The impact of crisis situations to the transport service of the territory for the selected hospital

P. Viskup, and K. Vichova

Abstract— Several cities in the Czech Republic have a traffic problem. We see a growing number of road vehicles, resulting in traffic accidents and traffic accidents. The traffic situation is fundamentally affected by crisis situations. If a crisis occurs - floods, the path is often flooded. An even more significant problem arises when a flooded road separates the city from two islands. It is, therefore, necessary for the city to address this problem. At the time of the crisis, it is essential to plan different routes for evacuation or supply. Before the city decides to make a change in the transport system, it is necessary to make a simulation to determine if the proposed system will be useful and help in the traffic situation of the city. The aim of the paper is to analyse the impact of crisis situations to the transport service of the territory for the selected hospital. In the introduction, there is a literature review of the problem of transport service in times of crisis and simulation traffic service. In the next part, there was analyse the transport operation of the hospital Uherské Hradiště. As a central part of the paper is a case study which solves the traffic situation in the nearest part of the hospital with the critical points of the solution. In the paper, there was used the software PTV Vissim as a first method. The second used method is Digital Flood Plan of the Czech Republic. At the end of the paper, there we can see the results from this software and digital plan.

Keywords — transport service, traffic streams, crisis management, floods, PTV Vissim.

I. Introduction

LOGISTICS in addressing emergencies and crisis presents a vital role. At this time, it is essential that the components of the Integrated Rescue System (IRS) have reached the destination. It is necessary that in the event of an emergency - a fire of the injured persons in need of treatment, they enter the Emergency Medical Services (EMS) as soon as possible. It is essential for the IRS components to have a secure city transit. The number and distribution of output bases depending on demographic, topographic and risk parameters of the territory of individual towns and city districts of the capital city Prague, so that instead of events in the area of different towns and communities it can be reached from the nearest outbound base in the landing time to 20 minutes determines EMS by the Act No. 374/2011 Coll., on EMS [1].

Due to the critical time of the EMS, a new base of EMS - Buchlovice was built in the Zlín Region. During the analysis before the construction of this base, routine exits on the E 50 road, section Buchlovice - Střílky were also taken into account. It is the territory of frequent traffic accidents, both for motor vehicles and for motor vehicle users. The travel time on the way to the hospital is significantly longer than the landing time from the base of the EMS. It is, therefore, appropriate to create a way to reduce this distance to the hospital.

The idea is to create a new transport service of the hospital Uherské Hradiště. The advantage of this new transport service is the complete avoidance of the city center with high transport capacity.

Transportation systems in general belong to areas where optimization have been used successfully. However, the complexity and size of the problems recurently limit the use of exact methods. In this paper we used simulation software PTV Vissim. [2]

The aim of this paper is to simulate the new path to the hospital. A model is a representation of actual or planned events, objects or systems. To create the model, it is necessary to abstract description of the properties of the system. The model shows the system at a certain level of abstraction with the aim of representing it in a mathematically credible manner. [3] Simulation is a method in which are looking for, calculate the state and behaviour of the real system using the system. [4]

Transportation can be devided according to several points of view, the basic breakdown by object of transport is passanger transport, freight transport and transmission of information. [5] The basic means, which can be used include: rail, road, air transport, ship, pipelines. [5, 6] In road transport, these are the dynamic models of freight management [7], finding the optimal path of vihecles [8], planning of transport demand [9] and determining the optimal frequency of deliveris. [10]

II. Transport Operation of the Hospital Uherské Hradiště

From the sustainable development of the city, the primary element should be the availability of a hospital from the city center by mass means of transport. Nevertheless, car transport

This project is realized as the research with a doctoral student, and it is the primary input for next research. This work was supported by Internal Grant Agency of Tomas Bata University under the project No. IGA/FAI/2018/001 and Tomas Bata University, Faculty of Applied Informatics, Department of Security Engineering.

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solutions present one of the critical roles. In this case, it is necessary to take into account the current capacity of private roads (intersections).

Regarding capacity, traffic flows are taken into account in the paper. By the physical analogy, the traffic flow also has its status variables. For now, we are based on the intensity, or the number of units of current passing through the site as the time unit. [11]

This hospital is connected to the road via the streets of J. E. Purkyně and Jiří z Poděbrad. The mentioned communications form the only access road to the hospital. It is also the only access road to another western part of the city - Štěpnice, Zahrádky, Mojmír, Průmyslová. Due to the current development, the capacity of the streets is almost exhausted. Then it is also problematic to pass through the EMS. Therefore, it is necessary to create a new landline for the operation of the EMS to and from the hospital.

The crossroads of the streets - Svatoplukova, tř. Maršála Malinovského, Svatoplukova, U Stadionu. The following figure shows this junction and their capacities are shown at selected time intervals.

Table I. Capacity of the interesting junction [12].

Entrance	**from A**	**from C**	**from D**		
Exit	**to D**	**to D**	**to A**	**to B**	**to C**
8:00 – 8:30 a. m.	48	118	64	7	40
8:30 – 9:00 a. m.	94	167	111	13	76
9:00 – 9:30 a. m.	101	166	89	9	67
9:30 – 10:00 a. m.	80	154	79	4	96
10:00 – 10:30 a. m.	71	148	75	5	92
10:30 – 11:00 a. m.	83	149	95	2	116
1:00 – 1:30 p. m.	60	107	81	7	109
1:30 – 2:00 p. m.	67	124	114	8	96
2:00 – 2:30 p. m.	80	130	120	8	93
2:30 – 3:00 p. m.	84	164	93	10	104
3:00 – 3:30 p. m.	99	134	125	13	102
3:30 – 4:00 p. m.	79	152	128	8	92
4:00 – 4:30 p. m.	68	127	123	9	97
4:30 – 5:00 p. m.	66	112	90	10	91
Total	**1080**	**1952**	**1387**	**113**	**1271**

Table I summarize the results of the exciting junction capacity, which is critical for the hospital. As can be seen in the table, the highest intensity of the way is in the time interval from 10:30 a.m. to 11:00 a.m. The second highest intensity of the road is in the time interval from 1:00 p.m. to 1:30 p. m.

The following figure 1 display the intensity of this junction from software PTV Vissim.

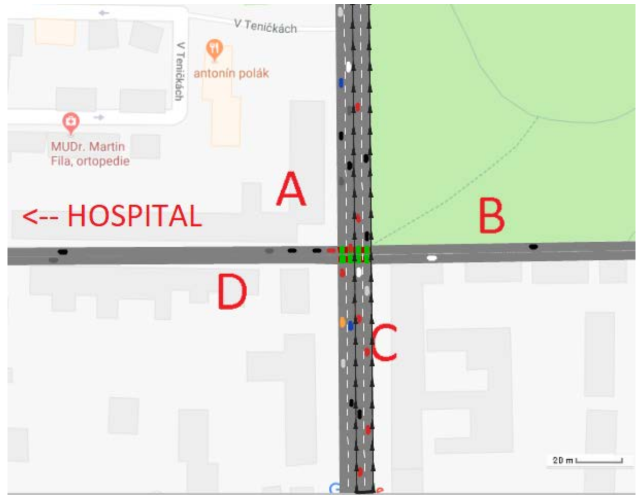


Fig. 1. Interesting junction [author].

III. Case Study

The city of Uherské Hradiště hit the flood in 1997, and a part of the hospital Uherské Hradiště was ordered to evacuate. The situation was further complicated by the fact that the driveways to the hospital were flooded. It was, therefore, necessary to select other access roads, which were not an ideal solution.

The aim of the hospital Uherské Hradiště should be to provide a new driveway that would allow free movement of ambulances to the hospital even in the emergency. This situation could be resolved by arriving from another side to the hospital. The town of Uherské Hradiště and Kunovice have available unconstructed areas which are intended for development. These areas could serve as a place for the future development of the hospital Uherské Hradiště. Therefore, new transport services would also be suitable.

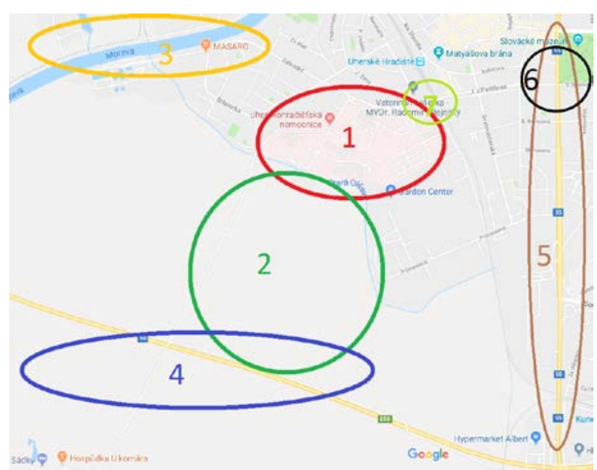


Fig. 2. Interesting areas [author].

Figure 2 shows the exciting areas in the map of the Uherské Hradiště, where:
1 – hospital Uherské Hradiště
2 – developmental area
3 – river Morava
4 – main way E 50 (out of the city)
5 – city way E 55 (in the city)
6 – exciting junction (Fig. 1.)
7 – underground (main way to the hospital)

Based on the designation of the areas of interest, it is appropriate to address the access road with suitable capacity, given the future construction.

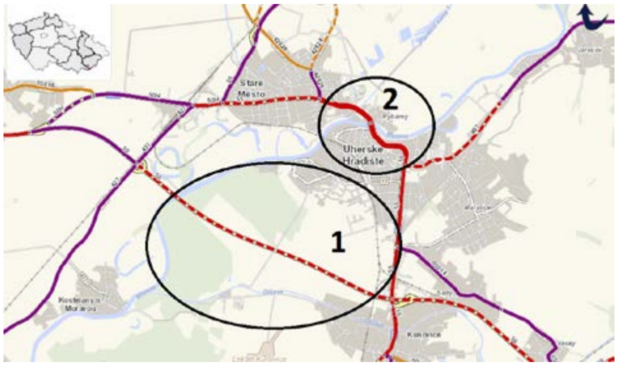
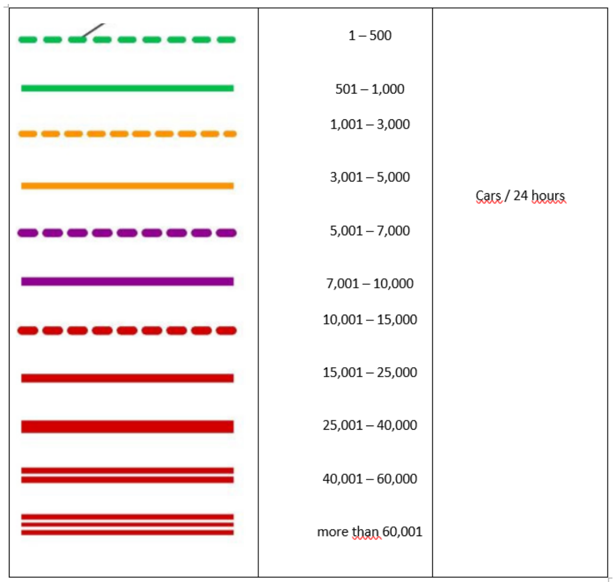


Fig. 3. Intensity of the city Uherské Hradiště [13].

Figure demonstrates the intensity of the road in the city Uherské Hradiště (2) and main way E 50 (1). Based on the following figure, which is a legend to the figure , we can see, that the intensity in the city Uherské Hradiště is greater than in the main way E 50. This intensity is bigger more than 15 to 25 thousand cars per one day.

Table II. Intensity – legend [13].



Next problem with the traffic in the city Uherské Hradiště is in the time of crisis – flood. The main road to the hospital is through the underpass of the railway line.

Fig. 4 Main way to the hospital [author].

IV. Critical Points of the Proposal

Within each proposal, critical points have to be taken into account. In the case of designing a new transport service of the hospital Uherské Hradiště, it is necessary to take into account the hospital protection zones and the noise limits.

About protection zones, it is magnetic resonance and CT. For these devices, the frequent passage of vehicles can affect the accuracy of the examination and thus the diagnosis of the patient. [12]

The following table shows the minimum distances from the centre of the magnetic field.

Table III. Minimum distances from the centre of the magnetic field [12].

Type	**Axis X/Y (m)**	**Axis Z (m)**
Steel objects to the weight 50 kg	5,5	6,5
Steel objects to the weight 900 kg	6,5	8
Steel objects to the weight 4500 kg	7	9,5
Mobile metal beds, chairs	5,5	6,5
Passengers cars	6,5	8
Trucks, lifts	7	9,5
AC transformers up to 100 kVA	12	8
AC transformers up to 650 kVA	13	12
AC cables up to 10 A	2	2
AC cables up to 50 A	2	2
AC cables up to 250 A	7	3
AC cables up to 1000 A	12	5
Refrigation unit for MR 3T	4	4

The table shows what the axle distances in the hospital's protective zone are. Due to the intention of this paper (building a new driveway), it is clear that the buildings with selected devices have an X / Y axis of 6.5 meters for passenger cars and an axis of 8 meters. As for trucks X / Y axis 7 meters and Z axis 9.5 meters.

The second critical point of the project is the noise limits from the proposed communications.

Government Regulation No. 217 from 2016 sets noise limits for public local communication III. classes and other unspecified classes.

Table IV. Traffic noise emissions values [14].

Communication type	Part of the day	$L_{Aeq,T\ (dB)}$
Road I. and II. class	Daily	65
	Night	55
Road III. classes and purposeful communications	Daily	60
	Night	50

Road traffic noise levels for the use of another +5 dB correction.

From the project, it is evident that the hospitals form purposeful communication (these are premises of hospital communication).

V. Methodology

The software which was used in this paper was PTV Vissim. The mentioned software was used for simulation of the new way in the city Uherské Hradiště. The second simulation of the hospital is the digital flood plan of the Czech Republic. This plan simulates states and consequences of major floods. There was simulated impact of the flood to the hospital Uherské Hradiště.

PTV Vissim software has been used to simulate transport services in the state of crisis. It is the software that solves microscopic simulations of individual and public mass transport. This program can affect both urban traffic, including cyclists, and motorway sections, including significant, cross-country intersections. The extensive analytical tools gathered in Vissim make it a tool for traffic planning and optimization of transport and transport systems, as well as some interfaces for different traffic management systems.

Vissim simulates some familiar but also unique geometric and operating conditions that occur in the transport network. The Vissim can define an unlimited number of vehicle types allows the user full range of multimodal operations. Types of vehicles include passenger cars, trucks, buses, cyclists, wheelchairs, pedestrians, airplanes. [15]

Vissim offers the unique ability to allocate vehicles to the network using one or a combination of three methods. The primary method assumes that traffic is stochastically distributed on fixed routes from a user-defined starting point to a destination point. The definition of junction maneuvers allows traffic to be distributed at a junction or several junctions. [16] Dynamic routes provide dynamic allocation of traffic to user-specified paths.

The Dynamic Load Method allows Vissim to assign traffic to the source/target matrix network (depending on vehicle time and category) and stochastic (load and load) loading techniques.

PTV Vissim software uses Wiedemann vehicle movement. The underlying assumption R. Wiedemann´s is such that the vehicle may be in one of four driving modes.

Uninfluenced ride - the driver is in no way affected by his movement. Thus, it moves in the determined direction and at the selected speed. It is not affected by moving vehicles or commands according to traffic regulations. In fact, the speed is dependent on the accelerator pedal and therefore is not constant. It is one of the reasons why the speed is entered in Vissim at intervals (e.g., 50 km / h is introduced at a range of 48-58 km / h). [17]

The vehicle approach process - the driver, gradually approaches the forward vehicle and progressively moves the speed until the desired safety clearance is reached between the car and the first vehicle.

Follow-up - the car follows the previous vehicle without any change in speed (except the speed variation at the specified interval). It is driving at the same speed as a vehicle in front of it and still keeps its safe distance from it.

Braking - if the driver cannot keep the required safety distance (the car is in front of him), the vehicle gradually decreases its speed and stops.

The following figure shows the boundaries of Wiedemann interaction states used in PTV Vissim software.

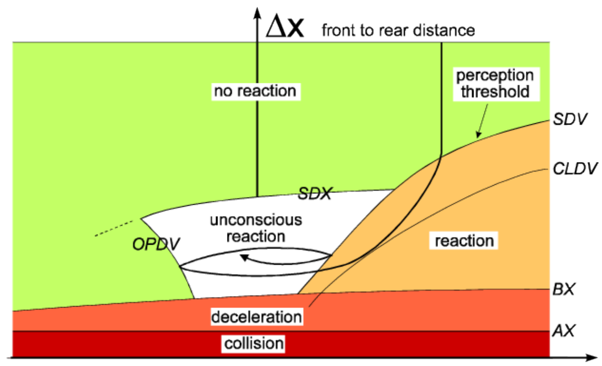


Fig. 6. Movement of the vehicles by Wiedemann [17].

This model has the following parameters:

• Average Stopping Distance (AX) - Defines the average required distance between stopped cars. Deviation ± 1 meter.
• Reserve part of needed safe distance (BX_add).
• The fixed part of the necessary safe distance (BX_mult). [17]

We determine the safe distance based on the following formula:

$$BX = (BX_{add} + BX_{mult} * z).\sqrt{v} \quad (1)$$

Where v is the vehicle speed (m / s), z represents the driving range (= 0.5).

The distance between two vehicles d (m) is calculated using the following formula:

$$d = AX + BX \quad (2)$$

The second mentioned way of simulation was the digital flood plan. This plan simulates the flooded area in the area of Q5, Q20 and Q100. These coefficients illustrate the effect of flood waves to the territory.

VI. Results

The part results is divided into two parts. Firstly, we are presented new way to the hospital based on simulation software PTV Vissim. Secondly, we are presented flooded of the hospital based on simulation software POSIM.

As has been mentioned several times, this paper intends to propose a new hospital transport service. It would be the connection of the first class road E 50 and the hospital area.

The following figure shows how to make a connection to this route. The simulation was done in the PTV Vissim program.

Because of the required capacity, a crossroads, a three-armed T-junction, were used. [18]

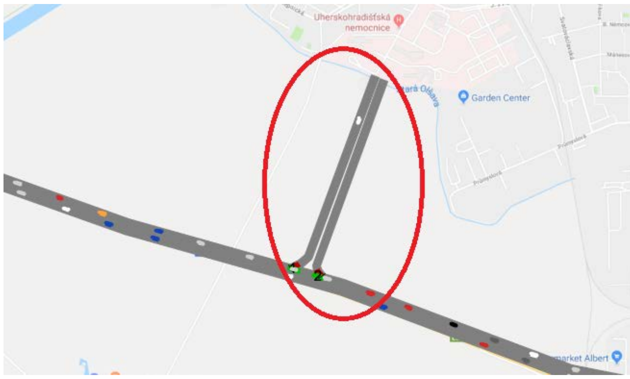


Fig. 7. New road to the hospital [author].

As part of the simulation, we tested the arrival of EMS vehicles, where significant positive time differences were observed.

Besides, the authors will continue to explore this area. Authors are already working on simulating traffic jams in the city when all road users will start using the new communications.

There is a problem at this time of the flood. If floods occur in Uherské Hradiště at the level of hundreds of water (Q100), the underground will be flooded. The following figure shows the underground as a main way to the hospital.

Fig. 8. Main way to the hospital and flooded area [19].

Figure 7 shows the main way to the hospital and flooded area. As can be seen in figure 7 the blue area presents the flood area in times of flood – Q100. Red highlighted area displays the underground. There is not a problem only in times of crisis – flood, however in times of intensive rain – torrential floods too.

That is the problem for the EMS. This problem can be solved by the new way which we present in part of results.

This proposal was also assessed using the SWOT analysis in the part of discussion.

VII. Discussion

The aim of the paper was to analyse the current transport service of the hospital Uherské Hradiště and its subsequent solution proposal. Firstly, an analysis of the route over time and distance was performed. It is only a basis that is not essential for the design of a new transport solution. Secondly, the method of analyzing the critical points of the project was used. The map has highlighted areas of interest that are referenced in work. Within these critical points, the distances of the magnetic field from the roads and the noise capacity in the roads with the impact on the hospital were solved. Thirdly, the PTV Vissim software was used, in which the new transport service of the hospital Uherské Hradiště was designed. Finally, a SWOT analysis of the proposed project was carried out.

Table V. SWOT analysis [author].

Strenghts	**Weaknesses**
Developing a city in a location that does not create increased demands for motor traffic. Faster transport service of EMS. Traffic service outside the critical location - passing under the bridge at the hospital.	When rebuilding the territory, additional investment in the city's transport infrastructure would be appropriate.
Opportunities	**Threats**
The building new parking space in the development area. Building new pavilions of the hospital in the development area. Building new residential premises (for employees) of the hospital.	Junction capacities. Financial demands of the whole project.

As has already been mentioned, article authors using PTV Vissim software continue to model traffic flows in the city.

VIII. Conclusion

The article dealt with the simulation of traffic changes in the city of Uherské Hradiště by the state of crisis. This goal was fulfilled, and there was a positive change in the traffic situation for the EMS. The proposed solution is easier and faster to provide access to the hospital in crisis situations. The authors of the article continue to work on simulation of the flood area in the nearest of the hospital Uherské Hradiště. Further simulations of junctions are made in Uherské Hradiště (in software PTV Vissim). It is believed that diverting traffic over a new route will significantly affect the hospital's transport services to citizens.

The authors are aware of the future prototypes of the D 55 motorway, but due to the speed of construction in the Czech Republic, this modelling will occur not earlier than five years. [20]

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REFERENCES

[1] *Emergency Medical System* Act No. 374/2011 Coll., Czech Republic ©2017 (Accessed: Marc 25, 2018)

[2] M. Weiszer et al., "Optimalization of parameters of transport systems using simulation methods", 2015

[3] J. A. Sokolowski, C. M. Banks, "Principles of modeling and simulation: A multidisciplinaty approach", 2009

[4] D. Malindzak et al., "Modeling and simulation in logistic", 2009

[5] M. Straka et al., "Distribution logistics", 2005

[6] D. Marasova et al., "Transport of logistic", 2007

[7] W. B. Powell et al., "Dynamic models for freight transportation", Transportation, handbooks in operations research and management science, 14, 2007

[8] J.-F. Cordeau et al., "Vehicle routing", Transportation, handbooks in operations research and management science, 14, 2007

[9] J.-F. Cordeau et al., "Transportation on demand", Transportation, handbooks in operations research and management science, 14, 2007

[10] L. Bertazzi, "Minimalization of logistic costs with given frequencies", Transportation research part B: Methodological, 31, 1997

[11] A. Cerna, J. Cerny, "Managerial decision-making on transport systems", Czech Republic, 2014

[12] L. Cerny, A. Jebavy, "Concept of transport service of the former hospital UH", 2010

[13] *Digital Flood Plan of the Czech Republic*, Hydrosoft Veleslavín, 2017.

[14] *Health protection from adverse effects Government Regulation* 217/2016, GR., Czech Republic, 2016.

[15] Software PTV Vissim (2018), Available from: http://vision-traffic.ptvgroup.com/en-us/products/ptv-vissim/

[16] X. Guo, H. Sun, X. Wang. "The design of traffic signal coordinated control", China, 2017.

[17] P. Hofhansl, "Application of microscopic simulation tools for evaluation and optimization of road infrastructure engineering solutions - instrument validation and standard setting", 2011.

[18] J. Siroky et al., "Transport technology", Czech Republic, 2016.

[19] V. Stanislav, A. Sonia, "PPP projects for transport constructions with respect to the life cycle cost in the Czech Republic", 2016.

[20] Road and Motorway Directorate of the Czech Republic, "Nationwide traffic aggregation 2016", 2017.

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