RISK MANAGEMENT IN TRANSPORT CRITICAL INFRASTRUCTURE

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ABSTRACT

One of the most important transport critical infrastructure sectors, which has impact to the correct function and public security of state, is road transport. A disruption of its operation may lead to the spreading of cascading effect on other sectors of critical infrastructure. Other industries in Czech Republic have ties to road transport as health, energy and more. There is a reason why society should dedicate its attention to the transport critical infrastructure as well as to the road transport. The paper focuses on the issue of traffic accidents, which mostly affect road critical infrastructure. The first part of the article focuses on the introduction to the issue. Another part focuses on the process solution after a roads traffic accident, where the disruption of critical road infrastructure occurs. At the end of paper, there is a proposal of the design of the system to manage the crisis, which is based on minimizing the likelihood of a case occurring.

Keywords:
Critical infrastructure, critical road, infrastructure, transport, extraordinary event, crisis situation.

1 CRITICAL INFRASTRUCTURE

Critical infrastructure is most often perceived as a system or process. Individual critical infrastructure elements are bindingly interconnected and instability of the one element can affect the functionality of another element. We must not forget that the failure of any element not only threatens the population, the economy, but also the state itself. It is also necessary not to forget the fact that individual critical infrastructure sectors are nowadays linked not only physically, but also cybernetic. As

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a consequence of these bonds is directly proportional dependence. Failure of one element of critical infrastructure affects directly or indirectly another element as a result of linking interrelations.

1.1 TRANSPORT CRITICAL INFRASTRUCTURE

Transport critical infrastructure section is divided into four elements that can be seen in Figure 1. Each of these sections is used not only for transporting people and goods (materials). In each country there is favored other type of transportation among people. In the Czech Republic, the most used type is the road transport. Based on this fact, I focus on this issue. Transport critical infrastructure is one of the elements of critical infrastructure, which is connected by links to other critical infrastructure elements. For this reason, we have focused on the vulnerability of critical road infrastructure that the risk of paralysis or restrictions can be prevented.

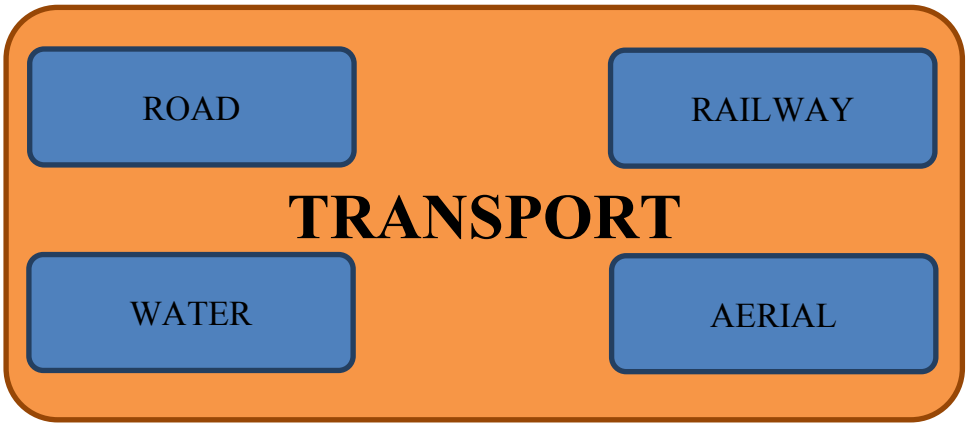


Figure 1 Division of the critical transport infrastructure [author]

1.2 INFLUENCE OF ROAD ACCIDENTS TO THE CONTINUOUSNESS IN THE ROAD TRANSPORT

Road transport is the highest percentage of utilization by human factor to move from one place to another. Each of us will think of an example in morning journey to work or to school. Road transport accompanies us at every step. We encounter the term accident on daily basis. Often we hear this term on the radio, television, Internet. It can also happen that we are direct or indirect participants in a traffic accident. This situation, according to its severity divides into the situation of crisis or emergency. In both cases, we can note that the integrated rescue system (IRS) has been dispatched to the location to resolve this situation.

Situations where the road traffic accidents happen greatly affect the continuousness of the road transport. Such crisis situations often emergencies are disruptive to the element of critical infrastructure and occur most commonly on the extension of IRS reaching time to the point where even tenths play a big role in saving human lives.

1.3 FACTORS AFFECTING THE ORIGIN OF TRAFFIC ACCIDENTS

Factors influencing the development of a traffic accident can be divided into two elements. The first element is the human factor, which can be largely influenced. The second element is the state of the road that we cannot so easily influence.

The origin of accidents is most influenced by the human factor. In cases where we follow the traffic rules, which are governed by Act no. 361/2000 Coll. we can influence these factors to a certain extent and reduce the possibility of accidents. We learn the particular factors influencing the origin of accidents in terms of motor vehicle drivers from the following points:

- Overcoming allowed speed.
- Overtaking in forbidden section of the road.
- Not giving way.
- Usage of alcohol or other drugs prior to driving.
- Not giving full attention while driving.

Many of us certainly ask at least one of the following questions. Do I also act correctly to not to be dangerous to myself and my surroundings? Do I create no dangerous situations on the road based on my behavior that lead to a traffic accident?

Yes, these are that questions where we can find answers by ourselves but most of us think that this topic has nothing in common with them. You are doing that, too! I do it as well as the people around.

The following table shows how the risk of accidents increases during various activities that most drivers do:

Table 1 Activities of drivers while driving a motor vehicule [1]

Activity	**Risk of accident**
Speaking\listening to the cell phone	1,3 x bigger
Tuning of en electric device	1,4 x bigger
Searching a phone number	3 x bigger
Usage of an electric device	7 x bigger
Texting of a short message (SMS)	23 x bigger

Behavior behind the wheel is an activity that can be affected if wanted. Each of us has ever looked while driving at a cell phone or did other things. All these activities greatly increase the risk of traffic accidents. Behavior behind the wheel not only affects emotions, mood, but also life situation in which we currently are. All activities except the full dedication to driving divert our attention and strongly influence our behavior behind the wheel. When traveling, we try to fully take advantage of the time by dealing with e-mails, phone calls or read news not only on social networks.

Think about your behavior and actions behind the wheels. Everybody of us can influence not only these statistics. By applying sufficient restrictions on these activities

we can decrease the risk of accident occurring which could cause serious injury or death. Also you can be that person or a person close to you.

1.4 CRISIS SITUATION INFLUENCED BY A TRAFFIC ACCIDENT IN THE CITY

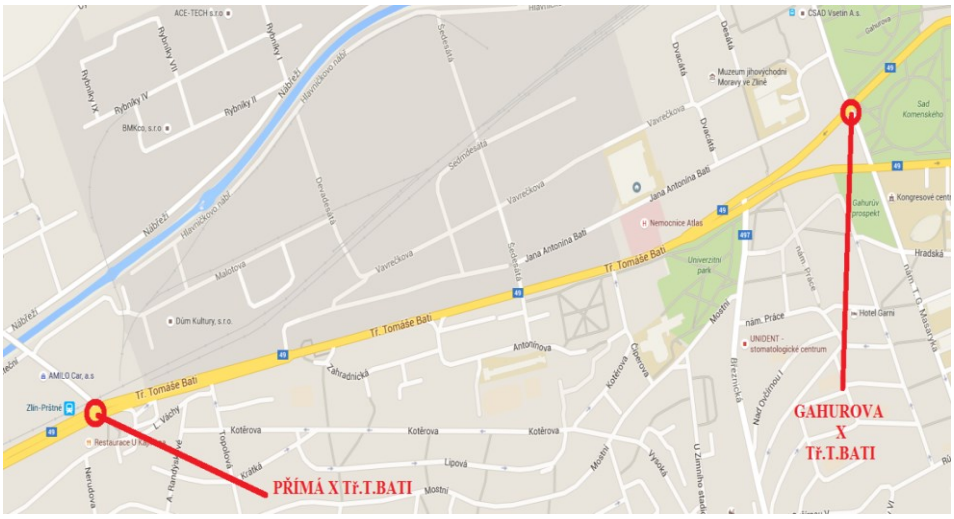
As already mentioned above, every crisis situation affects their relationships to other sectors of critical infrastructure. Individual components of the IRS are used to protect population and to help. The individual components also have their posts, which are strategically placed for proper coverage of their territory and of various remote locations within reasonable driving time.

After beginning of a crisis or an emergency the individual units of IRS are called to the point of origin based on the need. Each unit departs from his post, which we refer to as the so-called "START" and is directed at the so-called "TARGET" which marks the place of the incident. Between the start and the target, a plan of the perfect route with the shortest time splash takes place. When planning a route for transfer IRS crews, it might occur a crisis situation even due to a minor traffic accident. In these situations there is a negative impact on the time interval for arrival of the IRS units.

During the interventions of IRS, every hundredth of a second plays very important role in most cases. By saving the life of our greatest enemy is time. Today it is someone else but it can also be you the next time or someone you very close to you that will need help, and thanks to a moment of inattention, when you are watching the phone, was extended the arrival time.

2 ANALYSIS OF CURRENT STATE ON ROADS

During analyzing the current state, I focused on risk intersections in the city town. I monitored and analyzed previous action before the occurrence of a traffic accident at the mentioned intersections. These sites have been registered in the maps which can be seen on following figures.



Obrázok 2 Risk places in regional city [author]

Issue in country town is in the entire network setting of traffic lights. Driving through the country town is quite complicated because of non subsequent so-called "green interval".

2.1 ROAD NO. I/49 AT THE INTERSECTION OF STREETS PŘÍMÁ X TŘ.T.BATI

Road I/49 is a first class road to travel in the direction of Vsetinsko. This road is passed through every day by tens of thousands of cars. Mentioned intersection can be seen on the figure 2 to get a better imagination of this situation.

Mentioned street intersection of streets Přímá and street Tř. T. Bati has several aspects for creation of a traffic accident. From the direction of the Otrokovice to the direction Zlín, there is a great risk of accidents mainly from the reason of poor adjustment of the light signal. Motor vehicles that enter into the intersection in the time when the traffic lights from this direction show orange light signal and on the other hand from the direction of the street Přímá the traffic lights show already green light signal and it happens to the high probability of accident. In this situation no part of the road transport breaks the rules of road transport but still there is a possibility of a motor vehicle conflict.

The same situation can happen even if the car driving from the direction from Zlín to Otrokovice direction. In this case, we can conclude that the probability of the accident increases from the reason that these two lanes are closer to the street Přímá and the risk of accident rises.

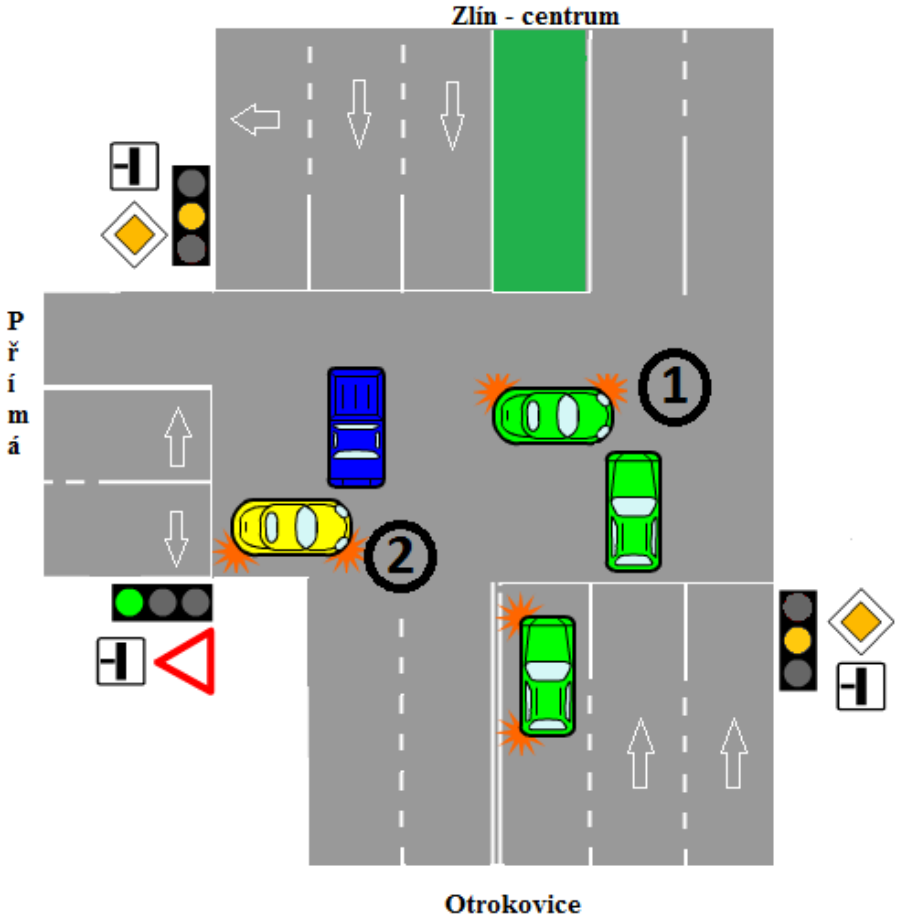


Figure 3 Intersection of streets Přímá and Tř.T.Bati on the road No. I/49 [author]

2.2 STREET NO. I/49 ON THE INTERSECTION OF STREETS GAHUROVA X TŘ.T.BATI

Intersection mentioned street Gahurova and the street Tř. T. Bati shown in fig. 4 is characterized by a high probability of great issues for critical infrastructure in case of an accident. This intersection can be marked as a very important not only from the point of view as is located on the main road in the direction to Otrokovice from the direction Vizovice or to Vizovice alternatively to Vsetín from the direction Otrokovice. This intersection to the direction Jižni Svahy is used not only for passengers transport but also for goods transport heading to the direction Fryštát. In case of an accident, there is a transport collapse on this road which paralyzes the majority of Zlin.

Issue of this intersection is located not only in the methodology of traffic lights but also in their intervals. Another aspect is the low capacity of traffic capacity at certain intervals, traffic signals and therefore it leads to intersection oversaturation not only at peak times.

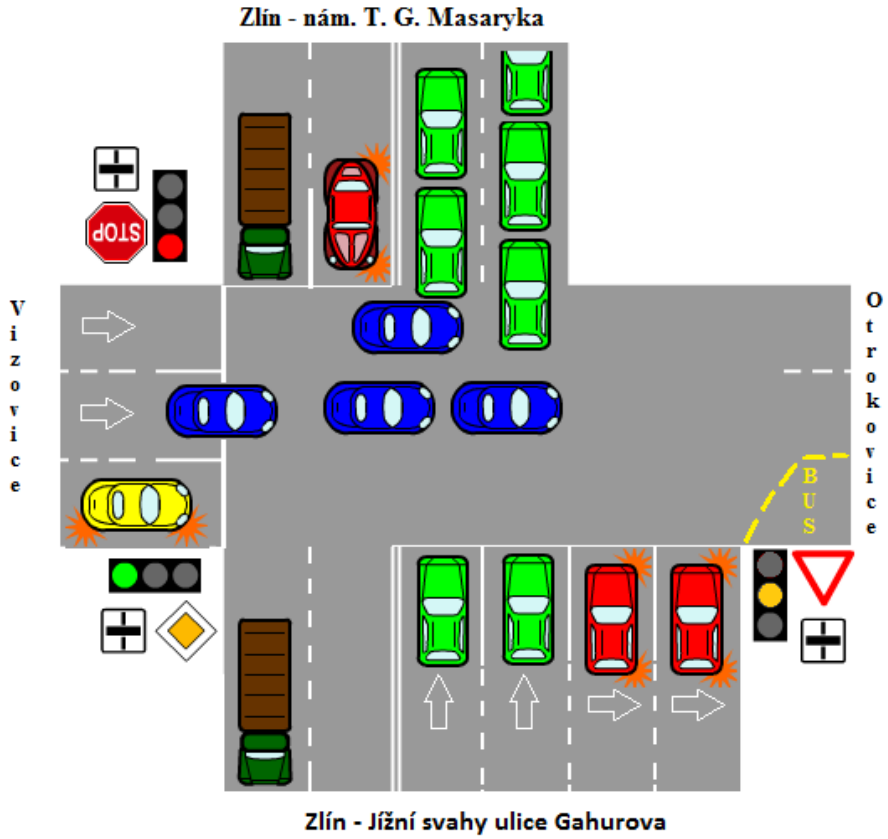


Figure 4 Intersection of streets Gahurova and Tř.T.Bati on the road I/49 [author]

3 PROPOSAL OF ELIMINATION METHOD TO DECREASE THE ACCIDENT RATE

After performing a very deep analysis of risk intersections in the county town, several aspects for remedy has been proved. Not all of them are obvious directly from already previous situations. After creation of older individual incident breakdown, it was confirmed that methodology for correct adjustment of traffic lights has not found such application as would be expected.

CONCLUSION

Established methodology cannot be used. Appropriate evidence are different settings of green intervals for pedestrians who cross the road at a time when drivers start to drive on the road. For this reason, there are unnecessary traffic accidents, when there is a conflict of pedestrians and motor vehicles. Our study looked at the intersection mostly from the driver's point of view. In our analysis, we are able to ensure such measures that should lead to reduce accidents in the county town. Speaking of sections where the occurrence of accidents with injuries can be seen often. Adjustment of light signaling setting is not so expensive, and in terms to avoid even a few accidents would be able to save not only state money but also money of insurance

companies due to lower number of injured persons in traffic accidents and damage to vehicles.

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LITERATURE

[1] MARTIN FARÁŘ. BESIP [online]. Praha: Ministerstvo dopravy, 2015 [cit. 2016-01-13]. Dostupné z: http://www.ibesip.cz/cz/pro-media/aktuality/202-delas-to-taky-kdo-se-nediva-umira

[2] Hromada, M., Lukas, L.: Methodology for selected critical infrastructure elements and elements system resilience evaluation. In: The 2015 IEEE Symposium on Technologies for Homeland Security, Waltham, USA (2015), ISBN 978-1-4799-1737-2

[3] Bohm, A., Jonsson, M.: *Supporting real-time data traffic in safety-critical vehicle-to-infrastructure communication*. In: The Local Computer Networks, pp. 614 – 621. Que, Montreal (2008), ISBN 978-1-4244-2412-2

[4] Bohm, A., Jonsson, M.: Position-Based Data Traffic Prioritization in Safety-Critical, Real-Time Vehicle-to-Infrastructure Communication. In: Communications Workshops, pp. 1 – 6. Dresden (2009), ISBN 978-1-4244-3437-4

[5] Lukáš, L., Hromada, M: *Simulation and Modelling in Critical Infrastructure Protection*, In: INTERNATIONAL JOURNAL of MATHEMATICS AND COMPUTERS IN SIMULATION, pp. 386-394 (2011), ISSN: 1998-0159

[6] MRÁZEK, Jan, PROCHÁZKOVÁ, Lucia a HROMADA, Martin. *MATEMATICKÉ MODELOVÁNÍ SILNIČNÍ DOPRAVY*. In Bezpečnostní technologie, systémy a management 2015, Sborník příspěvků 5. mezinárodní konference, 19. 11, 2015, Zlín, vyd.: 1., 2015 ISBN:978-80-7454-559-7.

[7] Apeltauer, T. (2011) Romodis – rozvoj moderních dopravních inteligentních systémů (modul 8 – Využití simulačních modelů v dopravě) [online]. 2011 [cit. 2015-03-24]. Dostupné z: http://www.romodis.cz/files/169118867.pdf. (in Czech)

[8] Apeltauer, T. (2013) Mikroskopické modely dopravy v pracovních zónách. [Habilitační práce]. Brno: University of Technology, 2013. (in Czech)

[9] Apeltauer, T., Holcner, P., Macur, J. (2009) Ověření některých modelů dopravního proudu, článek v Silnice a železnice, ISSN 1801-822X, KONSTRUKCE Media, Ostrava, 2009. (in Czech)

[10] Apeltauer, T., Holcner, P., Macur, J. (2013) Validation of microscopic traffic models based on GPS precise measurement of the vehicle dynamics. Promet - Traffic&Transportation, 2013, Vol. 25, pp. 157-167.

[11] Bogo, R., Gramani, L., Kaviski, E. (2015) Modelling the flow of vehicles by the macroscopic theory. Revista Brasileira de Ensino de Física, volume 37, Issue 1, 2015, pp. 1-8.

[12] Council of the European Union, Council Directive 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection.
[13] Ni, D. Equilibrium traffic flow models [online]. 2012 [cit. 2015-03-24]. Available from: http://people.umass.edu/ndh/TFT/Ch05%20Equilibrium.pdf.
[14] Young, W., Sobhani, A., Lenné, M.G., Sarvi, M. (2014) Simulation of safety: A review of the state of the art in road safety simulation modelling, Accident Analysis & Prevention, 66(2014), 89-103. doi:10.1016/j.aap.2014.01.008.