The CONDUITS KPIs and DST

Tools to support the prediction and assessment of the wider policy impacts of traffic management measures and ITS
1. The CONDUITS set of indicators
2. The case studies of the European project CONDUITS
3. The CONDUITS DST (Decision Support Tool)
4. The Brussels case study: VISSIM
5. The Stuttgart case study: 2MOVE2 (CIVITAS)
6. The Tel Aviv case study
7. Future developments
Cities needs when they have to chose an ITS

- Neutral assessment of ITS in urban environment
  - Ratio cost/benefit of an ITS investment
  - Assess the usefulness of an ITS as a whole
  - Identify the limits of an ITS

- Decision Support Tool (DST) for traffic managers and decision makers

- Allow comparison between different ITS solutions

- Control/assessment of an ITS implementation

- Possibility of sharing results between cities
Solution: KPIs with specific requirements

- Key Performance Indicators (KPIs) easy to use and communicate to decision makers and public
  - No or light extra work for the users
  - Clarity for the political decision makers and the public

- Adapted to cities individuality
  - Geographical scale:
    - sections, roads, zones, network, …
  - Adaptability:
    - Ability to use all kind of urban data that are relevant to quantify a performance
    - Weighting possibilities
The CONDUITS European R&D project goal and objectives

- **Goal of the CONDUITS project**
  - To establish a coherent set of Key Performance Indicators (KPIs) for ITS used for urban traffic management

- **Main objectives**
  - To define a set of Key Performance Indicators for identifying best practices and best technologies
  - To test these KPIs through real applications in:
    - Paris,
    - Rome,
    - Tel-Aviv,
    - Munich
    - Ingolstadt

\[
I_{MOB} = w_{PV} \cdot \frac{1}{|R_{PV}|} \sum_{r \in R_{PV}} \frac{ATT_{PV}^r}{D_r} + w_{PT} \cdot \frac{1}{|R_{PT}|} \sum_{r \in R_{PT}} \frac{ATT_{PT}^r}{D_r}
\]
Goal: improve attractiveness of public transport

Objective: Reduce public transport waiting time in junctions
IP: Average waiting time at stop line
IP: % of vehicles stopping at stop lines

Objective: Improve the public transports reliability
IP: Variance of headway between consecutive vehicles at the station
IP: % of vehicles arriving at the station on time

Data chosen to measure the Performance:
Vehicle’s momentary location
The CONDUITS set of indicators

KPIs Framework

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

Reliability
System Condition
Operational Efficiency
Mobility
Accidents
Direct Impact
Indirect Impact
C2I
Accessibility
Special groups
Total covered area
Motor Vehicles
Electric Vehicles
1. The CONDUITS set of indicators

2. The case studies of the European project CONDUITS

3. The CONDUITS DST (*Decision Support Tool*)

4. The Brussels case study: VISSIM

5. The Stuttgart case study: 2MOVE2 (CIVITAS)

6. The Tel Aviv case study

7. Future developments
CONDUITS case studies and their KPIs

- **Paris**: Implementation of a priority system to 3 bus lines and Construction of a new tram line
  - **Traffic efficiency**: mobility for buses and tram
  - **Traffic safety**: accidents for buses and tram

- **Rome**: General assessment of traffic efficiency
  - **Traffic efficiency**: mobility, reliability

- **Tel Aviv**: Implementation of new signal strategies
  - **Traffic efficiency**: reliability

- **Munich-Ingolstadt**: Application of feedback signs for drivers and Adaptive traffic signal control
  - **Traffic safety**: direct impacts, indirect impacts
Test in Paris – Bus priority (1)

- Priority on lines 26, 91, 96
- Implementation in 2006
- Anticipated average travel time savings about 30s per trip, allowing 1 bus less for each line
Test in Paris – Bus priority (2)

> Supplied data

> **Bus travel times** on a number of specific segments of given length on the 3 bus lines, before and after

> **Vehicle traffic speeds** on a number of specific segments of given length, affected by the priority measures on the 3 bus lines, before and after

> **Casualty numbers** due to road traffic accidents on a number of specific segments affected by the priority measures on bus line 91, over given periods before and after

> **Vehicle traffic flows** on the given segments, before and after
Traffic efficiency: Mobility index

\[ I_{MOB} = w_{PV} \cdot \frac{1}{|R_{PV}|} \sum_{r \in R_{PV}} \frac{ATT_{PV}^r}{D_r} + w_{PT} \cdot \frac{1}{|R_{PT}|} \sum_{r \in R_{PT}} \frac{ATT_{PT}^r}{D_r} \]

- minutes/km, weighted for public and private transport

Traffic safety: Accidents index

\[ I_{ACD-L} = \sum_{l \in L} \left\{ w_l \cdot \sum_{s \in SE} \left[ w_{se} \cdot \sum_{m \in M} \left( w_m \cdot \frac{ACD_{l,se,m}}{DTV_l} \right) \right] \right\} \]

- casualties per million vehicles, severity weighted
Test in Paris – Bus priority (4)

- **Traffic efficiency: Mobility index**
  - Separately for public and private transport

<table>
<thead>
<tr>
<th>min/km</th>
<th>Public transport mobility</th>
<th>Private transport mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Line 26</td>
<td>4.46</td>
<td>4.25</td>
</tr>
<tr>
<td>Line 91</td>
<td>4.63</td>
<td>4.33</td>
</tr>
<tr>
<td>Line 96</td>
<td>5.03</td>
<td>4.67</td>
</tr>
<tr>
<td>TOTAL</td>
<td>4.71</td>
<td>4.42</td>
</tr>
</tbody>
</table>

- Combined, with $w_{PT} = 0.7$ and $w_{PV} = 0.3$
## Traffic safety: Accidents index

- Separated by levels of gravity

<table>
<thead>
<tr>
<th>Line 91</th>
<th>Weighting</th>
<th>Deads Before</th>
<th>Deads After</th>
<th>Serious injuries Before</th>
<th>Serious injuries After</th>
<th>Slight injuries Before</th>
<th>Slight injuries After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycles</td>
<td>0.25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>2 wheelers</td>
<td>0.20</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>71</td>
<td>36</td>
</tr>
<tr>
<td>4 wheelers</td>
<td>0.15</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>27</td>
<td>20</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>0.40</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>11</td>
<td>51</td>
<td>51</td>
</tr>
<tr>
<td>Casualties/million vehicles</td>
<td></td>
<td>0.07</td>
<td>0.04</td>
<td>0.31</td>
<td>0.63</td>
<td>4.10</td>
<td>3.57</td>
</tr>
</tbody>
</table>

- Combined, with $w_{DEAD} = 0.85$, $w_{SER} = 0.1$, $w_{SL} = 0.05$
Test in Paris – Tramway (1)

- Construction of tramway line T3 in 2006 at Boulevards des Maréchaux
- It was anticipated to achieve the following goals:
  - Average speed of 20km/h
  - Daily traffic of 100,000 travellers
  - Regularity of the line with a tram every 4 min
Test in Paris – Tramway (2)

- Supplied data

- **Tram travel times** on the entire route, only after

- **Vehicle traffic speeds** on the entire route of the tram, before and after

- **Casualty numbers** due to road traffic accidents on the entire route, over given periods before and after

- **Vehicle traffic flows** on the entire route, before and after
Test in Paris – Tramway (3)

➢ Traffic efficiency: Mobility index

➢ Separately for public and private transport

<table>
<thead>
<tr>
<th>min/km</th>
<th>Public transport mobility</th>
<th>Private transport mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Tram T3</td>
<td>N/A</td>
<td>3.54</td>
</tr>
</tbody>
</table>

➢ Combined, with $w_{PT} = 0.7$, $w_{PV} = 0.3$

<table>
<thead>
<tr>
<th>min/km</th>
<th>$I_{MOB}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
</tr>
<tr>
<td>Tram T3</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Test in Paris – Tramway (4)

Traffic safety: Accidents index

For each severity level

<table>
<thead>
<tr>
<th>Tram T3</th>
<th>Weight</th>
<th>Deaths</th>
<th>Serious injuries</th>
<th>Slight injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Before</td>
<td>After</td>
<td>Before</td>
</tr>
<tr>
<td>Cycles</td>
<td>0.25</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2-wheelers</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>4-wheelers</td>
<td>0.15</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>0.4</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Casualties/million-vehicles</td>
<td></td>
<td>0.09</td>
<td>0.00</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Total, with $w_{DEAD} = 0.85$, $w_{SER} = 0.1$, $w_{SL} = 0.05$
Several techniques and technologies, including ITS, are used for traffic management in the entire Greater Rome area.

- **Supplied data:**
  - **Travel times** for public transport and private cars between all zones of the city and lengths of these routes.
  - **Occurrences of congestions** and their **average duration** on certain key routes of the urban road network during one year.
Test in Rome - General assessment (2)

- **Traffic efficiency: Mobility index**

\[ I_{MOB} = w_{PV} \cdot \frac{1}{|R_{PV}|} \sum_{r \in R_{PV}} \frac{ATT^{r}_{PV}}{D_{r}} + w_{PT} \cdot \frac{1}{|R_{PT}|} \sum_{r \in R_{PT}} \frac{ATT^{r}_{PT}}{D_{r}} \]

- minutes/km, weighted for public and private transport

- **Traffic efficiency: Reliability index**

\[ I_{REL} = 1 - \sum_{l \in L} \left( w_{PT} \cdot \sum_{pt \in PT} w_{l} \frac{CT^{l}_{pt}}{T_{w_{l}}} + w_{PV} \cdot \sum_{pv \in PV} w_{l} \frac{CT^{l}_{pv}}{T_{w_{l}}} \right) \]

- dimensionless, weighted by link and mode
Test in Rome - General assessment (3)

- **Traffic efficiency: Mobility index**
  - Separately for public and private transport

<table>
<thead>
<tr>
<th>min/km</th>
<th>Public transport mobility</th>
<th>Private transport mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Rome</td>
<td>N/A</td>
<td>5.41</td>
</tr>
</tbody>
</table>

- Combined, with $w_{PT} = 0.7$, $w_{PV} = 0.3$

<table>
<thead>
<tr>
<th>min/km</th>
<th>$I_{MOB}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
</tr>
<tr>
<td>Rome</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Test in Rome - General assessment (4)

- Traffic efficiency: Reliability index

- Routes weighted equally (assumption)

- $I_{REL} = 0.9959$
Reliability Index of Traffic efficiency

- $T_{\text{Congestion}}$
- LOS
- Speed
- Travel time
- ...

![Graphs showing congestion levels over the day with various metrics like LOS, Speed, and Travel Time.](image)
Recurrent Congestion during the Afternoon / Evening peak hours (~ 45 h/link/month)

- Deployment of new traffic management strategies
Test Tel-Aviv – New signal strategies (2)

- **Supplied data**
  - Level of Service (LOS) of Links in Ha’Shalom Arterial, along with Links lengths and Weights
  - Duration of congestion of Links in Ha’Shalom Arterial during the afternoon peak period

- **Weighting Methodology**
  - Time Frames: 5 time frames to reflect the typical traffic demand patterns
  - Link Categories: Arterial - Streets
  - Direction Categories
    - Inbound (to the city centre)
    - Outbound (out of the city centre)
### Test Tel-Aviv – New signal strategies (3)

#### Weightings

<table>
<thead>
<tr>
<th></th>
<th>Inbound</th>
<th></th>
<th></th>
<th>Outbound</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Morning Peak</td>
<td>Afternoon Peak</td>
<td>Off Peak</td>
<td>Morning Peak</td>
<td>Afternoon Peak</td>
<td>Off Peak</td>
</tr>
<tr>
<td>Arterial</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Local Streets</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

The new Strategies were implemented during the Afternoon Peak.
Results:

- Comparing the index during afternoon peak hours two months prior to the improvement of the signal program to two months following the improvement indicates an average increase of 36% in the index value.
- The decrease in the congestion duration was higher (~41%).
- General perception of representative travelers supported this figure.
- Within few months the decrease tendency of the index value stopped and within one year the index value became stable.
Test in Munich – Safety assessment (1)

- Installation of two feedback signs during a test period
- Measuring speeds at two urban streets (speed limits 50 and 30km/h) in both driving directions
- Flashing messages:
  Slow down!
  Thank you!
Test in Munich – Safety assessment (2)

- **Supplied data**
  - Time and Speed of each vehicle passing the location
  - Daily traffic volume and the number of vehicles exceeding the speed limit
  - Data available before implementation, during test period and after implementation of the feedback signs
Test in Munich – Safety assessment (3)

- Traffic Safety: direct safety impact

\[ I_{DS} = \sum_{l \in L} w_l \cdot \frac{INTERV_l}{DTV_l} \]

- number of shown warning messages/day
- average number for each time period: before implementation, during test period and after implementation
Test in Munich – Safety assessment (4)

- **Traffic safety : direct impact index**

<table>
<thead>
<tr>
<th>Actions / Vehicle</th>
<th>Before</th>
<th>Test period</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Paasostrasse (direction east)</td>
<td>0.45</td>
<td>0.26</td>
<td>0.37</td>
</tr>
<tr>
<td>2 Paasostrasse (direction west)</td>
<td>0.73</td>
<td>0.48</td>
<td>0.70</td>
</tr>
<tr>
<td>3 Friedenspromenade (dir. north)</td>
<td>0.15</td>
<td>0.12</td>
<td>0.15</td>
</tr>
<tr>
<td>4 Friedenspromenade (dir. south)</td>
<td>0.29</td>
<td>0.18</td>
<td>0.30</td>
</tr>
</tbody>
</table>

- Combined : with $w_{L1} = 0.2$, $w_{L2} = 0.2$, $w_{L3} = 0.3$, $w_{L4} = 0.3$

<table>
<thead>
<tr>
<th>Actions / Vehicle</th>
<th>$I_{DS}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
</tr>
<tr>
<td>Paasostrasse &amp; Friedenspromenade</td>
<td>0.37</td>
</tr>
</tbody>
</table>
Test in Ingolstadt – Safety assessment (1)

Congestion of the main axes during peak hours with traffic management by static green waves

- New adaptive green waves management
- Test of 2 kinds of algorithms for optimising green waves:
  - Hillclimbing algorithm
  - Genetic algorithm
Test in Ingolstadt – Safety assessment (2)

- **Supplied data**
  - Floating Car Data (FCD) assessed in a representative period by GPS-tracking of a small fleet of vehicles
  - **Daily traffic volume** via loop detectors
  - Data available before implementation, during test period of both algorithms

- **Scalability of calculation**
  - Link (basis)
  - Route
  - Network
Test in Ingolstadt – Safety assessment (3)

➢ **Traffic Safety: indirect safety impact**

\[ I_{IS-U} = \sum_{l \in L} w_l \cdot \frac{CS_l}{DTV_l} \]

- Critical situations: Number of occurrences speed exceeded the threshold
- Equal weighting of all links

<table>
<thead>
<tr>
<th>Link-ID</th>
<th>CSI</th>
<th>DTV</th>
<th>CSI/DTV</th>
</tr>
</thead>
<tbody>
<tr>
<td>11001</td>
<td>2421</td>
<td>755</td>
<td>3,21</td>
</tr>
<tr>
<td>11002</td>
<td>2716</td>
<td>642</td>
<td>4,23</td>
</tr>
<tr>
<td>11003</td>
<td>251</td>
<td>58</td>
<td>4,30</td>
</tr>
<tr>
<td>11004</td>
<td>545</td>
<td>107</td>
<td>5,10</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Separate calculation for each link
Test in Ingolstadt – Safety assessment (4)

Traffic Safety: indirect safety impact

<table>
<thead>
<tr>
<th></th>
<th>( I_{IS-U} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
</tr>
<tr>
<td>Route 1</td>
<td>3,7</td>
</tr>
<tr>
<td>Route 2</td>
<td>4,7</td>
</tr>
<tr>
<td>Route 3</td>
<td>4,4</td>
</tr>
</tbody>
</table>

- Combined, with \( w_I = 0,33 \) (equal for each route)

<table>
<thead>
<tr>
<th></th>
<th>( I_{IS-U} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
</tr>
<tr>
<td>Network</td>
<td>4,3</td>
</tr>
</tbody>
</table>

I_{IS-U} on route level

I_{IS-U} on network level
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Following step: the CONDUITS DST

- Implementation of KPIs requires consideration of several dimensions
- KPIs developed proved to reflect major phenomena
- Educated decision making is based on data
  - KPIs developed can contribute to a better ITS decision making
- Independent evaluation
Following step : the CONDUITS DST

- End of the CONDUITS project in May 2011
- Educated decision making is based on data: KPIs developed can contribute to a better ITS decision making and an independent evaluation
- Need of a DST easy to use by many cities in order to allow the sharing/dissemination of the results
- Financial sponsoring from Kapsch
- Call for ideas for the continuation
- Proposal of Brussels: design of a calculation module for the pollution indicator from files generated in a classic way by VISSIM
- Case study: Brussels
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7. Future developments
The Brussels case study

- Priority bus line 49
  - Many intersections with traffic lights

- 4 VISSIM simulations
  - Morning and evening peak hours
  - Situation before and after implementation
The CONDUITS Decision Support Tool (DST)

1st step: automatic calculation of the Pollution KPI in VISSIM simulations

\[
KPI_{\text{Pollution}} = \frac{\sum_{VT} \sum_{ET} W_{ET} W_{VT} Q_{VT,ET}}{\sum_{VT} \sum_{ET} W_{VT} W_{ET}}
\]

avec

- \( KPI_{\text{Pollution}} \): Pollution Performance Indicator
- \( W_{VT} \): Type of vehicle weighting factor
- \( W_{ET} \): Type of emission weighting factor
- \( Q_{VT,ET} \): Emissions by type of pollutant and by type of vehicle
The AIRE Model *(Analysis of Instantaneous Road Emissions)*

- Instantaneous Emissions Model (IEM)
- Passenger car & Heavy duty Emissions Model (PHEM)
  - Graz Technical University
  - High accuracy for fuel consumption, CO₂, NOₓ, PM in the traffic micro-simulation models
Estimation of the pollutant emissions by AIRE

IEM Tables

- Gradients
- Loads
- ...
- Engine type

Vehicles records
- Acceleration
- Speed
- Location
- ...

Estimation of the pollutants emissions
## Distributions used in AIRE (1)

<table>
<thead>
<tr>
<th>Vehicle Types</th>
<th>Fuel Types</th>
<th>Axles</th>
<th>Engine type</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>car</td>
<td>petrol</td>
<td>2</td>
<td>2-stroke</td>
<td>urban</td>
</tr>
<tr>
<td>lgv</td>
<td>diesel</td>
<td>3</td>
<td>4-stroke</td>
<td>rural</td>
</tr>
<tr>
<td>hgv rigid</td>
<td>lpg</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hgv artic</td>
<td>electric</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>bus 1 deck</td>
<td></td>
<td>6+</td>
<td></td>
<td>motorway</td>
</tr>
<tr>
<td>bus mini</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bus 2 decks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bus bendy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tram</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>coach</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>taxi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>motorcycle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Distributions used in AIRE (2)

<table>
<thead>
<tr>
<th>Engine capacity</th>
<th>Gross vehicle weight</th>
<th>Euro standard</th>
<th>Vehicle loads</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>under 150cc</td>
<td>under 2.5t</td>
<td>pre-Euro I</td>
<td>unladen</td>
<td>1996</td>
</tr>
<tr>
<td>150-250cc</td>
<td>over 2.5 t</td>
<td>I</td>
<td>half-laden</td>
<td>...</td>
</tr>
<tr>
<td>250-750cc</td>
<td>3.5-7.5t</td>
<td>II</td>
<td>fully-laden</td>
<td>2025</td>
</tr>
<tr>
<td>over 750cc</td>
<td>7.5-12t</td>
<td>III</td>
<td></td>
<td></td>
</tr>
<tr>
<td>under 1.4l</td>
<td>12-14t</td>
<td>IV</td>
<td></td>
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</tr>
<tr>
<td>1.4-2.0l</td>
<td>14-20t</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>under 2.0l</td>
<td>20-26t</td>
<td>VI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>over 2.0l</td>
<td>20-28t</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>26-28t</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>28-32t</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28-34t</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>over 32t</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>34-40t</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>40-50t</td>
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Calculation of the Pollution indicators

Vehicle Records

CONDUITS DST

Pollution KPI

Emissions Aggregation

Emissions Estimation

AIRE

Input Files

Vehicle Records Incl. Emissions
Calculation of the Pollution indicators

<table>
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<tr>
<th>t</th>
<th>Link</th>
<th>VehNr</th>
<th>Type</th>
<th>VehTypeName</th>
<th>WorldX</th>
<th>WorldY</th>
<th>WorldZ</th>
<th>Grad</th>
<th>a</th>
<th>vMS</th>
<th>DistX</th>
<th>IntaP</th>
<th>NOx</th>
<th>Particulate</th>
<th>CO2</th>
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<tr>
<td>0.5</td>
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<td>300</td>
<td>Bus</td>
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<td>170372.6384</td>
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<td>0</td>
<td>0</td>
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<td>5</td>
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<td>29.647849</td>
<td>1.011156</td>
<td>816.1057</td>
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<tr>
<td>0.5</td>
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<table>
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<tr>
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<th>TypeNam</th>
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<td>0.002347</td>
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<tr>
<th>TypeID</th>
<th>TypeName</th>
<th>SumDelta</th>
<th>NOx</th>
<th>CO2</th>
<th>Part</th>
<th>CarsCount</th>
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<tbody>
<tr>
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<td>Bus</td>
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<td>303</td>
</tr>
</tbody>
</table>

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Expected results of the bus priority

- **Short-term**
  - Increase average speed of the buses
  - Increase average speed of the private vehicles displacement parallel to the line
  - Reduction average speed of vehicles crossing the line

- **Medium-term**
  - Change of route choices for private car drivers
  - Reduction of time losses in the implementation area

- **Long-term**
  - Demand shift towards public transport reduces private car rides
The first results reflect the expected short term effects:

- Improvement of the public transport quality:
  - increase average speed of the buses
  - reduction of the stops at intersections

### First results of the case study (1)

<table>
<thead>
<tr>
<th>Ave. Speed [km/h]</th>
<th>Southbound</th>
<th>Northbound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>before</td>
<td>after</td>
</tr>
<tr>
<td>southbound</td>
<td>16.8</td>
<td>17.3</td>
</tr>
<tr>
<td>northbound</td>
<td>17.4</td>
<td>18.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Stops [-]</th>
<th>Southbound</th>
<th>Northbound</th>
</tr>
</thead>
<tbody>
<tr>
<td>before</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>after</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

- **Ave. Speed [km/h]**
  - Southbound: 17.3 km/h + 3%, 18.5 km/h + 6%
  - Northbound: 17.4 km/h, 18.5 km/h

- **Number of Stops [-]**
  - Southbound: 11 - 18%, 9 - 18%
  - Northbound: 7 - 43%, 4 - 43%
but... increase in pollution

... what is (hopefully) normal!
First results of the case study (3)

**Sensitivity analysis with a pragmatic methodology**

- The given demand levels of the relevant flows are progressively reduced in increments of 1% and the KPI values are recalculated for each scenario.

### Sensitivity analysis of the single pollutants

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Morning</th>
<th>Evening</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>- 1,5%</td>
<td>- 4,0%</td>
</tr>
<tr>
<td>NOₓ</td>
<td>- 3,5%</td>
<td>- 6,0%</td>
</tr>
<tr>
<td>PM10</td>
<td>- 0,5%</td>
<td>- 3,0%</td>
</tr>
<tr>
<td>KPI Pollution</td>
<td>- 1,8%</td>
<td>- 3,9%</td>
</tr>
</tbody>
</table>
Advantages of these Indicators

- Same methodology for all the indicators
- Calculation running with all kinds of data
- Easy weighting of the parameters
- Automatic calculation before, during and after the implementation of an ITS by using the VISSIM files as they are provided
- Allow sharing results got in other cities for similar ITS and the possibility to create a common DB with real measurements
Actual limits of these Indicators

- It will be necessary to wait a few years before having “before and after” data based on real measurements.
- Require a cost/benefit analysis to complete the set of KPIs needed to cover the overall sustainability assessment of an ITS.
- KPIs comparison between cities still needs an agreement on common weighting.
Future developments planned in Brussels

➢ Further steps: Road safety prediction module and Road safety prediction module

➢ Design of an integrated sustainability module using CONDUITS KPIs for VISSIM micro simulations

➢ Implementation of this integrated sustainability module for VISUM macro simulations and OPTIMA simulations
CONTENTS

1. The CONDUITS set of indicators
2. The case studies of the European project CONDUITS
3. The CONDUITS DST (*Decision Support Tool*)
4. The Brussels case study : VISSIM
5. The Stuttgart case study : 2MOVE2 (CIVITAS)
6. The Tel Aviv case study
7. Future developments
The Stuttgart case study

The Stuttgart Measures
The Stuttgart case study

Emission-based traffic control

Test site B14
- Main arterial road (3.5 km, 10 crossings, 2-3 lanes/direction)
- High traffic load, esp. in peak time
- High emissions
- Public transport, pedestrian and bicycle crossings

Modelling emission impact by
Microscopic Simulation
The Stuttgart case study

Emission-based traffic control

Test site B14
- Main arterial road (3.5 km, 10 crossings, 2-3 lanes/direction)
- High traffic load, esp. in peak time
- High emissions
- Public transport, pedestrian and bicycle crossings

Modelling emission impact by

Microscopic Simulation
The Stuttgart case study

Measures to reduce stop-and-go traffic are going to be implemented and tested:

- Dynamic speed limit: 50 km/h and 40 km/h
  (30 km/h on a section as recommendation)
- Depending on immission situation or traffic situation
- Speed enforcement by cameras
- Start of operation middle of 2014
- Increase public awareness for the measure
The Stuttgart case study

Evaluation:

- Comparison before (July 2013), intermediate (May 2014) and after situation (October 2014)
- Test of different scenarios for control strategy
- Measuring of immissions by measurement stations (NO2, PM10)
- Noise level (national guidelines)
- Traffic counts/observation, travel time measurement, Compliance rates
- Effects on pedestrians, public transport, cyclists and traffic safety

CONDUITS DST scenarios will be simulated and can be validated according the actual observation
The Stuttgart case study

Micro Simulation VISSIM -> CONDUITS/AIRE:

<table>
<thead>
<tr>
<th>VISSIM</th>
<th>single vehicle data every 0.5 s, travel time, average speed, congestion, stops</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONDUITS/AIRE</td>
<td>emissions NO$_x$, PM10, CO$_2$ -&gt; emissions KPI travel time aggregation</td>
</tr>
<tr>
<td>Other impacts</td>
<td>waiting time for pedestrians/bicycles, accident records, costs, sensitivity tests, cost-benefit analysis</td>
</tr>
</tbody>
</table>
The Stuttgart case study
The Stuttgart case study

VISSIM

Network

Vehicle Log File

CONDUITS / AIRE

Vehicle Types:
2 := lgv
3 := hgv rigid
5 := bus single deck
7 := car
8 := hgv artic
10 := motorcycle
The Stuttgart case study

Vehicle Log File incl. emissions

Pollution Aggregation Results

Average Travel Times
Advantages of the Conduits Tool for us so far:

- Good transferability and therefore an easy adaption into our system
- Fast assistance and support in case of technical problems
- Help to convince the city council with their decisions
- Predictive scenario-based estimation of impacts
- KPIs for Traffic efficiency and pollution
1. The CONDUITS set of indicators
2. The case studies of the European project CONDUITS
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6. The Tel Aviv case study
7. Future developments
Other developments outside Brussels and Stuttgart

- **Tel Aviv**
  - CIVITAS project 2MOVE2
    - Bus priority case study
  - To be completed by middle of 2014.
  - KPIs: Traffic efficiency and Pollution

- **Haifa**
  - Case study covers travel times in tunnel delivered through VMS. Aim of giving travel times is to encourage drivers to use tolled tunnel rather than alternative congested route.
  - KPI: Traffic efficiency (+ Pollution !)
Tel Aviv Mobility Management Workflow
Tel Aviv/Haifa TMS Architecture (existing & under construct.)
PT Priority – Means : Goal 1

PT Priority Signal Plans
- Explicit Policy
- Detailed Design
- Parameters Tuning

Field Operations

RT Traffic Management
- Detectors Data +SIRI SM
- Expected PI’s
- Decision Making Analysis
- Network Monitoring
- PI’s
- Alerts
- SP Selection

Means: Goal 1
Haifa City Tunnel
Haifa City Tunnel
Haifa City Tunnel
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6. CONDUITS DST implementation in Tel Aviv
7. Future developments
Future developments: some thoughts!

- Integrated DST module including Traffic – Road safety – Pollution reduction in a first step
- Scientific approach for the choice of the KPIs weightings
- "Validation" of these weightings by political representatives
- Impacts of different vehicle fleet compositions on the pollution KPI
- Feasibility study of a predictive social inclusion KPI module for future inclusion in CONDUITS DST
- Discussion with PTV for a better integration of the CONDUITS DST in their products
Another reason to use the CONDUITS KPIs and DST!

EC Urban Mobility Package adopted 13/12/2013

➔ EC Communication ‘Together towards competitive and resource-efficient urban mobility’

‘…the Commission will continue to support the development of an Urban Mobility Scoreboard, by identifying harmonised indicators to benchmark and compare the progress of urban areas across the EU. The Commission will build on work conducted in projects like EcoMobility Shift and Conduits.’

➔ EC staff working document Mobilising Intelligent Transport Systems for EU cities

‘……the monitoring of the deployment of ITS applications, and evaluation of their impacts (based on existing methodologies, outcomes of past projects e.g. CONDUITS …..), can greatly help decision makers in selecting the right ITS applications (or combination of ITS applications), in order to achieve their policy goals.’
The CONDUITS Decision Support Tool is free of charge and a user manual is available, as well as a technical support. Contact: Suzanne Hoadley, POLIS, shoadley@polisnetwork.eu