conduits

Evaluating the impact of ITS in urban areas

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From ITS impact assessment to decision support

One year after the formal conclusion of the EC-funded CONDUITS project, which culminated in the successful real-life validation of the new traffic management and ITS evaluation framework, work on further advancing the developed KPIs continues. With the support of Kapsch TrafficCom, the framework has been taken to the next level, which sees its use as a predictive decision support tool. The implementation of the pollution reduction KPI in purpose-developed software (CONDUITS-DST), coupled with the AIRE emissions model and the VISSIM microsimulation package, has been the first step, and its pilot application ("alpha testing") to a case study in Brussels has delivered promising results.

With the expressed intention of Kapsch to continue supporting the development of CONDUITS-DST for another two years, several tasks have been defined. As a first step, the tool will be expanded to accommodate more KPIs, starting with the traffic efficiency theme. In particular the mobility and reliability KPIs will be implemented, which, in a similar way to the pollution index, will build upon the outputs of traffic simulation to predict the performance and impacts of specific schemes. The implementation will be followed by a pilot case study in the city of Brussels for validation purposes.

A further step will involve an investigation of the feasibility of the inclusion of a road safety prediction module in CONDUITS-DST, based on the respective developed KPIs (accident numbers, direct safety impacts, indirect safety impacts). In contrast to pollution reduction and traffic efficiency, whose prediction is relatively straightforward on the basis of simulation, the development of a predictive framework for safety is a much more complex problem and requires consideration of a wide range of factors. It is widely acknowledged that the causes of accidents, and safety hazards in general, are only partly captured by the principles underlying traffic simulation, with a large part being attributed to individual driving behaviour. It is, therefore, likely that the development of the safety KPI module of CONDUITS-DST will require the consideration of models from the field of traffic psychology. As with the other modules, a pilot case study will be conducted for validation purposes in a city to be determined.

Aside from the development and "alpha-testing" of new modules, the next steps of the project will also concentrate on the further validation of CONDUITS-DST through additional case studies in different cities ("beta-testing"), featuring the combined use of all developed modules. This will enable more complete predictive assessment for urban traffic management and ITS schemes, as it will allow for the identification and quantification of potential "side-effects", which are of great importance to city authorities. It is planned to undertake 3 case studies, with a number of cities already having already expressed interest, including Zurich and Stuttgart. CONDUITS DST is free of charge.

A word from Kapsch

Surveys show that four out of five European city dwellers see urban traffic congestion, accidents and pollution as serious problems that need to be addressed urgently. Technologies addressing safety, environmental and congestion issues are not deployed on a wide enough scale at present. This may be due to a lack of understanding by both policy makers and the general public about the benefits or socio-economic advantages and the positive business models associated with ITS. Making ITS common currency requires a universal understanding and acceptance of its benefits. ITS is mainly about offering benefits to the user, e.g. guaranteeing a certain level of service, enabling good air quality, assuring trip planning reliability and predictable arrival times or enhancing safety to the traveler.

ITS measures are an important tool for politicians and not a toy for technicians. Prior to the deployment of ITS, city decision makers are mostly interested in knowing what are the expected benefits and impacts from the considered measures. After deployment of ITS, it is important to quantify the effectiveness with respect to the initial objective(s).

The CONDUITS DST provides a step in this direction. The tool allows city decision makers to evaluate the contribution of ITS and to benchmark ITS measures. It would be most useful and valuable to apply the developed model, in addition to Brussels, to other reference cities to verify its applicability. Therefore it is in the interest of Kapsch to support the municipalities in achieving their goals by continuing the CONDUITS project.

Josef Czako,
Vice President International Business Development
Kapsch TrafficCom

Applying the CONDUITS Decision Support Tool - a case study on bus priority in Brussels

The KPI framework for traffic management and ITS developed in CONDUITS was validated based on surveyed data from real life operations provided by public authorities. This proved the applicability of the KPIs for assessing improvements through ITS and the availability of the necessary input data within the public authorities. A similar validation process was undertaken for the CONDUITS Decision Support Tool. (DST). The basic requirements that had to be met were:

- Applicability for realistic case studies using simulation
- Usability by a public authority
- Generation of plausible results verified by the case study

The tests were planned at two levels. The first level involved a process of close dialogue between an "alpha tester" city and the scientific team of CONDUITS. At the second level, one or two further cities would apply the tool as "beta testers" supported by the team.

The case study for the "alpha testing" of the tool was provided by the Brussels Capital Region where a large scale public transport priority programme is being implemented. The major goal of this measure is the reduction of travel times by increasing the operational speed and by reducing delays around signalised junctions through priority signals for public transport vehicles. The anticipated improvements of this measure were verified in the planning phase of the system by means of micro-simulation. However it is likely that this measure will have, in the short term, the undesired side -effect of increased pollution levels from private traffic. This side-effect was to be evaluated by using the CONDUITS DST.

The concrete case study focused on the southern part of bus line 49, which connects the Metro station of Bockstael with the railway station Gare du Midi and serves the south-western part of the city centre. The line segment is ca. 8 km long and passes through 11 signalised junctions. (Figure 1).

The scientific team of CONDUITS was provided with four simulation scenarios concerning the morning and the evening peak hours "before" and "after" the implementation of the system. The simulations had already been used to verify the system's output in terms of number of stops and delay times for public transport vehicles and had thus already been validated by an external consultant for Brussels Capital Region. A consideration of changes in demand or route choice was not included in this case study so that the "after-state" actually reflected the situation immediately following the activation of the priority signalling.

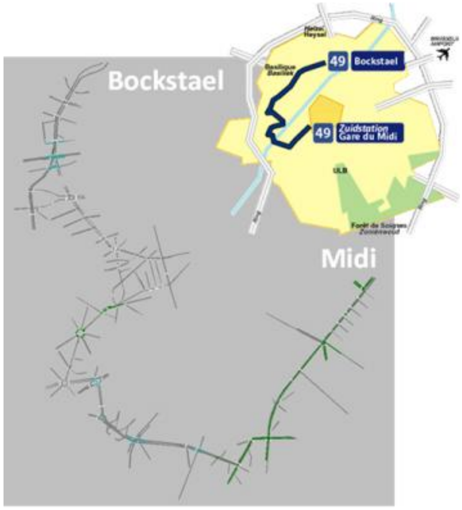


Figure 1: Line 49 and simulation network for the Brussels case study

In this particular case, the simulations had to be run again to extract the input data for the DST, since their original application was in 2011. However for future applications, even if they are done in cooperation with external consultancies, the data extraction for the DST can be integrated in the overall case study elaboration. The application of the tool itself can be conducted within any public authority since it does not require additional commercial software and takes very little time. On an average computer, the calculation of one scenario takes no longer than a few minutes.

The data needed from the simulation consist of detailed protocols delivering speed, acceleration, and breaking activity for a distinct group of vehicles at each predefined time step. For the purposes of this calculation the simulation step was 0.5 sec. This data can be easily obtained via the micro-simulation output files for the entire network. For measures already implemented, however, a sample of realistic floating car data provided by a test fleet can deliver a similar calculation basis. The simulation data are subsequently processed by the Decision Support Tool to an external emission module that calculates the momentary emissions of each vehicle at each time step and adds to the data set three additional items: NOx, CO2 and particulate emissions (Figure 2) and thus delivers the necessary input for the KPI calculation. For this study the emission module AIRE was applied. AIRE is a free of charge programme that is easily accessible to public authorities.

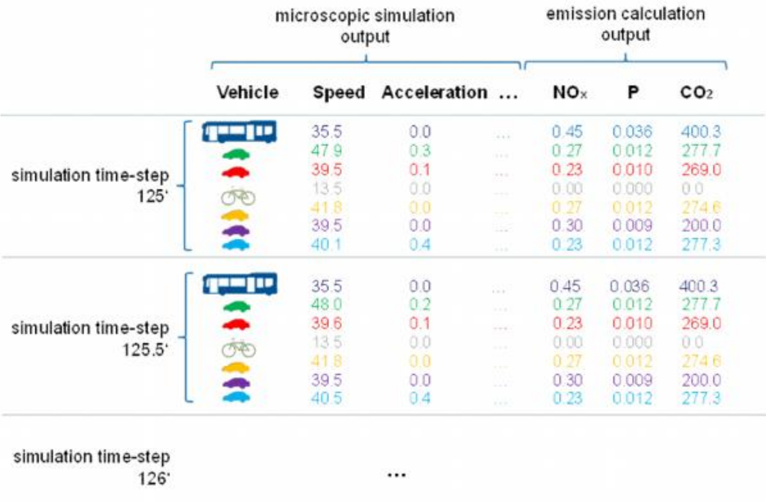


Figure 2: Structure of the required input traffic data for the KPI calculation

Figure 3 shows the results of the KPI calculation for pollution in the four scenarios. It is obvious that the values for the two after-scenarios are higher than in the before-scenarios. The increase is approximately 7% and 6% in the morning and evening peak periods, respectively.

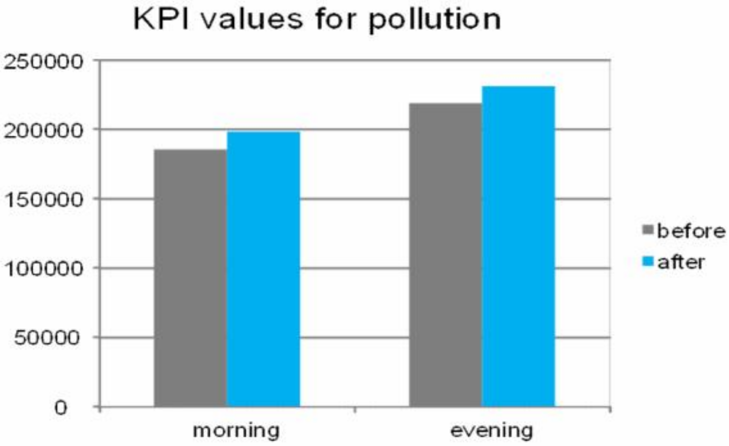


Figure 3: Results of the pollution KPI calculation

The overall trend in the results seemed plausible; however they were compared with a detailed, multiple-indicator evaluation. The effect on public transport delivered by the simulation was a 20-60% decrease in the number of stops and a 3-6% increase of the average speed - both plausible for such an implementation (Figure 4).

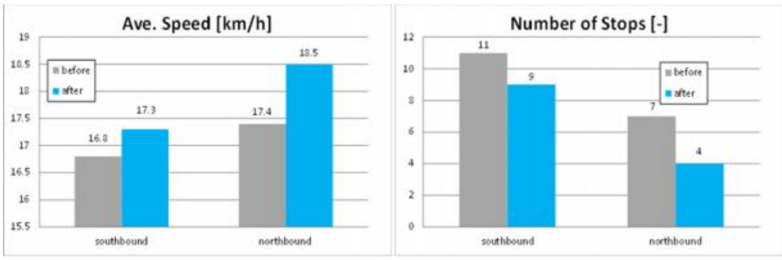


Figure 4: Impact of public transport priority on the quality of public transport

Unsurprisingly, the effects on private transport were the opposite, reaching up to a 5% increase in the number of stops for cars. Among the eleven junctions, two delay "hot spots" were identified, while the other junctions showed minimal difference. This more detailed observation confirmed that the results of the Decision Support Tool, however aggregated they might be, describe the effects on pollution in a realistic way.

The usefulness of such a result in the decision making process requires in a first instance a weighting of goals between the aims of public transport and car transport but also a deeper consideration of the system's effects on pollution. It is expected that after an amortisation period, the short term effects could be counterbalanced by a change in the route preferences of car drivers and eventually a demand shift towards public transport. Hence the question of how CONDUITS DST can support those further steps arose .

In the Brussels case study, a sensitivity analysis of the interrelations between demand and pollution will be undertaken over the coming months. By altering demand levels and re-calculating the KPI with the DST, a break-even point - at which the initial increase is counterbalanced - will be estimated. The feasibility of such a change in demand can then be discussed and included in the decision making process.

The CONDUITS Decision Support Tool

The CONDUITS-Decision Support Tool (CONDUITS-DST) is a tool created to calculate the expected impact of a new traffic management measure on pollution reduction (drawing on the pollution Key Performance Indicator (KPI) defined in the FP7 CONDUITS project). The DST essentially couples emission estimations derived from VISSIM micro-simulation vehicles' data with aggregated vehicle type emissions and runs these through the pollution KPI. The tool includes the following components:

- Emission estimation – this component evaluates the emissions of the vehicles registered in the VISSIM vehicle records using the AIRE tool provided by SIAS. Using this component is optional. If emissions are calculated by other tools/modules (e.g. emission module of VISSIM) and stored in the vehicle data file, it may also be used by CONDUITS-DST for the pollution KPI calculation
- Aggregation of the emissions by vehicle types along all defined mutations
- KPI calculation which encompass different mutations, vehicle types and emissions

The results generated by the tool enable easy comparison between different simulation runs and scenarios

CONDUITS DST Architecture

The CONDUITS-DST architecture is described in Figure 1. The right rectangle in the chart represents the optional calculation of emissions. The grey marked elements represent 3rd party applications which need to be owned by the user. CONDUITS-DST assumes the fundamental data was generated by the VISSIM micro-simulation tool.

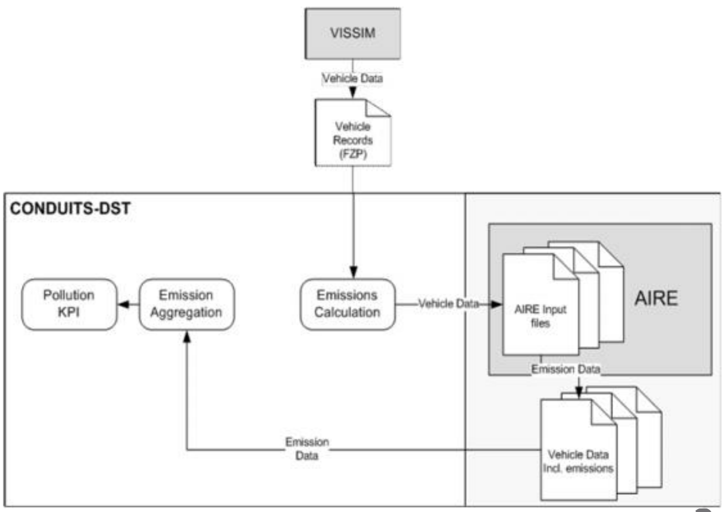


Figure 1 – CONDUITS-DST Architecture

Emission Estimation

Detailed emission estimation models often require data such as location, vehicle characteristics, velocity, acceleration, interaction status, etc. at any given time. This type of data, which can be obtained from micro-simulation software such as VISSIM, enables the calculation of the emissions either by the VISSIM built-in emission model or by using third party tools such as AIRE1.

AIRE (Analysis of Instantaneous Road Emissions) is an ancillary software programme specifically designed to process the outputs from traffic micro-simulation models and calculate vehicle emissions. AIRE incorporates over 3000 Instantaneous Emissions Modelling (IEM) tables which were derived from PHEM (Passenger car and Heavy Duty Emissions Model), developed by the Technical University of Graz, and enables emissions estimations for various engine speeds and engine loads.

AIRE has been specifically designed to be used directly with outputs from S-Paramics. CONDUITS-DST modifies the vehicle records generated by VISSIM to meet the requirements set by AIRE thus enabling the emissions to be calculated regardless of whether the main source was S-Paramics or VISSIM.

The VISSIM micro-simulation tool optionally generates diverse output files. The most detailed one is the vehicle record output (FZP file) which captures the status of each vehicle in the network at any given time and thus includes most of the data which is required to calculate the emission estimation using AIRE. The minimum data needed concerns the timely vehicle location, interaction, velocity and accelerations, as well as the static characteristics of the vehicle, i.e. its type in a minimal time resolution.

Execution of a simulation process is time consuming, thus in many cases the production of the FZP file is made for more than a single cause. For that reason, CONDUIT DST allows a flexible field's structure in the FZP file as long as the mandatory fields exist.

Aggregation of Emissions and KPI calculation

The pollution KPI itself is based on requirements specified in earlier stages of the CONDUITS project and is thus defined as the weighted sum of all distance-averaged emissions per vehicle and per vehicle type existing in the network. Therefore, the first part of the KPI calculation deals with averaging the emissions to each of the types. It was mentioned earlier that the FZP file is often produced for more than a single cause. Due to this, the FZP file is most likely to include several time frames, i.e. morning peak, evening peak, etc. A grouping is required for each to analyse the pollution KPI trend along time. In addition, to obtain statistically significant results, each scenario is executed in VISSIM with several mutations (seeds). The KPI procedure enables the aggregation of results of several mutation runs. The aggregation procedure which is the preliminary stage for the pollution KPI calculation enables the time frames and the seeds used to be defined.

The results of the aggregation are stored in an XML file which serves as the database of the results and can be used by third party applications.

Pollution calculation

The pollution KPI calculation is the final step of the process. As mentioned before, the CONDUITS DST enables the pollution KPI to be calculated on several seeds and time frames at once, thus enabling the emission progression over time and scenarios to be realised.

$$\text{KPI}_{\text{Pollution}} = \frac{\sum_{VT}\sum_{ET} W_{ET} W_{VT} Q_{VT,ET}}{\sum_{VT}\sum_{ET} W_{VT} W_{ET}}$$

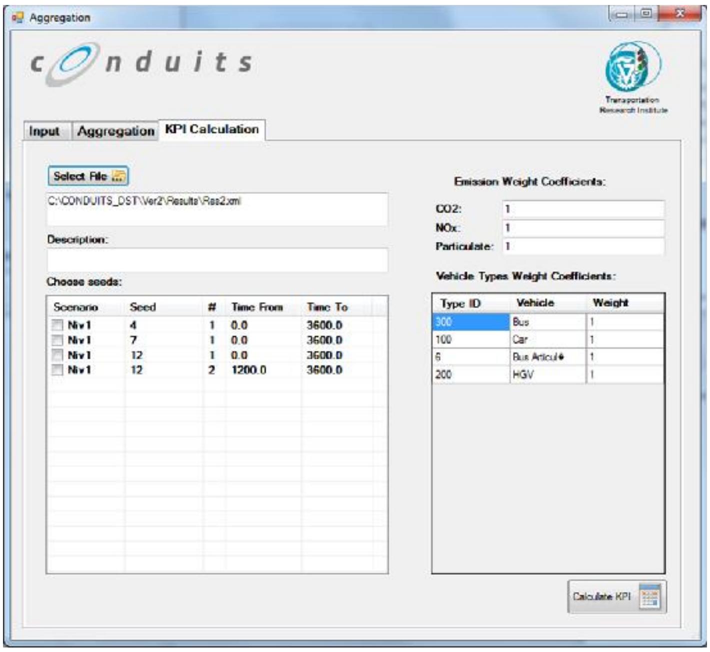
Where:

VT – Vehicle type

ET – Emission type

WVT – Vehicle type weighting factor

WET – Emission type weighting factor



For more information about CONDUITS activities, please contact:
Suzanne Hoadley, Polis, email: shoadley@polisnetwork.eu