eCO-friendly urban Multi-modal route PlAnning Services for mobile uSers

FP7 - Information and Communication Technologies

Grant Agreement No: 288094
Collaborative Project
Project start: 1 November 2011, Duration: 38 months

D6.2.2 – Pilot Results Consolidation

Workpackage:	WP6 - Pilot Realisation, Assessment and Evaluation
Due date of deliverable:	30 November 2014
Actual submission date:	30 November 2014
Responsible Partner:	TomTom
Contributing Partners:	TomTom, PTV

Nature: ■ Report   ☐ Prototype   ☐ Demonstrator   ☐ Other

Dissemination Level:

■   PU :   Public

☐   PP :   Restricted to other programme participants (including the Commission Services)

☐   RE :   Restricted to a group specified by the consortium (including the Commission Services)

☐   CO :   Confidential, only for members of the consortium (including the Commission Services)

Keyword List: algorithms, shortest path, route planning, time-dependent shortest path, alternative routes, private vehicles, heuristics

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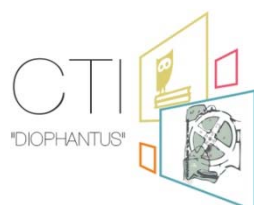
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Document history			
Version	Date	Status	Modifications made by
1.0	12.11.2014	Sent to internal reviewers and PQB	Michael Marte, TomTom
1.1	24.11.2014	Reviewers' comments incorporated (sent to PQB)	Michael Marte, TomTom
1.2	28.11.2014	PQB's comments incorporated	Christos Zaroliagis, CTI & Florian Krietsch, PTV
1.3	30.11.2014	Final (approved by PQB, sent to the Project Officer)	Christos Zaroliagis, CTI

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Summary
eCOMPASS WP6 was concerned with testing the prototypes that were developed in WP5 based on earlier results from the eCOMPASS project, namely for private vehicle navigation, for fleet management, and for tourist-trip planning including multi-modal public transportation routing. To this end, three field tests were performed, one for each prototype.
This report presents an overview of each of the field tests in terms of goals, design, and results. Details of pilot designs and results can be found in Deliverable D6.2.1.

Table of Contents

1   Introduction

eCOMPASS WP6 was concerned with testing the prototypes for private vehicle navigation, fleet management, and tourist-trip planning (including multi-modal public transport routing) that were developed in WP5 based on earlier results from the eCOMPASS project. To this end, three field tests were performed, one for each prototype.

This report presents an overview of each of the field tests in terms of goals, design, and results. Due to confidentiality reasons, a full presentation of pilots experimental designs and detailed findings cannot be disclosed in this public version (D6.2.2), and we refer to the restricted version D6.2.1 for an extensive account of all pilot details.

1.1   Private vehicles

The prototype for private vehicle navigation (as described in D5.1) is based on the TomTom navigation software stack and implements a feature called *in-drive alternatives* that provides route options (not only faster, but also more economic and other routes) while driving. This feature was developed with the intent to convince commuters that it makes sense to use a navigation device even in a well-known area in order to avoid traffic jams, to arrive earlier, and/ or to save fuel.

In the field test, we were interested in the perceived quality of the alternative routes (computed with algorithms developed in the eCOMPASS project, see D5.1) and in how often we can offer alternatives without annoying or distracting the driver.

1.2   Fleets of vehicles

The prototype for fleet management (as described in D5.2) is based on the PTV trip planning framework SMARTOUR. For the eCOMPASS prototype it was extended with interfaces for providing trips through the TomTom WEBFLEET service. Furthermore it integrates an advanced VRP (vehicle route problem) approach for computing compact and balanced trips. Both features were developed and integrated with the intent to specifically address uncertainty problems in the field of urban distribution and pick-up scenarios. To address these challanges, the eCOMPASS prototype provides IT support for logistic companies by offering planning and visualization capabilities.

In order to verify and validate the prototype, we used a hybrid approach of real-world testing and simulation where the results from the real-world test were used to calibrate the data instances for the simulation test.

1.3   Tourist-trip planning and multi-modal public transport routing

The prototype for multi-modal public transport routing (as described in D5.3) is functionally based on server components for passenger transport routing and trip planning as well as on content-aware services of the CGM (Content Gateway Module)[1]. The functional features consist of tourist-trip planning and multi-modal passenger routing capabilities. These features can be used in order to plan a touristic trip in an eco-friendly fashion by paying special attention to public transport services at

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[1] Actually two prototypes were developed, one based on HTML 5 and the other one a dedicated Android app. The field test was based on the former one.

planning stage. This way the prototype promotes public transport as such by raising awareness of public transport alternatives as part of a door-to-door routing.

In the field test we concentrated on the quality of the routing functionality. Moreover, to assess the usability & UX of the entire prototype, an expert review was conducted with the focus on compliance to usability norms.

2 Private vehicles

As part of WP5, a prototype for private vehicle navigation was developed as described in D5.1. This prototype is based on the TomTom navigation software stack and implements a feature called *in-drive alternatives* that provides route options (not only faster, but also more economic and other routes) while driving. This feature was developed with the intent to convince commuters that it makes sense to use a navigation device even in a well-known area in order to avoid traffic jams, to arrive earlier, and/ or to save fuel.

To assess this prototype, a field test was performed in the course of WP6. The test was split into two parts: In a pilot study we took cab drivers on a round trip through Berlin while the main study was performed with commuters in their daily routine. Both studies were conducted in a qualitative way with small random samples. We were interested in the perceived quality of the alternative routes (computed with algorithms developed in the eCOMPASS project, see D5.1) and in how often we can offer alternatives without annoying or distracting the driver.

In particular, the main research questions were:

- How often can alternatives be offered en route without distracting drivers too much?
- How relevant are the offered alternatives?
- How well do the alternatives match the drivers' own routes?

This information is required to tune the process of computing alternatives.

Our pilot findings are summarized as follows:

- Frequency: No participant perceived the number of alternatives offered while driving as distracting.
- Relevance: All participants perceived useful and less useful alternatives.
- Overall UX: The in-drive alternatives feature was rated predominantly positive.
- Usability: According to the SUS (system usability scale) score, the usability of the prototype is already very good.

3   Fleets of vehicles

3.1   Introduction

The prototype for fleet management (as described in D5.2) is based on the PTV trip planning framework SMARTOUR. For the eCOMPASS prototype it was extended with interfaces for providing trips through the TomTom WEBFLEET service. Furthermore it integrates an advanced VRP (vehicle route problem) approach for computing compact and balanced trips. Both features were developed and integrated with the intent to specifically address uncertainty problems in the field of urban distribution and pick-up scenarios. To address these challanges, the eCOMPASS prototype provides IT support for logistic companies by offering planning and visualization capabilities.

In order to verify and validate the prototype, we used a hybrid approach of real-world testing and simulation. The real-world test was conducted in September and October 2014 in the area of Berlin with a logistics company. Its results were used to calibrate the data instances for the simulation test.

In the following, we detail on the methods we employed, the study design, and our findings.

3.2   Real-world tests - Testing with the logistics company in TS Berlin

3.2.1   Logistics company test approach

We used a staged approach for conducting the test with the logistics company:

- Stage 0 – Preparation phase
    - Selection process to find a suitable logistics company as test partner for the project
    - Technical setup of in-car system, back-end system and interfaces
    - Test drives with fully fledged vehicle
- Stage 1 - Expert interview with the logistics company
    - To understand the business they are active in
    - To understand the existing problems
    - To familiarize the involved persons in the company with eCOMPASS and the specifically with the implementations of Task 5.2
- Stage 2 – Live tests in Berlin
    - Equipment test and set-up of operational system components
    - Going live and training of driver and dispatcher
    - Test driving in real world conditions
    - Data collection and monitoring of key performance indicators
- Stage 3 – Finalization
    - Post processing of collected data
    - Final interview with logistics company and reflection of eCOMPASS system
    - Result analysis

In total we collected data from 4264 km of driving. About 500 km were generated for verification and system tuning by a passenger car. About 3750 test km were generated by a CEP (Courier Express) van (Mercedes Benz Sprinter) in a real business environment. The test drives took place on 17 test days in September and October 2014. Two drivers, both male (37y and 33y) performed the tests. Furthermore two dispatchers, both male (63y, 34y), were involved during testing and interviews. During the tests in Berlin about 270 transport orders were taken into account for planning, execution, re-planning and analysis.

3.3   Simulation

Central advantage of a VRP simulation instance is to calculate reproducible results of large data sets without performing time and cost consuming real-world tests.

In eCOMPASS we use a hybrid approach of real-world tests to gain tuning and configuration recommendation advice for laboratory simulations. For the simulation part we use two test instances for validation purposes:

- Test instance "Hamburg" without order restrictions and unlimited vehicle capacities
- Test instance "Germany" with hard restrictions and limited vehicle capacities

3.3.1   Test instance Hamburg

In D5.2, we introduced various VRP approaches and assessed them by using a test instance based on real-world data. This test instance is re-used within this deliverable to further test, compare and validate results for the further tuned VRP algorithm approach.

The following conditions and assumptions have been made for the test instance "Hamburg":

- 1000 transport orders
- Greater area of Hamburg
- Data sets generated from real transport order data set and anonymized for testing purposes
- Constant service times at stop locations
- Transport orders represent one physical stop location each.
- Transport orders are described in the initial case (verification) without restrictions, e.g. no time-window, no weight and no volume restrictions. It is possible to apply order restrictions at a later stage if required (for validation).
- Unlimited number of vehicles and drivers are available.
- No time-limitations on availability for vehicles and drivers, except drive and rest rules are applied.
- Historic traffic information is taken into account for calculation of travel times.
- The vehicle routing profile is constant.

As part of the simulation several trip planning approaches (cf. D5.2) have been tested.

- Default planning approach – a standard approach which calculates a quick solution, respecting all restrictions
- Default planning with sequence optimization approach – a standard approach, respecting all restrictions, it calculates a quick solution followed by a sequence optimization per trip
- Default planning with post-optimization – a standard approach with a post optimization. It respects all given restrictions.
- PTV advance optimization – an optimization enriched with VRP findings on compactness and balancing. It respects all given restrictions.

3.3.2   Test instance "Germany with order restrictions"

The focus of this data instance is to simulate a planning case in which transport orders do include several restrictions, e.g. time windows for pickup and delivery. Furthermore, the vehicle fleet is modeled in a below capacity setting. Thus the freedom for optimization potential is limited.

The figure below presents in a graphical way the test instance - order locations (green boxes) and fleet depot locations (red pyramids).

The following conditions and assumptions have been made for the test instance "Germany with restrictions":

- 3000 transport orders
- Area of Germany and neighbor countries
- Data sets generated from real transport order data set and anonymized for testing purposes.
- Unsteady service times at stop locations
- Transport order instructions can consist of multiple orders per physical stop location.
- Transport orders are described including restrictions, e.g. time-windows, weight and volume restrictions.
- The number of vehicles and drivers is limited.
- Historic traffic information is taken into account for calculation of travel times.
- Different vehicle routing profiles are taken into account, e.g. large truck, small and medium trucks.

As part of the simulation several trip planning approaches (cf. D5.2) have been tested.

- Default planning approach – a standard approach which calculates a quick solution, respecting all restrictions

- Default planning with sequence optimization approach – a standard approach, respecting all restrictions, it calculates a quick solution followed by a sequence optimization per trip
- Default planning with post-optimization – a standard approach with a post optimization. It respects all given restrictions.
- PTV advance optimization – an optimization enriched with VRP findings on compactness and balancing. It respects all given restrictions.

3.4   Summary

The novel approach of compact and balanced trip designs does appear after several tuning iterations to be mature. The results of both simulation instances do well reflect the benefits of balanced and compact trips. These allow to increase the robustness of the trips generated in such a way, that additional or substituted stops can be easily added without significant increase of trip distance or duration.

Combined with findings of the real-world tests conducted with a CEP logistics company in the test site Berlin, this new planning approach seems very beneficial especially for highly dynamic transport businesses (in urban environments).

4 Tourist-trip planning and multi-modal public transport routing

4.1 Introduction

As part of WP5, a prototype for tourist-trip planning and multi-modal public transport routing was developed as described in D5.3. The prototype is based on HTML 5 and provides the following services to end users:

- Support to plan a touristic trip
- Customization of trip preferences
- Proposal of POIs for touristic trips
- Visualization of trips
- Multimodal passenger routing

To assess this prototype, a field test was performed in the course of WP6. The test was split into two parts: The pilot study was carried out with the primary purpose of evaluating the routing functionality while the main usability & UX evaluation (to explore the ergonomics of human-system interaction) was conducted by means of an expert review focusing on compliance to usability norms [DIN EN ISO 92 41 -11 and- 110].

In the following we detail on the methods we employed, the study design, and our findings.

4.2 Multi-method approach

The user research was performed in a qualitative way using the following methods:

- Observation
- Thinking aloud
- Interview
- Heuristic evaluation
- Expert reviews: DIN EN ISO 9241-11-110
- Scenario walkthrough

4.3   Single-phase pilot study design

For this pilot study, all 47 participants were recruited directly within their natural environment, e.g. waiting for the next bus or train on their current trip:

Phase	Approach
Real-life study (look-and-feel-experience) with focus on public transport within the natural environment of participants	Focused short interviews were conducted and the app was life tested with several destinations by comparing and assessing different proposals

There were asked to test the public transport routing function and evaluate the suggested route options, including offered alternatives:

4.4   Two-phase main study design

The main study was performed in two steps:

Phase	Approach
Heuristic evaluation DIN EN ISO 9241-11-110	The prototype was tested for compliance to the following dimensions (-110): 1. Self-descriptiveness 2. Suitable for the task 3. Controllability 4. Conformity to user expectations 5. Suitable for learning 6. Error tolerance 7. Suitable for individualization
Scenario walkthrough Focus on public transport routing Focus on trip planning	Predefined use case Plan different routes using different settings Plan different trips for three and seven days, respectively, using different settings

The app was evaluated on Windows using the browser Firefox 33.0.2 running on a 24'' screen with a resolution of 1920 x 1080.

4.5   Testing period and participants

The pilot study was performed on the 29th of September 2014 with 47 random participants who were recruited directly within their natural environment, e.g. waiting for the next bus or train on their current trips:

4.6   Results of the pilot study

All participants were asked to plan a route to their current destination using the public transport routing app. The following table summarizes their comments on the perceived route quality:

Aims		N= 47	Overall Relevancy Evaluation
Relevance of offered routes	⬆	87.3 %	✓ Out of two route suggestions (fastest and alternative) at least one was evaluated very positive regarding the relevance o *good, correct*
	⬇	12.7 %	o Only few participants did not perceive the offered route suggestions as the best ones, one due to the fact that he wanted to stop for a snack on his route

Out of 47 random samples, 87% of the participants perceived the route suggestions as positive and evaluated the relevance as good.
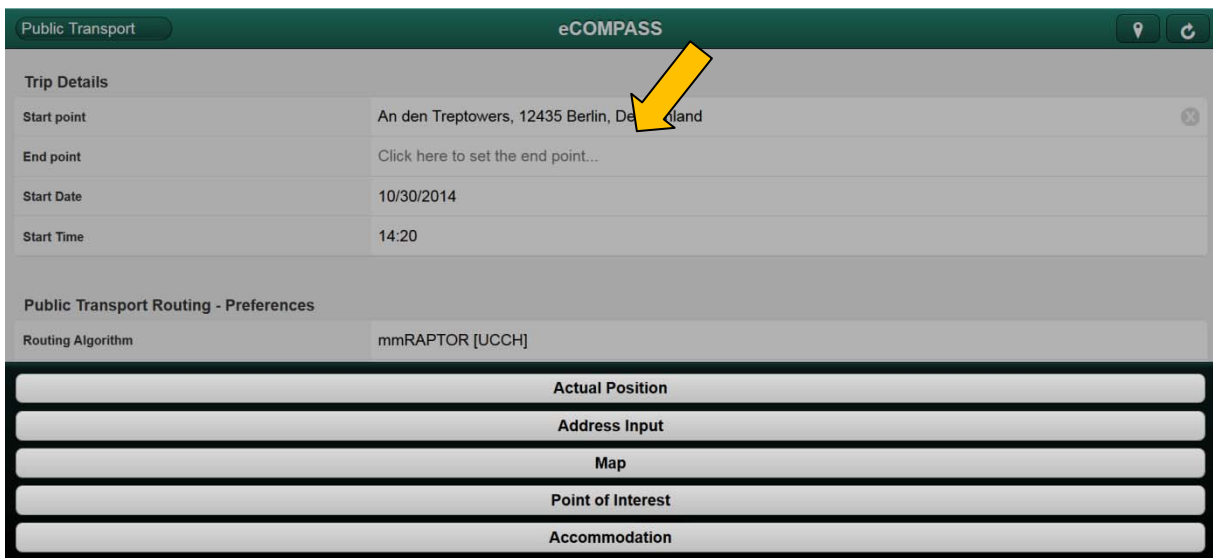
4.7   Tourist-trip planning
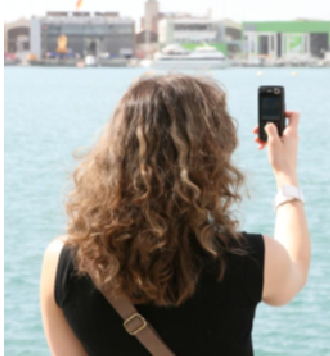
4.7.1   Start and end point definition

Start and end points are chosen like in public-transport routing:


Unfortunately, the planning starts immediately after choosing the end point with the default settings for dates, times, and preferences. It is unclear how to change the preferences, for example, and the user has to find out by trial and error. We suggest to add a button for starting the planning.

4.7.2   Tourist-trip planning preferences
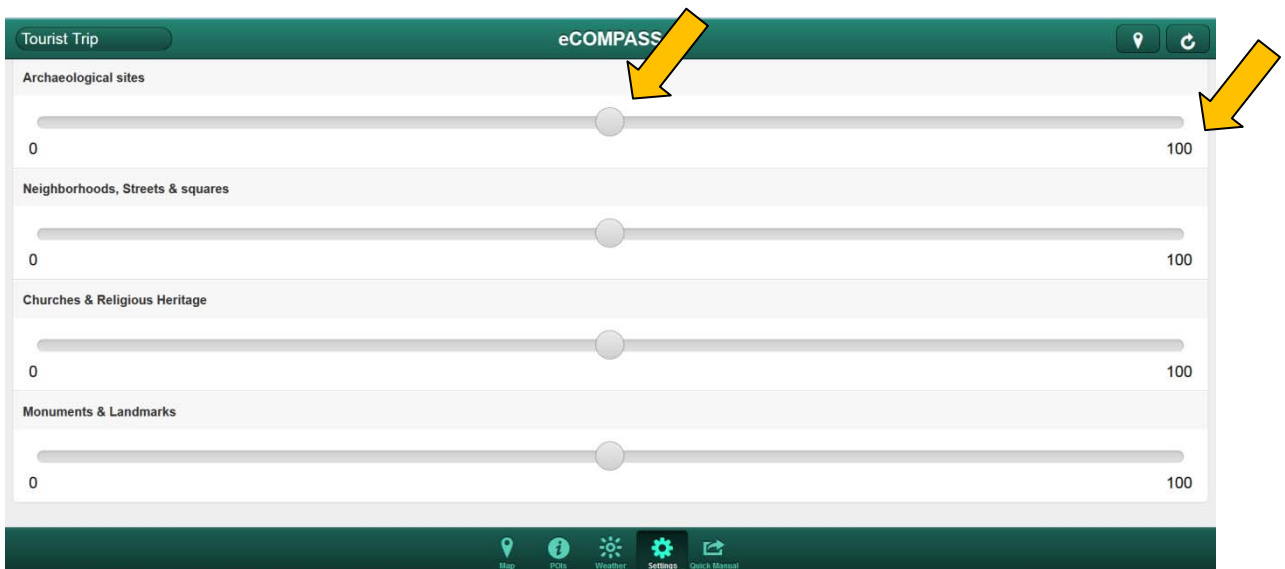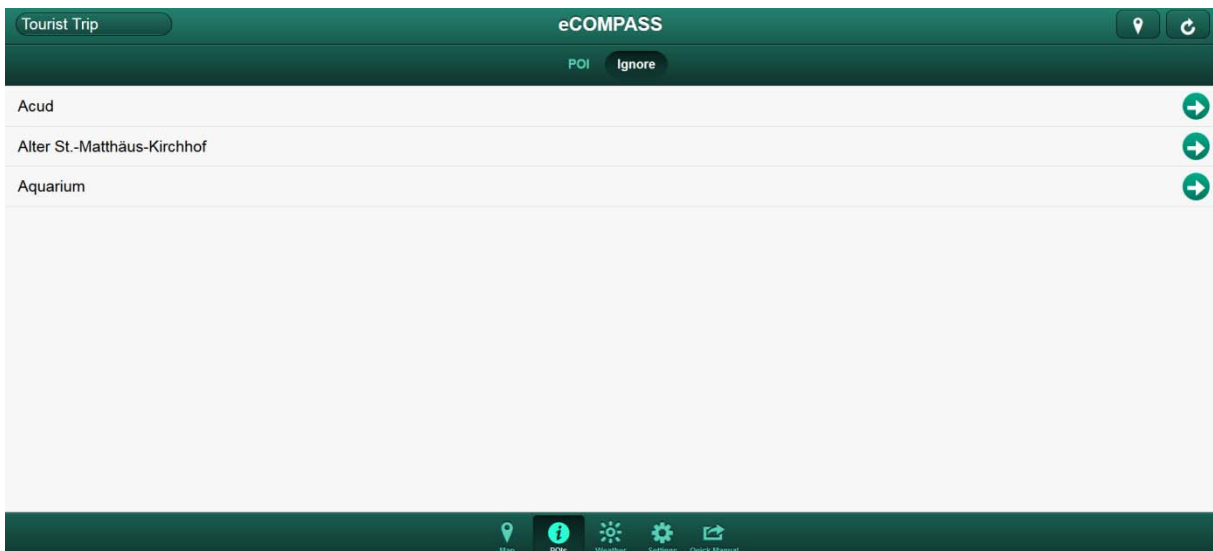
4.7.3   Points of interests

The POI info window has a button to add the current POI to the ignore list:
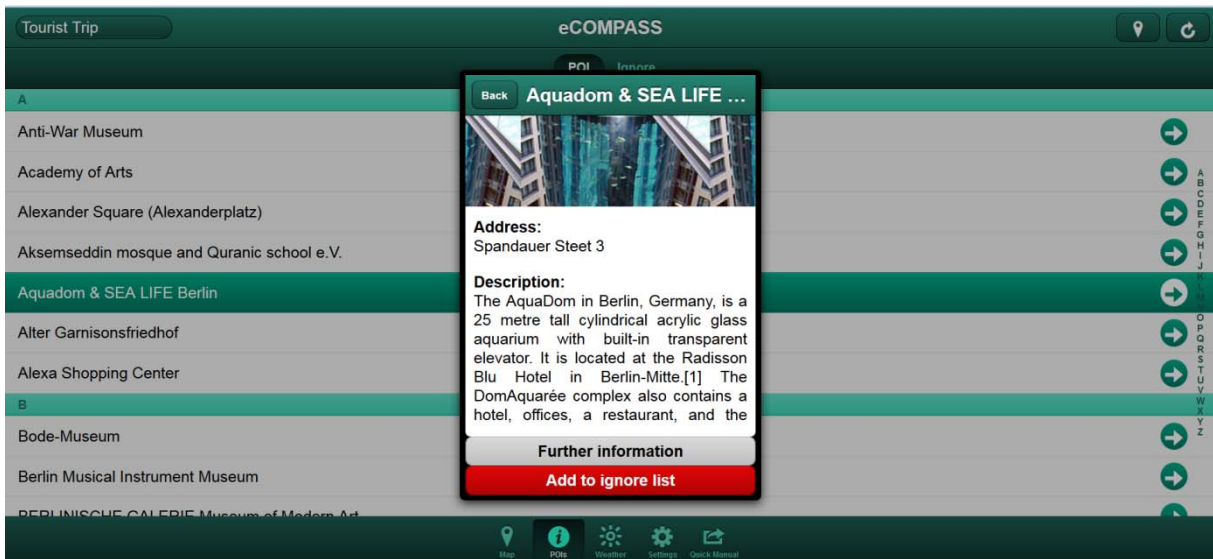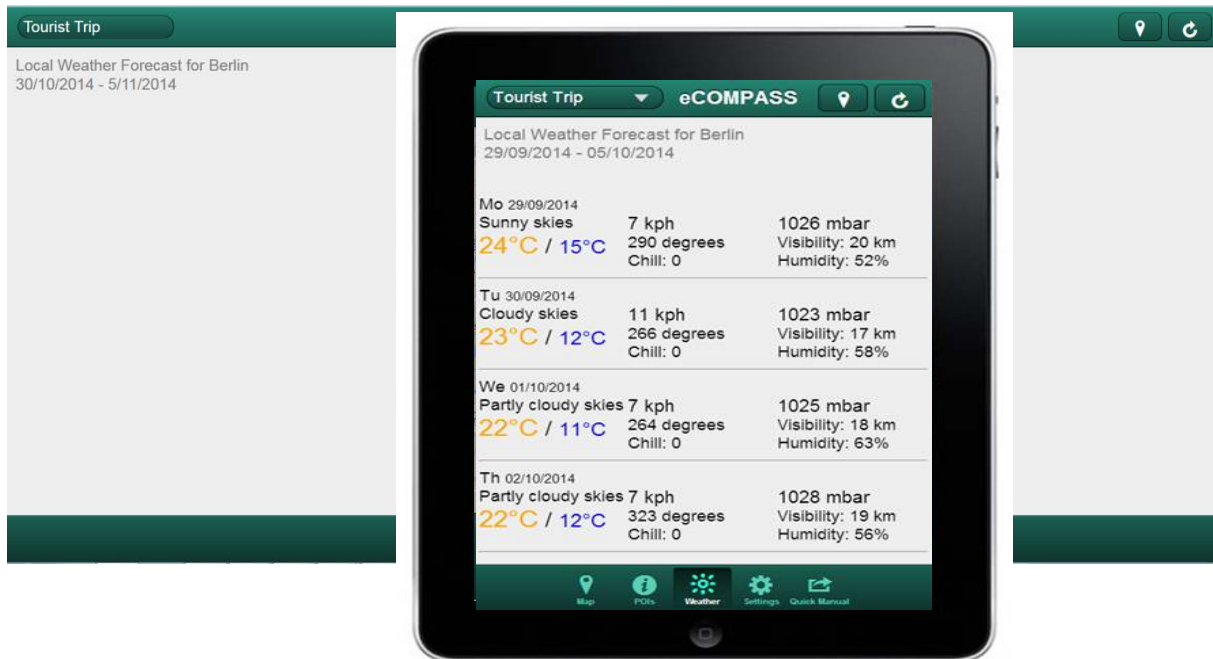

After tagging the POI, it will appear on the list of POIs to ignore:

4.7.4   Weather forecast for Berlin

The weather function allows a forecast of several days:

4.8   Summary

The prototype app allows the planning of tourist itineraries based on multi-modal public transport routing with the option to request alternative routes. Several input options for defining start and end points are available. POIs are chosen automatically based on user preferences (including the user-defined POI ignore list).

The prototype app can already be used in an efficient, effective, and "*satisfying*" (DIN EN ISO 9241-11) way.