TomTom Traffic Index: Toward a Global Measure

Nick Cohn
TomTom
De Ruyterkade 154, 1011 AC Amsterdam, The Netherlands
+31 20 75 75302, nick.cohn@tomtom.com

Abstract
TomTom created the Traffic Index to help planning organizations and transport authorities identify areas of concern in their road networks and to assist in making investment decisions. The Traffic Index is one of many initiatives that exist with the aim to understand urban mobility in a wider, international perspective. The Traffic Index is unique in its global coverage (cities on 6 continents) and in raising the awareness worldwide of the availability of 'big data' from new technology for use in improving mobility and sustainability of cities. This is exemplified by the recent agreement signed between United Nations Habitat and TomTom (1). The Traffic Index uses a single, uniform data source collected from navigation users across multiple countries and continents. The intention is to create a benchmark which makes it possible to evaluate congestion levels in an objective way, globally.

Keywords: Congestion, Traffic, Probe Data, Urban Mobility

A Global Traffic Index
Actual driving speeds and road conditions are critical to the road travel experience and trip-related decisions made by individual drivers. Accurate and complete information on driving conditions is important at the collective level as well, for it helps provide an understanding of overall mobility and accessibility conditions and associated economic and environmental costs for both users and planners. Gaining an understanding of where the most severe congestion and delays occur is necessary for planning authorities in order to take informed decisions about where to invest in new infrastructure or technology. Monitoring change in order to assess trends and the impact of investments is an essential part of good decision-making.

TomTom hopes to raise awareness among road users about the availability of information and technology which enables more effective decision-making before and during travel, with a goal of reducing travel time loss. By using modern navigation technology which incorporates historical and real-time data, drivers can use routes which minimize delay. The differences in congestion levels between peak and non-peak periods, visible in the Traffic Index Report, are reason enough for drivers (who have the flexibility) to consider different departure times. TomTom also encourages travellers to consider alternative travel modes where available, especially when real-time conditions indicate that public transport or, for example, cycling could significantly save time and frustration. The cities included in our Traffic Index report are often very active in developing and maintaining public transport, cycle and pedestrian networks and encouraging more sustainable mobility behaviour among their inhabitants.

These are the main reasons that prompted TomTom to create the Traffic Index.

The first Traffic Index report was published in 2012 (under the name Congestion Index) and included an analysis of congestion levels in a selection of cities during the first quarter of that year. The most recent report published was for the second quarter (Q2) of 2013. This report includes analysis of 169 cities in 27 countries. Table 1 contains the results of the Q2 2013 report for the 10 cities with the highest overall Traffic Index values globally.

Table 1: Top 10 Cities (ranked by 24-hour values) and Evening Peak Traffic Index

Rank across Q2 2013	City	Traffic Index Values		
		24-Hour	Morning Peak	Evening Peak
1	Moscow	65%	114%	133%
2	Istanbul	57%	81%	128%
3	Rio de Janeiro	51%	96%	125%
4	Warsaw	44%	87%	95%
5	Palermo	40%	65%	67%
6	Marseille	40%	74%	81%
7	Sao Paulo	39%	66%	100%
8	Rome	36%	84%	67%
9	Paris	36%	77%	72%
10	Stockholm	36%	75%	85%

The lack of uniform measurement information across multiple metropolitan areas, road categories and even countries has been an obstacle to gaining a clear and objective view of where and when congestion really takes place and at what level of severity. A heightened focus on performance measures in recent years, combined with widespread application of in-vehicle technology has created both new data sources and analysis methods for overcoming this obstacle.

Examples of these analyses are the reports created by the Texas Transportation Institute (TTI): the 'Urban Mobility Report'(4), the 'Congested Corridors Report'(5) and the National Mobility Monitor in The Netherlands (6). The wide interest from both government and commercial parties in these reports shows that there is a great need for reliable measurements which make comparisons, project prioritization and monitoring of changes possible across geographic areas and different parts of the road network. There is also a good deal of work being done to establish the best ways of using new data sources to calculate the best possible indicators of congestion (see for example Joe Cortright (7)), which shows that the field is clearly evolving. As creator of the largest international database of GPS-based traffic measurements, TomTom saw an opportunity to make a valuable contribution in this field.

All of these analyses fit in with a wider effort of government organizations and private companies focused on improving the sustainability of our urban transportation systems as well as modifying individual behaviour. This effort is exemplified by the C40 Cities organization (8), a network of 40 world cities working on reducing their urban carbon footprints and evolving toward higher sustainability. Similar is UN Habitat's sustainable cities program (9), which promotes sustainable transport as part of a wider, global program. UN Habitat recently signed an agreement with TomTom as both organizations have the same goal of reducing traffic congestion in the world's cities.

TomTom GPS Data

Starting in 2007, TomTom created a voluntary customer feedback loop to collect GPS speed measurements everywhere our customers are willing to provide them (and under strict privacy conditions abiding to the national data protection laws). The initial purpose of this was to embed actual measured speeds by time of day and day of week into the map for navigation purposes, providing customers the best routes and reliable estimated arrival times based on actual driving speeds as opposed to, for example, speed limits indicated on the road network. In doing so, we created a speed database for approximately 45 countries on 6 continents.

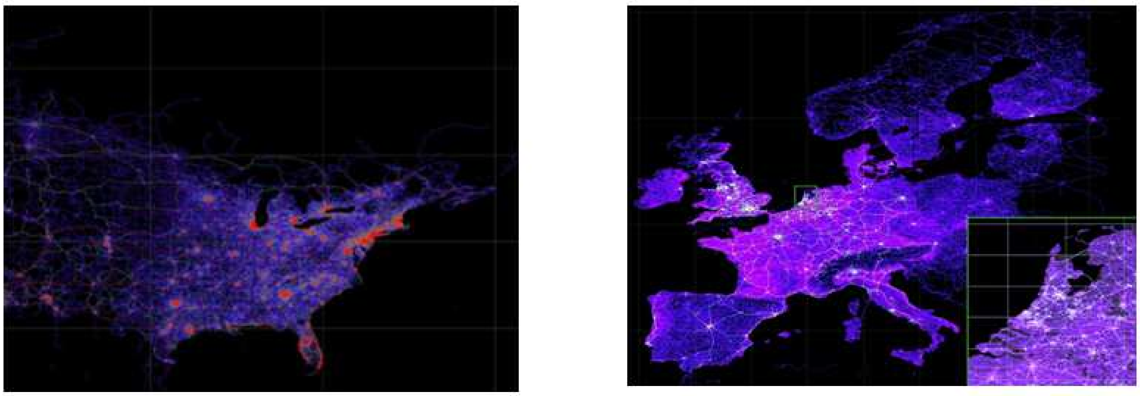


Figure 1 Example of plots of anonymous GPS measurements in US and Europe from a few months of TomTom probe data.

Clearly this database is valuable for several applications. TomTom makes it available for travel time reliability analysis, model validation and geo-marketing, to name a few. The database now includes over 6 trillion individual measurements and continues to grow.
The information included in the database consists of chains of individual GPS 'breadcrumbs', each of which has these characteristics:

- GPS breadcrumbs per 1-10 seconds depending on source
- Linked by unique, random identifier for 24 hour period
- Matched to map / road segment
- Time and date stamps
- Speeds (and derived travel times)
- Trip origins and destinations.

TomTom processes the raw GPS information in a number of ways in order to protect privacy, filter out possible inaccurate measurements and create geographic databases which can be queried. The most important part of this process is map-matching.
In the map-matching process, the GPS measurements are matched to a digital map using a map-matching algorithm. This process assigns each GPS speed measurement to a road segment with the highest possible confidence level. The algorithm looks at the path of consecutive GPS points in a journey file to define the route of a GPS device/vehicle in order to produce the most accurate speed information possible. For example, the map-matcher filters out traces which could not be matched to a map (due to, for example, changes in the road infrastructure, the use of the GPS device outside a vehicle, etc.), detects U-turns and the loss of GPS signals (for example, when driving in tunnels).
When the map-matching process is complete, an aggregated geographic database (geobase) of measured road speeds is produced. These geobases are updated regularly for each map of each region or country to take into account the growing historical GPS speed database as well

as updates and changes in the road network (map). This digital map with attached speed information is used as a source for all historical traffic products.

Traffic Index Methodology

The TomTom Traffic Index methodology uses this geographic database to calculate speed statistics on all road segments within the top 5 functional road classes that are located within each defined urban area boundary. This means that highways, major roads, secondary roads and local roads are included. The road segments vary in length between 2 meters to a maximum of 2 km, depending on the complexity of the road situation. For example a difficult crossing with a traffic light will have smaller segments than a long straight highway. The advantages of using such a detailed network compared to (for example) the TMC network are that the congestion can be calculated for more precise locations and include more of the local network.

The urban areas for which the Index is calculated are defined individually, because we found that official definitions vary so much by country in terms of how much rural area they include, that international comparisons would otherwise be quite difficult.

For each individual road segment, non-congested (free flow) travel times are determined based on 2 complete years of measurements. The Traffic Index calculation compares travel time measurements for that road segment during the course of the latest quarter (for example, Q2 2013) or an entire year to the free flow times of the same quarter or year. The overall Traffic Index value for a city is the weighted average percentage of extra travel time experienced by drivers in that city, 24/7 for the given calendar period, when compared to the free flow travel times. The Traffic Index is also calculated separately for the peak hours by the day of the week. The peak hour is determined separately for each city, based on the observed measurements and defined as the hour with the most congestion (the largest amount of extra travel time) observed in that city.

The results are weighted by the individual vehicle observations. That means that congested roads with large volumes have more influence on the results for a given city than quiet roads with low traffic volumes.

The report includes these statistics for each city:

- Overall Congestion Level (Traffic Index)
- Most congested day during the quarter analysed
- Estimated travel time delay per year for a commuter in that city
- Congestion Level for highways
- Congestion Level for non-highways

Results: 2013 Q2 Report

The tables below summarize the individual continent results (full reports are available on TomTom's public website). The South African report shows what can be learned at a national level, the Australia-New Zealand report shows a regional comparison. The results for the 10 cities in France are also shown below.

Table 2: Top 5 Cities in Europe

Rank in Q2 2013	City	Traffic Index Values		
		24-Hour	Morning Peak	Evening Peak
1	Moscow	65,2	114,4	133
2	Istanbul	57	81,4	127,5
3	Warsaw	44,1	88,6	95,2
4	Pelermo	40,4	65,3	66,9
5	Marseille	40,2	73,9	81,1

Table 3: Top 5 Cities in the Americas

Rank in Q2 2013	City	Traffic Index Values		
		24-Hour	Morning Peak	Evening Peak
1	Rio_de_Janeiro	50,5	96,2	124,9
2	Sao_Paulo	38,6	65,7	100,4
3	Vancouver	35,5	60,7	76,5
4	LosAngeles	35,1	54,6	78
5	SanFrancisco	31,8	53,3	70,7

Table 4: Top 5 Cities in South Africa

Rank in Q2 2013	City	Traffic Index Values		
		24-Hour	Morning Peak	Evening Peak
1	Johannesburg	31,1	79,2	73,1
2	EastRandNorth	27,9	64,9	78,7
3	CapeTown	26,6	92,1	60,6
4	Pretoria	22,7	51,8	49,3
5	Durban	19,8	48,9	45,7

Table 5: Top 5 Cities in Australia/New Zealand

Rank in Q2 2013	City	Traffic Index Values		
		24-Hour	Morning Peak	Evening Peak
1	Sydney	34,6	73	69,1
2	Auckland	33,7	78,7	80,5
3	Christchurch	32,4	58	62,5
4	Perth	29,4	49,9	56,3
5	Adelaide	28,8	52,3	48,3

Table 6: France

Rank in Q2 2013	City	Traffic Index Values		
		24-Hour	Morning Peak	Evening Peak
1	Marseille	40,2	73,9	81,1
2	Paris	35,7	77,2	71,6
3	Lyon	31	65,9	66
4	Nice	30,5	49,3	64,5
5	Bordeaux	27,6	58,4	70,9
6	Toulouse	26,2	68,9	62,9
7	Montpellier	25	45,5	57,9
8	Strasbourg	24,4	43,8	76,5
9	Nantes	20,9	51,5	55,3
10	Lille	20,7	52	52

Worst Days
The Traffic Index reports include the dates on which the worst congestion was measured in each city. While we do not always know the exact reasons for congestion, the table below provides a selection of cities showing the correspondence between events and weather and congestion conditions.

Table 7: Worst Traffic Days in Q2 2013: Selected Cities

City	Most congested day	Date	Event
Rome	Friday	2013-05-24	Public transport strikes
Paris	Wednesday	2013-06-19	Storms
Brussels	Wednesday	2013-05-08	Day before Ascension Day holiday weekend
Indianapolis	Sunday	2013-05-26	Indianapolis 500 race
Toronto	Friday	2013-06-28	Friday before Canada Day holiday weekend

Example Use by Road Authorities
Over the past few years, a number of road and transport authorities have used the TomTom database for planning and modelling purposes. The Traffic Index makes the database more usable for specific purposesFigure 2 is an example of how the Index values can be used to assist in understanding congestion at key bottlenecks. Another form of the same data, but for Marseille and Paris, is shown in Figure 3 and Figure 4. This type of information can also be used to look at change over time, including changes in specific bottleneck or 'hot spot' locations over time. This can assist planning authorities in determining the effect of new investments and changes in infrastructure or how new land use developments have altered traffic congestion levels over time and decide on future action. The Index can also be used by local governments as a basis for periodic network performance reporting.

Conclusions
The Traffic Index was conceived as a way of raising awareness about the potential that new data sources can have on transport planning and with the aim of encouraging drivers to make more informed travel decisions. The recent Q2 2013 report was published in November of 2013. Subsequent reports will continue to add coverage and depth over time and our goal is to continually work to make the information more useful and usable for a variety of applications.

Figure 2: Top Congestion Hotspots in Rio de Janeiro, Q2 2013

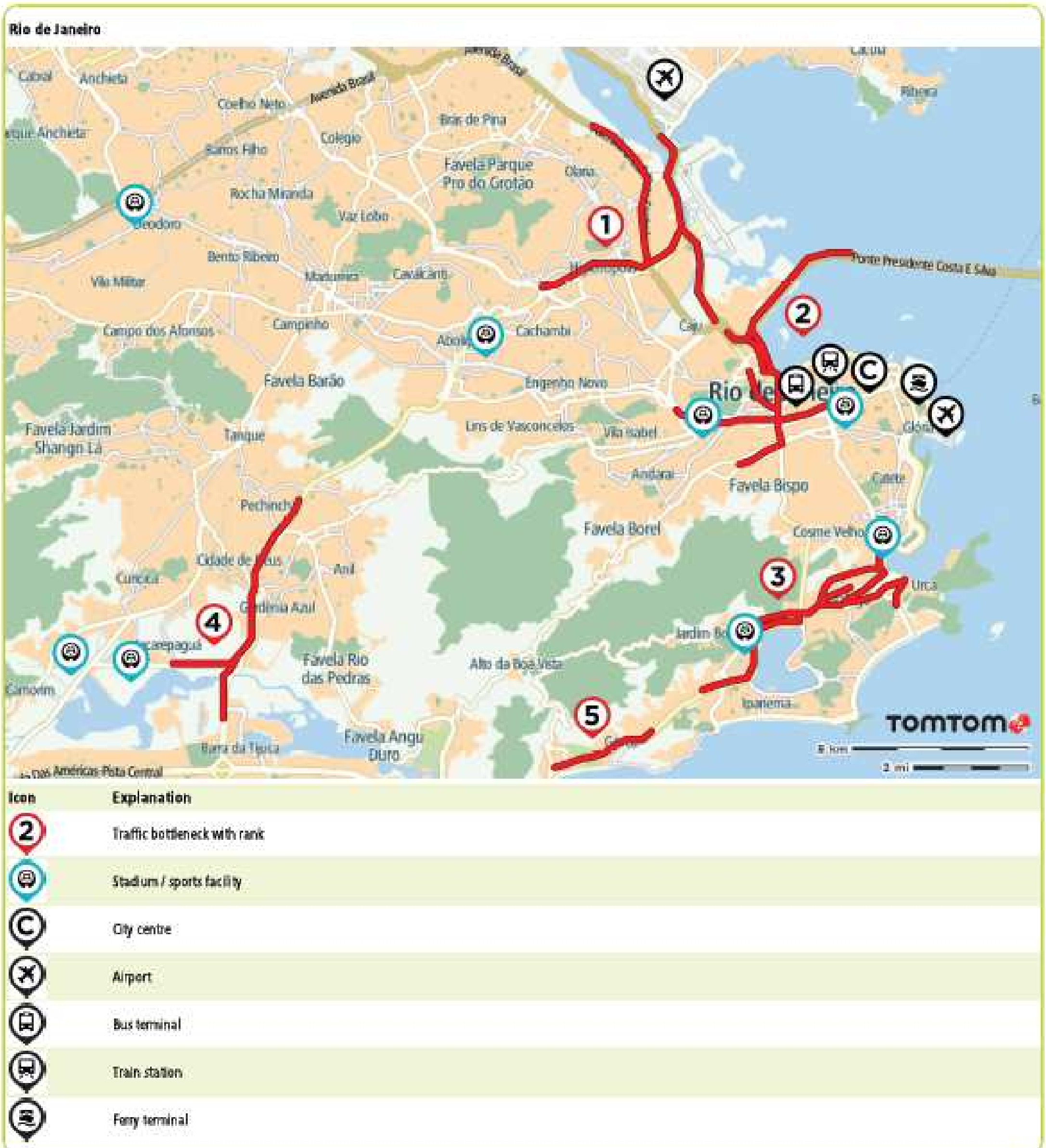


Figure 3: Selected bottleneck locations in Marseille, Q2 2013

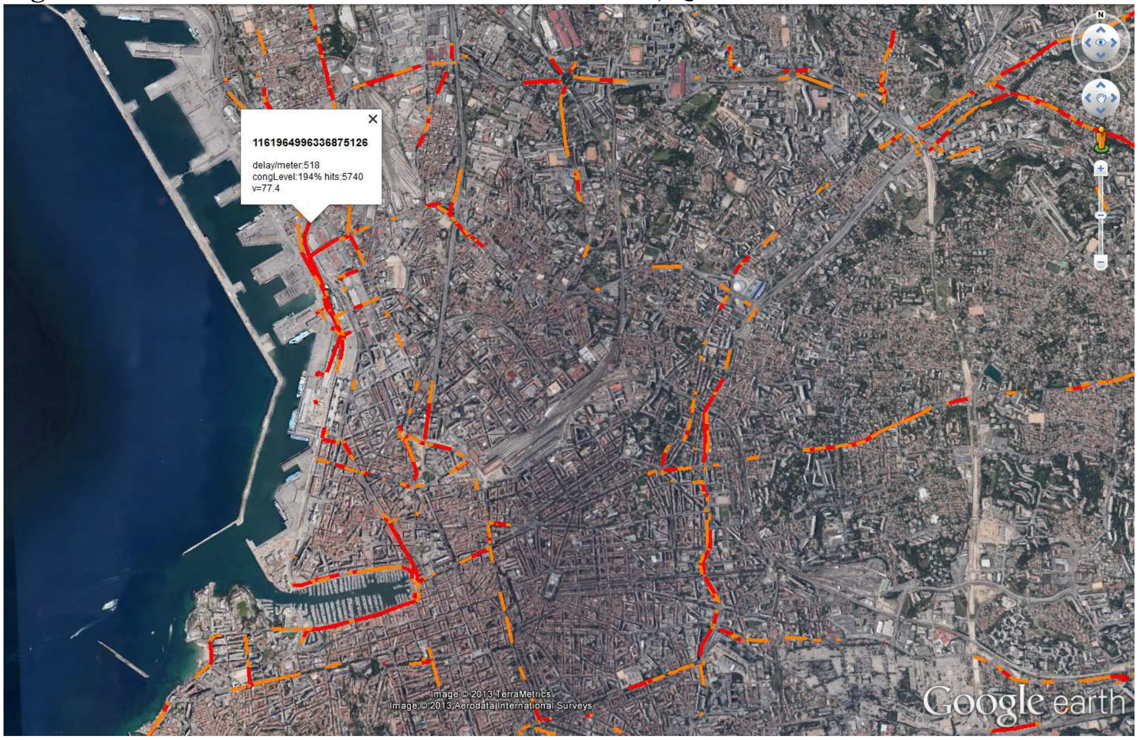
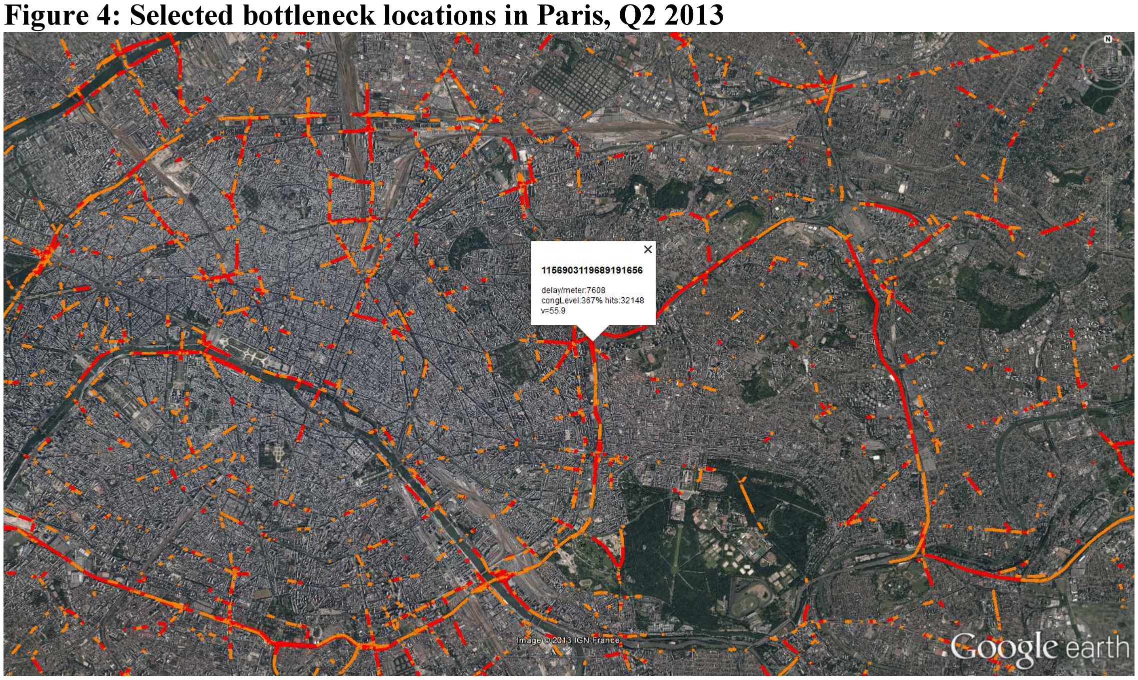


Figure 4: Selected bottleneck locations in Paris, Q2 2013



References

1. http://corporate.tomtom.com/releasedetail.cfm?ReleaseID=810331
2. http://www.siemens.com/entry/cc/en/greencityindex.htm
3. http://www.adlittle.com/future-of-urban-mobility.html
4. Texas Transportation Institute, September 2011.
5. IBID, November 2011.
6. Nationale Mobiliteitsmonitor 2009, Rijkswaterstaat Dienst Verkeer en Scheepvaart.
7. Joe Cortright, Measuring Urban Transportation Performance: A Critique of Mobility Measures and a Synthesis', September 2010.
8. http://www.c40cities.org/
9. http://www.unhabitat.org/content.asp?typeid=19&catid=540&cid=5025