Simulation,
traffic lights control

Krzysztof AMBORSKI[1]
Andrzej DZIELIŃSKI[1]
Przemysław KOWALCZUK[1]

SIMULATION OF URBAN TRAFFIC LIGHTS CONTROL

Simulation of traffic control is nowadays very important for dealing with increasing urban traffic. It helps to construct the strategy of traffic lights switching and determine alternative path in the case of an accident or traffic jam. In the paper we present the application of simulation tool DYNASIM being prepared by French company DYNALOGIC. It has big number of alternative possibilities in modeling of crossings and conditions. In the paper will be described exemplary simulation of chosen crossings in Warsaw with choice of several different conditions. The simulation package can be free available for universities for educational use.

SYMULACJA STEROWANIA MIEJSKIM RUCHEM ULICZNYM

Symulacja sterowania ruchem drogowym jest obecnie bardzo ważnym elementem w związku z rosnącym ruchem w miastach. Pomaga ona budować strategię działania w ustaleniu przełączeń świateł drogowych i wyznaczaniu alternatywnych dróg transportu w przypadku kolizji lub zatorów. W referacie przedstawiamy zastosowanie narzędzia symulacyjnego DYNASIM przygotowanego przez francuską firmę DYNALOGIC. Oprogramowanie to ma wiele alternatywnych możliwości modelowania skrzyżowań i warunków ruchu. W referacie opisana jest przykładowa symulacja wybranych skrzyżowań w Warszawie z wyborem kilku zestawów warunków. Pakiet symulacyjny może być nieodpłatnie udostępniony uniwersytetom dla celów edukacyjnych.

1. INTRODUCTION

Control of street traffic in urban conditions is nowadays crucial problem in majority of developed countries. Avalanche increase of vehicles number – before all personal cars and pick-up's – creates in many cities the situation which is difficult to manage. It is important not only to assure fluent movement of cars in chosen directions in specific time periods, but also determination of alternative ways in the situations in which original main communication ways are blocked - by road accident or cars being out of order. Basis for planning of control algorithms is gathering information about the traffic and traffic history on given crossing or/and series of crossings conjugated with a given one. But it is not

[1]Warsaw University of Technology, Faculty of Electrotechnics, POLAND;
Warszawa 00-662, Koszykowa 75. Phone +48 22 234-7615, Fax +48 22 625-6633

enough. There is also a need to observe the situation and adapt realized strategy to the changing road situation. For this purpose a number of various devices is used – such as induction loops, infrared sensors, radar sensors, photo and video cameras and others. Signals from these sensors are sent mosty through radio transmitters (for short distance) and further by fiber optics (for longer distance).

2. SIMULATOR DYNASIGNAL

2.1. Initial assumptions

Input data for simulation are divided on several categories:
Geografical data:

- Movement trajectory – determines the way on which vehicles are moving
- crossings – they have traffic lights, can also have some sensors
- input and output vectors – together with trajectory they determine flow of vehicles

Vehicles data:

- determine dimensions (length), maximal velocity and acceleration.
- Movement of vehicles is modeled by the equation:

$$A2(t+0.25) = a[v1(t) – V2(t)] + b(X1(t) – X2(t) – t\, v2(t) - L] \quad (1)$$

where:

- Ai(t + 0.25) — Acceleration of vehicle i at the moment "t+0.25"
- Vi(t) — Speed of vehicle i at the moment t
- Xi(t) — Position of vehicle i at the moment t
- a, b, t — Parameters that describe three types of acceleration for vehicle 1
- L — Length of vehicle

For every area of simulation we can measure following values:

- Flow of vehicles
- Transition time between crossings (mean and maximal values)
- Number of vehicles, moving between crossings
- Speed of vehicles (mean and maximal values)

Output data are delivered in Excel files. Structure of these files is not quite clear and should be carefuly analysed before interpretation.
Simulator DYNASIM can also deliver analysis of various detail degree (scenarios). One can consider only vehicles flow without data from the sensors. One can also take into account privileged public transport, etc.

2.2. Example of application

As an example of application let us consider one of typical crossings in Warsaw – the crossing which is next to Warsaw University of Technology, Nowowiejska and Al. Niepodległości (Fig.1). The main street - Al. Niepodległości - has 6 lanes, three on each side. Nowowiejska, the smaller one, has 2 lanes in each direction. It is pretty complicated, although not penultimate. Complication results from the fact that besides cars there are also public transport buses and streetcars. Moreover the streetcars (or tramways) can turn right and left, so separate traffic lights for them can be installed and used. There are also some constraints in turning on this crossing – namely turning left from Al. Niepodległości into Nowowiejska is forbidden for cars, but not for tramways (Fig. 2).

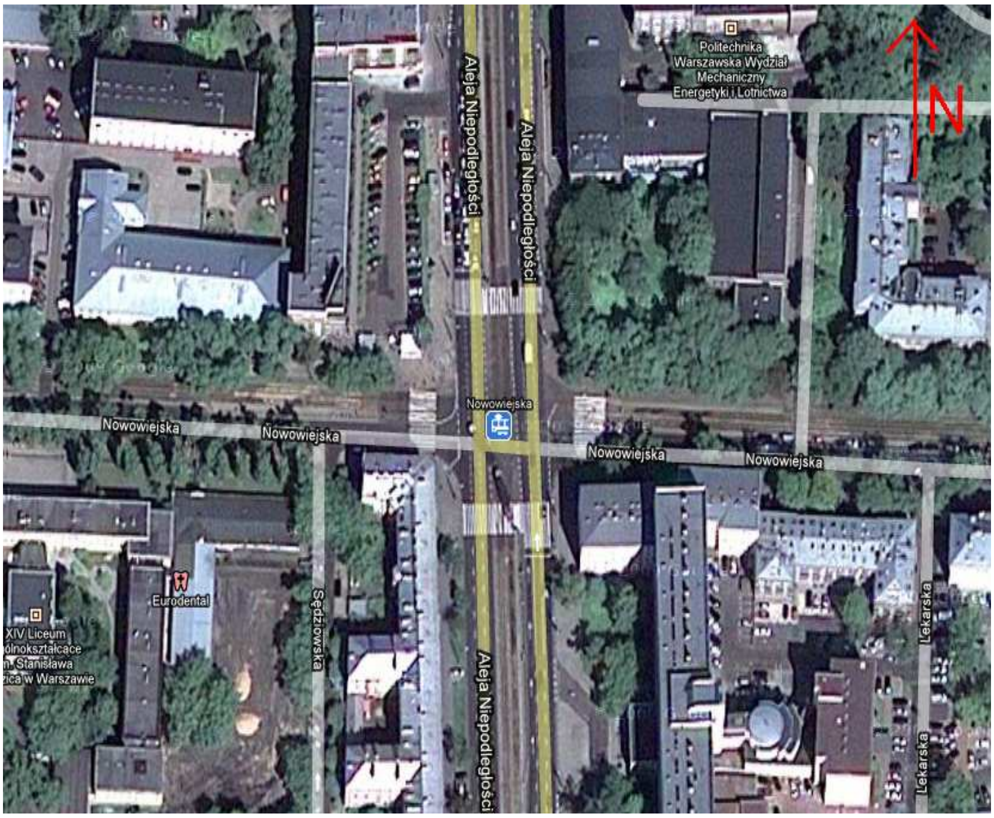

Fig.1. Air view of the crossing of Al. Niepodległości and Nowowiejska : turning left from Al. Niepodległości into Nowowiejska is forbidden for cars, but not for tramways.

In the simulation program the traffic lights are synchronized for all lanes in given direction (Fig.3). Traffic lights S1 and S2 are controlled by controller C1, traffic lights S3 and S4 are controlled by controller C2. Controllers C1 and C2 work with different scenarios (Fig.4).

Fig.2. Constraints in turning on the crossing of Al. Niepodległości and Nowowiejska.

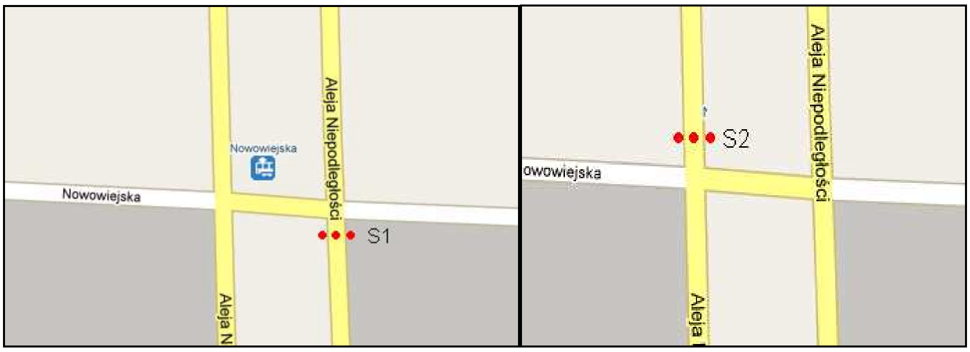

Fig.3a. Simulation of traffic lights on the crossing of Al. Niepodległości and Nowowiejska.

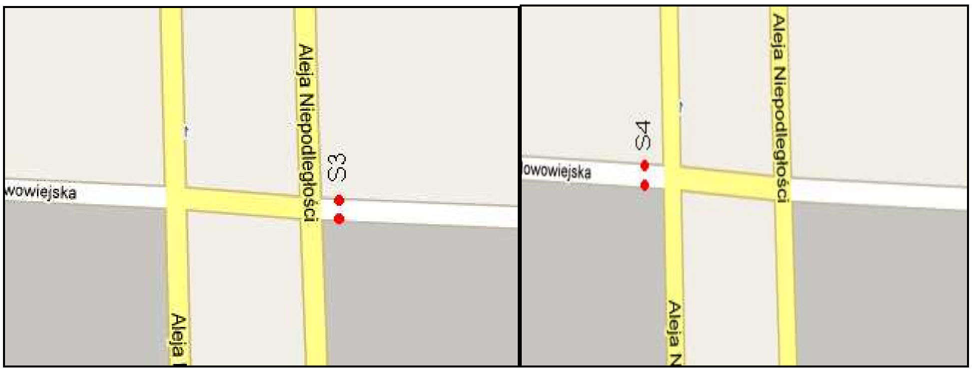

Fig.3b. Simulation of traffic lights on the crossing of Al. Niepodległości and Nowowiejska.

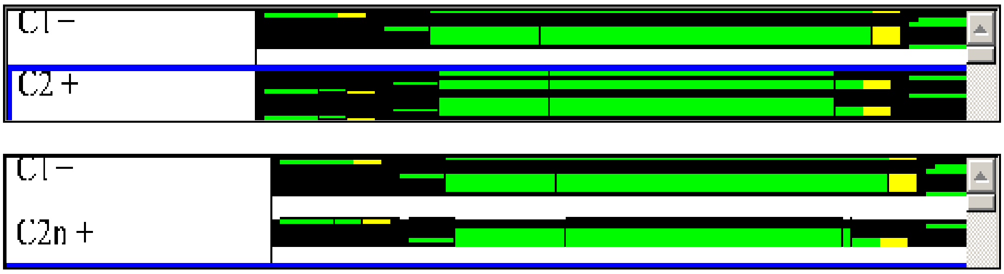

Fig.4. Scenarios for controllers in simulation of traffic lights on the crossing of Al. Niepodległości and Nowowiejska.

Simulation package Dynasim enables defining of:

- Traffic lanes for every direction,
- Sources of vehicles and the target of their way
- Trajectories
- Traffic lights with controllers.

Simulation conditions assumed traffic on the level of 20000 vehicles per day (data from General Traffic Measurement Office, forecast on the year 2010) taking into consideration peaks at hours 8:00 i 16:00.
Measurement period, to which sequential data are taken, is 1h.

2.3. Results of simulation.

Simulation has been performed 100 times for traffic in every possible direction. After averaging of results we got visualisation of the traffic in North-South direction (*Al. Niepodległości)* presented on Fig.5 and of the traffic in East-West direction (*Nowowiejska)* presented on Fig.6. In the simulation package DYNASIM we can also check what will be changed after introducing some changes in traffic organisation, e.g. by introducing bus lane on every side of main street – Al. Niepodległości. After changing simulation conditions we get simulation results as presented on Fig.7.

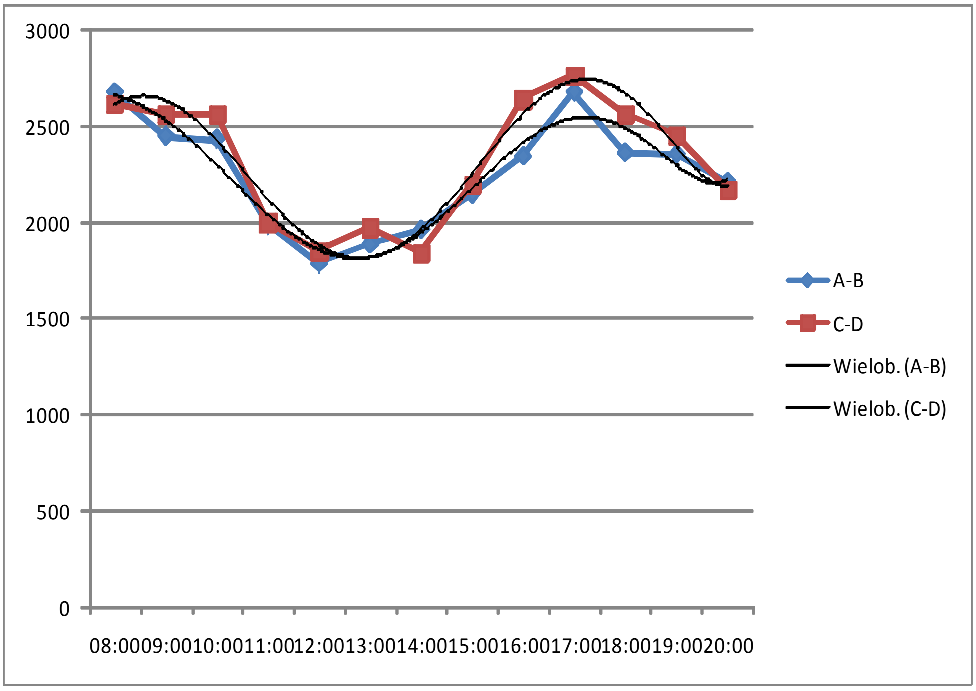

Fig.5. Results of simulation of traffic in North-South direction (Al. Niepodległości)

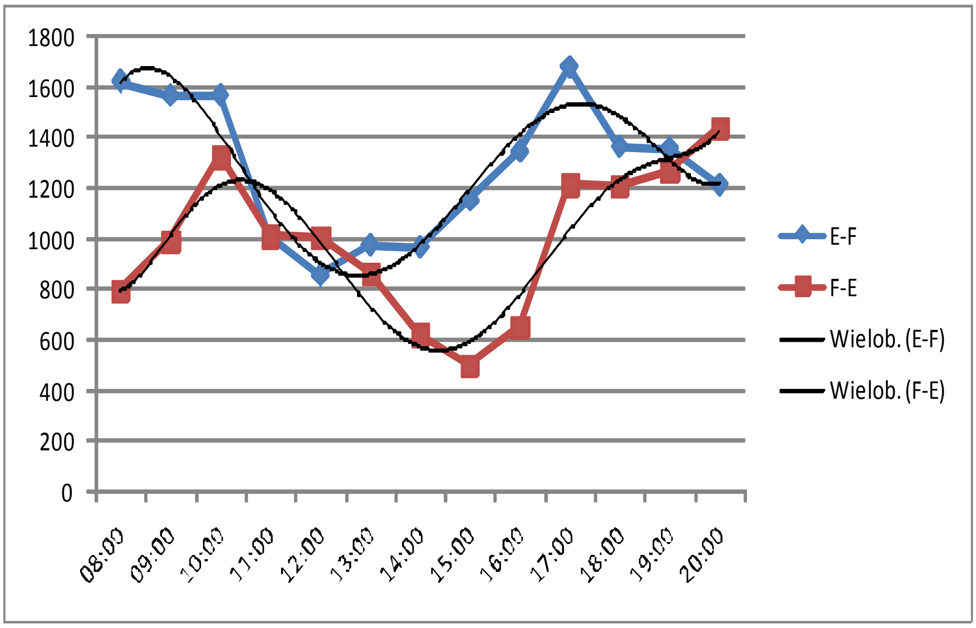

Fig.6. Results of simulation of traffic in East-West direction (Nowowiejska)

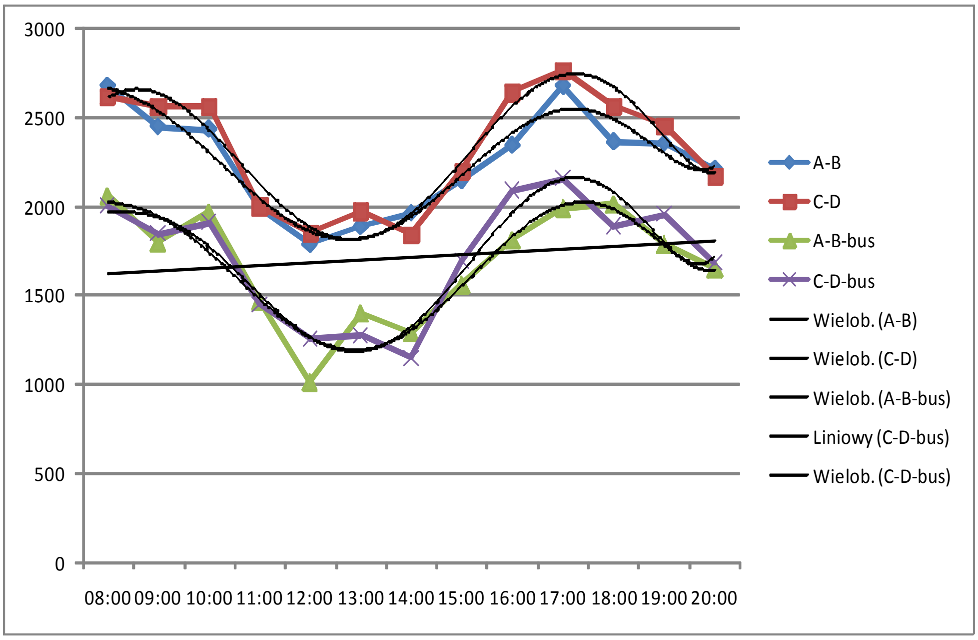

Fig.7. Results of simulation after introduction of bus-lane on Al Niepodległości.

3. CONCLUSIONS

Simulation presented in the paper is based on professional simulation program used for commercial purposes. It is easy to operate and efficient in everyday work. The program can be acquired free of charge for educational purposes.

4. REFERENCES

[1] Gaca S., Suchorzewski W., Tracz M.: *Inżynieria ruchu drogowego*, Warszawa, WKiŁ 2008.