

# **THE POWER OF NAVIGATION AND REAL TIME TRAFFIC: REDUCED CONGESTION + REDUCED CO2 EMISSIONS = SMART CITIES**

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## **Abstract**

The use of in-car real time traffic information by increasing numbers of drivers can reduce delay by enabling more efficient use of the road network. This paper looks at existing technology and recent evidence of how dynamic navigation and driver feedback can help reduce delay time, fuel use and thus greenhouse gas emissions.

## **Key Words**

Real time traffic, anonymous GPS measurements, floating car data, fuel use

## **Introduction**

The pace of deployment of in-vehicle navigation technology has increased in recent years. This technology provide users with a cascade of benefits including, but not limited to, financial savings in the form of reduced fuel use and shorter and more reliable travel times.

The road transportation sector is one of the top sources of greenhouse gas emissions (GHG) worldwide. We believe that significant reductions in GHG (and energy use in general) can be achieved by use of currently available, commercial technology. While vehicle fuel efficiency has improved over time, vehicle use and miles traveled have increased steadily and are expected to continue to grow<sup>1</sup>. This results in growing GHG emissions, compounded by congestion on the road network which increases along with vehicle miles traveled. Fuel consumption can be reduced at the vehicle level by avoiding congestion either by using uncongested routes or changing departure times) and by changing driver behavior (e.g. decreasing braking and idling). Reliable information for drivers regarding current traffic conditions, travel times and the fastest route to a destination can reduce congestion and improve the overall efficiency of the road network. Because the cost of many navigation systems, including those with real-time traffic information, is quite low, the deployment has been much more widespread than, for example, electric vehicles.

The next sections provide an overview of the different components of currently available in-vehicle navigation technology (including ‘connected’ systems) which contribute to savings in travel time and fuel use. Evidence of these savings appears in a wide variety of studies and drive test results, a selection of which are also summarized. Current efforts to better quantify the true savings are now underway in a project described at the end of this paper.

The structure of the paper is as follows:

1. Review of in-vehicle navigation and real-time traffic information technology which can reduce travel delay times and fuel use.
2. Review of driver feedback systems which can reduce fuel use

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<sup>1</sup> Texas Transportation Institute Urban Mobility Report, 2011.

3. Summary of a selection of recent studies which attempt to quantify the actual savings of these systems on travel delay times and fuel use
4. Conclusions and Next steps

The navigation and driver feedback systems reviewed are from the TomTom product portfolio

### 1. In-Vehicle Navigation Technology

Over the last 5 years, TomTom has developed new in-vehicle technology which combines four layers of information to provide the most efficient routing possible. All of this information is delivered in personal navigation devices as well as smart-phone applications and on the internet (<http://routes.tomtom.com>).

1. Base maps: All navigation begins with a good-quality, up-to-date map. Map errors lead to unnecessary driving and suboptimal routes (as well as driver frustration).
2. TomTom Map Share: Map corrections provided by drivers themselves allow drivers to improve their own navigation as well as help others with up-to-date accuracy.
3. TomTom IQ Routes: Measured driving speeds (based on GPS logging used anonymously) by time of day and day of the week are embedded in the map. This ensures that navigation routes are calculated using actual average speed conditions, avoiding roads that are usually slow due to congestion or physical road characteristics.  
As a variant on IQ Routes, TomTom developed a new routing option for drivers called ‘Eco Routes’. The purpose of this is to further optimize the routes provided to drivers in terms of fuel use. This routing option is described in more detail below.
4. TomTom HD Traffic: The fourth layer is composed of real-time traffic information (HD Traffic was introduced in Europe five years ago and in North America and other parts of the world in the last 1-3 years), which measures current conditions and is used for dynamic re-routing, helping drivers avoid traffic incidents. HD Traffic is described in more detail below.

**Figure 1: Navigation Layers**



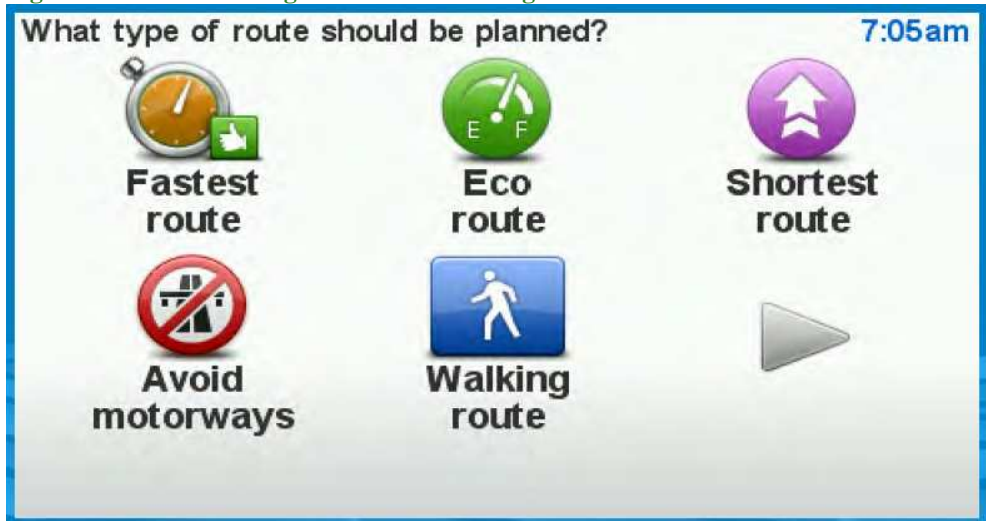
In the next paragraphs more detail on routing based on map information (Eco Routes) and on dynamic rerouting based on real-time traffic information (HD Traffic) is provided.

### **Eco Routes**

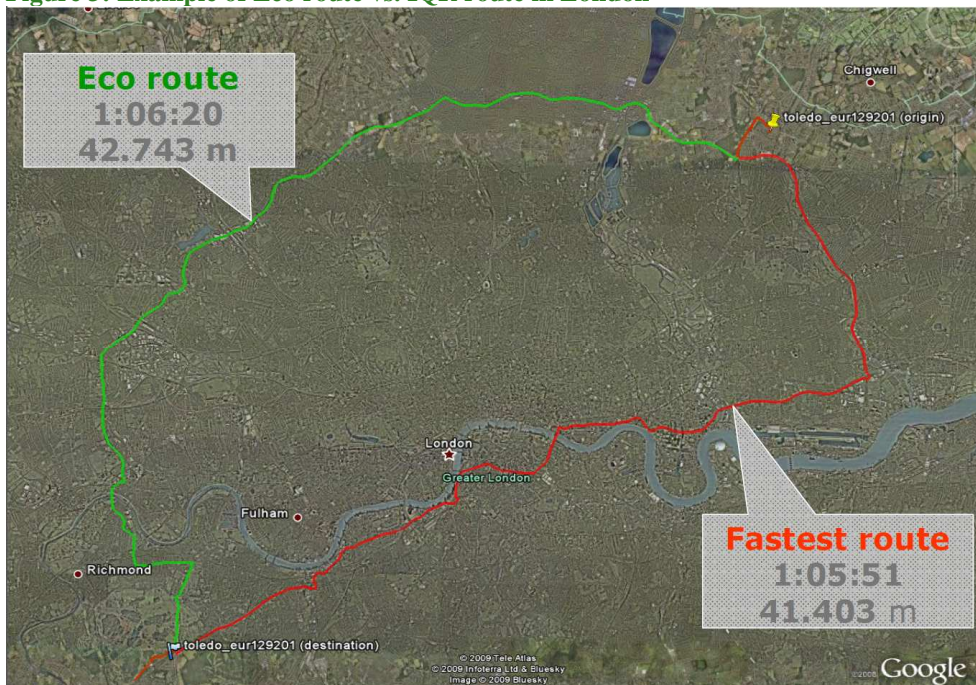
The TomTom Eco Routes model, introduced in 2009, enhances the IQ Routes model such that more fuel-efficient routes are being calculated. This routing is based on a specific list of parameters, including a distance penalty and a ‘stopping probability’. Adding a distance penalty makes a longer route appear

slower. Hence, long detours yielding just a few minutes' gain become unattractive and a reasonable trade-off between traveling time and distance is attained. The stopping probability predicts for each intersection how likely it will be that a driver has to decelerate and then again accelerate the vehicle when driving across a particular road crossing or road stretch. The stopping probability is taken into account during route planning so that, for instance, residential areas with a dense road network as well as certain acceleration-intensive crossings and maneuvers are less attractive to the route planner. We compared the Eco Routes model with the IQ Routes model and concluded that, on average, 1 out of 3 routes have better fuel economy with Eco Routes.

**Figure 2: TomTom Navigation Device Routing Choices**



**Figure 3: Example of Eco route vs. IQR route in London**



## **HD Traffic**

HD Traffic is TomTom's real-time traffic information service. It combines real-time speed measurements with information about road closures and incidents to provide information on current road conditions to drivers. HD Traffic was originally developed with the purpose of enhancing navigation, allowing for dynamic rerouting to ensure the fastest route to drivers' destinations given changing situations on the road network. HD Traffic in North America is based on the following input sources:

- **GPS Probes**

GPS probe data is collected from personal navigation device (PND) users who have opted to share travel time information on an anonymous basis. These are largely from connected TomTom PNDs, TomTom Business Solutions devices, TomTom embedded navigation devices in cars and TomTom navigation applications on Smartphone (e.g. iPhone). In some countries additional GPS measurements are collected from 3rd party fleet management companies. The sharing of data is a two-way process, and in exchange for receiving the LIVE Services data on the user's device, anonymous GPS traces are sent from users who have opted to share travel time information on an anonymous basis to contribute to the information sources for the next traffic situation update.

- **Journalistic Data and Road Sensor Data**

Journalistic data provides a very valuable source of information for drivers, including road closures, lane closures and accidents on the road. As there is no speed attached to a closed lane, TomTom isn't able to generate this information from our own data sources. TomTom receives this information from 3rd party suppliers who are actively monitoring the road network. This incident data information is also known as 'journalistic' or 'causal' information as it describes the reason for delays rather than the extent, or effect, of the delays.

Traditional road sensor data is also often collected in the TomTom real time traffic system – either directly from the operator of the sensor (government bodies) or through the 3rd party incident data aggregator. Where available, this additional flow data is fused with the probe flow data to provide the most robust data set from the available sources.

HD Traffic will evolve as more drivers become 'connected', either with PNDs, in-dash systems, smart phone applications or other technology which adds value to the travel experience. In the longer term, HD Traffic will be shaped by developments in vehicle-to-infrastructure and vehicle-to-vehicle communication, the use of extended floating car data as well as multimodal traveler information systems.

## **2. In-Vehicle Driver Feedback: Beyond dynamic navigation**

Navigation and travel decisions based on up-to-date maps and real-time information comprise just one important aspect of choices made by drivers which influence travel delay time and fuel use. Feedback to drivers on their driving behavior can result in behavioral change, particularly if drivers are made aware of changes they can make in order to reduce their own costs. Automotive manufacturers are beginning to offer this kind of feedback to drivers and fleet management systems have been offering driver-specific feedback for several years.

TomTom's Business Solutions provide one example of this driver feedback. Business Solutions is designed for commercial fleet management and as such provides different types of feedback which can help manage costs. The technology (in this case provided by TomTom, but other systems are also available) consists of:

- TomTom PRO7100 navigation device with HD Traffic and dynamic routing
- TomTom LINK 300 fleet management device
- TomTom EcoPlus fuel use management device
- Webfleet information system

Figure 4: In-vehicle systems for fleet management and driver feedback



PRO7100



LINK 300



EcoPlus

The PRO7100<sup>2</sup> is a navigation device which provides routing based on IQ Routes and HD Traffic. IQ Routes<sup>3</sup> consists of embedded, historical, measured traffic speeds which help ensure that the most efficient route is provided when navigating, avoiding slow, local streets and traditional bottlenecks.

HD Traffic provides real-time updates on the PRO7100 every 2 minutes.

The LINK 300<sup>4</sup> is built into the vehicle, providing accurate data to the TomTom back office servers about the vehicle position, trip information, standstill times, mileage and driving behavior.

The EcoPLUS<sup>5</sup>, in combination with the LINK 300, provides a real-time view of the fuel efficiency of each equipped vehicle, also showing where and when the fuel was wasted. It provides the driver with real-time feedback, helping change driving behavior in order to reduce fuel waste.

The Webfleet<sup>6</sup> management system continually collects all vehicle specific data. This includes driving hours, mileage, routes used, the location and duration of stops and driver behavior measures. Reporting functionality allows for creating statistical summaries by different calendar periods. Example reports are shown below.

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<sup>2</sup> [http://business.tomtom.com/en\\_gb/products/pro-7100-truck/highlights/](http://business.tomtom.com/en_gb/products/pro-7100-truck/highlights/)

<sup>3</sup> <http://www.tomtom.com/page/iq-routes>.

<sup>4</sup> [http://business.tomtom.com/en\\_gb/products/link/highlights/](http://business.tomtom.com/en_gb/products/link/highlights/).

<sup>5</sup> [http://business.tomtom.com/en\\_gb/products/accessories/ecoplus/](http://business.tomtom.com/en_gb/products/accessories/ecoplus/).

<sup>6</sup> [http://business.tomtom.com/en\\_gb/products/webfleet/highlights/](http://business.tomtom.com/en_gb/products/webfleet/highlights/).

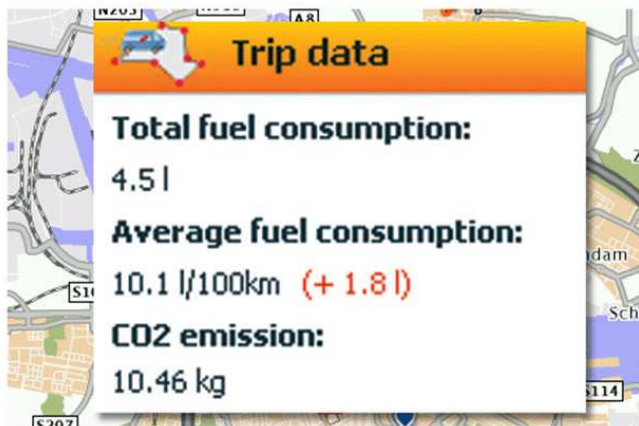
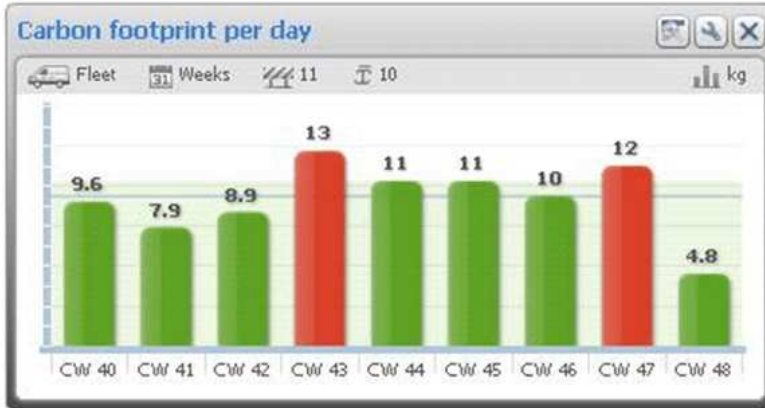
Figure 5: EcoPlus example reports

## Trip report (daily summary)

Object: --- All objects ---  
 Period: 21/07/2010 - 28/07/2010



Date	Begin / End	Duration	Trip time	Standstill	Odometer	Distance	Trips	Total consumption	Average consumption	
<b>365 - LA6478H00470</b>										
We	21/07/2010	08:32 20:04	11 h 32 min	5 h 22 min	1 h 01 min	38.668 km 38.867 km	198,7 km	8	15,2 l	30,0 l/100km 6,5
Th	22/07/2010	10:38 18:40	8 h 02 min	2 h 28 min	21 min	38.867 km 38.954 km	87,6 km	7	4,8 l	5,5
Fri	23/07/2010	09:46 23:13	13 h 27 min	3 h 02 min	34 min	38.954 km 38.055 km	91,1 km	5	9,1 l	10



### 3. Evidence of Travel Time and Fuel Savings

The logic of the navigation and driver feedback technology described above is clear: it should be possible for drivers to save travel time and fuel. However, actual savings are dependent on the individual driver behavior, travel choices and local conditions. The question remains as to what the actual savings are for typical users of this technology. In this section we summarize a selection of relevant studies, tests and reports which provide actual estimates of these savings. Each one focuses on different pieces of technology.

#### *NaviConnect Eco-Test Drive*

NaviConnect, a magazine, conducted a drive test in Germany<sup>7</sup>, comparing TomTom navigation with IQ Routes and HD Traffic to other navigation solutions (Falk and Blaupunkt). The test involved:

- Three identical A-Class Mercedes A 170 Blue Efficiency cars drove from Stuttgart via Heilbronn, Heidelberg to Mannheim/Ludwigshafen and back
- Test drivers rotated between the 3 cars and carried water-six-packs to account for the different weights of the drivers
- Test drives occurred on a Friday afternoon and the test area has a number of alternative routes of almost equal length including a good mixture of highways and secondary roads

The results, summarized in the table below, showed that up to 15% could be saved on fuel consumption by navigating with HD Traffic, when compared to navigating with other solutions:

**Figure 6: NaviConnect Results**

	<b>Blaupunkt</b>	<b>Falk</b>	<b>TomTom with HD Traffic &amp; IQ Routes</b>
Total distance driven	300km	300km	300km
Travel time/device prediction	319min/244 min	335min/236 min	293 min/238 min
Average speed	56km/hr	54km/hr	61km/hr
Average fuel use	8.25 liters/100km	9.07 liters/100km	7.87/100km liters
<b>Total fuel use</b>	<b>27.76 liters</b>	<b>27.08 liters</b>	<b>25.53 liters</b>

*TNO*.<sup>8</sup>

In cooperation with TUV and DLR in Germany and Virginia Tech Transportation Institute, TNO, a Dutch research institute, conducted a study of the effect of driving with a navigation system on traffic safety.

The survey study was conducted among a representative sample of drivers in Germany, the USA, the UK, France, Italy and Spain. The instrumented vehicle studies in Germany and the USA followed exactly. The results indicate that:

- the use of navigation systems has a positive effect on driver awareness

<sup>7</sup> NaviConnect, January 2009.

<sup>8</sup> TNO, 2008.

- the use of navigation systems reduces the driver's stress that the use of navigation systems reduces driver's workload
- the use of navigation systems has a positive effect on driver behaviour
- the use of navigation systems reduces travelling distances and time.

The results of the study showed that the mean distance travelled to reach the destination was shorter and the time needed to reach the destination was shorter when driving in an unfamiliar area with a navigation system. In terms of fuel efficiency (l/100 km), no differences were found between the situation with and without a navigation system. But given the reduction in the number of kilometers/miles driven in combination with unchanged fuel efficiency, the total consumption was reduced by using a navigation system.

#### *German Air and Space Institute (DLR)*

In a study completed in 2012, the DLR compared five different navigation systems in a field test in Germany.:

- The “**Bosch** Navigation” app running on an Apple iPhone 4 – the software had access to real-time information provided by INRIX called “Inrix Traffic”.
- A **Garmin** nüLink! 2340 navigation device with real-time traffic information provided by Navteq called “3D Traffic”.
- The “**Google** Navigation” app running on an HTC Desire device with Android also with real-time traffic information.
- **TomTom HD** 1000, a navigation device with TomTom's HD Traffic service.
- **TomTom XL**, a navigation device with IQ Routes but without HD Traffic service.

The results of this study show a 12% difference in travel time between the best and the worst navigation device. This difference is not very large but statistically highly significant. The mechanism responsible for this difference is the fact that in about 25% of the trips made, the TomTom devices sometimes found routes that were considerably faster than what the other devices found. Fuel use was not measured however, so the actual fuel savings were not quantified.

#### *Commercial Vehicle Driver Feedback: Case study in London, 2011*

The experience of a cleaning and hygiene specialist revealed how fleet management technology with driver feedback can reduce costs. Zenith Hygiene Group, boasting one of the largest ranges of cleansing chemicals and ancillary products in the UK, has slashed fuel costs across its 119 vehicle fleet after installing TomTom's WORKsmart - Eco solution. It has achieved this whilst maintaining between 22,000 and 24,000 deliveries per month. The company expects to reduce its distribution costs by £90,000 in just 12 months. The company reported that average vehicle miles per gallon rose from 26 to 43 in just four months, resulting in a reduction of fuel usage by up to 5000 litres per month. The company also calculates that their carbon foot print has been reduced by 33 lbs per day to 24 lbs per day. Zenith installed TomTom's tracking, navigation and ecoPLUS devices (described above) across its fleet, which includes 56 company cars and 63 trucks, in June 2011. It has since been able to improve vehicle routing and the deployment of its mobile workforce to customers, increasing on-time delivery performance and an increase in customer satisfaction. In addition the monitoring of driver performance by managers and by drivers, the technology has led to reductions in speeding, idling and harsh braking.

#### **4. Next Steps**

The above reference studies provide some evidence of the effects of navigation, real-time traffic information and driver feedback on travel time and fuel use. However, they do not provide a comprehensive measure of the effects of this technology and do not specifically quantify all of the potential effects. The individual and combined effects of different pieces of in-vehicle technology still



need to be systematically measured. One of the big challenges in doing so is the fact that the information offered by each layer of technology results in effects and behavioral change which varies from driver to driver and on the setting (e.g., urban vs. rural, congested vs. uncongested, travel purpose).

A new project, sponsored by the New York State Energy Resource Development Agency (NYSERDA), will help to further define and quantify these effects based on application of this technology in commercial fleets. This project seeks to deploy systems providing real-time traffic information and driver feedback in commercial vehicles in New York State. The goal of the project is to clearly demonstrate how the combination of in-car navigation systems, real-time traffic information and dynamic routing as well as driver feedback regarding efficient fuel use can reduce travel times and fuel consumption and thus emissions.

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