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PROCEDURE FOR OPTIMIZING ROAD TRAFFIC AT AN INTERSECTION

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Rezumat. *Prin optimizarea capacităţii unei intersecţii, specialiştii de trafic pot reduce congestiile economisind timp, reduce numărul accidentelor grave sau pot reduce comportamentul agresiv de conducere, cum ar fi trecerea pe culoarea roşie a semaforului. În lucrare sunt prezentate patru intersecţii din oraşul Halle, Germania asupra cărora au fost realizate modelări astfel încât traficul rutier să fie optimizat. Modelele de simulare a traficului joacă un rol vital în modelarea traficului permiţând inginerului de trafic posibilitatea de a evalua situaţii complexe de trafic ce nu pot fi analizate direct prin alte mijloace directe. Modelele oferă oportunitatea de a evalua strategii de control şi planificare a traficului la anumite ore şi pe anumite artere fără a folosi resurse costisitoare şi consumatoare de timp necesare pentru implementarea strategiilor alternative din domeniu.*

Abstract. *By optimizing the capacity of an intersection, traffic specialists can reduce congestion by saving time, reduce the number of serious accidents, or reduce aggressive driving behavior, such as passing a red light. The paper presents four intersections in the city of Halle, Germany on which modeling has been done so as to optimize road traffic. Traffic simulation models play a vital role in traffic modeling by allowing the traffic engineer to evaluate complex traffic situations that cannot be analyzed directly by other direct means. The models provide the opportunity to evaluate traffic control and planning strategies at certain times and on certain arteries without using costly and time-consuming resources required to implement alternative strategies in the field.*

Keywords: Visum , traffic, crossroad, optimization

1. Introduction

Congestion on urban streets and arteries (Fig. 1) leads to long delays, losses in the economy, increased air pollution and increased potential for accidents. We all know that the growing demand for transportation around the world has led transportation systems to reach their existing capacity limits.

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The use of Intelligent Transport Systems (ITS) can bring significant benefits to urban mobility, such as: better information of mobility users, more efficient use of infrastructure, a reduction of waiting times (in the station after the bus, in the car at traffic lights) or otherwise "lost" in traffic (and consequently a reduction in pollution), a direction of mobility in the direction of the patterns desired by the strategic planning documents, etc. [1].

It is also known that as the transport system becomes more sophisticated and complex, specialists need to adopt new measures for more efficient management of existing systems that have to cope with the increasing number of vehicles in traffic [4].

Fig. 1. Intersection in Bucharest

Two-thirds of all kilometers driven each year are on traffic-controlled roads. In some urban areas, traffic lights at congested intersections can control the movement of more than 100,000 vehicles a day. Traffic engineers are faced with the problem of determining the capacity of these intersections to reduce delays.

The Federal Highway Administration of America (FHWA) recommends that traffic lights be rescheduled every two to three years. There are other special circumstances that can immediately lead to the reprogramming of traffic lights: when a new traffic light is added or one of the existing traffic lights is reprogrammed; when traffic, pedestrian volume or turning movements change significantly, when access to a road changes or when a change in road geometry occurs. Knowing this, agencies still do not reschedule traffic lights at fixed times either due to monetary budget constraints or due to the lack of proof of the need to reschedule traffic lights. However, traffic patterns continue to change and increase, and without changing signal times delays can become significant.

Traffic simulation models play a vital role in traffic modeling by allowing the traffic engineer to evaluate complex traffic situations that cannot be analyzed directly by other direct means [6], [7]. Models provide the opportunity to evaluate traffic control and planning strategies at certain times and on certain arteries without using costly resources.

and time consuming to implement alternative strategies in the field.

For this reason, simulation models allow rapid analysis of traffic situations and various alternatives to reduce the risk, the costs of traffic jams.

At the same time, simulation models improve the decision-making process of transport planners and specialists.

The simulation provides the following data:

- potential projects for traffic planning;

- evaluation of operations planning and prioritization alternatives;

- improves the planning and evaluation of time and cheaper cost, comparing with pilot studies, field experiments of total implementation;

- uses multiple combinations of deployment or other complex scenarios in a relatively short time; reduced traffic dislocation .;

- presents / exposes strategies to the public / shareholders through graphic animation;

- operates and manages the existing capacity of the roads

- recommends the best model or control schemes to maximize the performance of transport facilities.

–produces the best plans using VISSUM, CORSIM, SimTraffic, etc. simulation models.

In general, the processes used by software tools consist of:

- development of the network / corridor representation / model;

- introduction of general parameters (geometry, traffic measurements, etc.);

- determining the coordination strategy;

- optimization of the traffic light cycle;

- optimizing the division of cycles;

- offset optimization;[2]

Traditional traffic light systems consist of setting green times for each direction of travel depending on traffic measurements. These green times remain constant for a very long time. However, this solution has the major disadvantage that it does not take into account the daily traffic conditions, respectively certain traffic peaks during certain time periods. Consequently, an intelligent traffic light system must take into account the values of car traffic as well as constantly adapt its green times to these conditions. Moreover, in determining the green time for a direction, the traffic values from the upstream and downstream intersections must also be taken into account.

A first solution to combat traffic is a continuous measurement of traffic at intersections and a communication of traffic values between intersections to establish the optimal green time.

The measurement of traffic at an intersection must take into account not only the number of vehicles but also their type and length. Thus, Doppler-based sensors [1] are the most recommended, due to their ability to give both information about the number of vehicles and their type. The traffic values thus obtained are transmitted to a unit of calculation (UC) (Fig. 2) of the intersection which receives the traffic values from the intersection as well as from the downstream and / or upstream intersections, these latter values function as correction values for the green time resulting in following the traffic indicator at the intersection.

Following traffic measurements, an intersection can be statistically characterized by time probability density of the number of vehicles. Such statistical information is also used in the calculation of green time especially in its initialization phase.

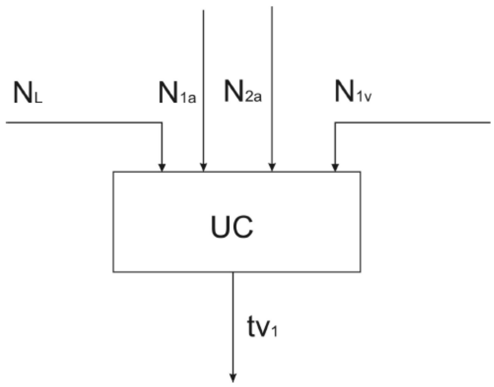

Fig. 2. Unit of Calculation model

Where:

N_{1a} - is the number of vehicles measured at the first downstream intersection;

N_{2a} - is the number of vehicles measured at the second downstream intersection;

N_{1v} - is the number of cars measured in the first upstream intersection;

t_{v1} - is the resulting green time.

The system works like a reverse loop thus being adaptable to traffic conditions. By imposing some constraints regarding the maximum and minimum green time, operating anomalies can be avoided, respectively permanent green or permanent red.

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This system can communicate traffic information between intersections so that an interdependence is created between them in terms of green time allocation. This leads to an optimization of traffic management and avoid traffic jams at intersections.

All data flowing between intersections is taken over by a master computing unit (Fig. 3). This unit centralizes all data for retention for further processing. Also, UC Master can intervene over the adaptive system and change the parameters in special cases, such as creating a green wave.

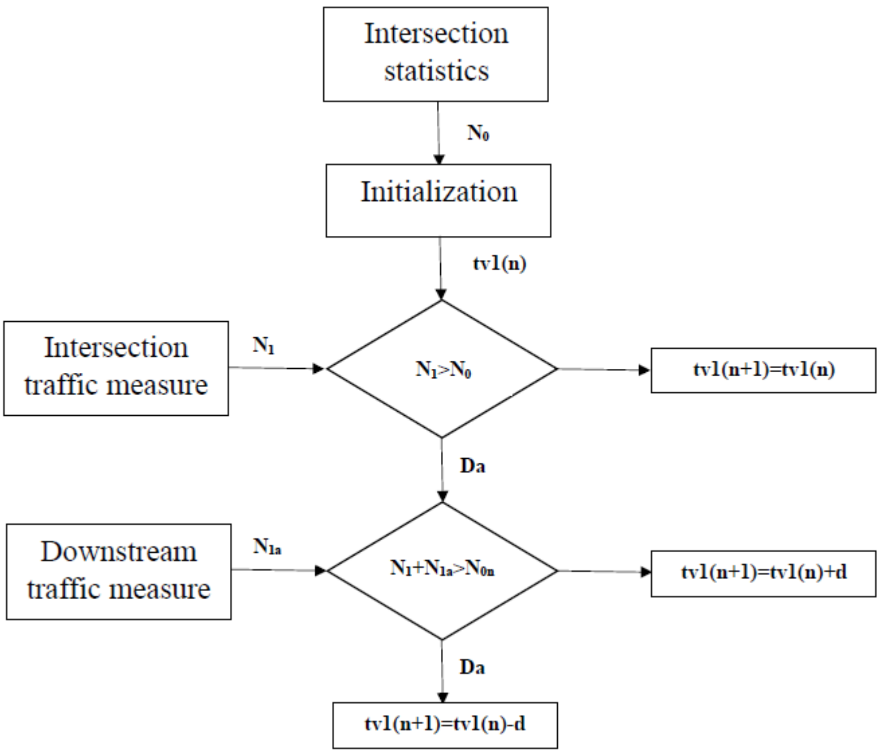

Fig. 3. Logic scheme of operation

2. Simulation of the model in VISUM.

Optimizing traffic light intersections has long been a problem for mitigating congestion in urban areas. The intersections were introduced in Visum (Fig. 4), according to the specific structure for each one. The following modules were used to model Visum PTV: Junction editor and control, intersection capacity analysis (ICA), Vissig, signal offset optimization. [2]

Signals play a key role in the quality of traffic flow in urban networks. This paper describes the automatic optimization of signals within PTV Visum.

In PTV Visum the following steps for optimization are performed: optimization of the green time, duration of the cycle optimization, optimization of the lag.

The paper presents four intersections in the city of Halle, Germany.

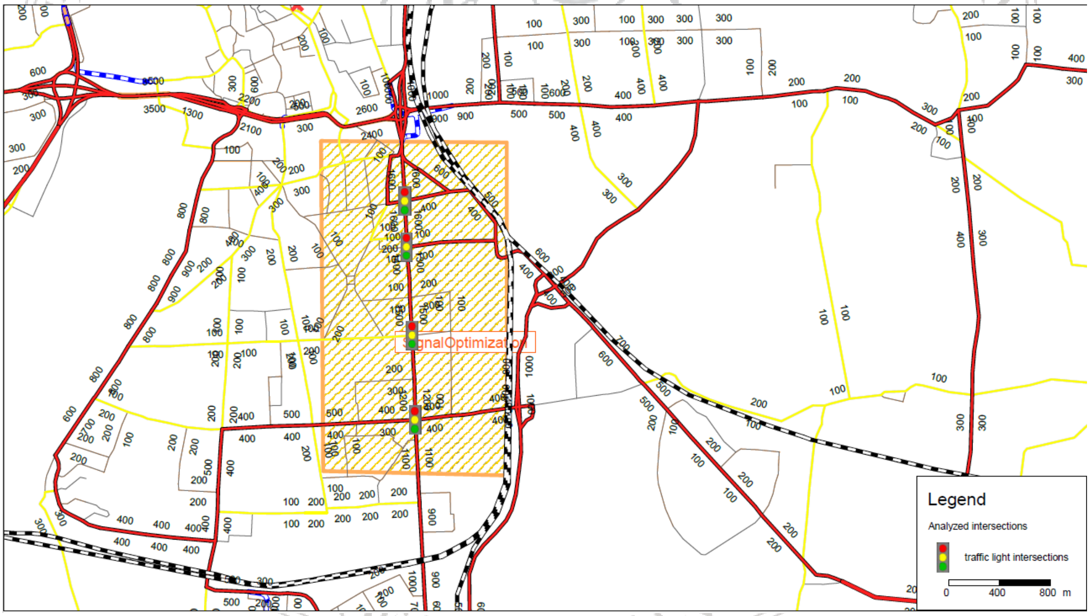

Fig. 4. Case-study: analyzed intersections - Halle – Germany

Service levels for signaled and unmarked intersections are given based on the average vehicle delay.

Service levels can be calculated for any intersection configuration, but service levels for those intersections are defined only for signaling and direct stop configurations.

Table 1. Service levels of intersections

Service levels	Traffic light intersection	Non-traffic light intersection
A	≤10 sec	≤10 sec
B	10–20 sec	10–15 sec
C	20–35 sec	15–25 sec
D	35–55 sec	25–35 sec
E	55–80 sec	35–50 sec
F	>80 sec	>50 sec

The intersection with service level E where the traffic flow is very high has a delay of 56 s which causes inconvenience to infrastructure users. The green times for this intersection are shown in Fig. 5. Greater attention must be paid to this because this level of service E entails a number of inconveniences both economically and environmentally [2], [5].

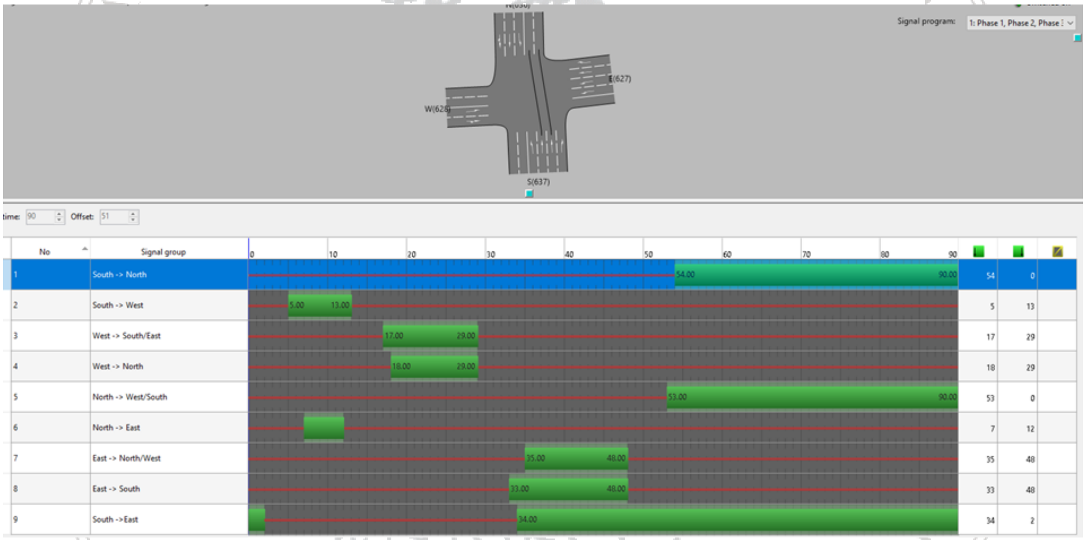

Fig. 5. Detailing the geometry of an intersection and the traffic light cycles

Vissig (Fig. 6) is an external program which enables you to manage complex signal control data. In the process, existing signal control data can be converted into new external controllers. The external signal control data is saved in a *.sig file. When opening a version file and when determining node impedance via ICA, the data is read from the Vissig file and temporarily con-verted into Visum data [2], [3].

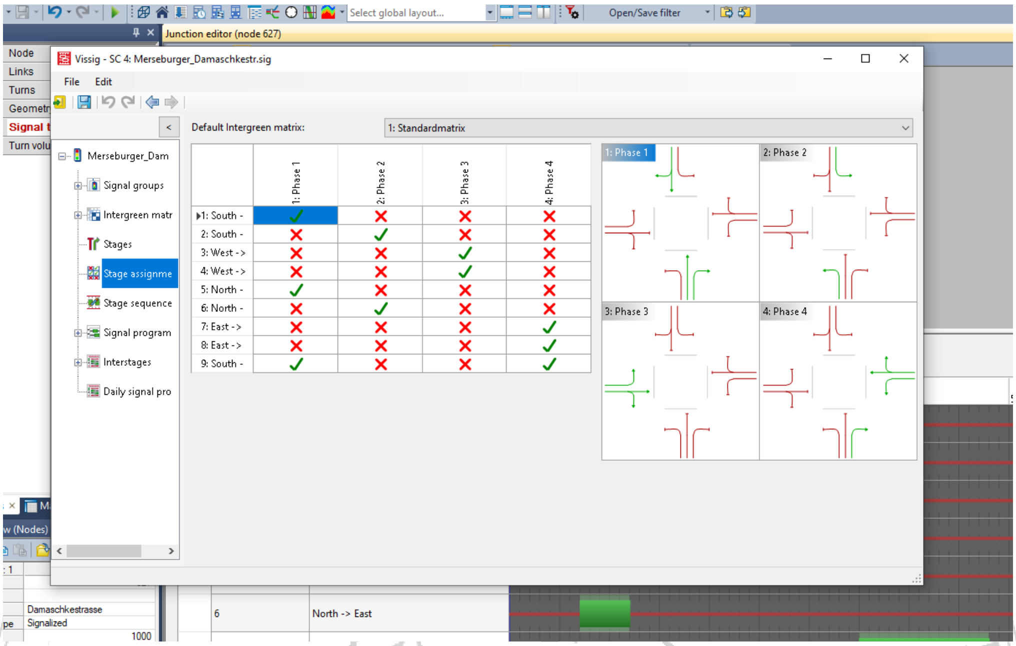

Fig. 6. Edit Vissig controller – Stage assignment

In Vissig, you can for example edit data as follows: Edit green times (Fig. 7) *graphicallyEdit* stages and display and edit the stage allocations of signal groups *graphicallyTime*-varying allocation of different signal programs to different time intervals at identical *nodesManage* complex signal controls located in the Visum n*etworkEdit* signal control data for a later Vissim export. [2]

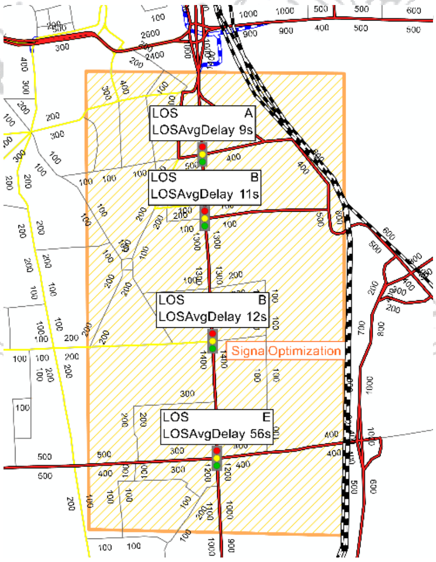

Fig. 7. Delays in intersections before modeling

Table 2. Initial data on the measurement of the intersection before modeling

Number	Intersection name	Type of signaling	Cycle time	LOS	LOSAvgD
1	Merseburg_Raffinerie	Extern	90	A	9s
2	Merseburg_Thueringer	Extern	90	B	11s
3	Merseburger_Huttenstr.sig	Extern	90	B	12s
4	Merseburger_Damaschkestr	Extern	90	E	56s

Compared to other procedures, using volume-delay (Fig. 7) functions by lane which are permanently re-calibrated by means of ICA causes a significantly improved convergence behavior, since the lane geometry and interdependencies between the individual turns via a node are regarded in detail. After assignment with ICA results the level of the intersection and the minimum delay in the intersection (Fig. 8). Signal cycle and split optimization always refer to individual signal controls. Signal offset optimization, however, is used to optimize the offset between the signal times of neighboring nodes in such a way, that vehicles can pass several consecutive signal controls on green. The general aim is to minimize the total wait time for all vehicles at the signal control [8], [9].

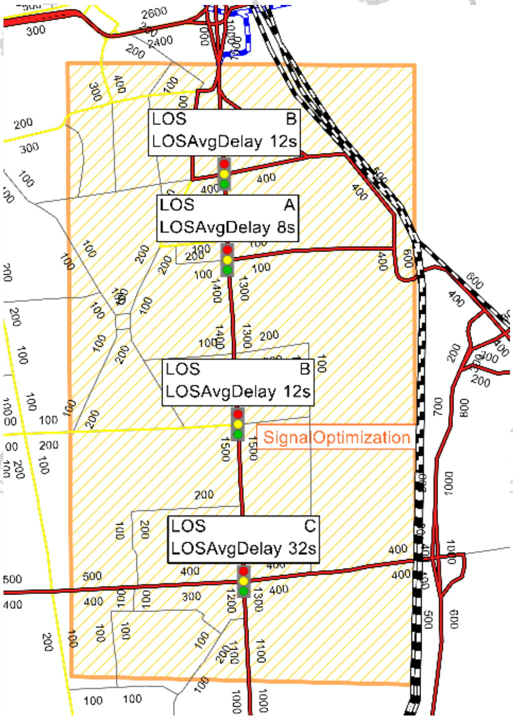

Fig. 8. Delays in intersections after modeling

Table 3. Modeling data

No.	Name of intersection	Type of signaling	Cycle time	Optimization method	LOS	LOSAvgD
1	Merseburg_ Raffinerie	External	90	Cycle duration and green time	B	12s
2	Merseburg_ Thueringer	External	90	Cycle duration and green time	A	8s
3	Merseburger_ Huttenstr.sig	External	90	Cycle duration and green time	B	12s
4	Merseburger_ Damaschkestr	External	90	Cycle duration and green time	C	32s

Table 4. Data before/after modeling in PTV VISUM

No.	Intersection name	Type of signaling	Cycle time	LOS		LOSAvgD	
				Before	After	Before	After
1	Merseburg_Raffinerie	Extern	90	A	B	9s	12s
2	Merseburg_Thueringer	Extern	90	B	A	11s	8s
3	Merseburger_Huttenstr.sig	Extern	90	B	B	12s	12s
4	Merseburger_Damaschkestr	Extern	90	E	C	56s	32s

3. Conclusions

This paper proposes an optimization model for traffic light intersections, which improves the performance of the traffic delay by 24s for the studied intersections, from level E to level C. The Visum software package that was used and calibrated to perform various simulation models for different traffic conditions and obtaining the waiting time for the purpose of evaluation. Conclusions were drawn based on the results of empirical simulations resulting from modeling in dedicated software.

The use of Visum software has many benefits and plays an important role in optimizing traffic, as presented above in the scientific paper reducing delays at intersections has led to a streamlining of traffic, which is also a reduction in pollution. These optimizations must be repeated at different intervals depending on the variation of traffic and the use of personal cars.

Abbreviations

ICA - Intersection capacity analysis

LOS - Level of service

UC – Unit of calculation

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