Intelligent Transportation in the Era of Big Data

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ITS Components

• **Intelligent Infrastructure** *(Traffic signs, sensors, VMS, to monitor, help, control, and make traffic more efficient)*

• **Smart vehicles** *(equipped with sensors enabling automatic crash notification, intelligent speed assist, intelligent cruise control, reverse and forward collision warning, GPS navigational systems, and alcohol ignition interlocks, .....)*

• **Information services** *(providing real-time guidance information, phone, in-car navigation systems receiving current traffic conditions to guide you around congestion hotspots, .....).*
Overview of ITS Applications

Intelligent Infrastructure

- Arterial management
- Freeway management
- Crash prevention and safety
- Road weather management
- Roadway operations & maintenance
- Transit management
- Traffic incident management
- Emergency management
- Electronic Payment
- Traveler information
- Information management
- Commercial vehicle operations
- Intermodal freight

Intelligent Vehicle

- Collision avoidance
  - Intersection collision warning
  - Obstacle detection
  - Lane change assistance
  - Lane departure warning
  - Rollover warning
  - Departure warning
  - Rear impact warning

- Driver assistance
  - Navigation
  - Driver communication
  - Vision enhancement
  - Adaptive cruise control
  - ...........

- Collision notification

Source: Research & Innovative Technology Administration - RITA
ITS For Sustainable mobility

• Growing interest in safety, security, quality and efficiency.
  – Using vehicles more productively can provide the same or better access to transportation services with 46-84 % less driving (source RMI Reasearch).

• Create vehicles and mobility society in which people can live with a sense of safety and comfort.
  – Reduction of congestion by up to 25%
  – improvement in the quality of travel
  – Improving the safety by up to 25%,
  – contributing to the European overall goal of reducing casualties by 50%,
  – CO2 emission reductions by 10%  
  (Source : EasyWay)
When the 3Is meet the 3Vs

• Intelligent Transportation Systems: the 3Is:
  – Instruments (smartphones, sensors, OBU, any hardware collecting, communicating and processing mobility data)
  – Interconnected (V2V, V2I, V2X) cooperative technologies
  – Intelligence (Software applications, Apps, graphical interfaces)

• Big Data relates to the 3Vs:
  – Volume is Big – Terabytes and petabytes,
  – Variety (what form-internal, external, structured, row,...)
  – Velocity (grows fast, changes quickly – Real time capture, low latency)
## How big is Big Data?

<table>
<thead>
<tr>
<th>Unit</th>
<th>Size</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit (b)</td>
<td>1 or 0</td>
<td>Short for binary digit</td>
</tr>
<tr>
<td>Byte (B)</td>
<td>8 bits</td>
<td>Enough information to create a letter or number in computer code. Basic unit of computing.</td>
</tr>
<tr>
<td>Kilobyte (KB)</td>
<td>$2^{10}$ Bytes</td>
<td>From “Thousand” in Greek. One page of typed text is 2KB.</td>
</tr>
<tr>
<td>Megabyte (MB)</td>
<td>$2^{20}$ Bytes</td>
<td>From “Large” in Greek. Roughly, 1 MB is the data of a traffic event per day. A mp3 song is 2-3 MB.</td>
</tr>
<tr>
<td>Gigabyte (GB)</td>
<td>$2^{30}$ Bytes</td>
<td>From “Giant” in Greek. Roughly the data from a traffic detector per day. 1 movie from the net.</td>
</tr>
<tr>
<td>Terabyte (TB)</td>
<td>$2^{40}$ Bytes</td>
<td>From “Monster” in Greek. NY Stock Exchange daily production.</td>
</tr>
<tr>
<td>Petabyte (PB)</td>
<td>$2^{50}$ Bytes</td>
<td>In 2020, 150 million actively connected vehicles will generate over 11 petabytes of data (annual).</td>
</tr>
<tr>
<td>Exabyte (EB)</td>
<td>$2^{60}$ Bytes</td>
<td>The world effective capacity to exchange info thru telecom is 670 EB in 2014. All sensor data record is 500 EB per day.</td>
</tr>
<tr>
<td>Zettabyte (ZB)</td>
<td>$2^{70}$ Bytes</td>
<td>The total amount of information available is forecast to be around 1.5 ZB</td>
</tr>
<tr>
<td>Yottabyte (YB)</td>
<td>$2^{80}$ Bytes</td>
<td>Currently too big to imagine</td>
</tr>
</tbody>
</table>
POLICY ISSUES

• How much of these big data do we need to get the job done?
• What happens in a world of transparency, with data widely available?
• Data ownership? Procurement of data?
• What about security? Driver Distraction?
• What about privacy of users?
• Can big data replace management?
• Are we talking of a new business model based on data?
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The Convergence of Intelligent Transportation and Electronic Toll Collection

The Future of Integrated Transportation Management Systems
A North American Viewpoint

October 20, 2014
History Lesson.....

• Mobility 2000 → IVHS → ITS / Telematics
• 28 User Services
• ETC was an integral part of the ITS Program
Divergence / Convergence Timeline

- ETC
- ETC/ITS
- ITS
- Early 1990s
Why the Divergence???

• Electronic Tolling had...
  – Commercialized Products
  – Standardization efforts
  – Strong Return on Investment

• ITS had....
  – Emerging Technologies
  – Demonstration Projects
  – Need for funding sources
The Convergence has Begun

• Electronic Tolling ...
  – Was transitioning into 2\textsuperscript{nd} or 3\textsuperscript{rd} generation systems (ETC-ORT-MLFF)
  – Widely accepted and deployed

• ITS had....
  – Mature, standards based technology
  – Demonstrated benefits
  – Cost effective applications
Divergence / Convergence Timeline

- **ETC**
  - Early 1990s
- **ITS**
  - ~2005
- **ETC/ITS**
  - 2010
- **Today**
  - 2014
Today Convergence is Required

• Managed Lanes …
  – Toll rates need to be set based on actual traffic conditions

• ITS ….
  – Is required to properly set toll rates

• Operations…
  – Traffic and revenue are managed by the same resources
LBJ / NTE Managed Lanes – Dallas, Texas
LBJ / NTE by the Numbers

North Tarrant Express.
- 2 road segments in 13.5 mile corridor
- 3 General Purpose, 2 Managed Lanes and 2 FRL per direction
- 11 Toll Zones
- Service commencement on June 2014
- Second Segment went live on October 2014

LBJ Express.
- 17 miles long corridor in 3 road segments
- 4 General Purpose, 3 Managed Lanes and 3 FRL per direction
- 18 Toll Zones
- First Segment went live on November 2013
- Second Segment went live July 2014
ITS & ETC  Integrated Technologies

TRS & DMS Signs

CCTV & MVD
Integrated Traffic Operations
Integrated Maintenance

Toll Zone Status: LBJ Zone 7T

Lane 2
66 MPH

Lane 1
69 MPH

Outside shoulder
72 MPH
Traditional Approach to Design

MOMS

Toll Zone & Sensors

TCS

Toll Ops

BOS

ITS Sensors & Equip

ATMS

TMC

511 & Public

MOMS
Integrated Approach to Design

- Toll Zone & Sensors
- TCS
- BOS
- MOMS
  - Toll Setting Module
  - Int Ops Ctr
- ITS Sensors & Equip
- ATMS
- 511 & Public
- ITS Sensors & Equip

The Convergence of ITS and ETC
Convergence of ITS and ETC

Integrated Transportation Management Systems

ETC

ITS
Driving Change: Managed Lanes
Driving Change: Connected Vehicle
Driving Change: Market Demand

- LBJ/NTE Express Lanes
- I-95 Express Lanes in Virginia
- I-95 Express Toll Lanes in Maryland
- I-75 and I-575 Express Lanes in Georgia
- NC I-77 HOT Lanes in North Carolina
- I-4 Managed Lanes in Florida
- ... More Coming
Dan Toohey
Kapsch TrafficCom North America

We Make Your Traffic Flow

Thank You
CHRISTINA EBLI
DRIVE

Accelerate cooperative mobility

AUTOSTRADA DEL BRENNERO SpA
BRENNERAUTOBahn AG
TS Italy Overview

- Italian A22 motorway
- Free flow
- 9 km, 2 ways
- 2 lanes/direction
- 10 Cooperative vehicles
- 5 Roadside ITS Stations (RIS)
- Service Centre in Trento
- 802.11p, UMTS, Ethernet
- Roadside sensors
TS Italy: location and infrastructure
Vehicle adaptation

- DRIVE C2X ref. VIS
- ITS-G5
- UMTS
- Positioning
- Vehicle data access
- Vehicle applications
- Logging system

5.9 GHz
Omnidirectional Antenna
6 dBi

Communication Control Unit (CCU)
ITS-G5

GPS antenna
Coaxial

UMTS
Coaxial

GPS
USB

Application Unit (AU)
Ethernet

Vehicle network
CAN

HMI (display)
VGA

Autostrada del Brennero SpA
Brennerautobahn AG
Infrastructure adaptation

- DRIVE C2X RIS architecture
- Directional antennas on roadside poles or gantries
- Roadside CCU’s connected to AU’s via optical fibre
- Traffic and weather sensors for TS specific data
Service Centre Adaptation

- **Office**
  - Test mng.
- **Service Centre**
  - **Drive C2X**
    - Test Management Centre
  - **Adaptation from Coopers**
    - Use Case Unit (for function trigger and config.)
  - **Legacy, no adaptation**
    - Road sensors
    - VMS
    - Databases, interfaces, etc.
- **Road**
  - **Drive C2X**
    - UMTS
  - **VIS**
    - ITS-G5
  - **RIS**
    - AU nr 1
    - CCU nr 1
  - **IS**
    - AU ...
  - **RIS**
    - CCU...
Functions

- Traffic Jam Ahead Warning
- In Vehicle Signage
- Wrong Way Driving
- Slow Vehicle Warning
- Car Breakdown Warning
- Approaching Emergency Vehicle
- Motorcycle warning
- Road Works Warning
This presentation showed a video here.

Get more information at [http://www.drive-c2x.eu/project](http://www.drive-c2x.eu/project)
Benefits

• safety
  telematics Horizon

• efficiency
  traffic management improvement
  traffic information improvement

• sustainability
  intelligent route guidance
  sustainable road traffic

• convenience
  safety – efficiency – implementation of commercial services
THANK YOU FOR YOUR ATTENTION!

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www.autobrennero.it
Using Big [Traffic] Data to help Drivers, Road Authorities and Businesses
Creating Traffic Information

Range of high-quality real-time data sources

- Fleet GPS
- Journalistic data
- PND GPS
- GSM
- In-Dash GPS
- APP GPS
- Detector loops / cameras
Car-centric Route Guidance – Benefits for ALL

TomTom’s missions

**Service Provider**

- Help drivers get to their destinations as quickly, safely and easily as possible.

**Road Operator?**

- Reduce traffic congestion for all road users, by enabling efficient use of existing infrastructure.

**Provide high-quality travel information so individuals can make better travel decisions.**

- Encourage travellers to think consciously about their options, in terms of (for example) departure time, route choice, travel mode.

**Actively work on the creation of new coalitions of the ‘players’ in the world of mobility.**

- Provide tools for transport authorities to manage traffic and plan
Traffic Management: Traditional Situation

Road authorities VS service providers

Inform Driver

Measure

Influence Traffic

Inform Driver

Measure

Guide Driver

Image of traffic congestion and navigation system.
Traffic Management 2.0

Road authorities & service providers

Inform Driver

Guide Driver

Measure

Influence Traffic
Working with transportation authorities
Our (Historical) Big Data looks like this...
Traffic Index

Index values calculated for each individual road segment.

Los Angeles

Istanbul
Traffic Index

Why and for whom?

• Encourage travelers to make smarter decisions using modern technology and information sources

• Help the public understand they should not expect cities to ‘build their way’ out of congestion

• Help authorities identify and diagnose trouble spots in the network and make more informed investment decisions
TomTom & Privacy

• Privacy is a true concern to us all. Nevertheless, when handled correctly it can also become an important differentiator in the marketplace. Collecting and using data from individuals must adhere to strict rules. At TomTom, we take privacy of our end-users very seriously. Our systems, software and the way in which we employ them, are built using ‘privacy by design’. For example, all of our location data is anonymized as soon as possible. Customers have to explicitly opt-in but can also opt-out at any given moment.

• TomTom avoids tracking of drivers by segregating location data into independent and short time sequences. TomTom also cannot and will not try and re-identify individuals from the location data collected. Additionally TomTom only delivers aggregated data and by doing so thwarts any residual potential for re-identification of individuals. Our approach has been independently verified by external audits, including a leading European Data Protection Authority.
TomTom Historical Traffic

Requirements:
The operating company managing the 407 toll road in Ontario requires reliable data for measuring travel times on the 407 facility. This is required for understanding overall performance as well as the travel time savings that the 407 offers drivers compared to alternative routes.

Solution:
TomTom’s historical traffic database, Traffic Stats, provides objective and easy-to-use travel time measurements and reporting which can easily be processed and, if necessary, combined with other data sources.
TomTom Traffic - Traffic Stats

Requirements:
Provide accurate, objective measure of the true benefits of a redesign of a motorway interchange (before & after study). This redesign is part of the Gauteng Freeway Improvement Project.

Solution:
TomTom GPS-based probe data was used to measure actual changes in speeds and travel times.

- Cumulative Travel Time has reduced from 23 min to 12 min
- Buccleuch to New Road used to take 15 min, which can now be done in about 5 min
- New Road in Midrand remains a bottleneck and increase the travel time with about 3-4 minutes
**Requirements:**
Customer wanted to understand whether a high percentage of drivers bypass a toll plaza on the AutoRoute – and are those that bypass the toll only local drivers or also long distance travellers. Existing loop counters did not provide information on route choice or origin.

**Solution:**
TomTom Origin-Destination data was used to provide the answers quickly using the stored retrospective data in the historical traffic database.
Requirements:
Customer wanted to test alternatives for their field surveys as a reliable travel time analysis tool.

Solution:
Chose TomTom Custom Travel Times as a source of GPS travel times due to readily available data to compare with other methodologies. Results confirmed TomTom has higher sample sizes and higher accuracy for all roads in Western Australia and is a cost-effective and time efficient option for their needs.
**TomTom Traffic - Custom Origin Destination**

**Requirements:**
Understand the travel market for the highway system in the Atlanta area based on actual measured trip movements, as a basis for studying toll revenue potential.

**Solution:**
An extended model was built based on Origin Destination matrices for a large number of on and off ramps in the Georgia area for different time spans to provide the data the customer needed.
VMZ Berlin
Berlin Traffic Control Centre

TomTom Traffic - Flow

Requirements:
Regional government in Berlin contracted VMZ (wholly owned subsidiary of Siemens) to run the traffic control centre to monitor traffic conditions and manage the traffic flow throughout the region – on major roads and secondary roads.

Solution:
Chose TomTom Traffic to provide speed information on all strategic roads in the region every minute. OpenLR location referencing used for information on all FRC 0-4 roads.
TomTom Traffic – Incidents and Flow

Requirements:
Regional traffic management agency wanted additional real-time traffic information to add to their existing data and improve their traffic forecasting capabilities and hence reduce congestion by taking pre-emptive action.

Solution:
Chose TomTom Traffic data due to its freshness and detail. OpenLR used to give insights into the performance of the secondary roads in addition to the major roads.
TomTom Traffic - Route Times

**Requirement:**
Government required contractors to ensure surface traffic was not affected during construction of tunnel to improve the major highway (A2) linking Belgium and Netherlands.

**Solution:**
Chose TomTom real-time route time information to monitor 24 representative routes every minute around the work zone to show no significant increase in travel times.
TomTom Traffic - Flow

Requirements:
Highest quality traveller information for the Basque area to enable the Traffic Control Centre to have a full view of the traffic status in the area to keep all routes operating efficiently.

Solution:
Chose TomTom Traffic Flow information to give their Traffic Management Control Centre the best insights into the real-time performance on the road network.
TomTom Traffic - Route Times

Requirements:
Traffic management at major event across multiple venues at the same time. Requirement to monitor travel times on specific routes and use information to alert drivers and offer alternative routes if necessary.

Solution:
Chose TomTom HD Route Times to monitor 120 key routes every minute throughout the period of the London 2012 Olympic Games. TomTom arranged a web portal to highlight current problem routes.
**TomTom Traffic – HD Flow and Origin Destination Analysis**

**Requirements:**
Trial new technologies available in the market to keep the city flowing. The focus of the trial was to find innovative ways to collect travel time information and motives.

**Solution:**
Chose TomTom HD Flow for the greater London area and a OD analysis for Tower Hill to understand, integrate, test, demo and present the innovative solution for collecting traffic data.
**TomTom Traffic - Traffic Flow & Traffic Stats**

**Requirements:**
Provide drivers with the best information available on traffic and road closures for the course of the Riyadh metro construction project, the largest in the world. Archive the data for use in transport planning analyses and performance reporting.

**Solution:**
TomTom traffic data fusion, Traffic Stats and mapping solutions, used together with apps and interfaces from partners.
TomTom Location Based Services

Requirements:
All Traffic Solutions builds and operates variable message signs. To be able to quickly collect and share accurate traffic information, they needed precise traffic data for which they did not have to invest heavily to cover multiple regions in the US.

Solution:
TomTom was able to supply All Traffic Solutions with market leading traffic information, which was easy to integrate in the variable message distribution system. The data has coverage on all major and minor roads in the US, and is fully customizable to be used in the existing architecture of All Traffic Solutions.
Questions??

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