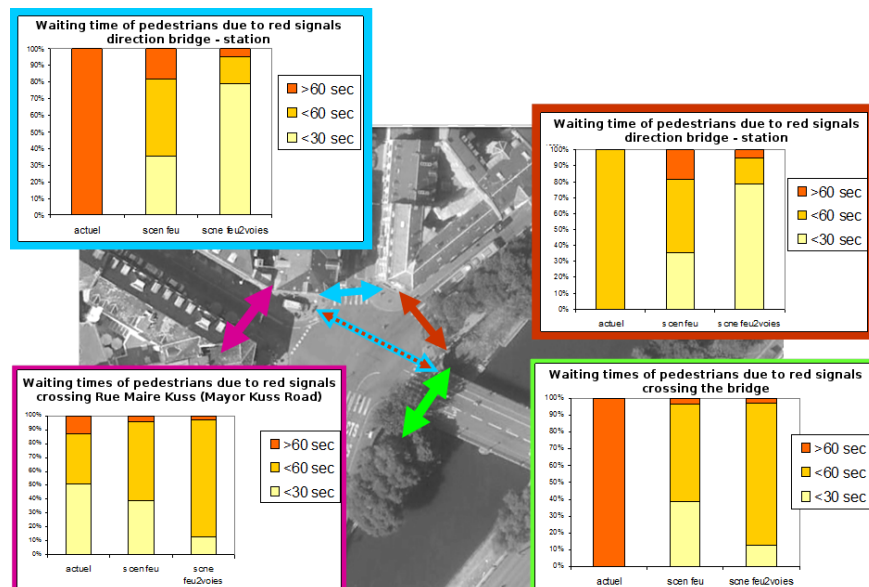

FIGURE 9: Simulation results: pedestrian waiting times at signals in comparison for the three scenarios as shown in FIGURE 8.
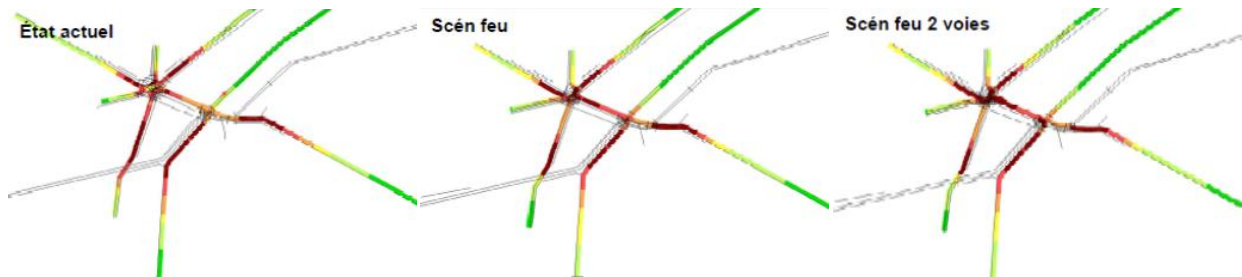
FIGURE 10: Result from an assignment computation with PTV Visum: speed-based LOS for vehicular traffic for the three scenarios as shown in FIGURE 8.
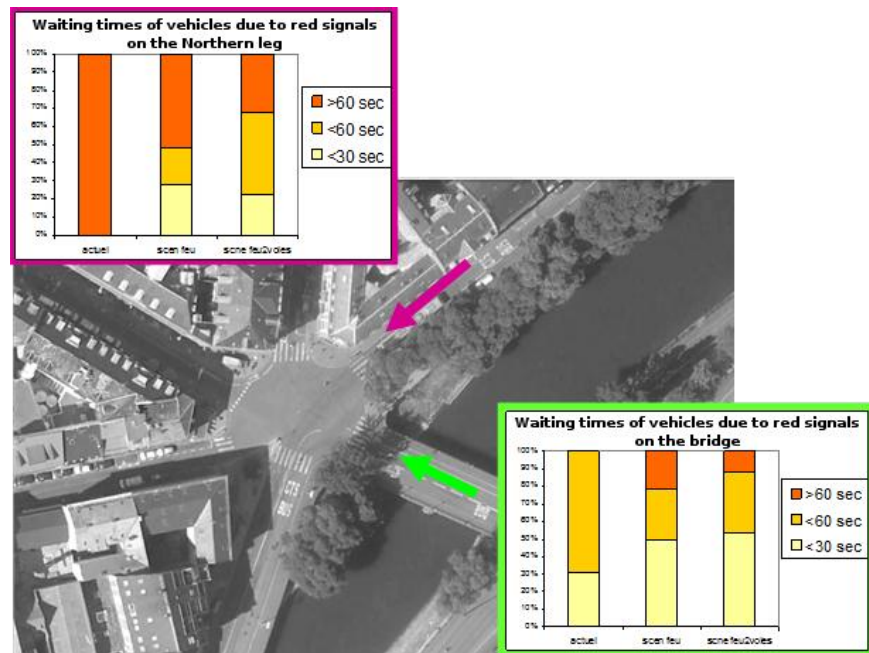

FIGURE 11: Simulation result: waiting times of motorized vehicles (private and PT) at red signals. Each of the two diagrams shows a comparison for the three scenarios of FIGURE 8.
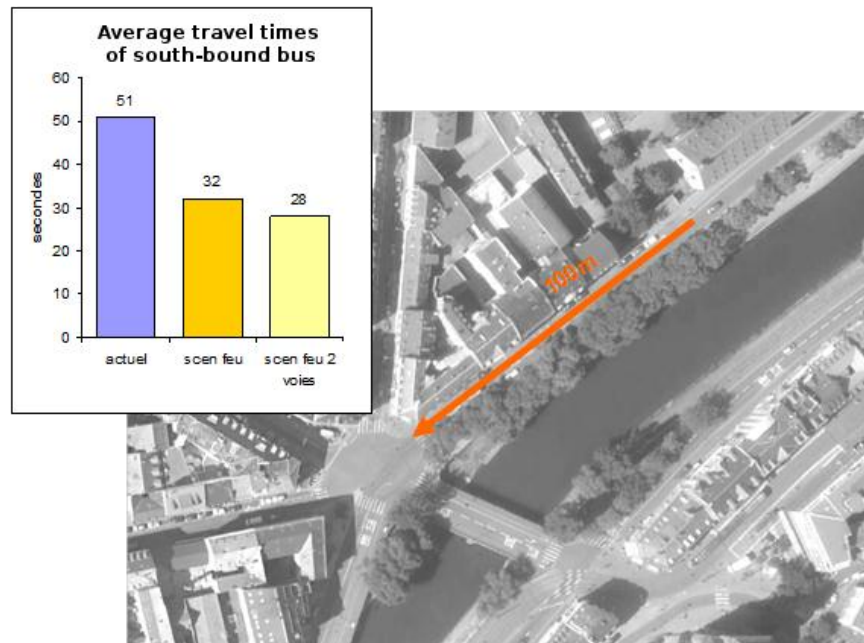
FIGURE 12: Simulation result: comparison of travel times of the south-bound bus for all three scenarios of FIGURE 8.

FIGURE 13: Initially proposed shared space configuration without traffic lights. This was not followed further nor was it simulated. Source: (Laugel und Reutenauer 2011).

HOW IS IT MODELED?

This section provides a technical overview and therefore addresses mainly readers who have already had contact with the software. A reader not interested in this can directly skip to the conclusions.

A micro-simulation planning tool is well suited to produce –almost as a by-product – 3D visual output which allows to easily communicate with the entire interested public, even with people who are nor engineering-affine. However, such (moving) pictures for a planner often blur what is going on inside. Therefore let us "deconstruct" the realistic pictures from the animations to the point where the technical character becomes visible. The first step is to remove the 3D model of the surrounding buildings which is shown in FIGURE 14.
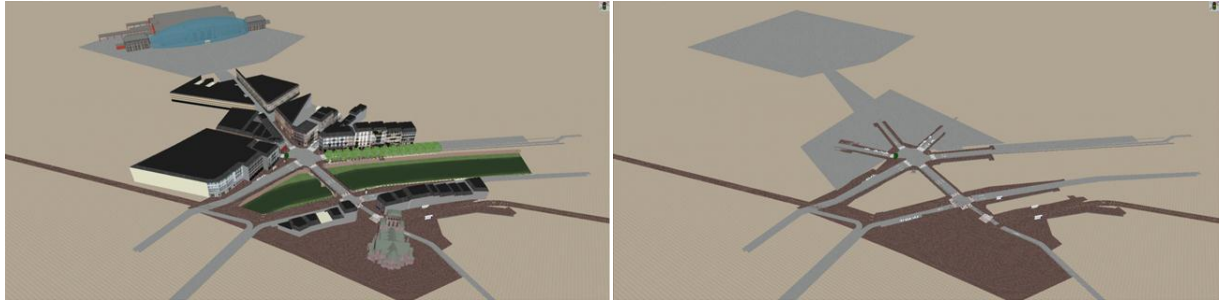

FIGURE 14: The model with and without 3D model of the surrounding buildings in the same 3D perspective. The 3D model of the buildings is neither necessary for the simulation nor does it have an impact on the simulation at all.

The next step is to change to a 2D (birds') perspective. This is done in FIGURE 15.
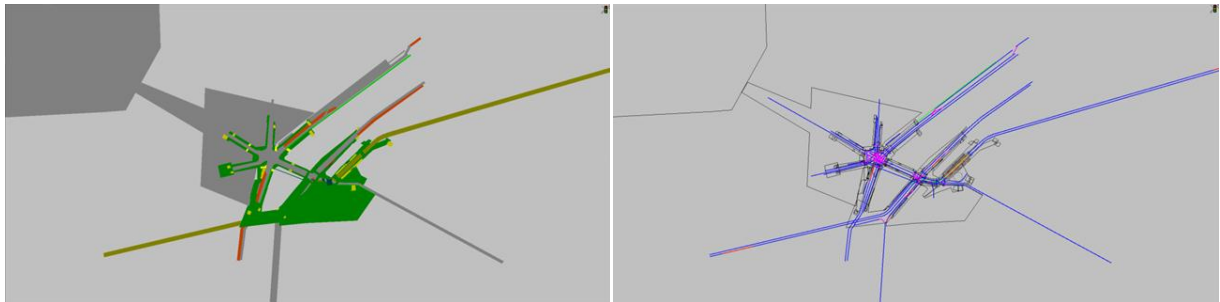

FIGURE 15: 2D perspective. The left image shows the network elements with the actual dimensions they have, the right image displays the elements which – functionally – are essentially one-dimensional (road lanes) to one-dimensional elements and displays those elements which are functionally two-dimensional (pedestrian areas) as polygons. In this way from the left to the right image the information is further reduced to the essential one.

So far the reduction steps were generic. The next step is to have a look at tool specific modeling elements like signals FIGURE 16 and other elements (conflict areas and priority rules) which control the traffic flow FIGURE 17 as far as the right of way is concerned.

Conflict areas serve to model areas of clear priority. Therefore they are used here to model the edge of the crossing area. They are quick to be put in place. Yielding drivers (or pedestrians) do not only consider the next vehicle with priority, but plan for one of a number of gaps in the oncoming flow to pass the conflict area. If a conflict area cannot be cleared in time by a pedestrian or a driver of the subordinate direction – this can happen for example to pedestrians when they are slowed down surprisingly by many

pedestrians walking in opposite direction – the driver or pedestrian with priority realizes this and does not move inside.
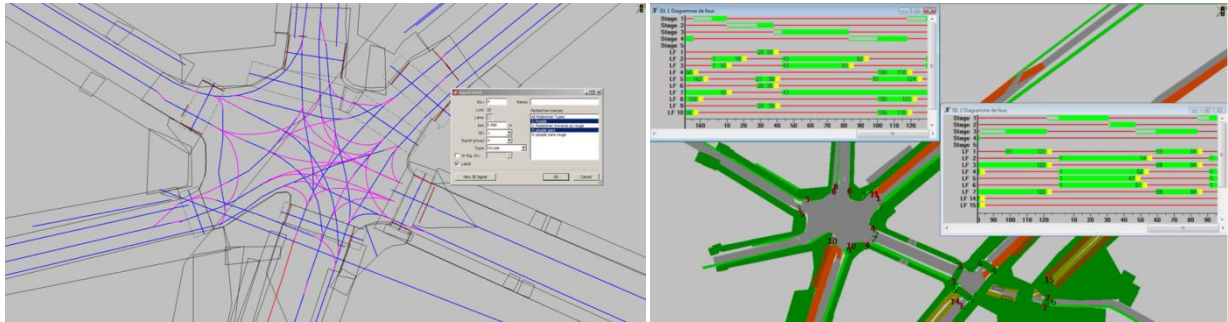

FIGURE 16: Left: zoom of the network view on to the western crossing. Links are displayed blue, connectors (connecting links) magenta, signal barriers red. Right: signal control programs which activate and deactivate the signal barriers during a simulation.
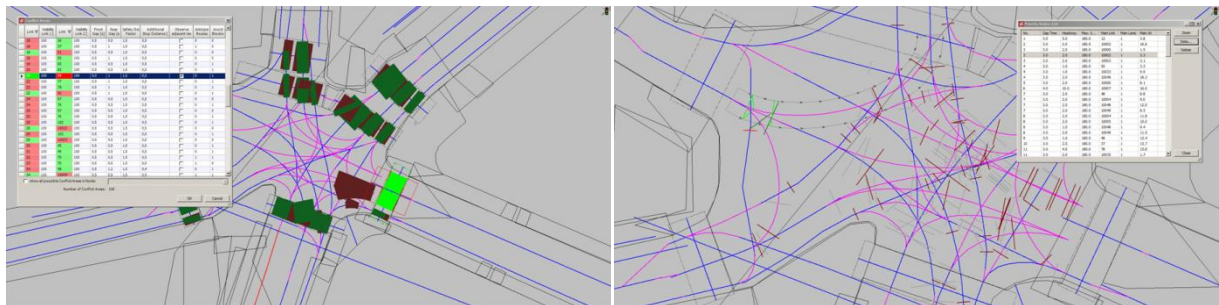

FIGURE 17: Left: Conflict areas. Right: Priority rules.

Priority rules can be used to model crossing points with less strictly defined priority, so situations which follow more a "first come first serve" rule. They require more effort to be modeled, but allow more flexible calibration. Yielding drivers or pedestrians only consider the next upstream conflicting vehicle or pedestrian and not subsequent gaps. Drivers or pedestrians with priority cannot realize if the exclusive area is occupied by a vehicle or pedestrian of the subordinate direction. Thus priority rules model a simpler behavior than conflict areas.

The model which computes the vehicle movement time step by time step is an extended version of (Wiedemann 1974). The according pedestrian simulation model is a combination of variants of the Social Force Model as discussed in (Johansson, Helbing und Shukla 2007) with extensions as for example described in (Kretz, Große, et al. 2011).

SUMMARY AND CONCLUSIONS

In this contribution Strasbourg's plan piéton was briefly summarized and as a part of it the traffic situation around the central Pont Kuss was introduced. At Pont Kuss a number of safety and convenience issues in pedestrian traffic have been found. This was the motivation for a multi-modal microscopic simulation project which – along the lines of the plan piéton – assessed measures to improve the situation for pedestrians. The assessment included both: benefits for pedestrian and potential drawbacks for

vehicular traffic. It could be shown in detail that clear benefits for pedestrians and for public transport are opposed by only small – if at all – drawbacks for vehicular traffic. As a result in fall 2012 the implementation of most of the suggested changes was commissioned.

The combination of detailed numerical and intuitive 3D output is helpful in a number of aspects: first it makes for a precise planning base which at the same time has a high chance to not only analyze known – difficult – issues, but also point to – simpler – issues which have simply been missed out at any of the involved traffic modes. Second, the 3D output is a great resource for communication with the public and especially those parts of the public whose expertise is far from engineering logic. Everyone can be given an idea of what is intended. Third, the detailed numerical output is a heavy argument in experts' and even more so public discussion to meet objections derived from false believes ungrounded fears or mere ideology. In this particular case one might think for example of a line of argumentation coming from a fundamental pro-car lifestyle or even identity.

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