

Validation of trigger points on the railway road crossing

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Abstract: This labor analyzes the causes of the tragic accident at rail crossing journeys provided by barriers, light traffic signs and traffic signs on the road. It was found that one of the problems that directly affect the safety is location of trigger points that start the device at road crossing. In aim of fast and accurate determination of new trigger points depending on introduced an easy drive on the track it was suggested to use a mathematical software packages.

I. INTRODUCTION

It's common, when it reaches the traveling rail level crossing with barriers, traffic light signs and traffic signs on the road to wait for a variable time arrival of train of relatively short time to the unjustifiably long, even for a few minutes.

Unfortunately, we have seen exceptional events in the traveling rail crossing accidents in the group with the consequence of killing people and great material damage. Despite of secured-railway crossings traveling light and sound signals and barriers, drivers of road vehicles move in the "slalom" ride between barriers. If it is asked why they do this, certainly they do not have rational explanation. However, if we analyze the Reports of the exceptional events in the territory of the Section of infrastructure nodes Novi Sad in the period 2001-2010 (based on official reports of Organizational entity for operational work Node Novi Sad), there is an interesting data. In most cases, participants in exceptional events, who ran road vehicles, are people who live in municipality where the exceptional event occurred and who are familiar with local circumstances. These people had knowledge that the time interval of lowered barriers is longer therefore they "estimated" that pass can be done between barriers before the train comes.

Railway "b" ray of corridor X (number of railroad Indija-Novı Sad-Subotica) is equipped with electro-relay signal-safety devices of the system "CI WESTINGHOUSE". Within this system there are devices to secure traffic at the point of intersecting roads and railroads in the level. Subject to the provisions of the Law on Safety in railway transport ("Official Gazette of FRY", No. 60/98) resulted Regulation on the railroad crossing and the road ("Official Gazette of FRY", No. 72/1999). This regulation ranked the degree of assurance traveling rail crossing in relation to: a triangle of clarity, purpose and range lines, road type, traffic density, the maximum permissible speed on the track, the length of journeys rail crossings and so on. In accordance with

these factors, provision of level crossings may be with [2]:

1. with traffic signs on the road and triangle of visibility,
2. traffic light signs and traffic signs on the road,
3. barriers with traffic light signs and traffic signs on the road,
4. bumpers and traffic signs on the road,
5. direct regulation of traffic on the road crossing and traffic measures in certain cases,
6. fences or other devices on the traveling rail crossing for pedestrians or cyclists.

This labor will discuss the arrangement of rail journeys in the level crossing with barriers, traffic light signs and traffic signs on the road.

The aim is that, for perceived shortcomings that were noted during the exploration, recommend other technical solutions proposed for a safer and more cost-effective traffic management.

II. CHARACTERISTICS ON THE RAILWAY ROAD CROSSING WITH BARRIERS, TRAFFIC LIGHT SIGNS AND ROAD TRAFFIC SIGNS

The technology of the device on the railway road crossing with barriers is related to the calculation of the maximum train speed on that section of track where the railway road crossing and time of closing barriers. In this case it is observed section of the railway Indija-Novı Sad-Subotica. Signaling and safety devices as well equipment on the railway road crossing were designed and incorporated 30 years ago and for the top speed of 120 km/h. Railway road crossing with barriers are activated by trigger pedal in the time of arrival of first axle of train over them. Trigger pedals are placed in a certain distance from the railway road crossing and in the literature are called "trigger points". Trigger points are set in accordance with the maximum speed of trains on that tracks and features of the track (curves, tunnels, bridges ...) and time is [1]:

- 12-15 seconds for the blinking (turns on and off of road light signals alternately, which are placed on either side of the road) and the time before ringing. Estimated time for this labor is 15 seconds;

- 5 seconds for the psychological effect that is occurring at the time of arrival of a driver who is approaching to the railway road crossing, which begins to close,
- 8-12 seconds for the closing barriers. At each railway road crossing it must be individually taken its length, because we have road crossings that cross two or more tracks (highway Sombor - Subotica at the entrance to the railway station in Subotica). To make this work, we take an arbitrary width of railway road crossing and the fixed time of 8 seconds.

By these elements we can determine the distance from the point of trigger railway road crossings and that is:

$$l = v_{trainmax} \cdot \sum t \text{ (m)} \quad (1)$$

Where:

$v_{trainmax}$ - maximum speed of the train,

$\sum t$ - total time required for closing barriers.

Total time required for closing barriers is obtained by:

$$\sum t = t_{blink} + t_{sp} + t_{ps} \text{ (s)} \quad (2)$$

t_{blink} - a period of 15 seconds for pre-ringing and alternately switching on and off light signals,
 t_{sp} - time of 8 seconds for closing barriers,
 t_{ps} - a period of 5 seconds was adopted in time for the security (psychological) reserve,

From formula (2) total time required for closing barriers on the road crossing $\sum t = 28$ seconds, and when the time included in the obtained formula (1) gives the distance from the point of trigger railway road crossings, which is for the maximum speed of 120 km/h, 933.33 (m). Figure 1 shows a sketch of the situation.

It is known that the speed on the track Indija-Novi Sad-Subotica (observed section of the railway in this labor) for the Timetable 2010/2011 of 50-80 km/h. These are the maximum speed of trains and there are frequent coasting, which are introduced due to the poor condition of the track and continue until the cause of the introduction of an easy drive. Resolve the cause of driving light sometimes occurs for several months. After examining the records of driving light on this part of the railway, we can conclude that they are on average 20-30 km/h.

The logical question then arises: what they do and how drivers react to road vehicles waiting in front of the closed barriers for the train that goes smooth ride of 20 km/h. Based on the formula mentioned above which we calculate the distance from the point of trigger railway road crossing, it is clear that the train, moving at a speed of 120 km/h after 33.7 seconds from the time point of

activation of trigger find on railway road crossing and drivers of road vehicles to wait in front of closed barriers only 5,7 seconds.

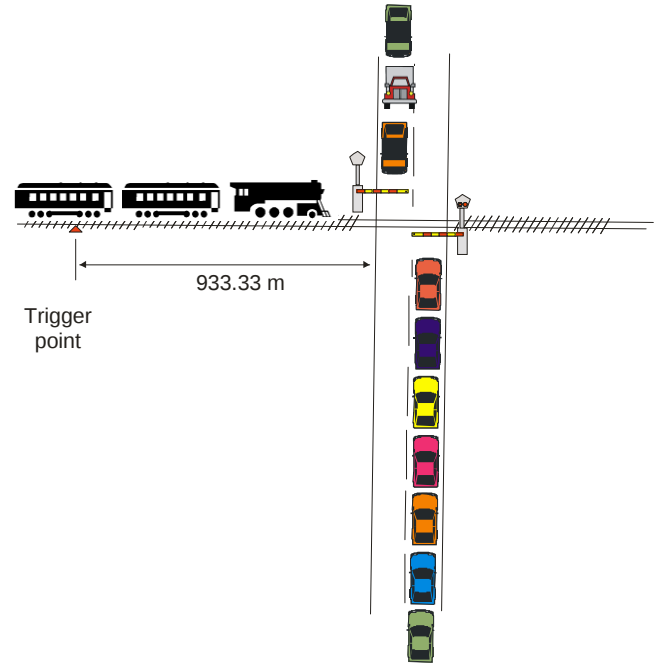


Figure 1: schematic view trigger points

However, if a train moving at 20 km/h it will be, from the moment of activation of trigger point to the arrival of the railway road crossing, moving of 169.7 seconds and drivers of road vehicles will be waiting in front of the closed barriers 141.7 seconds. Here we connect the fact that the local people who participate in traffic as drivers of road vehicles, familiar with the long retention interval in front of closed barriers railway road crossing. This is often the only motive why these drivers indulge in making "slalom" between the closed barrier railway road crossings that sometimes ends fatal.

A model for predicting the number of road vehicles and the total waiting time due to busy railway road crossings have a major impact on traffic flows at railway road crossing, particularly in its optimization, which contributes to shorter waiting time, delays, better utilization of transport capacity and others and on the other hand contributes to the greater income of transport companies as well to better economic development [3].

The intensity of road and railway traffic, then the time distribution of coming vehicle or trains directly affects the number of stopped cars and their total waiting time.

However, if the waiting time in front of closed railway road bumper unduly long, it will affect negatively at least two factors, which we will mention here, although the authors did not thoroughly research them.

These factors are:

- Economic factor
- Ecological factors.

It has not been done any of the recording level crossings for this labor. However, by examining the existing literature that deals with these issues, we come to the conclusion that it can be quantified economically unnecessary delays of road vehicles which wait in front of the closed barriers. That would be performed by calculating the amount of costs due to unnecessary delays of road vehicles. This is primarily to the costs incurred by commercial vehicles (vans, vehicles of various utilities and others). We have no right to disregard the costs of private persons. This is a very complex theory that must be escorted on the field recordings (the longer recording, it is better sample and quality results), recording of the different types of road vehicles (vans, fire engine, ambulance, utility vehicles for garbage disposal, large trucks, car, etc...). Then we would have to deal with the economic parameters such as the costs (direct and indirect) which are incurred by participants in the road that are waiting for the road crossing..

The twenty-first century will certainly be crucial in the area of environmental protection. It is therefore necessary for each project to define the environmental aspect of the project. Any negative impact on the environment requires a special approach and in the most cases requires total or partial elimination of the negative environmental impact.

Conclusively it is unnecessary retention of participants in road traffic generates harmful fumes. We are witnesses of resolution this issue in urban areas with traffic lights where the long wait under the light signal where it is set the timer that counts down the seconds of waiting for the appearance of green light in order to extinguish the engine.

I repeat that the authors are not engaged in the research of these factors, but we take the intuitive assumption that both are absolutely justified. Neither the high costs that were incurred by participants in road traffic, which unreasonably long wait in front of the closed barriers railway road crossings, or environmental pollution that arises in this case is not, nor can it be valued with a lifesaving. Therefore, the authors of this labor suggested a solution to this problem trigger points on the line in terms of speed of the train.

If we quantify the economic value of this work, we cannot without any calculation claim that it is economic justification for hiring two mechanics interlocking means to shift trigger points which is much lower than the costs generated by road traffic participants who needlessly waiting in front of the railway road crossings.

Using mathematics software Matlab [3] accurately and quickly you can get new for trigger chainage points depending on the introduced light train schedule.

III. USE OF PROGRAM MATLAB FOR DETERMINING THE TRIGGER POINTS

A. Setting task in MatLab

Resolving the problem of locating trigger points depending on the speed of trains which we assume that it was designed speed railway line of 120 km / h (railway

branch "b" on the part of Corridor X railway Indija-Novi Sad-Subotica). Therefore the system was designed and interlocking systems, as well railway road crossing with barriers for speeds of 120 km/h. From (2) it is known that activating of railway road crossing with barriers is 28 seconds.

It is necessary to write a program in MatLab so that the result gives the distance of trigger points in relation to arbitrary given speed of the train. Arbitrarily set speed of train is a vector of 120 to 10 with step -10.

As a graphic solution of this task we should get a diagram of train in the move of 120 km/h as the red line in the v-t coordinate system and the blue line to show a given speed of the train. Time is always limited to 28 seconds (1) in order not to change the device of railway road crossing.

For better presentation of the results, it is necessary to do, in the form of a graphical histogram, on the x axis speed movement and on the y-axis time in seconds it is necessary that train arrives to the level crossing with barriers.

B. The decision task in MatLab

Programming this task is performed by the vector of time entries from 0 to 28 seconds. This is the time which is necessary to train, travelling at 120 km/h that came to the trigger point of the railway road crossings. L_p represents the vector distance of train from railway road crossing with speed of 120 km/h. Previously we had to convert the speed from km/h into m/s. However, in the task we had to keep the speed in km/h to the outcome results. In the next view they are given the program steps:

```
>>Tut=[0:28];
>>Tut=0:28;
>>Lp=0:28;
>>V=120*(1000/3600);
>>Lvl=[0:28];
>>Vlv=input('Input decreased speed');
>>Vlv=Vlv*(1000/3600);
>>Lp=(28-Tut)*V;
>>Lvl=(28-Tut)*Vlv;
>>tab(:,1)=Tut';
>>tab(:,2)=Lp';
>>tab(:,3)=Lvl';
>>tab
>>grid on
>>plot(Tut,Lp,'color','b','marker','x')
>>line(Tut,Lvl,'color','r','marker','x')
>>legend('Decreased speed','Regular speed',0)
>>xlabel('TIME IN S')
>>ylabel('THE PATH TAKEN IN M')
```

The result of this program provides an interactive work of users and computer. The computer asks to insert the reduced speed. The user input the speed of the train, which may be of 10 km/h to 120 km/h. Since it is an easy drive to introduce the entire decade values were not necessary to generate a vector to a lower value in other words with shorter step.

In response to the set speed MatLab will calculate and display the result in three columns. The first column of the table is the seconds from 0-28. The second column represents the distance of the train speed of 120 km/h, in meters, and the third column represents the distance from the railway road crossing for a particular reduced speed. The table I give the view of results for a speed of 20 km/h. The first column of the table represents the seconds (0-28) needed that barriers go down. The second column represents the distance of a train from railway road crossing in the observed time when the speed is 120 km/h and the third column represents the distance of a train from railway road crossing for speed of 20 km/h.

From table I it follows that if the train is moving slowly at a speed of 20 km/h, it is necessary to relocate the trigger point for 155.56 meters in front of railway road crossings since the arrival of the train passes through trigger point total of 28 seconds.

TABLE I. RESULT OF LOCATION TRIGGER POINT DEPENDING ON THE SPEED

time	Distance trigger points for speed of 120 km/h	Distance trigger points for decreased speed of 20 km/h
0	933.33	155.56
1	750.00	150.00
2	722.22	144.44
3	694.44	138.89
4	666.67	133.33
5	638.89	127.78
6	611.11	122.22
7	583.33	116.67
8	555.56	111.11
9	527.78	105.56
10	500.00	100.00
11	472.22	94.44
12	444.44	88.89
13	416.67	83.33
14	388.89	77.78
15	361.11	72.22
16	333.33	66.67
17	305.56	61.11
18	277.78	55.56
19	250.00	50.00
20	222.22	44.44
21	194.44	38.89
22	166.67	33.33
23	138.89	27.78
24	111.11	22.22
25	83.33	16.67
26	55.56	11.11
27	27.78	5.56
28	0	0

. Graphic display is automatically regulated so that the second list highlights the graphical solution of this task.

From the above diagram it is clear that the train for 28 seconds presented in Figure 2 is a graphical representation of the task. From the above diagram it is clear that the train for 28 seconds to cross the 933 meters and is moving with $v_{max} = 120$ km/h (blue line diagram) and that for the same 28 seconds to cross the 155 meters and is moving with $v_{max} = 20$ km/h (red line diagram).

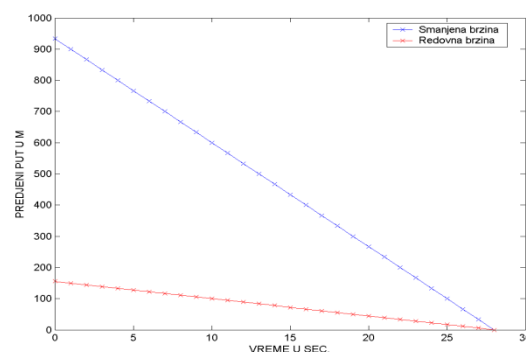


Figure 2: Graphical representation of results

The functioning of this program is based on a for loop that follows the 12 steps of the train speed and distance from trigger point until railway road crossings. The programming solution is:

```
>>vms=1000/3600;
>>l=120*vms*28;
>>v10=[120:-10:10];
>>v11=v10;
>>v10=v10*vms;
>>t10=[1:10];
>>n=length(t10);
>>for k=1:n
    t10(k)=l/v10(k);
>>end
>>bar(v11,t10)
>> Xlabel ('SPEED IN KM/H')
>> Ylabel ('time in seconds')
```

On Figure 3 is represented by a histogram that indicates the time needed for train to arrive from trigger point until railway road crossings. The last column above «120» shows that at a speed of 120 km/h takes 28 seconds (between 0 and 50 seconds). But at a speed of 10 km/h time that passes from crossing the train through the trigger points until railway road crossing close to 350 seconds.

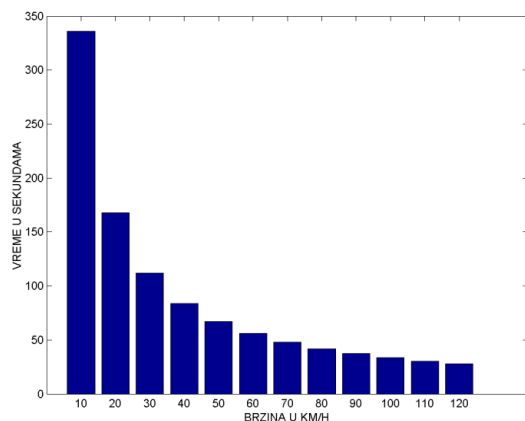


Figure 3: Histogram of time and speed

IV. CONCLUSION

This proposal was given a solution that can increase the level of security on railway road crossing with barriers. We are not engaged in economic evaluation of labor to change the location of trigger points of railway road crossing in relation to the imposed easy ride, nor were the aim of the labor. The aim of this labor was to demonstrate the application of a mathematical software package MatLab in a particular situation or in the process of determining new locations of trigger points.

The program was made to enable any user to, by entering a value easy drive, just get the necessary distance of trigger points. Determining the new positions and displacement of trigger points and replacing them to new positions, to prevent the participants in road traffic unnecessarily long wait in front of the closed barriers of railway road crossings. Thus eliminate the theoretical possibility of making disastrous decisions that drivers of road transport dare to go in the "slalom" between the closed barriers

It is represented the possibility of applying modern mathematical programming language, in practice, and in specific problems.

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