Traffic Flow Theory and Simulation

H. Taale

Lecture 13
Evaluation, Simulation and Guidelines
Evaluation, Simulation and Guidelines

Measuring and estimating effects of traffic management

dr. Henk Taale
TrafficQuest

March 26th, 2012
Contents presentation

- Dutch traffic and transport policy
- Evaluation
- Simulation
- Guidelines
- Case study pilot traffic management Amsterdam
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Congestion in The Netherlands

- August 1925: disaster tourism to Borculo (twister)
- May 29th, 1955: to the beach on Whit Monday
- February 8th, 1999: busiest morning peak ever: 975 km.
- November 29th, 2010: busiest evening peak ever: 870 km
Congestion trend

Index VVU (2000 = 100)

- Development
- Targets
Aspects of congestion

- Balance of traffic demand and capacity
- Blocking back important cause of extra delay
- Capacity drop gives more and longer congestion
- Suboptimal choice behaviour leads to unbalanced distribution
Traffic and transport policy

**Building:** “very effective, expensive, long”

**Pricing:** “politically difficult”

**Traffic Management:** “effective, less expensive and quick”
Mobility policy document

• New plans for spatial developments and mobility
• More responsibility for provinces and municipalities
• Strengthen the spatial-economic structure of the Netherlands
• Liveable and secure environment
• Improve accessibility
  – Extra lanes for motorways
  – Increase frequency of PT
  – More usage of rush-hour lanes
• Standards for travel time
Traffic management long ago

Eerste stoplicht by Eindhoven in beeld

Traffic lights from 1919-1929 by lakelandgov
Traffic management 21st Century

Photo’s by Rijkswaterstaat
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Policy evaluation
Policy evaluation

Planning and priority

Cost-benefit

Implementation

Impacts

Plan

Do

Act

Check

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Evaluation levels

strategic – tactical - operational
Evaluation types (1)

- Monitoring: trends in time
- Evaluation: analysis of data to determine effects
- Ex-ante (feasibility study, model study)
- Ex-post (measurements, surveys, etc.)
- Technical analysis (system performance)
- Impact analysis (traffic, safety, environment)
- Socio-economic evaluation (effectiveness, costs)
- Analysis of legal and institutional aspects
- Analysis of behaviour and public acceptance
Evaluation types (2)

• Expert judgement
• Literature scan
• Monitoring with trend analysis
• Simulation study
• Quick scan analysis
• Impact analysis
• Cost-benefit analysis

• Local measures
• Set of measures
• Network traffic management
• Program evaluation
• General overview
Monitoring trends

Source: SWOV
Quick scan evaluations

- A lot of extensive evaluations available
- Extensive evaluations need a lot of data and take a lot of time to do
- Need for quick evaluations to know the effects of pilot measures
- Since 2004 monitoring data available for large part of motorway network
- MoniGraph is a tool to process data and generate traffic indicators
Monitoring data

Photo’s by Rijkswaterstaat

[TSW] 10D001048014D0050005
[SIW] 1115904360 12-05-05 15:26 j 60 60 480 104 0 0 BLK G

seconds since 01-01-1970

date

time

indications of reliability

status of detection

congestion indicator

state of AID

flow

speed

10D001048014D0050009

1115904360 12-05-05 15:26 j 60 60 1320 99 0 0 BLK G

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Photo’s by Rijkswaterstaat
Speed contour and travel time plot

Snelheid contourplot A4L, 05-03-2007

Reistijd A4L, km. 75.898 - 70.3, 05-03-2007

- Referentie
- Trajectorie variabele snelheid
Rush hour lanes A12

- Motorway A12 between junction Gouwe and Zoetermeer
- Operational since January 2010
- Use hard shoulder lane as extra lane in the morning and evening peak
- A12 between Woerden and Gouwe
- Bottleneck 4 -> 3 lanes
- Operational since 03-12-2010
Rush hour lanes A12


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Results rush hour lane A12 Gouda-The Hague

- Demand
- Total distance travelled
- Total delay
- Congestion
- Travel time

Percentage change

Morning
Evening
Speed contour plots A12 Gouda-The Hague
Results rush hour lane A12 Woerden-Gouda

<table>
<thead>
<tr>
<th>Percentage change</th>
<th>Demand</th>
<th>Total distance travelled</th>
<th>Total delay</th>
<th>Congestion</th>
<th>Travel time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>-20</td>
<td>-60</td>
<td>-80</td>
<td>-100</td>
</tr>
</tbody>
</table>
Speed contour plots A12 – Woerden-Gouda
Traffic management scenarios A13, A15 and A27
Results TM scenarios

- Demand
- Total distance travelled
- Total delay
- Congestion
- Travel time

Percentage change

- A13
- A15
- A27

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Policy evaluation

• Accountability
  – Goals: do we reach the goals set?
  – Efficiency: if the goals are met, what is the contribution of policy?
  – Effectiveness: what are the benefits and costs?

• Learning (act phase)
  – What are the effects and under what conditions are these effects valid?
  – Is it possible to deduce rules of thumb?
Explanation increase congestion

Traffic management

- Bevolking Banen Autobezit +47%
- Brandstofprijs -4%
- Verlaging belasting wonen werk +6%
- Verlaging snelheid verlaging en trajectcontroles +6%
- Overige factoren +6%
- Nieuwe wegen -2%
- Extra stroken -8%
- Verkeersmanagement -6%

2000 - 149%
Investment and effects of ITS

Cost and benefits of the Traffic Management program
1995 - 2000

Costs and benefits discounted as of 1995
Cumulative costs and benefits (price level 1998)

Period 1995 - 2010
Period 1995 - 2020

Estimated costs
Estimated benefits

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Photo by 9lives
Relation evaluation and models

- Models used in feasibility studies
- On all levels of the PDCA cycle
- To decide whether or not to implement measures
- Cheaper than real-life pilots
- No impact on drivers and safety
- Easy to study alternatives
Scale levels

- National policy
- Regional policy
- Measures
- Determine problems
- Operations
Overview models

- National network
- Regional network
- Urban network
- Arterial
- Road section

- Time step:
  - Tenths of seconds
  - Seconds
  - Minutes
  - Quarters
  - Hours
  - Days
  - Tenths of quarters
  - Peak periods
  - Days
  - Years

- Prediction horizon:
  - National network
  - Regional network
  - Urban network
  - Arterial
  - Road section

- Models:
  - LMS
  - MIXIC
  - VISSIM
  - FlowSimulator
  - NRM
  - Dynasim:
    - Geen routekeuze
    - Routekeuze
  - Sidra
  - Saturn
  - StreamLine
  - MARPLE
  - STAQ
  - Integration
  - FLEXSYT
  - Metanet
  - PARAMICS
  - Metropolis
  - AIMSUN
  - Dynasmart
  - Contram
  - MARPLE
  - INDY
  - LISA+
  - FOSIM
  - COCON
  - STAQ
  - TrafficQuest

- Language:
  - Dynamisch
  - Statisch
Dynamic models

- Developed since the sixties
- In the first place for optimisation of traffic control plans
- Webster: microscopic simulation to determine delay formulas in 1958
- Take the time component into account
- Divided into:
  - Macroscopic (traffic as a flow)
  - Microscopic (individual vehicles)
  - Mesoscopic (hybrid form)
Models used in The Netherlands

- **Macroscopic**
  - FASTLANE
  - INDY
  - MaDAM (StreamLine)
  - MARPLE (RBV)

- **Mesoscopic**
  - DYNASMART
  - FLEXSYT-II-
  - METROPOLIS

- **Microscopic**
  - AIMSUN
  - FOSIM
  - Paramics
  - VISSIM

Photo by 9lives
FASTLANE
MARPLE (RBV)
Paramics
Advantages and Disadvantages

• Advantages
  – Realistic modelling of the traffic
  – Gives good knowledge of effects of measures
  – Visualisation and presentation

• Disadvantages
  – Need a lot of detailed input data
  – Calibration is difficult
  – Computer run time is (still) long for larger networks
  – Danger of focus on graphics!
Applications

- Effects of traffic management measures
- Effects of changes in the infrastructure
- Road works
- Testing of systems
- Training of operators
- Decision Support Systems
- Optimisation of traffic control plans
- Part of evaluations studies
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Problems with Evaluations (1)

- About 150 evaluations studies
- Non-uniform approach evaluation studies
  - Different for every measure
  - Different by every consultant
  - Different measure and statistical methods
  - Difficult to compare evaluations
- Local effects (not much research on network wide traffic management)
- Effects on safety and sustainability unknown
- No much information about driver behaviour
- Difficult to determine costs and benefits
Case ramp metering
Effects of ramp metering

- Increase in capacity
- Increase in speed

Coentunnel (1 on-ramp)
Coentunnel (4 on-ramps)
Delft-South (1)
Delft-South (2)
Zoetermeer
Schiedam-North
Barendrecht
Kolkweg
Vianen
Vinkeveen

Speed (km/hr)

-15 -5 0 5 10 15 20 25 30
## Overview important effects

<table>
<thead>
<tr>
<th>Measure</th>
<th>Effect on traffic</th>
<th>Effect capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Motorway Traffic Management System</td>
<td>Flow improvements 0%- 5%</td>
<td>0% to 5%</td>
</tr>
<tr>
<td>2 Speed Measures (80 km/hr zones)</td>
<td>Congestion varies from -40% to +53%</td>
<td>-9% to +4%</td>
</tr>
<tr>
<td>3 Ramp Metering</td>
<td>Speed on the motorway increases: +4 to +30 km/h</td>
<td>0% to +5%</td>
</tr>
<tr>
<td>4 Overtaking prohibition trucks</td>
<td>Different per location</td>
<td>-4% to +4%</td>
</tr>
<tr>
<td>5 Peak lanes (using hard shoulder)</td>
<td>Decrease travel times from 1 to 3 minutes</td>
<td>+7% to +22%</td>
</tr>
<tr>
<td></td>
<td>Extra traffic from 0% to +7%, delay -42% on average</td>
<td></td>
</tr>
<tr>
<td>6 Bus lanes, truck lanes, tidal flow lanes</td>
<td>Travel time busses/trucks –14 minutes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Travel time other traffic from –5 to +2 minutes</td>
<td></td>
</tr>
<tr>
<td>7 Measures for Road Works</td>
<td>Less demand, sometimes to –11%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Less traffic on the section with road works: to –38%</td>
<td></td>
</tr>
<tr>
<td>8 Traffic Signal Control</td>
<td>Change in travel times from –33% to +10%</td>
<td></td>
</tr>
<tr>
<td>9 Other measures</td>
<td>Congestion from –28% to +45%</td>
<td></td>
</tr>
<tr>
<td>10 Incident Management (camera’s)</td>
<td>Congestion –7% (Utrecht)</td>
<td></td>
</tr>
<tr>
<td>11 Dynamic Route Information Panels (VMS)</td>
<td>Congestion from –7% to –30%</td>
<td></td>
</tr>
<tr>
<td>12 Radio Traffic Information</td>
<td>Route changes, more change if travellers are informed individually</td>
<td></td>
</tr>
</tbody>
</table>
Problems with Evaluations (2)

- Lot of knowledge on traffic related aspects
- Not much known on the effect on policy indicators
  - Except for program evaluations and incident management
  - Relevant questions not asked?
- Effects for irregular conditions not known
- Not much known about conditions which are related to the effects
Guidelines

- Purpose of the guidelines
  - To structure and disseminate knowledge
  - To uniform methods

- Existing guidelines?
  - European guidelines (CORD, CONVERGE, TEMPO)
  - Guideline for policy evaluations
  - Guideline for impact analysis
  - Guideline for evaluation of traffic management scenarios
  - Guideline for simulation studies
Guideline for evaluation studies

• Organise project and write evaluation plan
• Select and describe measures
• Define use cases, situations and scenarios
• Define research questions and hypotheses
• Research design
• Indicators
• Legal issues
• Sensors and measurements
• Data collection, database and analysis tools
• Data selection and data analysis
• Answer research questions
• Report and communicate results
Evaluation plan

• Necessary for
  – Good tender procedure
  – Make sure that all parties involved have the same expectations
  – Improve comparability of evaluation studies

• Contents
  – Description of the measure
  – Goal of the evaluation
  – Research questions
  – Significance of effects
  – Research design
  – Indicators
  – Study area
  – Data collection
  – Data selection
  – Analysis
  – Report
  – Organisation
  – Communication
Guideline for simulation studies

- Define problem
- Define goals
- Choose model
- Prepare application
- Apply model
- Analyse results
- Report study
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Traffic management trial Amsterdam

- Network approach for traffic management
- Traffic Management Trial Amsterdam: test case
- Is coordinated network-wide traffic management cost effective?
- Coordinated control of the local traffic management measures
- Trial should provide knowledge about:
  - Optimising traffic flows in a network
  - Optimising local and coordinated measures
  - Coordinated application of traffic management in a network
  - Adaptation of the behaviour of the road users
  - Transferability of the results
Study area
Bottlenecks evening peak
Bottlenecks urban network peak periods

Legend
- Intersection blocked
- Blocking back to other roads
- Short cut
Selection of measures

- **Local approach**
  - Directed at separate bottlenecks
  - Optimise traffic flows on main road network
  - Optimise outflow from main road network

- **Network approach**
  - Directed at connection between bottlenecks
  - Reroute traffic aiming at an equal distribution on the network
  - Priority is for the ring road A10
  - Control inflow to the main road network
metering with traffic signal
ramp metering system
coordinated traffic signal control
improvement of merging
metering for motorway junctions
DTA model MARPLE

- Model for Assignment and Regional PoLicy Evaluation (MARPLE)
- Macroscopic, based on realistic travel time functions, also for controlled links, roundabouts and priority
- Route choice for predefined routes (deterministic and stochastic)
- Traffic flows through the network based on capacities of links and nodes (blocking-back)
- Part of Regional Traffic Management Explorer
  - Sketch planning and modelling tool
  - Quantify benefits of sets of measures
  - Compare different scenarios
  - National tool, independent of consultant
  - Plug-in of OmniTRANS software
Structure DTA model

- Transportation network
- Route set generation model
  - Routes
- Dynamic route choice model
  - Route flows
  - Travel times
- Dynamic network loading model
  - Travel demand
Approach modelling study

• Use an existing network as the base network
• Update network
  – Intersection types
  – Network types
• Measures (existing and new ones)
  – Infrastructure adjustments (capacity)
  – Ramp-metering (control algorithm)
  – Information to road users (route choice parameter)
• Calibration
  – Capacity of weaving sections
  – Demand for certain OD pairs
  – Traffic signal control settings
Netwerk
Calibration

Evening peak 2007

file per dag
- > 2 uur
- > 1 uur
- > 1/2 uur
- > kwartier
- ≤ kwartier
- geen data

2012-07/74

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Simulation runs

- Two periods
  - Extended morning peak (05:30 – 11:00 hrs.)
  - Extended evening peak (14:30 – 20:00 hrs.)
- Three scenarios
  - Base year 2007
  - Traffic management trial local
  - Traffic management trial coordinated
- Output indicators
  - Vehicle kilometres driven (per sub network)
  - Vehicle hours delay (per sub network)
  - Travel times for 25 relations
Results vehicle kilometres evening peak

- Ring A10
- Other MW
- Urban
- Total

Index kilometres

Base 2007
TMT local
TMT coordinated

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Results vehicle hours delay evening peak

<table>
<thead>
<tr>
<th></th>
<th>Ring A10</th>
<th>Other MW</th>
<th>Urban</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base 2007</td>
<td>110</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>TMT local</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>TMT coordinated</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
</tbody>
</table>

Legend:
- Red: Base 2007
- Yellow: TMT local
- Blue: TMT coordinated
Other benefits evening peak

- **Travel times**
  - 9 routes improvement > 1 minute
  - 15 routes improvement < 1 minute
  - 12 routes no improvement
  - 10 routes longer travel time < 1 minute
  - 1 route longer travel time > 1 minute

- **Savings in delay (simple calculation)**
  - TMT local: about 1000 veh.hrs less delay, per year sums up to EUR 1.9 million
  - TMT coordinated: about 1500 veh.hrs. less delay, per year sums up to EUR 3.0 million
Evaluation local measures

- Local measures implemented
  - 32 ramp metering systems
  - Connection with local signal control
  - Adjustments for 6 local intersections
  - Adjustment for some weaving sections on the A10

- Results
  - Delay on A10: -10.8% (simulation -10%)
  - Congestion: -14%
  - Travel times inner ring morning: -5.5%
  - Travel times outer ring morning: +10.3%
  - Travel times inner ring evening: -12.5%
  - Travel times outer ring evening: -7.0%
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Summary

- Traffic management is essential part of the Dutch traffic and transport policy
- Evaluation (with models or measurements) is common practise in The Netherlands
- A lot of experience with traffic management and traffic impact analysis
- Models are not the solution to a problem, but are tools to analyse the problem, study alternatives and choose the most effective one
- A model is as good as the person using it
ITS Edulab

- Cooperation Rijkswaterstaat DVS and Delft University of Technology
- Goal: connection between scientific research and the actual practice of Rijkswaterstaat
- Rijkswaterstaat DVS
  - Workplaces, PC’s, data, models, etc.
  - Research topics and questions
  - Part of the supervision of students
- TU Delft
  - Research questions
  - Supervision of students
  - Educational program and public relations towards students
Colophon

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Pictures: Rijkswaterstaat, Wikipedia

Thank you for your attention!