ANNALS OF THE ORADEA UNIVERSITY
Fascicle of Management and Technological Engineering
ISSUE #1, MAY 2014, http://www.imtuoradea.ro/auo.fmte/

MODELING AND OPTIMIZATION TRAFFIC PARAMETERS IN CENTRAL ZONE OF SIBIU USING INTELLIGENT TRAFFIC LIGHTS

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Abstract**—**The paper presents analysis of road traffic in the central area of the city of Sibiu, with intense traffic and consisting of three major intersections. The main objective of the work is optimization of traffic by proposing some solutions to improve concerning some changes in intersections geometry, implementation of new cycles and traffic light phases, as well as conception of an intelligent traffic light to help the traffic. The model carried out has to detect the presence or absence of vehicles and to react accordingly to solve congestion.

Keywords**—**computer simulation, intelligent traffic lights, traffic congestion, PLC controller

I. INTRODUCTION

Continuous growth of the number of vehicles in the past few years has led to a significant decrease in the traffic speed up efficiency, particularly in urban areas, so improving traffic in big cities has already become a major problem for today's society.

Usually the traffic bottlenecks are more frequently only at certain hours, known as peak hours, the period during which many road users use the same segment of road or these participants come from or are heading toward a common destination [1].

Bottlenecks are caused mainly by incapacity of the existing road infrastructure to support over capacity which have not had a development as significant as means of transport, fig.1., but they may appear, also because of the bad signal systems, gloomy weather conditions, road accidents, work in the area of roadway part. Avoiding blockage is beneficial both for the environment and for the economy, but it held up a growing demand of motor vehicles on the market for human consumption reaching to a greater number of cars in the traffic and default to a greater problem of decongestion of traffic [2]. A survey carried out by Institute of Transport from Texas has reported that the traffic jams in the largest 75 cities have been loss of 67.5 billion dollars of productivity in one year. Poor use of the of common transport means when people moves onsite from an area to another contributes to a large extent street clutter.

In some cities in which there is a high population density traffic jams are created and waiting queues in front are often very long.

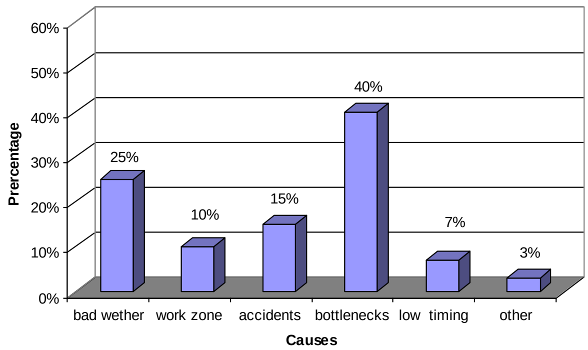


Fig. 1. The main causes of the traffic congestion

Under these conditions average driving speed decreases, the times of travel of certain distances substantially increase, fuel consumption increases leading to increased pollution of the natural environment [4], [5].

Negative effects of traffic jams:

a) Loss of time by drivers and passengers (cost of opportunity);
b) Unable to accurately establish the duration of a journey;
c) Delays which may result in: late arrival for employment,
d) Higher consumption of fuel;
e) impossibility of travel of first emergency vehicles in a convenient manner;
f) An increase in the levels of noise (noise pollution).

So, the traffic fluidization solutions are facing 2 main strands: improve town road space and improvement of indices for the use.

As a result bottlenecks in traffic not only increase distance travelled, but are also intended for detrimental effects on the economy and also for the drivers' health, which is now a very serious problem, not to be neglected.

II. TRAFFIC ANALYZE IN "PIATA UNIRII" AREA

A. Area description

The study area is located in the center of the city Sibiu, and is composed of 3 large intersections, streets of category II (the avenue Alba-Iulia, Corneliu Coposu Boulevard, the avenue Victoriei, the avenue Vasile Milea) and streets of category III (Dealului street, Banatului and Emil Cioran). Being very close to the historic center and many important institutions, the area is very well-traveled both of motor vehicles as well as pedestrians and often appear traffic jams.

The observation points of the concerned area are:

a) The intersection of the avenue Alba-Iulia, Str.Dealului, Banatului with Victoria Avenue (intersection 1);
b) Str. A. Saguna, the avenue Corneliu Coposu, the avenue Vasile Milea and street Emil Cioran (intersection 2);
c) The intersection of Corneliu Coposu Boulevard, the street Constitution and Hermann Oberth (intersection 3).

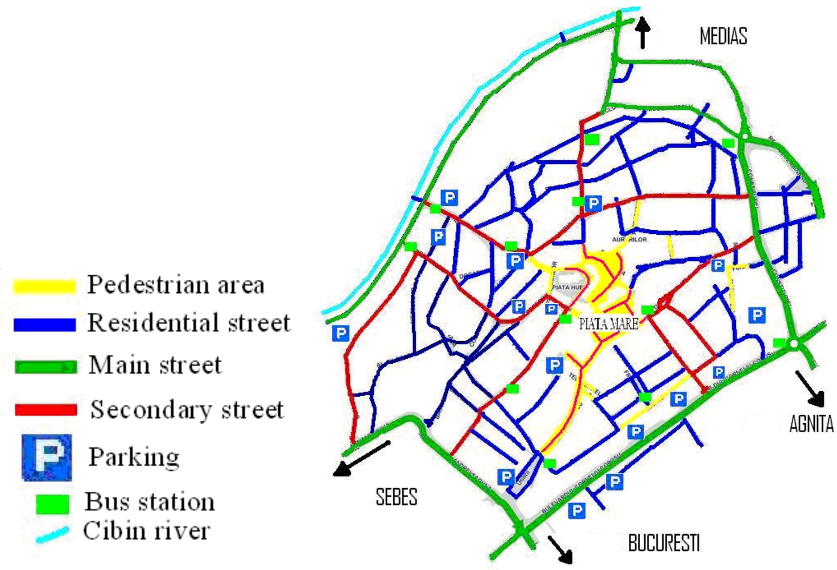


Fig. 2. Sibiu istorical center map

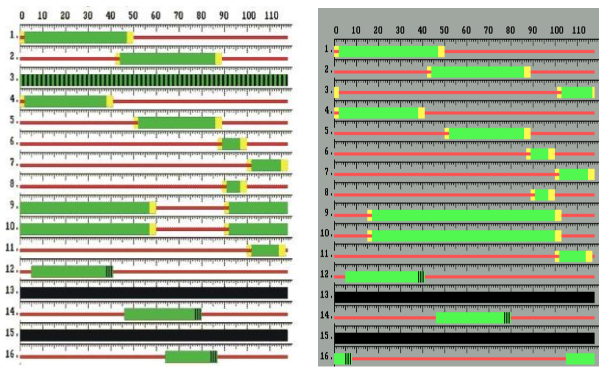
Although the geometry intersections presents a structure well organized, at first sight it is to be noted that at peak times their capacity of circulation is exceeded. In particular in the morning when most people go at the place of work and in the afternoon when they get back from work on some artery queues are created. In each of the three intersections flows of motor vehicles intersect the flows of pedestrians that influence negatively in that they are undisciplined and have a low speed.

So, access from the street Emil Cioran and Corneliu Coposu Boulevard at the crossroads is carried out with difficulty, very often creating queues in front of traffic lights. After several observations and analysis of situation, city authorities have decided changing the marks on the avenue Alba Iulia in such a way that the turning to the left to be able to carry out on two strips.

As a result of this amendment the island of refuge for pedestrians has been also moved on Cornelui Coposu Boulevard.

The findings made by the amendment of intersection geometry proved to be effective enough, large queues on a strip of left-hand turn on the avenue Alba Iulia disappearing. Also in some traffic light intersections the existing traffic light times, up in the month of December 2010 were no longer in an efficient manner owing to the changes of traffic flows and have been either re-calculated, or to be adopted a different geometry. So there have been analysis of traffic flows in the areas with the problem so as to be able to adopt a new system of traffic lights.

In Fig. 3 it can be seen cycle times with whom they have worked automatic signal lights up at the end of the year 2010 and the new cycle times that are implemented as a result of simple analyze [9].



Until the end of 2010 Beginning with year 2011

Fig. 3 Cycles and phases in intersection traffic lights

At this time a fault road traffic of Sibiu city does not disappear even if in the last year it has changed the geometry of big intersections in round point one.

B. Acquisition and primary input data processing

Collecting of traffic data has been carried out manually for 15 minutes on each arm of intersection. In the process of data collection there was followed: record the number of motor vehicles on each strip; recording time cycle, and each time (time of green, for red, for yellow, intermediate times); recording pedestrian traffic in the area; the length of the storage; performing street geometry and other facilities (islands routing and traffic separation, passages for pedestrians, pavements adapted) of intersection; presence or absence of means of public transport. Throughout the duration of the process of data collection is the aim of that errors of any kind shall be as little as possible, any error that has occurred in the collection has had a negative impact on final results. Knowing that traffic flows are composed of several categories of vehicles, they have been transformed in standard vehicles in accordance with the standard concerned. Primary data processing consists in consolidating, grouping, and the representation in the form of tables.

The tables below show volumes of traffic on every street in part to the entry at the crossroads.

a) Intersection 1 – Avenue Alba-Iulia, Dealului, Banatului and Victoriei Boulevard.

TABLE I
SUMMARY OF MEASUREMENTS OF TRAFFIC AT THE CROSSROADS 1

	Crossroad Avenue Alba-Iulia and Bd . Victoriei						
	Alba-Iulia Str.		Dealului – Banatului Str.		Bd. Victoriei		Total physical vehicles
7:30-9:15	(2)	(3)	(1)	(3)	(1)	(2)	
Cars	1023	87	1642	466	289	645	4152
Simple buses	24	0	14	6	0	12	56
Long buses	0	0	0	15	0	16	31
Minivans	18	9	47	11	32	18	135

b) Intersection 2 - Str. A. Saguna, Bd. Corneliu Coposu and street Emil Cioran.

Access at the crossroads is done on 3 lanes so: a strip for forward travel, a strip to the turning to the left, a band for both the turning to the right.

TABLE II
SUMMARY DATA FROM THE INTERSECTION 2

	Crossroad Str. A. Saguna, Bd. Corneliu Coposu and street Emil Cioran												
	A. Saguna (down)			Bv. Corneliu Coposu			V. Milea -A. Saguna (climb)			Emil Cioran			Total physical vehicles
7:30-9:15	←	↑	→	←	↑	→	↑	↑	→	←	↑	→	
Cars	563	886	121	585	443	140	1237	280	169	159	244	148	4975
Simple buses	16	18	0	13	18	0	7	8	6	0	0	0	86
Long buses	4	6	0	6	4	0	9	0	0	0	0	0	29
Minivans	10	42	2	10	16	6	49	5	0	0	8	3	151

c) For intersection 3 - Bd. Corneliu Coposu, Constitutiei and str Oberth Hermann. In this intersection mainstream, i.e. as a matter of priority, is to be considered access from Bd. Corneliu Coposu and vice versa and access at the crossroads on Constitution Str. and Balea Str. mark feeds are considered to be secondary.

TABLE III
DATA SUMMARY FOR INTERSECTION 3

	Intersection Bv. Corneliu Coposu, str. Constitutiei and str. Hermann Oberth									
	Constitutiei			Bd. C. Coposu			Hermann Oberth			Total physical vehicles
7:30-9:15	←	↑	→	←	↑	→	←	↑	→	
Cars	295	282	376	185	404	117	351	240	80	2330
Simple buses	0	15	12	2	6	0	6	7	4	52
Long buses	0	2	4	2	4	0	4	0	0	16
Minivanes	6	24	13	30	15	20	10	21	17	156

C. *Peak factor*

For peak factor calculation we take account of:

a) Locating the peak factor of traffic during a day;
b) Type of traffic artery;
c) Location of the point in urban network;
d) Traffic composition: homogenous or inhomogeneous traffic

It has thus calculated for each direction of each access of intersection, peak factor, the results being shown in the table below.

TABLE IV
CALCULATED VALUES OF PEAK FACTOR

Intersection	Access	Peak factor ←	↑	→
1	Str. Alba-Iulia 1	-	-	0,92
	Str. Banatului	0,89	-	-
	Bd. Victoriei	0,84	0,95	0,62
2	Str. A. Saguna	0,91	0,89	0,91
	Bd. Corneliu Coposu	0,89	0,82	0,87
	B-dul V Milea	0,78	092	0,87
	Str. Emil Cioran	0,89	0,82	0,75
3	Str. Constitutiei	0,83	0,86	0,78
	Bd. Corneliu Coposu	0,86	0,90	0,81
	Str. H. Oberth	0,85	0,86	0,81

D. MODELING AND SIMULATION OF ROAD TRAFFIC

For modeling and simulating of road traffic in the area under consideration was used software product Synchro Studio 8. The traffic data collected together with the intersections geometry have been implemented in the program and de results are shown in fig. 4.

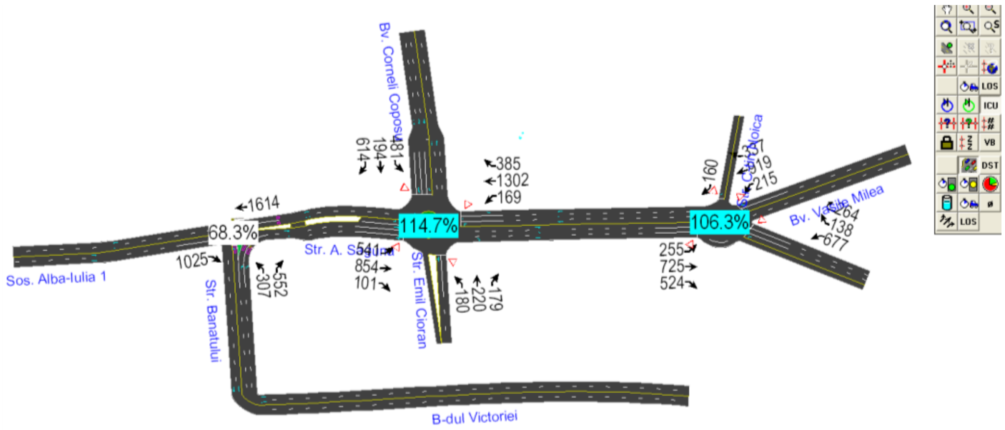


Fig. 4. Geometry of studied area

Simulation of road traffic in the three intersections were made into SimTraffic 8. The reports resulting from the simulation results show that the traffic junctions 2 and 3 takes place, there are major delays in intersections, delays of vehicles, the number of stops, average driving speed, fuel consumption and pollution of the environment on each segment in the area concerned.

In other words the ability to use the intersections has been exceeded and movement are not carried out in normal limits.

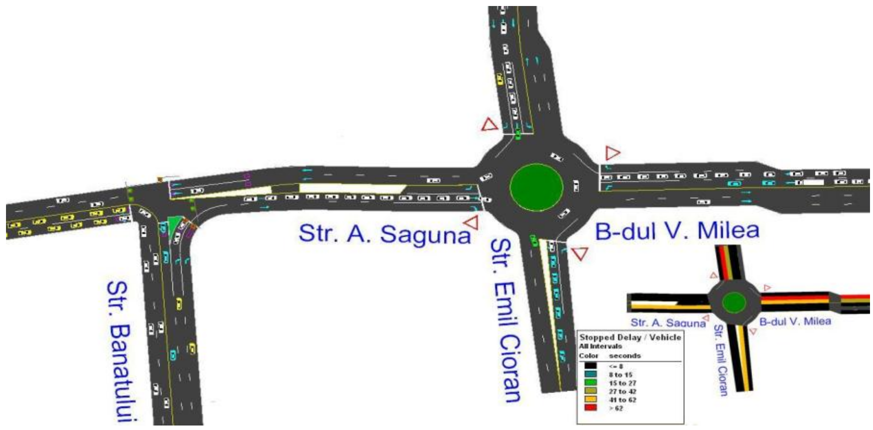


Fig. 5. Waiting queues and delays in intersection

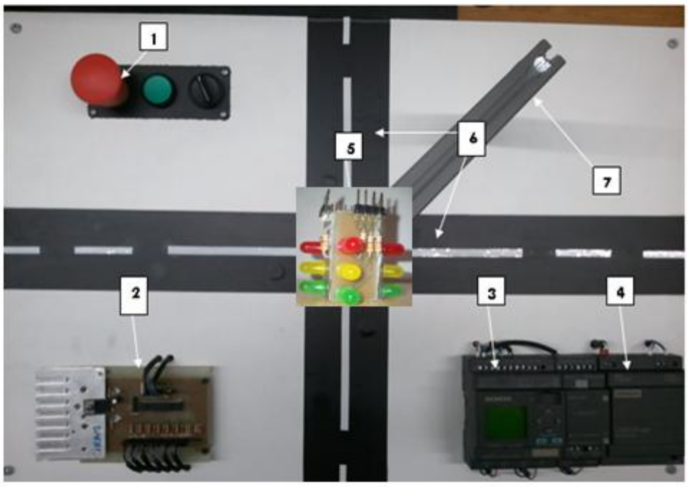
The proposed improved solution is to introduce an intelligent traffic light based on PLC and controlled by a microcontroller.

III. HARDWARE AND SOFTWARE FOR ACHIEVEMENT OF THE INTELLIGENT TRAFFIC LIGHT

By making intelligent traffic light is aimed at creating advantages by eliminating discomfort to stay for a long time in an intersection. For achieving and implementing intelligent traffic light we need leds, a PLC, microcontroller and inductive sensors [6].

System function description:

a) The LED's simulate the colors of traffic light: red, yellow and green;
b) Programming microcontroller provides LED aperture in a row;
c) PLC is used as back-up;



Legend:
1.Control panel; 2. Microcontroler board; 3. PLC (Programmable Logic Controller)
4.Power source LOGO SIEMENS; 5.Traffic light; 6.Road of intersection; 7.Traffic light pole

Fig. 6 Layout for intelligent traffic light model

An intelligent traffic light senses the presence or absence of vehicles and reacts according to the sensors output [3], [7]. In this system PLC takes a data from sensors and checks the priorities. After that PLC provides signal to traffic signals.

The intelligent traffic light works in four different modes are normal flow, peak time, off time. Peak time and off time modes are depended on the sensors outputs then change the status. Our intelligent traffic light totally depend on the sensors output and take decisions.

A. Programming of microcontroller PIC18F2321

Primary element is microcontroller PIC18F2321. Inputs from the sensors pass through a voltage divider because sensors give a voltage of 24 V and micro-controller supports a maximum 5 V.

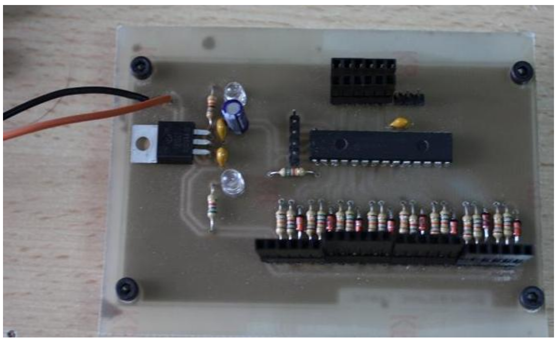


Fig.7 Microcontroller electronic block

The voltage regulator LM 7805 microcontroller is supplied with a voltage of 5V to 24V voltage date from the power supply. Zenner diodes used are intended to protect the micro-controller a voltage greater than 5 volts. The output voltage of a divisor is calculated with the following formula:

$$U_{out} = \frac{(R_8 \cdot 24V)}{(R_8 + R_9)} = 5V \quad (1)$$

The capacitor C_1 is acting for releasing the power micro-controller. Resistance R_1 acts as a pull-up to track the reset. Capacitors C_2, C_3 and C_4 play a role of filtering and smoothing of the voltage of power. LED1 and LED2 blinks for presence. The resistances R_{18} and R_{19} are designed to limit current through led.

The program of microcontroller, has been carried out in the C programming language mikroC PRO for PIC version 1.65 supplied by the firm Mikro Electronik [8]. Actual micro-controller programming has been carried out using the Pickit2. Through it, the file ".hex" (code machine) has been transferred into the memory micro-controller.

B .Programming of the PLC

Programming PLC has been carried out in LOGO! Comfort Soft version V7 of Siemens. Software product contains library for creating macro-commands that helps create a step-by-step sequences of control. After writing the program in the language FBD (Function Block Diagram), the program is transmitted via USB cable from the computer to the PLC so that it can be run.

C. Traffic light function

Once loaded the program on PLC and microcontroller they are running depending on the volume of traffic on each band, and the LED's will light up in the order in which the program was designed. When activating the button 3 on the control panel to power PLC - and microcontroller board.

When pressing the button 2 starts to run the program on microcontroller and transmits the signal to LED's, and implicitly to traffic lights. When pressing the button 1 stops microcontroller and semaphore is controlled by PLC.

Traffic light is set in the program that, at the outset to start on both directions on red after one of roads, that priority will change to green. It is set to run on green for

12 seconds then returns to red and the other one will operate on green as much time.

If all four lights indicate red, and on the road to indicate green and the sensor is actuated, then on that first time will increase by a further 6 seconds, it results that will have 18 seconds.

In a situation in which one of roads is not used but traffic light is to give priority to the other road and there was a motor vehicle waiting time of this motor vehicle is shortened from 12 to 6 seconds.

At the time when the light is red and the other road there isn't any motor vehicle then the waiting time is reduced to 6 seconds. The waiting time is equal in two situations:

a) when sensors are operate on both roads
b) when on both roads there is no traffic.

The program of PLC is then engaged in the Synchro Studio software to retrieve the traffic flow of intersection collected.

Such microcontroller is programmed in such a way as to ensure maximum capacity at the time when the intersection tends to become oversupply, and the volume of traffic will be distributed in such a way that all the queues formed to disappear within a period of time as short as possible.

IV. THE RESULTS OBTAINED BY IMPLEMENTING PROPOSED SOLUTION

An intelligent traffic light model has successfully been designed and developed. This interface is synchronized with the whole process of the traffic system.

This layout can easily be implemented in real life situations. Increasing the number of sensors to detect the presence of vehicles can further enhance the design of the traffic light.

After deploying the simulation there have resulted in some improvements through graphs comparative to delays, stops, travel speed, blockage, queues generated by the Synchro Studio software. So, there were reduced significantly the delay times of vehicles and increased travel speed.

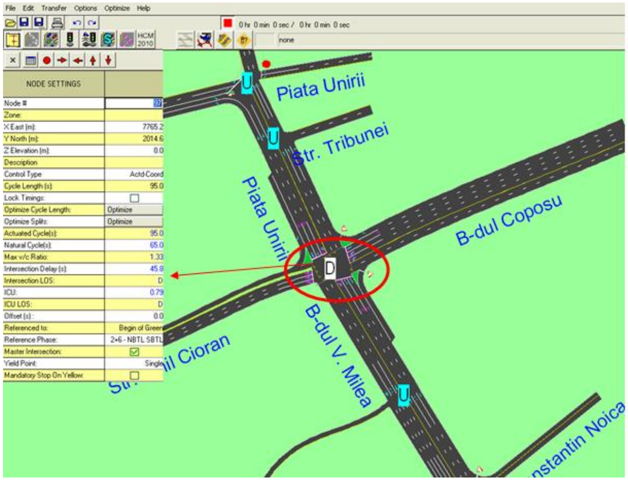


Fig. 8. Show levels of service

Quality service level has increased in all three intersections analyzed in particular at the crossroads 2 where from the level F of the service has been brought to the level D of service following the deployment of proposed solution.

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