Special subject

Travel Time Variability & Modeling
Road Traffic
Travel Time Variability
Introduction

What is Travel Time Variability?

– TTV is an indicator of the variability of travel time from an origin to destination in the transportation network (including any model transfer or en-route stops).
Introduction

• Objective
  – Investigate the measurement of travel time variability and reliability with floating car data (FCD).
  – We will consider that TTV is mobility performance metrics.
Statistical Indices

• Indicator:
  – Mean Travel Time (MTT)
  – Standard Deviation of Travel Time (SDTT)
  – The 95\textsuperscript{th} Percentile Travel Time (95\textsuperscript{th} PTT)
  – Buffer Index (BI)
  – Planning Time Index (PTI)
Statistical Indices

• Mean Travel Time:

\[ T_l = \frac{1}{n} \sum_{i=1}^{n} t_{li} \]

\( T_l \) – is equal to the sum of the travel times collected by a number of floating cars \((n)\), traveling on link “l”.

\[ T_l = \frac{1}{n} \sum_{i=1}^{n} t_{li} \]
Statistical Indices

• Standard Deviation of Travel Time
  – Is the measure of the dispersion of travel times which can be formulated as follows:

\[
\sigma_l = \sqrt{\frac{\sum_{i=1}^{n} (t_{li} - T_l)^2}{n - 1}}
\]
Statistical Indices

• The 95\textsuperscript{th} Percentile Travel Time
  – It measures the reliability of travel time, which indicates the delay on a particular link.
  – The 95\textsuperscript{th} PTT is the travel time of which 95\% of sample travel time are at or below this amount.
  – The difference between the 95\textsuperscript{th} PTT and MTT is called buffer time denoted as $T_{Bl}$.
• Buffer Index
  – BI is the extra time that a traveler should add to the MTT to ensure on-time or earlier arrivals.

\[
B_l = \left( \frac{T_{95\% l} - T_l}{T_l} \right) \times 100\%
\]

– Other percentile: 85\textsuperscript{th}, 90\textsuperscript{th}, 99\textsuperscript{th}
Statistical Indices

• Planning Time Index
  – The planning time index compares the longest travel time against a travel time incurred by free-flow traffic.

\[
P_l = \left( \frac{T_{95\%}}{T_{Fl}} \right) (100\%)
\]
• Start with Delays:
  – Travel times longer than a reference “ideal” travel time
  – Something can be done to reduce these travel times
• Question: Try to associate the words list with the graph?

- Freeflow Travel Time
- Recurring Delay
- "Normal" Delay
- "Abnormal" Delay
Case study

• Travel Time:
  – Freeflow Travel Time
Case study

• **Travel Time:**
  – Freeflow Travel Time
  – Delay:
  • Recurring Delay
Case study

- Travel Time:
  - Freeflow Travel Time
  - Delay:
    - Recurring Delay
    - Non-Recurring Delay:
      - "Normal" Delay
Case study

- **Travel Time:**
  - Freeflow Travel Time
- **Delay:**
  - Recurring Delay
  - Non-Recurring Delay:
    - "Normal" Delay
    - "Abnormal" Delay
Case study

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[Diagram showing a graph with axes labeled 'Distance' and 'Time'. The graph illustrates various time points labeled $T_0$, $T_1$, and $T_2$. The graph also shows segments labeled 'Stop line', 'Target speed', 'Stopped delay', 'Queue delay', 'Deceleration', 'Running speed', 'Control delay', and 'Acceleration'.]
Case study
Case study
Case study
Modeling Road Traffic
Modeling Road Traffic

Input → Model → Output

?
Modeling Road Traffic

What for?
- For design purposes
- For assessment purposes
- For traffic management studies
- For Network/system performance

Why?
- Cities expansion
- Building new road
- Public transport implementation
- Road network management
- etc

To understand
- Congestion
- Pollution
- Noise
- Accessibility
Modeling Road Traffic

Input ➔ Model ➔ Output

?
Traffic Models

Traffic Flow Models

Level of Details
- Micro
- Meso
- Macro

Operationalisation
- Analytical
- Simulation
Bruce D. Greenshields (Born in Winfield, Kansas)

First descriptions about traffic flow were derived from the observation done by Greenshields

Shown to public in 1933 (Proceedings of the 13th annual meeting of the highway research board)

Source: http://www.krbalek.cz/For_students/mds/clanky/Greenshields.pdf
Limitations of traffic simulations

• Simulations are resource limited
  – Resolution: Level of detail
  – Fidelity: Degree of realism
  – System size: The network size to be covered
  – Simulation speed: Speed of simulation compared to real time
  – Resources: Computational resources, programming time
Road model definition

• Microscopic models
• Mezoscopic models
• Macroscopic models
## Popularity

<table>
<thead>
<tr>
<th>Type of Simulation</th>
<th>Number of Packages</th>
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<tbody>
<tr>
<td>Microscopic</td>
<td>65</td>
</tr>
<tr>
<td>Mesoscopic</td>
<td>3</td>
</tr>
<tr>
<td>Macroscopic</td>
<td>16</td>
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</tbody>
</table>
Microscopic models

• Each vehicle consideration
  – system entities are objects with specific decision-making
  – detailed entities interactions simulation

• Advantages and disadvantages
  – difficult implementation and tune
  – most realistic
Macroscopic models

• Vehicle flow consideration
  – vehicle distribution function
  – flow equation

• Advantages and disadvantages
  – microscopic details not included
  – Lot of calculations but fast
  – only for global traffic network
Mesoscopic models

• No specific vehicle consideration
  – vehicles making decision itself but like pattern (no objects)
  – interactions are on characteristic level

• Advantages and disadvantages
  – better interactions tuning
  – attributes of vehicle not consider
## Popular microsimulation models

<table>
<thead>
<tr>
<th>Model</th>
<th>Organisation</th>
<th>Country</th>
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</thead>
<tbody>
<tr>
<td>AIMSUN2</td>
<td>Universitat Politècnica de Catalunya, Barcelona</td>
<td>🇪🇸</td>
</tr>
<tr>
<td>ANATOLL</td>
<td>ISIS and Centre d'Etudes Techniques de l'Equipement</td>
<td>🇫🇷</td>
</tr>
<tr>
<td>AUTOBAHN</td>
<td>Benz Consult - GmbH</td>
<td>🇩🇪</td>
</tr>
<tr>
<td>CASIMIR</td>
<td>Institut National de Recherche sur les Transports et la Sécurité</td>
<td>🇫🇷</td>
</tr>
<tr>
<td>CORSIM</td>
<td>Federal Highway Administration</td>
<td>🇺🇸</td>
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<tr>
<td>DRACULA</td>
<td>Institute for Transport Studies, University of Leeds</td>
<td>🇬🇧</td>
</tr>
<tr>
<td>FLEXYT II</td>
<td>Ministry of Transport</td>
<td>🇳🇱</td>
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<tr>
<td>FREEVU</td>
<td>University of Waterloo, Department of Civil Engineering</td>
<td>🇨🇦</td>
</tr>
<tr>
<td>FRESIM</td>
<td>Federal Highway Administration</td>
<td>🇺🇸</td>
</tr>
<tr>
<td>HUTSIM</td>
<td>Helsinki University of Technology</td>
<td>🇫🇮</td>
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<tr>
<td>INTEGRATION</td>
<td>Queen's University, Transportation Research Group</td>
<td>🇨🇦</td>
</tr>
<tr>
<td>PARAMICS</td>
<td>The Edinburgh Parallel Computing Centre and SIAS Ltd</td>
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<td>---------------</td>
<td>-----------------------------------------------------</td>
<td></td>
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<tr>
<td>PHAROS</td>
<td>Institute for simulation and training</td>
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<tr>
<td>PLANSIM-T</td>
<td>Centre of parallel computing (ZPR), University of Cologne</td>
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<tr>
<td>SHIVA</td>
<td>Robotics Institute - CMU</td>
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<tr>
<td>SIGSIM</td>
<td>University of Newcastle</td>
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<tr>
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<td>SIMNET</td>
<td>Technical University Berlin</td>
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<td>SISTM</td>
<td>Transport Research Laboratory, Crowthorne</td>
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<tr>
<td>SITRA-B+</td>
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<tr>
<td>SITRAS</td>
<td>University of New South Wales, School of Civil Engineering</td>
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<tr>
<td>TRANSIMS</td>
<td>Los Alamos National Laboratory</td>
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<tr>
<td>THOREAU</td>
<td>The MITRE Corporation</td>
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<tr>
<td>VISSIM</td>
<td>PTV System Software and Consulting GMBH</td>
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Classification based on traffic conditions

<table>
<thead>
<tr>
<th>Urban</th>
<th>Motorway</th>
<th>Combined</th>
<th>Other</th>
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</thead>
<tbody>
<tr>
<td>CASIMIR</td>
<td>AUTOBAHN</td>
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<td>MICROSIM</td>
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Objects modelled

<table>
<thead>
<tr>
<th>Object / phenomenon</th>
<th>Modelled</th>
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<th>Modelled</th>
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<tbody>
<tr>
<td>Queue spill back</td>
<td>87%</td>
<td>Parked vehicle</td>
<td>35%</td>
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<tr>
<td>Weaving</td>
<td>77%</td>
<td>Pedestrians</td>
<td>26%</td>
</tr>
<tr>
<td>Incidents</td>
<td>65%</td>
<td>Weather conditions</td>
<td>26%</td>
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<tr>
<td>Commercial vehicle</td>
<td>61%</td>
<td>Elaborate engine model</td>
<td>19%</td>
</tr>
<tr>
<td>Roundabouts</td>
<td>58%</td>
<td>Search for parking space</td>
<td>13%</td>
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<tr>
<td>Public transports</td>
<td>52%</td>
<td>Bicycles / motorbikes</td>
<td>10%</td>
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<tr>
<td>Traffic calming measures</td>
<td>42%</td>
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</table>
Modelling Techniques

• Weather conditions are modelled by the speed-acceleration behaviour (changes in the driver behaviour parameters) or by the free flow speed of vehicles.

• Parked vehicles are modelled by a particular destination node, side parking on links, temporary incidents or by a particular state of vehicle.

• Commercial vehicles are modelled by parameters such as power, mass, length, privilege on certain lanes.

• Pedestrians are taken into account when turning flows interact with pedestrian areas or in extending intersection all red periods to simulate walk periods.
Modelling Techniques

• Incidents are modelled by lane closure signs, blocked lanes, "scheduled vehicles" and slow vehicles.

• Public transport, essentially buses, are modelled by vehicles with fixed routes.

• Traffic calming measures are modelled by local speed limits, yield sign objects, Variable Message Signs and route guidance.

• Queue spill back is modelled by space constraint in car-following and in link changing.

• Weaving is modelled by forced lane changing, special lane changing behaviour, decision rules or lane changing logic.

• Roundabouts are modelled by lane segments and yield sign objects.