D1.3 – Road information services

<table>
<thead>
<tr>
<th>Due Date</th>
<th>31st May 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Delivery Date</td>
<td>10th April 2019</td>
</tr>
<tr>
<td>Document Author/s</td>
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</tr>
<tr>
<td>Version</td>
<td>1.3</td>
</tr>
<tr>
<td>Dissemination level</td>
<td>PU</td>
</tr>
<tr>
<td>Status</td>
<td>Final</td>
</tr>
<tr>
<td>Document approved by</td>
<td>Maia Buzuleciu, Giacomo Fioroni</td>
</tr>
</tbody>
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EXECUTIVE SUMMARY

This document reports on the status of the use cases in the WP1. These use cases are described in the D1.1 Datasets Release for Model Region. The deliverable is public. The main target readers of the document are the research partners in QROWD, and also potential customers among the cities. Cities might be interested in following the implementation of the smart mobility services developed in QROWD and in reading about a nice working relationship in between a city like Trento and a global industry like TomTom.

The status of the deployment of these three use cases developed in WP1 is described in this document. These use cases are in different implementation stages. For instance, the third use case is completed while the first use case is still in an implementation phase.

The main outputs of this deliverable are:
1. A report of the advancements in the implementation of the first use case in WP1.
2. A description of the update version of the first use case.
3. A report describing the completed implementation of the second (except for the On-Street parking use case which is almost completed) and third use case.
1 INTRODUCTION

In the context of QROWD, new smart mobility services are in the stage of implementation or already finalized. The document aims to report the status of every use case described in the D1.1 Datasets Release for Model Region, along three different lines of work.:

First of all, several historical traffic analyses were run in order to understand better the traffic situation in Trento and support the municipality in influencing it.

Secondly, partners worked and are still working on developing a prototype of a touristic network, showing in real time to drivers the best location to go skiing in the surrounding of Trento. The visualisation of this road information enables drivers to enjoy even more their free time. In addition, this should help in reducing traffic jams usually caused during winter time because of a rise of population on road willing to spend their free time in a ski resort.

Thirdly, strong support was given to several tools (Origin-Destination matrix, Route Monitoring, TrafficStats, Parking Probabilities) in the stage of prototypes. Today, all these tools have been integrated into products and are sold in the market.

The three use cases are currently in different stages of implementation:

- The use case 1, entitled the Touristic Network, is currently being implemented. Therefore, in the document is described the latest version of the use case. This use case includes in addition the Ski resort information.
- The implementation of the use case 2, entitled the Parking Services, is almost completed. Its implementation will be presented.
- The use case 3, related to Traffic Service, was updated because the results of all the historical analysis were not all consistent. However, the implementation of this use case is fully completed.

The structure of the document follows the different use cases designed in the first business case. Below can be found the structure of the different use cases in the WP1:

BC1-UC#1: Touristic Network - Analysis of travel time on strategic roads in the context of tourism
A) Route monitoring
B) Visualization using schematic map
C) Ski resort information

BC1-UC#2: Parking services – Data quality improvement
A) Off-street parking
B) On-street parking

BC1-UC#3: Traffic Services
A) Historical Analysis:
   1. The impact of the Christmas Market
   2. The case study of Trento a pole of attraction within Trentino
   3. Migration analysis from-to Trento
B) Road Event Reporter
C) TomTom City
2 IMPLEMENTATION ON GOING OF THE TOURISTIC NETWORK (BC1-UC#1)

The first use case was enriched from the previous versions, we describe below its final version. The development of the Touristic Network is currently going. Therefore, the implementation of the prototype is not described in this document but will be described in the D1.4 Final TomTom Pilot.

1.1 The final description of the Touristic Network’s use case

The Touristic Network mobile app, built in the research project QROWD, is designed to revolutionize winter tourism in Trentino, a province in the alpine region of northern Italy. The app offers to its users an overview of how much time is needed to reach any open ski resort in Trentino. The travel time calculation considers probable delays on the route (traffic jams, incidents), regardless of where the users are coming from. Additionally, information on available services and the status of ski resorts are conveyed. All this travel information helps the users to select the most optimal route option to drive to the best ski resort to meet their needs.

Figure 1: Schema representing the idea of the Touristic Network

SK1 = Ski resort n°1

The Touristic Network is designed in three parts:
1) The Route Monitoring
2) The Schematic Map
3) The Ski Resort Information

The Route Monitoring is the only step which is already implemented. Therefore, its implementation will be presented below in the document as completed, at the opposite of the Schematic Map and the Ski Resort Information which are currently being developed.
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In fact, the Touristic Network is composed by several elements which individually need to be already developed in order to be integrated together:

Figure 2: The different components of the Touristic Network

Below can be found the architecture of the use case.

Figure 3: The architecture of the Touristic Network
1.2 The Route Monitoring

- The Route Monitoring description:

The Route Monitoring is an easy-to-use web interface.

By providing users with information about current route travel times, delay times in comparison to free-flow traffic, and average data confidence level, the TomTom Route Monitoring service provides comprehensive traffic monitoring – making monitor custom routes.

Traffic managers can monitor conditions with travel times, delay times, and flow data, and then broadcast analysis and proactive measures through variable-message sign (VMS) integration, mobile or web apps, TV, and radio.

TomTom Route Monitoring is based on TomTom’s live traffic technology, which is created by merging multiple data sources, including anonymous measurements from GPS navigation devices, mobile phone signals and sensor data from governments.

- The use of the Route Monitoring in this use case:

As a first step in the development of the Touristic Network, the Route Monitoring tool was used in order to define the strategic routes leading to every ski resort in Trentino from the city of Trento. In the Route Monitoring platform, the origin and the destinations are static. For every defined route, an API is created. Therefore, for every route selected in the Touristic Network an API is given. It enabled the developing team to understand the specificities of every individual route. Indeed, the network defined in Route Monitoring (Origin: Trento / Destinations: all the ski resorts) enables to study the traffic there. For every route selected the live traffic is given. The precise locations of congestion are displayed as the live traffic situation is given by route segment.

Indeed, consequences on the traffic situation when comes the winter season can be appreciated on the Route Monitoring:

- The first screenshot below shows congested routes leading to ski resorts at morning time during the winter season. People willing to ski one day may reach the ski resort quite early in the morning. This explains why the routes leading to the ski resorts are congested. In addition, the 28th of December is a day of school holidays which means that more people are on vacation.

- In the second screenshot, this phenomenon cannot be well observed since it shows the traffic situation late morning at 11:47. Moreover, the 14th of February is not a day of school holidays, unlike the 28th of December.
Figure 4: Screenshot of the traffic condition to reach all the ski resorts in Trentino taken at 9:38 on the 28th of December 2017

Figure 5: Screenshot of the traffic condition to reach all the ski resorts in Trentino taken at 11:47 on the 14th of February 2019

The visualization proposed in the Route Monitoring could be very useful for the Municipality of Trento in order to be well-informed about the traffic situation and the consequences of the intense tourist activity during the winter season. The municipality could decide to influence the traffic by, for instance, displaying the multi-destination network (from Trento to every ski resort) in different places and in various manner using Variable-Message-Signs (VMS). Indeed, such information can impact people’s decision to go to busy ski resorts during the school holidays, for instance.
1.3 The Schematic map based on the multi-destination routing engine

One of the major ideas of the Touristic Network is to visualise the different optional routes in a simplified way. The road network should look like metro lines. In this use case, routes are simplified in an automatic way from the routing engine. This tool simplifying routes geometry is currently being developed. Several rules need to apply in order to get the best results in terms of route simplification.

In fact, building such a tool arises several questions:

- How should be represented the simplified lines to make the road network easy to understand? How junctions should be represented?

In this prototype, the decision was taken to keep some nodes along the route lines in characteristic points (main crossroads, change of direction) in order to keep the real geography of the space.

- Should the routes not overlap, as it can be observed on underground maps?

The prototype of the Touristic Network tries to imitate metro-lines map. Therefore, overlapping routes should be represented by separate parallel lines as it is several times presented in the example of Nuremberg underground in the picture below:

Figure 6: The Nuremberg underground

Source: Stadt Netzplan Nürnberg - HerrMay

- How much should the simplification follow the real geometry? How to represent the essential elements like lakes or rivers?

By not respecting the real geography of the place, the simplified map might not help drivers to get a correct sense of direction, distance and proximity of the area. In addition, representing the
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different essential elements like lakes, rivers but also famous monuments can be an orientation mark. Therefore, essential elements are very important and should be well represented. This is challenging in Trentino as there are some famous lakes and Trento is crossed by a river.

- How should the live traffic information be represented?

Several ways of representing the live traffic information are considered:

- The live traffic flow can be represented directly by colouring in red the lines corresponding to the roads to indicate traffic jams or apply any gradient. This can be done by referring every stretch of this simplified map with the reality using a location referencing method.
- Numbers indicating travel times and potential delays can be displayed for each route in the multi-destination network.
- Incidents can also be represented using traffic icons.

Proper visualization of the live traffic is currently being studied as the road network should be represented in a user-friendly manner. This would enable drivers to take a fast decision to which ski resort they should go to avoid traffic delays and populated areas. Therefore, all these challenges in the visualization need to be carefully thought and implemented in order to provide drivers with the simplest visualization of the road network.

Below is a screenshot showing the premature results from the prototype. The prototype is currently being improved to meet all these challenges which were described earlier.

**Figure 7: The prototype of the schematic map of the Touristic Network**
1.4 The ski resorts information

When the visitors and citizens plan to go to a ski resort, they also want to know what services are available there. They are interested by the ski slope status, the snow level, the weather and maybe also the services, shops located around the ski resort. Therefore, the most relevant information concerning available services in every ski resort were defined.

The relevant information and available services about ski resorts are listed below:

- Hotels
- Restaurants
- Stores
- Ski schools
- Ski rental location
- View points
- Ski resorts information:
  - Ski pass prices
  - Elevation info
  - Status of the ski resort: Close/Open
  - Runs/Slopes: number + status + level + km
  - Ski lifts: number + status
  - Cross-country trails: - km currently groomed
  - Sledding runs: - km open
  - Winter hiking trails: - km open
  - Snow information

Once the relevant information and available services are listed, different ways to collect these information were thought to provide relevant information for every ski resort, which should be displayed in the Touristic Network app.

1- Collection of datasets

A) The TomTom POI

The TomTom POI contains very interesting information on the services available in the ski resorts. Its current version includes 40 124 POIs for the whole region of Trentino. The POIs, in this dataset, are exclusively represented by points. The location of services such as restaurants, hotels, stores is given.

In this dataset the ski resort status is not described, but only available services in the surroundings and the location of the ski resorts. Therefore, one of the ideas is to improve the available information about the various ski resorts by collecting datasets from different sources and not using only TomTom POI.
B) Open datasets

The two open source datasets described below provide very interesting geographical information related to the shape of the ski slopes and the ski lifts. They will be integrated into the final prototype of the Touristic Network as ski resort information.

1. Ski Ropeway (open source)

The Ski Ropeway dataset is an open source dataset produced by the government of Italy and is available in Dati Gov Italy. The dataset contains 270 ropeways. The location of the various ropeways in Trentino is represented by lines.

2. Ski Slopes (open source)

The Ski Slopes dataset is an open source dataset produced by the region of Trentino: “Servizio Urbanistica e Tutela del Paesaggio”. The dataset contains 813 points constituting polygons.
These polygons represent the different ski resorts for the whole Trentino region.

Table 3: Ski Slopes' description

<table>
<thead>
<tr>
<th>Property Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AREA</td>
<td>Area</td>
</tr>
<tr>
<td>PERIMETER</td>
<td>Perimeter of the area</td>
</tr>
<tr>
<td>PIST_SCI_</td>
<td>Internal ID</td>
</tr>
<tr>
<td>PIST_SCI_1</td>
<td>User ID</td>
</tr>
<tr>
<td>SCI_CD</td>
<td>Code of the ski slope as assigned by the Touristic Office. Structure of the code:[skiresort].[location].[number]. -[skiresort](2 numbers):= 1..11; -[location] ::= code which corresponds to the description of the location as in sci_lc. -[number] ::= progressive numbering internal to the ski resort</td>
</tr>
<tr>
<td>XCOORD</td>
<td>Coordinate</td>
</tr>
<tr>
<td>YCOORD</td>
<td>Coordinate</td>
</tr>
<tr>
<td>UR_CD</td>
<td>Definition of the code indicating the land use assigned by the Urban Planning Office. Admitted values: Code 6100. Type, Length: Whole, 4. Unit: Numbered</td>
</tr>
<tr>
<td>SCI_NO</td>
<td>Sci slope name</td>
</tr>
<tr>
<td>SCI_CNC</td>
<td>ID number of every ski resort</td>
</tr>
<tr>
<td>SCI_CNO</td>
<td>Operator name</td>
</tr>
<tr>
<td>SCI_LC</td>
<td>Ski resort name</td>
</tr>
</tbody>
</table>

C) Websites - RSS

One of the ideas was to extract information concerning the status on ski resorts contained in various websites and to keep track of the status.

Several websites containing combined and precise information on all the ski resorts were listed. The main websites containing such information are:
- http://www.skiresort.info
- https://www.dolomitisuperski.com/it

Websites of every individual ski resort were also collected and listed. See below few of them:
Table 4: Listed websites

<table>
<thead>
<tr>
<th>Name of the ski resort</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panarotta 2002</td>
<td><a href="http://www.panarotta.it/">http://www.panarotta.it/</a></td>
</tr>
<tr>
<td>Ski area Lagorai</td>
<td><a href="https://www.skilagorai.it">https://www.skilagorai.it</a></td>
</tr>
<tr>
<td>Ski Center Lavarone</td>
<td><a href="http://www.alpecimbra.it/en/ski-area-alpe-cimbra/ski-area-folgaria/46-0.html">http://www.alpecimbra.it/en/ski-area-alpe-cimbra/ski-area-folgaria/46-0.html</a></td>
</tr>
<tr>
<td>Paganella Ski</td>
<td><a href="https://www.paganella.net">https://www.paganella.net</a></td>
</tr>
<tr>
<td>Ski Center Latemar</td>
<td><a href="https://www.latemar.it/en/winter/home-page-winter">https://www.latemar.it/en/winter/home-page-winter</a></td>
</tr>
<tr>
<td>Ski area Bellamonte – Alpe Lusia</td>
<td><a href="http://www.skiareaalpelusia.it/en/">http://www.skiareaalpelusia.it/en/</a></td>
</tr>
<tr>
<td>Alpe Cermis</td>
<td><a href="http://www.alpecermis.it/EN/">http://www.alpecermis.it/EN/</a></td>
</tr>
<tr>
<td>Ski area San Martino di Castrozza</td>
<td><a href="http://www.sanmartino.com/IT/ski-area/">www.sanmartino.com/IT/ski-area/</a></td>
</tr>
</tbody>
</table>

Despite several searches none of these websites offer an access to their information via RSS. Therefore, the information related to the ski resorts that contain these websites cannot be extracted or followed.

**D) Twitter**

Another idea was to collect and extract relevant information from Tweets. Tweets can be used to study the frequentation of certain ski resorts. Indeed, if several Tweets are compatibilized in one ski station the same day, it might certainly mean that this ski station was populated this day. In addition, certain Tweet-ed comments from ski resort visitors could also be very useful. For instance, visitors might complain or, on the contrary, be pleased about the snow level. Another example would be visitors who tweet their disappointments when a ski slope or a ski lift is not functioning or is closed. In fact, it could be very interesting to collect feedback from Tweets.

Figure 8: Information from Tweets planned to be collected

Using tweets as source of information is limited as anything which is not Tweet-ed is not known. Also, extracted information comes in many different languages. Moreover, the collected data is limited as anything which is not Tweet-ed is not known. Therefore, it could be very interesting to collect feedback from Tweets.
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very noisy.

The use case scenario of collecting Tweets is in close relation to WP4 and T4.4. AI4BD has set up a collection process within QROWN platform, especially the NiFi engine.

**Figure 9: Collection process**

For three months, Tweets were collected and processed. The focus was on processing multilingual information and to identify entities and to link those entities to other knowledge base systems. Unfortunately, only a small percentage of the tweets could be collected because of API access. QROWN team has used the free of charge API and defined filters in order to reduce the amount. During the experiment Twitter has limited the access of data within the API and therefore we couldn’t collect enough and relevant data. Nevertheless, the NiFi Twitter process is defined and can be used in a real case environment assuming the customer interested to use this service is willing to pay to Twitter a subscription fee to obtain higher volume of data (Tweets).
E) **Virtual City Explorer**

Another idea was to use the Virtual City Explorer, crowdsourcing tool, developed in the WP3 and described in D3.2, to collect new POIs in the ski resorts.

![Figure 10: The example of the entry of Cermis ski lift](image)

Unfortunately, this idea had to be abandoned because of privacy issue as the Virtual City Explorer is using Google Map Street View. From a legal point of view, TomTom cannot collect any dataset from Google Map.

### 2- Integration of available datasets

In order to integrate a unique dataset into the Touristic Network app, the TomTom POI will be combined with the two open sources datasets: The Ski Ropeway and the Ski Slopes.

Converging datasets is problematic as it can for instance potentially cause ambiguous duplications. Additionally, dealing with a diversity of data formats may cause complications.

The H2020 project SLIPO remedies these situations by providing the **SLIPO Workbench**, a complete software suite for handling the linking and integration of Big POI data assets. The SLIPO Workbench supports the entire lifecycle of POI (Points of Interest) integration (transformation, linking, fusion, and enrichment), by transferring the data integration problem to the Linked Data domain.

In this process:

- datasets are first transformed into RDF (via TripleGeo),
- interlinked (via LIMES),
- fused (via FAGI)
- and enriched (via DEER).

The SLIPO Workbench is simple to use and it is a cost-effective manner that delivers POI assets of increased coverage, completeness, quality, and timeliness. SLIPO Workbench reduces the effort, time, and cost to integrate POI data at a world-scale.

In the context of QROWD, the SLIPO Workbench is being tested and evaluated based on its efficacy and the user-friendliness of the process. Combining the different POIs located within and around the ski resorts offers a nice challenge to SLIPO.

SLIPO workbench will be used to enhance the TomTom POI with open and crowdsourced information contained in three datasets. It is expected to obtain an enriched POI dataset with a
bigger number of POI, a more precise geometry (polygons, lines) and more attributes. In total, four datasets will be interlinked and fusion. They are:

**Table 5: The three datasets transformed, interlinked and fusion in the SLIPO workbench**

<table>
<thead>
<tr>
<th>Name</th>
<th>TomTom POI - Trentino (North Italy)</th>
<th>Ski Ropeway</th>
<th>Ski Slopes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Licence</td>
<td>TomTom</td>
<td>Creative Commons Attribution 4.0 International (CC-BY 4.0)</td>
<td></td>
</tr>
<tr>
<td>Sectors</td>
<td>POIs</td>
<td>Ski resort</td>
<td>Ski resort</td>
</tr>
<tr>
<td>Owner</td>
<td>TomTom</td>
<td>Dati Gov Italy</td>
<td>Provincia Trentino</td>
</tr>
<tr>
<td>Open</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Format</td>
<td>Shp</td>
<td>Shp</td>
<td>Shp</td>
</tr>
<tr>
<td>Rate of Change</td>
<td>Static</td>
<td>Static</td>
<td>Static</td>
</tr>
<tr>
<td>Size</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 11: The integration of the different datasets
The expected result is to enrich the TomTom POI dataset with open source and crowdsourcing datasets, by adding some information related to the ski resorts themselves and related to available activities in the surrounding of every resort. After the integration work, the TomTom POI is expected to contain more information (geometry, extra attributes, more POIs, etc.). Its quality should be improved as a positive consequence of the integration work done in SLIPO.

We expect the TomTom POI to integrate polygons representing the ski resort as areas and ski lifts as lines in the map. This will improve the representation of these types of information in a more realistic way. As output, the final TomTom POIs dataset will contain a mixture of geometries (e.g., lines in the case of POIs representing ropeways).
Figure 13: The ski resort information enriched by the three datasets
3 IMPLEMENTATION OF PARKING SERVICES (BC1-UC#2)

The solution offered in this use case is to reduce the parking searching time keeping citizens and visitors informed about available parking spots by developing a complete parking service. This complete parking service incorporates Off-street parking and On-street parking.

The architecture describing this use case can be found below:

Figure 14: The architecture of the Parking services

1.5 Off-Street Parking

The description of the off-street parking can be found in the D1.1 Datasets Release for Model Region, page 14: "The Off-Street Parking is as spaces for vehicles to park which are located on dedicated property, usually in parking facilities like garages and lots."

The Off-street service is displayed on the QROWD dashboard.
Figure 15: The Off-Street Parking service displayed in the QROWD dashboard

The datasets are owned by the Municipality of Trento.

Table 6: Integrated Datasets in the Off-Street Parking service visualized in the dashboard

<table>
<thead>
<tr>
<th>ID</th>
<th>Dataset</th>
<th>Owner</th>
<th>Data Category</th>
<th>Type format</th>
<th>Open Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basemap</td>
<td>ArcGIS</td>
<td>static</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>1018</td>
<td>Occupation of underground parking places</td>
<td>Comune di Trento</td>
<td>Real-Time data</td>
<td>JSON - Fiware entity</td>
<td>Y</td>
</tr>
<tr>
<td>1023</td>
<td>RTZ restricted traffic zones</td>
<td>Comune di Trento</td>
<td>Static</td>
<td>GeoJson</td>
<td>Y</td>
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<tr>
<td>1024</td>
<td>Parking for people with disabilities</td>
<td>Comune di Trento</td>
<td>Static</td>
<td>GeoJson</td>
<td>Y</td>
</tr>
<tr>
<td>1033</td>
<td>Districts of Trento</td>
<td>Comune di Trento</td>
<td>Static</td>
<td>GeoJson</td>
<td>Y</td>
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<tr>
<td>1052</td>
<td>Location Parking meter</td>
<td>Comune di Trento</td>
<td>Static</td>
<td>GeoJson</td>
<td>Y</td>
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<tr>
<td>1061</td>
<td>Carsharing Trentino parking slots</td>
<td>Comune di Trento</td>
<td>Static</td>
<td>GeoJson</td>
<td>Y</td>
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<tr>
<td>1062</td>
<td>E-car charging stations</td>
<td>Comune di Trento</td>
<td>Static</td>
<td>GeoJson</td>
<td>Y</td>
</tr>
</tbody>
</table>
1.6 On-Street Parking

The description of the On-Street parking can be found in the D1.1 Datasets Release for Model Region, page 15. Below is a brief description of the On-Street Parking and the Parking Probabilities dataset (Data n°2005):

On-Street Parking is defined as parking for a vehicle that is permitted at the side of the driving street. The TomTom On-Street Parking service provides drivers with historical information about the expected parking availability on public streets in certain city areas. The probability of finding a parking spot on each permitted road stretch in the city is given for each specific hour of the day and day of the week.

The quality and quantity of the parking probabilities dataset for the city of Trento is constantly improved, as the aim is to provide the most accurate parking service. Therefore, TomTom had two times provided an updated version (2017, 2018) of the Parking Probabilities dataset for the city of Trento. The Parking Probabilities dataset is also visualized into the QROWD dashboard.

Figure 16: The parking Probabilities displayed in the QROWD dashboard

This visualization of the parking probabilities makes possible to study tendencies in the occupation of On-Street Parking. For instance, looking at the map, at night time the probability of finding a parking spot seems lower than during the day.
Figure 17: The parking Probabilities at night time displayed in the QROWD dashboard

The use case is still on going as the dataset n°1035, providing information on parking meters, should be integrated into the Parking Probabilities and be used to check the quality of the Parking Probabilities.

Table 7: Data in the implement the On-Street Parking service

<table>
<thead>
<tr>
<th>ID</th>
<th>Dataset</th>
<th>Owner</th>
<th>Data Category</th>
<th>Type format</th>
<th>Open Data</th>
<th>Already integrated?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1035</td>
<td>Information from mobile payment parking</td>
<td>Trentino Mobilità</td>
<td>Dynamic</td>
<td>CSV</td>
<td>N</td>
<td>No yet</td>
</tr>
<tr>
<td>2005</td>
<td>Parking probabilities</td>
<td>TomTom</td>
<td>Dynamic</td>
<td>XML</td>
<td>N</td>
<td>YES</td>
</tr>
<tr>
<td>2001</td>
<td>Advanced Navigable (Map)</td>
<td>TomTom</td>
<td>Static</td>
<td>SHP</td>
<td>N</td>
<td>YES</td>
</tr>
</tbody>
</table>

The Virtual City Explorer:

There was the idea to use the Virtual City Explorer to send virtual workers to collect information on restrictions of On-Street Parking. The work was to ask the virtual workers to take screenshots of parking signs and to answer to questions about the type of information provided by the parking signs. Aggregating the collected answers and pictures will inform on the permission to park and on certain limitations/restrictions (e.g. It is not allowed to park in this street every Saturday between 05:00 and 13:00 because there is a market). Unfortunately, this idea had to be abandoned because of privacy issue as the Virtual City Explorer is using Google Map Street View. From a legal point of view, TomTom cannot collect any dataset from Google Map. However, further collaboration are currently being explored to support TomTom in collecting restriction parking data.
4 IMPLEMENTATION TRAFFIC SERVICES (BC1-UC#3)

1.7 Traffic Analysis

In this chapter, the results of the different traffic historical analysis are described. In addition, TomTom City and Road Event Reporter status are presented.

Below can be found the architecture of all the different elements composing the use case n°3 "Traffic Services".

Figure 18: The architecture of the use case n°3

1.7.1 Results of the traffic analysis n°1 - The impact of the Christmas Market

The Trentino region is actively organizing cultural events all year. Some of these events attract a lot of visitors as the Christmas Market. The Christmas Market 2015-2016 has attracted about 730 thousand visitors in forty-six days (source: Mercatinodinatale). It contributes to a rise in traffic density which causes more traffic congestion. This analysis addresses the following question: How does the Christmas Market in Trento impact the traffic situation?

In order to measure the traffic disruption and also to predict jams during the Christmas Market every year, several traffic analyses comparing historical traffic data were run. The results from the data analysis shows that during the Christmas Market the city is more congested because...
of, among other causes, a tendency of tourist traffic. A loss of 3 to 5 km/h was observed, and the average speed dropped by 8% as a result of this study. Some interesting tendencies were observed:

- There is more traffic during morning and afternoon on weekends and during evenings on weekdays.
- The Brenner Highway/A22 is also impacted by more congestion during the Christmas Market and more specifically during weekends.

The analysis of the historical traffic data shows some tendencies and confirms that the city is more congested during the Christmas Market. More data would help in confirming this tendency. However, looking at the data itself it is very hard to really detect important disturbances in the traffic and detect the Christmas Market time or any other famous event in Trento.

The complete analysis can be found in Annex 1.

1.7.2 Results of the traffic analysis n°2 - case study of Trento a pole of attraction within Trentino

Trento has a geographical and economical central position within the province. It is the most populated town. The population of Trento (=118,160 inhabitants as of March 2018) totalizes approximately 22% of the total population of Trentino (=538,579 inhabitants as of February 2017). In the surrounding of Trento, some close urban areas also participate in the dynamism of the regional capital. Moreover, several medium and small towns, located in valleys and along the road network, are also part of the economy, especially in tourism and industry.

Therefore, the purpose of this analysis is to study traffic flows within Trentino in order to better understand the central position of Trento in the region. This study will focus on observing the commuting phenomenon. In order to do so, four data analysis were run using the Origin-Destination matrix. Below are the various data analysis:

1. Flows between Trento and other urban areas in Trentino during weekdays
2. Flows between Trento and other urban areas in Trentino during weekends
3. Flows between Trento and other urban areas in Trentino during the morning peak (weekdays)
4. Flows between Trento and other urban areas in Trentino during the evening peak (weekdays)

Origin-Destination (O/D) analysis:
The O/D Analysis allows a comprehensive understanding of the dynamics and movement within a city or metro area. TomTom has developed a platform allowing users to run O/D analysis based on historical traffic data. The TomTom O/D platform allows to run flow analysis between selected regions. The data is used in a way that only traces between the selected regions are counted. Moreover, the platform offers to visualize the data into a map. Matrix resulting from analysis run into the O/D platform can also be extracted.

TomTom O/D Analysis is based on nearly 10 years of historical data from more than 550 million devices: Smartphones, Automotive OEM customers, TomTom Telematics (fleet management), TomTom PNDs/Mobile apps, etc. It results of Floating Car Data (FCD)’s collection.

As conclusion of the analysis, there were more observations during workdays than during weekends. Moreover, strong connections between Trento, Mezzolombardo-San Michele all’Adige, Civezzano and Riva del Garda-Nago Torbole were observed.
In the analysis, there was no clear variation between the number of traffic flows from and to Trento at morning and evening time. Therefore, it seems that the number of people leaving is similar to the number of people coming, which is the typical observation in the case of commuting.

The complete analysis can be found in Annex 2.

### 1.7.3 Results of the Traffic analysis n°3 - Migration analysis from-to Trento

Trento participates in the economic dynamism of the north of Italy. The city benefits from its position along the Brenner Highway connecting Italy with the Northern Europe. Therefore, the aim of this report is to identify commuters and more generally flows between Trento and surrounding cities located in north Italy and south Austria, using the Origin-Destination matrix platform.

In conclusion from this report, drivers from/to Trento mainly travel to/from cities located along the Brenner highway. Commuting can be observed between Trento, Rovereto and Bolzano. A certain number of drivers travel between Trento and further cities like Milan, Brescia and Verona. Tourism or/and freight transportation can explain this phenomenon. During weekends, less traffic on roads can be observed and drivers seem to travel to further destinations, certainly for tourism purpose.

The complete analysis can be found in Annexe 3.

### 1.7.4 Challenges found

Several data studies were run to measure the impact of weather (black ice, snow, heavy rain) and of cultural events (other than the Christmas Market) on the traffic in Trento. Unfortunately, the outcomes were not showing any clear tendencies despite that these events might cause disturbances on the road network.

The reasons of such results are:
- First of all, these events are very short in time, only a few hours or days.
- The quantity of the traffic data, in other words, probes data are quite low in Trento as it is a medium-size city.

### 1.8 The Road Event Reporter

The description of the Road Event Reporter can be found in the D1.1 Datasets Release for Model Region, page 30. Below is a brief description of the Road Event Reporter:

TomTom’s Road Event Reporter service helps achieve this goal of reducing congestion by allowing cities and road authorities, event organizers, and fleet managers to collaborate and announce roadwork or stoppages to millions of users at once. Trusted partners can report road closures, accidents and other potential traffic disruptions using the Road Event Reporter, a web-based application. With the service’s easy-to-use interface, users can identify potential issues by visualizing current traffic flow, quickly create and edit road events on the screen and view current, upcoming, and expired events. Once the disruptions are reported, TomTom’s
Road information services

traffic fusion engine and moderation teams use GPS observations from millions of connected devices to validate the issue. The temporary disruption is then reported to users, encompassing in-dash systems, smartphones, navigation devices and web, to help improve routing calculations. In the end, traffic congestion is reduced, saving drivers’ time, fuel, and emissions.

An access to the Road Event Reporter (evaluation account) was given to the Municipality of Trento, so that the Municipality of Trento could test the tool.

1.9 TomTom City

The description of TomTom City can be found in the D1.1 Datasets Release for Model Region, page 32. Below is a brief description of TomTom City:

TomTom City is a web portal where are visualized the live traffic incident and the live traffic flow for a little less than 200 cities around the world. Calculations based on historical traffic data are also visualized in the form of charts. It is indeed a platform summarising the traffic situation in all these different cities. Their traffic situation is also compared from one city to another.

Since September 2017, the overview of the traffic of Trento is displayed on the web portal of TomTom City. The link to the Trento's page on the web portal can be found on this attached link: https://www.tomtom.com/en_gb/traffic-news/trento-traffic/traffic-flow

Figure 19: Trento’s traffic overview in TomTom City
Road information services

The two maps displaying live traffic flow and live traffic incident in TomTom City were copied in the QROWD dashboard of the city of Trento in order to keep citizens informed about the live traffic conditions.

Figure 20: Trento’s traffic overview in the QROWD dashboard
5 CONCLUSIONS

The status of implementing the new smart mobility services in the WP1 is in a good stage. Indeed, the third use case related to the traffic analysis and called Traffic Services was completed already in M22. Moreover, the second use case about the Parking Services is almost completed as the only element missing is the dataset n°1035 named “Parking Meter” which should be integrated into the Parking Probabilities.

The first use case entitled The Touristic Network is still in the implementation stage. There is a particular focus on this use case. In fact, this use case was several times redesigned in order to get a very interesting architecture and a strong impact in terms of reducing disturbances caused by traffic jams during the winter season in Trento. In addition to this, the use case was thought in a way it could serve multiple business cases in a large-scale focus. In this use case, the collection of crowdsourcing datasets was tested. Open datasets were collected, interlinked and fused with TomTom POIs in order to produce a single enriched data asset and removing duplicate entities.

Moreover, implementing the results from the QROWN challenge competing in “What the Hack? #4” and presented in D1.2 Hackathon are currently being explored as further collaboration in the development of QROWN legacy exploitation. This use case once completed would propose a service application regulating the traffic caused by tourism during the winter season.

The implementation of the WP1 is not fully completed but still in a good stage. The D1.4 Final TomTom Pilot will deliver the deployed prototype of the first use case.
Introduction

The Trentino region is actively organizing cultural events all year. Some of these events are reputed as the Trento Film Festival, the Festival of Economics and also the Christmas Market. These events attract a lot of visitors. The Christmas Market 2015-2016 has attracted about 750 thousand visitors in forty-six days (source: Mercatiniinvernotrentino.it). It obviously contributes to a rise in traffic density which can be the cause of more congestion.

Facing this problem, this historical analysis aims to measure traffic disturbance and also predict jams during the Christmas Market in Trento. Having a better understanding about the traffic situation allows traffic managers to influence it adopting solutions according to observed problems. Therefore, this study has the ambition to participate in the improvement of the traffic situation by providing insights into the traffic patterns during events.

In this analysis, we address the following questions by using historical traffic data:

**How does the Christmas Market in Trento impact the traffic situation?**
Methodology

• This report offers analysis of road segments, but also of areas.

• The same dataset has been used in different ways in order to show various aspects of the impacts on the traffic situation.

• The data results from the fusion of filtered, stored and map-matched floating car data (FCD). In total, 10 years of historical data has been collected by TomTom from more than 350 million devices.

Tools used in the report:

1. General analysis of the region:
   - Area Analysis
   - Origin-Destination

2. Routes/segments analysis:
   - Speed distribution
   - Speed profiles with confidence interval
   - Travel Time
   - Volume progression
Information about the Christmas Market in Trento

The Christmas market of Trento takes place in Piazza Fiera and Piazza Cesare Battisti, which are two main squares in the city-center.

The Christmas periods:
- In 2016-2017, the Market takes place from 18.11.2016 to 06.01.2017.
- In 2017-2018, the Market takes place from 18.11.2017 to 06.01.2018.

1. General analysis of the region:
   - Area Analysis
   - Origin-Destination
Area Analysis: **Comparison of the impact on roads during and not during the Christmas Market in weekend and weekdays**

In this Area Analysis, we consider data for the Christmas Market period of 2016-2017 and 2017-2018 which is compared to seven years of data.

As a result, the Area Analysis returns the average speed on the selected roads depending on the Functional Road Classes (FRC) (See the last slide).

**Parameters:**

Area selected: Exclusively roads, colored in black (FRC [1, 2, 3, 4]), are taken into account in this analysis.

**Comparison:**

- **During the Christmas Market:**
  - Dates ranges:  
    - From 18.11.2016 to 06.01.2017
    - From 18.11.2017 to 06.01.2018
  - Time range: 7:00-22:00

- **Not during the Christmas Market:**
  - Date range: from 01.01.2010 to 17.11.2017
  - Time range: 7:00-22:00

---

**Title:** Average Speed in Trento on weekdays during and not during the Christmas Market 2016-2017 and 2017-2018

- **During the Christmas Market** the average speed is lower. The city appears more congested. This congestion seems to result from **Touristic Traffic**.
- We observe an **average loss of 3 to 5 km/h** during the Christmas Market. The average speed drops by **8%**.
- The loss is mainly observed during **weekends** and also during **evenings on weekdays**.

---

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Origin-Destination Matrix:

The Origin-Destination Matrix allows you to understand dynamics and movements within a city or a larger region by looking at flows between defined regions.

Parameters:
- **Selected regions:**
  - Administrative regions (which have been remodeled in order to exclude the A22). In total, 11 regions are represented.
- **Date range:** Comparison during and not during the Christmas Market:
  - During the Christmas Market: 18/11/2016 – 06/01/2017 (50 days).
  - Not during the Christmas Market: 01/09/2016 – 20/10/2016 (50 days).
  - No distinction has been made between weekdays and weekends.
- **Time range:** 10.00 to 20.00
2. Routes/segments analysis:
- Speed distribution
- Speed profiles with confidence interval
- Travel Time
- Volume progression
Road Analysis:
- Speed distribution
- Speed profiles with confidence interval
- Travel Time
- Volume progression

Selection of roads on which traffic is affected by the Christmas Market:
1. Via Torre Verde
2. Piazza Venezia
3. Via del Brennero
4. Via Piazza

These roads have been selected as they represent well the tendency observed in most of the Trento road network.

Comparison:
- During the Christmas Market:
  - Date range: from 18.11.2016 to 06.01.2017 (50 days)
  - Time range: 10:00–20:00

- Not during the Christmas Market:
  - Date range: from 01.09.2016 to 20.10.2016 (50 days)
  - Time range: 10:00–20:00

---

Piazza Venezia

The chart of Speed distribution shows the density of vehicles at different speeds. X-axis represents speed and Y-axis represents the percentage of total cars driving at a particular speed in the given time period.

We compare two periods of time:
- The Christmas Market period is represented by red bars and the red curve (50 days: 18.12.2016–06.01.2017).
- The non-Christmas Market period is represented by grey bars and the grey curve (50 days: 01.09.2016–20.10.2016).

- The chart shows, according to the density index (in ordinate) that more drivers go slower than 20km/h during the Christmas Market than during a non-touristic season. Therefore, we observe that drivers tend to slow down during the Christmas Market. This can be explained by a higher density of vehicles on roads which might cause more congestion.
The first chart compares average speed during Christmas (in red) and Non-Christmas days (in grey) for the year 2016.
- The first chart compares average speed during Christmas (in red) and Non-Christmas days (in grey) for the year 2017.
- At night, the data is noisy resulting in a relatively large confidence interval. Between 6:00 and 21:00, the average speed can be estimated more precisely. Moreover, the Historical Traffic dataset is denser in 2017-2018 than in 2016-2017 because of more data sources. Consequently, the second chart shows more accurate results.

In the first chart:
- From 03:00 to 20:00, there is 95% confidence that drivers go slower during the Christmas Market than usual. The chart shows a traffic speed drop of 3 to 8km/h appearing mainly during the afternoon, and reaching its maximum value (8km/h) at 17:00.
- In conclusion, drivers go slower during the Christmas Market period because there is a higher density of vehicles on Trento’s road network which might cause more traffic jams (cf. chart on page 15).

The two charts show the average speed at different hours of the day from 7:00 to 22:00 on Piazza Venezia (see the picture). The charts compare the Christmas Market period (red curve) with an average of seven years of data (grey curve). The average speed is calculated for the week (1st chart) and for the weekend (2nd chart).

In general, Piazza Venezia is more congested during the Christmas Market:
- In the first chart, the average speed during the Christmas Market drops by only 1 or 2 km/h compared to the average from 14:00 to 20:00. People tend to go to the Christmas Market in the evening on weekdays.
- In the second chart, the traffic is more congested from 10:00 to 12:00 and from 14:00 to 20:00 during the Christmas Market. On average, the traffic has dropped by 2km/h to 4km/h. People tend to go more to the Christmas market all over the day on weekends than on weekdays.
This chart shows the number of vehicles on Piazza Venezia at every hour during weekends. Two periods are compared:

- The Christmas Market is represented by red bars (50 days: 18.12.2016 – 06.01.2017).
- The Non Christmas Market is represented by grey bars (50 days: 01.09.2016 – 20.10.2016).

- At night, from 20:00 to 06:00, the number of vehicles in Piazza Venezia is very low.
- The number of vehicles from 09:00 to 12:00, around 14:00 and from 16:00 to 18:00 is much higher during the Christmas Market. During the day, the volume of vehicles seems higher during the Christmas Market despite some exceptions observed at 13:00 and at 15:00. These results correspond to the assumption that people tend to visit the Christmas Market during morning and afternoon time on weekends.

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Via Piave

Title: The volume progression on weekends in Via Piave

Title: The average speed in Via Piave on weekdays

Title: The average speed in Via Piave on weekends

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Via del Brennero

Title: Vehicle density at different speeds comparing the Christmas Market period with the non-Christmas Market period in Via del Brennero

Title: The speed profiles with confidence interval of Piazza Brennero (Data from 2016 / Confidence 95%)

Title: The speed profiles with confidence interval of Piazza Brennero (Data from 2017 / Confidence 95%)

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Road information services

Via del Brennero

The volume progression on weekdays in Via del Brennero

The average speed in Via del Brennero on weekdays

The average speed in Via del Brennero on weekends

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Via Torre Verde

Vehicle density at different speeds comparing the Christmas Market period with the non-Christmas Market period in Via Torre Verde

The speed profiles with confidence interval of Via Torre Verde [Data from 2016 / Confidence 95%]

The speed profiles with confidence interval of Via Torre Verde [Data from 2017 / Confidence 95%]

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Analysis of impacts of the Christmas Market on the Brenner Highway in both directions. [Custom Travel Time]

Parameters:
- Route: A22 (both directions)
  - Direction 1: South to North
  - Direction 2: North to South
- Date range:
  - Christmas Market 2016-2017 and 2017-2018: 18/11/2016-06/01/2017 and 18/11/2017-06/01/2018
  - Non-Christmas Market: 01/09/2016-20/10/2016 and 01/09/2017-20/10/2017
  - Weekdays and weekends are treated separately
- Time range:
  - 07:00-10:00
  - 10:00-12:00
  - 12:00-14:00
  - 14:00-16:00
  - 16:00-19:00
  - 19:00-20:30
  - 20:30-22:00
Road information services

Observations:
- During the Christmas Market the city is more congested => Tendency: Touristic Traffic
- We observe a loss of 3 to 5 km/h => The average speed drops by 8%
- More traffic during morning and afternoon on weekends & during evenings on weekdays.
- The Brenner Highway/A22 is also impacted by more congestion during the Christmas Market and more specifically during weekends.
- More data would make this difference more visible.

For further developments:
- Compare the Christmas Market period with the complete winter season
- Use Origin-Destination in order to predict flows
- Compare weekends

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### Functional Road Classes (FRC)

<table>
<thead>
<tr>
<th>FRC Value</th>
<th>Short Description</th>
<th>Long Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Motorways, Freeways, Major Roads</td>
<td>All roads that are officially assigned as motorways.</td>
</tr>
<tr>
<td>1</td>
<td>Major Roads, Important than Motorways</td>
<td>All roads of high importance, but not officially assigned as motorways, that are part of a connection used for international and national traffic and transport.</td>
</tr>
<tr>
<td>2</td>
<td>Other Major Roads</td>
<td>All roads used to travel between different neighboring regions of a country.</td>
</tr>
<tr>
<td>3</td>
<td>Secondary Roads</td>
<td>All roads used to travel between different parts of the same region.</td>
</tr>
<tr>
<td>4</td>
<td>Local Connecting Roads</td>
<td>All roads making all settlements accessible by making parts (e.g., coast, sea, river and controls of a settlement accessible).</td>
</tr>
<tr>
<td>5</td>
<td>Local Roads of High Importance</td>
<td>All local roads that are the main connections in a settlement. These are the roads where important traffic to possible e.g., central roads within suburban areas, industrial areas or residential areas, etc.</td>
</tr>
<tr>
<td>6</td>
<td>Local Roads</td>
<td>All roads used to travel within a part of a settlement or roads of minor connecting importance in a rural area.</td>
</tr>
<tr>
<td>7</td>
<td>Local Roads of Minor Importance</td>
<td>All roads that only have a destination function, e.g., dead-end roads, roads inside living areas, alleys, narrow roads between buildings, in a park or garden.</td>
</tr>
<tr>
<td>8</td>
<td>Other Roads</td>
<td>All other roads that are less important for a navigation system:</td>
</tr>
</tbody>
</table>
|           |                              | * Private roads that must not be driven by a passenger car;*  
|           |                              | * Repair roads or roads that are especially damaged in such:*  
|           |                              | * Residential roads;*  
|           |                              | * A pedestrian bridge;*  
|           |                              | * Alleys that are too small to be driven by a passenger car.*                                                                                                                                                |
The case study of Trento: a pole of attraction within Trentino - Flows Analysis

01/09/2018
TomTom

Introduction

The province of Trentino is well-known for tourism as it is extremely mountainous. It covers a large part of the Dolomites and the southern Alps. The region is relatively wealthy and has a diverse economy. The province produces agro-food, handicrafts, food processing, paper, wood making, textiles, mechanics, materials for construction, etc. The service sector is also quite well developed.

Trento has a geographical and economical central position within the province. It is the most populated town. The population of Trento (≈118,160 inhabitants as of March 2018) totals approximately 23% of the total population of Trentino (≈536,279 inhabitants as of February 2017). In the surrounding of Trento, some close urban areas also participate in the dynamism of the regional capital. Moreover, several medium and small towns, located in valleys and along the road network, are also part of the economy especially in tourism and industry.

Therefore, the purpose of this analysis is to study traffic flows within Trentino in order to better understand the central position of Trento in the region. This study will focus on observing the commuting phenomenon.
Introduction to the Origin-Destination matrix

TomTom O/D Analysis is based on nearly 10 years of historical data from more than 550 million devices: Smartphones, Automotive OEM customers, TomTom Telematics (fleet management), TomTom PHDs/Mobile apps, etc. It results from Floating Car Data (FCD) collection.

It allows a comprehensive understanding of the dynamics and movement within a city or metro area.

The TomTom O/D platform allows to run flow analysis between selected regions. The data is used in a way that only traces between the selected regions are counted. Moreover, the platform offers to visualize the data into a map. Matrix resulting from analysis run into the O/D platform can also be extracted.

Traffic flow analysis in the Trentino region

1. Flows between Trento and other urban areas in Trentino during weekdays
2. Flows between Trento and other urban areas in Trentino during weekends
3. Flows between Trento and other urban areas in Trentino during the morning peak (weekdays)
4. Flows between Trento and other urban areas in Trentino during the evening peak (weekdays)
Flows from/to Trento during weekdays

Parameters:

- **Selected urban areas**: The selection of areas has been made manually and takes exclusively into consideration the most urban territories.
  - 21 selected areas: Trento; Riva del Garda-Nago-Torbole; Caldonazzo-Levico Terme; Moena-Camuzzo; Cavallina-Pradizza; Canal San Pellegrino di Primiero; Allano-Caprile; Mezzolombardo-San Michele all'Adige; Vigo di Fassa-Pesia-Vittorio-Veneto; Cansiglio-Stolico; Belluno-Rovigo; Ave-Brentesica; Dro-Varzo; Molo-Mosso; Mori-Cartano; Terragnolo-Palade; Rovereto-Griante; Cismon; Bolzano; Otto-Selzene. The selected areas are presented in a map on the next slide.

- **Date range**: 01/01/2014 to 31/03/2018 (4 years and 3 months of data). Weekends have been excluded. The study includes only weekdays from Monday to Friday. Bank holidays and school holidays are not excluded.

- **Time range**: 06:00-22:00 (CET)

- **Internal trips**: within selected regions are not considered. Only flows between regions are taken into account.

Selected urban areas in Trentino and areas around Bolzano including Bolzano
Traffic flows observed from Trento during weekdays
4 years and 3 months of data

Traffic flows observed to Trento during weekdays
4 years and 3 months of data
Traffic flows observed from/to Trento to/from areas in Trentino region during weekdays

- There are no clear differences between the number of flows from Trento to and from Trento.
- We observe that most of the drivers travelling from Trento go to:
  1. Messneron/Scorcada-San Michele all’Adige
  2. Crestenza
  3. Rovereto
  4. Bolzano
  5. Mori-Calfenni

The same phenomenon is observed at the destination of Trento. This is the typical profile of the commuting phenomenon. The number of people leaving is similar to the number of people coming.

Flows from/to Trento during weekends

Parameters:
- Selected urban areas: The selection of areas has been made manually and takes exclusively into consideration the most urban territories.
- 35 selected areas: Trento; Riva del Garda-Nago-Torbole; Caldiero-Levico Terme; Molveno-Calcazzeri; Cavallino-Treporti; Caneva-Tagliamento; Montevecchia-San Michele all’Adige; Vigo di Fassa-Folgaria; Verona-Fregona; Caneva-Tagliamento; Lago di Ledro; Bolzano; Treviso. The selected areas are presented in a map on the next slide.
  - Date range: 01/01/2014 to 31/08/2015 (4 years and 3 months of data). Bank holidays and school holidays are not excluded.
  - Time range: 06:00-22:00 (CET)
  - Internal trips within selected regions are not considered. Only flows between regions are taken into account.
Selected urban areas in Trentino and areas around Bolzano including Bolzano

Traffic flows observed from Trento during weekends
4 years and 3 months of data
- There are no significant differences between flows to Trento and from Trento.
- We can only observe a variation of 2% comparing flows from/to Trento for the area called Oro-Salorno. It means that 2% more people travel from Oro-Salorno to Trento than from Trento to Oro-Salorno. Unfortunately, the difference is not relevant enough to show a tendency.
Road information services

Comparing flows from/to Trento during weekdays and weekends

Traffic flows observed from Trento (absolute numbers)

Traffic flows observed to Trento (absolute numbers)

- In total, we count 76% more observations (referring to the Matrix) during weekdays than during weekends. The calculations have been done considering the same basis in order to able comparison. The two charts show absolute numbers to observe commute.
- There are no significant differences between flows from Trento and to Trento during weekdays and weekends. At the exception of Mezzolombardo-San Michele all’Adige where more flows are observed during weekdays than during weekends in both directions.
- During weekdays, more drivers travel from Trento to Mezzolombardo-San Michele all’Adige, Nevedo-Grigona and Bolzano. In the other direction, there are more drivers going to Trento from Rive del Garda-Nago-Torbole and Mezzolombardo-San Michele all’Adige.
- During weekends, more drivers starting their trip in Trento travel to Vermezzo-Teruel, Aro-Brenzone, Dro-Vezzano, Malvino-Cavallino, Morz Cellino and Vigo-Vattaro-Calviare. The same phenomenon is observed in the other direction.

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Flows between Trento and other urban areas in Trentino during the morning peak (weekdays)

Parameters:

- Selected urban areas: The selection of areas has been made manually and taken exclusively into consideration the most urban territories.
  - 21 selected areas: Trento; Riva del Garda-Nago-Torbole; Calsambrez-Lyk Verona; Moena-Canaletto; Cavallino-Pratello; Cansel San Maurizio-Primo; Albino-Castel; Mezzolombardo-San Michele all’Adige; Vigo di Uls Fuente; Vermezzo-Teruel; Cansel San Maurizio-Bericks; Bolzano; Bolzano; Bolzano; Bolzano; Bolzano; Bolzano; Bolzano; Bolzano; Bolzano; Bolzano; Bolzano; Bolzano; Bolzano; Bolzano; Bolzano; Bolzano.
  - The selected areas are presented in a map on the next slide.
- Date range: 01/01/2014 to 31/03/2018 (4 years and 3 months of data). Weekends have been excluded. The study includes only weekdays from Monday to Friday. Bank holidays and school holidays are not included.
- Time range: 07:00-10:00 (CET) – Morning time
- Internal trips within selected regions are not considered. Only flows between regions are taken into account.

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Selected urban areas in Trentino and areas around Bolzano including Bolzano

Traffic flows observed from Trento at morning time (07:00 – 10:00 / Weekdays)
4 years and 9 months of data
Most of drivers travelling from/to Trento travel from/to:
1. Mezzolombardo-San Michele all’Adige.
2. Rovereto.

From Trento, more drivers go to Mezzolombardo-San Michele all’Adige, Ora-Sakine, Rovereto, Cavallino-Predazzo, Riva del Garda-Nago-Torbole, than in the other direction (to Trento).

At the destination of Trento, more drivers have started their trip in Vigolo Vattaro-Caldonazzo, Cavallino, Nevalindo-Grigno, Ora-Vezzano, than in the other direction (from Trento).
Flows between Trento and other urban areas in Trentino during the evening peak (weekdays)

Parameters:

- Selected urban areas: The selection of areas has been made manually and takes exclusively into consideration the most urban territories.
  - 22 selected areas: Trento; Riva del Garda; Nago-Torbole; Caldonazzo-Levico Terme; Moena-Cavazzon; Cavallino-Prolazz; Canali San Donnino Pieve di Primiero; Alliano-Canfranc; Mezzolombardo-San Michele all’Adige; Vige di Non-Predazzo; Vezzolano-Terazza; Campegno-Stanico; Belluno-Ronzone; Avio-Brentonico; Dro-Yazano; Molveno-Cavedago; Mori-Calliano; Terragnolo-Foligna; Rovereto-Griamino; Grauson; Bolzano; Ore-Selmo. The selected areas are presented in a map on the next side.

- Date range: 01/01/2014 to 31/03/2015 (4 years and 3 months of data). Weekends have been excluded. The study includes only weekdays.
- Time range: 14:00-19:00 (CEST) – evening time.
- Internal trips within selected regions are not considered. Only flows between regions are taken into account.

Selected urban areas in Trentino and areas around Bolzano including Bolzano
Traffic flows observed from Trento at evening time (16:00 – 19:00 / Weekdays)
4 years and 3 months of data

Traffic flows observed to Trento at evening time (16:00 – 19:00 / Weekdays)
4 years and 3 months of data
Most of drivers travelling from/to Trento travel from/to:
1. Mezzolombardo-San Michele all’Adige,
2. Civate,
3. Rovereto,
4. Molveno-Caldes,
5. Vigo di Fassa-Caldonazzo,

We observe the same phenomenon during the morning peak.

During the evening peak, more drivers starting their trip in Trento travel to Vigo di Fassa-Caldonazzo, Novalano-Grigna, Mezzolombardo-San Michele all’Adige, than from these areas to Trento.

More drivers travelling to Trento have started their trip in Riva del Garda-Nago-Torbole, Ora-Sulzano, Rovereto, Bolzano, Vigo di Fassa, than in the other direction.

We observe that in general drivers going from/to Trento mostly travel to/from Mezzolombardo-San Michele all’Adige, Civate, Rovereto, Bolzano, Vigo di Fassa-Caldonazzo.

Moreover, there is no clear variation between the flows from and to Trento at morning and evening time, except in some cases:
- In the first chart, more drivers seem to travel to Trento from Riva del Garda-Nago-Torbole and from Bolzano at morning time, than in the other direction at evening time. Also, more drivers seem to travel from Trento to Mezzolombardo-San Michele all’Adige during evening time, than in the other direction at morning time.
- In the second chart, more drivers seem to travel from Trento to Bolzano at morning time and from Civate and Dolo-Vezzano to Trento at evening time.
In conclusion:

- There are more observations during workdays than during weekends.
- We observe a strong connection between Trento, Mezzolombardo-San Michele all'Adige, Civezzano and Riva del Garda-Nago-Torbole.
- There is no clear variation between the number of traffic flows from and to Trento at morning and evening time. Therefore, we conclude that the number of people leaving is similar to the number of people coming, which is the typical observation in the case of commuting.
- It is interesting to compare these results with the land use map of the region and also with the map of the population. It would be very useful in order to understand the movement of the population.
Introduction

Trento participates in the economic dynamism of the north of Italy. The city benefits from its position along the Brenner Highway connecting Italy with the Northern Europe. The Trento’s economy is dominated by tertiary services with tourism, financial intermediation and real estate, community services, etc. The manufacturing sectors are represented with textiles, material for construction, food processing and others. The primary sector is based on wine making and fruit production. By its dynamism, Trento attracts workers, students but also tourists. Being positioned along the Brenner Highway guarantees a function of stopover town.

Therefore, the aim of this report is to identify commuters and more generally flows between Trento and surrounding cities located in north Italy and South Austria, using the Origin-Destination matrix platform.
Introduction to the Origin-Destination matrix

TomTom O/D Analysis is based on nearly 10 years of historical data from more than 550 million devices: Smartphones, Automotive OEM customers, TomTom Telematics (fleet management), TomTom PNDs/Mobile apps, etc. It results of Floating Car Data (FCD)'s collection.

It allows a comprehensive understanding of the dynamics and movement within a city or metro area.

The TomTom O/D platform allows to run flow analysis between selected regions. The data is used in a way that only traces between the selected regions are counted. Moreover, the platform offers to visualize the data into a map. Matrix resulting from analysis run into the O/D platform can also be extracted.

Migration analysis from/to Trento

1. Migrations from/to Trento during weekdays
2. Migrations from/to Trento during the morning peak (weekdays)
3. Migrations from/to Trento during the evening peak (weekdays)
4. Migrations from/to Trento during weekends
Migrations from/to Trento during weekdays

Parameters:

- **Regions**: 11 Cities have been selected.
  - Trento
    - In the direction of north: Bolzano, Tirolo, Innsbruck.
    - In the direction of south: Rovereto, Schio-Thiene, Vicenza, Padua, Verona, Brescia, Milan.
  
- **Date range**: 01/01/2016 to 31/12/2017 (2 years of data). Weekends have been excluded. The study includes only weekdays from Monday to Friday. Bank holidays and school holidays are not excluded.

- **Time range**: 07:00 – 20:00 [CET]

- Internal trips within selected regions are not considered. Only flows between regions are taken into account.

The 11 selected cities:

The selected regions, which are represented by circles, do not take into account administrative regions of cities. The regions are defined depending on the urban sprawl of each cities. In the case of Trento, a larger area is taken into account as it includes surrounding villages.
• There are not clear differences between the migrations to Trento and from Trento.

• We observe that drivers from Trento mainly travel to cities close by, located along the Brenner highway: as Rovereto (36%), Bolzano (32%) and Verona (14%). The same phenomenon is observed at the destination of Trento.

Migrations from/to Trento during the morning peak (weekdays)

Parameters:

• **Regions:** 11 Cities have been selected.
  - Trento
  - In the direction of north: Bolzano, Tirolo, Innsbruck.
  - In the direction of south: Rovereto, Schio-Thiene, Vicenza, Padua, Verona, Brescia, Milan.

• **Date range:** 01/01/2016 to 31/12/2017 (2 years of data). Weekends have been excluded. The study includes only weekdays from Monday to Friday. Bank holidays and school holidays are not excluded.

• **Time range:** 07:00 – 10:00 [CET]

• Internal trips within selected regions are not considered. Only flows between regions are taken into account.
Destinations at the departure of Trento at morning time (07:00 – 10:00):

Migration to Trento from the surrounding cities at morning time (07:00 – 10:00):
Migrations from/to Trento during the evening peak (weekdays)

**Parameters:**

- **Regions:** 11 Cities have been selected.
  - Trento
    - In the direction of north: Bolzano, Tirol, Innsbruck.
    - In the direction of south: Rovereto, Schio-Thiene, Vicenza, Padua, Verona, Brescia, Milan.
- **Date range:** 01/01/2016 to 31/12/2017 (2 years of data). Weekends have been excluded. The study includes only weekdays from Monday to Friday. Bank holidays and school holidays are not excluded.
- **Time range:** 16:00 – 19:00 [CET]
- Internal trips within selected regions are not considered. Only flows between regions are taken into account.

**Destinations at the departure of Trento at evening time (16:00 – 19:00):**
Migration to Trento from the surrounding cities at evening time (16:00 – 19:00):

- At evening and morning time, most of migrations between Trento and surrounding cities are at the departure or at the destination of 1) Rovereto, 2) Bolzano, 3) Verona. These cities are all located along the Brenner Highway. Then, comes 4) Trento, 5) Brescia, 6) Padua, which are located further.

- Commuting phenomena are observed between Trento and Rovereto/Bolzano:
  - In the morning, 47% of drivers travelling to Trento from the selected cities are coming from Rovereto. In the evening, 48% of drivers coming from Trento and traveling to other cities go to Rovereto. In the other direction, 49% of drivers coming from Trento and travelling to other cities go to Rovereto during morning. Moreover, 45% of drivers coming from the selected cities and going to Trento during evening are from Rovereto.
  - In the morning, 38% of drivers traveling to Trento from the selected cities are coming from Bolzano. Only 28% of drivers traveling from Trento to other cities are going back to Bolzano during evening. We observe here a disbalance. In the other direction, 29% of drivers from Trento and traveling to other cities go to Bolzano during morning, and 20% coming from other cities and going to Trento are from Bolzano during evening.

- Some observations concerning Verona and other further cities should not be related to commuter as the distance is superior to 90km. However, it can be linked with tourism or freight transport.
Migrations from/to Trento during weekends

**Parameters:**

- **Regions:** 11 Cities have been selected.
  - Trento
    - In the direction of north: Bolzano, Tirolo, Innsbruck.
    - In the direction of south: Rovereto, Schio-Thiene, Vicenza, Padua, Verona, Brescia, Milan.

- **Date range:** 01/01/2016 to 31/12/2017 (2 years of data). Only weekends have been selected.

- **Time range:** 07:00 – 20:00 [CET]

- Internal trips within selected regions are not considered. Only flows between regions are taken into account.

**Destinations at the departure of Trento during weekends:**

![Map showing migration patterns](image-url)
Migration to Trento from the surrounding cities during weekends:

- Comparing per day, 35% less traces are collected during weekends than weekdays. Therefore, there are less observations during weekends. We can suppose that there is less drivers, so less traffic on Trento’s network.

- We cannot conclude significant tendencies as the amount of data is limited. During weekdays, migrations from/to Trento mainly occur along the Brenner Highway and mainly concern Rovereto and Bolzano. During weekends people tend to travel more to further cities like Verona, Tirolo, Innsbruck, Milan and Padua. This phenomenon can be linked to tourism. Unfortunately, the distinction between weekdays and weekends is not very visible.

- There is no significant differences in the number of trips going from/to Trento.

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In conclusion

- Drivers from/to Trento mainly travel to/from cities located along the Brenner highway.
- Commuting can be observed between Trento, Rovereto and Bolzano.
- A certain amount of drivers travel between Trento and Verona (13-14% of all drivers from/to Trento travel to Verona during weekdays and 14-16% travel during weekends). Tourism or/and freight transportation can explain this phenomenon.
- Comparing the different OD map flows, we observe that a certain percentage of drivers traveling between Trento and further cities like Milan and Brescia (3-5%) are not commuters as their trips have not been collected at commuting times and because of the important distance between those cities. They are probably traveling for tourism or/and freight transport.
- During weekends, we observe less traffic on roads and drivers seem to travel to farther destinations, certainly for tourism purpose.