# Traffic Bottleneck analysis based on Floating Car Data

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**Abstract**

Congestion is a growing and global problem, impacting the majority of people traveling in and around urban areas and goods transported. Governments are challenged to keep the traffic flowing, to reduce pollution and decrease the economic damage caused by congestion. Trustable data on a network-wide level enables faster, complete and more cost-efficient analysis, benefitting both the road owner and the individual road user. Due to the increasing volume of (connected) navigation devices in the market (navigation devices, smartphone applications and in-dash devices) Floating Car Data (FCD) becomes widely available. Floating Car Data provides rich information about speeds and traveltimes. As all this data is stored it becomes easy to query this database with stored FCD data and to extract the relevant information, even retrospectively! By comparing the speed and travel time in an area with the freeflow speed and travel time (normally speed driven at midnight) it becomes easy to identify the bottleneck locations and to assess the severity on a segment level. As a result it becomes easy to do before and after analysis, for example to measure the effect of infrastructural investments (is there really a 5 minute travel time gain due to that new tunnel?)

**Keywords:** Bottleneck analysis, Floating Car Data.

**Historical Traffic Solutions**

Historical traffic information is generated by collecting measurements from anonymous (connected) GPS navigation devices and anonymous GPS equipped Smartphones. Collecting this type of data is called Floating Car Data (FCD). FCD provides rich information about speeds and traveltimes. As all this data is stored it becomes easy to query this database and extract the relevant information concerning speed and traveltimes. By comparing the speed and travel time in an area or for a route with for example the midnight freeflow speed and travel time it becomes easy to identify the bottleneck locations and to assess the severity on a network level and on a local segment level. As a result it becomes easy to do before and after analysis, for example to measure the effect of infrastructural investments or changes due to behaviour campaigns. Below you find an example for an analysis done for roadworks at the A1 in Austria. The graph on the right side shows the impact on speed during the roadworks (July 2014) compared to freeflow conditions prior to the roadworks (July 2013).

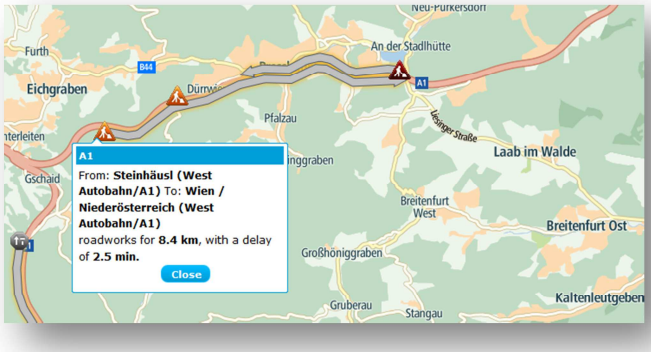


*Image 1 – Roadworks in Austria*

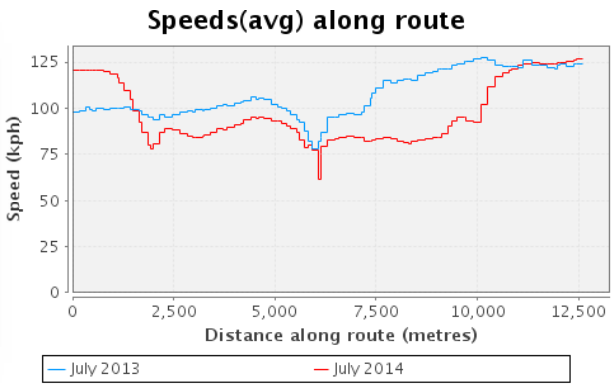


*Image 2 – Measuring the impact on speed due to the roadworks*

**Sources**

To collect the historical data revolutionary collection techniques are being used. As described, information from multiple sources are collected and stored. In Europe the following sources are used to create the historical traffic services:

1. GPS Data from TomTom navigation devices (PNDs)
2. GPS Data from TomTom Smartphone navigation applications
3. GPS Data from Automotive in-dash and on-dash devices
4. GPS Data from TomTom Fleet Management systems (Business Solutions)

By collecting GPS data from so many different sources TomTom has a fleet of Floating Car Data driving around the world that is unsurpassed by any other fleet. As 'connected embedded navigation' is the popular choice for navigation, the combined fleet of GPS devices is growing day by day with impressive speed and consequently the quality and coverage of the traffic information increases. Hundreds of millions of (connected) devices globally are able to contribute highly accurate and anonymous GPS probe data with the consent of the user. Examples users that share FCD in the automotive market include in-dash and on-dash

navigation devices or traffic services for Renault, Mercedes-Benz, Smart, Toyota, Mazda, Fiat, Alfa Romeo and Lancia. In the near future Peugeot and Citroen and others will join this group.

These source devices all monitor road traffic conditions continuously and when each of them contacts the TomTom servers for traffic information they exchange intelligence on the congestion they have experienced in the past few minutes on their journey. This information is anonymously stored in a traffic data store and made available for analysis.


*Image 3; different sources of accurate GPS data that are stored.*

Thanks to the continuous sampling of very precise GPS measurements, all groups of (connected) devices contribute to the accuracy of the travel time information. In order to make sure only information from inside the car is used a special filter is implemented so bicycle, public transportation and pedestrian data is filtered out. With a new GPS breadcrumb generated every few seconds on the device it is easy to accurately understand the road conditions for the vehicles and with just a few devices reporting anonymously for a specific road stretch it is possible to generate high quality traffic information with very detailed speed and travel time information with confidence.

Heat maps can visualize the volume of probes and the distribution over the road network. These heat-maps are essentially black sheets with all measurements plotted in top of this. The brighter the colour the more measurements were received. Please note that these are only TomTom devices (not 3rd party devices). For traffic data creation also other GPS measurements are added. In the images below you find a heatmap for Europe and North America[1].

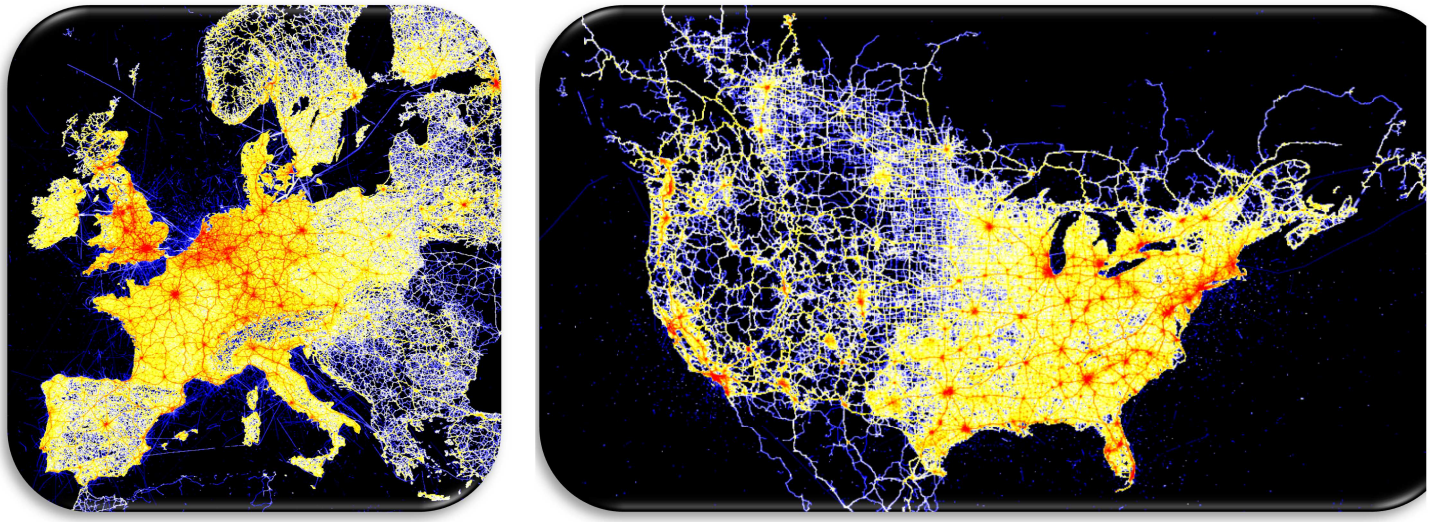

*Image 4; TomTom GPS measurements for Q3 2014.*

[1] Please note that TomTom is not limited to these countries but can collect data for any location on the world.

Using Floating Car Data from various sources result in a number of benefits compared to other ways of measuring travel time and speed information. As cars drive on all roads that are open for traffic it is possible to measure with floating car data travel times and speeds on all roads, even when construction works take place, forcing traffic for example to go on a temporary lane or drive on the other side of the dual carriageway. Also when new roads are opened, speed and travel time data can directly be measured and quickly be analysed. Additionally, the system does not have to wait until a vehicle has reached the end of a road section before the travel time is calculated as data can be received regularly along the route. Floating Car Data enables TomTom to accurately measure the speeds, also in case of low speeds or standstill conditions.

**Query the historical traffic database**

TomTom has built an interface that makes it easy to define a query in the historical data. In just three simple steps it can be defined:

Step one: Selection of the route or area

a. A route is selected in an interactive map window. In the window the starting point, end point, and up to three way points are entered either by text entry or by clicking the map. A route can be up to 75 kilometres long.

b. A search field is defined by drawing a rectangle in an interactive map. The desired street classes can then be selected. This selection is based on the "Functional Road Class" attribute.

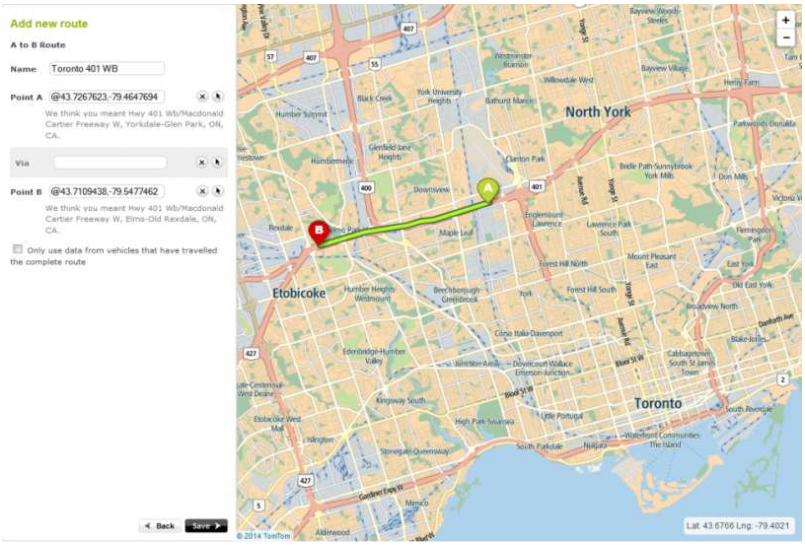


*Image 5; Defining a route*

Step two: Calendar selection of the period to be considered. The observation period is entered by selecting a start and end date in a calendar and can be defined more precisely by clicking on individual days. In this way, individual days (for example holidays) can be excluded from the query.

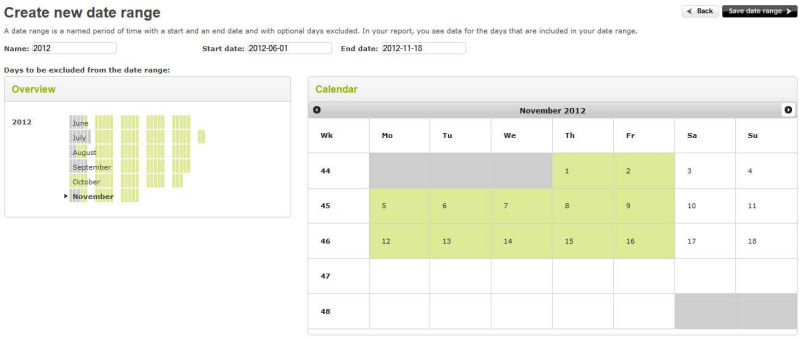


*Image 6; Defining a calendar selection*

Step three: Definition of time slices. The determination of time slices is done in a week plan. A database query can include up to seven time slices. These can include one or more hours, each of which can begin every quarter hour. The time slices must not overlap.

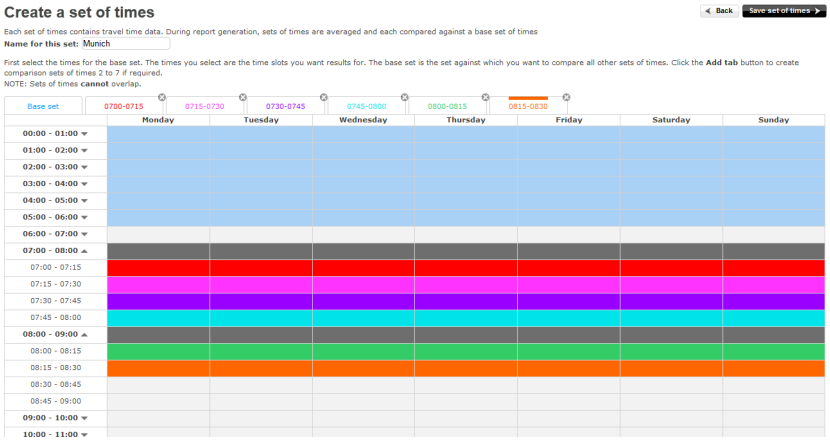


*Image 7; defining time slices*

The routes or areas, the calendar periods and the time slices defined by a user are saved so the exact same definition of for example a route can be used for future queries. The query results are downloaded directly from the portal. The data includes the route or area being considered in a KMZ or Shape file for importation into Traffic tools as well as speed data in Excel or .dbf format. In addition to the query definition, the Excel file includes the following data:

- Route length;
- Average number of data records per period
- Mean travel time
- Median travel time
- Relative travel time standard deviations
- Mean speed
- Speed percentiles

**Route Statistics for bottleneck analysis**

When the query is finished the results can directly be analysed. To explain the functionality we selected the Promenade Des Anglais in Nice as an example. For the query we used the calendar selection of January 2014 to November 2014. For the time sluices we spitted the morning rush hour up into 15 minute time bins. The route definition is displayed in image 8.


*Image 8; Promenade des Anglais*

By splitting the morning rushhour up into fifteen minute time slices it is possible to assess the impact of the rush hour in high detail. Output statistics show that during the night, while facing freeflow conditions, the travel time on this route is on average 10 minutes and 31 seconds. As part of the output you receive for each time slice (in this case 15 minutes) statistics about the average speed, median speed, average travel time and percentile travel times. Mostly used in traffic engineering is the 85$^{th}$ percentile travel time. In the table below you find further statistics for 85$^{th}$ percent travel times for the specific route. As clearly visible the highest 85$^{th}$ percentile traveltimes are measured between 08:15 and 08:45. Compared to the free-flow conditions there is a gain in travel time of 93% (from 10 minutes and 48 seconds to 20 minutes and 49 seconds)

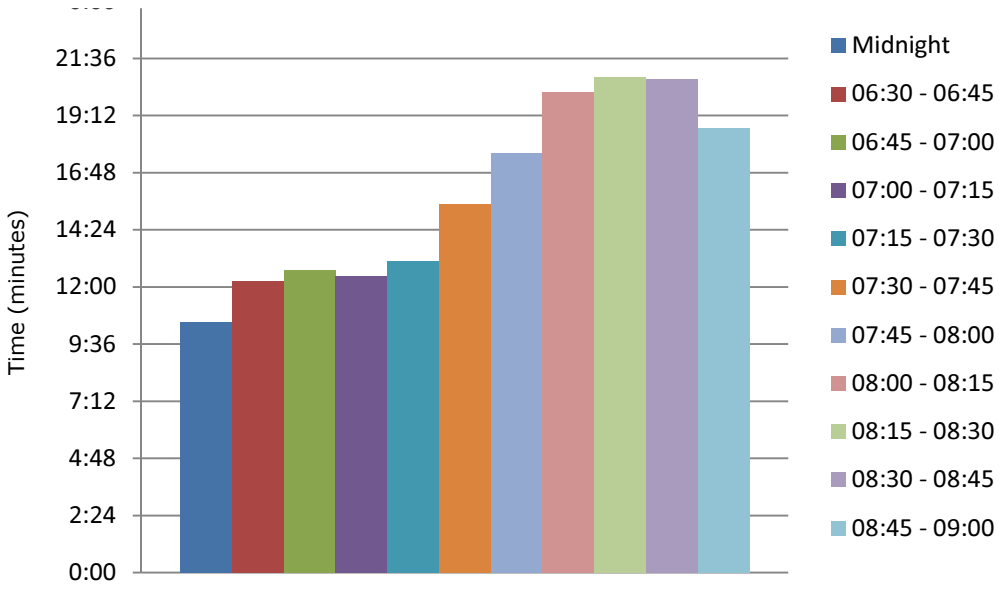


*Image 9; 85$^{th}$ percentile travel times for the Promenade des Anglais*

Statistics are not only provided for the full route, but also for all individual road segments. This enables the analysis of bottlenecks and congestion impact up to a road segment level. A value that can be used to quantify a bottleneck it the comparison of the realized average travel time with the average travel time measured during freeflow conditions. The result is a value (the travel time ratio) for each road segment that indicates how much additional travel time is required to travel through

this road stretch. A travel time value of 1 refers to equal traveltimes compared to freeflow conditions. A value below 1 refer to lower traveltimes then driven at midnight and ratio values above 1 refers to additional travel times compared to freeflow (e.g. 1.5 means that there is 50% more travel time measured). When applying this analysis for the route in Nice it becomes visible that the road stretches that face the highest amount of additional travel time are in the beginning of the route, close to Nice Airport. The values fluctuate throughout the route and the highest peaks are around 2, meaning the double amount of travel time is required to travel through this road segment

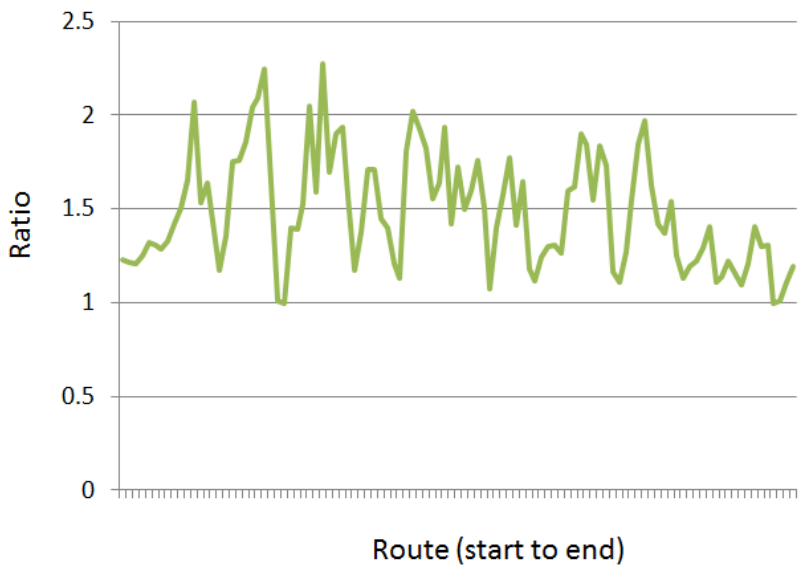


*Image 10; Travel Time Ratio's throughout the route*

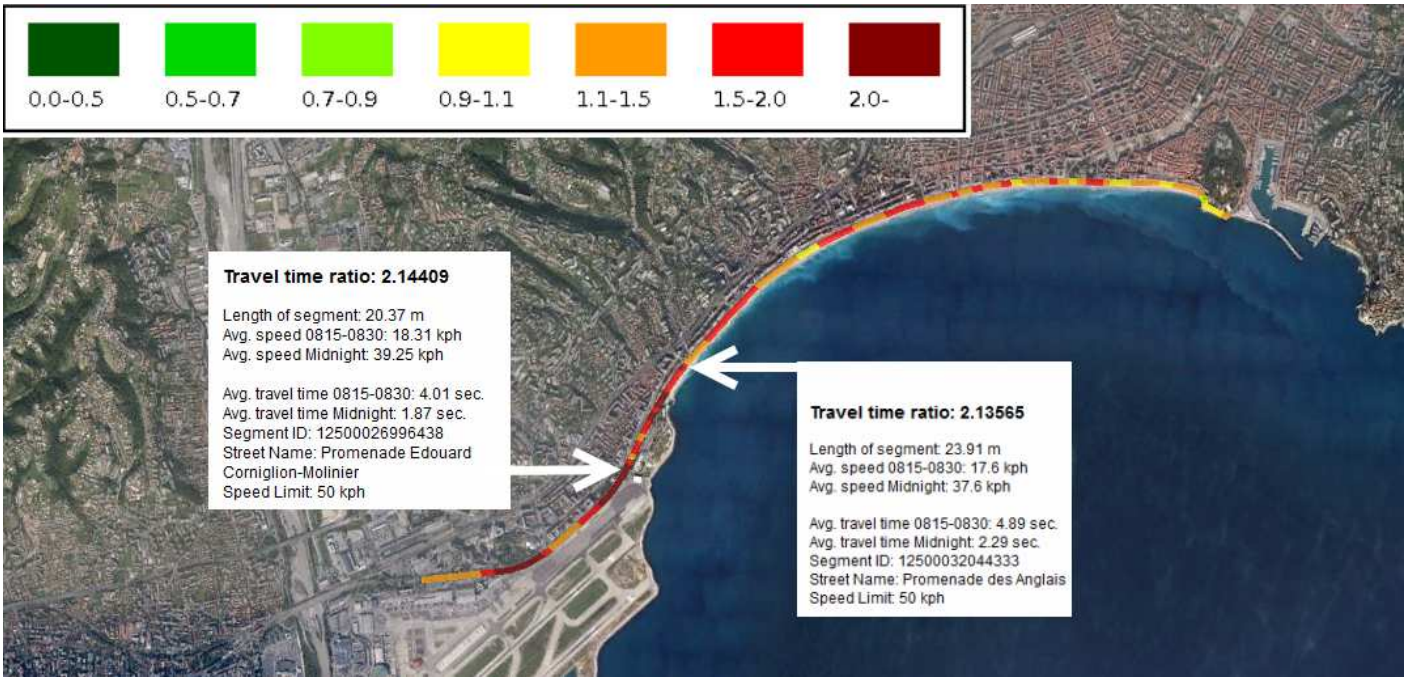


*Image 11; travel time ratio's displayed per road segment.*

**Before and after analysis**

The route based statistics can be used for before and after analysis for all locations. As an example we would like to analyse the A4 in the Netherlands between the cities The Hague and Leiden. During the years 2011 to 2013 major construction works took place at intersection Burgerveen in order to increase capacity. By comparing Q4 2010 with Q4 2014 it is possible to assess the improvements due to the construction works. For this analysis we reviewed both the morning rushhour and the evening rushhour.

*Image 12; selected route*

The analysis output shows the positive impact after the infrastructure changes. In the table below you find the average travel time for both morning and evening rush hour.

| | Travel Time |
|---|---|
| Q4 2010 Morning Rushhour | 00:18:27 |
| Q4 2010 Evening Rushhour | 00:17:54 |
| Q4 2014 Morning Rushhour | 00:15:10 |
| Q4 2014 Evening Rushhour | 00:11:38 |

*Image 13; Table showing travel times before (2012) and after (2014)*

As clearly visible in the statistics there is an obvious travel time gain when comparing the traveltimes in 2014 (after) with 2010 (before). For the morning rush hour there is an average gain of 3 minutes and 17 seconds while for the evening rush hour there is an average gain of 6 minutes and 16 seconds. The project was clearly a success. Reviewing the average speed throughout the route provides more insight in the benefits of the changes along the route. Image 14 shows the average speeds and there is a clear benefit of the changes. However, around meter 8.000 of the selected route the average speeds in 2010 are higher than in 2014. Further analysis would be required to assess why this is occurring.

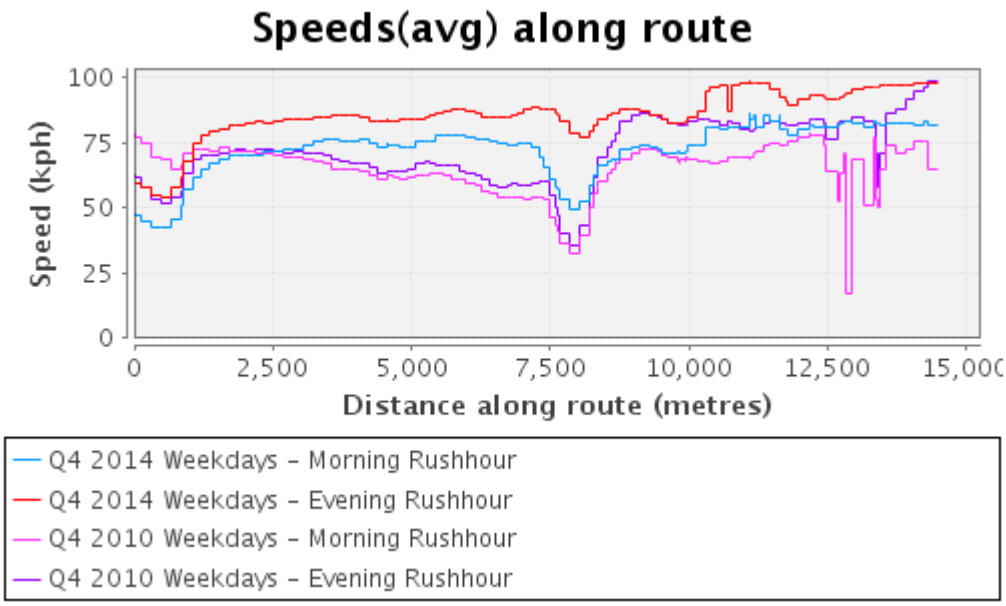

*Image 14; Table showing average speeds before (2012) and after (2014)*

**Conclusions**

Traffic data based on Floating Car Data enables analysts and researches to analyse travel times and speeds quickly and easily without the need to deploy roadside infrastructure to count and measure. Data is available retrospectively and can be used instantly. Results not only provide information on for a full route, but also for each individual road segment. Due to this level of detail it is possible to analyse and assess the network at a highly granular level. This can be done for bottleneck analysis like in the Nice example, but also for before and after analysis like shown for the Dutch A4 example.

**References**


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**Biography**


Name: MSc. Jeroen Brouwer

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Company: TomTom


Education: BSc in Traffic Management (2008)

Biography: Jeroen is a Traffic Engineer working for the TomTom Traffic department. After his study Traffic Management he worked for different Traffic Engineering firms in the Netherlands with a focus on Transport Modelling. Since 2010 Jeroen is working for TomTom and was responsible for various roles with a both internal and external focus. Currently Jeroen is a product expert for TomTom's historical traffic solutions globally with the role of Product Manager Historical Traffic Solutions