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The CONDUITS Key Performance Indicators

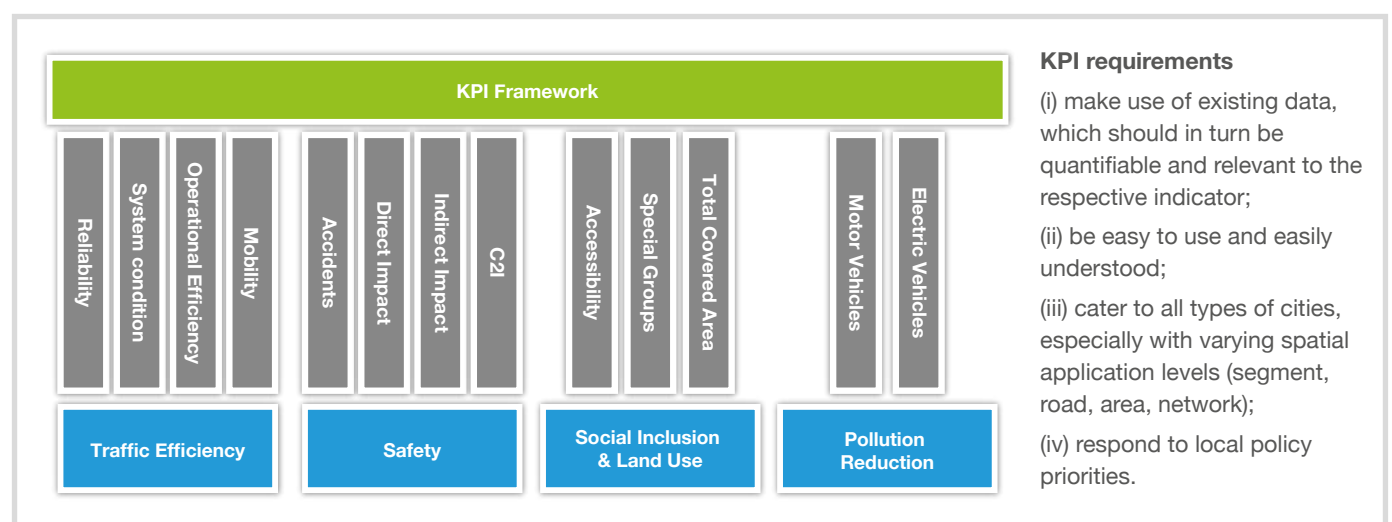**A useful tool for urban traffic management and ITS decision-making and evaluation**

The CONDUITS European project

It is widely acknowledged that intelligent transport systems are useful in assisting public bodies in their transport management tasks. However, it is not always easy for decision makers to select the most appropriate measure given the absence of a simple method for comparing the strengths and weaknesses of the different measures. It was for this reason that several cities, assisted by research institutes and universities, put together a proposal for a European research project to develop such a tool.

The CONDUITS project was accepted by the European Commission and ran from May 2009 until April 2011. Its main objective was to define and validate a set of policy-oriented Key Performance Indicators (KPIs) for traffic management and ITS in urban areas. The key performance indicator framework enables the most appropriate solutions to be identified as well as examples of good practice to emerge.

Definition of the indicators

The first phase involved identifying the main criteria required to measure the performance of an ITS in an urban area. The KPIs selected are shown in figure 1.

KPI Framework

Reliability · System condition · Operational Efficiency · Mobility · Accidents · Direct Impact · Indirect Impact · C2I · Accessibility · Special Groups · Total Covered Area · Motor Vehicles · Electric Vehicles

Traffic Efficiency · Safety · Social Inclusion & Land Use · Pollution Reduction

KPI requirements

(i) make use of existing data, which should in turn be quantifiable and relevant to the respective indicator;

(ii) be easy to use and easily understood;

(iii) cater to all types of cities, especially with varying spatial application levels (segment, road, area, network);

(iv) respond to local policy priorities.

The CONDUITS project case studies

CONDUITS validated the indicators in five case studies. In Paris, the 'Mobility' and 'Accidents' indicators were tested on three lines, on which a bus priority scheme was implemented in 2006. The 'Mobility' indicator enabled public transport to be compared with private vehicles and to arrive at a mobility calculation for each. The results are presented in a way that is very easy to understand by the non-specialist (table in figure 2)

I_{MOB} (min/km)	Mobility Public Transport			Mobility Private Vehicles			Overall		
	Before	After	Change	Before	After	Change	Before	After	Change
Line 26	4.46	4.25	-4.82%	4.46	4.65	+4.30%	4.46	4.37	-2.09%
Line 91	4.63	4.33	-6.55%	5.25	5.05	-3.89%	4.82	4.54	-5.68%
Line 96	5.03	4.67	-7.13%	2.71	3.02	11.55%	4.33	4.17	-3.63%
Total	4.71	4.42	-6.21%	4.21	4.26	1.14%	4.56	4.37	-4.17%

Figure 2: 'Mobility' indicator values for public transport and private vehicles

One bus line was the subject of a safety study using the 'Accidents' indicator, which allows weighting based on the severity of the accident and the transport mode of the victim. The results (without weighting for accident severity but with transport mode weighting) are presented in figure 3:

I_{ACD} per Mode (casualt./million veh)	Weights	Deaths		Serious injuries		Slight injuries		Overall	
		Before	After	Before	After	Before	After	Before	After
Pedestrians	0.4	1	1	6	11	51	51	0.42	0.50
Cycles	0.25	0	0	0	2	3	5	0.02	0.05
2-wheelers	0.2	0	0	3	3	71	36	0.40	0.24
4-wheelers	0.15	2	0	0	1	27	20	0.32	0.12
Total	1	0.07	0.04	0.31	0.63	4.10	3.57	0.30	0.28

Figure 3: 'Accidents' indicator values with weighting for transport mode

When applying the accident severity weighting, the indicator shows an overall safety increase of about 7%, based on a weighting of 0.85 for fatalities, 0.1 for seriously injured and 0.05 for lightly injured. These weights, however, can be varied according to policy objectives (e.g. fatalities could be more heavily weighted in other cases).

- In another Paris study, the mobility and accident impacts of private vehicles following the construction of the T3 tram on the Boulevard des Maréchaux in 2006 were measured.
- In Rome, the 'Mobility' and 'Traffic reliability' indicators were applied to all the main roads of the city and enabled both indicators to be followed in real time.
- In Tel Aviv, the 'Traffic reliability' indicator was used to optimise new traffic signal plans implemented to reduce recurrent congestion on the city's main corridor.
- In Munich, the 'Direct impact' and 'Indirect impact' safety indicators were applied to study the effect of a VMS deployed to encourage drivers to respect the speed limit in residential areas.
- In Ingolstadt, the 'Indirect impact' safety indicator was used to compare the impact on road safety of two traffic light algorithms on a major corridor.

Tel Aviv and Brussels have taken the CONDUITS results one step further. In Tel Aviv the CONDUITS Traffic Reliability KPI is now a part of AVIVIM, the city's online traffic management system, which uses real-time data to deploy short term strategies for traffic signal control.

The Traffic Reliability KPI is used for long term monitoring of the system's performance and deployment of long-term planning strategies. CONDUITS-DST is also being integrated in the process of deciding new road infrastructure projects in Brussels.

The development of a module to calculate the pollution indicator

At the end of the CONDUITS project, the Austrian company Kapsch TrafficCom expressed interest in taking the work of CONDUITS forward by means of sponsorship. Given that it would take a considerable amount of time to build up a database of ITS impacts based on the application of CONDUITS KPIs to real case studies, Brussels Mobility proposed to use the KPIs on traffic scenarios generated by modelling software, such as VISSIM. The indicators would enable values to be calculated before and after running the traffic simulation for a selected scenario, thus enabling the current situation to be compared with a "theoretical" situation generated by VISSIM. As cities often work with traffic scenarios and models, it would be possible to set up database showing the theoretical performance of different ITS in urban areas. In a second phase, once the ITS has been installed, it would be possible to measure the real values and to compare these with the theoretical values generated by VISSIM. The development of an automatic calculation module for the pollution indicator was set up and applied to a bus priority case study in Brussels.

The Brussels case study

The focus of the Brussels case study was the expected impact of the planned introduction of bus priority at traffic lights on bus line 49 by means of micro-simulation (VISSIM). Although bus priority is intended to encourage sustainable travel, it was expected that increased pollution levels would arise in the short-term as a result of holding back private transport. The case study analysed different VISSIM simulation scenarios: morning peak and evening peak, both directions and before and after implementation.
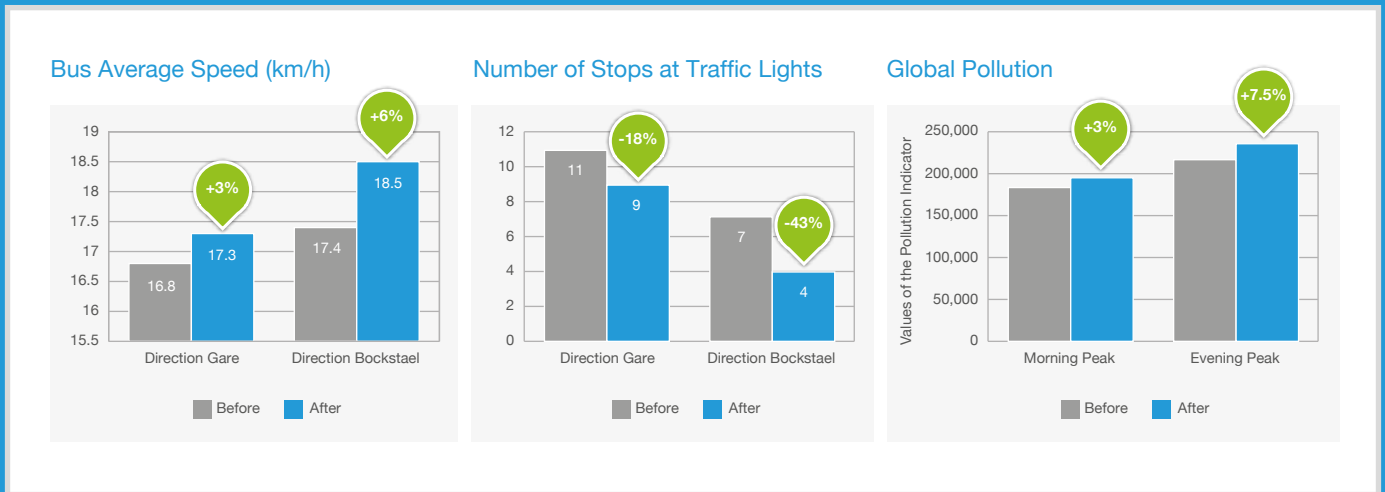
The results were as expected (figure 4):

Bus Average Speed (km/h)

	Direction Gare	Direction Bockstael
Before	16.8	17.4
After	17.3 (+3%)	18.5 (+6%)

Number of Stops at Traffic Lights

	Direction Gare	Direction Bockstael
Before	11	7
After	9 (-18%)	4 (-43%)

Global Pollution

Values of the Pollution Indicator

	Morning Peak	Evening Peak
Before	~183,000	~215,000
After	~193,000 (+3%)	~235,000 (+7.5%)

Figure 4: Results of the 'Mobility' and 'Pollution' indicator

The Brussels case study demonstrates that the indicators are most useful in quantifying and presenting the results in a very simple way. On the one hand, the average bus speed increased and the number of stops at signalised junctions decreased. On the other hand, the study showed that pollution levels would increase during peak hours. Through sensitivity analysis, it has then been possible to estimate the level of traffic reduction required in the medium term to mitigate the pollution increase. The pollution levels of the 1% incremental reduction of private traffic demand are shown in figure 5.
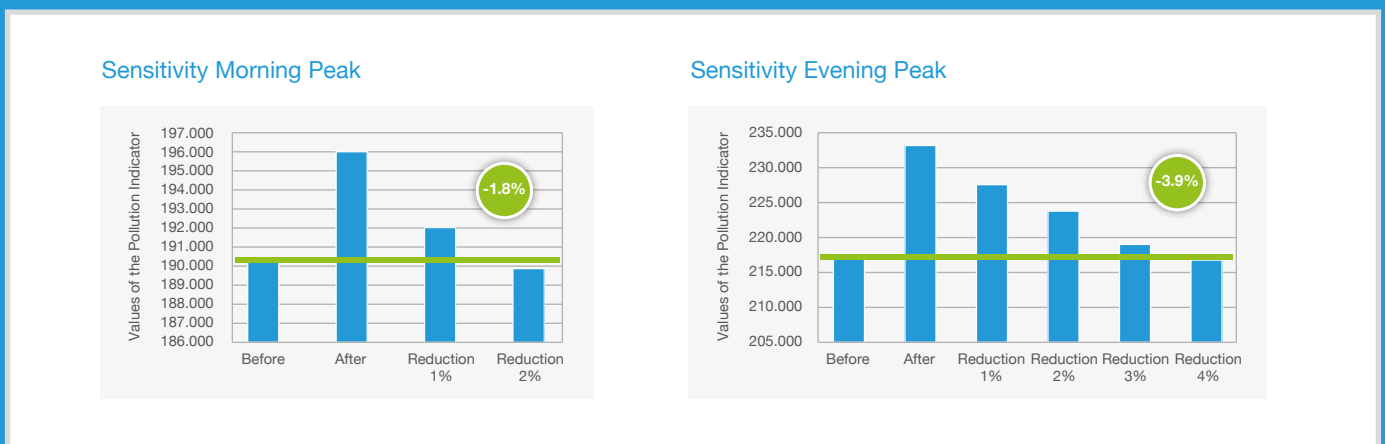
Sensitivity Morning Peak

Values of the Pollution Indicator

Before	After	Reduction 1%	Reduction 2%
~190	~196	~192	~189.5 (-1.8%)

Sensitivity Evening Peak

Values of the Pollution Indicator

Before	After	Reduction 1%	Reduction 2%	Reduction 3%	Reduction 4%
~217	~233	~227.5	~224	~218.5	~217 (-3.9%)

Figure 5: Pollution indicator sensitivity analysis

The charts show that a drop in vehicle traffic volumes of between 2% and 4% is required in the medium term. Additional measures may well have to be taken to optimise traffic during the evening peak. A sensitivity analysis for each type of pollutant can also be undertaken.

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The other applications under way at Brussels Mobility

Brussels Mobility has decided to mainstream the CONDUITS KPIs in the study phase of all new ITS. The fact that the CONDUITS KPIs can measure the effect of an ITS on traffic reliability, as well as on pollution and road safety (and on land use planning and social inclusion in the future) is appreciated by Brussels. This means that the choice of ITS can be made taking into account the full range of sustainable mobility policies. This 'sustainability' approach is equally valid for decisions at policy level.

Brussels Mobility is part of the second phase of Kapsch-sponsored study, which involves extending the current CONDUITS calculation module, called CONDUITS_DST, beyond pollution reduction to other CONDUITS KPIs, namely, 'traffic reliability' and 'mobility'. It is planned to add a 'road safety' indicator at a later stage. Brussels Mobility is planning to apply CONDUITS_DST to all the scenarios generated by its modelling programmes VISSIM, VISUM and OPTIMA.

VISUM is currently being installed by Brussels Mobility, which will likely enable the testing of the 'social inclusion' indicator. The studies will be carried out on all new road design projects. For each of these projects, the effect on cyclists will be examined. If the effect is shown to be negative for cyclists, the design proposal will have to be revisited.

The CONDUITS KPIs will also be incorporated in the new software being installed, OPTIMA, in order to understand the effects on traffic reliability, pollution and road safety. In particular, alternative routes will be analysed in case of a scheduled road closure (e.g., closure of a tunnel at night) or unplanned road closure (following an accident, for instance). OPTIMA will undertake the traffic simulations for alternative routes based on real-time traffic flow data. It will therefore be possible to select the best scenario based on the conditions and priorities of that particular moment in time, e.g., road safety or pollution in case of an ozone peak.

Future developments

ITS solutions should no longer be selected on the basis of traffic effects only. Impacts on road safety and pollution are equally as important and should be taken into account. Furthermore, in many cases, several different ITS solutions can address the same problem. To help select the most sustainable solution, the use of the CONDUITS KPIs can be very useful.

Besides Brussels and Tel Aviv, other cities, including Stuttgart and Haifa, are currently testing the KPIs and CONDUITS_DST. The results from these cities will contribute to a body of knowledge on ITS impacts, which could take the form of an ITS impacts database.

The CONDUITS KPIs and decision-support tool (CONDUITS_DST) are free of charge. For cities interested in using CONDUITS_DST, a user manual and technical support are available.

For further information:

Suzanne Hoadley, Polis, shoadley@polisnetwork.eu