

Vladislav KŘIVDA\*

SIMULATION OF TRAFFIC ON INTERSECTION AFTER CHANGE OF TRAFFIC PRIORITY

SIMULACE PROVOZU NA KŘIŽOVATCE PO ZMĚNĚ PŘEDNOSTI V JÍZDĚ

#### Abstract

This paper deals with problem of capacity calculation of intersection after change of traffic priority and with simulation of traffic using simulation software PTV VISSIM. This paper was prepared with financial support for project FRVŠ č. 2206/2011/F1/d “Innovation of Learning of Subjects from the Design of Urban Roads and Intersections”.

#### Abstrakt

Článek se zabývá problémem kapacitního výpočtu křižovatky po změně přednosti v jízdě a simulací provozu s využitím simulačního software PTV VISSIM. Příspěvek byl zpracován za finanční podpory projektu FRVŠ č. 2206/2011/F1/d „Inovace výuky předmětů z oblasti navrhování městských komunikací a křižovatek“.

### 1 INTRODUCTION

At present, there is a continual increase in traffic volume on the highways. This leads to frequent traffic jams, especially in places where roads intersect – i.e. on the intersections. Hence we need to look for new intersections with greater capacity - i.e. such as roundabouts, intersections with traffic lights etc. In some cases it is sufficient (and more cost-effective) to implement only minor building modifications or traffic-engineering measures – e.g. change of traffic priority.

Capacity calculations of uncontrolled level intersections are described in the TP 188 [1]. This standard describes only the intersections with “straight” traffic priority (when Major Street leads straight). For purposes of capacity calculations of intersections without “straight” traffic priority (when Major Street doesn’t lead straight) TP 188 can also be used but the formulas should be adjusted. Also, identification of the variables is changed – see Fig. 1 and Fig. 2. This identification of traffic flow was also used in calculations to describe the volume of the traffic flow (but it is in *italics*).

### 2 CAPACITY CALCULATIONS BEFORE CHANGE OF TRAFFIC PRIORITY

To demonstrate, how to use this modified capacity calculations, was chosen T-intersection (see Fig. 2-a) with traffic volumes according to Fig. 3.

Given the limited scope of the article there isn’t a detailed capacity calculation, but only the final result that was confirmed in the EDIP-Ka software.

---

\* Ing. Vladislav KŘIVDA, Ph.D., VSB – Technical University of Ostrava, Faculty of Civil Engineering, Department of Transport Constructions, L. Poděštné 1875/17, 708 33 Ostrava-Poruba, tel. (+420) 59 732 1315, e-mail vladislav.krivda@vsb.cz, <http://kds.vsb.cz/krivda>

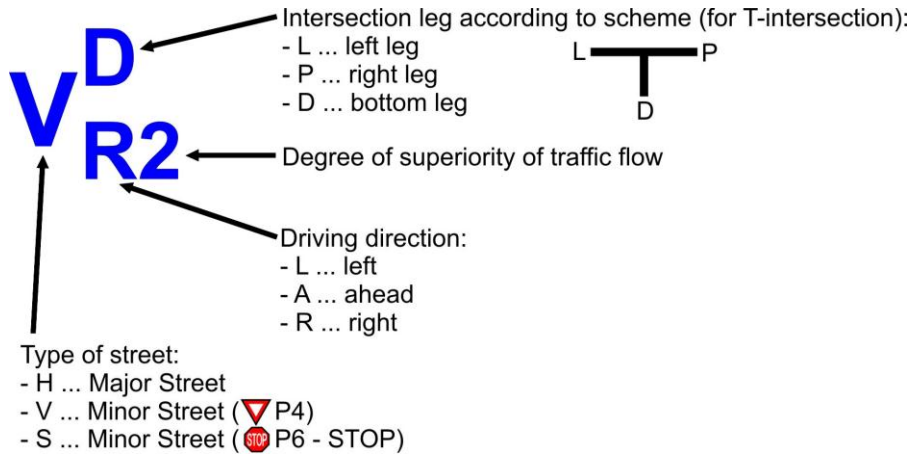


Fig. 1 The new identification of the variables (T-intersection). [author]

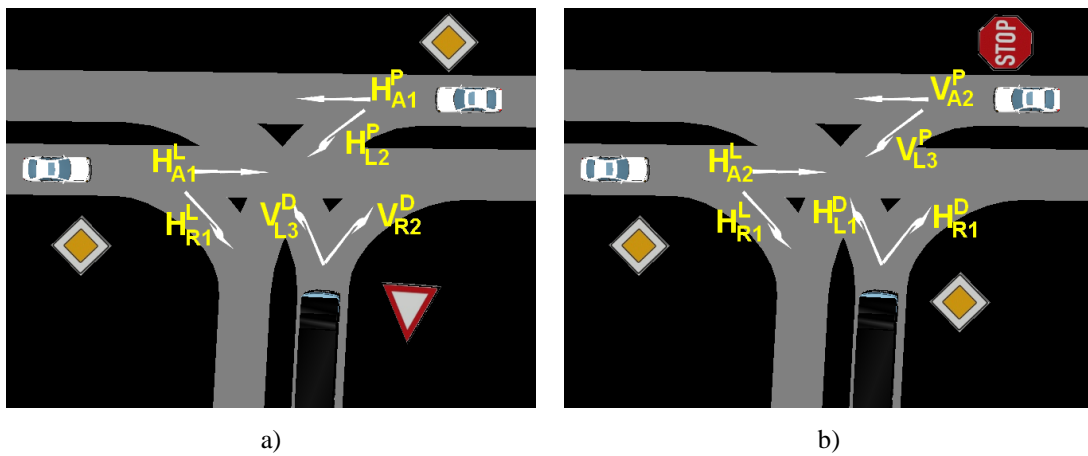


Fig. 2 The identification of the variables (T-intersection):  
 a) with “straight” traffic priority; b) without “straight” traffic priority [author].

Capacity of Minor Street:

$$C^{(V_{L3}^D)(V_{R2}^D)} = \min \left\{ \frac{V_{L3}^D + V_{R2}^D}{\sqrt[6]{\frac{a_v^{(V_{L3}^D)} \left[ a_v^{(V_{L3}^D)} \right]^{6+1} + \left[ a_v^{(V_{R2}^D)} \right]^{6+1}}{1800}}} \right\} = 381 \text{ voz/h} \quad (1)$$

where  $a_v$  ... ratio of entry volume and entry capacity.

Reserve:

$$R^{(V_{L3}^D)(V_{R2}^D)} = C^{(V_{L3}^D)(V_{R2}^D)} - (V_{L3}^D + V_{R2}^D) = 35 \text{ voz/h} \quad (2)$$

and medium time delay:

$$t_w^{(V_{L3}^D)(V_{R2}^D)} = 73,9 \text{ s} = 1,2 \text{ min} \quad (3)$$

Level of service (LOS) is “E” [1], which means an unstable state [1] and is therefore unsuitable.

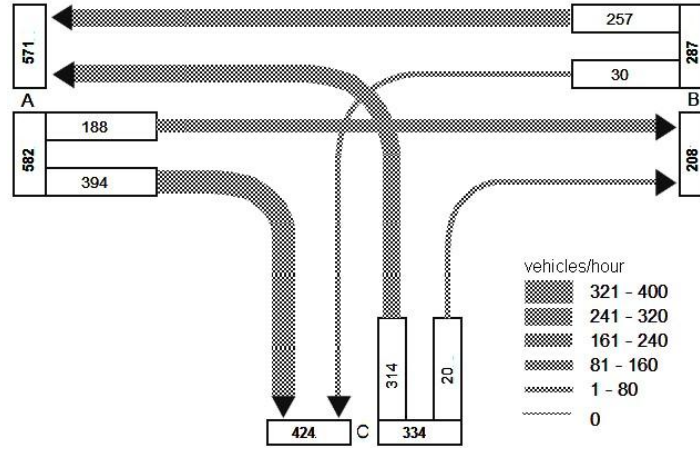


Fig. 3 Traffic volumes on T-intersection (veh/h) [author: EDIP-Ka].

### 3 CAPACITY CALCULATIONS AFTER CHANGE OF TRAFFIC PRIORITY

The traffic priority was changed (see Fig. 2-b) on the basis of traffic volume (according Fig. 3). Because the standard TP 188 describes only the intersections with “straight” traffic priority, I created my own program in MS Excel [2].

It is important to note the following relation between the intersection depicted in the Fig. 2-a (marked as K1) and the intersection depicted in the Fig. 2-b (marked as K2). Let's look at the traffic flows 1<sup>st</sup> degree –  $H_{A1}^P$ ,  $H_{R1}^L$  and  $H_{A1}^L$  (intersection K1). The traffic flow  $H_{A1}^P$  merges with the traffic flow 3<sup>rd</sup> degree  $V_{L3}^D$  and adjoins with the traffic flow 2<sup>nd</sup> degree  $H_{L2}^P$ . This means that the traffic flow  $H_{A1}^P$  on the intersection K1 is similar as the traffic flow  $H_{R1}^L$  on the intersection K2.

Analogously, we can proceed with the next traffic flows:

- traffic flow  $H_{R1}^L$  (intersection K1) corresponds to traffic flow  $H_{R1}^D$  (intersection K2),
- traffic flow  $H_{A1}^L$  (intersection K1) corresponds to traffic flow  $H_{L1}^D$  (intersection K2),
- traffic flow  $H_{L2}^P$  (intersection K1) corresponds to traffic flow  $H_{A2}^L$  (intersection K2),
- traffic flow  $V_{R2}^D$  (intersection K1) corresponds to traffic flow  $S_{A2}^P$  (intersection K2),
- traffic flow  $V_{L3}^D$  (intersection K1) corresponds to traffic flow  $S_{L3}^P$  (intersection K2).

Capacity of Minor Street:

$$C^{(S_{L3}^P)(S_{A2}^P)} = \frac{\sum_{j=1}^m I_j}{\sum_{j=1}^m a_{vj}} = \frac{I^{S_{L3}^P} + I^{S_{A2}^P}}{a_v^{S_{L3}^P} + a_v^{S_{A2}^P}} = 612 \text{ voz/h} \quad (4)$$

Reserve:

$$R^{(S_{L3}^P)(S_{A2}^P)} = C^{(S_{L3}^P)(S_{A2}^P)} - (S_{L3}^P + S_{A2}^P) = 332 \text{ voz/h} \quad (5)$$

and medium time delay:

$$t_w^{(V_{L3}^P)(V_{A2}^P)} = 10,8 \text{ s} \quad (6)$$

Level of service (LOS) is “B” [1], which means a delay without queues of vehicles [1]. It is then a significant improvement in comparison with the original state. Tab. 1 shows more results.

**Tab. 1** Capacities and reserves of individual entries before and after change of traffic priority.

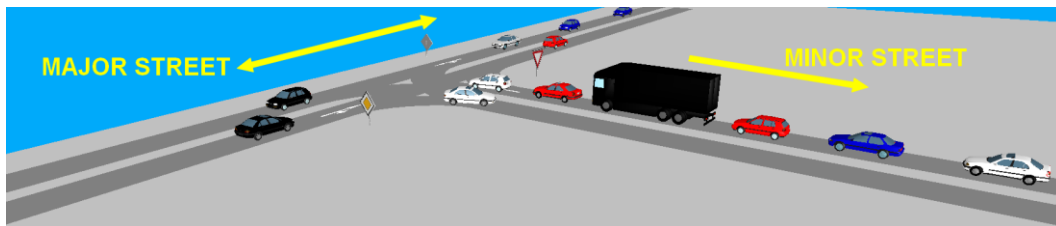
Entry	Volume [veh/h]	Intersection K1			Intersection K2		
		Capacity [veh/h]	Reserve [veh/h]; [%]		Capacity [veh/h]	Reserve [veh/h]; [%]	
A	582	1800	1218	67.7	1455	873	60.0
B	287	1647	1315	82.1	606	319	52.6
C	334	380	47	12.3	1800	1466	81.4

#### 4 SIMULATION OF TRAFFIC ON INTERSECTION

Modeling and simulation are main tools in many areas of human activities. It can allow increase effectively of processes and activities in designing, development and not only in engineering and technology areas, also in service and economic areas [3] – it also applies to transport.

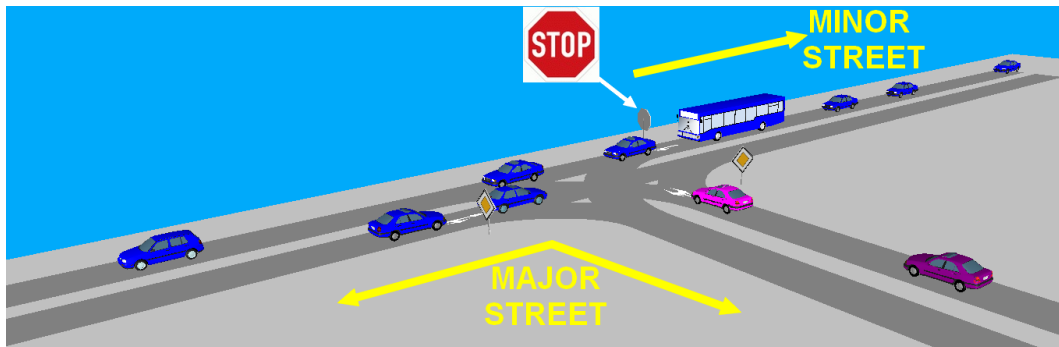
Department of Transport Constructions (Faculty of Civil Engineering) uses PTV VISION Software – a software system for transportation planning, strategic planning, transportation engineering and control. This software is used partly by academics and partly by students during compiling their theses (not only by students of Faculty of Civil Engineering, but also by students of transport fields on Faculty of Mechanical Engineering).

The situation on the intersection before change of traffic priority is shown in Fig. 4. Evidently there is a substantial queue of vehicles on the minor street. The actual simulation (in AVI format) is on this web page: <https://sites.google.com/site/krivda0ks0fs> - simulation #1.



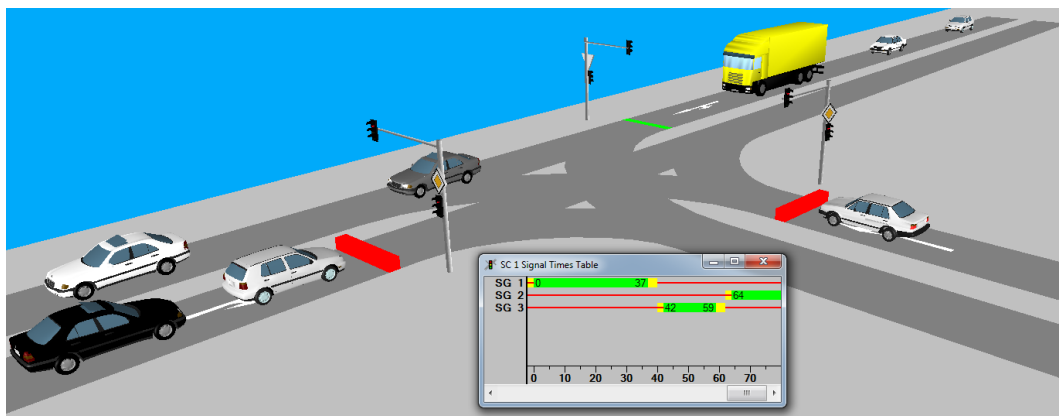
**Fig. 4** Simulation of traffic on intersection K1 (PTV VISSIM). [author]

After the change of traffic priority (see Fig. 5), although there was improvement on the original minor street, but the problem is moved to the other two legs (however the medium time delay is better – see capacity calculations above). The actual simulation (in AVI format) is on this web page: <https://sites.google.com/site/krivda0ks0fs> - simulation #2.



**Fig. 5** Simulation of traffic on intersection K2 (PTV VISSIM). [author]

The solving this problem is for example using the intersection with traffic lights – see Fig. 6 and simulation in AVI format on this web page: <https://sites.google.com/site/krivda0ks0fs> - simulation #3.



**Fig. 6** Simulation of traffic on intersection with traffic lights (PTV VISSIM). [author]

To control this intersection were selected three stages and cycle time is 90 s (see Fig. 7). Traffic flows on entry A are in the first stage (SG1), traffic flows on entry B are in the second stage (SG2), and finally traffic flows on entry C are in the third stage (SG3). The duration of green signal for individual signal groups SG are shown in Fig. 7.

During the watching this simulation, the design of the intersection with traffic lights appears as appropriate for fluency of traffic flow and for traffic safety. Can be assumed that the capacity of intersection with traffic lights will be much better than the capacity of uncontrolled intersection (it's necessary to examine the capacity calculation according to the relevant standards). The simulation shows that there are no significant queues of vehicles. Vehicles leave the intersection during the duration of the first green signal for their entry.

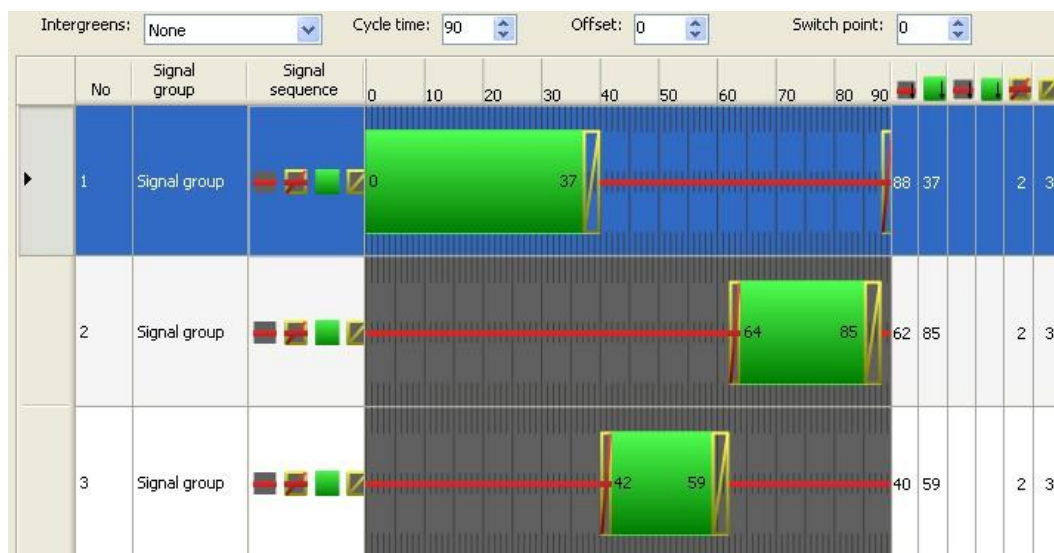


Fig. 7 Signal program (PTV VISSIM). [author]

## 5 CONCLUSIONS

The above examples show that we can use special simulation software for the basic vision about the traffic on new or rebuilt intersections. This way we can relatively quickly make minor or also more sophisticated modification – even without lengthy complicated calculations. We can do it before such change will be technically or financially difficult or impossible. However, it's obvious that, it's necessary to examine the capacity calculation according to the relevant standards.

Finally, it should be noted that the article is not aimed to find the optimal solution to the traffic on this intersection. It is already task for detailed investigation and precise capacity calculations. This article showed, inter alia, the possibility of using the standard TP 188 for capacity calculations of uncontrolled intersections without “straight” traffic priority (when Major Street doesn't lead straight).

## REFERENCES

- [1] *TP 188 Posuzování kapacity neřízených úrovnňových křižovatek*. Liberec: EDIP. Koura publishing. 2007, 64 p. ISBN 978-80-902527-6-9
- [2] KŘIVDA, V. *Kapacitní výpočty neřízených křižovatek podle TP 188* [TP-188.xls]. Ostrava, 2010
- [3] ŠIROKÝ, J.; BOČEK, M. *Využití simulačního prostředí WITNESS ve výzkumu a výuce technických předmětů*. In: Perner's Contacts 2003. Pardubice: Univerzita Pardubice, DFJP. 2003, vol. 4, p. 197-202
- [4] KŘIVDA, V.; ŠKVAIN, V. *Inovace výuky předmětů z oblasti navrhování městských komunikací a křižovatek*. Projekt FRVŠ č. 2206/2011/F1/d. Ostrava: VŠB-TU Ostrava, 2011