REVISITING THE FOUNDATIONS OF THE CZECH TRAFFIC CONFLICT TECHNIQUES

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Abstract:

Traffic conflict technique (TCT) is a method for the systematic observation of conflicting traffic behaviour. Since the late 1960s a number of various TCTs have been developed around the world in order to be able to collect intermediate data for road safety analyses, study driving behaviour, etc. In the early 1970s, first traffic conflict observations were conducted in the former Czechoslovakia. Since the beginning they relied on a severity assessed subjectively by the observers: some used to perform on-site observations, others relied on video recording and analysis in the office.

Both approaches have been used mainly for research and teaching purposes. In order to support their practical use, Centrum dopravního výzkumu, v.v.i. (Transport Research Centre) and Czech Technical University in Prague undertake a research project "Czech Traffic Conflict Technique Methodology" (KONFLIKT). Its objective is to unify both approaches and provide standardized methodology ready to be used by road safety practitioners.

In the course of the KONFLIKT project, quality of Czech TCT was investigated and its foundations had to be revisited. Several studies have been conducted to this end, including:

- reliability study, using on-line training application
- calibration study, comparing the results of on-site and video observation
- study of representativeness, in terms of sufficient observation duration
- process validity, comparing the types of conflicts and accidents
- product validity, comparing the frequency of conflicts and accidents

The paper reports preliminary findings of some of these studies. It also provides recommendations towards the guidelines for standardized assessment based on traffic conflicts.

1. Introduction

Traffic conflict is internationally defined as "an observable situation in which two or more road users approach each other in space and time to such an extent that a collision is imminent if their movements remain unchanged" (Amundsen & Hydén, 1977). The frequency of conflicts, considering their severity and types, may thus serve as an indirect safety performance indicator. Compared to traditional indicators based on traffic indicators, conflicts are more frequent and are not biased by underreporting. What is more, conflict observations may provide deeper insight into traffic processes, going beyond the retrospective accident analyses.

Considering these facts, various traffic conflict techniques (TCTs) have been developed in the world since the late 1960s. Traffic conflict technique (TCT) is a method for the systematic observation of conflicting traffic behaviour (Oppe, 1986). Since the late 1960s a number of various TCTs have been developed around the world in order to be able to collect intermediate data for road safety analyses, study driving behaviour, etc. Some of them use qualitative definitions, some are more quantitative. Swedish TCT, using time and distance estimates, have been deemed the most mature one (Tarko et al., 2009).

In the early 1970s, the first conflict observations were also conducted in former Czechoslovakia (Folprecht, 1975). Since the beginning they relied on a severity assessed subjectively by the observers: some used to perform on-site observations, others relied on video recording and analysis in the office. Nevertheless both approaches (TCTs) have been used mainly for research and teaching purposes. In order to support their practical use, Centrum dopravního výzkumu, v.v.i. (Transport Research Centre) and Czech Technical University in Prague undertake a research project "Czech Traffic Conflict Technique Methodology" (KONFLIKT). Its objective is to provide standardized methodology for both approaches which is ready to be used by road safety practitioners (Ambros, 2011).

2. Czech TCTs revisited

In the course of the KONFLIKT project, quality of Czech TCTs was investigated and its foundations had to be revisited. Several studies have been conducted to this end and some of them are described in the following sections:

- study of representativeness (determination of sufficient length of observation)
- product validity (comparison of frequency of conflicts and accidents)
- process validity (comparison of conflict and accident types)

Based on the findings of these studies, some recommendations were made and used in developing new Czech guidelines for traffic conflicts observation and evaluation.

2.1 Representativeness study

Before the conflict observation starts, some planning is needed. It usually involves a visit of a site and a short observation in order to obtain the picture of traffic conditions and potential conflicts. Based on this information, decision should be made about the required number of observers and also the sufficient length of observation. The time period should be long enough to collect the sufficient number of conflicts; on the other hand, it should reflect some practical limits. There should therefore be a balance between precision and feasibility.

The existing Czech TCT manuals (Folprecht & Křivda, 2006; Kocourek, 2011) have recommended one hour of observation as sufficient; however, no firm foundation for this has been provided. On the other hand, a number of foreign TCT manuals recommend periods up to several days; a description how to determine this period is often not described. In order to determine the sufficient study duration, several observations have been conducted – some of their results are reported in the following paragraphs which describe (1) hourly and (2) daily variations.

Hourly variations

One approach to determine the necessary study duration was described in a US manual (Parker & Zegeer, 1988; Schroeder at al., 2010) which estimates sample size with the following formula:

$$n = \left(100 \cdot \frac{t}{p}\right)^2 \cdot \frac{var}{mean^2}$$

where t is normal distribution statistics for a given level of significance, p denotes precision in percents, var and $mean$ characterize hourly conflict numbers estimated from previous studies. Based on this formula, Parker & Zegeer (1988) recommended between 3 and 39 hours required to estimate the hourly counts of various conflict types within 50% precision with 90% confidence.

To use the formula in the Czech conditions typical conflict frequencies had to be determined. It was possible to use the values from the study which collected the results of previous Czech studies, divided between various intersection types (Ambros & Turek, 2013). An example is given in Fig. 1: it shows hourly conflict counts depending on hourly traffic volumes at two types of 4-arm intersections with and without traffic signals.

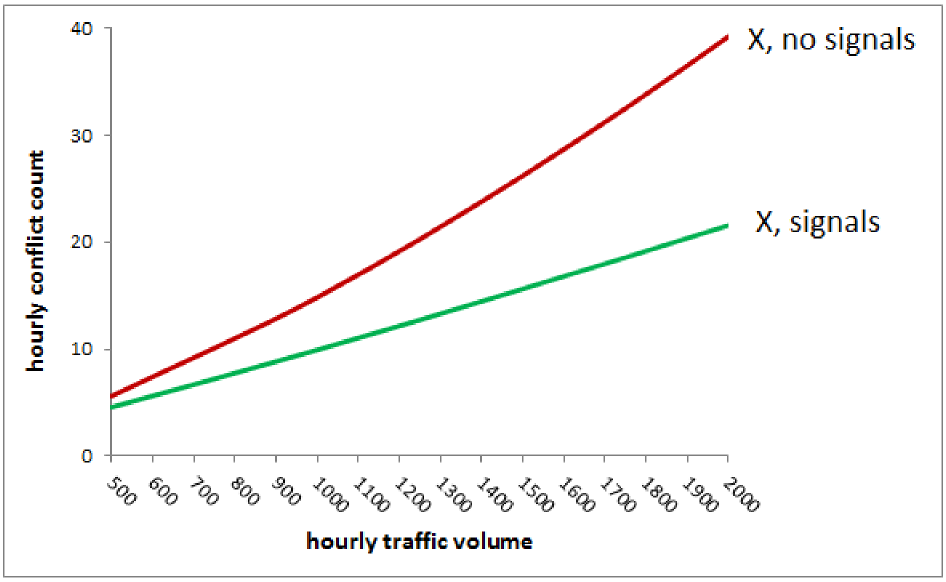

Fig. 1 Typical hourly conflict frequency based on a sample of 4-arm intersection observations

The lines in the graph mark the approximate boundaries of possible conflict count values: therefore, within hourly traffic volume 500 to 2000 one may expect between approximately 5 and 40 conflicts. These boundary values were used as an input to the mentioned formula. A confidence level of 90% was used. Since expected values are higher than the ones reported in the US manual, higher required precision was used in the calculation (25%).

The graph in Fig. 2 shows the results of the calculation. It is obvious that the majority of conflict counts should be covered up to approximately 4 hours of observation; lower counts require approximately double of this time.

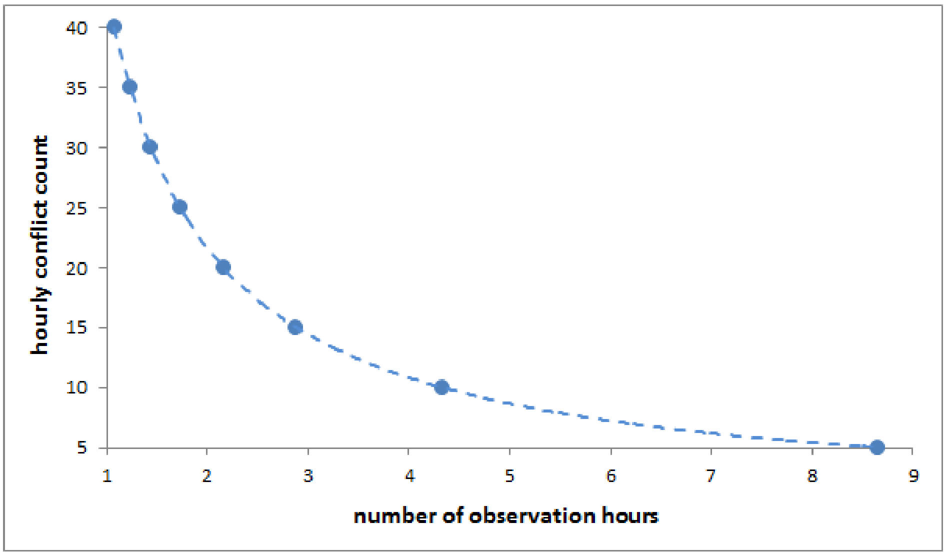

Fig. 2 Calculated number of observation hours based on hourly conflict counts

The same time periods held also for several conflict studies in 2013 (Ambros & Turek, 2013). Some of them were performed for 8 hours in 5 week days. After receiving the counts of the observed conflicts, cumulative moving average of hourly conflict counts could be calculated. The resulting graphs show the sufficient number of observation hours, where further time does not change the average significantly – see Fig. 3.

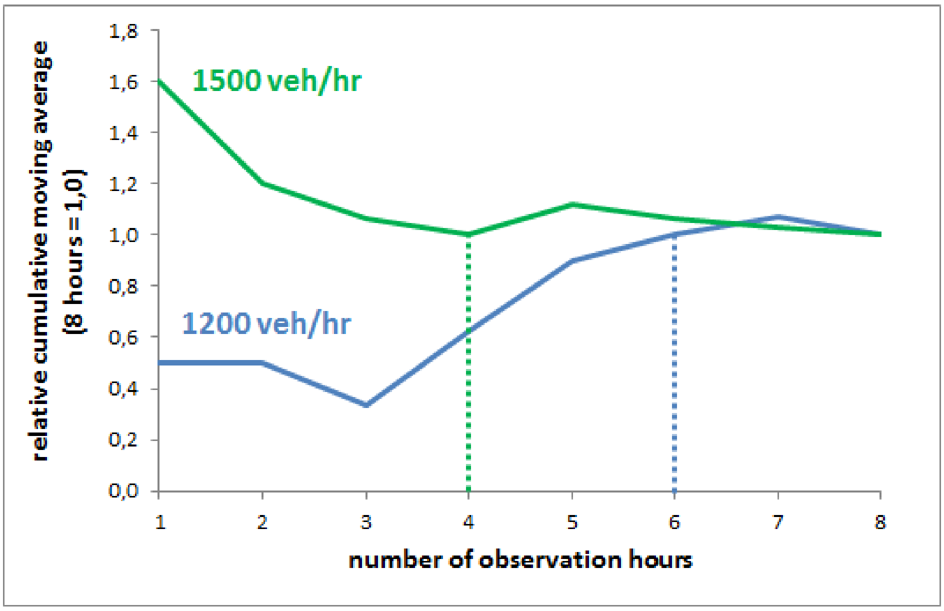

Fig. 3 Determination of required study duration based on relative cumulative moving average of hourly conflict counts for two 3-arm intersections with different traffic volumes

The graph shows relative cumulative moving average of hourly conflict counts, where 8-hour value is set to 1. Values come from an observation at two 3-arm intersections which differed in traffic volume: the first site had approximately 1500 veh/hr, the other one had approximately 1200 veh/hr. The graphs show that while at the first site 4 observation hours should be sufficient – the trend reaches the 8-hour value and does not change significantly in further hours; at the other site this threshold is 6 hours. It is therefore obvious that the study duration should be longer at lower traffic volumes, which corresponds with lower hourly conflict counts.

Considering feasibility, it may be recommended to conduct 4-hour observations; at lower traffic volumes the period should be extended to 8 hours. These requirements are comparable to Czech standards of short term traffic count durations (Bartoš & Martolos, 2012): they recommend 4 hours as a standard period and 8 hours as an extension. They also recommend conducting the studies between 7 – 11 and/or 13 – 17 o'clock in order to avoid off-peak hours.

Daily variations

Conflict observations may be conducted in more days – this is typical for a number of foreign TCT manuals. Following the previous study of hourly variations, daily variations were studied as well. An example from a 4-arm urban intersection in Brno will be used.

At first, differences between week days were calculated as deviations from the mean value in terms of mean squared error. Fig. 4 shows the errors when taking into account all week days (Mon – Fri); when considering Tue – Thu only, errors were lower. Traffic on these days is labelled "typical week day traffic" in traffic count guidelines (Bartoš & Martolos, 2012). Typical week days should be therefore preferred in conflict counts as well.

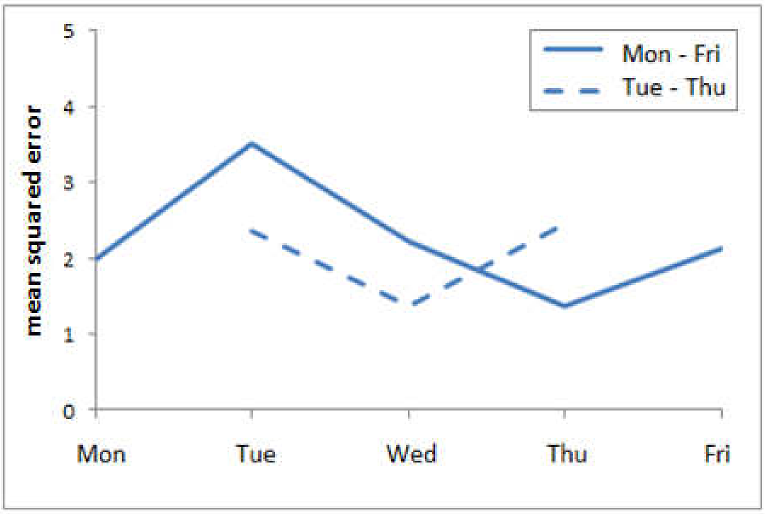

Fig. 4 Comparison of mean squared error of hourly conflict counts for all week days (Mon – Fri) or typical week days only (Tue – Thu)

Another question was how much do total conflict counts differ on these days. In order to answer this question three time periods were considered: 4 hours AM or PM (i.e. 7 – 11 or 13 – 17) and 8 hours (i.e. 7 – 11 and 13 – 17). The graph (Fig. 5) shows cumulative moving average of total conflict counts for these periods. It is obvious that values are relatively stable.

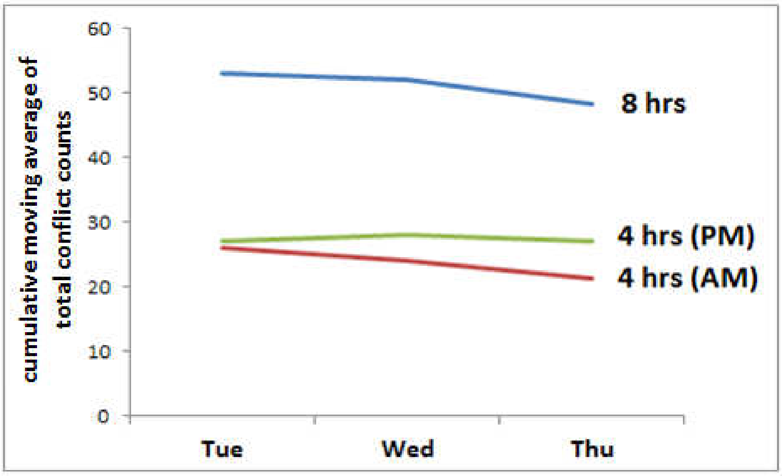

Fig. 5 Cumulative moving averages of total conflict counts for different observation periods

2.2 Product validity study

During TCTs history there have been various opinions on the validity of conflicts, from its meaning to definitions and calculation approaches. In its simplest form, the product validity is a relation between a conflict and accident frequencies at a chosen site.

It is obvious that the validity study requires large data sets of both conflicts and accidents data. What is more, it was noted that recorded accidents should not be used, since they may suffer from regression to the mean; an expected frequency should be used instead (Older & Shippey, 1980). This process was used at a sample of 3-arm intersections, utilizing the empirical Bayes estimates of their expected accident frequencies (Hauer, 1997).

Since the previous Czech conflict studies were all based on 1-hour observations only, the calculation could use these values only. The following Fig. 6 shows relationships between hourly conflict frequency and 6-year accident frequencies, both recorded and expected estimates calculated via empirical Bayes method.

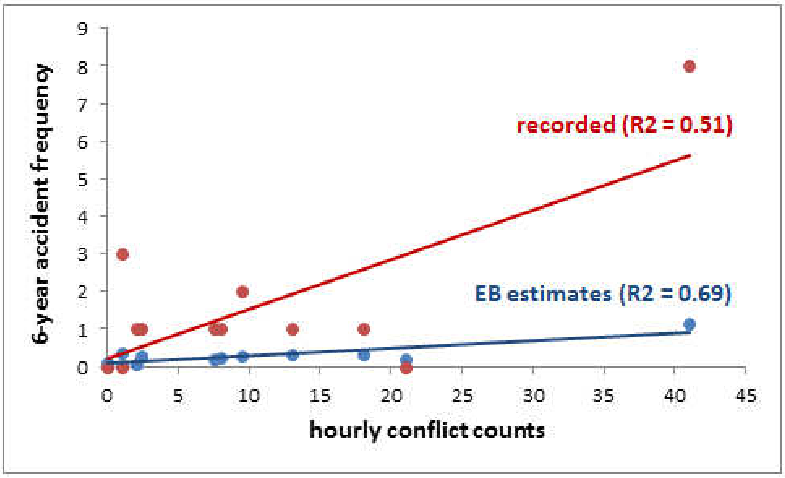

Fig. 6 Relationship between hourly conflict counts and 6-year accident frequency in terms of recorded accidents and empirical Bayes (EB) estimates

The relationships are shown as linear trends fitted to the data – the goodness-of-fit with empirical Bayes estimates improved (data points have lower variance) and R^2 raised from 0.51 to 0.69, i.e. almost by 40%. Should longer observations be used (for example 4 hours, as suggested in previous paragraphs), the goodness-of-fit may improve even more.

2.3 Process validity study

Process validity may be defined as a relationship between conflict and accident types; in other words: how much do the conflicts explain the process leading to unsafe traffic behaviour, conflicts and accidents.

An example of a 4-hour observation will be used. It was conducted at a busy 4-arm urban intersection in Brno; in total 26 conflicts were registered, mostly two types shown in Fig. 7. The conflicts in red circles make up 42% of conflicts. When accidents of the same type were considered, their proportion was 47%.

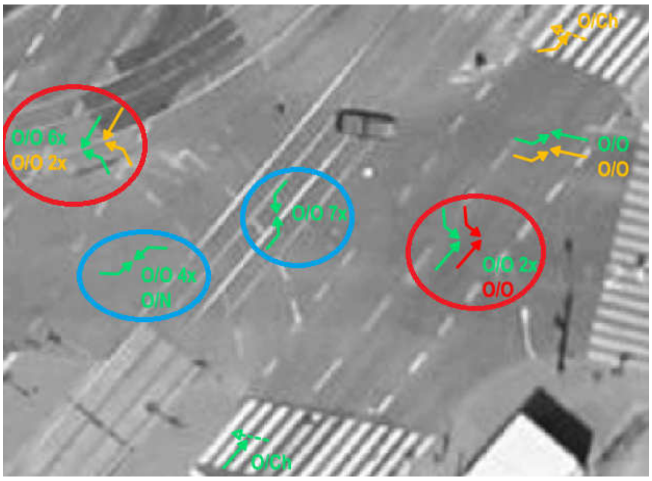

Fig. 7 Example of conflict diagram from 4-hour observation

In a similar manner, another comparison was made at a 3-arm intersection in Brno. The collision diagram involved 7 accidents (in 6 years) and showed problems with left turns and tram priority. Similar conclusions emerged from 4 hours of conflict observation which yielded 11 records.

These two examples show that a conflict may be considered a valid indicator of traffic processes: the conclusions they provide are comparable with findings obtained from accident analyses.

3. Czech TCT guidelines

Previous paragraphs presented some of the findings which emerged from the KONFLIKT project. The resulting experience was used to provide recommendations towards the updated guidelines for standardized safety assessment based on traffic conflicts. The guidelines (Ambros & Kocourek, 2013) consist of three main parts: training, observation, evaluation.

3.1 Training

Observers are one of the weakest links in chain of conflict studies (Lightburn & Howarth, 1980). Therefore, they have to be properly trained and need to detect and assess conflicts in a consistent way. To facilitate this, an on-line training application was developed in the project. It uses short video records of conflicts which user has to assess in terms of conflict type and severity. A single test consists of 30 videos and the resulting consistency should be at least 60%. Fig. 8 presents an interface of the application.

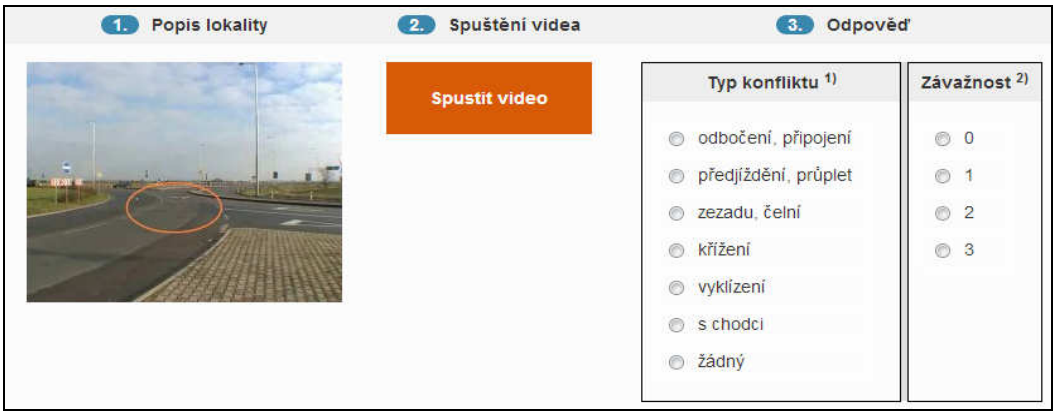

Fig. 8 Interface of a test in on-line training application

It should be noted that the training application is not a self-teaching tool – it is meant as a help to train the observers, bridging the gap between theoretical lectures and field observations.

3.2 Observation

As mentioned above, observations should be conducted at typical traffic conditions, i.e. in spring or autumn; Tuesday, Wednesday or Thursday; peak hours (7 – 11 and/or 13 – 17 o'clock). Observer records conflict types (in 6 types according to conflict paths) and assesses their severity according to a three-point subjective scale based on severity of an evasive manoeuvre. At the same time, traffic count is performed in order to estimate traffic volume. Conflicts are registered with their time, type and code of users involved in conflict and its severity in a recording sheet. A sketch is also made to record the paths of conflicting users.

3.3 Evaluation

In the office field conflict records may be transferred to visualization application. It enables creation of a conflict diagram and uniform handling of data. The diagram uses conflict type symbols and colours assigned to the severities (green, orange, red – analogously to traffic lights), as well as the code of users (Fig. 9). The other part of the office work is devoted to traffic volume data. Volumes on intersection arms may be summed up to obtain a total intersection exposure.

The final evaluation utilizes the graph of typical conflict counts (Fig. 1). A simple example may be put as follows: At an intersection traffic volume X veh/hr, Y conflicts per hour were registered. By plotting these X, Y values into the graph for specific intersection type, one can see whether the point is located below or above the line – it shows whether the intersection is assessed as safe (lower than average) or unsafe (higher than average).

Based on observed conflicts and also general behaviour, comments may be made, together with potential countermeasure suggestions.

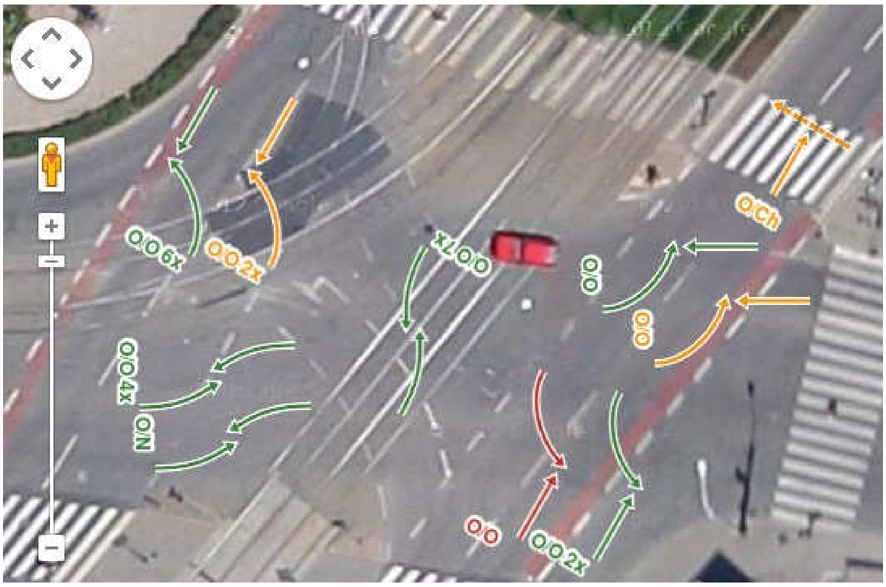

Fig. 9 Example of a conflict diagram created in visualization application

4. Discussion and conclusions

Traffic conflict techniques provide a useful tool of proactive road safety management; however, they are rarely used in real practice. In order to enable full utilization of Czech TCT, its foundations were revised within the research project KONFLIKT. The findings apply to both on-site and video observation; the main ones were summarized in the paper:

- Four hours of observation are sufficient to obtain representative hourly conflict count.
- In the case of lower volumes 8 hours should be used.
- It is enough to conduct such observation in one typical week day.
- Product validity as a relation between conflicts and accidents should be stated in terms of empirical Bayes estimates of expected accident frequency. An improvement of goodness-of-fit was observed, however, insufficient number of 4-hour observations is currently available.
- Process validity as a relation between conflict and accident types seems to yield good results: 4 hours of conflict observation yielded findings comparable to 6 years of accidents.

These results seem very promising. However, it has to be noted that reported findings are all based on a small sample of observed sites. The future efforts will be devoted to an extension of this sample both in time and space. There are also remaining gaps such as observation on road sections, effectiveness of training application, long-term observers' reliability, validity of specific conflict types and severity levels, comparison of results with foreign TCTs and others. In future, automated systems should also be considered in order to enable easier and longer data collection.

Nevertheless, the main challenge is to encourage practitioners in using the TCTs in proactive road safety management. To this end, the guidelines and the applications were made available on-line on the project's website (http://konflikt.cdvinfo.cz/ – in Czech only). These outputs were approved by three reviewers and will be certified by the Ministry of Transport. Moreover, its allowance organization Road and Motorway Directorate of the Czech Republic (ŘSD), which manages the main road network, expressed interest in using the guidelines, as well as Traffic Police Service Directorate. Should their interest become real commitment, the main goal of the project will be fulfilled.

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