The TomTom Manifesto – Reducing Congestion for All
Big traffic data for smart mobility, traffic planning and traffic management

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Traffic Flow Measurement Beginnings
Measurements and Modeling started in the 1930s

Greenshields, 1935
Measured Data from Stationary Detectors

- Induction loops or infra-red sensors
- Measurement at cross-sections
- Aggregated e.g. over 1 min
- Flow and/or speed measurements
- Infrastructural installation
- Expensive maintenance
Real-time Traffic: From Modeling to Measuring

Classical tools for observing traffic flow: Simulation and Data from Loop-Detectors

Simulated elementary traffic jam patterns:

[Three 3D graphs depicting simulated traffic patterns labeled MLC IDM, SGW IDM, and OCT IDM.]

Interpolated and smoothed data from loop detectors:

[Three 3D graphs showing interpolated data from loop detectors labeled A5 South, June 06, 2001, A5 South, May 07, 2001, and A5 South, July 31, 2001.]
Change
Smart vehicles start exchanging data
And they will change the way traffic is managed
Facebook Social Activity Graph
(friend interactions)
A Driver Community of 400M users globally
- ~10 billion measurement per day
- ~13 trillion measurements since 2007
Speeds Over Time (City, e.g. Berlin)
Speed Frequencies Weekdays (City e.g. Berlin)

Speed distribution

number of probes

Frequency
accDistribution

6 km/h
43 km/h
Highway DE, A13 Direction Dresden
Highway A100 Berlin, Direction Junction “Funkturm”
Construction Impact Berlin
Hauptstr. Direction Treptower Park
Road Traffic Analytics

Route Travel Times

Area Analysis
Segments Speeds in an area

Relative Probe Vehicle Flow
Proxy for traffic density

Traffic Index
City performance analysis

Speed Profiles
Speeds for navigation

Origin-Destination
Relations between zones
IQ Routes Speed Profiles

Static Speed Profiles for A10 (west, south bound)
Storage Requirements For Speed Profiles

The NL road network map: ~2 Mio. road stretches
European map: ~50 Mio. stretches in the graph
50 Mio. Stretches X 7 weekdays X 24 hours X 12
(to gain a 5 minute resolution)

**Difficult on sparse PND storage resources**
Find $n$ reference profiles out of $m$ real speed measurement profiles

$n$: $<100$
$m$: $2-50$ Mio. road stretches of a map graph
IQ Routes Historic Speed Profile - Example

A 13 Rotterdam -> Delft
Compression of speed profiles per road stretch

Each road stretch in the network graph holds a pointer to the best fitting reference profile (surrogate) for each weekday (7xInteger between {1..100})

Instead of a measurement matrix 7dx24hx12 (5 minute resolution) for each road stretch of the graph

- For each surrogate profile (~100) 24h+12 data sets for the speed have only be stored

- Surrogate reference profiles are created in a training run on demand

- Done
TomTom Congestion

Traveltime delays compared to free flow situation at night hours

http://www.tomtom.com/trafficindex
Traffic Index – Minneapolis/St Paul (1/2015)

Map showing Minneapolis and surrounding areas with congestion levels. The image includes a map with a section indicating Minneapolis with a congestion level of 17%. There are also charts showing morning and evening peak congestion levels for different days of the week. The charts show varying levels of congestion across the days.

Table showing comparison of traffic congestion in Minneapolis, Chicago, and Detroit. Minneapolis has the lowest congestion level at 17%, followed by Chicago at 27% and Detroit at 18%.

Chart indicating delay per day with a 30 min commute, showing an average delay of 16 minutes.
Route Analysis 2014
Traffic Demand and Flow Analysis (Origin Destination)

Selected link: links to links

Selected link: zones to zones

Route choice

OD Matrix

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<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
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<tbody>
<tr>
<td>A</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>20</td>
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WHERE DO THE TRAFFIC COME FROM?

Site owners want to know where customers come from that visit or pass by their location.
REAL-TIME TRAFFIC
GPS PROBE DATA SOURCES

- PND GPS
- Fleet GPS
- In-Dash GPS
- APP GPS
- Journalistic data
- Detector loops /cameras

IQ Routes
Traffic Incidents and Traffic Flow

19 May 2015 6:52

File contains information ONLY for the road stretches affected by incident/congestion

Accurate delay, start and end location

Current speed information on all relevant roads – both congested and freeflow
Traffic Incidents and Traffic Flow

19 May 2015 8:10

- File contains information ONLY for the road stretches affected by incident/congestion
- Accurate delay, start and end location

Current speed information on all relevant roads – both congested and freeflow
Time-Space Characteristics

Local detection (loops)

Moving Detection Floating Car

Probe vehicle (e.g. GPS)
About Hens and Eggs ...

Target: Detection of Jam clouds

High FCD vehicle penetration needed
Probe Data as the Input Source

Equipment percentage and traffic flow determine data density

Data amount grew exponentially

<table>
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<tr>
<th>Avg. Interval</th>
<th>100/h</th>
<th>500/h</th>
<th>1000/h</th>
<th>2000/h</th>
<th>5000/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1%</td>
<td>600 min</td>
<td>120 min</td>
<td>60 min</td>
<td>30 min</td>
<td>12 min</td>
</tr>
<tr>
<td>1%</td>
<td>60 min</td>
<td>12 min</td>
<td>6 min</td>
<td>3 min</td>
<td>1.2 min</td>
</tr>
<tr>
<td>10%</td>
<td>10 min</td>
<td>1.2 min</td>
<td>0.6 min</td>
<td>1.2 min</td>
<td>0.12 min</td>
</tr>
</tbody>
</table>

Received Floating Car Data

2010 2011 2012
Real-time Traffic
Highly granular traffic based on GPS probe data

- GPS data allows traffic observation everywhere
- Independent from stationary devices
- High Sampling rate
Static Location Referencing TMC (Traffic Message Channel)
Data Compression and map independency

### Incident Description

- TMC link ID
- Positive or negative direction on road
- Offset from start of link
- Offset from end of link

**Example:**
- TMC ID = 09876
- Positive direction
- + 200m from start
- - 150m from end

Offset of +200 m from start of link
Offset of -150 m from end of link
TMC vs Dynamic Location referencing with OpenLR™

Coverage increase with OpenLR™ in London urban area Compared to TMC

- OpenLR covers the whole network
- OpenLR works using different maps for encoding and decoding
- Open Source and royalty free
- Compact and on-the-fly processing (no pre-compilation with the map)
OpenLR Location Referencing

Encoder
- Lat, long
- FRC
- FOW
- Bearing
- length

Location reference

Decoder
- Lat, long
- FRC
- FOW
- Bearing
- length

Sender map

Receiver map
TomTom Traffic

Queue End Warnings

Traffic Flow and jam prediction

HOV lane handler

Automatic road work detection

Automatic road closure detection on lower FRCs
Queue End Warnings
Detection of queue ends for a safety warning in the navigation unit

- Over 35% of drivers have admitted to experiencing an accident caused by sudden or unexpected traffic holdups
- Jam ahead warning messages in traffic output can be used to create these safety messages with great accuracy
Impacts of Weather on Traffic

- Road network capacity changes
  - Head way distance increases, driver behaviour
- Demand changes
  - Average speed reduction
  - ETA deviation
- Extreme situations/danger
  - Icy roads, snow, heavy rain, sand storm
Moreover...

~30% of severe accidents are caused by critical weather!
Traffic and Weather
Snow & delay impact
Weather related traffic information (device)

- Bad weather that impacts traffic such as heavy rain, snow or hail is displayed by using weather data in our fusion engine
- Weather information will be used for improving traffic prediction
Connected, Smarter Car – TomTom components offer a seamless experience

Navigation Portal

NavKit & NavApp

Companion App
ADAS features gradually realize the HAD vision

Examples
- Anti-lock Braking System
- Adaptive Cruise Control
- Park Assist
- Traffic Jam Chauffeur
- Highway Pilot
- Full Automation
TomTom enables HAD cars to see beyond their sensors

**Real-Time Maps**
- 3D Lane Model
- Behavioral Data
  ...

**Software Components**
- Positioning
- eHorizon
  ...

**Connected Services**
- Advanced Traffic
- Advanced Weather
  ...

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The TomTom Traffic Manifesto
http://www.tomtom.com/trafficmanifesto

If 10% of the road drivers use HD Traffic guided navigation in conurbations there is a
1. Individual journey time reduction for informed users by up to 15%
2. A collective journey time reduction for ALL by up to 5%
How to estimate the journey time reduction claims in the TomTom Manifesto?

- Use of traffic modelling and simulation in a simplified road network
- Assume a share of equipped navigation users (e.g. traffic guided drivers)
- Assume high acceptance rate for detour choices when approaching a traffic jam!
- Results from simulation below for medium and high traffic flow

The (future) Collective Traffic Management Challenge
Load balanced vs unbalanced routing system using dynamic route guidance
Construction Management
Mobile VMS for Travel time Display

Seestrasse in Zürich, Schweiz

Usage of Flow Data for two routes towards Zürich. Data gets updated every 30 seconds

The main route faces delays due to construction works

By using Flow data and adding the travel times of the relevant segments together a accurate travel time is calculated

This travel time is displayed on the VMS sign and gets updated every 5 minutes.
Junction Analyzer
Statistics about junction delays

Analyze the performance of a intersection

Compare before with after a intersection upgrade

Rank the performance of a (set of) intersection (KPI’s)

Output information about:
- travel time ratio
- total delay time
- delay per junction
- stops per junction
- duration per stop
- number of measurements
- intersection ranking
Educated Guess 1st – Probe Data Source?
Educated Guess 2nd – Probe Data Source?

Absolute Speed: A13 - A113

Germany-PROD .dseg.chicago [ALL,0,E,P] A13 - A113 [27.1.2014 09:01:00-11:30:59]

NorthernEurope+motorway200_TeleAtlas_eur2012.06-22.0-33@993857.1340263775

Time [UTC]

Distance [m]

0.0 km/h